PROCEEDINGS

of the

United Nations Scientific Conference on the Conservation and Utilization of Resources

17 August—6 September 1949, Lake Success, New York

Volume VII, Wildlife and Fish Resources

UNITED NATIONS
DEPARTMENT OF ECONOMIC AFFAIRS
New York, 1951

E/CONF. 7/7

UNITED NATIONS PUBLICATIONS
Sales No.: 1950.II.B.5

Price: $ 2.50 (U.S.)
(or equivalent in other currencies)

ERRATUM

UNITED NATIONS SCIENTIFIC CONFERENCE ON THE CONSERVATION AND UTILIZATION OF RESOURCES, Volume VII. WILD LIFE AND FISH RESOURCES.

Sales No. for this publication should read:

1950.II.B.8

instead of 1950.II.B.5

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UNITED NATIONS SCIENTIFIC CONFERENCE ON THE CONSERVATION AND UTILIZATION OF RESOURCES

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The Proceedings of the United Nations Scientific Conference on the Conservation and Utilization of Resources are being issued in eight volumes as follows:

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Changes in Abundance of Fish Population

22 August 1949

Chairman:

C. J. BOTTEMANNE, Former Head of Institute of Sea Fisheries of the Indies, Batavia, Westeinde 134, Voorburg, the Netherlands

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Discussants:

Messrs. M. GRAHAM, A. L. PRITCHARD, D. W. PRITCHARD, WALFORD, HOFFMASTER, OPPEDAL, KASK

Programme Officer:

F. N. WOODWARD

[1]This paper was also presented to the participants in the Water Section Meeting of 30 August and is printed on pages 408—412 of Volume IV of these Conference Proceedings.

Changes in the Abundance of Fish Populations

GUNNAR ROLLEFSEN

ABSTRACT

The variable nature of Norway's seasonal fishing for cod and herring is outlined.

Reasons are given why the great fluctuations in the catches hitherto must be considered caused by other activity than that of man.

Different types of fluctuations occurring are described and analysed.

Fish along its coast are one of the few gifts which Nature has bestowed upon Norway. However, even this gift is not given with a liberal hand. When the schools of herring and cod approach the coast, the visit is of rather short duration. Besides this, in a series of years the resources of the sea seem to be unlimited, while the next series of years yield only small catches.

In the history of Norway, it has always been an occurrence of great importance when the fish failed to appear at the coast. The effects upon the economy of the country were not so serious if fishing conditions were unfavourable in a single year. When, however, the fisheries were idle for a longer period because cod or herring failed to come, then both the technical development of fishing and the economic development of the country had a setback.

The fluctuating nature in the fishing is revealed in the echoes from past days, reflected in tales and stories told from grandfather to grandson. Very early in the history of Norwegian fishing it seemed natural to use the expression "fishing periods".

The causes of the great fluctuations have, without doubt, been discussed with the same interest in olden times as now.

In the past, people regarded the fish as a gift from God; and when the fish failed to come, it was considered a punishment to be endured, due to their common and accumulated sins.

In our days, the fluctuations in certain stocks of fish are regarded as a result of changes in hydrographic and atmospheric conditions—changes which may be links in an oscillating chain leading out from the universe to the surface of the small revolving globe on which we live. Both of these opinions regarding causes lie outside the action of man. Fluctuations in other stocks of fish are, on the other hand, regarded as imposed by the action of man and considered amendable.

The passivity of the olden days has been replaced by the activity of modern times. By means of scientific investigation of the oceans, man has tried to gain knowledge of the life in the sea. The modern research worker will attempt to achieve a knowledge beforehand in the hope that he may be able either to predict the natural fluctuations in the abundance of the resources of the sea, or to propose changes if altering conditions are caused by man.

FLUCTUATIONS IN THE ARCTO-NORWEGIAN STOCK OF COD

Some remarks on the biology of the cod and the Lofoten fishing

Two seasonal and important cod fishings take place on the Norwegian Coast. Both fishings are based upon the very large cod population of the Arctic waters, "the Arcto-Norwegian stock of cod".

This cod has its home in the relatively shallow water area which is found north of Norway. The boundaries of this shallow water area are:

South: the Norwegian Finmark coast; the Murman coast.

East: Novaya Zemlya.

North: the Franz Josef Island group, and Spitsbergen.

West: the slope of the continental shelf.

The area is called the Arctic Ocean, or partially also the Barents Sea.

Investigations carried on for many years have shown that the mature cod found in this area undertake every year a spawning migration to the Norwegian Coast, while all young, immature cod remain in the area until one year maturity is achieved. Then also the young, first time spawners, will join the older spawners when in November the schools gather for the spawning migration.

The spawning schools of cod will mainly seek and stop on the spawning ground in Lofoten, arriving there in January and February. The spawning reaches the highest intensity in March, and in April the cod are on their way back to the feeding grounds in the Arctic.

The Lofoten fishing occurs in February, March and April; and, as an average over many years, about 20 million cod are caught during this season.

Returning to the Arctic, the spent cod will touch the Finmark coast. Also, the young, immature cod in May and June approach the same districts on a feeding migration; and the other important cod fishing takes place on the Finmark Coast in these months.

Fluctuations in Norwegian cod fishing

Thanks to statistics gathered since about the middle of the last century, we are able to picture the fluctuations which have taken place in cod fishing in the last hundred years.

Of special importance are the statistics taken from the Lofoten fisheries because of their detailed nature.

Also, the research work on the cod commenced very early, because of the importance of the Lofoten fishery; and in the following paragraphs will be given some results of these investigations as far as the fluctuations are concerned.

Fishing is dependent both on fish and fishing efforts. If there are no fish available, there will be no catches. If the fishing efforts are made impossible, there will also be no catches. One would therefore think that scarcity or abundance of fish would affect the catches made, and that favoured or hampered fishing efforts also would influence the catches.

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Analysing the Lofoten fishery, it is obvious that this is the case; and we are able to distinguish among several factors influencing fishing and the amount of fish landed.

From the curve which may be drawn, based upon the data of the actual number of cod caught in Lofoten every single year, we may visualize not only very great fluctuations from year to year, but we will also observe that three to five consecutive years may have greater catches than the following couple of years. And lastly, we are able to follow a trend which seems to be of long-range periodical nature. We are, in other words, able to distinguish between three different types of fluctuations in the amount of fish brought ashore:

1. Yearly fluctuations.
2. Short time fluctuations.
3. Long time fluctuations.

An analysis of these fluctuations shows that they have each a different background. Yearly variations may be ascribed to variations in the behaviour of the fish on the spawning grounds. One year the fish may occur on the more shallow parts of the banks. This makes fishing easier. The next year the fish may stay in deeper waters and in a manner which introduces difficulties for the fishermen. These changes in the behaviour of the fish seem to be connected with certain hydrographic conditions (temperature and extent of certain water layers), and we may therefore ascribe yearly variations in the catch partially to yearly variations in the hydrographic conditions of the sea. However, yearly variations in the catches are obviously also caused by yearly variations in the meteorological conditions in the fishing season. Stormy weather, occurring especially in the middle of the season, obviously hampers fishing operations; and we will find that the correlation between certain weather conditions and the catch is very pronounced.

Short time fluctuations, characterized by three to five successive years of higher or lower average catches than the next following years, seem to be intimately connected with the strength of the year-classes. By means of age determinations and length measurements of the cod, we are able to study the occurrence of the year-classes and the recruitment of the stock. We can state that there is a great difference between the arithmetical numbers of fish born in different years. We are able to distinguish between rich and poor brood years, and to measure the relative strength of year-classes.

The type of variations in the catches which we referred to as short-time fluctuations now coincide very closely with the strength of the year-classes appearing on the fishing grounds to spawn.

The correspondence between the catches and the abundance of the year-classes fished upon is so close that, based upon the knowledge of strength of the year-classes, a probable catch can be predicted. However, hydrographical and meteorological conditions prevailing during the fishing season may cause deviations of an average size of $\pm$ 10 per cent.

Long time fluctuations may also be discussed by means of the curve given. In the years from 1870 to 1895 the catches in Lofoten appear to be rather good. As an average, about 24 million individual fish were caught. During the following twenty-five years, 1895 to 1920, the catches were small, averaging only 12 million individual cod.

From 1920, increasing catches have brought the average of the last twenty-five years up to the level of the years 1870 to 1895. We may accordingly distinguish among three periods in Lofoten fishing in the last eighty years: a good period from 1870 to 1895, a less-good period from 1895 to 1920, another good period from 1920 up to the present.

Our knowledge of variations in the strength of year-classes and how these variations affect the size of the catches allows us to draw some conclusions as to the cause of the last good period.

In this sequence of years a couple of good year-classes have appeared. Those born in 1917, 1918, and 1919 were from two to four times as numerous as the year-class born in 1927 (which is chosen as a unit in the calculations). Then the year-classes of 1929 and 1930 were also above normal, and so was the year-class born in 1937. As the cod will seek the spawning grounds in Lofoten in greatest abundance when they are ten years old, we will find that the corresponding catches in 1927 to 1929, as well as the catches in 1939, 1940 and 1947, are ranging so high that the average catch of the period is raised to about 25 million fish a year.

We may therefore ascribe the high average catch in the last twenty-five years to the six good year-classes mentioned.

Although no exact age determinations are available describing the year-classes prior to 1917, we have very strong indications that a year-class born in 1912 originated the last good fishing period in 1920. Length measurements from this time are at hand, and from them we can deduce that the stock of cod in the years before 1920 must have been small. The reason is that the 1912 yearclass from its very first appearance in Lofoten dominated the catches.

As the last good period was characterized by a number of year-classes of high numerical strength, the stock in those years has obviously been correspondingly large; and as in any case the latter part of the preceding poor period certainly coincided with a very small stock, it may be well founded to regard the long-time fluctuations as a result of corresponding variations in the total stock.

It is evident that only six year-classes in the last thirty years have been of major importance. Still those few good brood years have raised the catches above the average. It may well be that the poor catches from 1900 to 1920 were due to the non-existence of any year-class of importance in those years.

Variations in fishing efforts are, of course, a matter which must be taken into consideration. In two ways, variations in fishing intensity may influence the catches. There may be a connexion between the intensity of fishing and the size of the catches. On the other hand, the intensity of the fishing efforts may also influence the abundance of fish.

As regards the cod fisheries off the coast of Norway, it is evident that fishing intensity has varied widely in the period under consideration. On one hand, we have great variations in the number of fishermen. On the other hand, we may state a development in the methods of fishing.

Our analysis of the connexion between the number of fishermen engaged in Lofoten fishing and the amount of cod landed reveals, however, that the variations in the number of men taking part in the fishing is contingent to a very large extent on the size of catches in the preceding years. The size of the catch in one year will, according to the experience of the fishermen, indicate the fishing prospects for the following year. Increasing catches in Lofoten are therefore followed by a delayed increase in the number of fishermen. In the same way, decreasing catches cause a decline in the number of fishermen in subsequent years. But these circumstances do not exclude the possibility that a larger number of fishermen would land more fish than a smaller number would. An investigation of this point shows, however, that variations in the catches in Lofoten have been independent of variations in the number of fishermen. There seems always to have been a surplus of men taking part in the fishing. The fluctuations in the number of fishermen seem to have taken place above a ceiling formed by certain limiting factors such as extension of fishing grounds in relation to amount of gear, and also to the size of the stock.

Still, a question may be raised as to whether or not the fluctuations in the Norwegian cod fisheries may be due to variations in the stock of fish caused by variable fishing intensity (taxation). We can safely state that this seems not to be the case.

In the good fishing period from 1870 to 1895 the landings were made from small open boats equipped only with sails and oars. In the five years from 1895 to 1900 the landings declined abruptly, and the catches remained very low for the next twenty years. However, in these years a very important development in the fishing fleet took place. The motor was introduced in the fishing boat, and boats with decks were common. Both these improvements increased the fishing efficiency of the fleet and of the men. Nevertheless, the catches remained small until 1925. Then in the next years a sudden increase in the landings took place; and even if great fluctuations have occurred, the average landings for the period 1925 until the present have been large.

The development of the fishing fleet has continued; and the increase in the catches could be regarded as a result of more intensive fishing. However, as explained above, the catches seem to be independent of variations in the fishing efforts. But there is another factor which is introduced in this last period and which is becoming of more and more importance.

Other countries began in the early thirties to develop high sea fishing of the Arctic stock of cod by means of large trawlers. In 1938 the Norwegian catch of Arctic cod amounted to 265,000 tons while the catches taken by other countries would be between 500,000 and 550,000 tons.

In spite of considerable additional taxation, the stock of cod seems not to have been over-exploited. It is, however, too early to express any opinion regarding the effects of the increased taxation if and when the stock will decrease for natural reasons.

The main point in this thesis is, however, to point out that none of the fluctuations hitherto observed can be regarded as functions of changes in fishing intensity.

Fluctuations in Norwegian cod fishing as they have appeared in the last eighty years must be regarded as determined by natural conditions lying outside the action of man.

FLUCTUATIONS IN NORWEGIAN HERRING FISHING

In January and February large schools of herring appear off the Norwegian Coast on spawning migration.

The herring approaches the coast from the Norwegian Sea. After spawning, the schools leave the coast, returning to their feeding areas in the Norwegian Sea and northern waters.

Fishing based on these herring is of great dimensions, and has been of great importance for the whole country. However, this fishing has also shown variations of a very outstanding nature. From old writings we are able to follow the fluctuations in herring fishing as far back as the sixteenth century.

According to these writings, the herring seems to be abundant in inshore waters for a period of fifty to eighty years, and then fall off for intervals of thirty to sixty years' duration.

There seem to have been four herring periods since the middle of the sixteenth century, but our knowledge of herring fishing in the sixteenth century is, of course, rather scarce.

From the beginning of the eighteenth century until 1784, we know that herring fishing took place on the west coast of Norway. From this year to 1800 there were no herring. In 1808 the herring reappeared, and the fishing lasted until 1876. During the next thirty years no herring approached the coast, but a new herring period commenced in the first years of this century and is still continuing.

Also, on the west coast of Sweden, similar fluctuations in herring fishing have occurred, and the variations there have been subject to extended investigations.

The Swedish herring periods seem to follow a time schedule of one hundred eleven or one hundred twelve years; and several authors treating of the fluctuation of herring fishing in Norway and Sweden have pointed to the alternating nature of the fluctuations in the two countries. The herring appearing off the Norwegian coast is a spring spawner. The herring off the Swedish coast is, according to our present knowledge, an autumn spawner. There is therefore very little probability of a direct connexion between the two.

We may ask where the herring are to be found when they are not at the coast. There are only two possibilities—either the schools of herring occur elsewhere but outside the range of the fishing fleet, or the schools may for some reason or other exist in a very reduced condition.

There are some indications of both possibilities taking place. When a herring period at the Norwegian coast comes to an end, we have reports that the herring schools then are seen far out to sea.

If this is so, there is a probability that hydrographical or other conditions may prevent the herring from entering the coastal banks for a series of years. The herring being on spawning migration will then have to deposit the spawn in other localities. As is known, the new-spawned herring eggs will sink to the bottom. There is a possibility that the conditions for the development of the eggs and the drift of the pelagic larvae may be unfavourable in other localities. The survival of the fry may be reduced, and accordingly also the new year-classes will appear in reduced strength.

It is evident that the interval between the two last herring periods in Norway was characterized by a very reduced stock. When the herring at the beginning of this century reappeared in inshore waters, the schools were small.

The age determinations on herring from this time show, however, that a considerable increase in the stock took place due to a very strong year-class born in 1904.

When this year-class entered the spawning stock in 1910 and succeeding years, the catches also increased.

CONCLUDING REMARKS

Owing to statistical data running for several years, it is possible to present a retrospective picture of the fluctuations in the great Norwegian seasonal fishing of cod and herring.

An analysis of the fluctuations shows that they have different backgrounds and that the fluctuations having the most serious effects seem to be of a long-time periodical nature.

These fluctuations seem to be very closely connected with fluctuations in the abundance of fish.

The causes of the fluctuations of the stocks of fish are not revealed but there are strong indications that the variations in the abundance of each single year-class are determined at a very early stage in the life of the fish.

There may be different factors determining the percentage of survival of the fry, but the amount of suitable and available food organisms must, however, be regarded as an important factor, as well as the transport effect of currents and the mechanical action of breakers and surf.

Much more knowledge is, however, needed in this field.

It is not possible by means of the material at hand to demonstrate a connexion between fishing intensity and the fluctuations of the two fish populations under consideration; but, according to estimates made of the cod, there seems to have been a slight decrease in their mortality rate during the war years.

Fluctuations in the Abundance of Herring on the West Coast of Vancouver Island, British Columbia

A. L. TESTER

ABSTRACT

Fluctuations in catch from 1933-1934 to 1945-1946 are attributed mainly to the effects of natural conditions in producing variation in the strengths of successive year-classes. Over the period, variation in the abundance of the year-classes does not seem to have been related to variation in the amount of spawn deposition, nor to variation in mortality during the seemingly vulnerable egg stage. It is probable that, within limits, the ultimate abundance of a year-class is determined by factors of mortality operative during the period of planktonic larval life. A negative correlation between abundance of the year-classes and mean air temperature during the period of larval development is found, but its biological significance is uncertain.

Recognition of the part played by natural conditions in producing fluctuations and trends in catch, and of the great reproductive resilience of the population, has helped alleviate fear of depletion. Since 1945-1946, catch restrictions have been relaxed on an experimental basis. As a result, the yield during the ensuing three years has been twice as great as that formerly permitted. Current studies are concerned with discovering the reaction of the population to the higher rate of fishing, the magnitude of an "adequate" breeding stock, and the causes of natural fluctuations in abundance.

INTRODUCTION

An investigation of the herring (*Clupea pallasii*) of British Columbia by the Fisheries Research Board of Canada has been under way for almost twenty years. Results for the west coast of Vancouver Island have been summarized recently (15)[1] and will be reviewed here, in part, with particular attention to natural fluctuations in abundance and their possible causes.

Schools of maturing and mature herring, mostly in their third and fourth years, but also including other age groups (8) enter west coast of Vancouver Island inlets from about October until spawning time in the late winter. This pre-spawning run supports a purse seine fishery (7), catch statistics of which furnish a fair measure of relative abundance (11).

Racial analysis (9, 13) and tagging (2) have shown that runs to the five west coast of Vancouver Island fishing areas constitute an essentially-discrete, though complex major population which may be dealt with as a unit.

During spawning, which occurs mostly in February and March, the eggs are deposited on vegetation within and just below the inter-tidal zone. Many spawning grounds of varied extent and location are utilized, yielding an aggregate of some 30 or 40 miles of spawn deposition in some years (15). As the grounds are mostly exposed at low tide, surveys of the extent and intensity of egg deposition may be made, thus furnishing roughly quantitative information on variation in spawning potential from year to year. Data may also be obtained on the nature, extent and causes of mortality of eggs during the two to three weeks, incubation period.

FLUCTUATIONS IN POPULATION ABUNDANCE

Fluctuations in catch and catch per unit of effort from 1933-1934 (referred to as year 1) to 1945-1946 (year 13) are shown in Table 1. Over the period, fishing has been subject to a date of closure (usually 5 February) and various other restrictions, including catch quotas. The latter limited the catch in certain areas of the major unit in years 2 to 5, and in all areas in year 13. Although catch quotas were in force in years 6 to 12 they were not reached. Despite

[1]Numbers in parentheses refer to items in the bibliography.

Table 1. Catch (tons) and Catch per Unit of Effort (tons per Seine per Day's Active Fishing) from 1933-1934 to 1945-1946.

	Year	*Catch*	*Catch per unit effort*
1.	1933-1934	22,900	44.1
2.	1934-1935	7,200	60.4
3.	1935-1936	24,800	67.9
4.	1936-1937	41,600	50.9
5.	1937-1938	30,300	35.3
6.	1938-1939	15,100	17.8
7.	1939-1940	16,500	18.2
8.	1940-1941	25,100	24.4
9.	1941-1942	17,100	21.0
10.	1942-1943	16,800	27.1
11.	1943-1944	9,100	16.5
12.	1944-1945	20,400	34.5
13.	1945-1946	27,500	47.7

these restrictions, the abundance of that portion of the fishable stock entering inshore waters during the fishing season (as indicated by catch per unit of effort), declined during years 3 to 6, remained low during years 6 to 11, and increased again during years 12 and 13. With due consideration to variation in the abundance of the spawning stock (as indicated by the spawning index, to be discussed later), it is assumed that fluctuations in catch per unit of effort roughly reflect fluctuations in the abundance of the pre-spawning run.

While exploitation by the fishery has doubtless influenced the magnitude of the observed fluctuations in population abundance, it seems evident from the increases in years 12 and 13, that they must be due primarily to natural causes—variation in the strengths of successive year-classes entering and passing through the fishable stock.

FLUCTUATIONS IN YEAR-CLASS ABUNDANCE

In Table 2 are included figures proportional to the abundance of the year-classes (sum of the relative numbers at each age in samples, weighted to catch per unit of effort in each year). The relative strengths of successive year-classes may thus be readily compared.

Table 2. Relative Abundance of Year-Classes 1931 to 1943, and Corresponding Spawning Index and Mean Air Temperature (deg. F., at Estevan Point) in each year of production

Year class	*Relative abundance*[a]	*Spawning index*[a]	*Mean air temperature March to June*	*July*
1931	624	3.4	48.5	57
1932	418	2.0	46.5	53
1933	680	2.4	46.25	54
1934	298	3.4	50.25	56
1935	283	3.3	47.0	56
1936	110	3.6	48.5	58
1937	230	2.5	48.25	57
1938	348	1.8	48.4	56
1939	268	2.6	48.25	56
1940	118	2.4	50.5	58
1941	161	2.5	51.25	59
1942	217	2.5	48.25	59
1943	741	1.7	47.75	55

[a]For explanation, see text.

The high population abundance during years 2 to 5 is attributed to the presence of three rich year-classes (1931, 1932 and 1933). The low population abundance over years 6 to 11 is attributed to the relatively poor strengths of the next nine year-classes, that of 1938 being the best but still only of average abundance. In year 12, the 1943 year-class joined the fishable stock in considerable strength in its second year. From information on age composition and relative abundance, good fishing was predicted in the following year (1945-1946). This came to pass when the rich 1943 year-class joined the fishable stock in force in its third year of age.

It may be noted that recent results (15) show that the 1944 and 1945 year-classes were also rich. The presence of three rich year-classes in succession, together with the abolition of catch limitations (as recommended by the investigators) resulted in large catches along the west coast of Vancouver Island in subsequent years: 1946-1947, 58,800 tons; 1947-1948, 45,200 tons; 1948-1949, 55,000 tons.

POSSIBLE CAUSES OF FLUCTUATIONS IN ABUNDANCE

One possible cause of fluctuation in the abundance of successive year-classes is variation in spawning potential. Information on spawning may be obtained from reports furnished by fisheries inspectors of the Dominion Department of Fisheries, who undertake annual surveys of the spawning grounds. In Table 2 is included spawning indices (average intensity for the five areas in categories of 1 to 5, i.e., very light to very heavy) for the years in which the year-classes were produced. This simple index follows closely ($r = 0.76$; $P = 0.01$) a more elaborate one, available only since 1937, which is based on miles of spawn times estimated intensity. While admittedly subject to a wide margin of error, it affords an interesting comparison between spawning potential and ultimate abundance of the progeny.

There appears to be no close relationship between the relative abundance of the year-classes and the spawning index in the years in which they were produced. It may be noted that the largest spawning (1936) produced the smallest year-class, whereas the smallest spawning (1943) produced the largest year-class, but the apparent inverse relationship is not statistically significant ($r = -0.30$; $P = 0.3$). The data indicate that, within the range of spawning potential occurring over the period, fluctuations in abundance are largely independent of the quantity of eggs deposited. This agrees with the views expressed by Hjort (3) for Norwegian herring and cod, but disagrees with those of Jensen (4) for Baltic herring, and those of other authors who have similarly postulated a direct relationship because of rhythmic cycles of abundance. The theoretical relationship between year-class abundance and spawning potential over its entire range has been discussed further by Kestevan (5) and Tester (15).

It follows that fluctuations in the abundance of successive year-classes must be due primarily to annual variation in survival rate at some stage or stages of the life history between egg deposition and recruitment.

The eggs of the Pacific herring, deposited partly in the inter-tidal zone, are subject to many sources of mortality not encountered by pelagic or demersal eggs of other important food fishes. Observations indicate that they are remarkably resistent to mortality from desiccation, frost, rain, crowding and mechanical injury. Mortality from factors such as these is believed to be small (1) and relatively constant from year to year.

Some of the more extensive spawning grounds occur in exposed localities. In some years (e.g., 1938) large quantities of eggs are washed ashore, often above the high tide mark where they die of exposure or are eaten by birds. However this factor, while doubtless contributing to variation in year-class abundance, does not seem to be critical. For example, weather conditions appeared to be equally favourable in 1940 and 1943, yet the medium spawning in the former year produced a small year-class, whereas the light spawning in the latter year produced a large year-class.

Predation by birds is a major source of mortality on most of the herring spawning grounds. The eggs are eaten by gulls when exposed, and by scoters and other diving birds when submerged. However, such records as are available indicate that the over-all percentage mortality from this cause is fairly constant from year to year, averaging about 15 per cent, although it varies considerably among individual grounds.

Herring eggs are known to die occasionally from unknown causes—possibly unfavourable oxygen or carbon dioxide tensions of the water (10). While the possibility of catastrophic mortalities of this nature cannot be ruled out, none of any magnitude was reported from the west coast of Vancouver Island in period under consideration.

It seems likely that the critical period in the life history occurs during the larval stage, between the time of hatching and metamorphosis. As a study of this stage has just begun, pertinent data are not yet available for discussion.

Attempts have been made to correlate variation in year-class abundance with variation in environmental factors such as river discharge, precipitation and salinity, but so far without success. Rounsefell (6) found a positive correlation between variation in average air temperature during the combined months of March to June and variation in the strength of successive year-classes (1921 to 1927) of herring in Alaska, warmer springs apparently resulting in year-classes of greater abundance. As shown by data included in Table 2, this relationship does not hold for the west coast of Vancouver Island. Rather, a negative correlation ($r = 0.-55$; $P = 0.05$) is obtained, which is even higher ($r = -0.65$; $P = 0.02$) when July air temperatures are used, suggesting that colder springs and summers result in year-classes of greater abundance. In the face of this conflicting evidence, at the present time it can only be concluded that a relationship has not been proven, despite the statistical significance of both sets of data. However, the co-variation found in British Columbia, which also exists between July water temperatures and year-class abundance, will be watched with interest in future years. In the meantime it is idle to speculate as to its possible biological significance.

PRACTICAL CONSIDERATIONS

Recognition of the part played by natural fluctuations in abundance in producing annual variation and trends in catch, and of the great reproductive resilience of the population over the existing range of spawning potential, has helped alleviate fear of overfishing. The studies have indicated also that the rates of growth and natural mortality among mature fish are such that a greater yield will result from a more intensive fishery (16), provided an adequate spawning stock is maintained.

In 1946-1947 catch quotas for the west coast of Vancouver Island were discarded on a trial basis, and concurrently, a more intensive investigation was launched in an effort to determine more precisely the effect of fishing on the stock, the relationship between spawning potential and recruitment, and the causes of natural fluctuations in abundance. During each of the first three years of the experiment, the catch was approximately twice as large as that permitted under the previously existing quota of 25,000 tons, thus producing an additional annual income of several hundred thousand dollars.

Both industry and administration realize that in all probability lean years will occur in the future as they have in the past, that, with the smaller accumulated stock, fluctuations in catch may be more violent than formerly, and that there is the possibility of reducing the spawning stock to or beyond the point (yet to be determined) at which reproductive resilience is exhausted. If the last possibility is realized, it is hoped that the consequent decline in recruitment may be detected and rectified before proceeding too far, and that valuable information will have been gained in the experience.

The ultimate object of the investigation is to formulate a management policy which will provide maximum sustained yield for all herring fisheries of British Columbia, most of which are still subject to quota limitations. Knowledge of the causes of fluctuations in abundance and ability to make accurate predictions of catch would assist materially in achieving this goal.

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Fluctuations in Fish Populations Owing to Climatic Changes

Å. VEDEL TÅNING

ABSTRACT

Studies in fluctuations of fish populations are very important for modern fishery biology and in recent time the causes of natural fluctuations have attracted more and more attention. Several examples of the influence of various environmental factors on the fluctuations in the abundance of year-classes in fish populations have been found, but our actual knowledge is rather scanty.

The climatic change in our time, especially felt in northern waters, has caused a long periodic fluctuation in some fish stocks of which that in the important northern cod-stocks is considered in this paper.

Experience gained during about twenty-five years of research work in northern waters is mentioned and supporting evidence from available fishery statistics is cited to show that the rise in temperature has opened huge areas of feeding grounds previously uninhabitable for the cod. This large-scale expansion of the distribution area has further resulted in a successive enormous increase of the cod-stock not experienced before during the short period of scientific fishery research work. This fluctuation has been of great commercial importance, and it is proposed that a general international hydrographic research programme be undertaken to follow the long periodic climatic changes in the sea. Predictions of similar future alterations in fish stocks in northern waters might be made by this means, and would benefit the great fisheries.

It is well known that in addition to alterations caused by seasonal and other migrations a fish population shows natural fluctuations in abundance, which may have an enormous influence on the total yield of the fishery from year to year or from one period of years to another. It is only during the preceding three to four decades that these fluctuations in various marine fish populations have been studied and several attempts have been made to explain their causes.

FACTORS INFLUENCING THE FISH POPULATION

The survival from stage to stage during the development of the fish is determined, *inter alia*, by one or several of the many factors composing the environment, but it has not yet been possible for modern marine biology to discriminate between the more important factors actually operating, even in the case of the most outstanding food fishes and in the various areas of their distribution. Several examples are known showing that in one case one factor, in another case another factor or a combination of several environmental factors, have called forth fluctuations in a stock of fish. We shall not discuss here the influence of actions by man, such as overfishing etc.

Among the natural causes producing fluctuations mention can be made of the direct or indirect influence of favourable or unfavourable hydrological or physical conditions (temperature, salinity, currents, agitation of surface water by storms, gas content in the sea water, fresh-water outflow from continental rivers, light intensity etc.); variation in food supply; variation in number of natural enemies; variation in migration of younger and adult stages; variation in number of spawning fish and number of eggs spawned; variation in population pressure etc.

Recent studies have emphasized that probably one environmental factor is very important, if not predominant, for the survival of the larvae and hence for the future history of the respective year's brood, viz., the presence of the proper food in proper quantities at the developmental stage when the newly-hatched larva has used the vitellum and now must feed on phytoplankton or microscopic animals. If the conditions are unfavourable mass death will occur. Probably we have here the factor determining the most important fluctuations in the year-classes of fish.

INCREASE IN STOCK OWING TO RISE IN TEMPERATURE

Studies in this young branch of fishery biology are very important but difficult, and our actual knowledge as to the effects of most of the natural conditions on the abundance of year-classes is very poor. Recently, however, we have seen an example of fluctuation in various fish populations in northern waters, which has been evident during about twenty-five years and the principal cause of which has been a rise of temperature over huge areas of the sea previously uninhabitable for the fish populations in question. This experience concerning the importance of big-scale expansions or contractions of distribution and feeding areas, has given us some knowledge of a cause of fluctuations the effect of which has not previously been very clearly understood; this knowledge is of importance for further studies and it involves possibilities for predictions in the future.

During the greater part of a lifetime we have witnessed rather prominent climatic changes especially in some areas of our globe. A rise of temperature has been observed especially in arctic-boreal areas and preferentially during the winter months. The difference from the average winter temperature in Spitzbergen was, for instance,—2.3 degrees C for the period 1911-1920, but for 1930-1940 it was + 6.6 degrees C, i.e., a rise of about 9 degrees C. Something similar has been observed in north Greenland where a rise of the average winter temperature in Jacobshavn was more than 4 degrees C from the beginning of the century to the late twenties. The effect on land has been obvious: the retreat of glaciers in both the northern and the southern hemisphere; the advance of the borderline of forest in mountains, of the ripening of cereals in the north; the increased growth rate of conifers in the north—these are only a few examples. And the effect of the increasing temperature in the sea, especially in northern seas, has not been less obvious: the area covered by floating ice has decreased in the arctic ocean, and so has the thickness of the ice (by 40 per cent); the period of navigation in arctic seas, e.g., at Spitzbergen, has increased, and the north-east passage has in periods been open for navigation. The rise of temperature in the sea, especially in the far north, has not only been met with in the surface layers but down even to depths of about 600 to 800 metres. The increase in surface temperature has been demonstrated far south in the Atlantic, even to the sources of the Gulf Stream; the rise here is, however, only about 0.4 degrees C as against 1 to 2 degrees C in northern seas. This rise in temperature was especially observed after about 1925 when the arctic water began to retire. Owing to this rise in temperature, immense stretches of banks in northern seas, previously covered with arctic water, have been made habitable for many species of animals including several species of food fishes normally avoiding arctic water. By the rise of temperature food fishes, such as the cod, for instance, have obtained an addition to their original area of distribution of thousands and thousands of square kilometres and with this an enormous augmentation of food, i.e., food competition has decreased, enabling an increase in individuals far beyond the normal.

When the fishery research work with the Danish research vessel "Dana" was resumed in the waters of Iceland and Greenland after the First World War we observed a conspicuous difference between observations in the years 1924 and 1925 compared with similar observations from the beginning of the century (1903-1909). For instance, the cod was found spawning in areas where this had not previously occurred owing to too low temperatures (e.g., off north and east Iceland and on the banks off west Greenland); moreover in 1924 big cod was already met with in abundance on west Greenland banks, where the species at the beginning of this century was present only in small numbers or not at all. For several other species we found similar conditions.

During the following years we observed on the yearly cruises in these northern waters small but clear displacements in hydrological and biological conditions, especially in the waters off north Iceland and at Greenland; alterations in the distribution, density and so on of some species of fish as adults or as fry; immigration to the northern areas of more southern species etc. All these signs pointed to an improvement of the environment. For one or two years a return to colder conditions was observed, followed, however, by even warmer conditions with strong immigration to northern regions of southern species not previously met with so far north. We suppose, therefore, that most marine animals in northern waters now might show alterations towards warmer conditions with respect to northern boundaries, densities, spawning grounds etc., if we had sufficient material from the preceding colder period for comparison.

It is obvious from all available observations that the rise in temperature is the capital factor for the northern displacement of the boundaries of the several animals. The rise in temperature made the advance possible; but we presume that the increase in density of several food fishes in the present period depends in addition on advantageous turns of other important factors such as light, phosphate, nitrate and so on, which are necessary for phytoplankton production and hence to the animal life on which food fishes are dependent. The sum of observations is, however, too scanty from the previous cold period, where very few adequate quantitative observations were secured.

It is impossible here to review all the facts collected during a lifetime relating to alterations, induced by the rise in temperature, in catch, distribution, density, propagation, growth, meristic characters etc. in several species of fish. As an example we will call attention to some facts relating to the most important species of fish in the northern waters of the North Atlantic, viz., the cod.

For this species the commercial fishery statistics show very clearly the changes in the stock.

Through many years a small stock of cod was known from the coastal districts and off-shore banks in west Greenland; it was fished to a small degree only by the Greenlanders but not in about 75 years by foreign fishermen. About 1924-1925 a conspicuous change occurred as shown by the statistics of the catch by Greenlanders in tons: 1911: 18; 1917: 250; 1925: 1,000; 1930: 8,160; 1935: 6,600; 1940: 7,000; 1945: 12,300; 1947: 14,900.

The first fishing vessels from north-west Europe appeared in 1924 and the total catch by the foreign fishermen rose rapidly as shown by the annual average catch (in 1,000 tons) for five-year periods: 1924-1928: 3.7; 1929-1933: 41.8; 1934-1938: 46.2.

During the warm period the growing cod stock has spread farther and farther north along the west coast of Greenland as the temperature has risen. A great interchange of cod occurs between some parts of Greenland and the spawning places at Iceland, but most probably the indigenous part of the west Greenland stock has also increased enormously and has contributed to the total effect.

In other parts of North Atlantic cod areas similar conditions are being encountered, viz., in the Icelandic area and in northern Norway, but also in the Bear Island and the Spitzbergen areas where cod fishing had been abandoned since about 1882.

The total yield of the cod fishery on the Iceland grounds was between 100,000 and 200,000 tons yearly in the period 1905 to 1921; after that there was a gradual rise to about 400,000 tons in 1929 and even to more than 500,000 tons in 1933. Then during the years previous to the Second World War (1934-1938) there was a drop owing to market and other conditions; the density of the stock was, however, higher or about the same as before, as is shown by the catch per day's absence from port of the English steam trawlers. The catch was about 2–2 1/2 tons per day's absence every year after 1930 as against only 1–1 3/4 tons previous to 1930.

The cod fishery in the Barents Sea and off the Murman coast also shows a similar increase; in five-year periods the English steam trawlers obtained the following catch in tons per 100 hours' fishing: 1924-1928: 16.5; 1929-1933: 20.7; 1934-1938: 45.1; 1947: 75.8.

Though some special conditions (e.g., the introduction of the Vigneron-Dahl trawl in the twenties and the very slight fishing during the Second World War) have had some effect on the result, the increase is obvious and the density of the cod stock must be enormous. When the cod in this area mature, the shoals migrate to the spawning places in Lofoten, north Norway, and here the fishery on big spawning cod (skrei) has increased to such an extent that the yield in the years from about 1920 to 1929 jumped from 6 to 7 million specimens to 43 million specimens.

As shown above, the catch of cod in all northern areas of the Atlantic has increased during the period of increasing temperature, which has forced the arctic water back. The cod populations in all the various areas considered have enlarged their areas of distribution—the Arctic-Norwegian stock probably most. The northern advance of higher temperatures occurred by degrees; and for each new year-class of cod, born during the warm period, young and adult fish on migration for food found good food possibilities in new areas, where previously low temperatures and poor feeding conditions stopped their progress or even meant death. The survival rate of good year-classes has therefore been high and has involved a successive rise of the stock of spawning fish when the several year-classes in due time reached maturity. And the total result has been the enormously rich period for cod that has been witnessed in our lifetime.

It ought to be mentioned here that the climatic change has extended the cod waters much farther to the north than the rise in temperature has restricted the inhabitable waters on the southern front, because the thermal rise here as far as we know was too slight to be of restrictive effect.

The very great economic effect of the present climatic change on the fisheries, especially in northern waters, raises the possibility of predicting years in advance a coming increase or decline in important fisheries owing to long periodic climatic changes. Admittedly our series of reliable observations are short, few and incomplete, and it is impossible yet to point out any periodicity. As far as we know we have had similar, but not so conspicuous periods in Greenland and/or Spitzbergen waters about 1820, 1840 and 1870 to 1880. In the present period, however, we have observed that the change did not occur abruptly but by degrees, probably reaching the peak in the thirties and forties. The retrograde movement will most likely also appear by degrees. As the temperature changes in the sea, in the surface layers as well as in deeper layers, are among the most prominent features, it is possible in the future to follow the conditions through systematic hydrological investigations.

With a view to follow hydrological changes of importance for the various stocks of fishes, we proposed in 1934 in the North-Western Area Committee of The International Council for the Exploration of the Sea, that series of hydrographic sections should be operated, if possible several times yearly, over the fishing banks off the Faroes, Iceland and Greenland from the coastal areas to deep oceanic water. The proposal was agreed upon (see *Rapports et Procès-Verbaux des Réunions*, vol. 89, 1934, pages 26-27), and some material of importance has since been secured. Because of the great importance of records from the open ocean as well (e.g., between the Faroes and Greenland) we have in recent years extended this continuous work to cover also the more open stretches of the sea. Similar hydrographic sections are now operated in various other areas of northern waters. And without doubt a general programme ought to be agreed upon internationally for the whole North Atlantic and North Pacific as well.

The value of the weather ships in this connexion should not be overlooked. By this means it should be possible to follow the climatic changes in the sea and to collect the basic material for predictions of the waves of changes which seem to be of paramount importance for at least some of the long periodic alterations in the great fisheries of the northern seas.

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The Present World Problem of Sea Fisheries[1]

JEAN LE GALL

ABSTRACT

That vast reservoir of life, the sea, the contents of which are constantly renewed offers us, especially in the as yet unexplored southern hemisphere, the possibility of satisfying most of man's needs in the animal proteins indispensable to the maintenance of the human organism, in fats, the world shortage of which threatens to continue, in mineral salts and in vitamins essential to the growth of the young and the maintenance of adults. This is of particular interest at a time when land food resources can only be maintained at a satisfactory level by means of intensive cultivation processes and when we have to reckon with the possibly long-term but ultimately inevitable prospect of their exhaustion.

The southern hemisphere offers vast, hitherto unused, marine resources. Scientific research leading to planned technical utilization should make it possible to use them as widely as possible without wasting them unthinkingly, as they were wasted in the northern hemisphere. This would help in postponing the inevitable and complete impoverishment of land food resources and would contribute to the greater well-being of humanity.

FISH AS HUMAN FOOD

The flesh of fish has always been a constituent of human food. Certain tribes subsist almost exclusively on fish and vegetable matter: no food deficiency is observed among them and they are even amongst the most healthy and robust of peoples.

Fish and sea-food are a noteworthy source of proteins of high nutritive value, of mineral elements (P, Ca, K, Mg), of oligo-elements (I, Br, Fe, Mg, Cu, Zn) and vitamins (A, B, B_1 and B_2 in the flesh and livers of many fish and vitamin C in the flesh of many molluscs).

Hence, fish can probably take the place of meat, especially in places where meat cannot be easily produced and where the fishing industry can be easily developed.

This substitution has the advantage that, in spite of its high food value, comparable to that of meat, fish is still economically within the reach of consumers, whether individuals or communities.

The sea offers us this natural wealth, whereas one calorie of land-produced animal protein requires seven original calories in the form of animal feed. Furthermore, the expenditure for catching fish, calculated in man-labour hours, is only half the cost of pork, for instance, which is regarded as one of the most easily produced sources of animal protein.

The investigation carried out by the United Nations Food and Agriculture Organization in 1946 showed that more than half of the population of the world (or a thousand million persons) were underfed (less than 2,250 calories per day, as against the 2,600 required to maintain normal health, to enable children to grow and to provide the body with the energy necessary for its maintenance and its work) and that in the best-situated countries at least one-third of the population before the war had an inadequate and ill-balanced diet as a result of deficiency in animal products, which are rich in the protein, mineral salts and vitamins essential to health but which are usually too expensive to be within the reach of all consumers.

The human consumption of proteins represents more than 50 million tons of proteins per year (M. Javillier). If the steady increase (estimated at 25 per cent of the present population) of the world population is taken into consideration, we must reckon that by 1960 man will have to be supplied with a quantity of protein of animal origin nearly half as great again (46 per cent, according to the FAO experts) as the quantity now available, which is already acknowledged to be manifestly inadequate.

The present world production of sea fisheries has been put at approximately 20 million tons, two-thirds or approximately 13 million of which is for human consumption; 40 per cent or approximately 5 million tons of this can be considered as edible and absorbable, so that, on the basis of an average content of 18 per cent albuminoid substances, we reach a yield of approximately 1 million tons of proteins.

The present annual needs are approximately 50 million tons; 75 million tons will be required by 1960, and the land alone will not be able to provide them.

Only if the hitherto unused resources of the unexplored seas are drawn upon systematically will it be possible to supply mankind with the additional nitrogenous food which is absolutely essential for its needs.

For our purposes, the edible marine species may be classified into two groups:

1. The *pelagic* species, which spend the greater part of their existence on or near the surface, congregate in shoals which are occasionally vast, and migrate periodically and reappear regularly at fixed intervals in well-defined regions, where the fishermen, with their age-old experience, are waiting to catch them.

Such fish are salmon, herrings, sardines, sprats, mackerel, albacores, cod and others.

2. The *benthonic* species, which spend most of their existence on or near the seabed and may also, especially at spawning time, congregate in shoals (smaller than in the previous case) and migrate, but not so far. Such fish are flat fish, hake and other Gadidae, Gurnards, Sparidae, Serranidae, etc., which are fished on a large scale.

THE PRESENT STAGE OF SEA FISHERIES

These species, which differ in their habitat, are caught by different methods.

(1) The pelagic species are caught:

By means of large straight nets, long sheets of netting stretched at varying depths near the surface at points where the shoals of fish are expected to pass, these nets either drifting with the currents (as in fishing for herring, cod;

[1]Original text: French.

mackerel, sardines, etc.) or else held in place on various types of frames (traps for catching herring and cod; mandragues for catching tunny-fish; trammel-nets, etc.),

By means of large enveloping and sliding nets, which may be called "active" tackle by contrast with the above, passive kind; with the "active" gear the shoal of fish when seen is rapidly encircled and held in the hollow thus formed. These turning and sliding nets are used for catching herring and other Clupeidae, mackerel and tunny-fish;

By means of hand lines (for cod-fishing), descending to varying depths and by draglines (albacores, tunny-fish and mackerel), and by drifting trawl-lines (sharks).

(2) The benthonic species are caught:

By means of deep lines and trawl-lines (cod, halibut);

By means of deep nets (cod, halibut); and

Mainly by means of trawls which, like huge open bags, are dragged along the seabed by the trawler and which sweep up everything they pass, filter the water and retain all the fauna of the seabed without distinction as to species and size.

This haphazard and very destructive device is at present the one most used in the sea fishing industry. Its use is fortunately limited by the nature of seabeds (it cannot be dragged along rocky and pebbly bottom) and by depth (it cannot be used successfully at depths greater than 500 to 600 metres).

Its use is thus limited to the continental shelf and its approaches, a great part of which is being fished and which show, especially in certain European seas, distinct signs of exhaustion due to overfishing.

THE NORTHERN HEMISPHERE

A quick survey of the great fisheries of the world shows that all the large commercial fisheries, with the exception of whaling which is now mainly carried on in the Antarctic, are situated in the northern hemisphere, both in the Atlantic and in the Pacific, and that the oceans of the southern hemisphere contain vast and hitherto unfished areas.

In all the fisheries of the northern hemisphere, which have been known and utilized for a long time, the activities interrupted or slowed down during the last war have practically returned to normal and the present total production stands at a level close to, if not slightly higher than, that of 1938 (reference year) or, according to figures as known, 20 million tons in 1948 as against 18 million in 1938.

Hence, the world sea-fishing industry has returned to the 1938 level; there are, however, new possibilities due to the renovation and modernization of the fleets, to their greater radius of action, to improvements in gear with a resulting increase in catching power and finally, to the improvement of navigation instruments and instruments for detecting shoals of fish.

The activities of this industry are still concentrated in the northern hemisphere; 98 per cent of the catches officially recorded are at present unloaded in the fishing ports of the seafaring nations of that hemisphere. By contrast, in the southern hemisphere, where the exploration of the seas has shown vast possibilities, certainly superior to those of the northern hemisphere, fishing has not progressed as it should have done, even though great maritime countries are situated in the south and in spite of the vast ichthyological resources of the neighbouring seas and the requirements of the populations, which, even before the war, were absorbing a large part of the products unloaded in the ports of the northern hemisphere, after the needs of those countries had been met.

The possibilities of developing sea fishing in the northern hemisphere are at present very limited.

The seabeds throughout the continental shelf, which is the only place accessible to trawlers (in the Atlantic and in the Pacific), show undeniable signs of exhaustion. Drifters are now obliged to make long voyages of over 3,000 miles from their ports of unloading to find fishing grounds which are still abundant enough to cover the very high costs of operation.

As yet, no fear of exhaustion is felt as regards the pelagic species, which escape catching devices for a large part of their existence owing to their periodic migrations. Annual fluctuations have indeed been observed in the catches of these fish, but this could be explained scientifically by reference to the influence of environment on the constitution of the stock and its migrations.

Better catches of these particular fish (Clupeidae, Scombridae and other migratory fish) could be obtained in Europe, as in America, by improvement of fishing techniques. Thus, "passive" tackle (straight drift nets) might be replaced by "active" tackle (turning and sliding nets) which give a higher yield, devices adapted to the type of fishing and to the seabed might be used (for instance, the Danish tow-net), wider use might be made of successfully tested instruments for detecting shoals of fish (echo-sounding Asdic) and finally, the biological study of migratory species might be developed systematically; although it is well-known in the case of some of them (Clupeidae, for instance) it is, as yet, quite unknown in others; for instance, the spawning grounds of tunny-fish are not known. Fishermen would thus be able to fish for larger concentrations of that fish than those they are now exploiting. At present, they are only catching these fish at the edge of their area of distribution when they disperse after laying their eggs.

THE SOUTHERN HEMISPHERE AND ITS POTENTIALITIES

The problem in the southern hemisphere is quite different.

The hemisphere contains vast latent reserves of fish that have never been touched.

The reports of research cruises undertaken in the various seas of the southern hemisphere are unanimous on the subject. The Clupeidae abound in the coastal areas, and Scombridae and the various species of Thunnidae, which are of vital economic importance, have been observed in large quantities in many places along the coast; various species are as abundant as Gadidae and Pleuronectidae are in the northern hemisphere.

The general inventory of all these resources has already been made, with emphasis on the possibilities of their utilization, but there is no detailed inventory. Industry will always be reluctant to launch an expensive and risky enterprise on the basis of general and, perforce, vague data. It will wait for science to show it the areas where the resources of the sea can be used with the certainty of catching enough fish to cover its heavy operational expenses and of making a substantial profit.

The question has been partially solved in certain maritime countries of the southern hemisphere, in America and in South Africa, for instance, where great strides have been made with the utilization of maritime resources, increasingly so since the end of the war.

FUTURE PROSPECTS

The detailed inventory is likely to continue everywhere and will deal with the study of edible species, their biology and their behaviour. This study will lead to the discovery of their places of concentration, of the spawning grounds of the species, and of their trophic areas of dispersion after laying. Fishermen will thus be certain to obtain abundant catches with the gear and techniques most highly commended by study and experimentation.

This vast programme of research implies the establishment of maritime laboratories, the use of special ships and the establishment of a body of specialized experts. It is therefore outside the scope of the nations directly concerned, since it will require large funds; for this reason, it should be international, with international methods of work and research, drawn up and discussed jointly, for the aim is to plan the industrial utilization of world resources for the greater well-being of humanity as a whole.

When this preliminary work has been accomplished, the creation out of nothing of many new industries, often far distant from the metropolis, will often involve great technical problems. In order to catch fish where it occurs and in order to treat it on the spot, vessels, floating factories, equipment and fishing gear selected according to the species to be caught will be required; home ports for equipment and others for unloading the treated products will also be needed, and it will often be necessary to set up everything on the spot.

The utilization of the catches will also involve research as to the best methods of treating and preserving fish varying with the purpose for which the processed goods are intended, and of the rational processing of the waste and by-products of the catch to extract fish meal and oil, fish fertilizer, nitrogenous extracts, vitamins, and opotherapic extracts. None of these resources should be neglected in an industry for which the operating costs are high. All these resources can contribute greatly to the production of animal proteins, whether by the use of fish fertilizer as a nitrogenous fertilizer in agriculture, or of meal, rich in nitrogen, phosphorus and mineral salts, for cattle feed.

It is at present admitted that the knowledge acquired on these latter questions is far in advance of the industrial application of such knowledge. This circumstance allows us to foresee great potentialities for the rational and total and, possibly. intensified utilization of the resources of the sea.

The Effects of Fishing on Norwegian Freshwater and Anadromous Fishes

SVEN SØMME

ABSTRACT

No statistics are available in Norway for inland fisheries. The annual yield may be estimated to about 3 million kg. Overfishing takes place in some areas. Checking is attempted by local regulations and artificial hatching.

The annual catch of Atlantic salmon amounts to about 1 million kg., according to the statistics, but may be considerably larger than this figure. The stock of salmon has probably been overfished for hundreds of years, but the overfishing has only become evident during the last fifty years, when available figures reveal an almost perfect balance between the amount of commercial salmon fishing gear and the catch per unit of gear. In four or five salmon streams where commercial and semi-commercial fishing methods have been abolished in recent years, the yield of the salmon fishing has increased more than 1,000 per cent in ten to fifteen years. It is to be expected that a considerable increase in the yield of Norwegian salmon fisheries may be created by restricting the number of fishing gear by means of a suitable licence system, thus securing better escapement of salmon to the spawning grounds.

The most important species of fish counted as freshwater fishes in Norway are: (1) the anadromous species, the Atlantic salmon (*Salmo salar*), the sea trout (*Salmo trutta*) and the migratory char (*Salvelinus alpinus*), and (2) the pure freshwater fishes of which the most important species is the brown trout (*Salmo trutta*). The inland fisheries also include other species of some importance, viz., two species of whitefish (*Coregonus*), the arctic char (*Salvelinus alpinus*), perch, pike, burbot and a few others.

The inland fishing is partly a semi-commercial, partly a sport fishery. No statistics are available. The lake area is approximately 13,600 sq.km., excluding streams and rivers. The annual output may be estimated to about 200 kg. per sq.km. (low productivity owing to geological and climatical factors), and the total annual yield of the inland fisheries may thus be in the vicinity of 3 million kg., representing a first-hand value of 10 to 15 million Norwegian Kroner. Most of this fish is consumed fresh or salted in farm households and by anglers and their families.

There is evidence that the inland fisheries have declined in some parts of the country in recent years, owing to overfishing, and that the catch accordingly is lower than the optimum catch. In most of these districts regulations have been introduced in order to give the fish proper protection against overfishing, and the areas are being stocked with artificially reared fish.

Pollution is generally not serious, but hydroelectric development has in some districts caused difficulties for the management of the fisheries. With the co-operation of the power companies these ill effects may be partly overcome.

Even though the salmon and sea trout fisheries in the sea and the rivers may yield a lower output, they are of greater importance commercially than the inland fisheries. According to the not too reliable statistics, the total output of the salmon and sea trout fisheries in 1946 was 981,538 kg. with a first-hand value of 5,124,683 Norwegian Kroner. The 1946 yield may be considered as normal.

Our statistics do not distinguish between salmon and sea trout, but the sea trout catch is probably far less than 10 per cent of the total catch, and thus relatively insignificant. Norway has about 300 salmon rivers.

Salmon research has revealed the following facts that are of importance as to the management of the salmon fisheries:

1. Practically all salmon seem to ascend their native river (i.e., the river from which they originate) in order to spawn.

2. The young salmon feed in the rivers 2 to 5 years (the main bulk 3 or 4 years) before migrating to sea. The river growth is very slow.

3. Some salmon return to spawn after one year in the sea, most after two years and a few after 3 or 4 years of feeding in the sea. Their growth in the sea is very rapid.

4. Very few salmon survive the spawning and may return to spawn more than once.

5. The feeding grounds of the salmon in the sea are unknown.

6. The migrations of the salmon in the sea before entering the rivers in order to spawn are very extensive and may cover thousands of miles. Salmon from one river thus contribute to the fishery along an extensive coastline.

7. Of tagged salmon, 97.33 per cent of the recaptures have occurred inside Norway, only 2.67 per cent abroad. This means that we are alone controlling our stock of salmon, and it is up to Norway to regulate the fishing so as to secure a sufficient escapement for the reproducing of the stock.

8. Salmon taggings give a return of nearly 50 per cent of the tags. The actual fishing is probably more than 50 per cent of the total run.

9. The total run may be estimated to less than half a million individuals as an average. More than 200,000 individuals are caught annually.

According to the statistics, approximately 85 per cent of the salmon are caught in the sea, 15 per cent in the rivers. The river percentage has sunk from 21.2 to 15.2 during the last twenty-five years (average for five-year periods). The sea fishing is commercial, most of the catch being sold for consumption inland and abroad. Before the Second World War, the main part of the catch was exported, mostly to Britain. In some years the export exceeded 800,000 kg. After the war the export has been insignificant and most of the salmon has been sold inland. This is partly because people have more money, partly because there is a shortage of meat in Norway. The river fishing is mostly semi-commercial, but sport fishing is also of some importance.

The most important gear for the sea fishing is the bagnet (kilenot), a small floating trap. The bagnet is cheap and may be operated by two men, in sheltered places even by one man. The bagnet fishing started in 1848 and had a rapid development between 1880 and 1900, rising from about 2,000 to about 9,000 bagnets. During the same period the average annual catch per bagnet sank from about 140 to below 80 kg. per bagnet. Thus having reached a level where the fishing did not pay, the number of bagnets decreased and the annual catch per bagnet increased till they stabilized at about 6,000 to 8,000 bagnets and an annual catch between 80 and 100 kg. per net.

In the rivers, a commercial or semi-commercial fishing with traps, seines, setnets and driftnets was established hundreds of years ago. As the sea fishing developed during the latter half of the nineteenth century, the output in the rivers decreased. As, however, the salmon was of great importance as food to many of the farmers, the fishing was maintained as far as possible, even below rentability, but the salmon eventually became so scarce that many of the fisheries were given up. Thus, also in the rivers, there has developed a balance between gear and output just as in the sea.

The Norwegian salmon fishing is not licensed. Any person owning or renting land is entitled to employ commercial salmon fishing gear from his land.

The total output of the Norwegian salmon fisheries show no sign of general reduction during the last sixty years. There are poor and rich years, causes for the fluctuations unknown, but no sign of danger to the stock of salmon as a whole.

This is a result of the balance between gear and output, in the sea as well as in the rivers. Any rise, natural or artificial, in the stock of salmon will result in an increased number of gear, thus tending to level the stock of salmon. Any deterioration in the salmon stock will create a reduction in the number of gear. The balance point is the rentability of the fishing.

There is considerable evidence that this level of balance is far too low, and that it may be possible, by simple means, to increase the output of the Norwegian salmon fisheries far beyond the present level.

In recent years a small number of salmon rivers in Northern Norway, belonging to the state, have been rented by angling associations. The commercial fishing has been stopped and only angling with a limited number of rods has been permitted. The annual output of the former commercial fishing in these rivers was very low, averaging about 200 kg. per year per river. Probably the actual situation was that salmon in these rivers were caught with seines and gillnets wherever and whenever they could be caught, though a few salmon escaped capture every year and were able to maintain the stock at a very low level.

It is a general experience in Norwegian salmon rivers that rod fishing with a lure gives a better escapement of salmon to the spawning grounds, because many salmon will never take a bait.

In all the North-Norwegian rivers where commercial fishing was stopped and only angling permitted, the annual output started rising. Within ten to fifteen years it had risen to approximately ten times the original output, and in one case even considerably more.

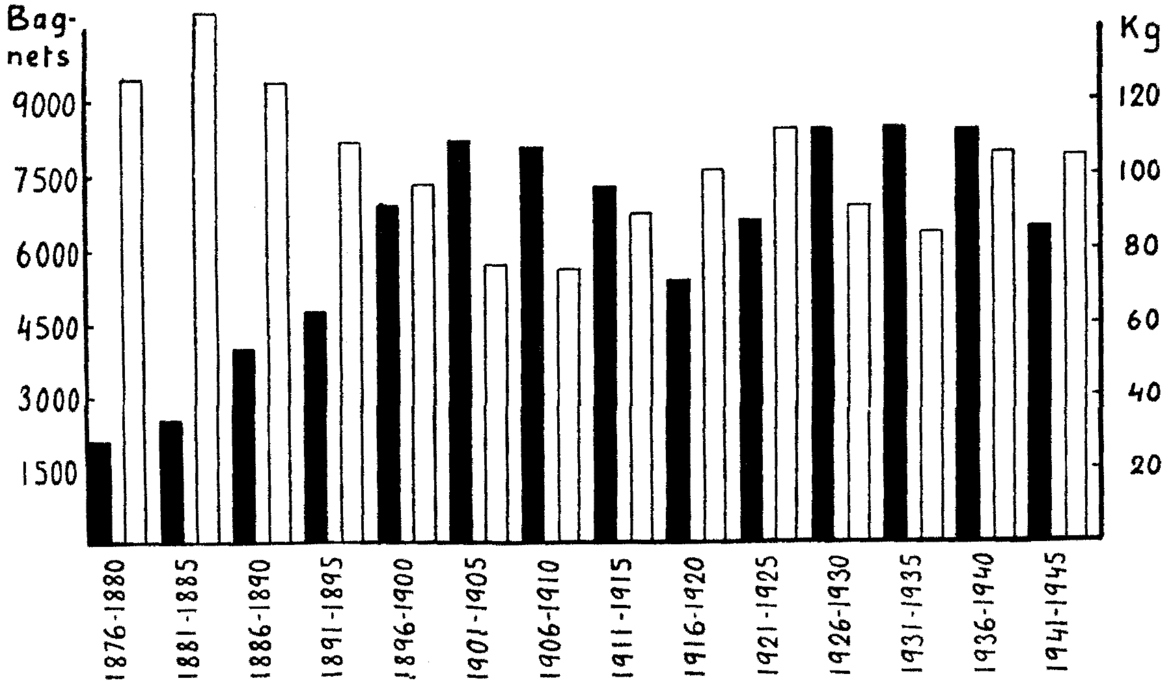

Figure 1. The balance between gear and output in the salmon fisheries. Average annual number of bagnets in five-year periods (black columns) and annual catch per bagnet (white columns)

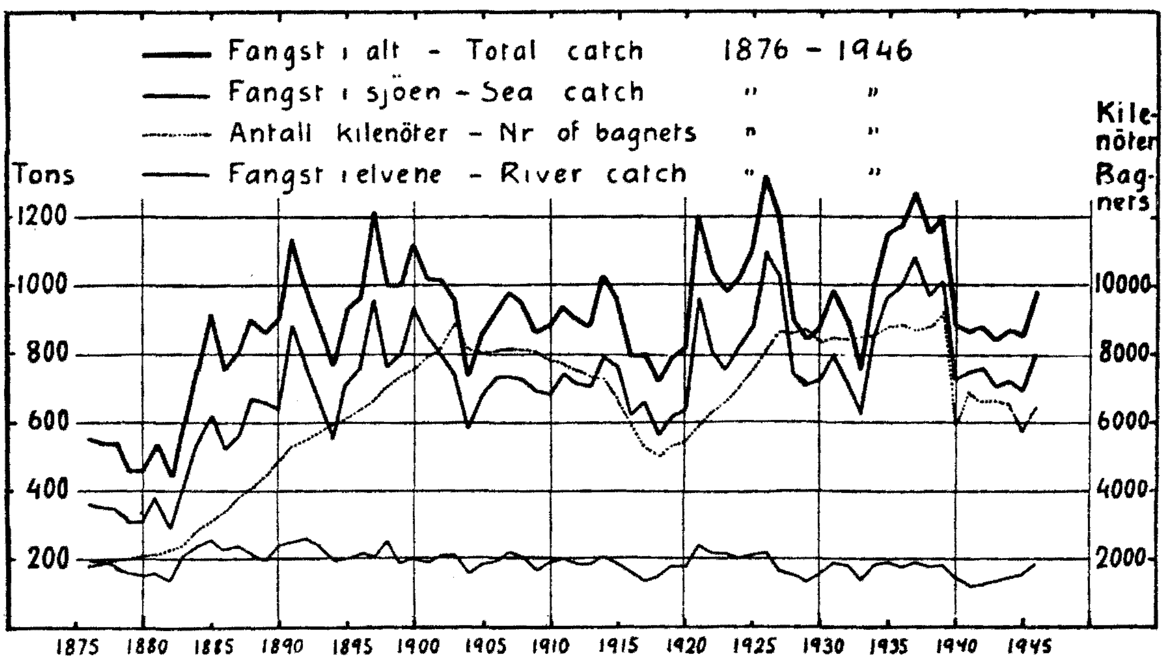

Figure 2. The salmon fisheries of Norway 1876 to 1946 and the annual number of bagnets in the same period

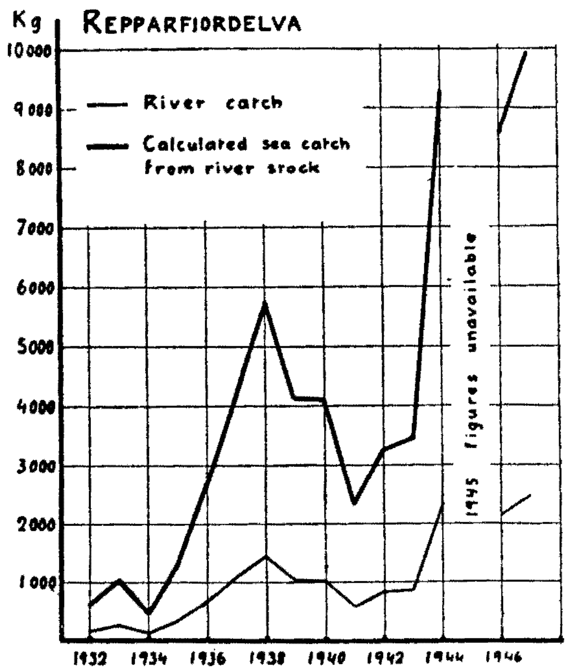

Figure 3. The Repparfjord River. The actual river catch shown by the lower (thin) curve. The corresponding calculated sea catch of the river stock (proportion 20 per cent river catch, 80 per cent sea catch of the same stock) shown by the upper (thick) curve

These examples leave no doubt that the output of the Norwegian salmon fisheries may be considerably increased by allowing a better escapement of fish to the spawning grounds. Our present laws order a weekly closing time of three days for all commercial gear (in some rivers five days), and an annual closed season from the end of August to the middle of April, besides details as to mesh measurements, restricted use of certain types of gear, etc.

It is evident that it will also be necessary to establish a control of the number of gear by introducing a licence for all salmon fishing and thus secure a sufficient escapement for spawning. With a protective licence system it should be possible to build up a larger stock of salmon and also to employ means of cultivation to raise the annual output of the salmon fisheries.

The Norwegian Ministry of Agriculture is in favour of such plans and is working among the fishermen in order to obtain their co-operation.

There is no evidence that artificial hatching has contributed to the maintenance of the salmon runs, though several small hatcheries are continuously operated.

It is probable that the yield of the salmon fisheries may be improved by introducing other species of salmon, for instance one or more of the Pacific salmon belonging to the genus Oncorhynchus. Such introduction should be carefully considered and planned. Preparatory investigations will be started early in 1949.

The Effect of Fishing Upon the Stocks of Pacific Halibut

H. A. DUNLOP

ABSTRACT

Commercial fishing for halibut on the Pacific Coast of North America is divided into two periods. In the first, a period of unrestricted fishing ending in 1930, the amount of fishing increased from a low to a high level. In the second period, one of controlled exploitation, the amount of fishing has been gradually reduced.

The separate stocks declined in size with each increase in the amount of fishing. The annual yields from them increased for a time, until fishing reached a certain level, and declined thereafter when subjected to further sustained increases in fishing. When fishing was constant or nearly so for a few years, the size of the stocks and their yields tended toward stability.

With a gradual reduction of about one-third in the amount of fishing during an eighteen-year period of controlled fishing, the stocks have doubled in size and the annual yields from them have increased about one-third. The size of each stock and the yield from it are now back to the levels that existed when an equivalent amount of fishing was being done during the period of decline.

Experience indicates that, within limits imposed by the biological characteristics of the species and the productivity of its habitat, the amount of fishing determines the size of each stock of halibut and the annual yield it can produce.

The commercial fishery for halibut, prosecuted by the vessels of the United States of America and the Dominion of Canada on the Pacific Coast of North America largely side-by-side in extraterritorial waters, began just over sixty years ago. Only the salient point in its history, covering its initial rapid growth, its subsequent serious decline due to excessive fishing, and its partial recovery under controlled fishing, can be given here.

The fishery began off Cape Flattery and the southern end of Vancouver Island. Expanding markets and improvements in types of construction and power added increasingly efficient vessels to the fleet and enabled them to extend their operations to more and more distant banks as fishing on the more accessible banks became less profitable. By 1910, the fishery extended in sheltered waters as far north as Cape Spencer, Alaska. Subsequently, it expanded into off-shore waters and south to Oregon and California and north into the Gulf of Alaska. After 1920, the fishery moved westward beyond Kodiak Island and soon covered the range of the halibut from northern California to Bering Sea, a distance of 2,000 miles.

Early in the fishery it was recognized that the supply of halibut on the longer-fished banks was being rapidly reduced but no serious concern was shown. Loss of yield from the older banks was more than offset by gain of yield from the newer ones, until 1915, when the total catch exceeded 68 million lb.

This complacent attitude changed after 1915. A preliminary investigation demonstrated a sharp decline in abundance of halibut on the older grounds and, in spite

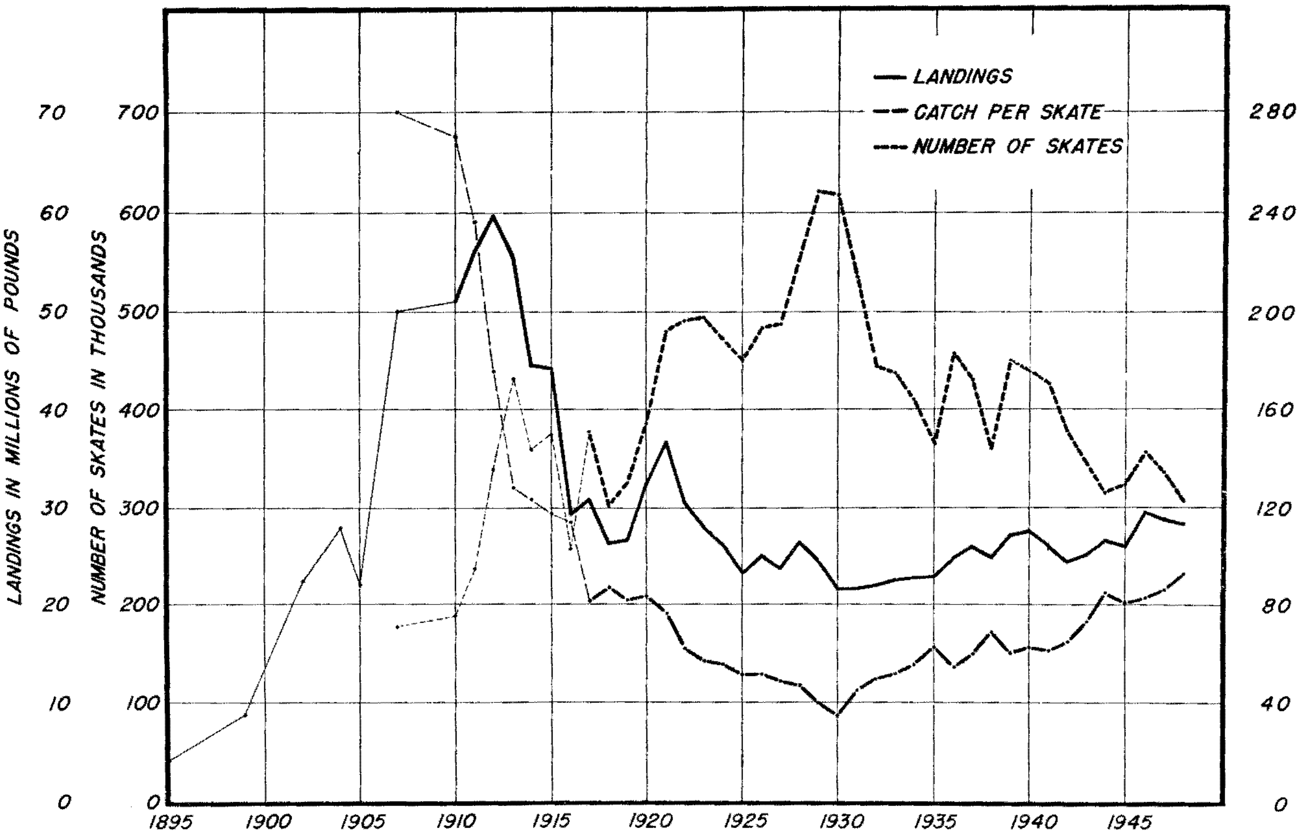

Figure 1

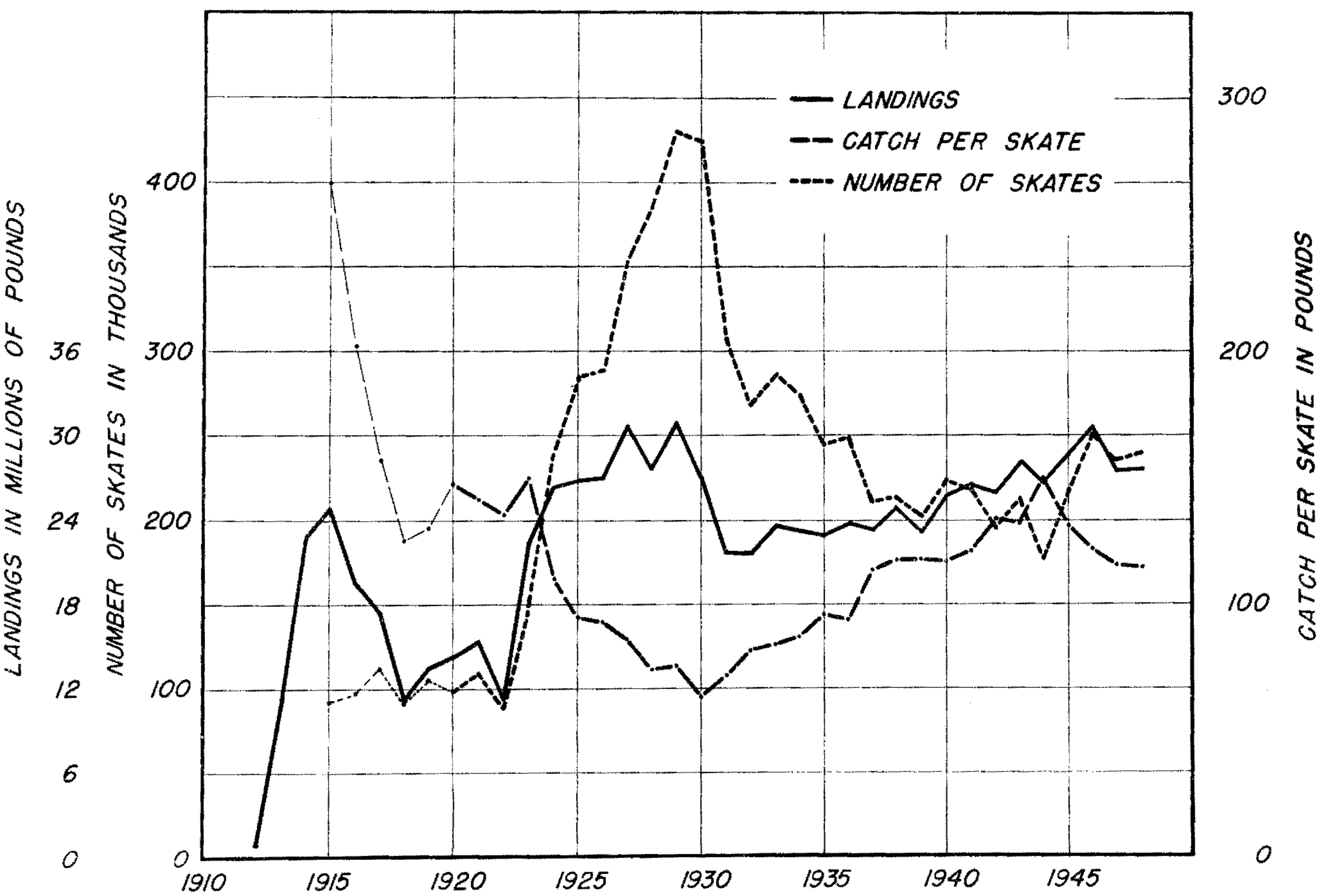

Figure 2

of the maintenance of fishing effort and the exploitation of new fishing grounds, the annual landings quickly declined to approximately 50 million lb. Joint action by the United States and Canada to conserve the fishery was urged with increasing insistence. This culminated in 1923 in the signing of a convention between the United States and Canada for the preservation of the Pacific halibut fishery.

The Convention of 1923, the first concluded anywhere for the preservation of a declining deep-sea fishery, instituted a winter closed period corresponding to the spawning season of the halibut and established the International Fisheries Commission of four members, two from each country. It required the Commission to investigate the decline in the halibut fishery and to make recommendations for its preservation and development.

Biological and statistical investigations were begun in 1925 by a staff of biologists employed by the Commission. They were designed to reveal the basic facts in the life of the halibut, and to measure the decline in the fishery and determine the cause.

Biological investigations were restricted to phases that had a direct bearing upon the problems of determining the condition of the stock of halibut and of devising methods for its rehabilitation. Age and growth studies revealed that halibut were slow growing, and did not enter the fishery in significant numbers until they were seven or eight years old or make an important contribution to the weight of the catch until they were eight to ten years old. Maturity studies showed that the females matured between their eighth and sixteenth years or at an average age of about twelve years, the males somewhat younger. Marking experiments revealed that the immatures were sedentary, whereas the matures migrated freely within broad limits. They also provided information regarding the rates at which the halibut were being removed by natural mortality and the fishery. The marking experiment and studies of the drift of the eggs and larvae demonstrated that the halibut on the long-fished grounds south of Cape Spencer, Alaska, and those on the recently-fished grounds west of Cape Spencer formed two practically independent populations which must be considered separately.

The statistics collected included all existing records of landings and all surviving records of vessels' fishing operations which could be found, showing fishing locations, the amount of gear fished and the catch taken in each operation. From these were obtained, for the southern and western grounds, the total catch, the average catch per "skate" or unit of gear and the resultant theoretical number of skates or units of gear required to take the total catch. These are given for the early years of the fishery on the left side of Figures 1 and 2.

It was easy to secure good records for current years but in working into the past it became increasingly difficult to obtain accurate records of operations.

The catch figures for years prior to 1910 are less reliable than those for 1910 and later years which were based on still existing, though incomplete, records of individual landings. Similarly, by reason of the small number and unrepresentative distribution of the fishing records for the earlier years, the catch-per-skate values for the southern grounds in the years prior to 1918 and for the western grounds prior to 1920 are only indicative of the general trend of abundance. This is especially true for the western grounds where almost one-half of the fishing grounds, with large stocks of non-migratory immatures of commercial size, were not fished until after 1920.

The investigations quickly proved that the abundance of halibut had not only declined greatly on all grounds but was still falling at a rapid rate, and also that landings were being maintained only by constant increases in the amount of fishing and the exploitation of new grounds. They showed that conditions were serious on the southern grounds where spawners had become very scarce, and were rapidly approaching the same condition on the western grounds, though a considerable spawning stock still remained there. They demonstrated that the closed season alone was unable to stop the decline and that additional regulation was necessary to preserve the fishery.

The statistics of the fishery on the southern grounds showed that each increase in intensity of fishing reduced the abundance of fish and was followed by a decline in catch, also that the declines in abundance and catch tended to cease during periods of constant or reduced intensity. They indicated that the intensity of fishing determined the abundance and the catch and that a suitable reduction in intensity would not only stop the decline of the stocks but also return them to higher levels.

The Commission reported its findings to the Governments of the United States and Canada in 1928. It recommended a division of the coast into regulatory areas, the application of annual catch limits to the individual areas and a reduction of those limits until the decline in each area was halted, also a continuation of the closed season and some other secondary measures. This authority was granted by a new convention negotiated in 1930 and was broadened in 1937 by a succeeding convention under which the Commission still functions.

Before the Convention of 1930 was ratified and regulations could be put into effect, the economic depression of the early 1930's intervened. It made fishing unprofitable and reduced the intensity of fishing in 1931 appreciably more than the current annual rate of decline in relative abundance. It was sufficient to halt the decline on each ground and to permit an increase in abundance.

The regulation of the fishery, begun in 1932, relied mainly upon the application of annual catch limits to the previously mentioned southern and western grounds or areas which produce more than 98 per cent of the coast catch. At the outset, approximately those levels of catch which had reversed the decline in abundance in 1931 were adopted. Thereafter, guided by statistical and biological observations of the changes in abundance and composition of the stocks of fish, annual catches were held below the poundage produced by the entry of young fish and growth. From time to time as the stocks accumulated and as the annual poundage increases became greater, the catch limits were increased. The resultant catch, catch per skate and calculated amount of fishing in each area and each year during the period of regulation are shown on the right in the accompanying figures.

The reduction in the intensity of fishing, resulting from economic conditions in 1931 and from the application of catch limits thereafter, has increased the abundance of halibut greatly on all grounds. The catch per skate in the southern area in 1948 was 167 per cent greater than in 1930. In the western area, the catch per skate increased until 1944 when it was 131 per cent above the level of 1930. Thereafter, it declined until 1948 to a condition of apparent stability about 80 per cent above the level of 1930.

The catch allowed in the southern area in 1947 and 1948 was 37 per cent greater than in 1930 or 1931 and was taken without apparent injury to the stock. In the western area, the catch in 1947 and 1948 was 27 per cent greater than in 1931. The larger catches of 1947 and 1948 were taken with 33 per cent and 22 per cent less fishing, respectively, than was required to take the much smaller ones of 1931.

The decline in relative abundance in the western area from 1944 to 1948 came as no surprise to the biologists associated with the halibut investigations. Failure of the catch to increase appreciably with great increases in the intensity of fishing after 1924 had convinced them years earlier that the levels of abundance and yield in 1924 approximated the optimum for the western population. Bearing in mind the probability of better conditions of survival and growth some years after the initial reduction of the stock, they had frequently expressed their belief that the maximum permanent yield from that stock would be approximately 30 million lb. The decline in relative abundance from the high point of 1944 to the level of 1924 and the increase in amount of fishing from the low point in 1944 to the level of 1924, with annual catches similar to that of 1924, has strengthened this belief.

An explanation of the increase in abundance after 1940 and the decline after 1944 can be found in available data. The rise and fall from 1943 to 1945 resulted largely from a war-time price dispute in 1944 which prolonged fishing to the end of November and permitted fishing on the dense schools of large mature fish which congregate at the beginning of the spawning season. The decline from 1944 to 1948 was caused in part by increased fishing in the eastern part of the area where the abundance of fish is lower. The remainder of the changes may well be due to the passage of unusually strong year-classes through the fishery.

Studies of the changes in the size and age composition of the stocks in the two areas, based on the lengths and ages of halibut in the commercial landings, were inaugurated the year after regulation began. They were sharply curtailed in the southern area and eliminated entirely in the western one by changed conditions in the fishery and loss of scientific personnel during the war. Sampling of the western landings has now been resumed.

The market samples from the southern area have revealed a marked increase in the number of halibut of spawning size and age, under the improved survival conditions brought about by regulation. They have also shown a gradual, though irregular, increase in the number of young entering the fishery. These irregularities, resulting from observed variations in the strength of entering year-classes, account for the sudden increases in catch per skate from 1936 to 1938 and from 1941 to 1945. An analysis of the samples from the western area is now under way to determine whether similar variations have occurred in the strength of entering year-classes in that area. An increase in the proportion of "large" in the commercial landings, in conjunction with the greater catch per skate, has already demonstrated a pronounced increase in the numbers of fish of spawning size in the western area.

Theoretical studies of the effect of changes in the intensity of fishing upon the size of the stocks and upon the annual yields from them were made in the early years of regulation. These dealt particularly with those years of decline that were covered by reasonably reliable statistics. Using the growth rates and the natural and fishing mortality rates indicated by biological investigations, the size of each stock and the yield that should be obtained from it with such changes in the intensity of fishing as had taken place in the fishery were calculated. The theoretical results corresponded so closely to those actually observed in the southern area and were sufficiently similar to those actually found in the western area as to justify the conclusion that the increases in the intensity of fishing had been responsible for the decline in size and in yield of the two stocks.

Similar studies, covering the succeeding period of increase under regulation, were interrupted by the war and have only recently been resumed. Completion of these must await the completion of new marking experiments to determine the natural and fishing mortality rates under the greatly changed fishing conditions which now exist. When the results of these experiments are in, it will be possible to determine more accurately the relation between the recent changes in the stocks and the changes in the intensity of fishing in the two areas. It should also be possible to ascertain the part played by an increased entry of young into the fishery under the improved conditions of survival brought about by the earlier reduction of the originally dense stock in the western area.

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Overfishing

MICHAEL GRAHAM

ABSTRACT

Signs such as high returns from marking experiments, large reactions to changes in fishing effort, downward trend in catch per effort and average size, cast doubt on the wisdom of *laisser faire* in the particular fishery concerned. Unless such signs have been observed, it is unlikely that there is overfishing yet, inevitable as it may be later, provided fishing is quite free. There is overfishing when reduction of stocks proceeds to a level of no profit or of too little yield. In remedy, the fixing of fishing is more important in itself than is achieving the best rate.

In the present state of our knowledge, and with the number of words limited, the subject may best be served by a series of propositions—not on a Euclidean basis but as summarizing experience, of which examples are given.

1. Overfishing means too much fishing for the stocks. A closer definition might be unduly hampering.

[1] Numbers within parentheses refer to items in the bibliography.

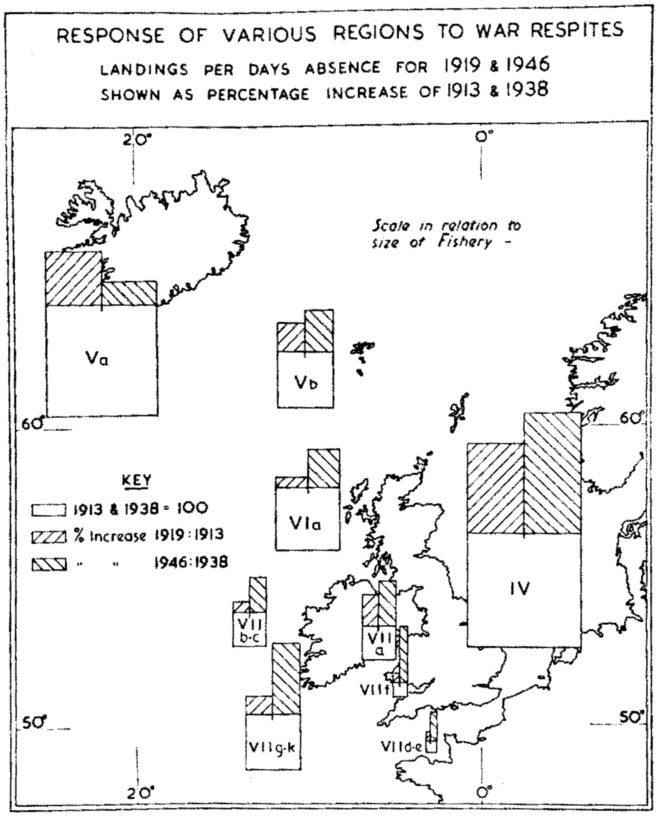

Figure 1. (The scale in each block is proportional to the magnitude of the fishery)

2. All stocks fluctuate naturally, but both policy and present theory deal with averages and trends over a series of years.

3. Unless fishing mortality is much greater than natural mortality, the question of overfishing does not arise. This is self-evident; but could be expressed algebraically on suitable assumptions.

4. The following are signs that it is worth investigating the question of whether there is overfishing:

(i) Marking experiments giving a high estimate of fishing. Example: plaice marking in the North Sea, 1903-1911, gave a rate of 0.7 (1)[1] i.e., 70 per cent of stock caught annually.

(ii) Effects of large changes in rate of fishing. Examples: (*a*) the chart (Figure 1) shows great increases in density of stocks near the British Isles when the hand of man was lifted from the fish, in two wars; (*b*) Holt and Margetts (9) reported that the change in cod stocks from 1938 to 1946, in the North Sea, was from predominantly small fish, of length 40 to 50 cm., to a very much greater proportion of large fish, of length 80 to 95 cm.; (*c*) that there was, according to them, a general increase in the weight-density of demersal fish in the central and southern

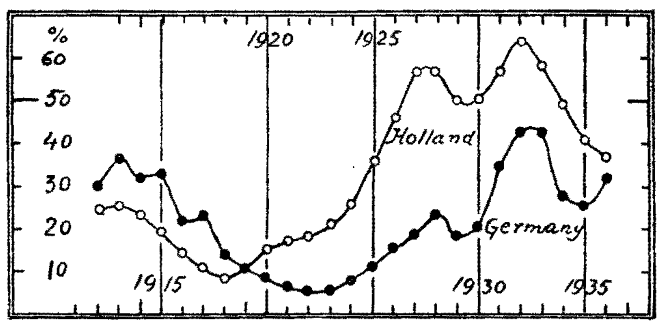

Figure 2. The Percentage proportion of sole, recorded as "Smalls" in Germany and Holland, 1911-1937. (Smoothed curves)

North Sea, in those areas fished by English trawlers in 1946, rather more than threefold; (*d*) that they reported marked increases in the densities of plaice, cod, haddock, sole and turbot, but not of dab and whiting; (*e*) and that the changes in plaice (Figure 3) and cod were due to increased survival resulting directly from the closure of large areas of the North Sea to fishing fleets between 1940 and 1945, the recommencement of fishing in such areas after the war causing a reversion in the condition of stocks towards that of 1938; (*f*) finally they found that there was evidence of alteration in growth rate of plaice in the later war years.

(iii) Downward trend in catch per effort. Example: Ansell, in evidence to the Royal Commission of 1883, showed the catch of "Prime, Soles and Butts" for each (sailing) trawler per annum to be falling rapidly from 1864-1867, viz.,: 1864, 15 ton 5 cwt.; 1865, 11 ton 15 cwt.; 1866, 9 ton 4 cwt.; and 1867, 8 ton 10 cwt.
Still further decline was shown by landings for the years 1876-1882, viz.,: 1876, 4 ton 14 cwt.; 1880, 5 ton 1 cwt.; 1881, 4 ton 19 cwt.; and 1882, 5 ton 15 cwt.
That is, the landing per vessel in 1881 was less than one-third of that in 1864.

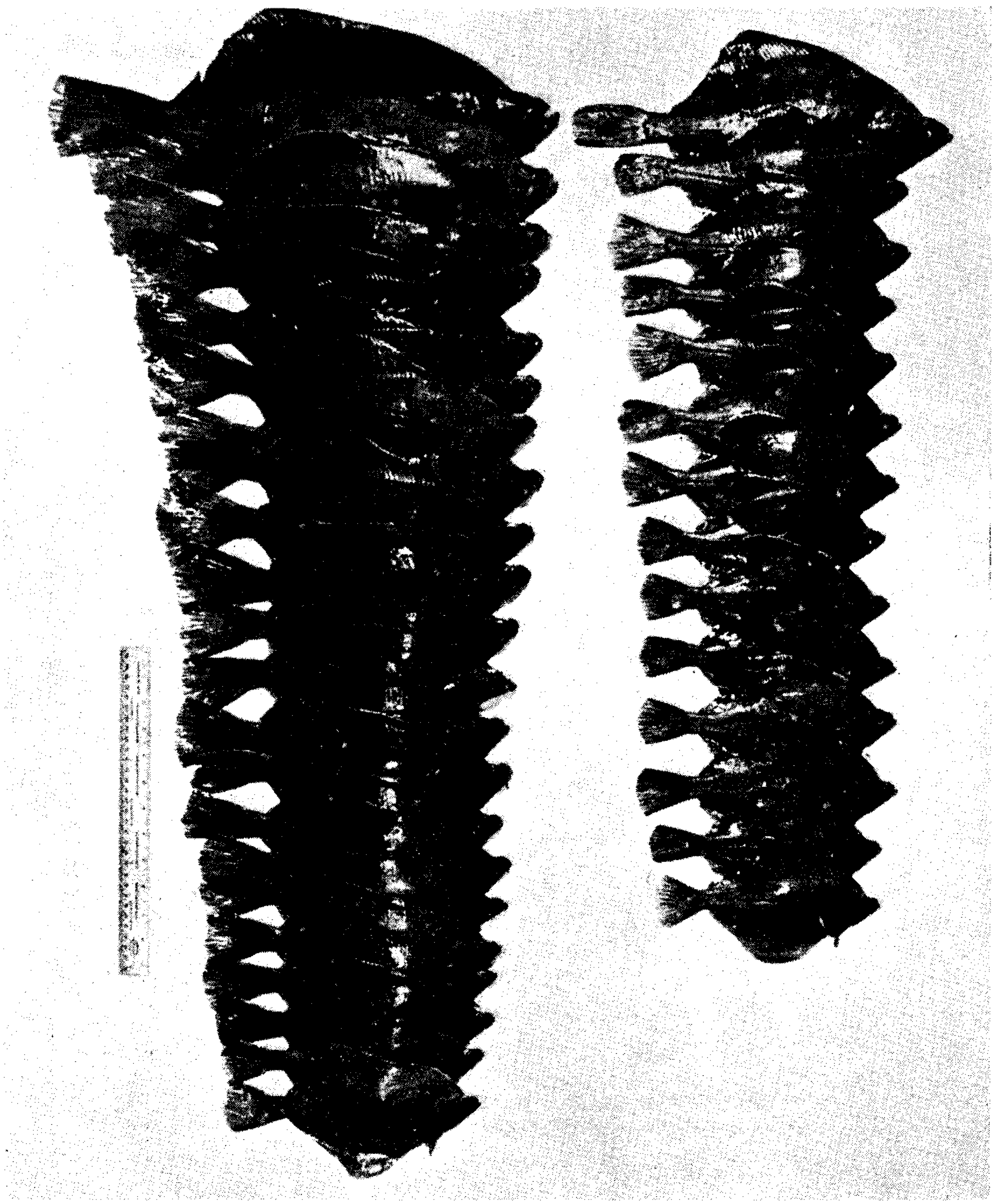

Figure 3. Typical catches of plaice for one quarter of an hour trawling in the North Sea. 1945 on left, 1938 on right

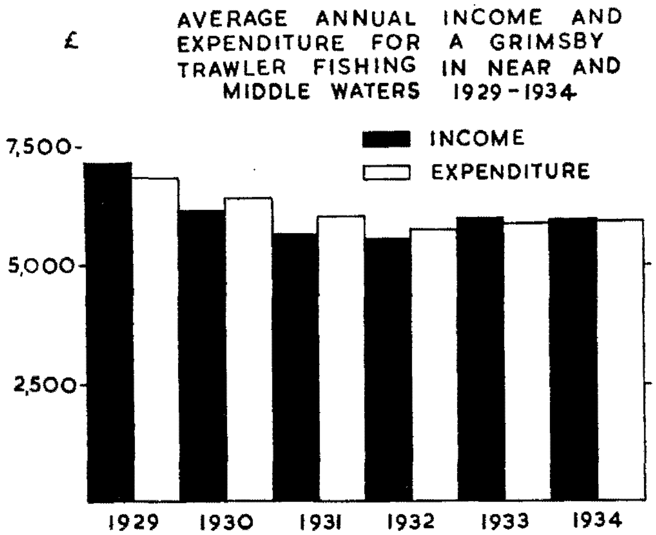

Figure 4

(iv) Downward trend in average size. Example: the increase in percentage proportion of soles recorded as "Smalls" in Germany and Holland for years 1911-1937 (Bulletin Stat. 1937) is shown in Figure 2.

5. None of the above four signs prove overfishing.

(i) A fishing rate of 0.7 might be too low if applied near the end of the life history of the fish.

(ii) The total landing over the series of years might have been greater but for the war.

(iii) Fall in catch per effort is not overfishing, because it could begin when the number of ships rises from one to two.

(iv) Reduction of size is not overfishing, because in virgin stocks the fish have been found to be too old, too large and too thin, for the market.

6. Overfishing takes place in either of two circumstances.

(i) Profit goes to nothing. Example: the White Fish Commission reported that, for trawlers fishing in near and middle waters out of Grimsby from 1929 onwards, earnings declined and profits vanished. There was a fall in gross earnings of 17 per cent in 1934 (which had been 20 per cent in 1932). The fall in earnings was not all due to the fall in price,

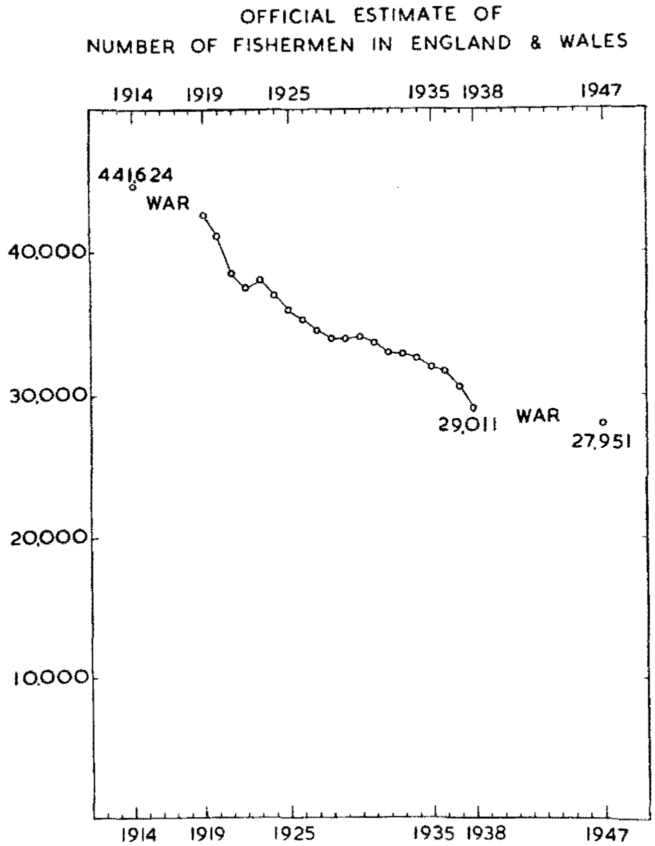

Figure 6

which was only 7 or 8 per cent—not enough to account for the fall of 17 per cent in gross earnings. The remainder must be due to less weight of fish. The trend in profits is shown in Figure 4. A chronic state of unprofitableness, combined with vigorous fishing, and less weight of fish in the sea, is fairly called "overfishing".

(ii) Total yield falls, causing disquietude. Example: Fig. 5 shows the effect on plaice in waters round Iceland of introducing the Vigneron-Dahl trawl and increasing fishing; in amplification, Vedel Tåning concluded that there was no doubt that the large fish very greatly decreased whilst the small fish increased relatively.

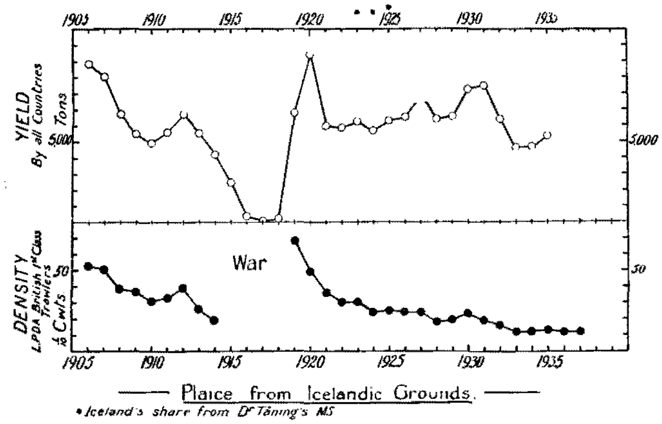

Figure 5.

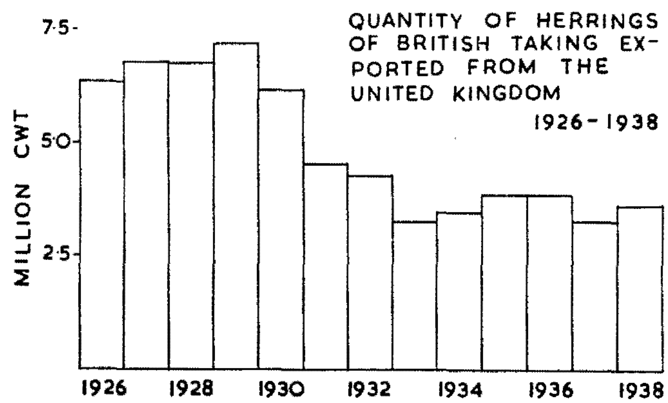

Figure 7

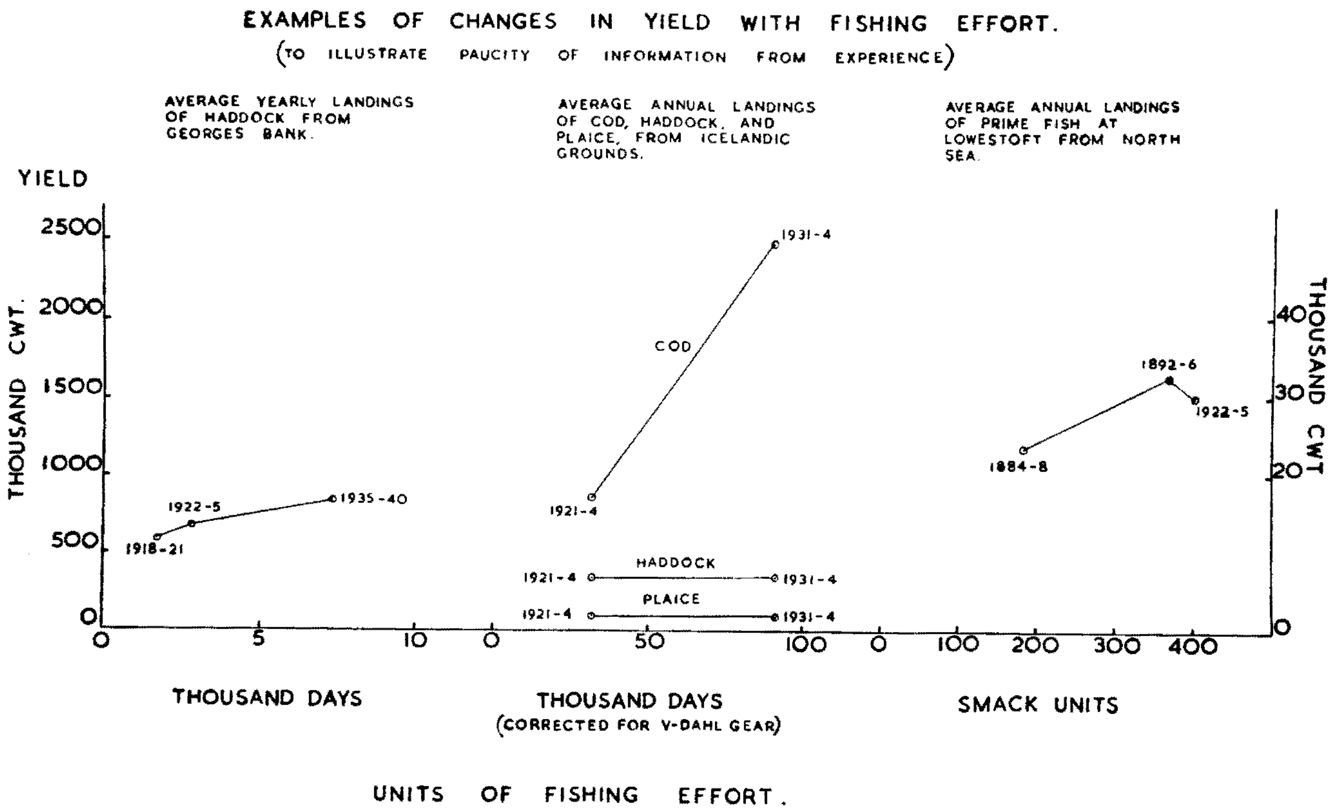

Figure 8

1910-1913 Small 6 per cent Large 35 per cent
1929-1932 Small 31 per cent Large 9 per cent
1937-1938 Small 31 per cent Large 8 per cent

But people did not mind the reduction of plaice because there was plenty of cod, so *pace* Russell, this was not "overfishing", although it was a good example of too much fishing to get the best out of a particular fish stock, that of plaice.

7. In either event the acknowledgment of overfishing depends on what people consider too much, as with over-exertion, overspending, over-reaching yourself, or "over" anything else. A more restricted definition might prevent something being done when it needs to be done; or might cause regulation when there is no need for it.

8. So, external circumstances are implied in the definition of overfishing. An example of a serious external event in which overfishing of the North Sea had a part was a persistent downward trend in the fishing population of England and Wales, shown in Figure 6; this was partly, but only partly, due to the chronic state of no profit in trawling in near and middle waters, shown above; and its immediate importance during Hitler's reign was the danger of vessels being sold abroad, when a major war was threatening.

9. The external circumstances will rarely be due solely to overfishing. For example, taking the circumstances mentioned in the preceding paragraph, the shrinking exports of herring (Figure 7) also reduced the number of fishermen; and the heavy landings of Arctic cod reduced the price of other fish in the years when cod was being landed in great quantity.

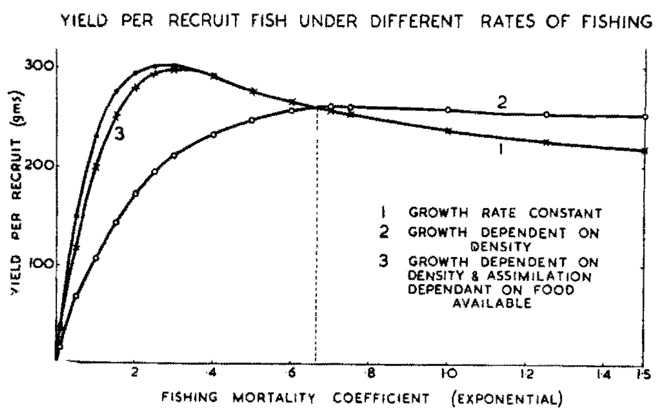

Figure 9

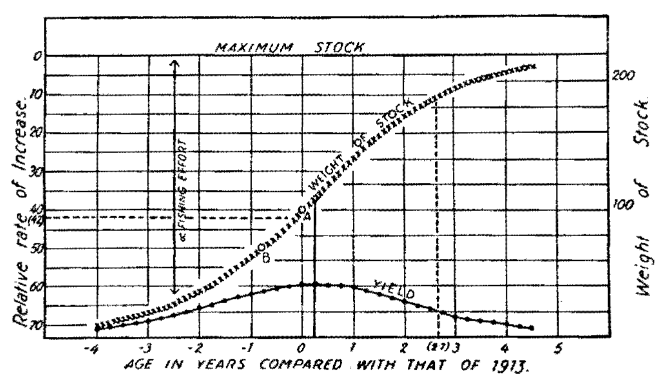

Figure 10. A crude form of the theory of fishing fitted to North Sea demersal stock

	1923	*1925*	*1927*	*1929*	*1931*	*1933*	*1935*	*1937*
Landings of cod...... (1,000 tons)	100	137	147	153	229	245	278	347
Price of demersal fish other than cod (halfpennies per lb.)	7.1	6.1	5.7	6.1	5.4	5.2	5.5	4.6

And the danger of selling ships to a potential enemy was only real, in the presence of overfishing, because the enemy's policy of expansion of the fisheries, was not solely governed by profit.

10. Baranov, Russell, Thompson and Bell, and others, considered a stock neither increasing nor decreasing by fishing, but held steady at different levels according to different rates of fishing. The problem is how would the yield vary in different states of equilibrium?

$$\text{fishing}_1 \times \text{stock}_1 = \text{yield}_1$$
$$\text{fishing}_2 \times \text{stock}_2 = \text{yield}_2$$

Fishery statistics give scattered information, providing no solution, as is clear from Figure 8.

11. In order to make a coherent graph of yield against fishing rate it is necessary to use theory; because statistics have not given us enough equilibrium points. Common sense is no guide by which to measure the right amount of fishing.

12. Beverton and Holt (4) give the following provisional curves for yield against effort of English-caught plaice in the North Sea. At different rates of fishing their formula is based on growth, suitably adjusted for changes in density of stock; on mortality; on age at recruitment; and on fishable life-span (Figure 9).

13. Plaice do not live alone, and it is necessary to make curves for each of the three staple species and take the weighted average as the best rate of fishing, in order to obtain either the maximum profit, or the maximum yield, or to make some compromise: or to accept the best we could get agreement on anyway.

14. I have also considered autocatalytic growth of all demersal fish flesh in the area, and fitted the changes as a result of the 1914–1918 war. This was not very satisfactory, if only because data points were so close together; but it may have been better than giving no estimate at all (Figure 10).

15. The best management of fishing is to leave it alone, until evidence shows that overfishing is approaching. At that point, it is much more important to fix fishing, including fixing mesh and the effectiveness of gear, than it is to achieve the optimum. In an overfished stock, unfixed fishing pursues the operator relentlessly; whereas not-the-best fishing, if fixed, gives him peace. It also gives him profit from new devices, provided he makes, where necessary, compensating reductions in fishing.

16. This paper was inspired by the symposium published in the Bingham collection, to which acknowledgement is made.

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(2) *Anon.*, "The White Fish Industry", *Official Report*, Cmd. 5130, London, 1936.

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(9) S. Holt and R. Margetts, "The Effect of the 1939-45 War on the English North Sea Trawl Fisheries". *Rapports et Procès-Verbaux*, vol. 122, 1948, Copenhagen.

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Summary of Discussion

The Chairman suggested that the meeting should begin its consideration of changes in the abundance of fish populations by examining the paper contributed by Mr. Rollefsen.

Mr. M. Graham submitted Mr. Rollefsen's paper on "Changes in the Abundance of Fish Populations".

Mr. A. L. Pritchard submitted Mr. Tester's paper on "Fluctuations in the Abundance of Herring on the West Coast of Vancouver Island".

Mr. M. Graham submitted Mr. Tåning's paper on "Fluctuations in Fish Populations Owing to Climatic Changes".

The Chairman called attention to Mr. Havinga's paper on "The Enclosing of the Zuyder Zee and its Effect on Fisheries" [1] and to Mr. Le Gall's paper on "The Present World Problem of Sea Fisheries".

Mr. M. Graham observed that he had followed with great interest the experiment being made in the Zuyder Zee, and wondered whether the Netherlands authorities had considered the possibility of stocking the Zuyder Zee with young flounder with a view to increasing the supply of that fish.

The Chairman thought that Mr. Havinga would be best qualified to reply to that question.

Mr. D. W. Pritchard disagreed with Mr. Tester's observations, which appeared to deny the existence of positive correlation between variation in average air temperature and variation in year-class abundance. Studies had been made in certain maritime areas which had clearly established that the temperature of the air furnished a positive indication of the average temperature of the water, and that, generally speaking, any fluctuations in temperature led to fluctuations in oceanographic conditions. In that connexion he referred to the new theory of Professor Walter Monk, of the Scripps Oceanographic Institute, on

[1]See footnote 1 on page 1.

the correlation between atmospheric and oceanographic circulation.

The CHAIRMAN asked Mr. Graham to present Mr. Sømme's paper on "The Effects of Fishing on Norwegian Freshwater and Adronomous Fishes".

Mr. M. GRAHAM pointed out that the paper contained an interesting summary of the currently known facts concerning salmon in Norway, and also contained a diagram showing fluctuations in the number of bagnets in inverse ratio to the annual catch per bagnet from 1876 to 1945. Parts of the diagram might be considered to provide an example of overfishing.

The proposal to introduce Pacific salmon (*Øncorhynchus*) into Norwegian waters was also worthy of note.

Mr. WALFORD submitted Mr. Dunlop's paper on "The Effect of Fishing Upon the Stocks of Pacific Halibut".

The paper described the findings of the International Fisheries Commission leading up to the 1930 Convention, under which regulation of the halibut fishery began in 1932. The decline in abundance and catch and in the size of the fish in the western and southern grounds prior to regulation was attributed to overfishing. Studies were being made and it was hoped that they would enable the relation between the intensity of fishing and improvement in the stocks to be accurately determined.

Mr. M. GRAHAM submitted his paper on "Overfishing". He paid a tribute to the experts on whose work he had based his study.

He had endeavoured to resist the tendency to attach too much importance to definitions. The idea of overfishing was a very old one dating back to the seventeenth century in England where it apparently had first arisen when the trawl was invented. For a long time it had remained a popular rather than a scientific theory, and while Mr. W. F. Thompson's group might have had more explicit ideas on overfishing after 1930, it had not succeeded in promulgating them. His own examination dealt only with trawl fishing in northern waters.

In Mr. Graham's opinion there could be overfishing only in relation to the existing conditions and he considered it useless to attempt to find a fuller definition of the idea. His aim in carrying out his study had been to group the symptoms, causes and effects of overfishing as they were brought out in the most recent experience. That was the purpose of the charts and diagrams accompanying his paper.

Although certain signs might indicate that in some cases there was overfishing, it could never be stated positively that such was the case. Therefore Mr. Graham agreed with T. H. Huxley's opinion, that it was for those who maintained that there was overfishing to furnish proof of it. As long as proof was not produced, there was no good reason to regulate fishing and thereby create new offences when it was not certain that the fishermen's operations were really harmful. It was for that reason that, after attempting for 15 years to spread the idea of overfishing, Mr. Graham had for several years refused to take that factor into consideration unless he had conclusive proof.

The CHAIRMAN opened the discussion on the papers which had just been presented.

Mr. A. L. PRITCHARD would limit his remarks to a few observations based on experiments with salmon fishing in other parts of the world.

Contrary to opinion in Norway, it was the general view in Canada that angling might have a great effect on the stock of fish. However, that country had adopted the same attitude as Mr. Graham's in regard to the idea of overfishing and its effects on stocks and was concentrating particularly on the study of natural fluctuations which had an effect on the stock of fish.

After a disturbing decrease, the stock appeared currently to be on the increase. Particularly, attempts were being made to improve the rivers and the condition of the spawning-grounds in order to make them more accessible to the fish. It would indeed be useless to restrict fishing if the fish were not able to reproduce.

As for methods of artificial stocking of which Mr. Sømme had spoken in his paper, Mr. Pritchard did not think that the result could be of particular interest. The problem of artificial stocking had been carefully studied in Canada. From the studies which had been made, it appeared quite unlikely that Norway could hope for substantial gains from introducing Pacific salmon into its waters. It was possible, on the other hand, that some results might be achieved by bringing in spring salmon. At any rate, the greatest attention should be given to the improvement of the spawning-grounds.

In any case, until it had been established that fishing was the principal reason for the decrease in stock, the number of fishermen could not be reduced. For that very reason there was no distinction between commercial and sport fishing in Canada and the same rights were granted to both.

Mr. HOFFMASTER wished to know why the introduction of a new species of salmon was being contemplated in Norway.

Mr. OPPEDAL pointed out that artificial stocking had been carried out successfully in some cases; for instance it was believed that the shad on the West coast of the United States had been artificially introduced from the East coast.

Mr. Oppedal explained that fishing in the inland waters of Norway was not commercial. River-side farmers on the lakes and rivers had the fishing rights which they generally leased to angling clubs and derived from the lease incomes which could not be disregarded.

He did not feel that the effects of angling could seriously endanger the stock of fish.

Mr. A. L. PRITCHARD pointed out that the actual reason for the stocking which was contemplated in Norway was, without doubt, economic and that that operation should not be considered from the aspect of preserving the supply of fish.

Mr. WALFORD pointed out to Mr. Hoffmaster that different species of salmon spawned at different times of the year and that therefore it would seem that there was no objection in principle to introducing Pacific salmon to Norwegian waters. He recalled that a similar experiment had been successfully carried out in the state of Maine, on the eastern seaboard of the United States.

In answer to Mr. Hoffmaster's question whether both species had the same feeding habits, he said that it was rather difficult to say as not enough was known of their habits on the high seas and it was at low depths that their rivalry would be greatest.

Mr. Kask described an experiment carried out in New Zealand around 1900, where three rivers had been stocked with salmon fry. In forty-eight years the salmon population of a mere few thousand had increased very little. Nevertheless the experiment could be considered useful since salmon had been successfully transplanted to a region totally lacking in such anadromous species. It was curious to note that the New Zealanders set no great store by those fish whose taste did not appeal to them, and they did not seem to appreciate the fact that, from a scientific point of view, it was certainly a remarkable experiment.

Mr. Walford stated that for the past fifteen years fishery biologists had been studying the problem of dwindling resources through overfishing. It was a question of primary importance to fishery control bodies. He would like to ask Mr. Graham, who was inclined to minimize the problem of overfishing, whether he had any suggestions regarding the lines along which the research work of biologists should be carried on.

Mr. M. Graham said that he could not tell the biologists what line their work should take. In reply to the question put to him, he could only point very generally to the instructions given to the English biologists attached to the Lowestoft research laboratory under the Ministry of Agriculture and Fisheries to which he himself belonged. He said that the only instruction given to these scientists was to establish what facts were conducive to the best possible utilization of stocks. In other words efforts were being made to put science at the service of fishing without any preconceived ideas on the matter.

In cases where overfishing definitely seemed to be exhausting stocks, biologists naturally studied the phenomenon thoroughly from all angles. Their main efforts however were directed at collating data in time so that, should the need arise, international agreements on rational fishing could be suitably modified. Biologists were thus constantly endeavouring to forecast the effects of overfishing in order to be able to remedy the situation in good time. He concluded that those services had no difficulty in forecasting several years ahead of the treaties in force.

Mr. Oppedal, in answer to Mr. Hoffmaster, said that the only restriction imposed on codfish fishing in Norwegian waters, as far as he knew, concerned the mesh size of nets.

The number of codfish otter trawlers was limited but he believed that the law was based rather on sociological considerations and was not aimed at safeguarding the abundance of stocks. Amendments to this law were under consideration.

The Chairman, summing up, made some observations which occurred to him as an economist.

The development of the fishing industry would undoubtedly result in lowering the price of fish. That was necessary if fish was to take the place due to it as a first class food on every table.

On the other hand if the fishing industry was to operate at full production, it was necessary to give a fair return to fishermen and therefore a readjustment of wages was needed. That result could be obtained only through raising the quantity of the yearly catch of each fisherman, in other words by improving fishing techniques.

Finally, with regard to overfishing, that problem had not only its practical but also its economic and social aspects.

The Chairman said that all those infinitely complex questions would have to be studied thoroughly both on the technical level and from the point of view of the social sciences.

Mr. M. Graham invited the members of the Section to join the small group of experts who hoped to profit by the current meeting to prepare a map showing the world's unexploited fishing grounds.

The Section had just discussed at length the problem of the exhaustion of stocks through overfishing. That problem was not only of practical importance; it had a psychological aspect which should be given attention. From a global point of view it was evident that fish stocks, far from disappearing, greatly exceeded the depletion due to fishing. There were several zones which were not exploited because they were too far away from world markets or because fishing in them was difficult, whereas in those where fishing had been continuously carried on for centuries there was an increasing number of restrictions, profits were falling off and new generations were hesitating more and more to devote their lives to an occupation which repaid their hard efforts so badly.

The advantage was thus obvious in estimating the possibilities and paving the way for measures which, in the near future, would make it possible to open up new fields to fishermen and put fish on everyone's table.

Mr. Graham and some of his colleagues had thought that the most useful preparatory work would be to prepare a map showing the various unexploited fishing grounds of the world. That map would certainly facilitate the Section's discussion on 25 August on the problem of latent resources. In that connexion, some preliminary work had already been done and they asked the other members to complete their work or correct it in the light of their own information. The map would be exhibited in conference room 13 until 25 August.

Developing Fishery Resources

25 August 1949

Chairman:

Michael GRAHAM, Lowestoft Research Laboratory, Ministry of Agriculture and Fisheries, Suffolk, England

Contributed Papers:

Latent Fishery Resources and Means for Their Development
Harold THOMPSON, Chief, Division of Fisheries, Council for Scientific and Industrial Research, Marine Biological Laboratory, Cronulla, New South Wales, Australia

Latent Fishery Resources and Means for Their Development
Cecil VON BONDE, Director of Fisheries for the Government of the Union of South Africa and Member of the Standing Advisory Committee on Fisheries of FAO, Capetown, Union of South Africa

Latent Fishery Resources and Means for Their Development
E. DE VRIES, Professor, Agricultural University, Wageningen, Counsellor to Ministry of Overseas Affairs, The Hague, The Netherlands, and
C. J. BOTTEMANNE, Former Head of Institute of Sea-Fisheries of the Indies, Batavia, Voorburg, The Netherlands

The Development of the Fishery Resources in Chile
M. J. LOBELL, Fisheries Consultant, Santiago, Chile

The Exploitation of the Egyptian Elasmobranchii
Ibrahim ABOU SAMRA, Director of Fouad I Institute of Hydrobiology and Fisheries, Alexandria, Egypt

The Shellfish Industry in Holland
P. KORRINGA, Government Institute for Fishery Investigations, Bergen op Zoom, The Netherlands

Propagation and Transplantation of Marine Fish
H. BLEGVAD, Director, Danish Biological Station, Secretary-General, International Council for the Exploration of the Sea, Charlottenlund, Denmark

Propagation and Transplantation of Marine Fish in Europe
Alf DANNEVIG, Director, The Flødevig Sea-Fish Hatchery, Flødevigen, Arendal, Norway

Summary of Discussion:

Discussants:

Messrs. WALFORD, AUDIGOU, HORA, MONOD, KASK, D. W. PRITCHARD, BOTTEMANNE, H. F. TAYLOR, E. DE VRIES, A. L. PRITCHARD, OPPEDAL

Programme Officer:

Mr. F. N. WOODWARD

Latent Fishery Resources and Means for Their Development

HAROLD THOMPSON

ABSTRACT

The major possibilities of increasing the yield from world fishery resources, other than those of the USSR and of fresh or brackish waters, are reviewed and an opinion is ventured that, if measures indicated are taken, at least a 20 per cent increase over the pre-war yield is probable. About two-thirds of this increase might be expected to derive from cold and temperate waters and in particular from the herring and gadoid fishes of the northern hemisphere; and about one-third from tropical and subtropical waters where pelagic fisheries, particularly those based on tuna and clupeoid fishes, offer the chief scope.

There is patent need of planned and sustained exploratory work, particularly in the warmer seas, and much scope and need for international co-operation in such work, which in the initial stages must by its very nature be a charge on the Governments concerned.

While, in view of the world food situation, it is imperative to exploit latent fishery resources, there is at least equal need to conserve the resources on which existing fisheries are based and to obtain from them the maximum sustainable yield.

WORLD FISHERIES (MARINE)

It will be useful, in enabling us to review in proper perspective the world's latent fishery resources, to glance at the sources and nature of pre-war fishery production.

The following estimated production figures have been adapted from Sandberg (7)[1]

World (Pre-War) Marine Fishery Production[2]

Japan	3,678,000	Newfoundland	204,000
United States (including Alaska)	1,842,000	Netherlands	159,000
USSR	1,557,000	Italy	138,000
China	1,311,000	Sweden	133,000
British Isles	1,060,000	Portugal	118,000
Chosen (Japan)	1,043,000	Denmark	114,000
Norway	926,000	British Malaya	89,000
India; Iran; Burma	907,000	Philippines	81,000
Germany	724,000	Mexico	70,000
Canada	544,000	Brazil	61,000
Spain	439,000	Kwantung	60,000
France	357,000	Argentina	55,000
Iceland	336,000	Venezuela	45,000
		All other	633,000

The all-over estimate is about 17,690,000 tons, of which about two-thirds was used for human consumption, and one-third for reduction to meal and oil. Asia produced 49 per cent of the total, Europe 32 per cent, and North America 16 per cent—i.e., 97 per cent in all, so that production by other continents was comparatively insignificant.

Fishing over all the oceans of the world, Japan controlled about 38 per cent of the total production; while, of the total, 98 per cent was taken in the northern hemisphere. By oceans, the approximate share of total production was: Pacific 48 per cent; Atlantic 47 per cent; Indian Ocean 5 per cent. Of the above percentages, 47 per cent (Pacific) and 46 per cent (Atlantic) respectively were produced north of the tropic of Cancer. The southern hemisphere was responsible for only 2 per cent of the total world production.

It is thus very evident that the cold and temperate waters of the northern hemisphere produce an overwhelmingly great part of the world's fish supplies. The broad expanse of the continental shelf in the North Atlantic Ocean and the North Sea provides suitable conditions for an abundance of fish belonging to the important gadoid (cod, haddock, etc.), and clupeoid (herring, pilchard, etc.) groups. In north and west Europe, production of gadoid fish (pre-war) was of the order of 1,361,000 tons annually, whilst that of herring was around 1,814,000 tons. From the great banks of the north-west Atlantic, 454,000 tons of cod were taken. The pilchard catch of the United States and Alaska exceeded 408,000 tons.

Annual Production Per Man, in Tons of Fish, Covered the Following Range:

Iceland	67
Great Britain	28
United States and Alaska	15
Newfoundland	5
Australia	4
Spain	2

Salmonids (salmon, etc.), pleuronectids (plaice, halibut, etc.) and scomberoids (tuna, mackerel, etc.) are groups which also made notable contributions to the catch.

In general, however, the great production was due to the tremendous abundance of a comparatively small number of individual species, both pelagic and demersal.

There is no comparable fishery in the cold and temperate waters of the southern hemisphere. This is probably due to the absence of embracing land masses—and of dense human populations to conduct fisheries—as well as to scarcity of broad shelf and bank areas, and to unsuitable bottom. In tropical and subtropical regions there is also a relative scarcity, and, in addition, the waters are on the whole poor in content of nutritive salts. Total plankton and fish production is much lower than in colder waters, and there is a multiplicity of species each represented by comparatively few individuals, which, even so, are apt to occur only seasonally.

Although under-development of fisheries is the rule in waters other than those of the northern part of the northern hemisphere, the smaller fisheries of these waters would obviously require to be multiplied manyfold to make a very significant addition to the total world fish supply. It is therefore of overriding importance to maintain the fisheries of the northern hemisphere at a consistently high production level through the application of scientific

[1]Numbers within parentheses refer to items in the bibliography.
[2]All weights in this paper are given in metric tons, unless otherwise stated.

conservation measures, as well as to develop those fisheries —particularly that for the abundant herring—which appear to be underfished, or are not fished at all.

MARINE FISHERIES—DEVELOPMENTAL POSSIBILITIES

COLD AND TEMPERATE WATERS: NORTHERN HEMISPHERE

While many of the fisheries of the highly productive northern portion of the northern hemisphere are being fished up to or beyond the economic limit and are passing or must pass to the maintenance stage, it is generally agreed that the great herring and cod fisheries show no signs of depletion, and, indeed are capable of expansion.

Herring

In 1946 (17) sixteen reporting countries landed 2.8 million tons of herring, equivalent to about 15 per cent of total world fish production.

The British herring catch in the years before 1914 was about half-a-million tons a year, but by 1933 it had dropped to about one-third of this amount. Not only could the former amount be regained, but it could be increased if markets can be found. According to Reay (6), canning or freezing of this fish is essential to extend human consumption. Considerably increased catches could be made round the remoter British islands and consumption could be spread through the whole year by storing frozen herring, taken in the plentiful spring and autumn seasons, to meet the scarcity of herring in winter. Increased adoption of scientifically designed smoke kilns would also stimulate the growing demand for lightly smoked herring. The large-scale development of the meal and oil reduction process would also radically alter the whole basis of catching and sale of herrings.

Herrings (with sardines) are highly important in the Japanese fisheries, yielding from one-third to one-half of the total catch. Since 1931, herring (*Clupea pallasii*) have yielded annual catches varying widely from about 43,700 to 1,024,000 tons (10). In this case it would be of great aid to production if predictions based on the biological study of dominant year-classes of herring could be made.

Comparable wide fluctuations (between about 20,000 and nearly 100,000 tons) have occurred in the annual herring production of the United States on the Pacific coast (14). In order to assist marketing and protect stocks an annual quota, similar to that imposed in Canada, has been allotted, being based on predictions from biological studies. War-time demand raised British Columbian production of herring, and about 117,000 tons were produced in 1945, but there has since been a recession and recourse to increased canning and reduction seems imperative to utilize quantities salted in war-time.

The vast production potentialities of herring are further illustrated by the record catch of 865,000 tons made by Norway in the year 1947-1948, the great bulk of the catch being disposed of by salting and reduction.

On the Atlantic coast the annual United States catch of herring varies from 13,608 to 40,824 tons. Large quantities are also produced by Canada and Newfoundland. More could be produced by these countries if markets were available. The large fatty herring of Labrador are scarcely utilized, and could be the basis of a reduction industry by suitably designed floating plant.

A species of small herring—*Clupea fuegensis*—has been observed in large shoals near Falkland Islands, and was taken during trawling experiments. Further investigation is required to determine the quantities available.

Enough has been said to indicate that a heavy increase, equivalent at least to a large proportion of current production, could be effected in herring catches. On the whole no catching problem exists. The chief needs are intense marketing activities, preferably under an international aegis backed by control, improved preservation methods, and an increased scale of reduction to meal and oil.

Pilchards and anchovies

The pilchard (sardine) provides the largest resource in the western hemisphere, part of the production coming from the northern area under review. Prior to the recent decline (due probably to combination of overfishing and of adverse fluctuation) production on the Pacific coast was stabilized at about 508,000 tons a year. Conservation measures based on results of sustained biological investigations are required to restore and maintain the higher level of fishing.

Since 1931 the annual Japanese sardine (*Sardinia melanostricta*) production varied widely from 406,000 to 1,654,000 tons (10). As in the case of herring average annual production could be increased by predictions based on a study of the varying strengths of dominant year-classes. There is no indication of depletion in this industry. In the case of that of the Pacific coast of North America, it would seem that little of permanent value is likely to be gained by the adoption of aids in locating shoals (aerial-scouting; echo-sounding), but that radical conservation measures must be applied.

It has been stated (14) that, of the few latent fishery resources (of the Pacific coast of North America) remaining to be developed, the northern anchovy seems capable of yielding the greatest returns, a rough estimate of the potential yield being 122,000 tons annually. Methods of catching and canning would require to be devised.

Cod

With an annual yield of about 2,032,000 tons per annum, the common codfish of commerce comes a close second to the herring. There is no clear indication that this species is being overfished, and some degree of increase in total catch may well be possible. In one region at least—Grand Bank (Newfoundland)—it has been shown (13) by experimental trawling that the catch per unit of fishing time is much greater than elsewhere and that an increased measure of exploitation is possible. However, we probably should not expect from cod, through increased exploitation, a rise in production of as high an order as that from herring.

However, it has been stated (14) that the "Pacific cod" is another of the few potential northern fishery resources not fully utilized. It occurs on banks reported to be larger, and with a greater potential production, than the Newfoundland cod banks, the centre of occurrence being the Gulf of Alaska and Bering Sea. From a peak catch of 13,608 tons, a decline occurred in pre-war years to 4,536 tons, the difficulty being distance of fishing grounds from markets. Given appropriate processing techniques, it is stated that quantities could be disposed of, greater than those of cod taken in the Atlantic.

Other undeveloped or under-developed fisheries

The vastarea of the north-west American continental shelf, greater than that of the North Sea, has been stated (14) to be rich in untapped resources, offering great opportunities for expansion of demersal fisheries in addition to that on "Pacific" cod and pollock. The 1943 catch from this area was about 261,725 tons. Investigations, under the auspices of the Fish and Wildlife Service, U.S.A., show, for example, that the yellow-tail flounder ("sole") is more abundant in the Bering Sea than any of the very valuable "soles" taken commercially further south (to the extent of 17,010 tons in 1943). The unexploited grounds cover about 600,000 square miles, in comparison with only 60,000 square miles already exploited. The same report states that Alaskan salmon production could be increased through application of scientific control by at least 22,680 tons annually; that the catch of rockfishes (5,443 tons were taken by trawl alone in 1943) could be increased greatly as has been done in the case of the rosefish (which now yields about 68,040 tons annually) off the Atlantic coast; that the king crab in Alaskan, and other rock crabs of more southerly waters, virtually unexploited, could, given the development of suitable fishing and processing methods, support a commercial fishery; and that exploratory fishing for shrimps in Alaskan waters would discover important new grounds.

It has been shown (5) that in Newfoundland there are considerable stocks of more or less unexploited fish. Chief among these is the "plaice", or long rough dab (*Hippoglossoides platessoides*). Thus, experimental hauls made off St. Mary's Bay, Newfoundland, yielded a maximum 3,400 cod and the extraordinary number of 62,000 "plaice" (ranging in size up to 75 cm.) per hour's trawling. The centre of distribution of "plaice" was found to be in the colder waters, including northern Grand Bank. These immense stocks are unexploited, although similar dabs to the extent of about 2,041 tons are taken incidentally during trawling on the more western banks by United States vessels, and marketed as "fillet of sole". Other little exploited Newfoundland fish are the "turbot" or Greenland halibut (*Reinhardtius hippoglossoides*), which occurs in considerable quantities in the deeper bays, and caplin, which here and elsewhere in northern Atlantic waters, could yield enormous quantities of frozen fish food (it does not can well) or form part of a reduction industry which, in Newfoundland, could be developed through the establishment of central processing stations where the great quantities of rejected cod trimmings resulting from heading and splitting the fish would justify plant installation.

Although off the Atlantic coast ground fish are most important, the United States catch yielding up to 272,158 tons per annum from the 260,000 square miles of banks extending from Long Island to Newfoundland, there are possibilities of expansion of other fisheries (14). Thus mackerel and menhaden, production of which averages respectively about 15,875 and 272,158 tons annually, are subject to considerable natural fluctuations, and the fisheries would benefit from prediction services based on sustained biological study. On the other hand, salmon, alewife and shad could yield increased catches if suitable conservation measures were applied. The catching of shad had dropped from 22,680 tons in 1896 to 4,536 tons in 1940. Conservation measures would also improve the yield (about 340,198 tons) of shore fishes (mullet, striped bass, etc.), and of lobster, which yielded 13,610 tons in 1800 and now yields only from 4,990 to 6,350 tons annually. Obviously there must be great expansion of biological studies to provide the bases for suitable controls of these fisheries.

It should be mentioned that full utilization of shellfish resources is not made. A large population of the common mussel, for instance, has been found by survey to extend from Cape Cod to central Maine, and this shellfish occurs plentifully as far east as Newfoundland. It rapidly encrusts floating objects such as mooring buoys and hence could be very extensively cultivated. It is esteemed in France and elsewhere, but suitable means of processing and marketing would have to be devised in the north-west Atlantic regions.

COLD AND TEMPERATE WATERS: SOUTHERN HEMISPHERE

The distribution of land masses, with accompanying submarine shelves, is much less favourable to fisheries in the far south. There is also lacking any large human population to exploit such resources as exist. A great deal remains to be discovered about the nature and extent of these resources, other than whales. Very great quantities of krill are, of course, known to exist, and possibly a method of catching them economically could be introduced; but all observers questioned state that they have, in the Southern Ocean, seen little or no evidence of the occurrence of pelagic fish. As to ground fish, little is known on the economic side, but the opinion is that the fishery resources may be disregarded from the economic standpoint. Small Nototheniiform fishes, suitable for local consumption, have been caught by handline along the Antarctic shoreline in kelp beds where such exist, and Norwegian fishermen have at times taken larger Notothenids, up to about two feet in length, in fair numbers on one or two banks off South Georgia. However, no serious trawling or pelagic fishing experiments have been carried out.

Hart (3) states that the Antarctic zone is the metropolis of the Nototheniiforms, which correspond to the rock fishes of the North Pacific; he states that they are "completely dominant over all other fishes in such small areas of the vast oceans south of the Antarctic convergence as are sufficiently shallow to support any coastal fish fauna." But he adds that they are unimportant and mostly too small. The Patagonian continental shelf is the largest expanse of sea shallow enough to support a considerable population of demersal fishes in the cold temperate zone of the southern hemisphere. The portion of this area (150,000 square miles) surveyed by "Discovery II" is rather larger than the North Sea, but the trawling results were not highly encouraging, although it was concluded that the area carries a stock of hake just sufficient to enable modern trawling to pay if suitable markets were made available.

Seals

Increased quantities of seal meat could be made available. The Pribilof Islands fur-seal fishery, based on a herd estimated at 3,386,008 in the 1946 census, and now, under conservation, possibly approaching optimum size, does, of course, utilize the seal carcases for meat and oil. However, there are undoubted possibilities of a considerable yield from seals in southern waters, and it is desirable to complete the census and biological observations recently instituted by Australia on these; whilst in the north, from Newfoundland to the White Sea, there was, prior to the recent war, an annual kill of from 200,000 to 500,000 seals (chiefly the pelagic harp seal) on the drift ice. The skins and oil are utilized but the carcases are chiefly discarded. It ought to be possible by including a few carrier vessels among the sealing fleets, to bring a large proportion of these in the frozen condition to processing centres. Likewise vessels with reduction or refrigeration plant aboard could utilize seals taken on the African and other coasts.

TROPICAL AND SUBTROPICAL WATERS

Those who have had experience of exploratory research in the warmer seas have on the whole been forced to the conclusion that fish populations are less dense there than in the higher latitudes of the northern hemisphere. Although the water masses are enormous in extent and must in the aggregate contain great quantities of fish, the catching of these economically in commercial quantities presents certain difficulties. By general agreement pelagic fish offer the best prospects of new or greater exploitation.

There is a general absence of the annual convection overturn which occurs in temperate and cold waters and returns an abundance of nutrient salts to the surface layers. Exceptionally, local enrichment of nutrients occurs—e.g., through the penetration from the south of cold currents to the South American and African coasts, and through the local upwelling caused by the south-west monsoon on the east African and Arabian coasts (this water circulates down the west coast of India where the major Indian fisheries occur).

Pelagic Fish

Many types occur, chief among them being scomberoids (tuna, mackerels, Spanish-and scad-mackerels), clupeoids (herrings, pilchards, anchovies) percomorphs and barracouta.

1. *Tunas*

These are primarily warm water forms, being especially abundant in the Pacific Ocean. Little is known of their biology, but they appear to engage in extensive migrations. An intensive fishery in remote regions might therefore adversely affect existing fisheries. There is urgent need of co-ordinated research, participated in by all interested countries, to determine the extent of migrations and the racial composition of the stocks. Tuna occurrences in any particular locality appear to fluctuate with variations in water conditions.

In pre-war years the total world annual catch of tuna averaged about 306,178 tons, about 10 per cent of which was taken in the Mediterranean, 23 per cent by United States of America, and 68 per cent by Japan. By 1940 the total catch had risen to about 317,518 tons.

The great Japanese tuna fishery was, in the 1930's, approaching a maximum in all areas except the southern regions (11). Intensive exploration resulted in the location and exploitation of albacore grounds in the mid-Pacific—chiefly at a depth of about 30 metres north of the line of convergence between the north equatorial and north Pacific currents. Little expansion of the albacore fishery can be expected in a southerly direction. Major yellowfin tuna grounds were found in almost all parts of the tropical zone in the west Pacific and Indo-Pacific regions—indications were that the best grounds are in the narrowest portion of the equatorial counter-current and at places where this current mixes with equatorial currents adjacent to it, most fish being captured at depths between 75 and 100 metres. The possibility is that a huge long-line fishery, chiefly for yellowfin and marlins, could be developed in the vast area stretching from Micronesia through the Dutch East Indies to the Indian Ocean: Smith (8) states that in Micronesia tunas, especially yellowfin, are abundant enough to give expectation of raising the peak catch from 34,020 tons to 90,719 tons. The following average numbers of fish were taken per 100 hooks set in the course of Japanese exploratory fishing (11):

East of Formosa	1.91	Banda Sea	8.40
East of the Philippines	6.35	Around Timor	9.19
Micronesia	5.23	Java (South Coast)	3.89
South China Sea	4.65	Sumatra (South Coast)	10.64
Sulu Sea	3.96	Nr. Andaman and Nicobar Islands	6.23
Celebes Sea	4.37		
North of New Guinea and Solomon Islands	4.21		

For comparative purposes, it may be added that in Japanese waters the total tuna catch per 100 hooks averages between three and four fish.

The Japanese catch of striped tuna (skipjack) has hitherto greatly exceeded that of all other tunas combined. Skipjack distribution was found to be more or less co-extensive with that of yellowfin, although it tends to congregate round the island groups. This species could also be more extensively fished. In recent years it has been shown to occur extensively in summer in southern Australian waters, where two species of bluefin tuna also occur in commercial quantities. There is no doubt that expert fishermen with suitable equipment could take many thousands of tons of tuna in Australian waters.

It may be that in order to prosecute an all-year round tuna fishery fairly large vessels will have to be utilized. Surface fishing by the live-bait method is the rule in summer and fishing with long lines at depth in winter. Initially, the Japanese utilized two types of small vessels to carry out these operations separately, but the trend has been towards building larger vessels equipped for both types of operation. It may also be found necessary in more remote areas to make at least some use of mother ships to accept the catches of fishing craft, and to store bait, which is not always readily available in tropical regions.

In the east Pacific the tuna fishery has expanded southwards and from the results of recent surveys it appears that further great expansion is possible, especially off Chile and Peru. Development may also be possible of tuna fisheries off north-west and South Africa, and off parts of the east coast of North and South America.

2. *Mackerels and Scad-Mackerels*

Considerable increase in production of mackerels and mackerel scads is possible in portions of the tropical and subtropical area, although the density of population is not as a rule on a scale comparable to that of mackerel of northern waters. Observers have indicated that small but useful fisheries for Spanish mackerel could be maintained in areas such as the West Atlantic, north-west Australia, and New Guinea, whilst there have been shown to be (seasonally) large schools of blue mackerel off south-west Australia, and of scad-mackerel off south-east Australia. Commercial purse-seine fishing tests on these scad have consistently yielded catches of sixteen to twenty tons apiece. A fishery yielding many thousands of tons per year could be supported by this scad population. Owing, however, to the more or less unsuitable weather conditions prevailing during a portion of the season, which extends over at least nine months, the vessels engaged would require to be equipped to engage at times in an alternative method of fishery—e.g., seine-trawling.

3. *Clupeoid Fish*

The common herring of commerce does not occur in the warmer seas, but there are in certain areas other clupeoids, presumably capable of giving moderate yields. Thus in New Zealand waters several hundred tons each of herring and pilchard are taken annually, but the shoals are apt to be small and scattered and often difficult to locate. Aerial scouting should aid in enlarging the catches. Similarly considerable shoals of small pilchard have been observed in southern Australian waters and have yielded lampara-net catches of up to 3 tons apiece. Production of the order of several thousand tons a year seems possible, and canning has commenced. Herring species and sardines are widely distributed in the west Pacific, probably on a similar scale of density, and although small fish and seasonal in occurrence, could yield worthwhile returns if suitable means of capture—e.g., modified paranzella nets—were employed. Fiedler and others (15) reported that enormous shoals of anchovy occur off Chile and Peru, twelve sets with an unsuitable purse-seine net yielding an average of 765 lb. per set. Provision here of larger power vessels would increase the existing catch of herring and anchovy many-fold.

In the Atlantic, vast resources of anchovies and pilchards have been reported (1) as occurring off Brazil in the rich Amazon region, and doubtless occur to a lesser extent elsewhere off the east coast of South America. Smaller occurrences of fish of this type could be utilized in the Caribbean area, while it has been stated that more use could be made of sardines occurring off the coast of north-west Africa and other portions of the African coast. Thus it has been held that the South African catch of pilchards (c. 31,751 tons per year) could be trebled or quadrupled. Considerable development of the hilsa fishery is possible in Indian and Chinese estuarine waters. Improvements in fishing, handling and transportation techniques are called for in these cases.

4. *Barracouta (Snoek, Sierra)*

This species is very plentiful over a wide range, extending round the world in cooler parts of the subtropical zone. It is already the basis of considerable fisheries in South Africa and Australia, yielding around 9,000 and 6,000 tons respectively in these countries. In south-east Australia the catch, which has been limited by the available markets, has increased in recent years and could be further increased, while the stocks in south-western Australian waters remain to be exploited. Given a solution of the marketing problem, there is little doubt that the total Australasian catch could be at least doubled. Off the South American coast, trolling tests are required to determine the density of occurrence of this species. It has been found to can well and to form an excellent base for the manufacture of fish pastes.

Many other pelagic fish species (marlin, garfish, pike, flying fish, Australian salmon etc.) could yield increased catches. Flying fish are stated to be abundant in the Micronesian region, and Australian salmon, which yield around 5,080 tons annually, are now being taken in increasing quantities in Western Australia, and with the development of a market could, in New Zealand waters, yield much more than the 102 tons taken at present.

Trawling

There is no large-scale trawling industry in tropical or subtropical waters. The south African trawling industry yields about 25,400 tons per annum (it is noteworthy that South African fish production has multiplied fivefold since 1934), and those of south-east Australia and of New Zealand about 7,268 and 1,334 tons respectively. While the New Zealand trawling fishery is not thought likely to expand to any extent, official opinion is that the region round Chatham Islands could support at least two trawlers. Australian and Japanese trawling experiments have disclosed the existence of areas of 4,000 and 6,000 square miles of trawl grounds respectively in the Great Australian Bight and on the north-west Australian continental shelf. In the latter area bream, snapper, perch, etc., yielded an average catch of 4 cwt. per hour's trawling. Given the use of large refrigerated trawlers, it would appear that the Australian trawler catch could be about doubled.

Extension of trawling seems possible in African waters. Steven (9) refers to vast untapped resources which require exploration on that broader part of the west African shelf extending from Cape Verde to the Niger. He states that there are approximately 50,000 square miles of good trawling ground here.

Wheeler (16) mentions the existence of two banks—total area 22,000 square miles—in the Mauritius-Seychelles region, in addition to 10,000 square miles of plateau. He gives an estimated total annual production from these areas of 304,800 tons. Wheeler states that preservation would present the chief problem in developing this fishery.

Two good trawling banks of 1,000 square miles are reported from the Ceylon region and it has been estimated that these could accommodate 100 trawlers. The average yield, consisting chiefly of percomorph fishes, is given as 376 lb. per hour's trawling. The Ceylon Government has instituted a trawl fishery, commencing with eight trawlers, and will exercise marketing control.

Experimental trawling has been unsuccessful in other Indo-Pacific waters (e.g., off Bengal, Madras, Bombay, Burma, Malaya, Indonesia, the Philippines, and Queensland, Australia), but it is hoped that trials to be made with smaller vessels and gear will in some cases yield more hopeful results. According to Hardenberg (2) large gear will not be economical in tropical waters—in order to get results, multiple small gear units will be required. Drawbacks are the absence of marketable flatfish and the general absence of prime trawlfish, the catch being predominantly of percomorphs.

Prospects of Fisheries Expansion, using other Gears

1. *South America*

For 1942, the total estimated fish production (1) was 249,025 tons. Five of the eleven countries with coastline yielded 95 per cent of this total, and for this reason alone there is obvious scope for expansion, which has begun in recent years. The fishery as a whole is under-developed. For example, given a few modern powered craft, it is thought that Chile's fish production—38,102 tons in 1942—could be increased fivefold, while the pre-war annual production of Argentina, up to 5,443 tons, could be approximately doubled. Off Peru (15) an average of 5.4 fish were trolled per hour of experimental fishing, using from five to ten lines, and this is said to indicate that commercially valuable fish can be caught by troll in quantity.

In general, prerequisites for expansion of South American fisheries are finance for improved fishing craft, the initial employment of imported fishing experts, markets for surplus production, institution of modern fish handling, preservation and transportation methods, tuition of local fishermen, formation of co-operatives, and centralized official control.

2. *India*

It is held (4) that the production of marine fish by India—about 426,700 tons annually—could be increased, while there could be an accompanying improvement in fish-handling, etc. The area of proved grounds has been estimated at about 5,000 to 6,000 square miles. This is about 5 per cent of the area within the 100-fathom line, and there is undoubtedly a great amount of reef ground (and this applies also to south-east Asia generally) on which line and trap fishing could be used—e.g., around Laccadive, Maldive and Andaman Islands. It is possible that successful use could be made of 79 ft. diesel seine-trawlers, capable also of using long-lines, or of mother ships carrying fishing dories. Undoubtedly the Japanese *muro-ami* method would succeed on reefs, but this requires about twenty skilled and strong young men.

3. *China*

There is room for substantial development of the Chinese marine fisheries, particularly if powered vessels are used to go further afield. However, much of such an extended fishery would be at the expense of that previously conducted under Japanese auspices.

Some of the other possible fishery extensions—many of a lesser order—may be mentioned. The warmer oceans harbour a large proportion of sharks and rays. On the United States Pacific coast approximately 18,144 tons of shark are taken yearly, and this may be about the limit possible. However, a great expansion of the South American shark fishery—e.g., that of Chile and Peru—has been indicated (15) to be possible, and on the Atlantic coast the shark catch (14) has been increasing rapidly, up to 4,536 tons being taken annually. There is in general insufficient available knowledge of shark distribution. Thus an extension of the Atlantic fishery southward to the Caribbean area and the South American coast may be possible. In African waters there are similar possibilities of enlarging on the South African annual catch of 2,495 tons by extending the fishery to new regions.

The New Zealand fisheries return a remarkably constant yield of around 18,000 tons per year. Apart from possible increased yields from clupeoids, salmon, barracouta, and trawling already mentioned, the present annual catch by lines of about 1,000 tons of blue cod could be doubled. There are known to exist practically virgin blue cod and groper grounds, the exploitation of which will involve the use of capable vessels to withstand weather conditions. Knowledgeable opinion is that, taken as a whole, New Zealand fish production might be doubled by developing an intensive fishery for the lesser-used species.

In the Caribbean area there appears to be little prospect of a greatly increased production. However, attention has been drawn to the series of banks and cays extending from Jamaica in a west-south-west direction to the Mosquito coast of Central America, and also to the Caicos Islands and the British Honduras area, as potential sources of additional fish supply. It has been estimated, for example (12), that the British Honduras annual fish production of about 1,800 tons could be trebled or quadrupled.

A considerably increased production is possible from shell-fish in the warmer seas. The yield of spiny lobster in South Africa has risen from 227 tons per annum pre-war to 3,175 tons in 1947 and the Australian catch is undergoing a similar expansion, more crayfish grounds having been found off Western Australia. While the great shrimp fishery of the South Atlantic and Gulf Coasts probably requires regulation to ensure maintenance of the 1940 production of 261,272 tons, there are indications that shrimp fisheries could probably develop elsewhere—e.g., off Peru, where also extensive areas of clams and mussels have been observed and await exploitation.

DEVELOPMENTAL POSSIBILITIES—ATTEMPTED ESTIMATE OF TOTAL ADDITIONAL PRODUCTION

It is to be expected of this introductory paper that in it an effort should be made to assess the total increased world fishery production which can, on the existing evidence, be anticipated, and which indeed is a probability if the measures referred to are taken. After allotting to each resource mentioned above what appears to the author to be a reasonable additional production tonnage, the opinion is hazarded that total increased production could be:

Cold and temperate waters	ca. 2.7 million tons
Tropical and subtropical waters...	ca. 1.3 million tons
TOTAL	ca. 4 million tons

This is a little over 22 per cent of pre-war production. Whilst the figure must of necessity be subject to considerable modification and will no doubt be so modified in the light of experience reports and subsequent discussions at these meetings, it is thought that overestimates and underestimates of increased production in the various fishery subsections will to some degree cancel out, and that the order of increase is that indicated.

This estimated increase does not include any possible increase from the marine fisheries of the Union of Soviet Socialist Republics. Nor, since the subject will be dealt with under another section, does it include the considerable increase to be expected from large-scale development of fresh and brackish or salt water fisheries by pond culture and fish-farming.

METHODS OF EXPLORATION AND DEVELOPMENT

The great need for exploration lies in the warmer oceans. The onshore and estuarine fish resources of the countries bordering these oceans have naturally been the first to be exploited, but for the greater part techniques could be improved upon—chiefly by the provision, with official aid, of more powered craft and refrigeration facilities.

The chief scope for expansion lies in the determination, through well-equipped official survey vessels, of the offshore and oceanic resources. In comparatively recent years we have seen a beginning made with such surveys—e.g., trawling and pelagic fish surveys in Australian waters, the trawling survey of the Patagonian shelf and off Ceylon, and the general survey of the Peruvian resources. There is immediate need for large-scale multiplication of such surveys, particularly in India, Africa, South America, and Oceania. Furthermore, the work must be planned and sustained over a considerable period of years in order to be carried to completion, discover the short and long-range fluctuations of fish occurrences and the natural causes therefor, and to interest the necessary personnel, which will consist of experienced marine biologists and skilled fishing and technical personnel, together with crews recruited, for climatic and economic reasons, from the regions concerned. Owing to the peculiar difficulties associated with developing new fisheries in warmer waters, private enterprise is unlikely to undertake the survey work, which must be financed and prosecuted by Governments, up to the stage where the more promising prospects are revealed. The vessels employed will be either small powered craft with limited range, and especially equipped for performing only one or two types of fishing operations such as seine-trawling and long-lining, or purse-seining and trolling; or for oceanic work, larger craft with wide range, such as the large type of tuna clipper, which could, of course, carry out additional operations such as trolling and long-lining, or large trawlers for areas such as the north-west Australian grounds. Mother-ships equipped with dories might have their place also, but the factory ship is not required at the exploratory stage, since there is no need to preserve and land the fish caught.

At the next stage—the attempt to utilize such resources as offer commercial prospects—Governments may themselves undertake, at least for an initial test period, mass-catching operations and the preservation, processing, and marketing of catches, or assist private enterprise to do so. The assistance could take the form of monetary aid; or of providing specialized gear, including nets, and aerial scouting, echo-ranging and echo-sounding aids to locate fish shoals; ensuring a guaranteed market; predicting fish runs; and giving technical advice on preservation and processing. Governments should also foster the education and technical training of fishermen, and the formation of fishermen's co-operatives, so that costs can be cut at all stages, and a sense of responsibility inculcated. Aid may in certain cases have to be given in the provision of harbour, cold-storage and transportation facilities.

INTERNATIONAL CO-OPERATION IN EXPLOITATION

Some of the benefits of international co-operation have been seen as a result of the work of the European Council for the Exploration of the Sea, and the North American Halibut and Salmon Commissions. This co-operation in investigation of the colder and temperate regions is being intensified, and bears particularly on conservation of fisheries. The great task ahead in exploring and exploiting the resources of the vast tropical and subtropical regions cannot be satisfactorily performed without concerted action in the fields of administration, research and development. The size of the area to be covered, the often scattered nature of the fish populations, possible wide migrations, the necessity of perfecting fishing techniques and obtaining a composite picture of oceanographic conditions, require simultaneous and sustained effort at a great number of points throughout the oceans as well as coastally, and a pooling and assessing of results. There is also need for a master plan, probably of world-wide scope, for co-ordination of industrial operations to secure the appropriate flow of fish products through various channels and to prevent over-supply. It is therefore highly desirable to finalize the formation and inaugurate the work of the several regional councils which it is proposed should be formed under the aegis of the Food and Agriculture Organization of the United Nations. It is clear from the working of the European Council that international co-operation supplies stimulus and engenders continuity.

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Latent Fishery Resources and Means for Their Development

CECIL VON BONDE

ABSTRACT

Iu world fisheries it appears as though their exploitation has reached economic maxima in certain specific countries, whilst there appear to be latent resources in others.

Trawling is probably now being exploited to its maximum productivity and attention must be turned to pelagic fisheries.

Evidence of latent potentialities appear in the Latin American countries, the west and east coasts of Africa, Australia, the Central Pacific and possibly others.

Methods of exploration and development should be based on the combination of fisheries research work to be conducted by the proposed FAO Regional Councils for the Scientific Exploration of the Sea and such work conducted by each constituent country of each Council. Thus each country should have its own organization for dealing with its inherent problems and the knowledge thus acquired should, through the Regional Councils, be made available to the Division of Fisheries of FAO for dissemination to the United Nations. In this manner a clear-cut picture of world fisheries could be obtained.

Whilst there is evidence of the existence of oceanic stocks of pelagic shoal fish such as tuna, pilchards and herring, nevertheless more research is necessary before arriving at definite conclusions.

Active steps should be taken to increase fisheries production throughout the world to augment the deficiency in proteins in the present-day diets. More attention should be paid to the utilization of plankton and the manufacture of by-products from waste materials.

For international co-operation in exploitation it is necessary to have international agreements on problems of fisheries conservation.

All maritime countries should be invited to contribute the views of their fishery experts on the extent of their known and latent resources so that they may be developed for the benefit of all mankind.

INTRODUCTION

A review of world fisheries (1)[1] clearly indicates the rapid strides made in the development of fisheries the world over, and it would appear that, except in certain countries, the fishery resources have been exploited to the limits of their possibilities in conformity with sane conservational practice. Thus countries like the United States of America, Great Britain, Norway, Japan, Canada, to mention only a few, are probably exploiting their fishery resources at their economic maxima and there seems to be little possibility of the discovery of latent resources capable of development.

On the other hand, countries like the Union of South Africa, Australia, Argentina and others show evidence of latent resources which would become apparent after exhaustive fisheries and marine biological surveys have been conducted in their seas.

It is extremely difficult, without first-hand information or knowledge of the fisheries of certain countries, to dogmatize as to the potentialities for expansion or development, and this paper must of necessity to a certain extent be looked upon as one of conjecture and is written with the knowledge of the background of conditions at present appertaining in the Union of South Africa, and in other countries, based on published reports.

A study of the fishery laws of various countries clearly shows that all countries with well-developed and highly-organized fisheries have come to the conclusion that measures of conservation are necessary, these conclusions being obviously based on the fact that the known grounds are being exploited to the maximum of their productivity, and that overfishing is a menace which looms largely on the horizon of any projected increase in output.

[1]Numbers within parentheses refer to items in the bibliography.

LOCATION OF UNDEVELOPED FISHERIES

Although the area of the hydrosphere is estimated at from 130 to 140 million square miles—about three-quarters of the earth's surface—which is 60 per cent of the earth's surface in the Northern Hemisphere and 80 per cent in the Southern Hemisphere, nevertheless the area of sea capable of exploitation for commercial fisheries is only a small proportion of the total area of the hydrosphere, as commercial fishing is, broadly speaking, confined to the limits between the shore and the 300 fathoms contour. It must be conceded, however, that certain types of pelagic fisheries are practised further offshore than the limits of this contour.

The demersal fisheries, principally trawling on the continental shelf and beyond, are probably the most exploited branch of all and it does not appear to be likely, except in a few isolated instances, that latent trawling grounds of a magnitude and prolificacy of those known to world fisheries will be discovered.

In the Union of South Africa latent grounds do exist and their extent and potential productivity have been surveyed and are thus available for exploitation.

We must rather look to the pelagic line—and net-fishing areas where, at certain seasons of the year, owing to their principal stocks being composed of migratory species of fish, these fish abound, whilst at other seasons, there is a marked falling off of supplies. A study of their migration—in short, finding out where the fish go in the off-seasons—is one which should prove productive. This is obviously a task of gargantuan proportions but one that is not beyond the realms of marine biological research.

Latent fishery resources are known to exist in the seas of Kenya Colony and Zanzibar (2, 3), but only in areas where line-fishing can be practised—trawling being impossible owing to the unsuitable condition of the sea floor. The spasmodic fisheries carried on by the natives of these territories are capable of expansion by the employment of modern boats, gear and technique.

The whole of the west coast of Africa from the northern boundary of South West Africa to the Mediterranean is as yet unsurveyed and although fisheries, *per se*, are practised to a minor degree, nevertheless there should be grounds available for exploiting pelagic fisheries abounding in species like tuna and others.

In Australia (5) the need for explorative work in connexion with pelagic fish was felt when the Council for Scientific and Industrial Research in 1933 decided to engage in a programme of fishery investigation, with *inter alia*, the provision of "a vessel specially designed for exploration for pelagic fish".

Though it appears that pelagic fish in areas such as the South Coast of New South Wales and north-east of Tasmania are not likely to yield results comparable with those in certain well-known fishing grounds in other parts of the world, there appears to be good prospects of substantial development. Dakin (6) states "in Australia we are in the position that most of our fishing areas are still unknown and rest almost in the virgin state, crying for exploration". This was true in 1934, but since then much fishery research work has been conducted there and the fisheries have expanded. Whether all the latent resources have been tapped is a matter on which the Australian Government can give an authoritative answer.

The South American countries appear to be capable of developing their latent fisheries resources to a greater extent by the adoption of organized methods of fisheries research.

The recent publication on Fisheries Statistics by FAO (7) shows figures for exports and imports for countries like Argentina, Bolivia, British Guiana, Colombia and Peru, but no mention is made of landings of fish in these countries. No statistics appear to be available for countries like Brazil and Chile, so that it is difficult to evaluate the fisheries of Latin America, although many other South American countries have substantial potential fishery resources (8).

METHODS OF EXPLORATION AND DEVELOPMENT

The ideal arrangement for the gathering of information on the latent resources of the world, on which explorative and developmental methods may be based, might be found in a centralized body of experts with all the necessary and concomitant equipment for marine biological and fisheries survey at its command. This obviously would entail the equipment of a number of ocean-going survey vessels, fully staffed with qualified marine biologists and fisheries experts, which can be sent to any country requiring such services, but it is feared that the costs involved would be prohibitive.

A solution to this problem should rather lie in the combination of the following two methods:

1. The Food and Agriculture Organization of the United Nations at its Copenhagen Conference in 1946 discussed the idea of regional councils for the scientific exploration of the sea and the following resolution was approved at the 1947 session of FAO:

"That FAO should take action to initiate the formation of Regional Councils for the scientific exploration of the sea in parts of the world not now actively served by similar bodies, giving primary consideration to the following areas: North Western Atlantic, South Western Pacific and Indian Ocean, Mediterranean Sea and Contiguous Waters, North Eastern Pacific, South Eastern Pacific, Western South Atlantic, Eastern South Atlantic and Indian Ocean."

During 1948 the Indo-Pacific Fisheries Council was established at a meeting held in Bagaio, Philippines.

These regional councils would be composed of experts from the various countries which fall within each region and their boundaries are tentatively set out as shown in the accompanying chart.

The functions of the proposed Regional Councils for the study of the sea would be:

"(*a*) To formulate the oceanographic and biological aspects of the problems of conservation and development of the resources of the high seas, ...; the most efficient methods of obtaining maximum production without endangering future supply; . . .;

"(*b*) To assemble available knowledge on these subjects;

"(*c*) To suggest to governments how national programmes of research may best contribute to filling gaps in such knowledge;

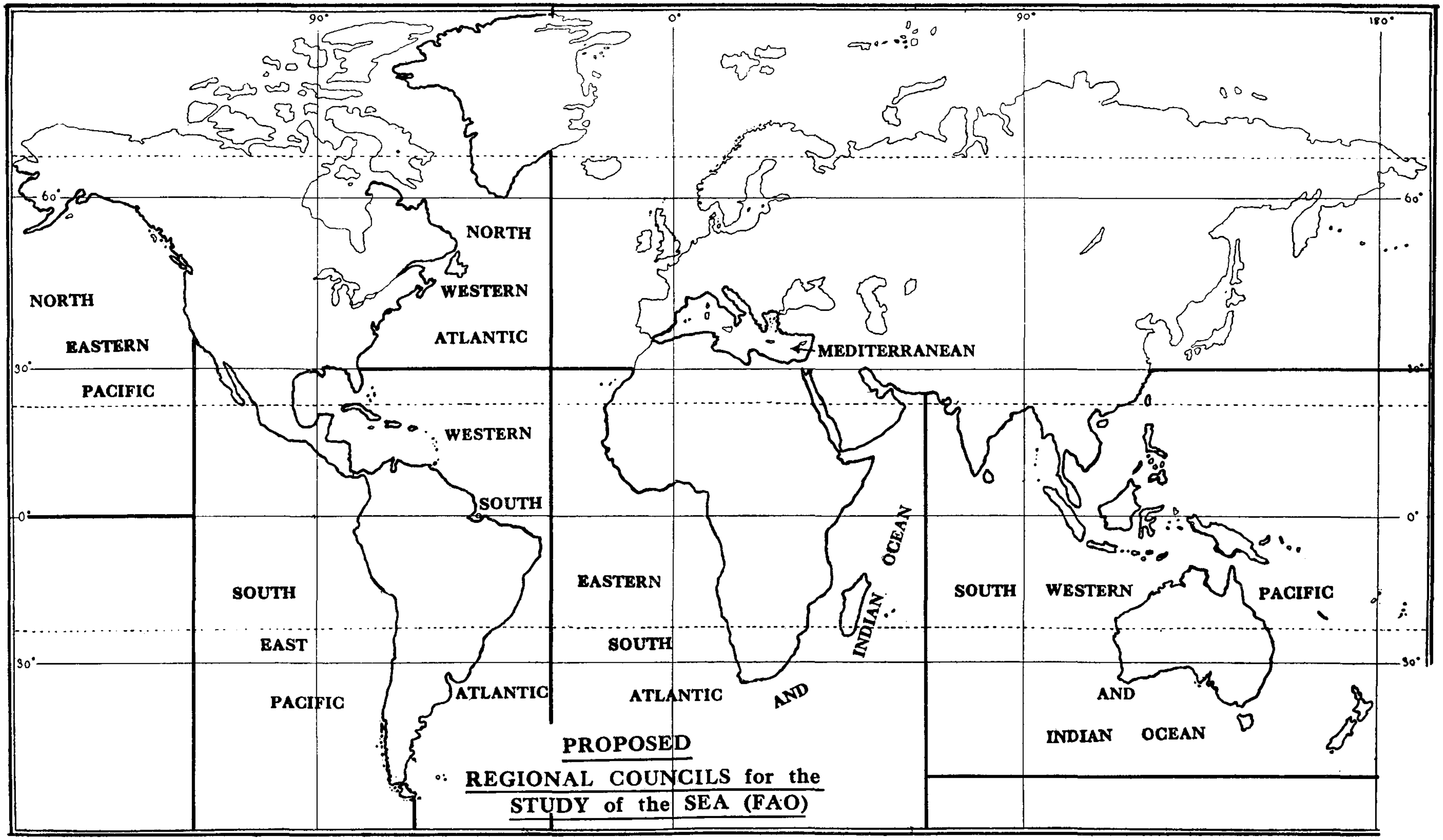
"(*d*) When it is appropriate, to undertake co-operative research directed to this end;

"(*e*) To make available, through publication, authoritative data derived from correlation of work conducted in the region;

"(*f*) To consider and report upon such questions concerning the scientific aspect of the resources of the sea in each region as may be referred to them by other international authorities."

2. Each country producing fish and fishery products should be encouraged to constitute its own organization to deal with its particular and inherent problems in fishery research.

Most maritime countries with a potential fishery industry already have bodies dealing with fisheries research, mostly financed and sponsored by their respective Governments. A specific case of one of the proposed regional councils is the Eastern South Atlantic and Indian Ocean, which is bounded by Lat. 30° N—60° S, Long. 30° W—65° E. The Union of South Africa falls within the scope of this proposed council and its Government has provided a well-staffed Division of Fisheries (4) to deal with its immediate fishery



PROPOSED REGIONAL COUNCILS for the STUDY of the SEA (FAO) research problems. There are three research vessels attached to the Division and one is shortly to be replaced by a modern fishery research vessel of 1,300 tons with a range of 6,000 miles, complete with every type of research equipment.

The solution would, therefore, appear to be that each member Government of each regional council should set aside funds for fisheries research in its own immediate seas and that each council should, through a centralized secretariat, act as a liaison body with, and report its findings to, the FAO Division of Fisheries, which can then collate them and publish them for the benefit of world fisheries. The development of latent fisheries of each region, based on such scientific exploratory work, could then be encouraged.

A factor in exploration which has recently made strides in certain countries is the employment of aerial reconnaissance for the location of shoals of fish—a method which has great possibilities for the exploitation of pelagic fisheries. During the Second World War, Navy blimps were used to help in the United States war food programme, and this method could be further developed.

Recommendations as to methods of exploration and subsequent development would best be left to the fisheries authorities of the various regions concerned.

EVIDENCE OF EXISTENCE OF OCEANIC STOCKS

There appears to be such evidence in the areas that in the past were scantly exploited, viz., the western and central Pacific Ocean and the waters adjacent to Latin America. A generalized statement on this matter can, however, only be made when the areas have been surveyed and the results collated by the various countries concerned. Therefore, it is virtually impossible to elaborate on the present extent of oceanic stocks except to state that we know of their existence in the form of large shoals of fish like tuna, pilchards and herring in many oceans of the world.

POTENTIAL CONTRIBUTION TO WORLD FOOD SUPPLY

The present position of the world food supply shows a grievous shortage of most of the essentials for a balanced diet. This shortage of land-produced food has resulted in increasing attention being paid to the sea as a source of protein, and an awakening of interest in the latent potentialities of fisheries has become patent.

Since the cessation of hostilities nearly every maritime country has increased its production of fish very materially compared with pre-war statistics, and sea-foods are now augmenting the lack of proteins caused by the shortage of land-foods.

As the stress in fisheries—no matter which sphere we examine, be it fresh fish or by-products for animal nutrition —is on the production of proteins, perhaps it is germane to mention the valuable source of protein to be found in marine plankton. Since the prodigious growth of certain whales, including the formation of great food reserves in the blubber, is built up entirely on a planktonic diet, it would be worth while to enquire whether some of this wealth of food could not be taken directly from the sea and used for human consumption, or as a valuable addition to the food of stock. Zooplankton has been reported to have a nutritive value equivalent to the best meat, and phytoplankton equal to rye flour. Extracts of plankton from the North Sea have been found to contain carotene, chlorophyll and Vitamin A.

As there is still an enormous waste of valuable materials in the fishing industry, attention should also be focussed on the utilization of this waste for the production of essential by-products.

INTERNATIONAL CO-OPERATION IN EXPLOITATION

The exploitation of certain fishery resources throughout the world has always been attended by the spectre of greed for gain. Many resources are exhaustible or expendible, and unregulated competition for them will eventually lead to commercial failure. It has been possible for certain nations to effect agreements on conservational problems as widely different as Whaling, Fur Seals, Pacific Halibut, Pacific Salmon and others, and therefore it is not beyond the bounds of possibility that international co-operation in the global exploitation of fisheries may be achieved.

The question of national sovereignty over seas of individual countries is one which bristles with legal complications (9, 10), and countries which have imposed rigorous conservational regulations and restrictions on their nationals look askance at the predatory practices of foreigners. This is a question well within the ambit of the United Nations which can tackle it at the point where the League of Nations left off.

CONCLUSION

All maritime countries should be invited to contribute the views of their fishery experts on the extent of their known and latent resources, and steps should be taken to develop them for the benefit of all mankind. Such information should be submitted to the United Nations after collation by FAO, and then distributed to all member nations. Such international co-operation can then only result in the much-needed improvement of nutritional standards of all nations needing such assistance.

A concerted study of the latent fishery resources throughout the world will prove that fisheries can greatly assist in alleviating the present food shortage. This objective can be achieved by a frank discussion of all the concomitant features briefly dealt with above at the United Nations Scientific Conference on the Conservation and Utilization of Resources. But every participating country must pull its weight to achieve this laudable object.

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Latent Fishery Resources and Means for Their Development

E. DE VRIES and C. J. BOTTEMANNE

ABSTRACT

Fish has a high protein content, and especially for densely populated countries is an indispensable element in the diet. Japan and Norway are among the countries where fish and fisheries products supplement the diet, which is poor in meat and other animal proteins. Undoubtedly there are many more possibilities of increasing the nutritional value of the diet by higher fish consumption.

Since about 1920 it has been the definite policy of the Government of Indonesia to increase sea fisheries and the inland fisheries in the Indonesian Archipelago. Especially for Java and Madura—one of the most densely populated and most intensively cultivated areas of the globe—this is very important. The fact that the metropolitan territory along the North Sea has been pioneering with herring-fishing, whaling, cod-fishing and other types of fishing since mediaeval times, has been of great help in these attempts.

In Indonesia a great number of types of fisheries and fish cultures has developed.

The following enumeration gives a general idea of the vast range of possibilities.

SEA FISHING

Tropical seas have long been supposed to be poor in density of fish population. This opinion was based on the results of plankton investigations. This opinion will, however, probably have to be revised as the result of recent research in foreign countries. Also in Indonesia doubt has arisen concerning the completeness of the collected data on plankton. The situation can be best formulated in the words of Martin D. Burkenroad in the *Far Eastern Quarterly*, 1946: "The position has been quite widely held, that the warm seas are inherently less fertile than the cold ones, because of a lower content of nutrient substances for plant-growth. However, recent studies have suggested that this is a superficial distinction only and that questions of the rate of turnover of the crop of plankton .... etc. are involved which greatly complicate the theoretical calculation of basic productivity."

This point of view coincides with the results of the practical marine research in the Indies from 1931 to 1941. In the next pages an account will be given of the data, experience and results which were obtained in this respect in the years mentioned. They will be dealt with under the following heads:

(*a*) Existing fishery resources,

(*b*) Latent fishery resources,

(*c*) Methods of exploitation and development of both.

(a) *Existing fishery resources*

Only a small part of the sea-area of the Archipelago, perhaps only 15 per cent, is really fished (of the Java Sea, for instance, only a strip fifty miles wide off the northern Java shore). In the other seas it is even less. Nevertheless the whole production of the sea-fisheries of the Archipelago may be estimated at about 325 million kg. in 1941, of which 100 million kg. came from the fisheries of Java. Bagansiapi, the second fishing harbour of the world, had a production before the war of 70 million kg. from estuary fisheries.

This production was accomplished by means of surface circle-nets which bear a resemblance to the Californian lampara and which were responsible for perhaps one-third of the total amount; estuary fisheries, which brought in another third, and several kinds of coastal fisheries and tuna fisheries.

Research with actual fishing proved, that the Java-lampara fisheries which contributed about one-half to the total Java supply, could be estimated to catch less than 10 per cent of the amount of fish which could actually be seen. It was soon discovered that in almost every respect the chief problem would be to find better methods and better fishing equipment, which at the same time would not necessarily need to be of Western pattern.

As a matter of fact it appeared that circle-net fishing could be motorized in the western region of the Java Sea but that catches did not respond to motorizing in the eastern region. As a result a fishery was developed in Batavia, using small motor-boats. The last year before the war, a motorized coral-reef fishery from the same harbour was built up on the Japanese pattern. In the Surabaya region trawl fishing was proved to be possible and even profitable with medium-sized vessels. These fisheries did not exist at all before. They were halted when war broke out in Europe, the fishing grounds lying in maritime areas.

(b) *Latent fishery resources*

One of the chief aims of the Institute of Sea-fisheries in Batavia was to take stock of the possibilities in the big areas where practically no fishing existed. The result of the activities in this direction is contained in the following points:

1. The whole belt of muddy water around Borneo, to an average width of some 20 miles from the shore, is in principle suitable for trawl fishing with medium-sized motor-vessels. The production can be large, some 100 million kg. It is technically impossible in this region to use the estuary fishing methods of Bagansiapi.

2. In the middle of the Java Sea a much larger production can be had by modernized circle-net fishing—no purse seine—with medium-sized motor-boats. A yield of 50 million kg. is estimated to be possible.

3. On the whole the same methods can be used in the eastern Archipelago and perhaps in the China Sea.

4. Tuna resources are very large, especially in the eastern Archipelago, but they are practically undeveloped. Technical difficulties, such as the shortage of live bait, retard development. Development would not give satisfactory results if no modern motorships were used. The Indonesian fishery of this kind, which is very limited, is exactly the same as the Japanese and the Californian fishery for tuna,

except that primitive equipment is used. The species are the same as those hunted by the California fishermen, though perhaps their percentages in the total catch differ to a certain extent. A production of some 30 or 40 million kg. must be possible. The product is expensive and may be exported.

5. Estuary fisheries in Sumatra can be developed by using improved fishing methods, and methods of transport.

The same is valid for the ordinary fisheries along some of the muddy coasts. The existing production can surely be increased by some 60 million kg.

6. Several kinds of smaller fisheries, as those for "snapper" can be developed by using improved methods and boats.

7. Fishing for big tuna, south of Java and Sumatra in the Indian Ocean was proved to be possible by the Japanese before, and to a greater extent during the war. Shark fishing seems also a possibility there in certain months of the year.

8. Big sardine shoals appear irregularly off the south-east coast of Java.

9. The whole of the New Guinea region comprises nearly all of the above-mentioned fishing possibilities, though of course not all in the same quantities.

(c) *Methods of exploitation and development*

The existing exploitation of fishing resources in the Indies is a small-scale business and is done by small boats. Catch per fisherman with the Java circle-net amounts to an average of not much more than 1 ton a year, whereas for the Californian purse-seine-sardine-fisheries it is something like seventy times as much. Free introduction of large-scale fishing methods would no doubt do too much harm in the greater part of the fishing areas which are already in use.

Improving small-scale methods appears to be difficult. Improvements require medium-sized boats, and medium-sized business, in most cases. What can be done for the small-scale fisheries lies more in the field of economic measures and organization. These however, can not create a large production in the undeveloped fisheries areas. For that purpose in most cases, large-scale exploitation will be necessary, at least in the first ten or fifteen years. Plans in this direction are being devised. Parts of the undeveloped areas are nevertheless suitable for small-scale exploitation and are therefore more or less reserved as areas of expansion for the population.

Consumption of fresh fish in the Indies may be estimated on Java to amount to about 7 kg. (in Japan about 40 kg.) per person per annum. It is easily seen that a doubling of the consumption in the whole Archipelago would require no less than 300 to 400 million kg. This of course must come chiefly from at least medium-sized fishing. In this calculation the imports, which amounted to 120 million kg. were not included.

INLAND FISHERIES[1]

1. *Fish catching*

(*a*) In rivers,

(*b*) In swamps,

(*c*) In lakes,

(*d*) Exploitation of artificial reservoirs.

2. *Fish growing*

A. Growing fish in fishponds

(*a*) Sea-water and salt-water ponds along the seashore,

(*b*) Fresh-water permanent ponds.

B. Growing fish on irrigated fields

(*a*) Wild fish and cultivated fish growing on "closed" fields (wet fallow),

(*b*) Cultivation of fish in rotation with yearly rice crop,

(*c*) Cultivation of fish in rotation with twice yearly or three times in two years rice crop,

(*d*) Cultivation of fish between growing rice.

Where and if enough water is available, Indonesian inventiveness has found methods to cultivate some kind of fish or shrimp, under almost unimaginable circumstances. Some ponds along the coast have seasonal salt and fresh water, and fish are cultivated both in sea water and in fresh water.

Large parts of the low coasts are in this way gradually changed from salt marshes into salt-water pond, fresh-water pond and finally rice-field.

In some instances a yearly growth of the coastline of 200 metres has been established.

The cultivation of fish on irrigated fields makes fishing a kind of agriculture. A primitive way is to increase the height of the small dykes around the fields, to then let in water from the river and close the sluices and dykes. In the meantime the field enjoys a kind of wet fallow, a period in which weeds are killed in the mud and the humus and mineral content of the soil is restored.

The most intensive type of cultivation is a crop of fish between the growing rice. Young fish are set out at the time of planting and "harvested" at the time of the first weeding (six weeks). In some cases even three successive "crops" of fish can be grown during the season of one rice crop and the additional animal protein is a most important supplement to the rather monotonous vegetable diet of the peasant. It needs no explanation, that such very intensive types of fish growing are only possible where enough water of good quality is available.

Application of phosphate fertilizers to ponds and rice-fields is in a number of cases a paying practice. A warning has to be given in two respects:

(*a*) Unsound exploitation of fishponds, especially negligence with the growth of certain algae and an imperfect control of the level of the water by dykes and sluices may cause a serious endemic, or epidemic, malaria. However, a "hygienic" exploitation of the ponds is possible and in many cases more economical than badly kept ponds.

(*b*) Where fish are grown on paddy fields, the soil is permanently or almost permanently flooded. Not every type of soil can be used in this way without a serious deterioration of its texture. Also not all varieties of paddy are suited to this system. It must be stated therefore that intensive inland fisheries are a highly specialized and rather intensive type of "animal husbandry" and that therefore

[1]Ir. A. E. Hofstede, *Fisheries and Fish Growing in Indonesia.*

their application seems to be restricted to tropical countries with a highly-developed peasant agriculture, fertile soil and an adequate water-supply. Even within these limitations however, it can become a very important element in tropical agriculture and in the diet of densely populated tropical lands.

Quite recently, the Government of Surinam invited an expert from Indonesia to develop similar systems for the marshy coastlands of Surinam in Latin America.

As in the case with sea fisheries, research plays an important role in this development. In Indonesia, a special laboratory with experimental ponds has been established at Buitenzorg. In one instance, the introduction of two hitherto unknown species of fish in the lakes of Southern Celebes and subsequent extension work, raised the export of dried salted fish from 3 metric tons to 5,000 metric tons in a period of five years.

Pure chance plays a role, as everywhere. A new fish (*Tilapia mossambica Peters*) was introduced in Java in the thirties from Africa in an unknown way. This fish is euryhalien, hatches all the year round, and therefore does not require introduction of young fish after every harvest. It lives on algae which otherwise would raise the danger of malaria, and is thus a godsend for millions of Indonesians. It gives catches of 400 kg. of fish per hectare in ponds which were considered to be neglected.

The problems of conservation and transport are of some importance in marshes, lakes and large centres of permanent ponds, but are negligible for the cultivation of fish in smaller ponds and on rice-fields. Here, the fish can be brought directly to the door of the consumer.

INTERNATIONAL CO-OPERATION

International co-operation exists in different forms:

(*a*) The Council for the study of the sea in the South West Pacific and the Indian Ocean;

(*b*) The Indo-Pacific fisheries council, which will be the prototype of analogous councils in other marine regions;

(*c*) The whaling conference and international conventions for the conservation of herring, salmon and other fish.

International exchange of experience, of results of scientific research in the biological, the technological and the social field may prove to be of very great value.

GENERAL REMARKS

This preliminary report may be concluded with a few general remarks.

Scientific research has been undertaken since the establishment of a fishery station at Batavia to study the food habits, egg hatching, migration and other physiological peculiarities of the most important species of fish. Types of catching and conservation (by ice, canning, salting) of fish have been evolved on this scientific basis.

Later on a number of experimental stations in the Archipelago were established to find methods of application of this scientific research to practical fishing. Economic factors are as important in this field of extension and advice as are the scientific. Transport and the problem of conservation are two of these factors. Furthermore, the credit and marketing problems are vital to sound development.

In connexion with its special character, development of inland fisheries in tropical regions is expected to have a greater effect as in Europe.

Finally it is important to state that the character of research in inland fisheries is quite different from that in sea fisheries.

In the first case it is possible to have production well in hand and therefore the solution of biological problems will be the main concern of the research. In the second case "catching" will be the difficult point, so that special attention must be paid to the improvement of means of catching.

The Development of the Fishery Resources in Chile

M. J. LOBELL

ABSTRACT

The oceanic regions forming the western boundaries of Chile are reputed to support great latent fishery resources but little development progress was made until about 1944 when a technical mission from the United States made a thorough investigation of the resources and the industrial possibilities of their utilization.

The plan of studies included field work at sea, fishery technology, finding of facts on the existing industry and an analysis of background and economic factors.

The report of the technical mission was favourable and indicated that development of the latent resources should be undertaken. The *Corporación de Fomento de la Producción*, an instrumentality of the Chilean Government, employing the report of the mission, prepared an integrated ten-year plan which is progressing through the efforts of private capital assisted by the *Corporación*.

Probably the greatest problem in developing latent fishery resources is to provide sufficient stimulus to private enterprise since a wholly state-controlled and developed fishing industry does not offer much chance for continuing success. The experience of Peru, which has formed a modern fishing industry in less than ten years, is a good example of what may be accomplished by co-operation between government and private interests.

Development of latent fishery resources must always take into full consideration the costs of potential production for, although many mass markets exist, full consideration must be given to the purchasing power of possible consumers.

INTRODUCTION

The extended sea-frontier of Chile is one of the great productive oceanic regions of the world. The latent fishery resources have been considered, for many years, to be capable of supporting vast and prosperous fishery industries. But, in spite of the apparently brilliant potentialities, development of the fishery resources has languished. No real progress was made until about a decade ago when the *Corporación de Fomento de la Producción* (Chilean Development Corporation) was brought into being and entrusted with the development of the aquatic and other natural resources.

The *Corporación de Fomento* initiated its activities with grants of long-term credits to processing plants and it organized a company to produce and sell fresh fish at low prices in the great population centres. Realizing that the individual, small fisherman represents the real backbone of the fisheries, it also instituted a system of long-term loans at low interest rates to enable these men to acquire boats and gear.

After several years of sporadic activity, the directorate of the *Corporación* became aware of the grave lack of basic data with which to orient an intelligent fishery development scheme. In 1944, therefore, the Government of Chile secured the services of a technical mission from the United States Department of the Interior. This mission was charged with the responsibility of making a thorough investigation of the aquatic resources and industrial possibilities; and, on the basis of its findings, to provide the necessary recommendations for the subsequent formulation of an integrated plan for fishery development.

The personnel of the technical mission had varied and ample training and experience and consisted of two fishery engineers, a fishery technologist and an aquatic biologist. The work of the mission was divided into four major fields as follows:

1. Field work at sea: Exploratory and experimental fishing; collection of biological and oceanographic data.

2. Technological: Examination of existing processing plants and methods; analyses of oil and meal; evaluation of products, fresh fish distribution and marketing.

3. Port inquiries: Censuses of fishermen, boats and gear; species caught and available and their seasons and abundance; prices; port facilities and communications.

4. Background and economics: Imports and exports of fishery products; transportation; distribution and marketing facilities; costs of production, consumer preferences; purchasing power; review of previous reports and studies.

In spite of the above divisions the investigative programme was never a rigid one and it was often possible to combine two or more of the above items, especially when in the field. The enterprise was facilitated by the fact that the Chilean authorities furnished assistants and collaborators of intelligence and ability.

FIELD WORK AT SEA

For this phase of the investigations, the Chilean Navy provided its hydrographic-survey vessel, the "Vidal Gormaz". This ship, while extremely useful for long-range cruising and as a floating headquarters, was not of a type which could be used for fishing except as might be done with the small boats carried aboard. Since it was desirable to collect specimens for classification and do some exploratory fishing, a considerable amount of time was spent in this activity using the ship's launch and rowboats, especially in the archipelagos of southern Chile.

Although the results obtained with the "Vidal Gormaz" were of great value, it is certain that much better data would have been obtained with a modern, medium-sized fishing vessel equipped for all types of experimental fishing and manned by an experienced fishing crew.

Previous studies, including those in Peru, Puerto Rico and Trinidad, have demonstrated the value and utility of using commercial-type fishing vessels for exploratory surveys. Comparing the results obtained, it would appear that the additional expense of chartering, maintaining and operating a fishing boat as an adjunct to a fishery development survey is fully justified.

For general exploration and experimental fishing, the Pacific Coast purse-seiner is almost ideal. These vessels are staunch, well powered and seaworthy. They may be used efficiently for practically all kinds of fishing and oceanographic work; they have great hold capacities, long cruising endurance and excellent living accommodation. For investigations which deal entirely with trawling, it would be more advantageous to employ a typical North Atlantic trawler. Purse-seine vessels may be secured in sizes from less than 50 ft. in length to more than 100 ft. Equipped with multi-purpose winches, pilot-house controls and other labour-saving devices, they are operated with small crews, even when working with standard fishing gear.

The equipment to be carried aboard would, to a great extent, be conditioned by the characteristics of the resources in the region where operations are contemplated. As a general rule, the following items of gear should be considered: purse-seines (5/8 in. and $3^1/_2$ in. stretched mesh); otter trawls of varied-sized meshes and for various types of fishing; long-line gear for bottom fishing and for flagline fishing; gillnets of varied mesh sizes; trammel nets; beach seines; trolling gear; handlines; fish and crab traps; harpoons; dipnets; spears and shellfish dredges. All of the above equipment should, so far as possible, be of standard commercial type. An ample supply of spares and mending supplies, as well as net preservatives, should be included as a basic requirement.

Scientific apparatus should certainly include surface and reversing thermometer, water-sampling bottles, plankton nets and a depth recorder. Ample provision should be made for preserving and storing collections of specimens for later study. However, unless the expedition is a part of a long-range programme with adequate personnel and laboratory facilities, an intensive oceanographic investigation should be avoided. Extensive collections of the flora and fauna can be made as a part of the experimental fishing and these collections may be delivered to appropriate experts for classification.

Personnel aboard the experimental fishing vessel should be composed, as completely as possible, of professional fishermen, preferably ones who have had a varied experience. For the purpose of making observations of the work, recording data and preserving specimens there should be aboard the vessel as a part of its normal complement a fishery engineer and an aquatic biologist. If the work is to include a considerable amount of oceanographic investigation, it would be wise to have an oceanographer aboard.

The exploratory fishing programme should be devised to cover as thoroughly as possible the fishable waters of the region concerned to employ all of the applicable types of gear and, at the same time, to collect biological and oceanographic data. Great consideration should be given to possible seasonal and also annual fluctuations in abundance and availability. An exploratory fishing survey of less than one year, while furnishing interesting information, cannot be regarded as conclusive. It may, however, in certain instances, provide a stimulus for private interests to initiate the development of some particularly promising latent resource.

The actual fishing operations should be as closely controlled as possible in order to give adequate data which, when analysed, can supply comparable catch-per-unit-of-effort measures. The basic factors are fishing time, number of units fished and yield. Intelligent interpretation of these factors must take into consideration such variables as the depth of water, type of bottom, bait used, sea and weather conditions, the time of day, water temperature and salinity.

TECHNOLOGICAL INVESTIGATIONS

The principal duties of the fishery technologist attached to the technical mission to Chile was the examination and evaluation of the existing processing plants and their methods of operation. With the co-operation of university laboratories, routine chemical and bacteriological tests were made, chiefly to assist the industry in overcoming certain processing problems. Due to the limited nature of the survey, it was not considered feasible to install a fishery technological laboratory. Practical work was accomplished in canneries, salteries and fishmeal plants and excellent results were obtained under these conditions.

For a complete, long-range programme of fishery development, a technological laboratory is of great value but such installations are not found in countries where the fisheries have not reached importance. In some of these countries, however, agricultural experiment stations might furnish facilities which can be utilized. It is questionable that, for a short-term, fact-finding programme, it would be advisable to set up a technological laboratory since the real benefits from such work are those which come from continuing investigation and research and the chief support for such work comes from a progressive industry. Even though a technological laboratory is not installed it is essential that a technologist be included in the personnel of any investigation studying fishery development.

PORT INQUIRIES

The greater part of this information was collected by the men aboard the "Vidal Gormaz". At each port, detailed data as to the number of fishermen, number of types of fishing craft and number and types of fishing gear were collected, usually through the good offices of local officials. Interviews with fishermen and others were utilized to obtain determinations on the species available and those fished, seasons and abundance and other pertinent facts.

Investigation was made into costs of production, the prices paid by the public for various fishery products, transportation and marketing methods and facilities and other factors concerning the commerce in fishery items.

Considerable emphasis was given to studies of the facilities of the ports to determine their potentialities for locating fishery industries.

Information to be secured by a port-to-port canvass is extremely valuable since it provides a first-hand contact with the existing fisheries which cannot be acquired in any other manner. Such a survey is most easily conducted through the use of the exploratory fishing vessel.

BACKGROUND AND ECONOMICS

The question most usually asked by residents of countries having latent fishery resources and little or no development is—"Why?" The reason may be simple or it may be complex but it is well conceded that fishery industries do not occur by spontaneous generation. There must exist a series of favourable conditions for fishery development of which the existence of latent resources is but one. The fish in the sea do not make an industry nor are they of any use unless they are caught, processed and marketed within the bounds of economic feasibility.

When a thorough study is made of the past history of attempts toward fishery development, it is often found that sufficient weight was not given to the economic factors of markets, costs and selling prices. Investigation of costs of production balanced against total and individual purchasing power may indicate that local fishing industries cannot compete on a freely competitive market. It is not rare to find that some national markets lack the necessary purchasing power, both because of small population and low earnings, to justify the installation of modern fishing industries. A careful study of existing transportation, distribution and marketing facilities and methods, from the standpoint of the costs of these services, will often divulge the reason for the lack of development of latent resources.

Useful clues may often be obtained from analysis of import-export data on fishery products for long series of years—especially as regards the kind and value of the products imported and the countries of origin. Consumer preferences, built up over generations and bulwarked by low prices often determine the success or failure of local fishery development enterprises.

CONCLUSIONS

Analysis of the information and data secured by the technical mission made it possible to answer the following key questions:

1. Are the aquatic resources of the type and in sufficient abundance to justify development?

2. Are the potential domestic markets large enough and wealthy enough to absorb a reasonable portion of the potential production; and, if not, can export markets offer a reasonable basis for sales?

3. Will anticipated production costs be at a level to enable products to compete favourably on local and export markets?

4. Are accessory, but key, factors such as ports, water-supply, transportation, fuel supplies, labour, shipyards, taxes and import and/or export duties favourable to industry development and, if not, can they be made so?

The technical mission considered that the situation in Chile for fishery development was favourable and in its report it roughed out, by means of concrete and appropriate recommendations, the basic characteristics, orientation and limits of a fishery development programme.

The realization of the development programme then became the responsibility of the *Corporación de Fomento*. Employing the mission's report as a base, a ten-year integrated fishery development programme of definite projects was devised. This plan includes the installation of new processing industries, port improvements, construction of vessels, manufacture of gear, research in technology and biology, improvement of transport and distribution facilities and a complete financial and economic study.

The implementation of the plan has been slow due to exchange difficulties and the prior claims of financing of other, more basic, industries such as steel and petroleum. However, progress is being made. Development is based on a policy of free enterprise aided, as necessary, by capital and credits from the *Corporación de Fomento*.

Probably the greatest problem in the development of latent fishery resources lies in the implementation and realization of the recommendations of the experts entrusted with the investigations. At some point there must be a shift from ideal propositions to practical projects. It is extremely doubtful that a wholly state-controlled and developed fishing industry can be successful. The fisheries are too individualistic, widespread and complex to be operated by government employees.

On the other hand, free private enterprise will usually be backward in developing the latent fisheries, especially in those countries where more proven and attractive investment possibilities exist. Since the fisheries depend so much on public works such as ports and water supplies and since exploration and experimentation are often costly, it is not too much to expect that Government will give concrete assistance in providing a greater measure of security to private investors.

There is little doubt that where private capital is sufficiently stimulated by government assistance, development is rapid. This is well demonstrated in the case of Peru which, in the short space of less than ten years, has developed an excellent modern fishing industry.

There is no doubt that many latent fishery resources exist and that when these are developed they can supply large amounts of food. But the costs of production, transportation and distribution must be within the limits of the purchasing power of the consumers. There are tremendous mass markets which might be supplied—the problem is to enable the product to reach these markets at price levels which are advantageous both to producer and to the consumer.

The Exploitation of the Egyptian Elasmobranchii

IBRAHIM ABOU SAMRA

ABSTRACT

The Red Sea is well known for its dense population of Elasmobranchii (cartilagenous fishes). Experiments have been undertaken by the Fouad I Institute of Hydrobiology and Fisheries for extraction of oil from shark livers. The livers were found to contain more than 50 per cent of oil which on analysis showed a yield of 186,000 international units of vitamins in some species, or three times the amount contained in cod liver oil. Other species also gave a high percentage of oil and vitamins.

The expenses connected with exploitation are not great. The necessary items are:

1. Equipment of the Institute's research ship (the "Mabahiss") with necessary fishing gear and instruments such as:

	£
(a) Motor boat, cold storage, sounding machine, electric apparatus for detection of fish, nets, hooks, ropes, wires, etc. This item is roughly estimated at about	**10,000**
2. Erection of a pilot plant in Suez at an estimated cost of roughly about	**11,000**
Total... about	**21,000**

INTRODUCTION

The fact that the Red Sea is well known for its dense population of Elasmobranchii (cartilagenous fishes), especially of sharks, has led the Fouad I Institute of Hydrobiology and Fisheries to investigate the extent to which use might be made of this fish in Egypt. Sharks are not highly esteemed as food; the small ones are usually eaten but large sharks are not welcomed by the fishermen. As a rule, if a large shark is trapped in a net, the fishermen try to release it because it is useless for the market and it endangers their lives as well as their nets. The menace would, however, turn into a blessing if an organization were to be established for the exploitation of sharks as a source of vitamins.

In the early days of the Second World War in a preliminary investigation of the extraction of oils from the livers of cartilagenous fishes, it was shown that these livers occupy most of the abdominal cavity and constitute a high percentage of the total weight of the body of the fish. The oil in turn amounts to more than 50 per cent of the weight of the liver itself. In pursuit of this work, the physical and chemical properties of the oils extracted from three different cartilagenous fishes were determined. It was also shown that such oils furnish a very rich source of vitamins A and D.

A sample of oil extracted from *Carcharias* gave the amazing yield of 186,000 international units (I.U.) of vitamin A.

For the exploitation of fishes of the shark family, an organization should be established on the Red Sea coast, possibly at Suez as near as possible to the localities where sharks are abundant. Such an establishment would be concerned with fishing for sharks and extracting their oils. There would also be an opportunity to make use of by-products remaining from such an operation. The tissues could be dried and powdered to give a superior feed of high dietetic value for cattle and chickens, such feed being greatly needed in Egypt. The refuse could be utilized as manure and the skin as a high-grade shagreen leather. In fact 100 per cent of the shark could be utilized.

THE RESULTS OF THE EXPERIMENTS

PREPARATION OF THE SAMPLES FOR ANALYSIS

For all the researches in this work the oils from the livers were obtained as follows:

The fresh livers were chopped into small pieces and ground almost to a paste, mixed well with common salt and left overnight in an ice box. A layer of oil was found floating which was decanted and filtered through coarse filter paper. Steam was then allowed to pass over the remainder of the liver paste and common salt for not more than fifteen minutes, when another layer of oil floated which was decanted and filtered in the same way. A hand press was then used to extract the remnants of the oil left in the livers. This last portion appeared to be half emulsified and was difficult to separate from other liquids, but centrifuge was found to be very efficient in separating the two phases.

The following results were obtained:

	Weight of liver	*Weight of oil*	*Per cent*
Rhynobatus	2,115 grammes	1,269 grammes	60
Trygon	2,650 ,,	1,457 ,,	55
Carcharias	3,250 ,,	1,885 ,,	58

It was observed that the oils could be very easily separated from some livers while from other livers, even though they contained a high percentage of oil, the oil could not be readily separated.

RELATIONSHIP OF THE OIL OUTPUT TO THE WEIGHT OF THE FISH

Since the proportion of the liver to the total weight of a fish increases with the size of the animal, it is obvious that a large fish contains a liver which weighs more than the total weight of the livers of two smaller fish of combined weight equal to the larger fish. Furthermore, the percentage yield of oil increases with the size of the liver and the oil output from one large liver is greater than from two smaller livers of equal weight.

As a result, the yield of oil is not proportional to the total weight of the fish processed and it is desirable to use as large size fish as possible for a successful fish oil industry.

In addition, there seems to be a seasonal change in the oil content and vitamin concentration. This deserves further investigation.

PHYSICAL CHARACTER OF THE OILS

The specific gravity of the oil was determined by means of a pycnometer and calculated at 15 degrees C. The refractive index measurements were carried out by a Zeiss refractometer.

The solidification point of the oil has been fixed according to the usual rules (see Table 1).

CHEMICAL CHARACTER OF THE OILS (see Table 2)

The unsaponifiable matter

The determination of the unsaponifiable part was made by Fahrion's method, which proved to be especially appropriate for the examination of fish oil. The shaking of the saponifiable part with the help of ether by this method has given much better results than the shaking with petroleum ether by other methods. The only defect in Fahrion's method is the fact that in some cases there arise rather long-lasting emulsions which have to be removed by the addition of small quantities of alcohol. The unsaponifiable remainder is dried at 100 degrees C to its constant weight.

The free fatty acid value

The determination of acidity was done by titration with N/10 KOH, 10 per cent normal solution of potassium hydroxide together with phenolphthalein as indicator. For the analysis 50/50 ether alcohol was used as the solvent.

Saponification number

About 2 grammes of the oil were saponified with 25 cub. cm. 1/2 N KOH (alcoholic potash) on a water bath, boiling for thirty minutes. The hot solution was titrated with 1/2 N HCl (half normal hydrochloric acid) using phenolphthalein as indicator.

Twenty-five cub. cm. 1/2 N KOH (half normal potassium hydroxide) was boiled for thirty minutes and titrated with 1/2 N HCl (half normal hydrochloric acid).

If the weight of oil is A, and the quantity of alcoholic KOH used for saponification is D, then $\frac{28.05 \times D}{A}$ = The saponification number.

Iodine number

About 0.2 gramme of the oil was weighed in a glass-stoppered Erlenmeyer's flask and 10 cub. cm. tetrachloromethane was added. Fifty cub. cm. N/10 $KBrO_3$ (10 per cent normal solution of potassium bromate), 1 gramme KBr (potassium bromide) and 10 cub. cm. dilute (12.5 per cent) HCl (hydrochloric acid) were added with constant shaking. This was left overnight in the darkness. 10 cub. cm. N/2 sodium arsenite were added and the mixture was shaken until discolouration occurred. 20 cub. cm. HCl (concentrated) were added and titrated with N/10 K BrO_3 (potassium bromate) with the addition of indigo carmine as indicator until a faint yellow colour appeared. A blank experiment was done in the same way.

If a = volume of N/10 K BrO_3 for titrating oil (50 measured-burette reading),
b = blank experiment reading,
g = weight of oil,

Then the iodine number is $\frac{(a-b) \times 1.2692}{g}$

Hehner's number

This number indicates the quantity of insoluble fatty acids included in unsaponifiable matter. Two to three grammes of the oil were saponified with 50 cub. cm. alcohol, then 1 gramme KOH was added when the alcohol had evaporated. The whole was dissolved in 50 cub. cm. hot water and acidified with 20 per cent HCl.

The fatty acids were separated and a small quantity of paraffin was added. The solution had to be kept in a hot water bath until the fatty acids were separated on the surface and the liquid above and below was clear. When the acids solidified, they were filtered until free from chloride.

The residue was dried to its constant weight in an atmosphere of inert gas to prevent the oxidation of fatty acids.

THE PHYSICAL AND CHEMICAL PROPERTIES OF FATTY ACIDS

The physical and chemical properties are shown in Table 3.

Table 1. Physical Properties of Oil Extracts from the Livers of Some Elasmobranchii from the Red Sea and the Mediterranean

Species	*Specific gravity*	*Refractive index*	*Solidification point*	*Colour*
Rhynobatus	0.9273	1.4795	5	Light brownish yellow
Trygou	0.9352	1.4687	4	Light brownish yellow
Carcharias	0.9364	1.4526	3	Light yellow gold

Table 2. Chemical Properties of the Oils

Species	*Unsaponifiable matter*	*Free fatty acids*	*Saponification number*	*Iodine number*	*Hehner's number*
Rhynobatus	6.86	1.2	195	147	91
Trygon	7.21	1.4	186	162	92
Carcharias	3.58	.8	188	158	88

Table 3. Physical and Chemical Properties of Fatty Acids

Species	*Solidification point*	*Melting point*	*Colour*	*Neutralization number*	*Iodine number*
Rhynobatus	31	34	light brown	191	136
Trygon	30	32	light brown	188	161
Carcharias	28	30	yellow	190	113

DISCUSSION

In each species the oil has a characteristic colour and only in rare eases is there a difference in colour which may be duc to the time of storage of the liver before extraction.

The oils are clear and transparent in temperatures higher than 24 degrees C; they become slightly turbid between 24 degrees and 18 degrees and below 18 degrees C solid glycerides are separated.

This group of fish oils has a high content of unsaponifiable matter (almost 80 per cent), consisting mainly of cholesterol, higher alcohols and unsaturated hydrocarbons.

The free fatty acid value is a small one and does not exceed 1.4. The saponification number varies between 180 and 200. The iodine number has different values.

VITAMIN CONTENT

The most interesting data are those relating to vitamin A. Owing to lack of the necessary apparatus at the Institute, the samples extracted were taken to the Faculty of Medicine, Cairo (to the Biochemical Laboratory) and analysed under the supervision of Dr. Aly Bey Hassan, Professor of Biochemistry and now Dean of the Faculty of Medicine. To our great astonishment samples of the oil extracted from *Carcharias* by the method mentioned above gave a value of 186,000 I.U., or almost three times the value of cod liver oil.

The oils of Rhynobatus and Trygon had values of 85,000 and 78,000 I.U., respectively, and are also considered to be of high potency.

Vitamin D was unfortunately not estimated.

PROJECT FOR THE EXPLOITATION OF SHARK-LIVER OIL

1. The Institute's research vessel (the "Mabahiss"), which is now being completely overhauled, and its scientific staff should survey the Egyptian waters of the Red Sea so as to locate sharks and give an approximate figure of the possible amount that could be fished daily. For such work the "Mabahiss" should be equipped with the following:

(*a*) Necessary fishing gear such as nets, hooks, ropes, wires, etc.

On the basis of these promising experimental results, it would appear desirable to organize a project for the exploitation of shark liver oil. The requirements for such a project and the probable cost are outlined below.

(*b*) Necessary scientific instruments such as sounding machines, modern instruments for detecting fishes, etc.

(*c*) An efficient cold storage should be built in the ship.

All the above equipment would probably cost about £5,000; the supplying firms would, of course, provide a more accurate estimate.

(*d*) A small motor-boat should be purchased for use with the "Mabahiss". This would cost about £3,000.

2. A pilot plant should be erected in Suez or in the nearest suitable place to the shark fisheries. Such a plant would be intended for large-scale experiments. Two rooms would be sufficient, one for a laboratory and the other for a press and boiler. As a rough estimate about £5,000 would be necessary.

3. The laboratory attached to this plant should be equipped with the apparatus required for the scientific work related to the oils and for their analysis. A photometer is one of the instruments that should be available in such a laboratory. About £1,000 is estimated as the cost of the equipment of the laboratory.

The total amount involved in the project represents a sum of about £14,000.

The pilot plant would be used only for the production of oil. Later it could be enlarged as warranted by the quantities of fished sharks. A by-product plant could also be added later.

The Shellfish Industry in Holland

P. KORRINGA

ABSTRACT

The Dutch shell-fish industry is an outstanding example of a scientifically conducted management of natural resources leading to an optimum production, both in quantity and quality. The former free fishery yielded only a small fraction of the crop produced by the shell-fish farming of our days.

The main condition for the development of a sound shell-fish culture is the leasing of all the natural beds and potential fattening grounds to the shell-fish farmers. The rent is not fixed at a too low level, and the proper framing of effective leasing conditions is an important factor. Thorough police-patrolling prevents theft, poaching and infringement of regulations. Scientific advice and guidance, provided by the Government, assists the oyster farmers in attaining the highest efficiency in spat production and in combating both oyster enemies and oyster diseases. An efficacious sanitary control ensures public confidence in the safety of the products of the Dutch shell-fish industry. Fruitful interrelationships between shell-fish farmers, administration and biological research, ensures the highest possible level of management of natural shell-fish resources and a safeguard against the use of wasteful methods.

INTRODUCTION

Though the statement frequently met with, that a continuous cordon of natural oyster-beds and mussel-banks once fringed the western coastlines of Europe from Spain to Denmark, is not free from exaggeration, we may rest assured that shell-fish have been found there in many places since time immemorial.

The growth of the human population of western Europe, the steadily increasing wealth, and the improvement of the means of transport have brought about a gradual rise in the demand for shell-fish in the last few centuries. The demand increased to such an extent that the production of the natural beds could no longer cope with it. Though an attempt was made to stem the impending depletion of the beds by regulating the free fishery, by enforcing size-limits and by closed seasons, these efforts at most slowed up the depletion process. At the present time it is rare for a valuable mollusc like the European flat oyster (*Ostrea edulis*, the queen of the oysters) to occur in appreciable numbers on natural beds.

That the oyster did not disappear completely from the markets of western Europe, but can be found there in quantities and qualities far superior to those of the past, is entirely the result of a new development, which was started about 1860, and is known as oyster culture. Later a mussel culture was likewise created, through which both the quantity and the quality of the mussel (*Mytilus edulis*), an important sea-food in several countries of western Europe, could be raised considerably.

OYSTER CULTURE

One of the main features of oyster culture is the withdrawal of the natural oyster-beds from the free fishery and their disposition to private oyster farmers or companies for oyster culture. In the Netherlands this highly important change in management occurred in the year 1870, though at first not without strong opposition from shortsighted advocates of the old rights to free fishery. Leased to oyster farmers were both the original natural oyster-beds and vast areas where oysters had never occurred naturally, owing to a lack of suitable objects (collectors) for the larvae to settle on. Nevertheless such areas are often highly suitable for oyster farming. The view that the maximum productivity of a given area can be predicted from the untouched natural beds is totally erroneous. The potential shell-fish production of an area often far surpasses production attained without the intervention of man.

The potential oyster bottoms in the Oosterschelde (Netherlands) have been parcelled out in rectangular plots of 12, 20 and 30 acres. The rent charged by the owner of the bottoms (the Dutch Government) varies according to the suitability of the parcels for the oyster industry. As the parcels were leased by free auction (always for a certain number of years), the oyster farmers could themselves decide about the suitability of the different plots. The rents for the best grounds exceed the rents of the most fertile arable soil. High rents are considered a benefit to the management of the oyster industry, as they are an inducement to the oyster farmers to keep their parcels in prime condition, in order to obtain as large a crop of first quality as the parcel can yield. Neglect of the beds is not only unwise, in view of the high rents, but the Board of Fisheries even has the right to withdraw parcels in case of neglect, and to hand them over to other oyster farmers.

It is the duty of an oyster farmer to keep his parcels in good condition and free from oyster enemies and pests. The Government, on the other hand, has undertaken the establishment and maintenance of an efficient police supervision. The police officers, cruising with their crews in the governmental patrol-boats, see to it that everyone fishes only on his own grounds, and that none of the many regulations is infringed. The rectangular plots, arranged in a systematic way, facilitate supervision of the beds to no small extent. The Government further assists the oyster farmers in their efforts to raise the quantity and quality of their oysters by providing biological research.

POPULATION STUDIES

A successful combination of private enterprise and scientific management led to a sensational rise both in the quantity and the quality of the Dutch oyster. The yield of the free fishery on the natural beds in the Oosterschelde fluctuated from 500,000 to 1 million oysters per year in the period from 1840 to 1870, and those oysters were often irregular in size and shape. After the establishment of the Dutch oyster culture, the production could be raised to 30 million or 40 million oysters per year, now predominantly oysters of first quality.

Efforts to raise the production to a still higher level failed, however. It appeared that the conditions of nourishment, though exceptionally favourable in this estuarine area, assigned definite limits to production. A detailed study of statistical and biological data concerning Dutch oyster culture for the period 1870 to 1940 clearly demonstrated that poor quality and high mortality are inevitable when the population of the oyster-beds is too dense. Complaints about unsatisfactory quality and heavy losses began to be heard from the moment that more than 100 million oysters of two years and older, plus an unknown quantity of very young oysters, were present in the basin of the Oosterschelde. One hundred million is the maximum population a good management should allow here.

There is also a minimum level below which the population cannot be allowed to sink without serious danger to a remunerative culture. The production of young oysters depends, among other factors, on the number of larvae produced by the mother-oysters. If the number of mother-oysters is too small, only very favourable weather conditions can lead to a fair set. If the production of oyster larvae is more liberal, owing to the presence of a greater number of mother-oysters on the beds, even an average water temperature in the summer months is sufficient to ensure a fair set, and with warm weather an abundant set may be expected. On an average the oyster farmer must be able to harvest enough spat to amply compensate his expenses and efforts in spatfall operations. Scientific investigations demonstrated that the minimum population level which ensures a reasonable potential spatfall in the Oosterschelde is 15 million oysters of two years and older. Below this level the chance of a good spatfall is so dependent on favourable weather during the main peak in the production of oyster larvae, that we can no longer speak of a well-balanced and well-managed oyster culture.

Curiously enough, I know of no oyster district anywhere else in the world, where the biological maximum and minimum levels of the oyster population have been computed on a scientific basis.

SPAT PRODUCTION

On a natural oyster-bed the new growth-rims of the shells of the adult oysters are the only clean and suitable materials on which the oyster larvae can settle down. All other objects are covered by too much silt or organic growth to allow attachment of the larvae. Consequently oysters are found in clusters on a natural bed, generation upon generation. Clustering results in poorly-shaped oysters. Moreover a great many young oysters, which are difficult to separate from their substratum, get lost if the older oysters (bearing them) are brought to the market. The chance for oyster larvae to find suitable collectors outside the natural beds is extremely limited, a fact which has often led to the erroneous belief that oyster larvae do not travel far from the bed where the mother-oysters once ejected them.

Oyster farmers increase the quality and the quantity of young oysters by offering the larvae a suitable material (collector), placed at the proper time in adequate places. In this way the chance for the larvae to find a suitable substratum is enormously increased. Thus the total production of young oysters comes to surpass many times the settlement on a natural bed. If the proper material has been used in catching spat, the young oysters can be detached from the collector in due time, or the collector disintegrates by itself, so that well-shaped young oysters are produced. In the Oosterschelde, a body of water which favours the reproduction of the oyster by its suitable hydrographical and biological conditions, the types of collector most in use are lime-coated roofing tiles (3 to 4 millions) and mussel shells produced by the mussel canneries (10,000 to 15,000 cub. metres per year).

The oyster farmers are faced with the problem of deciding when to plant collectors, so that they will not be silted over or covered with organic growth before the oyster larvae are ready to attach. The Dutch Government Institute for Fishery Investigations renders assistance by issuing bulletins at frequent intervals in the course of the summer season, in which water temperatures, the number of oyster larvae per 100 litres, and the growth of those larvae and setting prospects are given. The result is that the productivity of the collectors, especially of the tile-collectors, is greatly increased. Formerly one-third or even one-half of the collectors appeared to bear no spat at the end of the season, because they had been planted too early or too late. This no longer occurs. Though the intensity of setting may differ from year to year, the oyster farmers are able to approach the optimum set by acting upon scientific advice. Less work and material are now required therefore to catch a certain number of young oysters than before the establishment of the prediction service. The collectors very rarely remain barren today.

Biological investigations recently carried out in the Oosterschelde revealed that it is possible to predict even months in advance the particular day when a great peak in the production of oyster larvae can be expected.

COMBATING OF ENEMIES AND DISEASES

Competitors, enemies and diseases occur in every oyster region. Sometimes the oyster-men are themselves unintentionally responsible for promoting such pests. Thus the Dutch oyster farmers planted tremendous quantities of old cardium shells several years following 1920, in an effort to raise the production of young oysters for which there was a great demand abroad after the highly destructive and mysterious oyster mortality in England and France in 1920 and 1921. The result has been that many beds were covered with a layer of cardium shells, which changed the ecological conditions. The slipper limpet (*Crepidula fornicata*), which is of American origin and which was unintentionally introduced in English coastal waters, found a very congenial home on those shell-beds. It reproduced there at an astronomical rate with a devastating effect upon Dutch oyster culture.

Shell-disease, caused by a fungus spreading from its burrows in old shells honeycombed with perforating algae, also became prevalent, exploding shortly after 1930. An extensive and intensive biological research, mainly carried out in the field under natural conditions, at least revealed the true character of this once so mysterious disease, which threatened Dutch oyster culture with extinction. Methods have been found to combat both *Crepidula* and shell-disease effectively. The scattering of hard resistant shells, like cardium shells, is no longer allowed. Only rapidly disintegrating shells, like mussel-shells, may now be planted on the beds. Old beds of shells have been removed by intensive simultaneous dredging, by which means the niduses of both *Crepidula* and the shell-disease fungus were eliminated. In this work all the Dutch oyster-men participated from well-understood motives of self-interest. Moreover scientific methods have been found and worked out to disinfect young oysters shortly after they have been attacked by shell-disease, methods which have been adopted by our oyster-men with the greatest success. There is good reason to believe that the joint effort to get rid of the niduses of *Crepidula* and shell-disease will greatly improve the conditions for oyster culture in the Oosterschelde. This is a result of fruitful co-operation in biological investigation and practical oyster farming.

FATTENING OF OYSTERS

By far the greater number of Dutch oysters are fattened in the very same district where they have been produced as spat, viz., in the basin of the Oosterschelde. Only in periods characterized by an extremely dense oyster population, have part of the larger oysters been transplanted to other waters, not suitable for reproduction but offering satisfactory fattening conditions.

In other countries, e.g., in France, spat production and fattening are effected in different regions. Centres of spat production there are the Gulf of Morbihan and the Basin of Arcachon. French fattening districts are the Marennes area and the Etang de Theau, the latter on the Mediterranean.

Every oyster-producing country should see to it that spat production is intensified in those places where spatfall prospects, as well as other factors playing a part in spat production, are optimal. Young oysters can be transplanted to areas where fattening conditions favour the production of excellent market oysters. Dutch oyster farmers are lucky indeed, to find both qualities combined in one water, viz., the basin of the Oosterschelde.

HARVESTING AND MARKETING OF OYSTERS IN THE NETHERLANDS

Whenever it has been possible to do so without danger to the life and the quality of the oyster, mechanical devices have been introduced in an effort to rationalize the production of this delicious sea-food. Oysters that are ready for the market are harvested by dredging. As modern oyster-men subdivide their parcels as far as possible, they are in a position to place oysters of different size and age on separate beds on their parcels, so that dredging operations in the harvesting of old oysters cannot cause any harm to the young oysters that are still growing. This subdivision of oyster-beds is encouraged by the Government since it is an efficacious means for keeping the beds in prime condition. In this respect oyster culture in its modern and highly developed form closely resembles horticulture.

After a careful grading, the oysters are marketed. The overwhelming majority of oysters produced in the Netherlands is destined for export, mainly to Belgium and England. The oyster farmers store their product in oyster-basins, which serve as wet store-houses, so that the oysters can be packed and shipped at any moment, irrespective of weather, tide and seasonal press. First-class oysters taken fresh from the water, well-packed in wooden barrels, and delivered promptly are sure to fetch the highest price. Large oysters are sold at $0.11 each today by the Dutch oyster-men, and smaller grades for $0.05 to $0.10. This clearly demonstrates what high quality and excellent service can do for the European flat oyster, which is a valuable product of distinguished taste and flavour. In Europe there are no cheap oysters from natural beds to depress these prices.

SANITARY CONTROL

European oysters are eaten on the half shell without any preliminary cooking or baking so as not to spoil their delicious marine flavour. As is the case with milk, ice-cream and similar products, a thorough and reliable sanitary control is required to protect the oyster-eating public against possible infection with typhoid fever, which might be caused by the eating of oysters that have been kept in polluted water. Oyster-beds and oyster-basins as well as samples of oysters themselves, are regularly examined by a bacteriologist in charge of shell-fish control. Harvesting of market oysters from polluted beds is not permitted. Oysters grown in such beds must be placed for a prolonged period on clean beds before marketing is allowed. Only oysters accompanied by certificates of cleanliness, warranted by the Government, are admitted on the Dutch and foreign markets.

In the more than forty years of its existence, not a single case of infectious disease, brought about by the consumption of Dutch oysters, has come to the knowledge of the Dutch bacteriological service.

MUSSEL CULTURE

Mussels (*Mytilus edulis*), provided they are of good size and quality, may be considered an excellent sea-food. Cooking or baking makes them ready for the table. There is a good demand for this product, especially in France, Belgium and England. Unlike oyster-beds, natural mussel-beds still exist on a large scale in western Europe. The mussels harvested on such natural beds are often irregular in size, poor in quality of the "fish", and contain sand in the intestinal tract, which annoys the consumer.

Therefore the Dutch mussel farmer visits the rich natural mussel-beds every year, and dredges for young mussels (mussel-seed) when and where the Government allows him to do so. It is very fortunate that the Dutch natural mussel-beds are sufficiently productive to allow mussel-seed fishing from year to year.

The mussel farmer transports the mussel-seed, fished in the Waddensea (situated in the northern parts of the Netherlands) to the Province of Zeeland, where he scatters it carefully over his well-prepared parcels, leased from the Government. The Zeeland streams, being exceptionally rich in nourishment, are highly suitable for the growth and fattening of mussels. As soon as the mussels have attained the size and quality required by the market (which in the Zeeland waters occurs after a sojourn of one to two years) they are dredged by the powerful dredge-boats of the mussel farmers. Before packing and shipping them, the mussel farmers place their products for several days in thick layers in shallow and sheltered water. This is done to give the mussels a chance to rid themselves of the sand and silt they have ingested during the dredging operations. At the end of this process of self-purification, the mussel farmer takes his mussels aboard again, whenever possible with dipnets, to prevent any whirling up of sediments. In case the pressure of his business prevents him from carrying out this time-consuming practice, the purified mussels are taken up by means of very careful dredging.

Part of the mussels is sold to the canneries, where nicely flavoured preserves are made. By far the greater part is sold in the shell on the markets of western Europe. In recent years the Zeeland waters have produced from 40 to 50 million kg. of mussels, with a value of approximately $1 million.

INTERRELATIONSHIPS

The high level of development of the Dutch shell-fish industry, which has led to great prosperity among those engaged in the exploitation of the natural shell-fish resources, may be attributed to the intensive interrelationship and close co-operation of very different agents.

First of all, the area concerned is suitable for the shell-fish industry, as it is well protected and sheltered, rich in nourishment, and provided with an adequate subsoil. Next, the oyster and mussel farmers do not maintain their ancestral prejudices and methods, but are always eager to improve their methods and ever ready to utilize the results of scientific investigations. Their industry cannot be stabilized once and for all, since hydrographical, biological, social and commercial factors are likely to change gradually or suddenly, so that our farmers of the sea should always be ready to set the sails according to the wind. The Government lends them a helping hand by giving them biological advice as well as by assisting them with continuous biological research. This information is supplied to them through personal contact, bulletins and lectures. On the other hand, the oyster-men often come to the laboratory with their problems and observations. The result is fruitful co-ordination. Current problems as well as technical aspects thus receive the full attention of the scientific worker.

The police officers who survey the beds possess a wide knowledge of and experience with oyster farming and often act as fatherly advisors to the oyster-men. Further, they assist both the biologist and the bacteriologist in the taking of samples and the carrying out of field investigations. But for their technical assistance many of the important results of the biologist's work could never have been obtained.

The police-patrol is controlled by the Fisheries Board of the Zeeland Streams, which leases the parcels to the oyster-men and mussel farmers, and frames the necessary regulations. In this work the Board receives advice from its experienced police officers, who are sometimes technical fishery specialists rather than police officers in the usual sense of the word.

Finally, the biological investigator also keeps in regular touch with the Board of Fisheries.

This triangular interrelationship; (*a*) shell-fish farmers, (*b*) Board of Fisheries, and (*c*) biological investigations, in which the police officers ashore or on the water often act as mediators, ensures the highest possible standard of management of the Dutch shell-fish resources, and is a safeguard against the use of wasteful methods.

OYSTER FARMING IN OTHER COUNTRIES

The present author had the honour and the pleasure to study on the spot the shell-fish industry in many other countries. Thus a sojourn of half-a-year (1948) in the United States enabled him to become acquainted with the shell-fish industry along the shores of the Atlantic, the Gulf of Mexico and the Pacific. Though interesting and modern developments have been encountered here and there, his general impression is that in the United States the optimum production, both in quality and quantity, has not yet been attained. Proper management of the natural resources and the further development of potential possibilities are often rendered completely impossible by the oyster fishers themselves, who simply do not want to be converted into shell-fish farmers. In many places enterprising oyster farmers cannot get hold of the most suitable grounds—these being reserved for an ancestral form of free fishery—and have to stand by and witness the gradual decline of many rich, natural oyster-beds.

BIOLOGICAL ASSISTANCE IN THE DEVELOPMENT OF OYSTER CULTURE

The shell-fish industry requires biological research and guidance in the field of marine ecology. Laboratory physiology can lead to useful results for the industry only in some special cases. Unfortunately marine ecologists are rare nowadays, cell-physiology and biochemistry being more fashionable fields of study.

As far as possible the scientifically trained investigator should be seconded by technical assistants with a thorough practical knowledge of the shell-fish industry and its methods. As far as possible the biologist himself should have made a study on the spot of the different methods of shell-fish culture, as used in different countries. Moreover he should develop some insight in the commercial aspects of the shell-fish industry, as this industry is dynamic in character. Changes in hydrographical or biological as well as in social or commercial factors often necessitate an alteration in the methods employed. The broader his knowledge of the various aspects and the closer the interrelationships with both the farmers of the sea and the administration, the more valuable his advice will be.

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Propagation and Transplantation of Marine Fish

H. BLEGVAD

ABSTRACT

Propagation and transplantation of marine fish are resorted to in order to increase the stock of fish, and therefore the fishing, in a specific body of water. These objectives may be attained (1) by liberation of artificially-hatched larvae of a species which inhabits the body of water, but which has been reduced in stock, usually by overfishing; (2) by transplantation of economically valuable fish to waters where they were not previously to be found; or (3) by transplantation of full-grown fish from dense stocks with a slow growth-rate to waters where the particular species is not numerous, but where food conditions are favourable.

(1) Mention is made of Scottish and Norwegian experiments in hatching cod and plaice. In the opinion of the author, the liberation of tiny larvae into the sea has no prospects of success, although there is promise in the more recent Norwegian experiments to bring flatfish beyond the critical stage just after hatching by feeding them on Nauplii of *Artemia salina.*

(2) After describing successful transplantations of shad, striped bass, trout and salmon, as well as unsuccessful transplantations of herring, for instance, the author argues in favour of transplanting species of fish from the southern hemisphere to the northern.

(3) As an example of successful transplantations of the third category, a detailed description is given of the Danish transplantations of plaice. By transplanting 2 to 4 million plaice from areas near the west coast of Jutland to the Limfjord and to the Belt Sea, the fishermen have earned an additional income of 200,000 to 400,000 Kr. annually, while the expenses of the State for this purpose amount to 70,000 to 80,000 Kr. Attention is drawn to the fact that a similar transplantation to the Dogger Bank in the North Sea would probably prove remunerative, and that there are possibilities of transplantations in other countries, where conditions correspond to those found in Denmark. Finally a summary is given of the most important experience gained through the Danish transplantations.

INTRODUCTION

Around the middle of last century a violent discussion arose as to whether the riches of the sea were inexhaustible, or whether by human interference it was possible to reduce or even to exhaust them. It was, in particular, the English trawlfishery in the North Sea, then undergoing rapid development, that gave rise to the discussion. As a result of biological investigations of fisheries undertaken on that occasion, it became apparent that it was indeed possible to reduce and even to exhaust the resources of the sea. Consequently efforts were made to counteract the decline in the stock of fish. It was quite natural that methods which had been successfully employed in rearing fresh-water fish by artificial fertilization and hatching of the eggs were imitated, in order to increase the stock of marine species by liberation into the sea of artificially hatched fry of salt-water fish. An attempt was also made to transplant valuable species of fish to places where they might find good possibilities of development. In the following remarks the two methods will be dealt with separately.

REARING OF SALT-WATER FISH

In Scotland, T. Wemyss Fulton started large-scale hatchings of artificially fertilized plaice eggs, 150 million larvae being liberated in the course of the years 1896 to 1901, and in Norway G. M. Dannevig and O. Nordgaard worked with liberations of cod and plaice larvae, respectively. Alf Dannevig, son of the former, still carries on hatching and liberation of cod larvae from the Flødevigen Sea-fish Hatchery in southern Norway.

The question now is whether such liberations into the sea of recently hatched larvae are remunerative. This is very difficult to ascertain. An endeavour has been made through quantitative fishing experiments to determine the number of a year's brood in the littoral region, and in some cases it has been found that in those years when larvae had been liberated, the amount of yearlings ascertained later was greater than in the years in which no larvae had been liberated. It is now known, however, that natural conditions in the sea cause heavy fluctuations in the number of surviving fry, so that the ascertained increase in the amount of year-broods may very well have natural causes.

In addition recent investigations have proved that the factor which decides whether a year-class is to be rich or poor is not primarily conditioned by the spawning of more or less eggs or the hatching of more or less tiny larvae. To a far greater extent it is determined by the physical and biological conditions in the sea at the time when the eggs are hatched and the larvae are driven along unresistingly with the current. If conditions are favourable, it is not especially important whether 1,000,000 million eggs have been spawned or only 10,000 million; the year-class will still be rich, and represent a comparatively large increase of the brood of the year. If conditions in the sea are unfavourable, on the other hand, the larvae will perish in such large quantities that the year-class will be poor.

All that is known at present about these matters seems to indicate that the time when the tiny larva has just been hatched from the egg, has consumed the yolk sac and has begun taking up nourishment by itself, is a particularly critical point in the life of the fish. If at that time the surrounding water layers are poor in the plankton nourishment required by the tiny larva, it will perish. The same thing will happen if at the time mentioned a particularly large number of predatory animals are gathered in these water layers. The larva will likewise perish if, at the stage of its development where it seeks the bottom, it is carried by the current to places unsuitable for its continued growth. Thus, both cod and plaice, for instance, when they have reached the bottom stage, must be carried to the littoral zone along the coasts in order to grow, for only here are found the animals on which they must feed during their first year; but since the eggs are spawned in comparatively deep water, the tiny larvae will perish if the current does not carry them in to the coast just at the time that they have become big enough to seek the bottom.

This view is supported by many other observations. It has been found that a year-class may well be rich even if the number of mother fish is heavily reduced, and on the other hand an unusually large number of spawning mother fish may well give a poor year-class. It must be borne in mind that the fish spawning pelagic eggs (eggs floating in free water)—and these are the fish that we are dealing with here—will spawn so many eggs (a full-grown cod or plaice may well spawn a million eggs) that there will always be enough to produce a rich brood, if all the larvae are allowed to develop.

Thanks to systematic, quantitative fishing experiments carried on along the Danish coasts for more than forty years, it has been discovered that exceedingly rich quantities of brood may still occur, although the stock of spawning mother fish is known to have declined heavily on account of the intensive fishing of recent years. But, on the other hand, the protection which was given to the stock of fish in the North Sea during the two world wars and which resulted in a heavy increase of the amount of spawning fish, did not simultaneously result in a greater than usual amount of young fish near the coasts.

When it is recalled that the larvae, which are liberated freely into the sea under the experiments mentioned above, are liberated just at the most dangerous stage of their lives—namely, just after the yolk sac has been consumed—it will be understood why many fishery biologists are sceptical regarding the use of such measures.

Several experiments have been made in rearing the larvae beyond this stage, but the many unsuccessful results seem to verify what has been stated earlier as to the hazards of this stage in the development of the fish. In recent years, however, G. Rollefsen (10, 11)[1] has succeeded in bringing flatfish beyond this stage by feeding them on *Artemia* nauplii.

As is well known, eggs of *Artemia salina*, a brackish-water crustacean living in southern Europe, may be shipped in dry condition and remain capable of development for years. In 1939 Rollefsen wrote about his experiments: "Technically there is no serious difficulty with the rearing of flounder larvae, whether done in large or small vats, such as Petri dishes, and experiments have shown that 50,000 to 100,000 larvae may easily be reared in a 200-litre tank.

"The rearing percentage is very satisfactory—as high as 50 to 75 per cent—with a very low mortality after eight to ten days.

"The feeding problem seems all-important while temperature, salinity and pH are minor factors within fairly wide limits before influencing the experiment.

"The metamorphosis occurs very unevenly—some larvae take to the bottom after about four weeks—others remain pelagic up to six or eight weeks even at a temperature of some 10 degrees" . . . .

"The hatching of *Artemia* eggs is carried out at 20 to 30 degrees by aeration and stirring. Some 25 to 50 g. of *Artemia* eggs are required per day for half-a-million fry. About 6 kg. of *Artemia* eggs collected in Romania, Italy and Spain have been at disposal for these experiments."

In order to control the effect of the liberation of the young flatfish, Rollefsen has crossed *Pleuronectus platessa* ♀ with *Pl. flesus* ♂ and liberated both newly hatched and hybrids which were reared to the bottom stage in the small Borgenfjord near Trondheim. In March 1946 about 3 million and 300,000 hybrids of the two stages, respectively, were liberated. Percentage observations on the occurrence of young hybrids were made in the autumn; the degree to which the metamorphosed fish remained in the locality was also investigated, and very promising results have been obtained in both respects.

Nevertheless this matter must be said to be in the experimental stage and we must await with expectation a continuation of these experiments on a commercial scale. They should certainly be extended to other species of fish. If we really succeed without great costs in rearing salt water fish to the bottom stage, where they are not nearly so helpless as in the pelagic stage, great perspectives are open. Experience from fresh water fisheries points rather conclusively to the fact that in many cases it is more remunerative to liberate 100 six-month-old fish than 1,000 tiny larvae.

It has been proved by Danish investigations (6) that particularly cold winters usually result in a poor year-class of plaice. It is thus possible in certain cases to predict the occurrence of a poor year-class. If it should be possible to counteract predictable declines of stock by liberating artificially-reared bottom-stages of plaice, fluctuations in the stock, which are highly disadvantageous to the fisheries, might be levelled out.

TRANSPLANTATIONS

A distinction must be made between two different kinds of transplantation: (*a*) liberation of valuable food fish into areas where they have not been found before, and (*b*) transplantation of food fish from overcrowded areas to areas with a thinned-out stock but with good nutritional conditions.

Transplantations of the first category have been stimulated by a whole series of experiments, the majority of which were carried out in the latter half of the nineteenth century, many being failures and others successful to such an extent that entirely new fisheries have arisen.

One of the most successful enterprises of this kind is probably the transplantation of shad (*Alosa sapidissima*), a clupeid, living in the sea, but entering the rivers in springtime to spawn. Its habitat is the east coast of North America.

[1]Numbers within parentheses refer to items in the bibliography.

Artificial hatching and liberation of larvae of this fish was first tried in 1848 in order to counteract the decline in the stock. When the attempt proved successful, experiments were made to liberate tiny larvae into the tributaries to the Mexican Gulf, but with no result. In the period between 1873 and 1892 large amounts of fry were transplanted to the Great Salt Lake and other lakes in the State of Utah, and in the Colorado River, but still with no result.

In 1871, on the other hand, experiments to transplant 12,000 larvae from the Hudson to the Sacramento River were successful, and in 1873 the experiment was repeated with 35,000 larvae. In the period 1876-1880, 609,000 additional larvae were liberated into the Sacramento River, and well over 900,000 larvae into the area north thereof. Out of this comparatively small amount of larvae the shad has now propagated enormously and extended to an area stretching from Los Angeles in Southern California to Chilkat in south-eastern Alaska. In 1882 it had reached the Columbia River and in 1891 the Fraser River in British Columbia and the Stikine River in southern Alaska. There was a gradual and parallel increase in the catch; from California alone the landings of shad rose from 100,000 lb. in 1888 to 750,000 lb. in 1892 and in 1927 was no less than 4.1 million lb. Since then the yield has remained fairly constant at this level.

Striped bass or rockfish (*Roccus lineatus*) is a fish of the serranides having its original home on the east coast of North America from Florida to New Brunswick. It grows much larger than the shad, and like the shad it lives mostly in the sea but in springtime enters brackish water or rivers to spawn.

This fish was transplanted in the shape of a comparatively large brood, rather than larvae as in the experiments with shad. In 1879, 132 young fish of a length of 28 to 76 mm. and 30 medium fish were transported from Navesink in New Jersey to the Pacific Coast; 135 survived the transport and were liberated in the northern part of San Francisco Bay. The second and last transplantation took place in 1882 with 300 fish of a length of 127 to 229 mm. which were liberated near the same place.

The effect of these small transplantations was amazing. In 1889, only ten years after the first liberation, a yield of 16,296 lb. was noted, and in 1892, a yield of about a half-million lb. In 1904 the figure had reached 1.8 million lb. The catch had later to be regulated owing to much too intensive fishing (4, 12).

Among the successful transplantations of fish must also be reckoned the transport of salmon and trout to New Zealand. The distance involved—from Great Britain to islands in the southern hemisphere—created great initial difficulties. Fertilized eggs were used but their development was delayed by keeping them on ice at a low temperature. In 1868 the first attempts with European salmon were made, these failed, but subsequent transplantations were successful, although it appears that the salmon does not take to the sea as in Europe, but remains in fresh waters. At any rate salmon are now so numerous in the rivers that it has been possible to establish hatching stations which supply neighbouring rivers with salmon larvae.

The rainbow trout (*Salmo iridius*), the Quinnat salmon (*Oncorhynchus tchawytcha*) and the Sockeye (*Oncorhynchus nerka*) have also been successfully transported to New Zealand, where they have adapted themselves to the changed climatic conditions and spawn in March and April. The rainbow trout was imported many years ago into Europe from the Pacific Coast of the United States, and is now the most important fish in pond culture. Salmon and trout have also been successfully transported from Europe to many other countries, among others to the East Indies and South America.

Experiments in transporting the European herring to New Zealand, however, were among the unsuccessful transplantations. Both in the 1880's and in 1913 attempts were made with fertilized eggs, each time meeting with failure.

No doubt many other experiments, which have not been described in the literature, have failed. But the above-mentioned, extremely successful transplantations of fish to areas where they were not found before, indicate further possibilities of success. The main consideration is that the transplanted fish should find approximately the same hydrographical and biological conditions that they had in their place of origin.

Most transplantations have hitherto been from northern Europe to the southern hemisphere. Since conditions in the two hemispheres are in many respects analogous, it can be reasonably assumed that valuable fish from the southern hemisphere may also be successfully transplanted to the northern hemisphere. With modern means of transport, as for instance the aeroplane, such transplantations might easily be undertaken. Care must be taken, however, that the new species do not multiply at the expense of local, more valuable species. Such transplantations are a task for future initiative.

The second kind of transplantation, which instead of introducing new stocks, supplies new individuals to an already existing stock, has been practised on a notably large scale in Denmark.

Transplantation in the Limfjord.

The Limfjord is a narrow sound separating the northern part of Jutland from the southern part. In certain places the sound expands to broader parts, the so-called broads. It had long been noticed by the fishermen on the Limfjord that the plaice in the westernmost of the broads, which is connected by means of a narrow canal with the North Sea, were comparatively small but numerous, whereas the plaice in the inner broads were very large and fat but few in number. The question then naturally arose, whether it would not be expedient to remove the small plaice from the westerly broad to the inner broads so that they might grow large. On account of the narrow connexion between the broads they were apparently unable to find their way in themselves.

With some government support the first transplantation of plaice took place in 1892. Eighty thousand plaice were transported in well-boats to the inner broads of the Limfjord, and as this experiment seemed successful, it was repeated in subsequent years, but still only on a small scale. Dr. C. G. Joh. Petersen, then Director of the Danish Biological Station, took very great interest in this matter and began a more careful investigation of the plaice stock in the Limfjord to see if there was a real basis for these transplantations. He found that the plaice does not spawn in the Limfjord at all, and that the stock is renewed solely by immigration from the west through the aforesaid canal connecting the westernmost broad with the North Sea. Moreover, he found that the immigration does not extend as far as the inner broads, where—generally speaking—there were no plaice other than those transplanted thereto.

His most important result, however, was that he was able to prove that in the westerly broad the plaice are dense to the point of overpopulation, and that their growth-rate is slow because they are constantly half-starved, so keen is the competition for food. As the density of the plaice stock declines gradually towards the inner broads, the growth of the plaice increases. Finally Dr. Petersen by marking some of the transplanted plaice was able to prove that they do not migrate from the transplantation areas, and that from April to October of the same year they increase their length by no less than 10 to 13 cm. and their weight fivefold. He therefore strongly recommended much larger transplantations, the first being carried out in 1908, when well over 1 million plaice were transplanted.

Since then—with the exception of a few years during the two world wars—these transplantations have been carried out regularly, comprising a number of plaice varying between one and three million. (Figure 1). The State grants an annual subsidy of 20,000 Kr. (30,000 Kr. in recent years) for these transplantations. Every year bids are received from fish exporters who have the number of well-boats required for these transplantations. The one entrusted with the work offers to supply the stipulated number of live plaice to the places of liberation at a fixed price per kg. He then makes arrangements with the local Limfjord fishermen for the fishing; this occurs in April under strict supervision by the State, which also supervises the liberation of the plaice from the well-boats. The stipulated price is paid only for fish fully capable of living at the place of liberation, but it very seldom happens that a part of the cargo must be rejected.

At the liberation the transplanted plaice measure 18 to 24 cm. (average weight 60 to 100 grammes) and are usually two to four years old. In order to obtain full advantage from the transplantations, trawls and Danish seines have been prohibited during the first six and one-half months after the transplantation, and in addition the size-limits for plaice in the transplantation areas have been raised to 28 cm., two cm. more than those in force in other Danish waters.

While it is the Fisheries Inspectorate which supervises the transplantation, seeing that it is competently carried out and that only undamaged fish and fish fully capable of living are liberated, it is the task of the Danish Biological Station to exercise scientific control over the transplantations. The control includes among other things the marking of a number of the transplanted fish, usually 500 to 1,000 specimens. By means of these markings, it has been proved that only a negligible number of the transplanted plaice again leave the Limfjord, and that during the first summer the growth-rate is 10 to 13 cm., while in the westernmost broad from which they originate it would have been only 2 to 3 cm.

The fishermen of the Limfjord are, of course, well pleased with the policy of transplantation because their income is thereby increased. The plaice fishery as a result of the transplantations yields returns estimated at somewhere

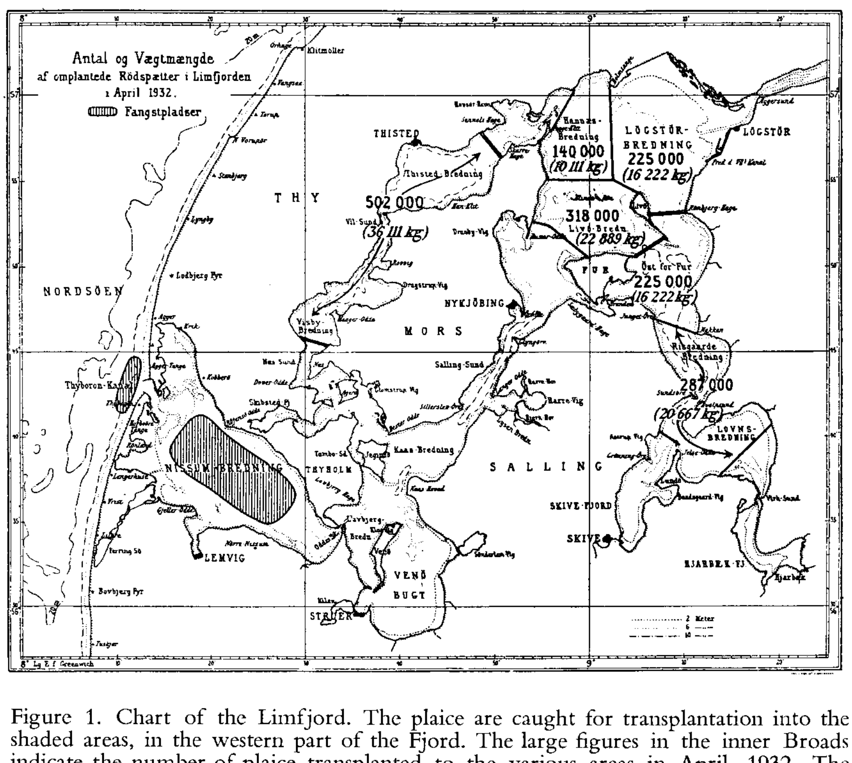

Figure 1. Chart of the Limfjord. The plaice are caught for transplantation into the shaded areas, in the western part of the Fjord. The large figures in the inner Broads indicate the number of plaice transplanted to the various areas in April, 1932. The figures in brackets denote the corresponding quantities in kg.

between 100,000 and 200,000 Kr. annually, against expenditure of 20,000 to 30,000 Kr. by the Government.

The fishermen's associations have often contributed to the cost of transplantation, but as the first section of the Fishing Act states that all Danish subjects are allowed to fish in all Danish waters, the Limfjord fishermen cannot be called upon to pay for measures from which others are allowed to benefit. It is therefore the State alone that defrays the expense involved.

Nearly all the transplanted fish are fished out within one year; only a few very large plaice are found thereafter. Since there is some natural immigration into the broads adjoining the westernmost broad, no plaice are liberated here; but in the remote innermost broads there would be practically no plaice, if the transplantation did not take place.

Transplantation in the Belt Sea.

The yield of the plaice fishery in the Belt Sea—the waters round the Danish islands of Fünen and Sealand—rose rapidly from the beginning of this century until the year 1912, when a maximum of 3,400 tons was attained. During the years 1915-1918, there was an equally rapid decline on account of war conditions, to a yield of about 800 tons as in 1907. Having been left in peace for four years the stock of plaice accumulated once more so that the yield rose sharply in 1919, only to decrease steadily during the following decade until the bottom level was reached in 1929. The intensity of fishing had not decreased, however, for the statistics show a rise in the number of fishing gear.

The explanation of the rise and decline in yield is as follows. By the end of the last century the Belt Sea contained a large accumulated stock of small slowly-growing plaice. Intensive fishing with the Danish seine then started, and the yield rose rapidly though not in proportion to the increase in intensity. During the First World War fishing was greatly reduced so that the stock again accumulated. For the second time the yield showed a considerable rise, then declined steadily during the following years although there was no diminution in the fishing effort.

This is a striking example of overfishing: an accumulated stock was worked to such a degree that the yield, after a short period of increase, decreased in spite of constant or even mounting intensity of fishing.

The reduction of the yield after 1919 gave rise to the idea of transplanting North Sea plaice to the Belt Sea in order to restore the rapidly decreasing population of the latter water.

After some preliminary experiments carried out by Dr. A. C. Johansen (7), the first large-scale transplantation was started in 1928: one and a half-million plaice (weight 103,000 kg.), taken partly from the westernmost broad in the Limfjord and partly from Horns Reef in the North Sea off Esbjerg, were transplanted to the Belt Sea.

The procedure was mainly the same as in the Limfjord: through the Board of Fisheries an agreement was made with a fish-merchant, who had the necessary means of transport, to supply the stipulated weight of plaice of 17 to 25 cm. in length from the North Sea at a fixed price and under certain conditions. The most important conditions were as follows:

1. After being landed at Esbjerg the plaice were to be kept in well-boxes for at least 48 hours before being carried overland to Fredericia (a harbour on the east coast of Jutland) in a closed fish-lorry. (This was necessary in order to rid the plaice of the stomach content, consisting of crushed shells of bivalves, which in transit overland might hurt the intestines of the fish.)

2. At Fredericia the plaice had to be kept in well-boxes for at least another 48 hours. (To allow the fish to accustom themselves to the fresher water of the Belt Sea.)

3. From there they were carried to the place of liberation by well-smacks of at least 20 tons gross. The maximum load was fixed at 2,000 to 2,500 kg. as estimated by the Fisheries Inspectorate.

4. The contract price was paid at the place of liberation, but only for fish which in the judgment of the government inspectors were likely to live.

5. Liberation of the fish was to begin during the first half of April and to be concluded before the end of the same month.

As in the Limfjord the actual work of liberation was supervised by the Fisheries Inspectorate, and the markings and the working up of the results by the Danish Biological Station. Two to three thousand fish were marked every year during the first years but later on only about 1,000 fish per year were marked.

As the first transplantation proved to be extremely successful, the transplantations were continued during the following years, the annual number of transplanted fish in the period from 1928 to 1939 inclusive being between 1 and 2 million plaice. The Second World War, however, put an end to this activity, which was not resumed until 1946.

While in 1928 the plaice were taken partly from the Limfjord and partly from the Horns Reef, they were taken solely from the Horns Reef in the period 1929 to 1939 (see Figure 2). In this area there is a constant overpopulation of plaice with a slow growth-rate. Since 1946 all plaice have had to be taken from the Limfjord, but the long transport on well-boats (sometimes 24 hours or more) has apparently not resulted in a mortality of any importance (hardly 2 per cent). Consequently these transplantations will be continued.

It has been demonstrated by the investigations carried out by the Danish Biological Station that the transplantations to the Belt Sea, like the Limfjord transplantations, have been successful. Marking experiments have brought to light the following facts.

1. The percentage of recaptures of the transplanted North Sea fish shows that at least one-third of all the plaice transplanted are recaptured by fishermen. The recapture of marked plaice ranged between 21 and 39.5 per cent from 1928 to 1933, decreasing subsequently to figures between 7 and 12.5 per cent because no rewards were paid after 1934 for marked plaice below the minimum size, and also because the former fee of 2 Kr. per label forwarded was reduced to 1 Kr. Accordingly most of the labels were not forwarded, and a calculation based on these figures cannot be made. From the monthly recaptures of marked fish before 1934 the value of the North Sea fish recaptured by the fishermen can be calculated month by month. From these calculations it appears that the total

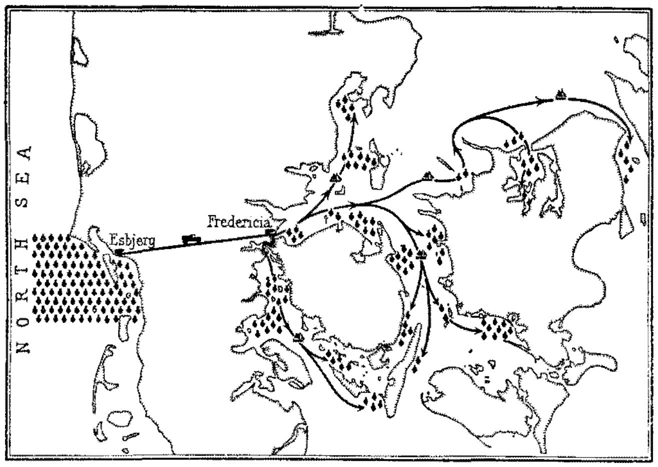

Figure 2. Diagram of the Transplantation Experiments from the North Sea to the Belt Sea during the years 1929—1933. The plaice were caught in the Horns Reef area at Esbjerg, where they were kept in well-boxes for 2—3 days before the transport by fish lorries to Fredericia. Here the fish again were kept in well-boxes for some few days. The transport to the places of liberation took place by means of well-smacks.—In the figure each fish denotes 10,000 plaice and the ways of transport are shown by heavy black lines

value of the fish—marked and unmarked—recaptured amounts to 100,000 to 200,000 Kr., while the actual cost of the transplantations may be put at about 40,000 Kr. The Government's annual grants are about 50,000 Kr., but part of this sum (about 10,000 to 12,000 Kr.) goes to the scientific control, marking work, rewards for the marked fish sent in by the fishermen etc.

2. The marked plaice remain near the localities where they have been liberated.

3. The growth of the transplanted plaice is very rapid, 10 to 12 cm. during the first growth-period, which is more than the growth of the local Belt Sea fish (see Figure 3). At the same time they have gained five-fold in weight.

It is a well-known fact that the North Sea plaice are racially distinct from the plaice of the Belt Sea. The shape, too, is different, the North Sea fish being more slender, so that the fishermen are usually able to sort out the transplanted fish in their catch. On this basis, they all admit having benefited from the transplantations.

The transplanted North Sea fish are older than the Belt Sea fish of corresponding size, the former being already three to five years old at transplantation, while the Belt Sea fish of the same size are only two years old. Also the otoliths are different, the growth-rings being uniform and rather broad in the Belt Sea plaice, whereas the rings in the North Sea fish show an inner series of very narrow zones, corresponding to the number of years spent in the Horns Reef area, and another series of broad zones, testifying to the rapid growth in the Belt Sea. Accordingly race and age analyses have enabled us to ascertain the percentage of North Sea fish in the catches of the fishermen. From these observations we have calculated the income of the fishermen from the transplantations to be a sum varying from 100,000 to 200,000 Kr. annually.

Thus, by calculating in two different ways we have come to the same result, that these transplantations have been very profitable. In order to bring about increased results from the transplantations, a closed season for female plaice in the transplantation areas was introduced in 1933, the closed season being the months of February and March, the spawning period of the plaice. In fact, it has become apparent that many of the transplanted plaice spawn in the Belt Sea, and while the male plaice are good marketable commodities, the spawning females are meagre and watery, so that they should be spared.

Other possibilities in transplantations

Small experiments of transplantations of plaice from the North Sea to local waters have been carried out with varying success by Swedish, Norwegian and German groups. Experiments with marked plaice have indicated that a large-scale transplantation from the English and Danish coasts to the Dogger Bank in the North Sea would no doubt be a remunerative enterprise. Plaice from over-populated areas with a slow growth-rate here grow 13 cm. from April to November, i.e., at least as much as the North Sea fish in the Belt Sea. Although the International Council for the Exploration of the Sea has repeatedly recommended this project it has hitherto been impossible to carry it out in the absence of an agreement as to who is going to defray the costs calculated in 1930 at £3,000.

There is now, however, a good prospect that the Danish State will undertake this task. Marking experiments have proved that more than 80 per cent of marked plaice liberated at the Dogger Bank have been recaptured by Danish fishermen. A removal from the Horns Reef area of an even considerably large number of plaice for transplantation purposes would mean no disadvantage whatever to the stock of this locality. It has been calculated (5) that at least 100 million plaice of the size used for transplantation are crowded in this narrow area. If anything, a thinning out of the stock must be considered an advantage in bringing about a more rapid growth of the remaining individuals.

Cod may also be transplanted. At a time when there were very few cod in the Limfjord a few well-boat loads of cod of 25 to 35 cm. were transported from the Kattegat

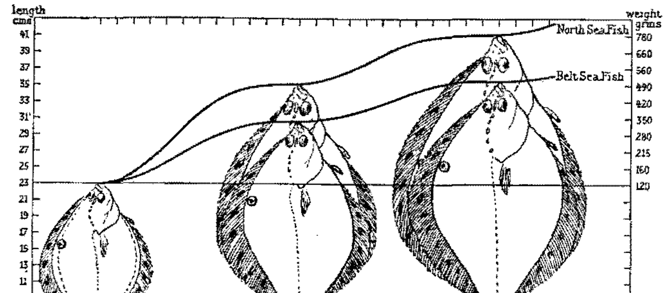

Figure 3. Growth of marked plaice in the Belt Sea. Transplantation Experiment of 1928. The upper curve gives the growth by length and by weight of the transplanted North Sea plaice, the lower curve illustrates the growth of the local Belt Sea fish. Notice the more oblong shape and the protruding snout of the North Sea plaice. In the figure on the left the shape of the North Sea fish is indicated by dotted lines

to the inner broads of the fjord, where they throve well; but when there was again a natural immigration of cod to the Limfjord these transplantations were discontinued.

Transplantations such as the ones mentioned in this paper can unquestionably be carried out successfully in other countries. The exceedingly efficient fishing gear of the present time will lead to overfishing so that it might prove remunerative in many places to renew the stock through transplantation of fish from waters where there is a dense concentration of slowly-growing fish.

EXPERIENCE GAINED FROM TRANSPLANTATIONS

Experience gained from the transplantations of the past forty years in Denmark has proved that the following points are important in obtaining a favourable result:

1. The transplantations should be planned by the fishery authorities on the basis of biological investigation of the fishery; but the practical execution should be entrusted to an expert or a firm which has the technical equipment required, and is able to give surety for the fulfilment of the conditions stipulated.

2. The transportation of the fish should take place in the cold season. If the transport is carried out in well-boats the latter should not be loaded too heavily, and the voyage should take place in calm weather. If the transport takes place overland the fish must first be kept in well-boxes until their stomachs and intestines are emptied. In cool weather the plaice are then fully capable of living in boxes with straw in closed lorries, provided the transport—preferably at night—does not last more than about twelve hours.

3. The fish should be neither too small nor too large. For plaice a total length of 17 to 24 cm. has proved suitable.

4. The fish should be liberated at places where food conditions are favourable and where the original stock is scarce.

5. Measures must be taken to spare the transplanted fish, especially at first, partly through provisions for size-limits, and partly through a reduction in the use of certain detrimental fishing gear; in addition, a closed season during the spawning period has proved expedient.

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Propagation and Transplantation of Marine Fish in Europe

ALF DANNEVIG

ABSTRACT

The culture of sea fish in Europe dates from 1884. Experiments have been made with cod at Flødevigen, Norway and with plaice at Dunbar, Scotland and at Trondheim, Norway. Rearing of plaice and a bastard, *Pl. platessa* ♀ × *Pl. flesus* ♂, has also been undertaken at Trondheim. The techniques are well developed and the hatcheries liberate about 75 per cent of the spawned eggs and larvae about a week after hatching. The cost of production is about £2 per million (pre-war) for the cod larvae. The rearing of flatfishes is also very successful.

The experiences of the fishermen with respect to the utility of the culture were promising, and so were the direct experiments. Since there was uncertainty as to the effect of natural variations upon the results, the problem of sea-fish culture was investigated on a broad basis. The findings were as follows:

1. The percentage of eggs hatched in nature is evidently extremely low.

2. The occurrence of larvae in the insulated fjords in southern Norway is so small that the liberation of larvae is likely to have considerable importance.

3. There will not ordinarily be an exchange of larvae between the fjords and the waters outside the coast.

4. Theoretically the utility of sea-fish culture cannot be denied, and the results obtained from the earlier experiments, can be taken—as far as they go—as positive evidence of the utility of the culture.

The transplantation of young plaice has been undertaken by the Danish government for years. By tagging experiments and statistical analysis, it has been shown that the work pays.

When Professor G. O. Sars in 1864 at the great Skrei-fisheries in Lofoten identified the cod egg and described the development of the embryo, the larval and post-larval stages, he also considered the usefulness of taking care of the eggs, hatching them and liberating the larvae in the fjords.

The problem of sea-fish culture was thus raised. Experiments on the techniques were carried on in several countries, and the hatching of millions of eggs of several salt-water fishes was subsequently carried out on an ever-increasing scale. Much money was devoted to the work, and quite naturally the question arose: Does it pay? During the early period of sea-fish culture the question had to be answered on the basis of the experiences of the fishermen, which were often most favourable (United States and Norway). Later an attempt was made to give the results in figures based upon direct experiments.

In Norway experiments were undertaken by Knut Dahl and my father G. M. Dannevig (1)[1], the founder of the Flødevig Sea-fish Hatchery. Two fjords were fished in the autumn to ascertain the number of the O-group of cod in the littoral region. In the same way the Stendalsfjord was examined by my father, and I, a student at the time, had the opportunity of participating in the experiments every year except in 1903 (2). The results per haul with the seine were as follows (the figures in italics indicate the years when cod fry were liberated):

Locality:	*Hauls:*	*1903*	*1904*	*1905*	*1906*
Hellefjord	21	1.9	6.5	*7.5*	
Søndeledfjord............	106	4.8	*15.2*	*11.5*	
Stendalsfjord	34		13.5	*22.2*	*28.0*

In Scotland experiments along the same lines were carried on with plaice (3). In Loch Fyne, 142,880,000 plaice larvae were liberated in the six years from 1896 to 1901 and the number of plaice of the O-group in the littoral region was taken each year. A count was also made during the six following years when no larvae were liberated, with the following results: from 1896 to 1901, 81.1 plaice per hour of fishing; and from 1903 to 1908, 39.6 plaice per hour of fishing.

The results attained by direct experiments were very favourable with respect to the artificial propagation of cod as well as of plaice. The results were, however, explained by the sceptics of sea-fish culture as a result of the natural yearly variations in the propagation of the species, and also as a result of the influence of the currents. It was pointed out, moreover, that it was not sufficient to increase the stock of young fish. If they did not stay in the fjords, the economic returns to the local fisheries might be problematic.

In a paper on the experiments with hatching the plaice in the Trondheimsfjord, O. Nordgaard (4) considered the effect of the liberation of plaice larvae on the actual quantity of fish caught, and while his evidence was not conclusive, he was of the opinion that the experiments were very promising.

In 1911 when I was given charge of the Flødevig Sea-fish Hatchery, I thought it more convenient to postpone direct experiments and instead to stress the work of examining the hydrographical and biological factors involved in sea-fish culture. My chief programme was to investigate:

1. The percentage of hatching of pelagic eggs in nature compared to that in the hatcheries.

2. If the number of larvae liberated was high enough to be of importance in relation to the natural reproduction.

3. The natural conditions of importance to the survival of the fry, artificial as well as that hatched in nature. The causes for the natural fluctuations.

4. The biology of the young, whether they stayed in the coastal waters or emigrated.

These investigations have been going on ever since, often under rather difficult conditions. The results are given in a number of papers (5) and may be summarized as follows:

In the hatcheries, approximately 75 per cent of the eggs spawned are hatched and then liberated in the fjords about a week later at a cost of about £2 per million cod fry (pre-war). As for the hatching of eggs in nature, Apstein (6) has figured out how many fish eggs in early stages are required to produce one larva. His results were:

Plaice	171.3 eggs
Flounder	470.0 eggs
Cod	72.0 eggs

H. C. Williamson (7) gives the following number of eggs in the different stages (α ε) for some species in Loch Fyne, March to June 1898:

	Eggs					*Larvae*
	α	*β*	*γ*	*δ*	*ε*	
Cod and haddock ...	3,562	1,467	1,219	467	574	92 (cod)
Plaice	129	101	166	42	87	7

I have been working on the same problem. Some of the results of investigations in Canadian and Lofoten waters are given in papers by Johan Hjort (8) and by me (9). These waters, however, are not suitable media for determining the survival of eggs. The currents may carry the eggs away from the spawning places. If the hauls are made at the very place of spawning, the eggs will represent only early stages, while if the hauls are made farther away, there may be few eggs, and all in late stages. The time of fishing in relation to the chief spawning season is also of the highest importance.

The best material at hand is from the Oslofjord (Dannevig 1945), where the inner part is well insulated. The experiments here have been going on for four years, three cruises being made every spring, in the early, middle and late season of spawning. The results are as follows:

Egg net: 1 metre in diameter, horizontal hauls of 10 minutes at 0, 10, 20 and 30 metres

	Cod and haddock eggs				*Identified*			
		Stages			*Cod*		*Haddock*	
Locality	*Total*	*I*	*II*	*III*	*Egg*	*Larv.*	*Egg*	*Larv.*
Inner fjord	10,463	8,349	1,763	351	176	76	6	3
Percentage...........		(80)	(17)	(3)				
Outer fjord.........	11,134	5,884	4,610	640	451	232	27	56
Percentage...........		(58)	(36)	(6)				
Skagerack	1,945	800	917	228	87	106	28	24
Percentage...........		(41)	(47)	(12)				
TOTAL	23,542	15,033	7,290	1,219	714	414	61	83
Percentage...........		(64)	(31)	(5)				

[1]Numbers within parentheses refer to items in the bibliography.

In comparing the number of identified cod eggs to cod larvae and young ones, it must be remembered that the age of the latter may represent a much wider span of development than that of the different egg stages. No percentage is therefore reckoned.

The percentage of eggs in late stages increases as one goes from the inner fjord towards the Skagerack. In the inner fjord the survival of the eggs may be hampered directly or indirectly by the sewage from Oslo. The locality investigated in the Skagerack is relatively deep and it is likely that spawning occurs but sparsely, giving few eggs in early stages. It is evident, however, that the number of eggs is greatly reduced during the development in all localities, and that the number of young is exceedingly low. What factors are involved in the destruction of the eggs and the larvae cannot be discussed in this paper.

In the inner fjord 76 cod larvae and young ones were caught in 192 hauls. If we assume that each haul filters 100 cub. metres of sea water, we have 4 larvae per 1,000 cub. metres. The layers containing cod larvae in the inner Oslofjord comprise about 5,000 million cub. metres. We thus ought to have a mean of approximately 20 million cod fry simultaneously in that locality. In 1938 between March 10th and April 25th approximately 100 million cod larvae were liberated in the same locality. The pelagic fishing gave the following number of cod fry per haul:

Mean 1936-1939: 0.4 fry per haul (1938 included);

Mean April 1938: 1.0 fry per haul;

Mean May 1938: 2.0 fry per haul.

The cod fry was more numerous in the year larvae had been liberated, and a few years afterwards the fishermen found an extraordinarily good supply of young cod. On the other hand, the 1938 year-class of cod was also exceptionally good in places where no cod fry had been liberated. The apparently good results may therefore be due to the hatching of a very high percentage of the eggs spawned in the inner fjord. The number of vertebrae etc., of the young cod in the inner fjord differed from that in the outer, thus the cod larvae in the inner fjord were endemic.

The results from any liberation of larvae, it must be understood, depend upon the natural conditions. If these are favourable, we may expect good results—and vice versa. The question therefore arises: Is it possible to ascertain in advance whether the conditions are favourable or unfavourable? This question may now be answered in the affirmative with some reservations. Studies made during the last few years both in nature and in the laboratory have supplied much knowledge on the matter.

On the basis of the results obtained from broad investigation, new direct experiments on the usefulness of liberating cod larvae were started in the Oslofjord in 1936. The war put a stop to the work but now we hope to continue the experiments. In my opinion the prognosis is very favourable.

By tagging experiments, vertebrae counting etc., it has been demonstrated that the number of cod living in the fjords and *skjaergard* is stationary to a high degree. If as a result of experiments it is established that the stock of young cod can be augmented, we may be sure that the district where liberations take place will benefit therefrom.

Mr. G. Rollefsen, director of the scientific staff of the fisheries in Bergen, has demonstrated the effect of liberating sea-fish larvae by producing a great number of bastards (*pl. platessa* ♀ x *Pl. flesus* ♂). They were liberated in the small Borgenfjord, near Trondheim, and the ratio of bastards to plaice in the littoral region was ascertained some months later. The results were as follows: (10)

	Liberated bastards	*Percentage of bastards*
1935.........	2 million	1.5
1936.........	13 million	30.0
1937.........	7 million	0.5
1938.........	10 million	96.0
1939.........	7 million	40.0

The bastards evidently survived at a very high rate. By rearing experiments it was shown that the plaice and bastard larvae did not thrive in the same pond, but that the bastards dominated. When the plaice were reared alone, the survival rate was very high. By means of Rollefsen's method of feeding the fry with artemia larvae, it is now possible to rear great quantities of flatfish larvae to the bottom stage and to gather data on the economic advantages of the method.

The hatching of lobster has been carried on in Newfoundland, in particular. In Norway we have been rearing the lobster larvae, but experiments were interrupted by the war (11). By stripping the berried lobsters caught, the eggs may be hatched and the larvae liberated or reared.

The effect of transplanting new species to localities has been strikingly demonstrated. I will but mention the introduction of several anadromeous salmonidae to New Zealand and the transplantation of shad (*Clupea sapidissima*) from the Atlantic to California. The salmonidae were transported as eggs, the shad as newly hatched larvae. Transplantation of young fish on a commercial scale has been carried on in Denmark with some interruptions since 1892. On the west coast of Jutland there is a very dense population of plaice at a size of about 25 cm. Transplantation of the young fishes to the inner waters results in marked improvement in growth. Blegvad (12) reckons that the economic return from the transplantation may equal some 100,000 Kr. at an expense of about 50.000 Kr. a year.

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Summary of Discussion

The CHAIRMAN said that eight papers had been prepared for the present meeting. These had been distributed to the participants. He proposed that the present group devote itself to a discussion of the general topic without attempting to summarize the various papers.

The Chairman recalled that some members of the Section had met to draw up a map of the sea areas of the world in which fishing was undeveloped or insufficiently developed. The question of latent resources was of the utmost importance and would doubtless give rise to a long general discussion; the Chairman therefore requested the members of the section to take up the discussion immediately without devoting any time to the study of the individual papers which had been duly considered by the authors of the map in the course of their work.

He requested Mr. Walford to tell his colleagues of the result of that work.

Mr. WALFORD stated that it was obvious from the figures which were available that the world production of fish at present amounted to approximately 17,690,000 tons, of which two-thirds were used directly for human consumption and one-third was converted into various industrial products.

Asia produced 49 per cent of the total quantity of fish caught, Europe 32 per cent and North America 16 per cent; the remaining areas of the world produced 2 per cent. 98 per cent of the fish were caught in the Northern Hemisphere and only 2 per cent in the Southern Hemisphere. Production was distributed in the following manner among the oceans: Pacific Ocean: 48 per cent; Atlantic Ocean: 47 per cent; Indian Ocean: 5 per cent.

A relatively small number of species could be considered as constituting large populations. In the Atlantic the cod and haddock families represented 10 per cent and herring, 15 per cent of the total fish population; in the Pacific, sardines represented 10 per cent and tunny, 2 per cent.

The productivity of the waters of the Northern Hemisphere was due to the presence of those few species with very large populations. Account must also be taken of the fact that the Northern Hemisphere had numerous fisheries provided with modern equipment and that its waters were more suitable for trawling than those of the Southern Hemisphere.

The experts who had met to draw up the map had almost unanimously agreed on the possibility of developing herring and cod fishing over a large part of the world.

In the Arctic Ocean, off Newfoundland, cod fishing had certainly not been as extensive as might be expected; the same was true for the shoals of cod in the Barents Sea, which were practically untouched.

In the European waters of the Atlantic and off the Eastern coast of North America, there were definite possibilities for the expansion of herring-fishing. Certain technical problems had to be borne in mind, however, for herring were present in great numbers during a relatively very short period, so that the catching, smoking and preserving must be done rapidly, although large quantities were often involved—whence the need for technical improvements in the fishing industry.

In regard to plaice, there seemed little doubt that the suitable fishing grounds covered approximately an area of 600,000 square miles, whereas at present only 60,000 square miles were being exploited.

There were no pelagic species in the Antarctic. To develop fisheries there, a good deal more would first have to be known about the biological conditions of the species inhabiting those waters and about the hydrographic and oceanographic factors affecting those conditions.

Mr. Walford pointed out that there were large numbers of tunny along the coasts of Africa, as well as numerous clupeidei and anchovies.

Anchovies were found also off Brazil, and anchovies and pilchards in great quantities off the west coast of South America.

The southern waters of Africa and Australia would also seem to be very rich in fish.

Herring was stated to have been found off the coast of Patagonia, but there was no confirmation of that statement.

In Asia, there were numerous species of tunny, which might usefully be fished.

Clupeidei had been noted off India, but very little information concerning them was yet available.

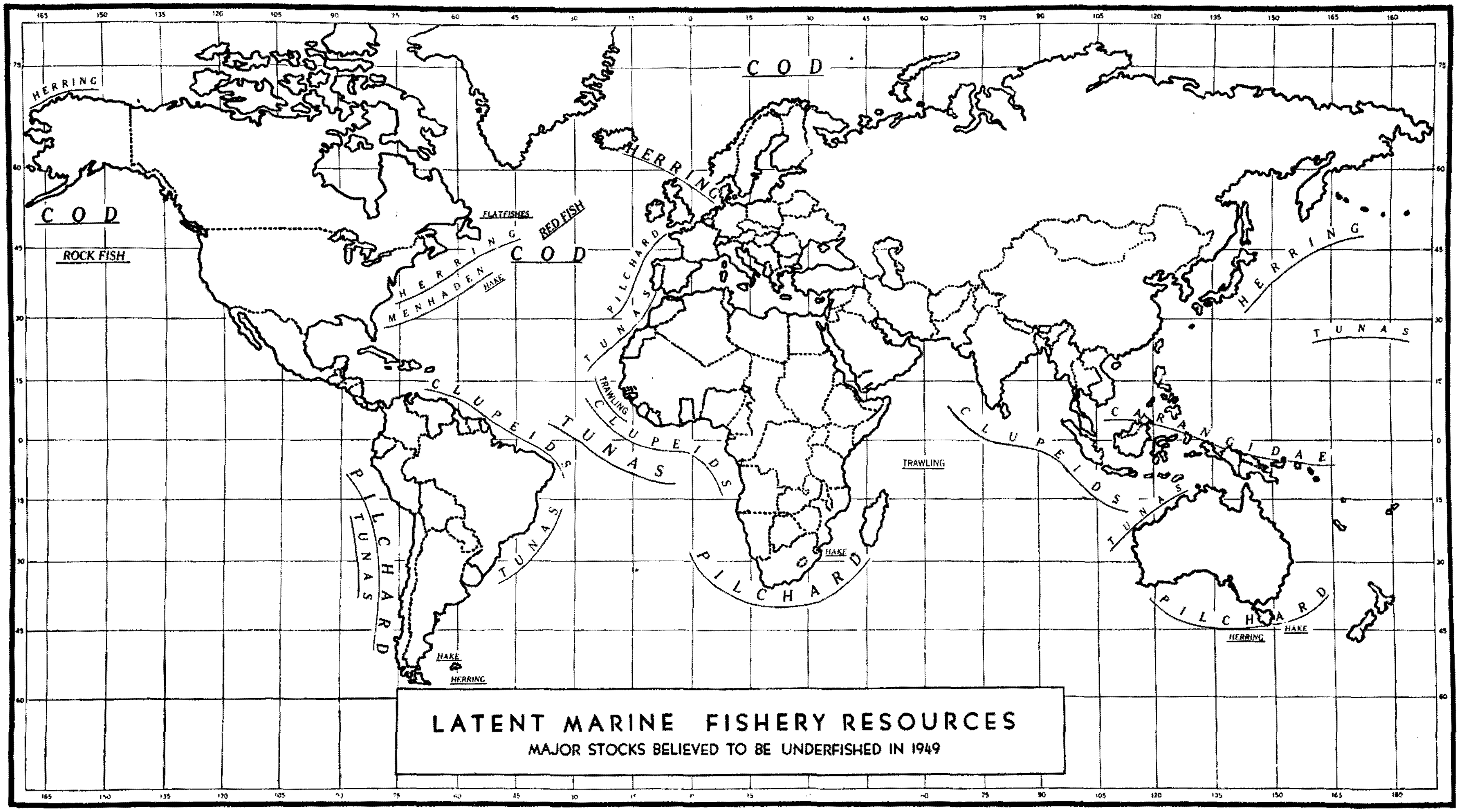
Lastly, there were certainly unexploited populations of salmon and redfish in the Atlantic and off Alaska.

Such was the available information on the basis of which the map of the fishery resources of the world had been drawn up.

Mr. Walford remarked that that information referred to only a few species, of which there were sufficiently large numbers to justify the hope that the present production of fish in the world might be increased.

There were, of course, other species which should be noted, especially the mackerel and barracudas of tropical waters, but the authors of the map had wished to restrict themselves to the most numerous populations.

Lastly, Mr. Walford cited estimates provided by Mr. Thompson of the total increased world fishery production. According to Mr. Thompson, the total yield of fish caught in temperate waters could amount to 2.7 million tons, and



LATENT MARINE FISHERY RESOURCES

MAJOR STOCKS BELIEVED TO BE UNDERFISHED IN 1949 that from tropical and subtropical waters to 1.3 million tons, or an increase of 22 per cent as compared to pre-war production. Those figures did not take into account information concerning the USSR, which was not available. Mr. Walford emphasized that that percentage estimate had been based on the information available, and that it referred only to the species mentioned; it was a very conservative estimate, and there was every reason to hope that progress would be made with the introduction of new ecological methods. In fact, the estimate of 22 per cent represented a minimum.

The CHAIRMAN suspended the meeting for five minutes to enable the experts to examine the map submitted for their approval.

The CHAIRMAN requested Mr. Walford to report on the additions and corrections to the map which the members wished to make.

Mr. WALFORD stated that, according to the general opinion, tunny should occupy more space on the map. In fact, shoals of tunny had been noted off both the west and east coasts of South America. The presence of fish of the menhaden family had been noted on the east coast of North America from Maine to Mexico. Lastly, it would seem that there were completely unexploited populations of fish of the menhaden species off Dakar, as well as "kages" off Patagonia and Newfoundland.

The CHAIRMAN requested the experts who had communicated that information to submit additional details.[1]

Mr. AUDIGOU stated that having recently had the occasion to consult the FAO library in Washington he had been able to obtain the information which he had just communicated concerning the presence of tunny off both coasts of the South American continent. The information in question was very vague as to the exact place where the fish had been located, and as to their number. It would seem, however, that they had been found beyond the continental shelf.

Experiments would have to be continued before exact figures would be available. Mr. Audigou added that tunny was no longer found to the south of South America, as those fish had been noted only off the northern two-thirds of each coast.

Mr. HORA pointed, in that connexion, to the importance of the geography of the sea-bed in estimating latent resources. In the absence of direct proof, geography was the only way of determining fairly accurately the ecology of any given region. The first step to be taken in any study of that kind was to explore the sea-bed.

In India, for example, experimental trawling had been carried out in the regions of Bombay, Madras and Bengal; those explorations had revealed large quantities of cartilaginous species which offered only limited interest from the point of view of fisheries. The fact that along the west coast there was only a 70-mile stretch less than 100 fathoms deep, and that along the east coast the width of bed less than 100 fathoms deep was only 50 miles, was an important factor in assessing the latent resources in the coastal regions of India.

[1]The final suggestions were incorporated in the map reproduced herewith.

Mr. Hora remarked that there were no large continental shelves in the Southern Hemisphere and that no exact information was available concerning the extent and depth of the seas. The study of the geography of that region was therefore an essential prerequisite to any assessment of latent resources.

The CHAIRMAN recalled that Mr. Wheeler had mentioned that there was a large unexplored region north of Madagascar: he suggested that it should be marked on the map as being suitable for trawling.

Mr. HORA was of the opinion that that might be done, if it were ascertained that the waters were of a depth not exceeding 100 fathoms. Obviously those zones could be designated as apparently suitable for trawling only on the basis of the geographical information available, and no indication could be given as to the nature of the fishing anticipated.

The CHAIRMAN proposed putting on the map, opposite the region in question, the word "trawling" in small print.

It was so decided.

Mr. MONOD mentioned a few particulars on the location of the fisheries along the west coast of Africa.

He agreed that considerable importance should be attached to the fishing of the *pelagic* clupeid among the most important of which was the menhaden. A fish of that family, the *Ethmalosa dorsalis*, was already much fished by the natives from Cape Blanco to the Congo. That fish was used in a certain number of canning factories for the preparation of fillets which resembled herring fillet. It was caught in cast-nets, drag-seines, or drift-nets. Experiments had been made with surface circle nets, and that was doubtless the method which should preferably be used for a large-scale fishing industry.

The fact that there was not enough biological information about that fish was an obstacle to its exploitation. There was no doubt that it was a limivorous and microphagous clupeid which ate only very little animal plankton; it fed on the bottom of the sea and consequently remained very near the shore. In the Bay of the Cameroons its movements appeared to be governed by the degree of salinity of the water. The places where it laid its eggs were not yet known, but several biologists were trying to discover them.

Mr. Monod also mentioned the presence along the same coast of a fish of the Sardinella genus, of the *eba* or *cameronensis* species, which was caught in cast-nets and drift-nets.

In addition to those clupeid fish must be mentioned the tunny, which was also abundant along the west coast of Africa and the exploitation of which was still to be undertaken. Fishing enterprises in the Cape Verde Islands were already canning tunny. That was a resource which was assured and of great importance.

In addition to those pelagic species, there were many others in the waters of French West Africa, where it seemed trawling was destined to play a more important part. Mr. Monod had more particularly in mind the continental shelf which bordered on the Spanish Sahara, French Mauretania and Senegal. It was not yet known how far that trawling zone extended to the south, but it seemed to be extremely rich in bottom fish. That abundance of deep-sea fish appeared to be related to the hydrographic conditions: it was certain that the Canarian current considerably increased the amount of nutritive salts and plankton in those waters.

In regard to the current development of shark fisheries, Mr. Monod stated that that cartilaginous fish was not a resource to be neglected, even from the point of view of food. In French Senegal, in Guinea and on the Ivory Coast, sharks were caught in nets, more seldom with lines, and a 25 cm. mesh net had even been adopted recently. Various species of shark were being caught in that way. One advantage of the shark was that there was not a single part which was not utilized: its oil possessed vitamin properties; its flesh, salted or smoked, was edible; its skin and fins offered commercial possibilities. Mr. Monod thought that that was a partially unexploited resource, but one which might not prove to be inexhaustible. In French West Africa, for example, a certain decrease in the number of sharks had been noted since the fishing had been systematically organized; enterprises had been obliged to spread out their fishing stations along the coasts instead of having them closer together, as had at first been the case.

The CHAIRMAN observed that it was unlikely that there were large populations of sharks. He wondered therefore whether Mr. Monod might not think it advisable not to include that species in the list of the principal unexploited resources.

Mr. MONOD said that as he had already pointed out, sharks did not seem to be an inexhaustible resource. It would therefore be better not to mention them among the major resources still to be exploited.

Mr. HORA agreed with Mr. Monod.

The CHAIRMAN asked Mr. Monod whether he thought trawling off the coast of French West Africa should be indicated on the map.

Mr. MONOD replied in the affirmative, but specified that the trawling area should be confined to the coastal strip extending from Rio de Oro to Senegal inclusive.

The CHAIRMAN then asked Mr. Monod whether the existence of tunny along the tropical coast of French West Africa should be indicated.

Mr. MONOD thought an addition should be made to the map so as to indicate the existence of tunny in the eastern part of the tropical waters of the Atlantic, as far north as the Madeira Islands. It was even possible that albacores moved from the Bay of Biscay as far south as the Canary Islands.

The CHAIRMAN suggested further that all species of fish that belonged to the Clupeid family and that had been mentioned by Mr. Monod as existing off the coast of French West Africa should be listed under that generic name.

Mr. KASK pointed out that there was general agreement that fishing in the region of the continental shelf could be increased. The continental shelf, however, represented only 9 per cent of the total area of the oceans and the oceans themselves represented three-quarters of the total area of the earth. The development of deep-sea fishing beyond the familiar regions of the continental shelf was one of the factors that might increase the production of fish considerably. Tunny, for instance, undoubtedly existed at greater depths beyond the continental shelf.

In Japan, where methods of fishing were almost unequalled, tunny had been found wherever they had been sought, provided the temperature of the water was suitable to that fish. At greater depths and on the high seas the habit of the tunny differed from the tunny of the continental shelf, so that other methods of fishing had to be used.

The speakers thus far had merely listed the fishing resources on the continental shelf and had shown the possibility of doubling the production of fish in the regions that were known. Mr. Kask felt, however, that a far greater increase in the resources in fishing could be achieved by deep-sea fishing. Deep-sea fishing naturally required higher technical standards than coastal fishing, and consequently the investment of a larger amount of capital, as great distances had to be covered and the fish had to be preserved; but modern equipment and methods made it possible to solve those difficulties. The time had therefore come to begin research on the possibilities of fishing beyond the continental shelf.

The CHAIRMAN suggested that a list should be drawn up of studies that should be undertaken in the hydrographical and biological fields.

He also thought the map should be inserted in the record of the Conference's discussions, so that it might be used by the various countries.

Mr. D. W. PRITCHARD asked whether the map should not also show the resources in crustacea.

The CHAIRMAN replied that it did not seem advisable to indicate marine crustacea on the map because they did not constitute a resource of sufficient importance.

Mr. D. W. PRITCHARD asked whether the fishing of king crabs in the Barents Sea was not sufficiently important to be mentioned on the map.

Mr. WALFORD said that in preparing the map the experts had mentioned a species only if the catches totalled more than 100,000 tons. As far as he knew, the fishing of crabs did not reach that figure.

Mr. MONOD pointed out that the map did not show that tunny existed in the Pacific although that fact had been proved by the investigation being made in Polynesia.

The CHAIRMAN said that that would be marked on the map.

Mr. BOTTEMANNE pointed out, in regard to the total fish production of the world, that the figure mentioned by Mr. Walford did not include the yield in Indonesia and underestimated that of the tropical countries. He estimated the total production at approximately 20 million tons.

The CHAIRMAN thanked Mr. Bottemanne for the additional information he had supplied.

He invited the well-known United States economist, Mr. H. F. Taylor, to take part in the discussion.

Mr. TAYLOR explained that he had studied the world yield of fish in connexion with work he had carried out for North Carolina University. He had calculated, on the basis of statistics from Northern and Western Europe, Canada, the United States and Japan, the production of which amounted to approximately 60 per cent of the total world production, that clupeidei represented 46 per cent of the total fish production of those countries. It could, therefore, be assumed that clupeidei broadly represented half of the world fish production.

He had produced a table whereby the amount of fish caught in various regions could be easily compared by using a three-dimensional scale similar to the one shown on United States road maps to indicate various distances.

Mr. AUDIGOU said that lines of latitude and longitude should be shown on the map.

The CHAIRMAN said that that observation would be borne in mind when the final map was constructed.

Mr. KASK thought that generally speaking, tunny figured too prominently on the map.

The CHAIRMAN agreed and suggested indicating tunny in type of the same size as for the European herring.

Mr. KASK agreed.

The CHAIRMAN suggested that a list be drawn up of the appropriate biological, hydrographic and technical data indispensable for the better development of fishery resources. For example, the habits of the tunny varied from one region to another according to the prevailing biological and hydrographic factors. The laws which governed the distribution of tunny in the various seas were as yet unknown and should be ascertained.

Mr. WALFORD said that United States biologists were studying sea currents in those regions of the Pacific where tunny was found, so as to determine the kind of water it generally frequented.

A knowledge of the habits of the tunny would be of considerable help in fishery. For example, on the west coast of America tunny occurred in dense shoals which fed as they travelled, so that they were easy to fish. In the Pacific and along the African coasts, on the other hand, they moved about in scattered shoals, travelling very rapidly, which made them difficult to fish.

The CHAIRMAN pointed out also that a better knowledge of the biological facts would facilitate herring-fishing. Owing to the fluctuations of that kind of fish special methods had to be used to bring it in rapidly. One particularly interesting method, used in North Sea herring-fishing, was to predict the year-classes by scale analysis. It would be difficult to use that method in tropical waters as the scales of tropical fish were much less marked than those of fish in temperate waters. Biologists should, however, try to establish scientifically a method of prediction of year-classes of fish by sample analysis.

Mr. E. DE VRIES stressed the importance of undertaking a new oceanographical research. It was known, for example, that plankton fed on the phosphates in the water. Changes in the phosphate content of the water corresponded to changes in the currents. Such data were useful in studying fish.

Mr. AUDIGOU thought that as soon as the tunny spawning-places were known, much useful data regarding their fishing would be gained.

Knowledge of the spawning-places of the cod had made it possible to develop its fishing considerably.

Mr. WALFORD said that United States biologists, engaged on research in Central America and the Pacific, had found the fry of various types of tunny. They were on the verge of discovering the spawning-places, but had not yet found the spawn.

Mr. KASK stated that almost half the salt-water fish in the world were clupeidei. In the United States, for example, the Californian sardine catch alone represented one-quarter of the yield of the United States fisheries. For reasons as yet unknown, the catches of clupeid fish were subject to considerable variations. For example, a few years ago sardine catches had declined appreciably for no apparent reason after reaching a maximum of almost a million tons a year, but had subsequently begun to rise again and were continuing to do so.

Researches into that problem had been undertaken by the United States Government in co-operation with the State of California, the University of California, the Californian Academy of Sciences, the Scripps Institute of Oceanography with financial help directly from the fishing industry. Both staff and finances had been pooled for those researches which had concerned the distribution of pelagic clupeidei and also the biology and life of the fish, the hydrography, oceanography and plankton.

Only teamwork of that nature could lead to satisfactory results in the study of the problem.

Mr. A. L. PRITCHARD added that since joint research had been begun in California, it would be helpful to interest more northerly regions in that work. It had been noticed that when there were large sardine catches along the Californian coast, some of the fish moved northwards up the Canadian coastline. The same phenomenon was not apparent when the shoals were smaller. The fisheries in the north would certainly be glad to receive any information on the movements and size of those shoals. They might be able, for their part, to give certain information on fishing in their area. International co-operation to study the problem would certainly be extremely useful.

He wondered why the word "cod" appeared in such large letters to the north of Norway on the attached map. According to certain surveys, cod-fishing was not developed in that region.

The CHAIRMAN said that he was responsible for the entry and that he had based his decision on the research work carried out by the Biological Board of Canada in Nova Scotia and by Professor Thompson in Newfoundland.

He noted that several divergent opinions had been expressed on the cod-fisheries in the Barents Sea, of which he had made a particular study. His own opinion was that the cod-fisheries in that region could be developed still further.

The war had interrupted trawling in many countries but had had practically no influence on that type of fishing in the Barents Sea. Research into the effects on resources of the discontinuance of fishing had shown that so far as fish other than cod were concerned those resources had increased almost fivefold during the six war years. With regard to cod, no appreciable increase had been noted as a result of the interruption in fishing. The utilization of resources was not, therefore, the principal factor accounting for the decrease in fish resources.

Researches carried out in the Barents Sea also showed that cod was a pelagic fish. Cod, which was able to live at different depths, might therefore be fished in regions other than those near the coast line, where cod-fishing was carried on at present.

Dr. Rollefsen, however, who had studied the problem of fish mortality, was of a different opinion. His calculations showed that, in a given area, mortality increased in proportion to the number of trawlers in the fishing fleet.

The Chairman concluded that additional research was necessary in order to find a solution to the problem on which, as he had already stated, several divergent opinions had been expressed.

Mr. A. L. Pritchard said that according to accurate and indisputable information, there was every reason to hope that cod-fishing could be intensified in the Atlantic.

Mr. Kask pointed out that certain experiments had shown that cod moved about at medium depths in the sea. Recently, spotting by supersonic methods and radar had shown the existence of unsuspected shoals at such depths. Dr. Rollefsen had noticed such a shoal and had had the idea of sinking a camera in the immediate vicinity of the shoal. The photographs had shown that it was a shoal of cod. That proved that cod could move about at greater depths and in areas other than the continental shelf than those in which it was usual to find them.

Mr. Oppedal said he had been surprised to hear certain statements to the effect that the stocks of cod in the waters north of Norway were not fully exploited. In his opinion, those speakers who had mentioned Dr. Rollefsen's conclusions had gone further than Dr. Rollefsen most likely would go. In speaking of the problem of the disappearance of fish in certain regions, the Chairman had very justly pointed out that scientific investigation hitherto had given only some indications as to the effect of intense fishing; it had proved that the exploitation of resources was not the principal factor which should be taken into account. The problem of resources hitherto not exploited or not fully exploited should be considered with the same scientific logic. Recognizing that present knowledge was limited, all that could be said was that continued and intensive studies of certain known and unknown resources should be carried on or undertaken—preferably on an international basis.

Mr. Walford pointed out that the map was purely hypothetical. The exact facts would be established by the studies at present being carried out.

The Chairman agreed with the opinion put forward by Mr. Oppedal and proposed that the expression "major stocks known or believed to be underfished in 1949" should be replaced by "major stocks believed to be underfished in 1949".

However, the exploitation of resources was not the only factor to be taken into account in studying fish disappearance. Dr. Thompson, Dr. Berger and several French scientists had studied the influence of water temperature on fish mortality, in that connexion. He agreed that water temperature was an important, if not a dominant factor, and thought further research into fish distribution, biology, hydrography and oceanography was essential. At all events, such research was necessary in the Barents Sea, with which he was personally concerned.

He then passed to the problem of fish which had moved far from coastal waters or were difficult to catch for other reasons and recalled that a meeting on fishing techniques would take place in the near future.

Mr. Walford wished to say a few words on the need to improve fishing equipment, particularly in areas where fisheries were not well equipped. Many centres were in urgent need of refrigerating apparatus, Africa did not possess enough salt, and preserving apparatus was needed in all fishing centres.

The Chairman pointed out that those questions would be discussed at the meeting on fishing techniques. He thought that in many cases factory-ships would be necessary, first in order to reach distant sources and secondly to ensure cheap transport for the catch. There were many advantages in processing fish on the spot.

Mr. Bottemanne made a distinction between the needs of fisheries in areas already being exploited and those in areas where there were as yet no fisheries. In the latter, the simplest means should first be used. For example, in Indonesia, the greatest need was for small boats and fishing equipment. Factory-ships were not essential in such an area.

Mr. Hora thought that in tropical countries the first need was to obtain a suitably equipped vessel for exploration, working on an international basis. Only a craft or crafts of that kind would make it possible to locate fishing shoals in the vast unexplored areas.

Further, it was necessary to use existing supplies to the full. Thus, in certain areas where there was considerable fishing, more than two-thirds of the catch was made into fertilizer, and only one-third used for consumption. If it were possible to consume or preserve a greater part of the catch, the fishermen would work harder and make greater profit. Moreover, preserving should be carried out with due regard to the tastes of the native inhabitants. The exploitation of resources should thus be the synthesis of closer understanding between the fisherman and the consumer.

The Chairman said that questions of sale and publicity would be placed on the list of items to be considered at the meeting on technological development.

Mr. Bottemanne agreed with the last part of Mr. Hora's statement. Nevertheless, in Indonesia at least, the amount of fish wasted or made into fertilizer was very small. He also thought that the opinion of the consumer was as important as that of the fisherman. Persons responsible for the development of fish resources must choose between the three following solutions: organizing new fisheries; supplying people with a cheap and abundant food product; developing existing fisheries. He thought the second solution should be chosen.

Mr. Hora then stated what he considered to be the best procedure to adopt in regions where fish resources were not yet sufficiently developed. First, existing equipment had to be improved within the economy of the operatives in the industry. At the same time, the fisherman's efficiency and output should be increased. For that, he should learn to go further afield. If he used a rowboat, the six or seven hours taken to reach the fishing ground and to return were fatiguing and unproductive. He would have to be towed out by a power vessel in the first instance and later he would be able to obtain a boat enabling him to fish with maximum efficiency. Preservation and quick transport represented other important stages in the development of fishery resources.

Mr. E. DE VRIES thought it was as necessary to study world fish consumption as fishing methods. The world consumed two-thirds of the fish that was caught, a figure which already stood at 20 million tons a year. According to inquiries on that topic, production in Indonesia could be doubled by intensive exploitation and the establishment of new fisheries. The current consumption of 3 kg. of fish per person per annum would thus be raised to 6 kg. A worldwide increase in consumption might perhaps present certain difficulties, particularly since most countries looked upon fish as a substitute for meat. That was why it was necessary to study problems connected with fish consumption and to demonstrate to the consumer the advantages of a protein-rich food like fish.

Mr. BOTTEMANNE agreed with Mr. Hora as to the need for developing fisheries where they existed. But in order to be able to supply the world with cheap and abundant food, it was necessary not only to develop existing fisheries but to create and organize new fisheries. In the tropical regions, for example, very simple methods and equipment would make it possible to achieve that purpose.

Fisheries Statistics and Technological Development

2 September 1949

Chairman:

Nazir AHMAD, Deputy Director of Fisheries, Comilla, East Bengal, Pakistan

Contributed Papers:

Statistics on Economic Features of the Fisheries
Stewart BATES, Deputy Minister of Fisheries, Ottawa, Canada

Economic Statistics on Marine Fisheries
P. F. LOUIS, *Administrateur principal de l'Inscription maritime, Direction des pêches maritimes, Ministère de la Marine Marchande*, Paris, France

Fisheries Statistics
The Netherlands Government, The Hague, The Netherlands

Statistics on Economic Features of the Fisheries
G. M. GERHARDSEN, Chief Economist, Fisheries Division Food and Agriculture Organization of the United Nations, Washington, D.C., U.S.A.

Statistics on Economic Features of the Fisheries of the United States
Edward A. POWER, Chief, Statistical Section, Branch of Commercial Fisheries, Fish and Wildlife Service, Department of the Interior, Washington, D.C., U.S.A.

Recent Advances in Methods of Handling, Preservation, Processing and Distribution of Fish. Developments in Utilization, New Products and By-Products
Olav NOTEVARP, Director, Norwegian Fisheries Official Research Laboratory, Bergen, Norway

Recent Advances in Methods of Handling, Preservation, Processing, and Distribution of Fish; Developments in Utilization, New Products and By-Products
Frode BRAMSNAES, Director of the Technological Laboratory of the Ministry of Fisheries, Copenhagen, Denmark

Recent Advances in the Handling and Processing of Fish
G. A. REAY, Department of Scientific and Industrial Research, Torry Research Station, Aberdeen, Scotland

Methods of Detecting Fish by Echo Ranging and Echo Sounding
J. RENOU, *Chef du Service presse-information de la Marine nationale*, Paris, France

Recent Advances in Various Technological Aspects of Handling Fish and Fish Products
H. L. A. TARR, Acting Director, Fisheries Research Board of Canada, Fisheries Experimental Station, Vancouver, B.C., Canada

Technological Advances in Fishing Methods
J. L. HART, Pacific Biological Station, Nanaimo, B.C., Canada

Saury Lift-Net Fishing with Light
Shigene TAKAYAMA, Central Fisheries Station of Japan, Tokyo, Japan

Technological Development in Fisheries with Special Reference to the Factory Ship in the United States
A. W. ANDERSON, Chief, Branch of Commercial Fisheries, Fish and Wildlife Service, United States Department of the Interior, Washington, D.C.

The French Sea Fish By-Products Industry
J. PÉRARD, *Président du Syndicat Général des Industries de Traitement des Sous-Produits de la Pêche Maritime*, Paris, France

Summary of Discussion:

Discussants:

Messrs. POWER, HORA, BOTTEMANNE, OPPEDAL, M. GRAHAM, A. L. PRITCHARD, WALFORD, P. F. JENSEN, H. F. TAYLOR

Programme Officer:

S. RAUSHENBUSH

Statistics on Economic Features of the Fisheries

STEWART BATES

ABSTRACT

Factors affecting welfare, as well as production and distribution, should be measured. Unified service, however, is desirable and this requires co-operation among different branches of administration.

Data on employment in fisheries, and dependence on the industry, is best obtained by means of sample surveys. These may be supplemented by material from population census and in other ways.

Measurement of inventment in fisheries may be based on information in annual statements of firms and (for fishermen) on data collected through a system of licensing. Costs of production are properly a field for investigation with sampling techniques.

Statistics of catches should be collected as directly as possible from original source. The "sales-slip" system, therefore, is most desirable. The use of enumerators is satisfactory in special circumstances. Other methods are generally objectionable.

Current reports on utilization of catch, in form of finished products, are needed by the fish trade. These should be collected from fish processors as often as required. A complete coverage of the processing industry is necessary. Current price reports are also required, covering representative ports, markets and products, similarly collected.

Information on distribution or marketing may best be obtained by special investigation of shippers' records. Adequate data on transportation is rarely obtainable. Complete data on inventories is difficult to obtain, but reasonably satisfactory results are yielded by combination of general and sampling surveys.

Classification of foreign trade statistics, to conform with production statistics is often difficult — but most desirable.

Domestic consumption of fish products may be measured by means of sampling procedures, supplemented by general information on prodnction and distribution.

The provision of a statistical service for the fisheries concerns the business man, the administrator and the policy-maker connected with this industry and trade. The interests of all three have to be kept before us. Although our purpose is to provide general background material, and to focus discussion on the questions we think should occupy the attention of the meeting, our treatment of these questions is probably coloured by our own experience in Canada.

GENERAL CONSIDERATIONS

The magnitudes to be measured may be grouped under two heads:

(*a*) Those relating to production and distribution, and

(*b*) Those relating to welfare.

There is, of course, considerable interconnexion between these groups. The price of fish as landed, for example, affects both the income position of the fishermen and the production costs of the processor. Nevertheless, we gain a wider perspective on our subject by approaching it from both these points of view.

(*a*) Under the first head, then, are included these matters:
Investment,
Costs,
Production (volume and value),
Sales or marketing, and
Stocks.

(*b*) Under the second head we include data on:
The fishing population,
Efficiency, and
Gross and net income (catches, prices).

When we come to treat of methods of collection, however, we shall consider the measurement of all these as phases of a single integrated system. There are very practical reasons for doing this. Usually the collection and compilation of statistical data is the responsibility of governmental authorities, who are concerned with both welfare and the operation of the national economy. Much of the data is collected from individuals and firms, for whom the completing of questionnaires and statistical forms may be a burden, if not a nuisance—depending upon the quality of the service provided by the Government in return. An integrated statistical system, therefore, by eliminating duplication, reduces to a minimum the total effort involved in this work and makes for better quality in the statistics themselves—and quality here is more important than quantity. Interpretation of the data collected also involves simultaneous consideration from all angles.

The problem is simplified, of course, if all statistics are collected by a single authority. Very often, however, this is not the case—it is perhaps seldom practical. Those engaged in compiling and "processing" statistics of catch or production, for example, ought to have complete familiarity with the activities they are hoping to measure. Only if they have this knowledge will they be able to spot the slips and errors that inevitably occur in the course of collection and compilation. Knowledge of the details of the industry and trade is also of vital importance in the planning and organization of surveys, the designing of forms and the like. Such knowledge is acquired only through close association with the industry in an administrative or investigational capacity. Thus the branch of government charged with fisheries research and administration is usually also the best equipped to maintain most of the routine statistical services for the fisheries and to initiate and carry out special surveys.

On the other hand, certain phases of a statistical service may be intimately involved with other branches of the government machine: the connexion between the work of the customs authorities and the collection of information on foreign trade is an obvious example. Moreover, the responsibility for certain statistical services may be vested in particular branches of the government: the census authorities perhaps. Consequently, a properly integrated statistical service for fisheries will almost always involve co-operation among a number of collecting authorities, as well as close liaison between all these and their sources in the industry and trade. Specific instances of this will be indicated below.

EMPLOYMENT IN, AND DEPENDENCE ON, THE FISHERIES

Statistics of the numbers of persons engaged in the fisheries may be obtained from various sources: from census material, from the payrolls of firms in the industry and from records of fishing licences issued. As a rule, no single source is completely satisfactory. The data obtained through the general population census are necessarily based on a more or less arbitrary definition of the terms "fisherman", "fish handler", etc. Moreover, the use of enumerators without special knowledge or understanding of the industry often leads to untrustworthy results from the population census. The census, usually decennial, is too infrequent to be sufficient.

The books of fish buyers and processors may contain adequate information on the numbers engaged in secondary fishing operations, on rates of pay, on seasonal fluctuations in employment and turnover. They seldom contain similar information relating to primary operations excepting in instances where fishermen are employed directly by processing firms or are members of producers' co-operatives. On the other hand, licensing systems commonly apply only to persons engaged in the primary operation of fishing. Together, these two sources can be utilized in certain circumstances to provide a considerable range of information on employment in the fisheries. Thus it might be made a condition of obtaining a fishing licence or permit that the recipient report to the issuing authority on his costs, returns, etc. Only rarely is this a practical procedure, however. "Paper work" is not popular with fishermen, and the opposition to revealing information on income to any governmental authority (which is also the taxing authority) is usually intense. In this phase of the statistical service, therefore, a licensing system usually will provide only general information on numbers of fishermen and on the types of operation engaged in.

Somewhat more extensive information may be obtained by means of a special census. This is usually only practical as a supplement to the general quinquennial or decennial population census. If carefully prepared and carried out it may provide useful details concerning the fishing population: income position, diversification of activities and dependence on the fishing industry. For the purpose of such a census the status of fishermen must be defined, and here considerable difficulty may be encountered. In areas where high-priced species of fish occur, particularly, people may fish for a very short season and then return to their main occupation (farming, lumbering etc.) Nevertheless the catch by such operators may constitute a large proportion of a district, regional or national total. The solution to the problem of definition can only be determined by the use to be made of the data collected. Thus, if a study is to be made of the structure of the primary fishing industry, the value of the individual's catch will probably be the best criterion. If emphasis is placed on a sociological survey of fishing communities, the time spent in fishing operations may be the proper test.

Even specially prepared census surveys, however, are subject to certain weaknesses. Those directing economic research in fisheries cannot always exercise sufficient control over the work of collection during the taking of a census. This has to be left to the ordinary enumerators and their supervisors. The results are liable to be uneven. A census is also very costly and can only be undertaken at intervals of five or ten years. Moreover, for many purposes it covers more ground than is necessary. For a study of costs of production in primary fishing operations, degree of dependence on fishing or alternative occupations, and the like, sample surveys often yield fuller and more satisfactory results. These have the advantage that they can be closely supervised by the authorities conducting the research. They permit of greater detail in questionnaires. They can be carried out as frequently as changing conditions may require, and they are relatively inexpensive.

Sample surveys are of two main kinds. A questionnaire may be taken into the field by properly trained investigators, and the required information obtained in interviews with representative fishermen. This is a useful technique when, for example, a rapid review of the current income position is needed. Or alternatively, as in surveys covering a longer period of time, a number of fishermen may be selected to maintain a continuous record of their operations. The record forms can be designed by the directors of the research project and the work of the fisherman-reporters supervised by the research staff. The problems to be dealt with in carrying out surveys of this kind are: (*a*) the selection of representative or "typical" fishermen and communities, and (*b*) ensuring that a really complete and continuous record is kept. Fishermen with the will and ability to undertake this work are usually in the "Highliner" category. Consequently, the results of such surveys tend to have an upward bias. And each fishing community is liable to have its own peculiar characteristics, failing to conform to type and thereby making difficult the broad application of results from restricted surveys.

INVESTMENT IN PLANT AND EQUIPMENT

Data on investment in the fishing industry are required from time to time for purposes of government "planning" or as a guide to the industry's present or future prospects. When the industry is highly capitalized, with the instruments of primary production (fishing craft and gear) as well as processing plants under large-scale ownership, the collection of these data presents no great problem—given good will. The information is seldom required more often than once a year and may be obtained from the annual statements of the firms in the industry or by means of special questionnaires—in the latter case together with information on production, etc. (see below).

With a decentralized industry of small-scale units the problem of statistical collection is more difficult. In this case the unit is often a one-man business, the communities are numerous and scattered. There are no accountants and auditors to complete statistical forms. In these circumstances information on boats, gear and other assets may have to be obtained through the field officers of the fisheries administration, who are usually familiar with conditions in their individual districts. But to require fishery officers or inspectors to make a census of the capital assets of the fishing community presents them with a number of difficulties: the practical difficulty of viewing each and all of the assets involved and the "theoretical" one of properly appraising the value of them. If a licensing system is in effect these difficulties may be lessened materially. The fisherman can be required to apply annually for his licence supplying a description of his productive assets with his formal application. The information supplied may include the age and condition of boat and engine, the number of nets, lines, traps and other items of gear, docking facilities curing sheds, materials on hand and the like. In this way a register of fishing craft and other assets can be compiled. Appraisal of the value of these items may, under certain conditions, have to be undertaken by the central statistical authority. If this function is left to officers in the field, the results may lack comparability. The difficulty may be overcome, with the addition of useful information to the administration's knowledge of local conditions, by proper direction of this part of the officers' work.

COSTS OF PRODUCTION

Although production costs are closely related to investment and output, the collection of cost data involves other techniques. Current information on the supply and prices of equipment for the fishing industry, if required, may be obtained from the manufacturers of, or dealers in, marine engines, nets, bait, etc. Detailed information of this kind is rarely required as part of a continuous statistical service, but data for the construction of series of index numbers may be very useful.

Generally, cost data are needed as bases for judgment of the relative efficiency of plants of different size, location or organization, units of equipment of different types and sizes, or different operational methods—occasionally also as bases for price making. These data, therefore, must be collected with care and in great detail. The field of production costs is thus one for specialized studies, and for the application of sampling techniques. To this work must be brought the special knowledge of the engineer and the accountant, as well as that of the economist. The procedure in the estimation and analysis of production costs in manufacturing is well established. The study of the costs of fish processing plants does not raise peculiar problems—apart from the prevalence of the small-scale operation in certain areas, with its accompanying lack of adequate records.

Studies of the costs of primary producers (fishermen) have been less common and it may be useful to consider them for a moment. Such studies may be undertaken as part of an investigation of fishermen's net income. When measuring costs and efforts the coverage should be complete —for example, the labour-time expended in activities (repair, etc.) ancillary to fishing as well as in actual fishing operations should be properly accounted for. Employment of unpaid members of the family is often a complicating factor here. The adjustment of inventories and the calculation of depreciation throw up some thorny problems. An average depreciation period for boats and engines can be determined without too much difficulty but usually quite widely differing periods will apply in different fisheries depending upon the sturdiness of construction and the strain to which the asset is subjected in fishing operations. On the other hand, items of gear such as lines and hooks are clearly expendable and their purchase or renewal should be treated as an operating cost. Between these extremes there is a range of items, including nets and traps (and occasionally even engines), which may be depreciable or not, depending on length of continuous use and other factors.

VOLUME AND VALUE OF PRODUCTION

Catch

From a long-term viewpoint the economist's interest in the statistics of primary production in the fisheries, i.e., the catch or landings, is perhaps identical with that of the biological scientist. Currently, however, he is concerned with these statistics because they relate to the welfare of the fishing population and to the market situation. As a guide in these matters, statistics of the catch are not likely to be required in as great detail, nor with such frequency, as they are for administrative purposes or purposes of biological research. For the economist and the business-man, certain "key" species are apt to dominate the picture. The success or failure of the fisheries based on these determine both the fishermen's income position and the volume of supplies entering the market. Because of the effect on the market also, it is often useful to have a continuous current record of the progress of the important "runs". Weekly reports however, are usually sufficient for this purpose unless the market is influenced by day-to-day fluctuations in supply. On the other hand, for the biologist and administrator daily reports of the catch are almost always desirable in great detail both as to species taken and as to point of origin. The frequency with which catch statistics are collected, and the detail in which they are required and compiled, therefore, may often be determined by biological or administrative, rather than economic considerations.

The technique to be employed in the collection of catch statistics will be determined largely by local conditions. Statistical data should be collected as directly as possible from the original source. Since in most commercial fisheries the catch, immediately upon being landed, is sold to a fish buyer, the ideal procedure would be to have a copy of the document covering this transaction forwarded to the statistical authority. Such sales-slips or tickets can be designed to include all the detail required by the several interests involved, and the compilation of reports from them may be made with any desired frequency. In the case of long fishing voyages it may be necessary to supplement the sales slip with excerpts from the log book. Generally, the fish buyers should be made responsible for the submission of the material, and the central statistical authority for all compilation.

Alternatively, periodic reports may be obtained from the buyers or, in special circumstances from the fishermen, based on their records of purchases and sales, respectively. This is less desirable than the preceding plan because it involves compilation by persons poorly equipped for the task, and thus invites errors and evasions. Where there is a centralized, well organized fish market, however, the employment of trained enumerators may provide data on landings with reasonable completeness and accuracy, based on the record of quantities weighed out or auctioned. This may be supplemented by information from fishermen on the location of capture. On the whole, it is a more cumbersome system than the one using the so-called "sales-slip".

In areas where fishermen do not market their catch in the raw form but process it themselves for sale to the cured fish trade, current reports on landings may have to be obtained from fisheries, administrative officers or from other responsible parties (e.g., municipal authorities) in the districts concerned. This procedure almost always involves for the collector an element of personal estimate, small or great, depending on particular circumstances.

Information on individual catches, on catch per unit of equipment and related data may be furnished by the cost studies mentioned earlier in this paper. This is another phase of the statistical service best handled by the sampling method.

Finished Products

The source of information under this head is the fish buyer and processor. Statistics should be collected directly from these by the central authority. Where plants are small and numerous, however, it may be necessary for practical reasons to have officers of the field administration act as intermediaries. In this connexion we may point out the need for improved methods of bookkeeping in the fish trade generally.

Current information on the disposition of the catch (i.e. amount sold fresh, frozen, canned, salted, etc.) is required to meet the need of both business and administration for a forecast of the supply position of the various fish products on the market. This means continuous monthly or weekly (rarely more frequent) reports on the quantities of fish going into the several product forms. Under very favourable circumstances the information may be entered on the sales-slip together with the catch data —when each lot of raw fish purchased is "ear-marked" for a definite use. Absolute accuracy is not essential for this type of service and is often unattainable since some of the raw fish purchased by a processor during a given period is often stored for future disposition.

A second kind of report on processing or manufacturing may be required, in which accuracy rather than speed is the main consideration. This is a survey of the annual regional and national output of fish products, the share of the fishing industry in the gross national product. Generally, a report from the manufacturers at the end of each year is satisfactory for this purpose. Since industrial firms frequently have also to submit annual reports to government on their usage of materials, power, and labour, on investment programmes and the like, an effort should be made to co-ordinate the production report with these others. This will usually require close co-operation among several branches of government administration—fisheries, labour, taxing and perhaps others. It is desirable that, if possible, the period covered by the report should coincide with the "production year", rather than the calendar or fiscal years if the latter arbitrarily divide important fishing seasons. This facilitates comparison with trade data. The procedure may be less desirable from an international point of view, however.

PRICES

Price quotations for raw fish (fish as landed) should be obtained regularly at representative fishing ports and stations. Since prices are normally uniform over fairly extensive areas a complete coverage is unnecessary. The uniformity may be checked periodically. The frequency with which price reports should be prepared and issued depends on the rapidity of price changes in the fisheries involved. When prices are fixed by agreement between fishermen and buyers at the opening of a season such reports need not be frequent. When, however, prices fluctuate with the day-to-day interplay of market forces daily reports may be desirable. In the latter case it will usually be most convenient to have the work of compilation and publication carried out by subsidiary offices of the central statistical authority located close to the sources of information.

Similar considerations apply with reference to prices at other trade levels: f.o.b. manufacturer's plant, wholesale and retail. Retail prices, particularly, often present wide variations according to distance from source of supply, type of outlet, etc. Reports on these to be useful may require to be given in "high", "low" and "mean" terms. Usually, "key" commodities only need be included.

MARKETING (DOMESTIC AND FOREIGN TRADE)

Under this head are included statistics of freight movements, imports and exports, inventories and domestic consumption: adequate statistics of shipments by road, rail, water or air transport are always difficult and sometimes impossible to obtain. Railway companies, for example, are usually able to furnish data on car loadings and deliveries only in bulk categories such as "frozen fish" "canned goods" etc. For the detail of such shipments recourse must be had to the consignor: the manufacturer of fish products or the wholesaler, as the case may be. Since the firms' accounting systems often do not permit of ready compilation of information in the form required, special surveys are usually necessary. These may be carried out by means of questionnaires or through personal investigation of the records by research workers on the staff of the statistical authority, and sampling methods may frequently prove useful.

As mentioned previously, the collection of statistics of foreign trade is normally a function of the customs authorities. Those concerned with fisheries statistics generally, however, should see to it that the classification and description of fish products in foreign trade data (with regard to form, net weight, etc.) conform as closely as possible with those of production statistics. With respect to export statistics, this can probably best be accomplished by educating exporters of fish products in the proper completion of export entry forms. Given co-operation from the fish trade, those responsible for the compilation of export statistics will have no difficulty in preparing reports along the lines desired by the fisheries economist—and usually demanded by the trade itself. Because of the physical bulk of the material, perhaps, it is seldom possible to compile and issue such reports oftener than once a month. Occasions arise when this is an inconvenience. Special compilations are sometimes feasible.

Peculiar problems are met with in classifying import statistics. Imported commodities are grouped according to tariff categories, which often bear little relation to the actual commercial categorization. Comparison with production and export data thus becomes extremely difficult. Amelioration must await a detailed and rational grouping of fish products in tariff schedules.

With reference to statistics of fish inventories, while questions of inadequate classification may arise, the most vexed problem relates to the ownership of supplies held in storage. Figures of total supplies of frozen, cured and canned fish held by manufacturers and wholesalers are quite readily obtained by means of questionnaires completed and submitted each month (usually as of the first), or oftener. Information as to the quantity actually unsold—which is of considerable interest to the trade—is, however, very difficult to obtain. This arises particularly in the case of frozen fish because ownership of the product may change hands several times while in public or other storage. A further consideration is that significant quantities of canned fish are usually held by the retail trade. It is impractical to collect continuous information on this, but sample surveys from time to time may be utilized to establish the dimensions and seasonal trends. The same applies to the quantities of cured fish sometimes held by fishermen-producers and shore merchants preparatory to marketing.

A number of sources may be tapped for information on the domestic consumption of fish products. Data on the "retention" of fish within a country may be distilled from the statistics of production, foreign trade and inventories. The reliability of the results will depend upon the quality of these statistics. Much supplementary information may be gathered by means of sampling surveys. These may be carried out along two lines: (a) an investigation of the sales of fish distributors, and (b) an investigation of the buying habits and preferences of consumers.

An important gap in present information in most countries is the absence of statistics on the catch in the game fisheries, but in time this too may be filled.

Economic Statistics on Marine Fisheries[1]

P. F. LOUIS

INTRODUCTION

The economic statistics at present published by the principal countries of the world possessing a marine fishery industry show a great deal of diversity.

Apart from differences in scientific and technical terminology (already a major source of confusion), it is apparent that in a given country the statistics are usually compiled in terms of traditional rules and the particular aspects assumed by the fishing industry in that country, and still more with an eye to the Administration's objectives in regard to control and foreign trade requirements. This latter point indeed is emphasized in the preface to the 1948 Yearbook of Fisheries Statistics published by the United Nations Food and Agriculture Organization, which brings out the still considerable difficulties standing in the way of a general census of marine products. Nevertheless, the remarkable effort which this publication represents and to which our grateful acknowledgments are due, has made it possible to synthesize a large number of statistical data which are comparable with one another and are thus capable of providing a comprehensive picture of the fishing industry throughout the world.

At the same time, it should be noted that the figures usually provided by economic statistics on fisheries are rough data chiefly concerning catches, fishing craft and personnel, and international trade. With regard to production, these figures do no more than estimate the fishing resources utilized and their quantitative results.

While the importance of such documentary material both on a national and, still more, on a world-wide plane, should not be underestimated, it is worth enquiring—and that is the object of this study—how far and in what way these economic data may help in the conservation and proper utilization of that great natural source of wealth which is represented by fish and marine products.

NEED FOR CONTROLLING THE USE OF MARINE RESOURCES

The reasons for such a step are obvious. In contrast to any resources of the soil or subsoil that remain the property of the country in which they are situated and which exploits or cultivates them and supervises their development, the resources of the high seas are unique in belonging to no one and therefore in being available to all. Hence everyone draws on the common store with the means at his disposal and simply calculates the amount that he has taken. For any given country the fisheries statistics are the outcome of this calculation. They express, we repeat, the gross result of a national enterprise applied to a common and generally remote fund in regard to which no accounts are kept. There is no need to emphasize that this indifference in regard to a common asset was natural and unimportant so long as the wealth of the sea was regarded as "inexhaustible". This comforting view, however, has once and for all been dispelled by the revolution brought about in the fishing industry by the discovery and rapid development of intensive fishing methods and by the constantly growing requirements of the population. We now know that the common treasure is threatened and must be husbanded if we wish to continue having the benefit of it for a long time to come. To husband it means to see to its conservation and to regulate the use of its product.

Economic fishery statistics should help us in this task by providing certain particulars which, in their present state, they fail to bring out, and by enabling a much wider interpretation to be made of the items they already provide. More specifically, we consider that the data in question should bring us into closer touch both with the centres of production, by supplementing our information about catches and distribution points, and with the consumption of fishery products, by giving a more accurate account of the various ways in which those products are used.

As this constitutes a re-orientation of economic statistics, we shall sum up, very briefly, the steps which could be taken to achieve this. At the same time we shall not close

[1]Original text: French.

our eyes to the great practical difficulties which here and there will certainly stand in the way of the application of these measures. For since the objective is international by nature—the protection of world fishery resources in the interests of all—it can be fully achieved only in so far as each one (that is to say, each nation concerned as producer and consumer) is willing and able to make its individual statistical contribution by amending its customary methods.

THE FUNCTION OF STATISTICS

In regard to catches, there can be no question of ordinary fishing statistics replacing the biological information provided by specialized scientific organizations whether national or international; these organizations are chiefly concerned with the study of the ocean depths and their population, with the main object of formulating general laws governing the development and movement of the various species, and this research is often of a speculative nature alien to economic statistics. But the latter may be of great assistance to scientists by indicating no longer merely the total volume but the actual composition of catches made in the various places frequented by fishing craft. If supplied once or twice a year, such data would no doubt make it possible to verify scientific theories and to confirm the recommendations made to fishermen by the biologists; this would tend to reinforce a collaboration which today is recognized as essential for the protection of marine resources.

A very desirable supplementary step would be to obtain estimative data on the technical methods used in making catches of known size. These data would give in broad categories the number and type of fishing craft and equipment used as well as the proportion of the catch ascribable to each type of equipment. Thus the combination of these two classes of information—the composition of the catches and the technical conditions in which they took place—would lead to a proper appraisal of the state of marine stocks and would greatly facilitate the conservation of fishery resources. It would be possible, in particular, to control internationally the exploitation of fishing-grounds in danger of depletion and to direct fishing craft towards grounds which are still well-stocked. It would also be possible in the light of these data to study the optimum composition of fishing fleets and to impose conditions on the use of the most destructive appliances.

Measures of this kind, while eminently desirable, would no doubt require a certain keeping of accounts at sea of which many fishing enterprises in the world are not yet capable; but they can be put to the test in the sphere of industrial fishing which is already sufficiently concentrated and well organized.

A number of countries, including France and the countries members of the International Council for Sea Exploration, now supply that body with statistics of their catches compiled in respect of the main fishing zones in European waters; and this should provide encouragement. It should be noted, moreover, that certain very complete general statistics probably contain the elements necessary for the communication of the desired material, requiring only a different method of presentation. However, countries which have not yet been able to elaborate such statistics, could be given simple and carefully studied directions through the agency of a qualified international body, such as the Fisheries Division of the FAO.

DISTRIBUTION AND CONSUMPTION OF MARINE PRODUCTS

The first service to be performed by economic fishery statistics is to specify the nature of the catches and hence to provide information on the state of marine resources and their exploitation. They should, however, be required to perform the second and even more necessary service of showing quantitatively the use made of marine products. A natural resource is only truly protected when it is sanely and rationally used, and it would be illogical to conserve a source of wealth and take no interest in the use that is made of its product. Economic fishery statistics, however, if properly compiled, can provide at least an approximate account of the distribution and consumption of this product.

In order to achieve this aim it would seem that statistics should be compiled at each of the important stages through which the product usually passes: markets, handling and processing industries, and international trade.

But here, even more than at the production level, there will be many technical difficulties due largely to the dispersal of the produce over a vast and sensitive economic market. Even if for this reason the work can at first be carried out only in one of the above sectors, it is nevertheless desirable to undertake it as it should shed more and more light on a very complex subject.

Within the narrow scope of this study it is only possible to indicate the main categories of information which should be collected and co-ordinated for a better understanding of the course followed by the products.

DATA REQUIRED

At the fresh fish market stage (direct consumption) and in respect of the largest of these markets, two sets of basic statistics should be compiled, weekly if possible.

(a) *Quantities and selling prices of fresh fish*

The first set of statistics would concern the quantities of each of the main species of fish brought to market. The second would show the selling prices prevailing. Since the large markets are, generally speaking, regularly supplied by one or more individual ports, a first comparison of great value could be made between the catches (treated as far as possible according to their zones of origin, as stated above) and the disposal of the fish. This would provide valuable information about the nature of the demand—the preferences of the consumers—and the conditions governing the absorption of the species caught. This purely economic information would combine with the information gathered directly at the production end to suggest the general directions to be given to fishermen. Basically, however, a knowledge of the two terms, quantity and price, would enable the characteristics of the great selling markets to be determined. For each centre, price trends compared with consumption trends would reveal the optimum conditions for local or regional distribution. As a second stage, the comparison of the data from the principal centres of the same country would bring out their common features and their contradictions and thus make it possible to draw up a national plan for the distribution of the immediately consumable production—already directed—and, on the same scale, a plan for the development of outlets.

Whatever difficulties may be anticipated, it has become essential to undertake this work without delay. The almost complete interruption of world trade during the war years led a number of countries to expand their fishing industries very considerably, and since the end of hostilities, the nations which had suffered heavy losses in fishing craft have rapidly reconstituted and modernized their fishing fleets. Hence it is no longer a question of administering a shortage but, on the contrary, of coping with an output of fish which is greater than it was in 1939. The control and stabilization of national markets can alone ensure that this new abundance will be used to best advantage and this double aim can only be achieved, particularly in regard to the fresh fish markets, to the extent that those markets are studied and organized rationally.

Furthermore, a definition of the possibilities and limits of these markets will make it easier to seek and establish fresh outlets which are essential to a considerable number of producer countries, since it is necessary both to make full use of available resources and to maintain sound economic conditions in the various fishing industries.

(b) *Supply and output in the canning industry*

At the national level it is the canning industry which almost always constitutes the main outlet after the direct-sale markets. Although the producers in this field, which is properly speaking industrial, are more familiar with statistical work, there can be no doubt that much documentary and research work still remains to be done in a number of countries. It should first be noted that the canning industries mainly handle seasonal fish, the commonest among which are herrings, sardines, sprats, mackerel and tunny. But, although these species constitute the raw material of these industries, they also supply the fresh fish markets throughout their catching season. This two-fold utilization of the supply should be accompanied by a particularly thorough knowledge of its outlets, without which there must be a danger of disorganizing one or other of the two markets. A heavy demand for a particular seasonal species on the fresh fish markets may interfere with the supply to the canning plants, either by creating a shortage of the raw material or by raising its price. On the other hand, large industrial purchases may in turn upset the balance of the fresh fish markets. Statistical data will therefore be essential in regard to these markets and in regard to the species sought by the canning plants, since these industries, whose activity is usually seasonal but which have to provide a return on large investments, must avoid any serious disturbance in the supply and price of the products they handle.

But these statistics on supply will have to be supplemented by other statistical data on the output of the species used: comparison of the gross quantities and finished products and estimate of optimum production. The latter seems of particular importance as it should help in the organization and development of the canning industry, which in turn affects an essential part of the marine fishing industry. Each individual branch of the canning industry may be led (and is in fact compelled sooner or later) to rationalize and modernize its production and hence to increase its output. This necessitates both a search for fresh supplies of the kind of fish handled (which often entails, on the general plane, the prospecting of new fishing-grounds) and the handling of other marine species or products in order to make full use of the plant installed. It should be noted that this full utilization in turn calls for fresh outlets, and leads, in the industrial field, to the establishment of subsidiary processing industries in which fishery by-products (surplus and waste) are acquiring increasing importance. Here, too, statistical data on supply and output are required to fulfil the same functions.

It remains to say a few words regarding international trade statistics.

INTERNATIONAL TRADE STATISTICS

It is clear that all the foregoing suggestions ought to be applied by each country in regard to its own fisheries and related industries. The results achieved would thus primarily serve the country's own interests, but the publication and, above all, the co-ordination, of these results would provide wider knowledge of the exploitation and utilization of the main areas producing, consuming and processing marine resources. The finishing touch would be added if these valuable data could be supplemented by a co-ordinated survey of the world trade in marine products.

There is no shortage of statistical data in this field, but they are incomplete in the sense that most countries publish their foreign exchange figures in a somewhat cryptic form, owing to old traditions inherent in commercial exchanges, and still more for reasons of convenience. It will of course be extremely difficult to conquer individual habits here but it would surely be possible to secure the inclusion in national statistics of foreign trade of a number of common headings covering the main species of fish and marine products and the countries of origin and destination. This would provide information which it is extremely desirable to have—in the first place from the practical point of view, as it would complete on a world-wide plane the cycle of information required to help in the exploitation, husbanding and distribution of a great natural source of wealth; and secondly from the psychological point of view, as it would mean that the peoples at last intended to work together for their common future.

Fisheries Statistics

DATA SUBMITTED BY THE NETHERLANDS GOVERNMENT

As regards the size of the fleet and the quantities of fish landed by this fleet reference is made to Appendices A and B. Though the portion of the fleet lost in the war has not yet been fully replaced, the quantities landed with the means available exceed those supplied before the war. In this connexion, however, it should be stated that on the one hand the general pre-war depression also prevailed in the fishing industry and, on the other hand, that several ships were enlarged and provided with heavier motors.

Until recently fish prices were tied to a maximum. From 1 February 1949, however, the prices have practically been free, except those for herring and shrimps. The price level has fluctuated somewhat since prices were decontrolled, but the average level is higher than the former maximum level so that it has risen towards the price level obtaining in the adjacent countries. Statistics on the course of prices have not been made as these were of little account when maximum prices prevailed.

Cost of production: In this connexion it may be remarked that an exact calculation is difficult, because several costs have been expressed in a percentage of the gross returns so that the amounts of these items are subject to variation. It has appeared, however, especially in the case of smaller trawlers and inshore fisheries, that the minimum gross returns required to meet the cost accounts per trip were frequently not attained.

The rise in prices after decontrolling has had a favourable effect in the Netherlands. During and after the war the cost accounts showed a constant rise which has now come to a standstill, while even for certain raw and auxiliary materials slight falls in prices have become evident.

Marketing: In the Netherlands any fishing craft is under the obligation to sell its catch by auction. The landed fish are bought by the wholesale trade or by the processing and other industries and passed on by the wholesale trade to processing and other industries, and to the retail trade.

For the wholesale and retail trades requirements have been set with respect to professional skill, commercial practice and solvency. The products of the fish-preserving industry are subject to sanitary inspection, and the law further provides for a control on products detrimental to health. Therefore, certificates of health or soundness are required for some products.

Part of the fresh fish is disposed of in the fresh state and part is processed into smoked, marinated or quick-frozen products or into preserves. Some products are consumed mainly at home, such as mattie and marinated products (except mussels) whereas others, such as oysters, fish preserves etc., are chiefly exported. (See Appendix D 1 as compared with Appendix B.)

Organization of industry: The industry is organized in central economic groups and economic groups representing a definite group of processing or other industries. Outside this organization the various factories engage in little co-operation. Combinations, trusts etc., are not found. The factories work individually. Only in certain cases are orders executed jointly, e.g., in the fish-preserving industry.

Home consumption: In 1938 the total fish consumption in the Netherlands amounted to approximately 10 kg. *per capita.* This figure includes all sorts of fish and shell-fish. For 1947 this figure was 13.3 kg. and for 1948 it was 12.1 *per capita.*

Foreign trade: The chief importing countries are Sweden, Norway, Iceland, France and Denmark. The export is mainly directed towards Belgium, Germany, the Union of Soviet Socialist Republics, Czechoslovakia, France, England and the Mediterranean area and the Netherlands Oversea Territories.

For further details, see Appendices D 1 and D 2.

APPENDIX A

Number of Ships and Tonnage of the Dutch Fishing-fleet in the years 1938, 1947 and 1948

	Number	Gross tonnage
Fleet on 31 December 1938		
Steam trawlers	95	19,789
Steam luggers	51	9,356
Motor trawlers	4	833
Motor luggers	252	29,783
Other motor vessels	505	13,402
Total	907	73,163
Fleet on 31 December 1947		
Steam trawlers	62	14,228
Steam luggers	30	5,645
Motor trawlers	6	1,460
Motor luggers	206	27,521
Other motor vessels	406	11,289
Total	710	60,143
Fleet on 31 December 1948		
Steam trawlers	63	14,844
Steam luggers	29	5,358
Motor trawlers	8	2,093
Motor luggers	213	29,523
Other motor vessels	431	12,368
Total	744	64,186

APPENDIX B

Supply of Fish and Fishery Products in the Netherlands

(Quantity in 1,000 kg. and Value in 1,000 guilders)

	1938		1947		1948	
	Quantity	*Value*	*Quantity*	*Value*	*Quantity*	*Value*
Fresh herring	23,225	1,560	42,410	10,715	47,167	11,788
Salted herring	74,578	6,840	89,856	29,680	92,141	33,712
Sprat	369	17	253	92	544	160
Mackerel	6,944	498	1,685	674	5,615	2,135
Haddock	7,760	1,091	7,087	2,516	4,396	2,285
Cod	5,557	892	9,418	3,203	3,083	1,864
Coal fish	2,158	153	557	140	1,179	460
Whiting	2,835	206	5,594	1,361	3,591	982
Ling	298	49	65	31	228	148
Stockfish	410	87	245	96	236	162
Plaice	8,213	1,394	11,093	4,646	13,561	5,259
Flounder	588	138	1,167	800	2,400	1,270
Dab	2,077	223	1,454	359	3,609	983
Sole	1,415	1,235	1,646	2,525	1,432	3,266
Turbot	869	496	720	794	562	928
Brill	238	104	102	76	121	126
Lemon sole	148	69	37	26	88	95
Grey gurnard	490	59	484	95	851	237
Cat-fish	259	43	55	19	297	219
Horse mackerel	1	—	171	21	283	58
Ray	166	33	86	14	190	59
Skate	120	15	39	8	58	28
Smelt	565	74	230	74	249	121
Oysters	849	684	1,137	2,591	1,442	3,255
Mussels	44,431	1,012	57,437	2,987	53,032	2,741
Shrimp preserves	3,560	511	4,440	2,156	4,372	2,293
Shrimp (dried)	14,384	227	7,057	188	3,336	90
Other shell-fish	1,481	101	623	279	752	300
Pike perch	127	44	1,191	1,277	936	1,204
Pike	—	—	2	1	7	5
Perch (fresh-water)	47	10	243	92	188	102
Bream	56	4	416	125	489	149
Roach	18	1	202	48	261	45
Eel	2,817	1,313	4,589	15,074	4,791	12,640
Immature fish	4,002	50	4,027	111	4,282	119
Other fish	1,552	427	225	224	2,932	951
TOTAL	212,607	19,660	256,043	83,118	258,701	90,239

APPENDIX C

Fish Processing Industry

1. Fish-preserving factories: 43 in number, including 15 mussel-preserving factories. Little production before the war.
   Production in 1948:
   - 6,000 tons of fresh herring
   - 1,000 tons of fresh salt-water fish
   - 600 tons of mussels (net weight)
   - 200 tons of fresh-water fish
2. Smoke-houses: 150 in number. Processed product unknown before the war.
   Estimated production in 1948:
   - 10,000 tons of salted herring
   - 4,000 tons of fresh herring
   - 3,000 tons of eel
   - 1,000 tons of fresh salt-water fish
3. Pickling factories: Approximately 150 in number. Processed product unknown before the war.
   Estimated production in 1948:
   - 7,000 tons.

APPENDIX D 1

Exports of Fishery Products in the Years 1934 to 1938, Inclusive (Average), 1947 and 1948

(Gross weight in kilogrammes and value in guilders)

	Average 1934 to 1938 inclusive				*1947*					*1948 (net quantity)*				
	Quantity		*Value*		*Quantity*		*Value*			*Quantity*		*Value*		
	1,000 kg.	*per cent*	*1,000 gld.*	*per cent*	*1,000 kg.*	*per cent*	*1,000 gld.*	*per cent*	*1,000B.fr.*	*1,000 kg.*	*per cent*	*1,000 gld.*	*per cent*	*1,000 B.fr.*
1. Pickled and sea-salted herring	64,482	44.65	5,399	41.31	46,492	38.66	19,382	39.16	320,191	44,018	39.36	23,358	42.53	385,874
2. Bloater (all sorts)	3,877	2.68	523	4.00	2,307	1.92	1,925	3.89	31,801	4,788	4.28	4,179	7.61	69,037
3. Fresh herring and sprinkled herring	17,887	12.39	1,098	8.40	9,824[1]	8.17	2,783	5.62	45,975	8,753	7.83	3,390	6.17	56,003
4. Salted cod, haddock, ling, coal-fish, halibut, whiting, torsks, "kelen en lippen en kibbeling" (edible parts of the head)	362	0.25	21	0.16	—	—	—	—	—	8	0.01	3	0.01	50
5. Dried cod (stockfish), haddock, ling, coal-fish and torsks	76	0.05	58	0.44	3	—	7	0.01	116	59	0.05	111	0.20	1,834
6. Anchovy, salted in tons or ankers (1 anker is 8⅓ gallons), not including spiced, so-called Norwegian anchovy	1,253	0.87	423	3.24	1	—	2	—	33	1	—	2	—	33
7. Smelt, fresh or smoked	564	0.39	92	0.71	50[2]	0.04	33	0.07	545	—	—	—	—	—
8. Eel (fresh-water), fresh	224	0.16	73	0.56	36[3]	0.03	45	0.10	743	141	0.13	264	0.48	4,361
9. Eel (fresh-water), smoked	39	0.03	50	0.38	33	0.03	137	0.27	2,263	29	0.03	150	0.27	2,478
10. Salmon, fresh, salted or smoked	147	0.10	171	1.31	1[4]	—	6	0.01	99	1	—	5	0.01	83
11. Other salt-water fish, fresh	8,538	5.91	2,245	17.18	6,300[5]	5.24	4,143	8.37	68,442	2,717	2.43	3,055	5.56	50,469
12. Other salt-water fish, smoked, salted, dried or steamed	316	0.22	58	0.44	7	0.01	8	0.02	132	35	0.03	42	0.08	694
13. Fresh-water fish	1,411	0.98	358	2.74	2,147[6]	1.78	1,913	3.87	31,603	1,817	1.62	2,151	3.92	35,534
14. Oysters, oyster brood and seed	782	0.54	500	3.83	1,345	1.12	2,388	4.82	39,450	1,040	0.93	2,164	3.94	35,749
15. Mussels and mussel seed	40,801	28.25	938	7.18	43,690	36.33	5,023	10.15	82,980	41,646	37.23	4,510	8.21	74,505
16. Lobsters and spring lobsters, fresh	360	0.25	353	2.70	270	0.22	1,220	2.47	20,154	107	0.09	887	1.62	14,653
17. Shrimps, unscaled	1,475	1.02	239	1.83	996	0.83	678	1.37	11,201	726	0.65	774	1.41	12,786
18. Shrimps, scaled	253	0.18	162	1.24	105	0.09	325	0.65	5,369	158	0.14	652	1.19	10,771
19. Other shell-fish	1,067	0.74	91	0.70	183	0.15	207	0.42	3,420	456	0.41	280	0.51	4,626
20. Preserved fish, shell-fish	490	0.34	217	1.65	6,466	5.38	9,267	18.73	153,091	5,346	4.78	8,938	16.28	147,656
TOTAL	144,404	100.00	13,069	100.00	120,256	100.00	49,492	100.00	817,608	111,846	100.00	54,915	100.00	907,196

[1]Net quantity, 6.779 [2]Net quantity, 42 [3]Net quantity 23 [6]Net quantity, 1 [4]Net quantity, 4.410 [5]Net quantity, 1.532

APPENDIX D 2

Imports of Fishery Products 1934 to 1938 Inclusive (Average), 1947 and 1948

(Gross weight in kilogrammes and value in guilders)

	Average 1934 to 1938 inclusive				*1947*					*1948 (net quantity)*				
	Quantity		*Value*		*Quantity*		*Value*			*Quantity*		*Value*		
	1,000 kg.	*per cent*	*1,000 gld.*	*per cent*	*1,000 kg.*	*per cent*	*1,000 gld.*	*per cent*	*1,000 B.fr.*	*1,000 kg.*	*per cent*	*1,000 gld.*	*per cent*	*1,000B.fr.*
1. Pickled and sea-salted herring	2,072	13.99	163	4.68	1,405	16.24	410	5.63	6,773	76	1.21	40	0.46	661
2. Bloater (all sorts)	55	0.37	6	0.17	12	0.14	13	0.18	215	—	—	—	—	—
3. Fresh herring and sprinkled herring	2,333	15.76	184	5.28	1,216[1]	14.06	288	3.96	4,758	40	0.64	12	0.14	198
4. Salted cod, haddock, ling, coal-fish, halibut, whiting, torsks, "kelen en lippen en kibbeling" (edible parts of the head)	1,059	7.16	123	3.53	243	2.81	165	2.27	2,726	505	8.07	478	5.53	7,897
5. Dried cod (stockfish), haddock, ling, coal-fish and torsks	591	3.99	194	5.57	791	9.14	1,123	15.43	18,552	602	9.61	916	10.60	15,132
6. Anchovy, salted in tons or ankers (1 anker is 8⅓ gallons), not including spiced, so-called Norwegian anchovy	26	0.18	5	0.15	134	1.55	107	1.47	1,767	11	0.18	10	0.12	165
7. Smelt, fresh or smoked	2	0.01	—	—	5[2]	0.06	1	0.01	16	—	—	—	—	—
8. Eel (fresh-water), fresh	720	4.86	376	10.80	503[3]	5.82	774	10.63	12,786	596	9.52	1,254	14.52	20,716
9. Eel (fresh-water), smoked	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10. Salmon, fresh, salted or smoked......	529	3.58	365	10.48	59[4]	0.68	144	1.98	2,379	107	1.71	370	4.28	6,112
11. Other salt-water fish, fresh	1,361	9.19	232	6.66	3,789[5]	43.80	2,812	38.63	46,454	3,953	63.14	4,306	49.84	71,135
12. Other salt-water fish, smoked, salted, dried or steamed	302	2.04	29	0.83	—	—	—	—	—	4	0.06	5	0.06	83
13. Fresh-water fish	81	0.55	40	1.15	36[6]	0.42	86	1.18	1,421	12	0.19	49	0.57	810
14. Oysters, oyster brood and seed......	279	1.88	138	3.96	60	0.69	88	1.21	1,454	73	1.17	85	0.98	1,404
15. Mussels and mussel seed	271	1.83	6	0.17	—	—	—	—	—	—	—	—	—	—
16. Lobsters and spring lobsters, fresh...	555	3.75	450	12.92	300	3.47	1,059	14.55	17,495	143	2.28	796	9.22	13,150
17. Shrimps, unscaled	37	0.25	7	0.20	—	—	—	—	—	—	—	—	—	—
18. Shrimps, scaled	2	0.01	1	0.03	—	—	—	—	—	—	—	—	—	—
19. Other shell-fish	—	—	—	—	—	—	—	—	—	—	—	—	—	—
20. Preserved fish, shell-fish	4,528	30.60	1,164	33.42	97	1.12	209	2.87	3,453	139	2.22	318	3.68	5,253
TOTAL	14,803	100.00	3,483	100.00	8,650	100.00	7,279	100.00	120,249	6,261	100.00	8,639	100.00	142,716

[1]Net quantity, 951 [2]Net quantity 3 [3]Net quantity, 376 [4]Net quantity, 45 [5]Net quantity, 3.146 [6]Net quantity, 29

Statistics on Economic Features of the Fisheries

G. M. GERHARDSEN

ABSTRACT

Fisheries statistics have to be nationally useful but should be internationally comparable, if they are to serve the fisheries industry, the fishermen, the traders, biologists, economists etc.

Two years' experience of the Food and Agriculture Organization indicates that the regularity and coverage of many publications on fisheries can be improved.

Much is still to be done in practically all countries to improve statistics on landings, utilization, processing, internal and external trade etc.

In landings statistics, difficulties in respect of species names and classification, conversion to comparable stage of dressing etc., are encountered. In trade statistics, difficulties are experienced in respect to terminological inconsistencies and commodity classifications.

Much must still be done to improve the measurement of the amount of fishing effort in clearly demarcated fishing areas.

INTRODUCTION

This paper is based on two years' experience in the Fisheries Division of the Food and Agriculture Organization. The organization has among its functions that of encouraging the collection and publication by member nations of basic fisheries data, as far as possible according to uniform methods, and also that of publishing international digests of such statistics.

Fisheries statistics from as many countries of the world as possible have therefore been assembled and collated, then converted and reclassified for comparability. What had been prepared up to the end of 1947 on the basis of national publications was included in the *FAO Yearbook of Fisheries Statistics, 1947*. Between the first issue and the second, which is to appear toward the end of 1950, supplementary material such as current statistics on world fisheries has, since August 1948, been made available by means of the FAO *Fisheries Bulletin*. More specialized statistics on production and trade have been published in a commodity study entitled "Salted Cod and Related Species". A similar statistical-economic study on herring products is in preparation.

There is a tendency for world-fisheries statistics to become stereotyped. Not always have the governmental agencies in charge been alert to changes in the kind of statistics needed. Tables no longer useful are maintained merely for the sake of continuity; others which would be highly desirable are either not worked out at all or not published. In many countries investigators complain about lack of statistics on fisheries topics. Even when hurriedly prepared, reports from such committees contain many valuable statistics and many intelligent notes which facilitate reading of official publications on statistics. Moreover, the need for improvement of national statistics on economic features is signified by the fact that many Governments would put out supplementary (cheaply reproduced) reports. Unfortunately these publications, although unrestricted, only reach a very limited number of readers. (Only publications on exports and imports are generally adapted to changing needs).

Our work on bringing together and using fisheries statistics from many countries has gradually led us into a study of the possibilities for making fisheries statistics more reliable and useful within each country and for introducing more uniform methods in collecting and reporting them.

Our experience makes it clear that an attempt should be made to satisfy simultaneously the needs of the biologist, the technologist, the economist, the administrator and the fisheries industry itself.

In some regions interest in improving fisheries statistics has already been demonstrated. Individual countries have started revisions, and exchange of information between countries has been intensified. While it is hoped that these notes may be of help, it should be emphasized that FAO's experience does not yet cover all fields of fisheries statistics, nor is it necessarily proportionate to the importance of the various items.

PRESENTATION OF LANDINGS STATISTICS

About 75 per cent of the estimated landings of the world are recorded statistically more or less regularly. In most countries, statistics on fish catches are recorded at the time of landing, because that is usually the time of marketing, when quantities are measured, prices determined etc. As trade habits vary, however, fish catches are recorded at various stages of dressing. Where, for example, cod is landed as "wet salted", its weight is only about 40 per cent of what it was when taken from the sea.

If the stages of dressing were clearly indicated and factors were given for converting from one stage of dressing to another, national publications would be more valuable, and landings in different countries could easily be compared. Upon request from FAO, several countries have supplied such factors.

It is also necessary to convert quantities to the same unit, i.e., the metric system units, and to convert to that unit quantities originally measured in volume or numbers. (Statistics on crustaceans are often given in numbers.) Some non-metric units are well known and clearly defined; others need a clear definition.

Further, the various species of fish and other aquatic products must be clearly identified, and listed in a uniform order. Allied species should be grouped according to international standards.

National publications should contain summary tables prepared in a uniform way.

Much difficulty has been caused by delay in the printing of national publications. There is often a lag of many years. Because of the urgent need for end-of-year figures FAO has now for three years, 1946, 1947 and 1948, with considerable success, requested tentative figures on landings, utilization and end products for the main species groups. The reporting countries account for some 50 per cent of the world landings.

Subsequent checking has shown these tentative figures to be quite accurate; they definitely serve a useful purpose in showing current and recent trends in world fish production. It adds to the value of these statistics that figures on landings have been converted by the reporting countries to a common basis of round fresh weight.

ORIGINAL RECORDING OF LANDINGS STATISTICS

While the collection of fisheries statistics has had to be adjusted to local conditions, most of these statistics are obtained through questionnaires which are submitted to fish merchants or to fishermen, or to both. There is seldom an effective way of checking the exactness of the information given. While much is still to be desired with regard to accounting in the fisheries industry, improved methods have been adopted during the last two or three decades, and it may well be that greater use can be made of them in assembling the original data.

Both from a biological and from an economic point of view, it would be desirable to have information on each individual landing. This could be achieved by means of a copy of the receipt slip which is usually issued at the time of sale. Where necessary, the receipt slip could be supplemented by excerpts from logbooks. Receipt slips already form a basis for statistics on fisheries in many sections of the industry. Introduction of statistical machines should make it possible to utilize this background material extensively. The form of the receipt slips could be gradually influenced by the collecting agencies.

Fishermen from some countries occasionally or regularly land their catches in foreign countries. For countries where such landings by their nationals are of importance, serious problems arise. It is not possible to have representatives in the foreign harbours in order to record such landings of their nationals. The exchange of information between the countries must be encouraged.

STATISTICS ON UTILIZATION OF CATCHES

Official statistical publications contain only fragmentary information on how the catches are used. It will never be possible to answer this question accurately because statistics are collected at an early stage in the disposition of the raw material, when transferred ashore from the fishing craft. The FAO questionnaire shows that a number of countries can estimate fairly well the utilization of the various species; it might be worthwhile to include such statistics in regular publications. These statistics might be refined if data on raw material can be obtained from the various processing industries.

Statistics on the utilization of catches are closely related to statistics on end-products. Good estimates have been given by a number of fish-producing countries.

IMPORTS AND EXPORTS STATISTICS

Statistics on domestic fisheries products trade are almost non-existent; there are fairly good statistics on imports and exports. In our publications we have included such external trade statistics for some sixty-five countries. Many of these countries followed international minimum classification. For some other countries which did not follow that list it was possible to reclassify the items. The minimum list is, at present, being revised by the Statistical Commission of the United Nations Economic and Social Council. Meanwhile, the Fisheries Division is using its own breakdown to distinguish between the major groups of commodities passing into international trade.

Although improvements have been achieved by unifying trade classification attention should be given to other aspects of these statistics. If correctly recorded, statistics on exports from one country should correspond approximately with those on imports into other countries. Such comparison was made in the study of salted fish and a good deal of inaccuracy was found. Several cases were encountered where information on countries of origin was inaccurate.

Clarity of language in the itemization of trade statistics should be studied. The necessary special terms should be properly defined.

AMOUNT-OF-EFFORT MEASUREMENT

It is important to measure the actual yield of the various fishing grounds and relate it to the amount of effort devoted to fishing at each particular ground. Statistics of this nature, as well as being valuable to biologists, could form the basis for research on cost of production, and thus be useful from the point of view of economy and management.

It is not sufficient to count the number of men who were engaged in fisheries at any time during the year. Many countries place their fishermen in vague categories, many of which are actually too loose to be of very much use. It might be better to group the fishermen according to the length of time each year that they are occupied in the fisheries industry. This breakdown should be used for each of the main fisheries of the country concerned. If necessary, it could also be used for each size group of each particular craft type.

The statistics on fishermen may be supplemented by relating them to several other possible sources, e.g., registrations in conjunction with the issuance of fishing licences required by law.

With respect to craft used in the industry, many countries have realized that reporting the total number is not sufficient, but details on the fleet are seldom comparable. There are several possible ways of improving statistics in this respect. One possibility would be agreement upon uniform measuring of vessels. The most useful background for statistics on fishing craft would be registers, which should contain the name of the craft, its number, if any, its length, the width and the depth of the hull, the year of construction, the make of the engine and the horsepower, whether equipped with echo-sounder and wireless telephone, kind of winch, the particular fishing activities for which the vessel was designed, and so forth. From a national point of view the cost of construction may also be useful.

Many countries already have such registers of fishing craft. They might be improved, however, and the establishment of international standards in their form would benefit all concerned. On the basis of such registration, several kinds of internationally comparable statistics could be prepared.

Much emphasis should be placed upon the need for knowledge about the time spent on each trip and in actual fishing operation. This could perhaps be arranged as part of the information obtained through sales slips. Such information not only makes for more accurate research as to the yield from each fishing ground, but also aids the owners of the vessels in relating their own experience with that of others. It has a bearing on the question of overhead costs and their distribution between the various seasons. It also has a bearing on any governmental attempt to survey prices obtainable and recommendable for various kinds of products.

Statistics on Economic Features of the Fisheries of the United States

EDWARD A. POWER

ABSTRACT

The collection of basic employment and production statistics in the United States is considered a state rather than a federal function. However, only about one-half of the states supporting important commercial fisheries collect detailed fishery statistics.

Establishment of statistical systems by slow degrees is recommended. Once a statistical system is established, it is essential that use be made of the figures, or the quality of the data will decrease.

Experience appears to indicate that, in the United States, it is more profitable to confine the limited federal collection of data to areas where the maximum co-operation with other agencies is obtained.

Special manufactured products surveys can be used to obtain some knowledge of catch trends.

The collection and publication of daily fishery production, price and movement statistics is one of the most valuable services provided the fishing industry. Despite the improvement in the collection and dissemination of fishery data in the United States, economists are still handicapped by the lack of essential data.

The collection of national fishery statistics in the United States is of comparatively recent origin. The first surveys by the Federal Government were made about seventy years ago, when the collection of annual data on the number of fishermen, fishing craft and gear employed, the volume and value of the catch and related information was undertaken. Funds for the collection of fishery statistics have been limited and in only one year (1931) was it possible to obtain complete information on the employment, catch and production of manufactured fishery products in all sections of the country. During the period from 1880 to 1927, surveys were conducted annually in less than 25 per cent of the statistical regions into which the country has been divided. Since 1927, annual coverage has been raised to nearly 75 per cent, there has been a great increase in the collection and dissemination of current market data, and facilities for economic fishery research have been greatly expanded.

Regulation of the fisheries in the United States is a responsibility of the individual states. In the absence of a treaty with a foreign Government affecting certain fisheries, or limited special legislation requiring submission of statistical reports, the Federal Government must obtain its fishery statistics on a voluntary basis.

Since the Federal Government is, in most instances, unable to require the submission of statistical reports by fishermen or dealers, and since the funds for the collection, tabulation and publication of fishery data have been limited, it has been necessary to rely to a large extent on the individual states to collect basic fishery data. It has been felt that this is properly a state function. The field of federal activity is assumed to lie in co-ordinating the collection of fishery statistics in the various states; assembling and publishing the data; in collecting and disseminating current market information; and in preparing special statistical studies of the fisheries relating to production, distribution, marketing, consumption and related activities.

When the Federal Government first undertook the collection of fishery statistics about 1880, little data were obtained by the individual states, and it was necessary to secure the information required almost entirely by personal interview of fishermen, dealers and others acquainted with the industry. To a considerable extent, the data were obtained by sampling and, while the degree of accuracy in many instances was less than was desired, the figures were of great value in demonstrating the importance of the industry and in indicating employment, production and marketing trends. Since 1880, many of the states have established systems for collecting data on their fisheries. However, even today, only about one-half of the states having important commercial fisheries attempt to collect detailed data on the quantity and value of the fishery products taken by their fishermen. Unless the Federal Government conducts surveys to collect information on the fisheries of the remaining states, the data are not obtained.

There appear to be two principal reasons for the failure of individual states to establish systems for collecting fishery data. First, the failure to recognize the economic and biological value of the data; and, second, the apparent high cost of collecting, tabulating and publishing adequate fishery data. While the cost of not having fishery statistics, which often results in lost business opportunities and depleted fisheries, is much greater than the cost of setting up systems for collection of fishery statistics, such systems are expensive, and it is often difficult to obtain the necessary funds for their establishment. If an attempt is made in a state to undertake the establishment of an organization for collecting detailed economic and biological data on all phases of the fisheries, the cost is frequently so great that funds cannot be secured. Often, a more successful approach is to undertake the collection of current data on the yield of certain important fisheries, the catch by certain types of gear, or other activity that can be handled without a great increase in staff and funds. As the value of the data is demonstrated, it is frequently possible to expand the coverage and eventually obtain adequate economic and biological data.

Once a system for the collection of fishery statistics is established, it is essential that continued use be made of the data. This can best be insured by publication of at least monthly and annual summaries of the figures. This serves several purposes. The individual supplying the data is aware that the information furnished is being used, the personnel engaged in assembling and releasing the figures must keep all phases of the work up-to-date, constant use of the data brings to light errors that might not otherwise be detected, and use of the information establishes its value and insures continued authorization to continue the activity.

The statistical activities of the Fish and Wildlife Service concerned with the continental United States have evolved into three major lines of activity, handled by the same number of sections in the Branch of Commercial Fisheries. They are the Statistical, Market News, and Economic and Cooperative Marketing Sections. The Statistical Section is concerned with the collection of detailed data on employment in the fisheries, craft and gear operated, volume and value of the catch, and the production of manufactured fishery products. In addition, the Section, in co-operation with other federal and state agencies, collects and publishes monthly statistics on the production of fish meal and oil, freezings and cold-storage holdings of fishery products, and detailed information on the landings in certain ports and states. As was indicated earlier, the information is obtained largely on a voluntary basis. The methods used in collecting annual statistics relating to the employment of men, craft and gear, and the catch are nearly as varied as the states supporting commercial fisheries. In some areas, the information can be assembled largely from records maintained by state fishery departments. In others, the major portion of the data are available from current detailed economic and biological records collected by Service personnel and state fishery departments. In many states, even today, little current or annual information is available, and it is necessary for Service employees to assemble employment, gear and catch statistics from tax records, dealers' sales slips, shipping records, and by interviewing management officials and individual fishermen. It is recognized that the data assembled on the fisheries of the latter states cannot have the degree of accuracy or value that exists in areas where detailed daily catch records are collected. Therefore, it has been the policy of this Service to devote the major portion of its statistical activities to the areas where the maximum co-operation is obtained from other agencies. In this manner, a greater volume of continuous detailed data becomes available.

In attempting to conduct statistical surveys of the fisheries with insufficient funds to cover all sections of the nation each year, the Service has had the problem of deciding whether to alternate from year to year in the collection of the data in certain areas, or to establish permanent offices in the more important regions and collect annual data in those areas. Both methods have been tried. The conclusion has been reached that it is best to establish permanent field offices in certain areas and conduct annual surveys in those regions. This has left certain areas without coverage for periods of five to ten years or more. While this is unfortunate, it seems preferable to conducting alternate-year surveys for several reasons. Agents assigned to conducting alternate-year surveys are unable to maintain normal home life, and they are inclined to seek other employment. This causes a heavy turnover in the field staff and results in a large portion of the surveys being conducted by inexperienced agents. Since an agent cannot become adequately acquainted with his field until he has conducted two or more complete surveys of the area, it is evident that a combination of heavy turnover and alternate-year surveys would not result in the collection of satisfactory data. When alternate-year surveys are conducted, agents cannot become well-known to members of the industry, and it is difficult to secure the confidence of dealers and fishermen. It is difficult, also, to prevail upon buyers of fish and shell-fish to keep detailed records of their purchases or to revise their bookkeeping systems so that essential data can be readily obtained. This is frequently possible when a permanent agent is assigned to an area.

There are certain types of monthly and annual data, which are of unusual value to the industry, that can be collected, for the most part, by mail. It is possible, therefore, by conducting these relatively inexpensive surveys, to supply the industry and government agencies concerned with the fisheries, with valuable trade information, and at the same time, obtain an indication of the trend in the catch of items accounting for over 50 per cent of the United States catch. The Statistical Section of the Fish and Wildlife Service conducts monthly surveys of the domestic freezing and cold-storage holdings of fishery products, the production of fish meal and oil, and the stocks of fish oils. Annual surveys are conducted to obtain data on the domestic production and value of canned fishery products, by-products and packaged fish.

At various times, the collection of these data has been attempted by agencies of the Federal Government in connexion with special business or agricultural surveys for similar types of data. It has been found that the collection of fishery data by agencies other than the Fish and Wildlife Service, or its predecessor agencies, has been unsatisfactory. The large number of species involved, the many forms in which individual items are marketed, the varying open and closed seasons, make it difficult for personnel not intimately familiar with the fishing industry to assemble or supervise the assembling of fishery production and marketing statistics.

While the monthly and annual fishery statistics collected by the Fish and Wildlife Service are of value in demonstrating the importance of the nation's fishery resources, in indicating the condition of the fishery resources, and have many other uses, they are not sufficiently current to provide the fishing industry with the daily production, price and movement statistics it requires for efficient operation. To fill this need, the Fish and Wildlife Service opened its first Fishery Market News office in February 1938. Today seven offices, located in the principal production and distribution centres of the nation, release an average of nearly 7,000 two-page to four-page reports each day. These contain information on the landings, receipts, shipments and prices of fishery products, daily and weekly cold-storage movements, import data and related information. The purpose of the reports is to apprise the producer and shipper of terminal market supplies and prices, and to make known to the wholesale dealer the production in fishing areas, and the prices and supplies in competing consuming centres.

In addition to the primary uses, there has come to light a number of lesser-known ways in which the Fishery Market News bulletins have been of assistance to the industry. Without doubt, the daily reports have served to promote a better understanding between producers and wholesalers. With a daily unbiased report containing information on market supplies and prices, the fisherman has a check on his probable return. The lot of the unscrupulous dealer is made harder since low returns which deprive fishermen of their just due are rendered more obvious. What the fisherman may consider a low return is often verified by the report revealing conditions—such as an oversupply of another species—that caused the depressed price. Again, discerning fishermen can note, and the price quotations will bear out, the contentions of wholesalers, that a low return often is the result of haphazard packing, no grading as to size or quality, and a general non-conformity to the demands of the market. This day-by-day reiteration of facts slowly brings to the attention of the fishermen the point that the wholesalers have their marketing problems; and likewise, to the dealers, that perhaps the fishermen have had some just cause for their complaints.

The factual and current aspects of the information issued have been of considerable aid to businesses dealing with the industry. For example, transportation companies, in settling claims due to damage or the delayed arrival of fishery products, are spared the necessity of checking numerous dealers' books to ascertain a fair price for settlement. Banks and coldstorage companies have found it more feasible to make loans on frozen fishery products with the current holdings and prices readily available. Fishery supply concerns have their agents or salesmen receive the report so they may keep in close touch with market conditions and be better able to serve their customers.

Statistically, this service also has been exceptionally valuable. The mere listing of the species received in the various terminal markets has provided fishermen with new outlets, and buyers, in inland centres, with more convenient sources of supply. The breakdown of receipts into species, origin, and method of transportation has provided hitherto unavailable information useful to economists in market studies, to biologists in conservation work, and to the trade in promoting remedial legislation.

The successful operation of Market News offices is dependent upon rapid collection and dissemination of fishery market information. Speedy collection of fishery data in the areas served by the Fish and Wildlife Service's offices is obtained by employing part-time market reporters in producing centres. Full use is made of telephone, teletype and telegraph facilities by reporters in submitting data to Market News offices and between the various offices. Full use is likewise made of rapid duplicating, folding and addressing equipment.

Because of the reliance of the industry on the information released in the Market News reports, it is necessary that special care be taken to ensure that each office is staffed with personnel having a wide knowledge of fishery production and marketing practices. This has been found to be particularly important since the major portion of the information collected is published the day it is obtained, and there is little opportunity for checking or revising data prior to their release.

While the collection and dissemination of current monthly and annual fishery statistics is necessary to the welfare of the nation and the fishing industry, the job is only half done when the basic facts are made available. The information must then be analysed and used. The Fish and Wildlife Service employs a staff of economists to conduct basic studies of such matters as employment and labour problems in the fisheries, effects of imports on the domestic fisheries, *per capita* consumption studies, cost studies, effects of marketing agreements, subsidies, price support problems, and parity prices in connexion with their possible application to the fisheries, and similar studies. These essential services could not be conducted without basic employment, catch, price and utilization statistics. Unfortunately, despite the considerable improvement in the collection and dissemination of fishery statistics that has taken place in the United States in recent years, the economist is still severely handicapped by the lack of much essential data. Employment and catch statistics are collected only intermittently in several important areas of the country; little or no information is obtained on stocks of manufactured fishery products, other than frozen; and little information is available on the sport catch of commercial species, which, in some areas, equals or exceeds the production by commercial fishermen.

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Recent Advances in Methods of Handling, Preservation, Processing and Distribution of Fish. Developments in Utilization, New Products and By-Products

OLAV NOTEVARP

ABSTRACT

A view of the utilization of the world's catch of fish illustrates the possibilities of obtaining more animal protein for human food from fish. Large amounts of surplus fish are used for oil and meal production only, and advances in processing may substantially increase the quantity of fish products available for food.

The effect of temperature upon storage life is illustrated for fresh and frozen fish. Advances have been made in handling and transportation, but no revolutionary new method for keeping fish fresh has appeared. Filleting and freezing have developed very quickly, and the production of frozen fillets may now be estimated at three times that in 1939. Very low storage temperatures have been shown to be decisive for the quality of frozen fish and to make extensive marketing of an excellent frozen product possible.

Salted and smoked fish processing has been improved by refrigerating, artificial drying and controlled smoking, fish meal and oil production by utilization of the press liquid for condensed fish solubles and by dry rendering. Production of high potency vitamin oils has been developed and new fish products such as amino acids, fish albumen and enzymes are made. Other new products, for example, edible fish flour may become important as inexpensive sources of protein.

INTRODUCTION

The world's catch of fish before the last war has been estimated at about 17 million metric tons annually (1)[1]. After the war the total catch has not reached the same level, mainly because the fisheries of eastern Asia, (which before the war yielded more than one third of the world's catch), have not been fully restored. Based on available data for the most important fisheries (2), the world's catch may be judged at about 13 to 15 million tons for 1947, for 1948 a little higher.

The decrease of fishing in some countries has been larger than the difference indicates, because new technical aids for the fishing vessels, such as echo sounding and radio, have made the existing fishing fleet much more effective.

Developments in fishing vessels and in fishing gear have also helped to increase the catch. In addition, new fisheries have been established, and sponsored by FAO, new fishing areas being studied and under development. In spite of the fact that some great fisheries are exploited fully and may decrease, it may be assumed that the world's catch of fish soon will surpass the pre-war figures.

An increased catch of fish should mean more food available for man. The use of fish as food is however, dependent upon the utilization, processing and preservation of this highly perishable raw material to products which will keep and are fit for marketing and consumption. Therefore advances in the processing and conservation of the catch may be at least as important for obtaining more food from fish as increasing the catch. The possibilities in this direction may be strikingly demonstrated by a general review of the present utilization of the total catch of fish, and of the possibilities of better utilization.

THE FOOD VALUE AND UTILIZATION OF FISH

Fish flesh contains about 18 per cent protein, the most important nutrient in fish, and fish protein has been shown to have at least as high nutritive value as protein from meat (3) (4).

Fifteen million tons of fish correspond to about 7 or 8 million tons of edible fish flesh, dependent upon how the fish is processed, containing about 1.3 million tons of protein. This amount represents 7 kg. a year or 20 grammes animal protein a day for about 185 million consumers. Each million ton increase in the production of edible fish flesh represents 20 grammes animal protein a day for 25 million persons.

Increase of these quantities may be achieved by increased fishing, but also by better utilization of the present catch. According to the available data about 5 million tons of edible fish flesh was used for human food before the war, or about two-thirds of the edible part of the catch, of which a very large part was surplus fish used for fish oil and fish meal only. According to available data (5) the world's annual fish meal production in 1938-1939 may be estimated at about 1.3 million tons, corresponding to about 7 million tons of raw fish material, of which by far the largest part was surplus fish which could not be utilized as food.

The part of the catch utilized as human food increased after the war, but huge amounts of fish are still used for oil and meal production. A substantial amount of the oil is, however, now refined and utilized as edible oils or fats.

Oils or fats are contained in all fishes, in their flesh or livers or in both. The oil content differs very much for the different species, and for the same species according to size, fishing seasons and areas. Therefore an estimate of the total amount of oil contained in the fish catch is deemed to be very approximate, but 15 million tons of fish may be assumed to contain about 1.5 million tons of fat or oil. An appreciable part of this is at present lost in fish waste which is not utilized.

The fish oils are, due to their content of the fat soluble vitamins A and D, very important. Fish liver oils are known to be outstanding in this respect, but also the body oils of marine fishes have a high content of vitamin D, and contain appreciable amounts of vitamin A. The most important body oils of herrings, sardines, halibut and salmon, contain usually more than 50 I.U. of vitamin D

[1]Numbers within parentheses refer to items in the bibliography.

per gramme, i.e., more than a hundred times the vitamin D content of ordinary butter. The total amount of vitamin D in the fish catch may be judged to be an amount sufficient for the yearly requirements of at least 500 million youngsters, and that of vitamin A for at least 300 millions. Unfortunately the vitamins of the oils which are hydrogenated or polymerized are destroyed by the processes used, and a substantial part of the oils is used for animal feeding.

Fish contains many other valuable nutrients, e.g., water-soluble vitamins and mineral constituents. Iodine must be regarded as important, because fish are far richer in iodine than other ordinary foods.

SPOILAGE, HANDLING AND TRANSPORTATION

The chief causes for the rapid spoilage of fish have been shown to be the action of certain bacteria and enzymes. The degree of spoilage may be determined by bacterial counts, but according to extensive investigations also by the trimethylamine formed, e.g., derived from the trimethylamine oxide contained in most marine fishes (6) (7) (8) (9). For other species the content of ammonia has been shown to characterize the freshness. By simple chemical determinations of these bases rapid information about the freshness of the most important species of fresh fish is obtained.

The perishable properties of fish make careful handling and preservation necessary for fish which cannot be used or processed shortly after catching. The importance of cleanliness during handling to get the incipient number of bacteria as low as possible has been demonstrated, and the effects of germicidal washing and germicidal ice for cooling the fish have been studied.

Irradiation has been proposed for inactivating bacteria on fish. "Electron sterilization" with high speed ultra-short impulses of electrons from the "capacitron", 3 to 5 million volts and about one-millionth of a second, has been proposed for inactivating the bacteria and enzymes in fish without altering the fresh condition (10). After this "cold sterilization" in airproof containers or packages it has been claimed that the fish keep fresh at ordinary temperatures for months, but recent investigations do not seem to confirm the claims. The enzymatic spoilage of fish is not checked, and some alterations in flavour, taste and texture, and chemical changes in proteins and fats are caused. It may be justifiable to conclude that the possibilities of fish preservation by this method have been much exaggerated.

Spoilage of fatty fish is also caused by rancidity, because fish fats contain highly unsaturated fatty acids which react with the oxygen of the air and rapidly develop a rancid taste during storage. Comprehensive investigations have been made to find means for preventing rancidity and many antioxidants have been tested. A number have been found to have some effect, but ascorbic acid, vitamin C, may be the most promising one. When applied in sufficient amount, e.g., 0.04 per cent of the fish, this substance is able to decrease the rate of rancidification very substantially (11). This effect is very important because rancidity limits the storage life of many fish products. The high price of ascorbic acid may, however, restrict its use commercially.

The rate of spoilage is highly dependent upon the temperature of the fish. A great number of tests have shown the rate of ordinary spoilage between 20 and 0 degrees C to be reduced to about half when the temperature is lowered 6 to 7 degrees C (12) (13). Accordingly, fresh fish having a storage life of two days at 20 degrees C (68 degrees F) will keep: about four days at 13 degrees C (55 degrees F); about eight days at 6 degrees C (43 degrees F); and about fifteen days at 0 degrees C (32 degrees F).

The spoilage starts as soon as the fish are killed. To keep them fresh as long as possible, chilling to about 0 degrees C immediately after they are caught is of vital importance. Any delay in chilling reduces the storage life. If fish which will keep fifteen days at 0 degrees C when chilled as soon as they are caught, are stored two days at 13 degrees C before they are chilled, they will keep only about seven to eight days more at 0 degrees C.

Ice is still the ordinary means for the chilling and storage of fresh fish, but storage conditions have been improved by general use of insulated holds and by mechanical refrigeration. Rapid chilling with brine has been adopted to some extent with good results, especially on board fishing vessels (14). Freezing the fish on board the fishing vessels and keeping them frozen until they are processed, e.g., by canning, filleting or freezing, has been developed, and is in common use for tuna fish (15) (16).

For the cooling of fresh fish during transportation, ice on the fish is still in general use, but insulated and refrigerated vehicles and containers have been commonly adopted to protect the ice from melting. Carbon dioxide ice, "dry ice", is to some extent used as a refrigerant. Its high cooling effect per unit of weight and its dryness are advantageous in transportation, and the carbon dioxide gas formed inhibits the growth of some fish-spoiling bacteria (17). Owing to its low sublimation temperature, minus 79 degrees C, dry ice lends itself very well to refrigeration of frozen fish during transportation, for which it is extensively used.

Mechanical refrigeration during land transportation of fresh and frozen fish has been increasing, but the difficulties in constructing satisfactory refrigerating units of this kind evidently have restricted their application. Improvements in railway transport have been achieved by the use of overhead ice bunkers and of eutectic ice (18).

FISH PRODUCTS AND PROCESSING METHODS

Fish products may be divided into three groups:

1. Fish products for human food.
2. Fish meal and oil.
3. By-products and new products for specialized use.

Fish products for human food represent in general the best utilization of the fish, and the first aim for advances in fish processing should be to utilize as much of the catch as possible for this purpose. Chilling, freezing, canning, salting, smoking and drying are the most common processing methods. Their application preserves the main nutritive value of the fish for human nutrition.

Products of the second group are made from surplus fish, fish livers and fish waste. The oil is extracted by heat or solvents and the non-fatty residue dried to fish meal. Fish liver oils are to a great extent prepared for human use. Fish body oils undergo refining, hydrogenation or polymerization to edible fats and oils, or they are used for animal feeding and industrial purposes. Fish meals are used for animal feeding, and their nutrients are only indirectly and with great losses made available for humans.

Products of the third group, e.g., condensed fish solubles, fish flour, fish albumen, amino acids, enzymes and cholesterol, may be produced for animal or human nutrition, or for pharmaceutical or industrial purposes. They are made from fish, fish waste, fish organs and fish oils.

The purpose of processing and preserving fish for food is to preserve their original sea-fresh condition as unaltered as possible for the consumer, or to convert the fish to palatable products which contain the important nutrients of the fish and will keep a sufficient length of time. It is usually agreed that as much fish as possible should be prepared for consumption in the fresh or frozen state. However the seasonal character of many of the greatest fisheries, yielding huge amounts of fish within a short time, and long distances between the fishing grounds and the markets, call for other means of preservation, too. Canning and salting have been the most important processing methods, and the world's annual from production about 1940 to 1942 has been estimated at about 1 million tons of canned and 1½ million tons of cured fish (1).

Canning preserves the fish in a cooked condition for years. Wet-salted or dried-salted fish have more limited keeping properties, and require more labour for preparation before they are consumed than canned, fresh and frozen fish. Therefore the trend in modern fish processing has been to utilize more fish for freezing and canning. These methods demand, however, modern plants and machinery, which may be too expensive for very short seasons. Salt curing makes preservation of large quantities of fish by simple means possible, and must be regarded as very important for utilizing the large catches from fisheries of seasonal character. The salting of fish is also one of the less expensive methods for preservation.

For utilizing modern processing plants in different fishing seasons and areas factory ships are important, and many advances have recently been achieved in this field (19) (20) (21).

FRESH AND FROZEN FISH

Developments in fast transportation have made good fresh fish available to many more people than before. However, the time fresh fish may be kept in a good edible condition, e.g., by icing or chilling, is limited to about twelve to sixteen days after they are caught, according to species and fishing methods, and long-distance fishing vessels such as trawlers frequently have difficulties in delivering a satisfactory fresh product.

Chilling and icing have to some extent been improved by better cleaning, germicidal treatment of the fish and the fish holds, and the use of germicidal ice. These measures may increase the storage life two to four days.

To enhance the keeping properties of fresh fish it is of major importance to keep them continuously chilled from the time they are caught until they reach the consumer. Any increase in their temperature at any time during handling or distribution increases the spoilage rate and reduces the time they may be kept fresh. The practice of taking the fish out of the ice when exposed for sale in the markets and the lack of sufficient cooling in the retail distribution outlets result in much spoilage which might be avoided. However, the understanding of the effect of temperature is growing, and handling has been much improved.

Filleting has been very important for the transportation and marketing of fresh and frozen fish. Packaging and transportation of fillets means savings in boxes and freight, and when processed in a sanitary manner and satisfactorily chilled fresh fillets may keep longer than eviscerated fish.

Filleting is in general done by hand. Different types of filleting machines have been developed, and some are used commercially (22). However, none of the machines used definitely have the possibilities for replacing substantially the hand-filleting of white fish, but the developments in this field are rapid. For other fish, such as herring, filleting machines have come into general use, especially in the canning industry.

Fish freezing has increased very much in the last ten years. The world production of frozen fish fillets in 1947 was about three times as high as in 1939. The increase is especially due to new plants in Canada, Newfoundland, Iceland, Norway and the United Kingdom.

Frozen fish was some fifteen years ago regarded to be inferior to fresh, as the changes in the fish flesh caused by the freezing and the subsequent storage tended to make it less palatable and dry. Quick freezing of the fish was developed to prevent these changes, but recent research has shown other factors to be more important.

The causes for the deterioration are likely to be colloidal or structural changes of the proteins (denaturation) (23) (24) (25) (26). Under adverse conditions the muscle cells become dry and fibrous and lose their power for keeping the muscle juice absorbed after thawing. The larger ice crystals formed by slow freezing were formerly said to puncture the cell walls and to cause the loss of juice. Later extensive experiments have, however, proved the effect of the freezing rate to be negligible except for very slow freezing rates (e.g., slower than about 5 mm. thickness from one side per hour), and storage conditions have been found to be the chief cause for the changes (27) (28) (29) (30) (31). The storage temperature determines the rate of deterioration, and according to the experimental results, as for fresh fish, lowering the storage temperature 6 to 7 degrees C reduces the rate to about half. Frozen fish having a storage life of one and a-half months at — 10 degrees C, accordingly will keep:

About three months at — 16 to 17 degrees C. (+ 2 degrees F);

About four and a half months at — 20 degrees C. (— 4 degrees F); and

About nine months at — 26-27 degrees C. (— 16 degrees F).

In frozen fatty fish, development of rancidity is the limiting factor, and the temperature has been shown to affect this process correspondingly (31) (32). Therefore the storage temperature for frozen fish should be lower than formerly assumed, and advances are being made in this direction. New plants are designed for storage at — 25 to — 30 degrees C and old plants have been improved.

The freshness of the raw material has also been found to influence very much the quality of the frozen product and its keeping properties. Freezing does not improve quality, and fish kept in ice for a week or more, as often practised for trawl fish, yield a lower-grade product. Therefore, freezing at sea means an important improvement, and freezing the round fish on board the fishing vessels instead of icing it, and keeping it frozen until it is thawed, filleted and again frozen as fillets, has been tried with good results (33).

Other improvements, e.g., the use of antioxidants and moisture vapour-proof packaging materials, also enhance the quality of frozen fish.

Frozen fish obtained from absolutely fresh raw material is excellent, and when stored at proper temperatures compares with that of the best fresh fish. By utilizing the results of recent research, a frozen fish which is as good as fresh may therefore be distributed to all important markets. Satisfactory marketing is, however, dependent upon transportation and distribution means which will keep the fish at the proper low temperature until it reaches the consumer. Considerable advances in refrigerated transportation have been achieved, but for many markets distribution equipment has to be procured before frozen fish in a really first class condition may be obtained.

SALTED, DRIED AND SMOKED FISH

For wet salted and dried salted fish refrigerated storage and transport have been introduced. Cold inhibits the growth of brown moulds and salt-resistant red or pink bacteria, which have been the main cause for spoilage of salted fish, and storage at + 4 to + 2 degrees C prolongs considerably the time that salted fish may be kept in prime condition.

Much progress has been made regarding the artificial drying of salted fish, especially in Canada. New driers have been developed, and in some districts artificial drying has completely replaced sun drying (34).

In fish smoking, great improvements have been achieved by the introduction of smoking tunnels having controlled air humidity, velocity and temperature, and controlled smoke density (35) (36). A more uniform and controlled smoking than in the old vertical kilns is achieved, the necessary smoking-time may be reduced to less than one-third and savings are obtained in labour, fuel and fish.

CANNED FISH

The advances related to canned fish products are manifold and some of the more important ones are dealt with in experience papers. The successful introduction and use during and after the last war of refined and partly polymerized fish oils for sardines has been important for meeting the shortage of such vegetable oils as olive oil. The development of the aluminium can has made fish canning possible when tinplate could not be supplied, and the delicate and soft properties of this metal should make an increased use of aluminium cans reasonable.

FISH MEAL, HERRING AND SARDINE MEAL

"Fish meal" means meal made from any kind of fish. There is however a great difference between fish meal made from lean fish offal, "white fish meal", and that made of whole fat fishes, as herrings, sardines (pilchards) and menhaden, containing 6 to 10 per cent oil.

White fish fillet waste and heads contain very little fat, and no oil is obtained from them. However, the ordinary continuous process of rendering has been the cooking, pressing, and drying of the "presscake" to fish meal, involving a great loss of water-soluble nutrients in the press water. New dry rendering methods by which all nutrients of the raw material are obtained in the meal have been introduced, and the yield of meal is increased by some 20 to 30 per cent. Owing to the increased yield and higher protein content the most economical dry rendering methods may double the value of white fish offal.

From fatty fish offal and surplus fatty fishes the oil has to be extracted, generally by cooking and pressing. The introduction of modern centrifuges for separating the oil from the press liquid has greatly improved this process as compared with the former gravity settling.

The water fraction of the press liquid, the "stick water", contains 20 to 25 per cent of the proteins of the fish and other water-soluble constituents. It has usually been discarded. Dry rendering methods have recently been developed which avoid the loss, but the greatest practical results so far have been achieved by concentrating the stick water in multi-stage vacuum evaporators to a syrup containing about 50 per cent water, "condensed fish solubles" (37) (38) (39). This product has been proved to have excellent growth promoting properties, especially caused by its high content of water-soluble vitamins, and essential amino-acids. It has successfully been used as a substitute for dried skim milk. The production of condensed fish solubles has developed since 1940. In 1948, about 15,000 tons were produced in the United States. This quantity may be more than doubled if all stick water in the United States is saved, and multiplied many times if the stick water in other important fatty fish meal producing countries is utilized in the same way.

Extensive research is going on to correlate technically and economically the production of condensed fish solubles and the different dry rendering methods available, and to determine the effect of different drying conditions and of storage upon the most important nutrients in the fish solubles and in the meals.

FISH LIVER OIL AND FISH BODY OILS

Cod liver oil has for a long time been recognized as a very important source of the fat-soluble vitamins A and D. In the last fifteen years many other fish livers and also fish viscera have been found to contain oils which are much richer in these vitamins, and the production of high potency fish liver oils has developed into an important industry. Halibut, tuna and shark livers which formerly were wasted now yield vitamin A and D in amounts larger than those from cod livers (40).

Great improvements have been achieved in the production of fish oils by introduction of centrifuges and other modern technical equipment. However, in Europe the greatest advances madere garding fish body oils are their refining and chemical conversion to edible fats and oils. Owing to their unsaturated nature, fish oils rapidly become rancid when exposed to air. By modern refining, distillation, hydrogenation and polymerization methods, stable hydrogenated fats for margarine production and stable edible oils for canning, baking and other purposes for which vegetable oils formerly were used, are obtained (41). Especially in America, advances have also been made in converting fish oils to satisfactory drying oils for painting, and in the development of other industrial uses.

A substantial part of the fish oil production in many countries is now utilized for edible purposes. The refining and treatment destroys, however, the vitamins of the oils, and huge amounts of vitamin D are lost. Improvements have been achieved by separating the vitamins and the sterols from the oils by molecular distillation (42) or by solvent fractioning or extraction before the refining process.

NEW PRODUCTS AND BY-PRODUCTS

An important group of new products from fish is based on the waste from white fish filleting and on surplus white fish. About 45 per cent of the proteins in eviscerated, headed fish is contained in the fillet waste, and utilization of the large quantities available for products which may be used for human food, instead of for fish meal for animal feeding, is very important.

Fish flour for edible purposes may be made by dehydration of fresh, assorted and washed fillet waste, or from eviscerated, headed and washed white fish. A light coloured flour having only a slight fishy odour and taste may be obtained. It contains 75 to 85 per cent protein, B-vitamins, important minerals especially calcium and iodine, and should lend itself as an important component of many foods. Tests made in 1940 with flour from cod proved an admixture of 6 to 8 per cent with whole wheat meal produced a bread whose appearance and flavour did not differ from those of bread made from whole wheat only. According to recent experiments the slight fishy odour of flour made of fillet waste may be removed by modern refining methods, and an admixture of 20 per cent refined fish meal to whole wheat meal has been tried without giving a detectable taste to bread or biscuits made thereof. Fish flour of this kind may also be used for many other foodstuffs, and has the possibilities of furnishing large quantities of animal protein for human food at very low cost.

Fish albumen for edible purposes has been commercially produced in Germany since 1939 (43). Pure fish meat is extracted to remove fishy tasting substances, and the protein is made soluble by alkali, neutralized and dried. The resulting fish albumen may be used as a substitute for dried white of eggs, e.g., for baking purposes and as an emulsifier. After the war, pilot scale production of fish albumen started in some countries outside Germany.

Fish protein for industrial use may be made by dissolving fish waste in alkali and precipitating a substantial part of the proteins by acid. The protein obtained has properties very like casein, and may likewise be used for plastics (buttons), paints and glue. However, no commercial utilization in this direction is known.

Amino-acids are now important by-products from fish waste and fish organs. Fish contains all the essential amino acids, and arginine, lysine, cystine and tryptophane are now commercially made from fish material. Several others have been made, but the demand has been too low for commercial production (44) (45). The main production of amino-acids from fish occurs in San Pedro, California, where also *histamine* is commercially produced from fish products.

Cholesterol is contained in fish body oils, and is now separated from sardine oil in a rather pure form. *Synthetic vitamin D-3* is made from the cholesterol by oxidation and irradiation. *Proteolytic enzymes* are commercially produced from the pyloric caeca of fish.

Fish leather, insulin, bile acids and liver concentrates containing the anti-pernicious factor may be mentioned as other new by-products. Fish roe and milt and fish intestines are very good sources of cholin, and intestines utilized for fish meal together with offal enhances the feeding value of the meal.

As a whole, fish and fish waste are utilized much better than before, but the possibilities are far from being exploited fully. The huge amounts of surplus fatty fish, as herrings and sardines now used for oil and meal, may have the greatest possibilities. Utilization of much more of these large protein resources for food may be the most important progress to be made in the fish industry.

THE PRICE OF DIFFERENT FISH PRODUCTS

Comparisons of price for foodstuffs are usually made on the caloric basis. However, such correlations are not justified for foods whose value is dependent upon the nutrients as such, e.g., proteins, minerals and vitamins, and not upon their fuel value. Because animal protein is expensive, but necessary for human nutrition, and the most important constituent of fish and fish products, it seems reasonable to compare lean fish products to each other on a protein basis, and fatty fish on a protein and fat basis (price correction for fat content).

The cost of protein in fish as they are delivered by the fishermen is very low for most of the species caught. It may be judged to be about 50 to 110 cents per kg. edible protein for eviscerated and headed cod and cod species, and about 20 to 50 cents for herrings and sardines. The price for meat (cattle) to the producer may correspond to about 300 to 400 cents per kg. of protein.

For different finished fish products the wholesale prices in Norway correspond in general approximately to the following prices:

	Cents per kg. edible protein
Cod and cod species:	
Fresh, eviscerated and headed	120 to 170
Fresh fillets	140 to 180
Frozen fillets	180 to 220
Wet salted fish, split	120 to 140
Dried salted fish, split	130 to 150
Stockfish	110 to 120
Fish flour, refined (calculated)	about 40
Herrings:	
Fresh	60 to 100
Fresh fillets	110 to 140
Frozen fillets	140 to 170
Canned kipper fillets	about 300
Canned sardines	about 1,000

Stockfish and salted fish are the less expensive cod fish products, frozen fillets the most expensive. Fresh herring is the least expensive of all ordinary fish products, canned products the most expensive. The cost of protein in edible fish flour is far lower than for any other fish product, and fish flour should especially be important for people who need animal protein, but who can't afford to pay the price for regular foodstuffs furnishing enough of such protein.

The prices illustrate the processing costs and may give some information as to the most economical way of utilizing fish. It should, however, be emphasized that the keeping properties, distribution costs, ease of handling and preparation and palatability of the products also are of major importance. The demand may also be a decisive factor as to which products preferably should be produced.

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Recent Advances in Methods of Handling, Preservation, Processing and Distribution of Fish. Developments in Utilization, New Products and By-Products

FRODE BRAMSNAES

ABSTRACT

Small differences in temperature in low temperature storage of fresh unfrozen fish mean big differences in keeping quality. For instance, 12 days were required to reach a trimethylamine value of 15 in cod fillets stored at -0.3 degrees C (31.5 degrees F) while five days sufficed when the fillets were stored at + 2.8 degrees C (37 degrees F).

The value of sodium nitrate as preservative for fresh fish both as a dip for fillets and as a preservative incorporated in ice has been proved. The use of this preservative in the amounts necessary should meet the approval of the Health Authorities, who long ago have accepted the use of sodium nitrate in meat products.

Ascorbic acid, used either as a dip before freezing or in the glazing water, seems to be capable of retarding the rancidification with most frozen fish. NOGA and ethyl gallate have in some cases shown the same effect, but some investigators have found that the use of these anti-oxidents may lead to a slight off-taste in the frozen fish. Many experiments have shown that fish protein is equal or superior to meat and milk protein. Feeding test with bacon-pigs have shown that when using fish meal instead of skim milk fewer feed units were necessary for a given weight increase. However, if the fish meal contains more than 0.5 per cent fat there is a risk of getting rancid bacon, even if the feeding of fish meal is discontinued two months before the slaughtering.

The landings of fish in the three Scandinavian countries in 1947, in tons, were as follows:

	Norway	*Sweden*	*Denmark*
Total landings	1,065,000	156,000	194,000
Price to fishermen ...	$60 million	$25 million	$30 million

These figures include the following landings of herrings, mackerel, sprats etc.: in tons,

	Norway	*Sweden*	*Denmark*
Total landings	653,000	90,000	41,000
Price to fishermen ...	$24 million	$11 million	$4 million

Sweden and Denmark are geographically well situated for the distribution of fresh fish and most of the landings are consequently disposed of in this way. In Norway, which lies further afield, the quantities used for salting and for meal and oil are considerable—approximately 250,000 tons and 500,000 tons yearly.

FRESH FISH

Canadians have shown that when bacteria invade the fish muscle their most frequent mode of entrance is through the skin rather than by the way of the blood vessels. Because it takes about ten days when the fish is properly chilled for the bacteria to penetrate the skin, it is of great importance to wash the fish thoroughly before distribution or filleting. The Canadians have demonstrated that many generally used washing procedures are not effective, and care should therefore be taken to control the reduction in bacterial count before introducing any washing method into practice.

Some years ago we found, quite incidentally, that fresh fillets stored at + 1 degrees C (30 degrees F) kept for 19 to 21 days, while fillets stored at + 2 degrees C kept for only 11 to 13 days. In Canada they recently found the same variation with the storage temperature, (see Table 1).

This means that we must be careful to keep the temperatures in fish holds and storage rooms for fresh fish as low and constant as possible without risking the freezing of the fish. We will be looking forward with great interest to learning about the results of the Canadian experiments with insulated fishing vessels. Denmark, which has a fairly big export of fresh fillets to Central Europe, has for some years been using boxes insulated with wood wool for this transportation.

Table 1. Cod Fillets Stored at Different Temperatures

Storage temperature	*Days to reach trimethylamine value of 15*
+ 2.8 degrees C (37 degrees F) . . .	5
+ 0.6 degrees C (33 degrees F) . . .	7
+ 0.3 degrees C (31.5 degrees F). . .	12

CHEMICAL PRESERVATIVES

Chemical preservatives have long attracted much interest in the handling of fresh fish. Earlier experiments using benzoic acid, hydrogen peroxide, lactic acid, or chlorinated water, either incorporated in the ice or as solutions in which fillets or round fish were dipped, did not give a sufficiently better keeping quality of the fish to justify the extra cost of handling.

In 1940-1941 Tarr demonstrated the value of sodium nitrite as preservative for fresh fish both as a dip for fillets and as a preservative in ice. Since then he and his colleagues have followed up this matter, and I wish here to pay a tribute to the excellent and inspiring work done by the two Canadian laboratories in this and other fields.

In addition to preserving fish by interfering with microbiological growth nitrite preserves fish by retarding the reduction of trimethylamine oxide without necessarily retarding bacterial growth. The effect is influenced by pH which should be kept below 7.

Danish experiments, among others, have confirmed the earlier findings. We found for instance that when using ice containing 1 per cent sodium nitrite the keeping quality of the fish was increased 50 per cent at pH 7. The appearance and the flavour of the fish were not affected.

Saltpetre, sodium nitrate, is a well-known preservative in the meat industry and its use is approved by the health authorities. It is generally accepted that the efficiency of saltpetre is due to its conversion in the meat into sodium nitrite. In our experiments a nitrite content of 0.1 per thousand was found in the fish muscle. Health authorities normally accept up to 0.2 per thousand in the meat products. This means that an approval by the authorities of a nitrite-ice treatment or a nitrite dip should not be out of question.

Tarr has shown that a medium containing 0.0025 per thousand hydroxylamine retards the growth of bacteria isolated from fish. Our experiments mentioned above included, therefore, this chemical also. A fifteen-minute dip of fish fillets in a 2 per thousand solution of hydroxylamine prolonged the life of the fillets from 14 to 28 days. Only minor changes in appearance and flavour occurred. The uptake of the chemical was of the order of 25 milligrammes per lb. fish. It remains yet to prove that hydroxylamine is acceptable from the health point of view.

ANTI-OXYDANTS

Much progress has been achieved in the study of the possible use of anti-oxydants in the fishing industry.

As regards fish oils the advantages are now certain. For example protection factors of 30 or more against loss of vitamin A have been obtained with one-tenth NDGA (nordihydroguairetic acid) added to halibut liver oil.

When it comes to preserving the fat of the frozen fish against rancidity the results have not been entirely encouraging.

Tarr, who was the original advocate of the anti-oxydant dips, still favours ascorbic acid and ethyl gallate.

A report from Seattle says that no effect was obtained when dipping fillets in NDGA, and tests with ascorbic acid with certain West Coast species gave only slight improvement.

The Norwegians stored herring fillets at — 10 degrees C (14 degrees F). Some of the fillets had before freezing been dipped for 2 minutes in the following solutions: 2 per cent ascorbic acid, 1 per cent ascorbic acid, one-tenth per cent NDGA, and 0.5 per cent ethyl gallate. All the anti-oxydants used were effective, but only ascorbic acid left no off-taste in the fillets.

It appears thus as stated in the introductory paper that ascorbic acid is the most promising chemical for protecting frozen fish.

The results of a commercial trial were recently published.

Fisherman's Federation, Canada, sent a carload of 30,000 lb. of frozen salmon fillets from the West Coast to one of the eastern provinces. Some of the fillets were treated with ascorbic acid. 5 to 6 months later the untreated fillets were unsaleable, while the treated fillets still could be sold. The treatment seemed to prolong the keeping quality of the fish by four months.

Twenty pounds of fillets were dipped at a time in a wire basket, and a twenty-second dip in a 0.5 per cent ascorbic acid solution gave sufficient penetration of the acid into the flesh. Other experiments indicate that the percentage of the acid in the fish should reach 0.04. The Hoffman-La Roche people have published the data given in Table 2 for dipping of mackerel.

We find that the amount of acid used in obtaining the percentages given in the last column of the table is somewhat bigger than estimated in the table. With the present high price of ascorbic acid one can reckon that the treatment costs a fraction over one cent per kg. (0.5 cents per lb.).

Table 2. Dipping of Mackerel in Ascorbic Acid Solutions

Acid solution (Per cent)	*Length of dip (in seconds)*	*Acid consumed (mg. per lb.)*	*Percentage acid in fish*
1	10	120	0.027
2	10	205	0.045
1	60	150	0.032

Viewing the problem from the side of the Food and Drug Administration it should not be necessary to demand a declaration on the use of ascorbic acid as has been done in Canada, but no advertising of additional nutritional value due to the employment of ascorbic acid should be tolerated.

The most economic way to use ascorbic acid seems to be to dissolve it in the glazing water. By doing so one simultaneously obtains a relatively non-cracking glaze. If a thick glaze is desired the glazing water should also contain Irish moss, methyl cellulose, or a similar agent.

Anti-oxydants may find other uses in the fishing industry than those mentioned above. The U.S. Quartermaster Corps has demonstrated that brine-packed, salt-cured herring and mackerel are given additional storage stability of five to six months by coating the individual fish with edible oil containing NDGA. The cost of such a procedure is estimated at 2 cents per lb. of final product. This will probably prove too expensive under normal trade conditions.

Danish experiments with canned cod-liver paste showed that an addition of 0.1 per cent ascorbic acid to the paste effectively retarded the darkening and the rancidity which normally set in soon after the opening of the can. A similar effect was produced with 0.05 per cent NDGA or ethyl gallate, but a slight off-taste was observed in these cases.

CANNED FISH

The Scandinavian fish canneries are rapidly moving towards almost complete mechanization. However, some canners are hesitating because they see that the quality of the products as a whole is inevitably suffering simultaneously.

An efficient Swedish machine has been constructed for heading and eviscerating mackerel and herring. The machine makes a slant cut in order to save the nape flesh. The Norwegians have built an inexpensive machine for the filleting of herring used in making kipper snacks.

Several types of continously working kilns have been installed for the smoking of brisling-sardines and kipper fillets. One is of the horizontal tunnel type, where the brisling on tray racks first is cautiously dried and then passes through a zone where hot air is mixed with smoke'. In this as well as in the next mentioned type the air is forced through the trays. This seems to be preferable. The second type consists of two vertical tunnels, and the trays individually move first upwards through one tunnel and then downwards through the other. A mixture of hot air and smoke is passing in the opposite direction.

As in many other countries there is in Scandinavia a tendency towards high-short sterilization. When using old methods, fish balls, for example, are processed at 105 to 110 degrees C (221 to 230 degrees F), but browning of the fish meat is often met with. This can be avoided by preheating the cans in the retort for 10 minutes at 100 degrees C

(212 degrees F) and then processing for 14 to 15 minutes at 120 degrees C (248 degrees F), and by doing this a better sterilizing effect is obtained too. The new method requires wider tubes for steam and cooling water and more elaborate, preferably automatic control instruments on the processing retort.

FISH MEAL

Many experiments of late years have shown that fish protein is equal or superior to meat protein. In 1945 Almquist stated that high quality fish meal is a complete source of amino-acids on the basis of analytical data. He concluded that fish meal is one of the few sources of protein that support normal chick growth entirely by themselves.

In 1946 Duell and co-workers proved that the dried fat-free flesh of mackerel, sardines and tuna was superior in nutritive value to casein, using rat growth as criteria.

In 1946 Beveridge reported that the dried fat-free flesh of halibut, herring, sole, salmon, etc., when fed to rats caused them to gain more weight per unit of protein consumed than when dried beef flesh, casein, or egg albumen was fed.

Fish meal is today extensively used in Scandinavia as animal protein feed for pigs and poultry. As an example of the otherwise many well-known excellent properties of fish meal I shall mention some Danish experiments with pigs raised for bacon production. The results are given in Table 3, and they show that when using fish meal instead of some or the whole of the skim milk, usually given as animal protein, fewer feed units were necessary for a given weight increase.

Table 3. Feeding of Pigs for Bacon Production by Using Fish Meal as Substitute for Milk.

	Daily ration per pig		
	2.8 kg. skim milk	*180 g. fish meal during the whole period*	*180 g. fish meal until pig weight of 60 kg.; then skim milk*
F.U.[1] per pig daily	2.11	1.97	2.04
Daily weight increase in grammes	611	632	640
F.U. per kg. weight increase	3.46	3.11	3.19
Percentage sugar-beets in fodder	34.0	38.0	36.3

1 kg. grain was fed daily and sugar-beets *ad libitum.*

Similar results were obtained when potatoes were fed instead of beets or when no beets or potatoes or like fodder were used. The fish meal was of the quality mentioned at the bottom of Table 4.

[1]F.U. = Feed units = Grain units = Feeding value of 1 kg. of wheat.

The disadvantage in using fish meal is that the fatty constituents in the meal become rancid and thereby more or loss spoil the pork meat. The rancid taste is especially noticable in slight salted pork as will be seen in Table 4. In this table the results are given for Danish feeding tests with different types of fish meal.

The general opinion has been that fish meal does not do any harm if one stops feeding it to the pigs about two months before slaughtering. The experiments show that this assumption does not hold true when the pork is used for bacon production, and the Danish Bacon Control has been forced temporarily to forbid the use of fish meal in the feeding of pigs.

The highest score in the tests shown in Table 4 is 5, and the results are an average from many pigs. A large taste panel of bacon specialists was used. The experiments show that only fish meal with less than 0.5 per cent "fat", i.e., determined by the usual methods of analysis, leaves no off-taste in the salted pork.

Table 4. The Quality of Pork Meat in Variation of the Fat Content in the Fish Meal Used in Feeding the Pigs.

Animal protein source		*Score for flavour*		*Percentage of samples with off-taste*
		unsalted	*light-salted*	
Skim milk	(a)	4.6	4.5	0
	(b)	4.5	4.6	0
Meat and bone meal	(a)	4.1	4.1	11
	(b)	4.4	4.2	6
Fatty fish meal (over 7% fat). The whole feeding period.	(a)	3.8	2.9	94 (fishy)
	(b)	3.4	2.6	98 (fishy)
Fatty fish meal (over 7% fat) until 60 kg. weight; then only milk.	(a)	4.4	3.8	50 (fishy)
	(b)	3.9	3.6	68 (fishy)
Extracted fish meal (ca. 2% fat). The whole feeding period.	(a)	4.2	4.0	30 (fishy)
	(b)	4.1	3.5	63 (fishy)
Extracted fish meal (ca. 2% fat) until 60 kg. weight; then only milk.	(a)	4.4	4.1	20 (fishy)
Fat-free fish meal (ca. 0.5% fat). The whole feeding period.	(a)	4.3	4.0	6 (fishy)
	(b)	4.3	4.1	10 (fishy)
Fat-free fish meal[1] (ca. 0.5% fat) until 60 kg. weight; then only milk.	(a)	4.3	4.4	0
	(b)	4.4	4.3	0

(a) Without beets or potatoes.
(b) With beets or potatoes.

[1]This fish meal was of Norwegian origin and was produced from herring by evaporation (no stick water produced !) followed by a solvent extraction of the fat.

Recent Advances in the Handling and Processing of Fish

G. A. REAY

ABSTRACT

Chilling in crushed ice has definite limits as a preservative of fresh quality. Whilst some improvement in its application is possible, these limits preclude chilling as a satisfactory solution of the problems of landing "white" fish in fresh condition, particularly from distant waters which yield half the British catch, or of evening out the flow of supplies of either "white" fish or herrings, the latter being markedly seasonal.

Quick-freezing and low temperature storage are the only solution. To ensure uniform high quality, "white" fish must be frozen at sea and the possibilities are being explored. Herrings are being satisfactorily frozen on shore but progress is hindered by scarcity of plant and relatively high costs.

There is considerable development of the Torry Research Station type of mechanical kiln, which brings the conditions of smoke curing under close control and affords a clean, uniform product, with savings in labour and materials.

Although of small interest to the consumer in normal times in a country well supplied with fresh fish, the dehydrated products developed for the Services in war-time appear to be well adapted for export to undeveloped countries, provided costs could be reduced in ways suggested.

INTRODUCTION

The present British herring catch (220,000 tons in 1947), nearly all taken on overnight trips, could be more than doubled without endangering stocks; but the home market is limited by the high perishability of the fish, inadequate means of preservation, and marked seasonality of supply (mainly June to December). A winter import from Norway amounts to nearly one-fifth of the total home consumption. Over one-quarter of the total catch is exported, mainly salt cured (1) (2) (3) (4)[1].

The present supply of "white" fish, mainly cod and allied species, practically all consumed at home, is about 820,000 tons (for the year 1947). More than half comes from distant waters (e.g., Bear Island, Barents Sea, White Sea, Iceland, Greenland, Newfoundland) on three-week to four-week trips, and a large proportion of this is landed stale, some inedible. For these and other reasons vessels are no longer able to fill up before they must return home (5) (6).

CHILLING

This term is used here as meaning packing with crushed ice, the only method employed for fish intended for immediate distribution on landing.

"White" Fish

Even with the most careful handling and storage in plenty of ice, gutted "white" fish remain reasonably fresh for no longer than about twelve to fourteen days. In commercial practice, the limit is at best little more than one week, a period exceeded by at least half the total catch before landing (7). How far and at what cost potential improvement of the order indicated could be realized is not clear. Temperature is apparently the most important variable. More ice might be used, particularly where heat inleak into holds is greatest, and/or insulation improved, with perhaps additional mechanical refrigeration. Some of these measures are being tested commercially. However, because of the long periods of time involved and the perishability of the fish, no startling general improvement in quality can be expected. In any case, ships would stay out longer, if possible, in order more nearly to fill up.

Herrings

Research at the Torry Research Station has shown that ungutted British-caught herrings become stale in twelve to eighteen hours at 13 degrees C (55 degrees F), but remain reasonably fresh in plenty of ice for about two to four days depending on original condition. Thus, it is just possible with thorough chilling to distribute herrings for fresh consumption from mainland, although not from outer-island ports. Normally ice is not used on the herring drifter, whilst during land transport in boxes the fish to ice ratio is about 5: 1. Substantial improvement can only be obtained by icing at sea (ratio 2: 1) to chill the fish to 2 degrees C (36 degrees F) or below, followed by chill distribution. Much heavier icing on shore than is usual would, however, effect considerable improvement. No serious large-scale attempts have yet been made to improve chilling to the limit. CO_2-snow-cooled transport of normally iced fish has shown a small improvement.

FREEZING AND COLD STORAGE

Herrings

With assistance from Torry Research Station, the Ministry of Food experimented in 1944 on pilot-plant scale with about 140 tons of herrings. Seven pound blocks of fish in single layer were quick-frozen in two 6-station plate-freezers (each 504 lb. in two hours) and in a continuous truck-and-tray air-blast tunnel, 9 ft. 8 in. long, (1,344 lb. in two hours; air speed 900 ft. per minute; inlet temperature —27 to —28 degrees C (—16 to —18 degrees F), outlet 5 degrees C (9 degrees F) higher). Freezing times for cooling from 0 degrees to —5 degrees C (32 to 23 degrees F) were 30 to 70 minutes—well within the Ministry's limiting requirement of 120 minutes. Plate-frozen fish were wax-paper wrapped; air-frozen were "glazed"; both were stored in 42 lb. cartons at about —18 degrees and —21 degrees C (0 and —17 degrees F) and distributed after three, six and nine months. The fish kept in very good condition for six months at the lower, and for about three months at the higher temperature, and were very well received by retailers, kipperers and consumers. These results confirmed previous laboratory experience (8).

Following these trials, the Herring Industry Board (2) (3) (4) have operated a full-scale (1 ton per hr.) crossflow air-blast plant and three 30-station plate-freezers in Shet-

[1]Numbers within parentheses refer to items in the bibliography.

land; a large commercial firm, nine 30-station plate-freezers at Yarmouth; and four 30-station plate-freezers at Fraserburgh. These operations have confirmed the technical possibility of freezing and storing herrings satisfactorily for a period of months and thus, of spreading a seasonal supply over the year for both freshing and kippering. Laboratory tests have indicated that freezing for immediate distribution in uninsulated transport would afford a higher quality product than existing chill transport of unfrozen fish.

Development is proceeding very slowly; only some 3,335 tons were frozen in 1947. Main reasons (4) are scarcity of suitable plant and insufficient margins in a controlled price structure as compared with those allowed for fresh herrings. The short fishing season in any locality together with the difficulty of providing alternative use of plant presents a further economic problem. Mobile plants, on shore or at sea, may be the solution. This is under close consideration by the Board and by the industry. In the case of the Board's seasonally operated plant, the cost of quick-freezing and distribution to retailer appears (for 1947) to be about 1.18 pence per lb. and that of storage at —21 degrees to —23 degrees C (—5 degrees to —10 degrees F) for 6 months, 1.46 pence per lb., a total of 2.64 pence per lb. The present frozen pack appears to be too expensive in labour and in packaging material to be the basis of an industry commensurate with the large potential supply of raw material. Research is in progress with a view to mechanizing the whole process on the basis of a larger "glazed" unit block.

"*White*" *Fish*

Research has shown that quick-frozen fresh "white" fish can be stored virtually without change for four months at —21 degrees C (—5 degrees F) and eight months at —29 degrees C (—20 degrees F) (9). Since 1946 the Ministry of Food has encouraged the quick-freezing of "white" fish with storage at —18 degrees C (0 degrees F) or below at all the main ports in order to even the flow of supplies, and to distribute fish to the consumer in somewhat better condition than if it were chilled. 11,079 tons (wet intake fish) were used for freezing in 1947, and 48,000 tons is the target for 1949. Development is again hindered by shortage of plant.

From what has been said about the general quality of the "white" fish landed and the fact that surpluses derive largely from distant water catches, it is clear that freezing on shore cannot consistently provide a high-grade product on a really large scale. The only way to supply really fresh "white" fish all the time is to freeze at sea those fish that cannot be satisfactorily preserved by chilling. A fresh assessment of the possibilities of doing this is at present under way prior to large-scale trials.

SMOKE CURING

Smoke curing affords a welcome means of diversifying the presentation of fish. Actually more kippers are consumed in Britain than fresh herrings (3: 2); and there is a substantial trade in smoked "white" fish.

Smoke curing also affords short-term preservation by partially drying the fish and impregnating it with antiseptic substances. A well-cured herring (kipper) or "white" fish (e.g., "finnon" cure) is one that has been cold-smoked (e.g., at 27 degrees C (80 degrees F)) for such time as it has lost 15 to 20 per cent in weight by evaporation; and it will keep in first-class condition for several days at 16 degrees C (60 degrees F) and still be palatable after a week. At 0 degrees C (32 degrees F) it will be first class for a week and palatable for two or three weeks. Heavily salted and heavily cold smoked products, such as "red" herrings, keep well for months in temperate climates and can be distributed successfully in the subtropics. There is still a large potential export market for such cures, which no longer are attractive to the British consumer (10) (11).

The traditional method of curing fish by hanging them in tall natural draught vertical kilns over smouldering wood fires has many disadvantages even with well trained operatives. Much troublesome labour is expended in filling and emptying the kilns and in shifting fish to counteract the wide variation in smoking and drying conditions in the kiln so as to produce a cure fairly uniform in appeal and keeping quality. The extent to which adverse external atmospheric conditions, particularly high humidity, can be offset is severely limited. The cure is also apt to be smutty from the fires. Just before the war a new type of horizontal smoking kiln with external smoke producer was devised at the Torry Research Station (12). Fish borne on trolleys are smoked at closely controlled temperature, humidity, smoke density and air speed, uniform distribution of smoke and air over the cross-section of the kiln being a specially important feature. In this way uniform curing of fish has been achieved with reduction in the average time of curing (from about 8 to 4 hours), a saving of some 20 per cent at least in the labour of filling and emptying the kiln, and some saving in wood fuel and in spoiled fish.

The Herring Industry Board and the industry are now successfully operating several of these new kilns; and several more installations are planned. The kiln is also in use in one factory in British Columbia (13) and in one in Newfoundland. Future development of the smoke-curing industry appears to be clearly along this line. Experience has shown, however, that owing to separation of the controls of temperature and smoke density, and the fact that colour is, usually in the case of herrings and frequently in the case of "white" fish, put on by dyeing prior to smoking, there is a danger of producing an under-smoked cure with detriment to flavour and keeping quality.

In the new type of kiln there is no dehumidifying device, humidity is controlled by increased ventilation. In hot and humid climates, therefore, it would be impossible to produce the "cold smoked" article of temperate regions. Hot smoking would be obligatory and the kiln is suitable for this.

DEHYDRATION

Following laboratory research, (14) the Ministry of Food in the summers of 1944 and 1945 operated a small factory for dehydrated herrings based on a truck-and-tray modification of the Torry smoking kiln (15). Cooked herring fillets were minced and dried in about four hours in moving air at about 77 degrees C (170 degrees F) and about R.H. 25 per cent. The product was packed under nitrogen in tin plate (603 x 904) cans holding 4 lb. without mechanical compression. Total production was about 85 tons, which was taken up by the Army. Storage life in fairly satisfactory condition was two years at 10 degrees C (50 degrees F) and 6 months at 37 degrees C (99 degrees F). Dehydrated kipper, cod fillet and cod fillet with added hardened oil, were also produced in smaller amounts. These products, especially kipper and fatted cod, can be made into palatable fish cakes, kedgerees, etc. Although not of much interest in normal times in a country with large supplies of fresh fish, these products are very suitable for distribution in tropical countries, where a few experiments have indicated that they might be well received.

Processing costs were about 1 shilling per lb. of product, of which packages accounted for 3 pence, the largest item. Raw material (about 3 pence per lb. for herrings and 6 pence per lb. for cod) was by far the major element in total cost, because of the high weight ratio of input to output, which is about 6 for herring and 16 for cod. The product could no doubt be cheapened for tropical markets by greater compression, bulk packaging, the use of whole fish instead of fillets (which yields a tolerable product in the case of herrings) and, of course, larger-scale production. At prices paid for raw material for herring meal and oil production (about 1 penny per lb.) the ex-factory cost might perhaps be reduced below 1 shilling per lb. of product.

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Methods of Detecting Fish by Echo Ranging and Echo Sounding[1]

J. RENOU

ABSTRACT

The remarkable results obtained during the last war by the radar of the air forces against surfacing submarines and by the echo-ranging devices of surface vessels against submerged submarines have led to investigations being made during the past four years as to whether the same devices could be used for peaceful purposes and particularly for the detection of shoals of fish.

Numerous experiments have been made. They have definitely established the following facts :

1. An echo-ranging device, whatever it may be, can detect any shoal of fish whatsoever at distances varying from 200 to 2,000 metres, provided that the conditions of propagation in the water are not extremely unfavourable ;

2. With the indications furnished by an echo-ranging device, a fishing-boat equipped with that apparatus can be guided directly to the shoal, the depth of which is then revealed by the echo-sounding instrument ;

3. Taking into account the ecological factors, the detected fish can be identified in most cases by studying the echo-ranging and echo-sounding recordings.

Echo-ranging can therefore be an effective aid to fishing. Aerial detection can also render valuable assistance, though in exceptional cases only, either when the water is transparent enough to allow the fish to be seen at a depth of several metres or when the shoal of fish comes to the surface to disport itself or to escape.

The experiments, methods of investigation, results obtained, practical conclusions and future prospects are summarized in the appended experience paper.

EXPERIMENTS

During the past thirty years supersonic waves have been used to detect submerged obstacles. This method of detection led, between the first and second world wars, to the invention of the echo-sounding device for the purpose of giving in the vertical plane of the ship the depth under the hull; subsequently it led to echo-ranging, the purpose of which was to detect the presence, position and movements of submarines. These very useful apparatuses were gradually improved and became instruments of such accuracy that it became possible to detect many other obstacles besides those which they were first intended to discover. Thus even before the war of 1939 the echo-sounding apparatus served from time to time to detect shoals of fish off the coasts of the Nordic countries (the work of the Norwegians Oscar Sund and Sven Runnström on herrings, followed by much other work, particularly that of Albert L. Tester in Canada).

When peace returned, the problem of detecting shoals of fish by supersonic means was studied more thoroughly.

[1]Original text : French.

Without going into the details of all that has been accomplished throughout the world in this important subject, we would refer to the work done by the Norwegian Professor Einar Lea, the American Professor Osgood R. Smith and the British scientists Wood and Hodgson, and proceed to a brief description of the experiments carried on in France under the direction of Lieutenant de vaisseau J. Renou and the biologist Tchernia, which in number and variety undoubtedly exceed any that have been made in other countries.

These experiments which were carried out in 1946, 1947 and 1948 on board several warships equipped with echo-ranging and echo-sounding devices, and thermometers for taking the temperature of sea water, took place off the French coasts of the North Sea, the Channel and the Atlantic, off the coast of Morocco and in the vicinity of Newfoundland; they made it possible to study the process of detecting ten different species of fish (sardine, anchovy, sprat, tunny, herring, mackerel, cod, haddock, hake and sea bream) and to prove that each species could be detected with great accuracy.

METHOD OF DETECTION

The latter experiments resulted in the gradual working out of a method of search and detection that is likely to be very useful to scientists and fishermen.

The method of detection is as follows:

A ship, preferably of small size and equipped with echo-ranging and echo-sounding devices and with a bathythermograph (since the temperature and salinity conditions of the water determine the presence of the species to be detected) visits the area where and at the time when certain species of fish are usually caught. It can also utilize boats engaged in fishing as guides.

Echo-ranging

Its echo-ranging device is set working in the same manner as those of anti-submarine escorts during the war. The apparatus permanently sends out directed supersonic waves which make a wide sweep of 5 to 5 degrees towards the bow of the ship. The apparatuses recording the reception of the echoes obtained from an obstacle are put into operation: loudspeaker, luminous recorder, graphic recorder. The echo-sounding apparatus is not in operation.

In a given direction, for instance, at 40 degrees off the bow to port, an echo is obtained. Examination of the chart shows whether it corresponds to the top of a rock or to a wreck. If it is a shoal of fish, its distance is immediately noted.[1]

The pursuing vessel heads towards its objective which usually moves at a low speed, a few knots at most, except in the case of tunny, the pursuit of which requires rapid movement, about 15 knots. Hence the chaser can carry on the search at his ease, study the fish, ascertain, at various distances, the apparent diameter of the shoal, horizontally and vertically, and thus gradually get some idea of the dimensions of the moving wall presented to him. In the recording loudspeaker the echo obtained has a short or muffled sound according to the conditions of movement and doubtless also of density of the shoal; but that very complex problem has not yet been thoroughly studied.

Thus the echo-ranging apparatus in normal conditions detects a shoal of fish at some hundreds or thousands of metres, follows it at distances of fifty to fifty metres and by means of an order to the helm and a few last minute rectifications can guide the experimenting trawler or ship right over the shoal. The graphic recorder of the apparatus even provides an additional detail, which is superfluous in many cases: the speed at which shoal and pursuer are approaching each other.

Echo-sounding

At about 200 metres from the obstacle, the echo-sounding apparatus is put into operation. All that remains is to await the moment when a clear trace appears on the band of the graphic recorder giving the depth of the shoal and another giving its dimensions calculated in relation to the time taken by the pursuing vessel to reach and overtake the shoal.

This inscription which appears on the graphic recorder at variable distances from the emission surface or the echo on the bottom is clear proof of the presence of fish. A light explosive may be dropped and result, as a further proof, in identification of the species detected.

RESULTS

We have to admit that all these experiments did not permit of such logical research and did not give complete results. In the case of the ten species mentioned above, the echo-sounding apparatus did not always provide visible marks. The trace of cod at great depth never appeared on the recorder of the echo-sounding apparatus. The marks of tunny were very rare. On the other hand, sardine, anchovy, sprat, herring, mackerel and sea bream provided very clear inscriptions which should permit positive identification without the necessity of having recourse to explosives in the future. In compensation, big fish such as cod and tunny are sometimes detected individually and they then provide distinct echoes which abruptly break the monotony of an empty sea or one which is stocked with vastly extended shoals, as is sometimes the case in the sea.

The echo-ranging and the echo-sounding devices can thus provide fishery protection vessels called upon to carry out scientific observations or fishing trawlers with a very important aid to their work. For the trawler it is even greater than might be supposed because the trawler is beset by hidden enemies: wrecks, jagged rocks, sharp points on the bottom of the sea, all harmful obstacles that tear the nets. The echo-sounding apparatus can be a great help, but it is a blind instrument which indicates the danger too late when the vessel is passing over it. The echo-ranging apparatus listens ahead of the ship and reports on the obstacles ahead. It is a marvellous instrument for detecting a wreck or an unknown rock: the fisherman can then turn aside

[1]The French surveys were undertaken in different areas: the warm waters of the Gulf of Gascony in summer: 15 degrees; the cool waters of the North Sea at the approach of winter: 12 degrees; the cold waters of Newfoundland: 0 to — 4 degrees. The maximum distances which decrease with the rise in temperature at which shoals of fish were detected were 2,300 yards off Newfoundland for cod, falling to 600 yards for sardines near the coast of Morocco. Moreover, it sometimes happens, as was observed during the war in regard to other obstacles, that fish detected at a great distance are lost during the approach and rediscovered at a short distance. There are in fact zones of silence.

and choose a route free from snares where he can let his net drag without danger.

Have these experiments already been of service to fishing? In some cases the answer is in the affirmative. For instance, they have been useful in studying along the coast of Morocco the ascending movements of sardine in relation to light; they have made it possible to determine at a given time of the year the distribution of herring in a vast area abounding with fish; they have made it possible to find and indicate to fishermen (who, on the whole, have made little use of these appliances, owing to the instinctive and proper distrust of seamen for scientific instruments that are too perfect) the places where sardines and cod concentrate. They have gradually brought about a trend of ideas as a result of which Professor Einar Lea was able to read a paper to the International Congress for Sea Exploration at Copenhagen in October 1946, on the detection of herring shoals by means of echo-ranging, while the following year the French team (Mr. J. Renou and Mr. Tchernia) made a new report on the results obtained, supplemented in 1948 by a further report from Mr. Tchernia alone.

FUTURE PROSPECTS

It is quite certain that it is now possible to consider a new technique for exploring that part of the sea which lies between the surface and a depth of about 200 metres. In the United States manufacturers of echo-sounding apparatuses are perfecting devices to discover, besides the bottom, the presence of the fish sought by fishermen. It seems reasonable to suppose that in the vertical plane of the ship as well as in the horizontal plane it will be possible to inscribe on the recorders the characteristic traces of the detected fish. Doubtless, the sea, a capricious and moving element, will often make the search more complicated than it is in theory. The propagation and range of supersonic waves is irregular. Propagation takes place in principle in a straight line but varies with the temperature, pressure and salinity. One day the reception is good and the next day it may be very bad. The fishing areas are very often areas with considerable currents or movements which are picked up by the echo-ranging apparatus and disturb its recordings. Finally, under present conditions, apparatus so precise and intricate as the echo-ranging device, which requires under the hull a fairly large cap containing a quartz or magnetostrictive projector, can neither be installed on fishing vessels which run aground in ports nor used by non-specialized operators.

Hence, while research is still being carried on in this subject in order to increase results and to extend the area of investigation, scientists, shipbuilders and fishermen should not be induced to instal or to employ indiscriminately such complicated apparatus as echo-ranging devices, constructed for different purposes and exceedingly intricate, for the use that fishermen would like to make of them. It would be of greater advantage to urge future makers and users of these instruments to simplify the processes making the instruments less costly and easier to work, read and repair.

Subject to these reservations, it is not outside the bounds of possibility that in a few years' time fishing fleets, either composed of low-tonnage trawlers and guided by a flotilla leader equipped with all the necessary scientific apparatus or a group of large trawlers like cod fishers operating on their own account and possessing echo-ranging and echo-sounding apparatuses, radar and a bathythermograph, may replace the little ships which now practise their fishing trade in the face of so many risks.

No doubt it will be possible, although the results have so far hardly been appreciable, to lighten the search for fish, with the help of aeroplanes which would report certain species on the surface or close to it.

The Governments themselves would then need a fishery protection service, vessels and aeroplanes equipped with up-to-date scientific instruments in order to protect the reserved fishing areas (similar to game reserves) which would have to be delimited so as to protect fish that can be found too easily, and to give the fish a chance to breed and increase in size.

Recent Advances in Various Technological Aspects of Handling Fish and Fish Products

H. L. A. TARR

The present acute world shortage of food has resulted in considerable research concerning the nutritive value of products derived from both plants and animals. It is now well known that fish flesh constitutes one of the most valuable sources of animal protein which is so essential for proper growth of both man and farm animals. From this standpoint, fish has been shown to be at least as nutritious as meat, and, in countries where fish is relatively plentiful and its consumption is low, attempts are being made to increase the use of fish in the diet. Investigation has now shown that the nutritive value of fish and fish wastes in the feeding of livestock does not depend solely on its content animal protein. The digestive tract and internal organs are excellent sources of certain-watersoluble vitamins that are found in the condensed fish solubles forming a by-product of the fish meal industry, and found to some extent in the fish meals themselves. Many years ago it was shown that fish liver is a good source of the anti-pernicious-anaemia factor, and it has recently been established that fish viscera contain considerable quantities of a possibly related "animal protein factor" which is necessary for adequate growth and productivity of farm animals. This factor is probably vitamin B_{12}. Pacific Northwest experiments have shown that fish viscera form an excellent food for fish in hatcheries, and have suggested that the reason for this lies partly in the ability of such material to supply a necessary animal protein factor (vitamin B_{12}?) in the fish diet.

The problem of spoilage and resultant waste of fresh fish continues to occupy an important position in research programmes. It has long been realized that improvements are required in existing techniques of icing fish on vessels. Recent developments have included a study of insulated vessels, of specially constructed fish holds in which lower temperatures can be maintained by combining icing with mechanical refrigeration, and of germicidal ices. The necessity for strict sanitary procedures in handling and processing fish as landed is slowly becoming appreciated. Advances in this field include the adoption of sanitary metal filleting tables equipped with removable boards and flumes or belts for conveying fillets and offal. Machines have been designed for washing fish before filleting, and also for filleting fish. Brine dips for preventing drip in defrosted fish, and application of small amounts of relatively harmless substances to retard bacterial spoilage or oxidative rancidity in frozen fillets have been recommended and in certain instances have been adopted. Improved vapour-proof packaging materials for fillets, including aluminium foil, polyethylene glycol, pliofilm and certain grades of cellophane have been studied, some of which retard drying and, to some extent, appear to hinder development of oxidative rancidity. The value of various detergents in washing fish plants and vessels and of subsequent application of germicides with and without addition of anti-corrosives has been studied.

Freezing is now a well-recognized method of preserving fish, but it is lamentable that so little attention is sometimes paid to proper storage conditions. Rapid freezing and a constant storage temperature of 0 degrees F, or preferably —25 degrees F, in the case of fatty fish, should be adhered to. Even with optimum storage conditions, slow alterations occur which are probably, in part at least, due to enzyme action and drying out or desiccation of the exposed surfaces is always a danger. Drying can be almost eliminated by use of jacketed cold-storage rooms, adequate glazing of whole fish and proper packaging, and certain techniques are available whereby rancidity development can be retarded considerably. Unfortunately, toughening of the flesh (denaturation) and loss of flavour occur even at low storage temperatures, and scientific means of overcoming these alterations remain to be discovered. Chemical substances have been found which prevent ice glazes on fish from cracking, and others are known which, when incorporated in glazes, will retard rancidity development and attendant rusting of exposed fat. Possibilities in increasing fish catches and improving quality by employing refrigerated ships have been realized. Thus in the United States, the 8,800 ton "Pacific Explorer" has landed over 2,000 tons of frozen tuna after a single trip to distant waters. In one trip the British whaling factory ship "Balena" landed 4,000 tons of edible meat, 3,200 tons of cattle fodder and 163,000 barrels of edible oil. Much time is being devoted to a study of railway and other refrigerated transportation of fish on land.

Advances in canning technology include the use of aluminium cans in certain Scandinavian countries, and of the development of corrosion-resistant can enamels. Many new canned marine products have been evolved and in the preparation of these smoke, salt, tomato puree, spices, thickening agents and oils of vegetable and marine origin have been used. The brown discolouration which frequently occurs in flesh of certain marine white-fleshed fish during canning has been shown to be due largely to the non-enzymic browning reaction and remedial methods are being investigated. Some of the internal corrosion of cans in the case of fish products has been attributed to the chemical action of trimethylamine oxide. Several investigations regarding the optimum conditions for processing crab meat have been carried out and appropriate recommendations regarding the use of acid dips and processing temperatures and times have been made. A notable advance in salmon canning in which a skinless-boneless product is produced with the aid of patented skinning and filleting machines has aroused considerable interest.

Considerable attention is being given to the possibility of preparing by-products from fish. Insulin was prepared in Canada from fish pyloric caeca almost thirty years ago, and, in view of a possible world shortage of this pharmaceutical experts in Denmark, South Africa, Canada, Great Britain and other countries are investigating its occurrence in whales and sharks.

Sterols are required in the preparation of certain hormones and the D vitamins. Cholesterol and other sterols occur in and have been insolated from mussels, fish meal and fish oils.

Fish oils are still the only commercial source of vitamin A, though their position is rather uncertain in view of the possibility of commercial production of a synthetic product. Modern solvent fractionation procedures have greatly facilitated preparation of vitamin A concentrates from low-potency fish oils.

Synthetic egg white, protein hydrolysates and peptones have also been prepared from fish flesh.

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Technological Advances in Fishing Methods

J. L. HART

ABSTRACT

High-speed diesel engines, radio-telephone, and echo-sounding are of established general usefulness in many fisheries. Range-finders and automatic pilots have proved of definite value in particular fisheries. Aerial detection of fish and the use of echo-ranging have been the subject of encouraging experiment and may have potentialities in increasing fishing efficiency.

The full effect of some newly-established technological advances in methods of catching fish are still to be felt. The emancipation from sails and oars which began with the introduction of steam power and which extended to smaller boats with the development of the gasoline engine has been made more complete with the increased dependability of all types of engines and particularly with the recent improvement of the high-speed diesel engine which renders it adaptable for use in small vessels to give them the advantages of compact safe fluid fuel combined with ample hold-space and living accommodation. The improved efficiency in many fisheries of the vessels and their crews which result from this introduction, although difficult to assess exactly, is substantial.

The general use of the radio-telephone has greatly increased the efficiency of fishing in many operations. The feeling of added security has encouraged the offshore exploitation of several fisheries by small vessels. However, the greatest contribution made by radio-telephone is in bringing a large number of fishing units quickly to operate on any accumulation of fish which may be discovered. The effectiveness of fishing for many species and with many gears is thereby greatly increased.

Of the new developments, echo-sounding challenges the radio-telephone as having been most effective in increasing the efficiency in catching fish. Aside from its recognized value as a safety device, the echo sounder has proved of great value in detecting schools of cod (14)[1] and herring (15) for direct exploitation, and shoals of "feed" as indications of the presence of demersal fish for trawlers, salmon seiners etc. It has proved particularly valuable in fisheries in which the bottom contours are followed during actual fishing operations such as long-lining, trolling and trawling, and especially in the last by indicating obstructions on the bottom which would destroy the gear.

Radar (6, 9, 10) and the direction-finder increase the efficiency by saving running-time in inshore and offshore waters respectively, and the latter is useful otherwise by assisting fishermen in reaching fishing grounds either in running out from port or in approaching other vessels which are on fish. It seems likely that the usefulness of direction finders will increase with the additions to transmitting stations along the coast. As far as known, loran has not been called into use in fishing operations.

The uses of aircraft in fishing are of two kinds. Aircraft have permitted the exploitation of isolated lakes in northern Canada by freighting the fish to market during the winter. Aircraft are also used in scouting for fish. They are successfully used in the clipper tuna fishery in finding accumulations of fish (1, 2) and bait (7). They are employed to some extent in spotting whales (3) and basking sharks (8) and reporting the positions by radio. On numerous occasions sardine (*Sardinops*) schools have been detected by aeroplane or dirigible, but the long-term value of this method of scouting remains to be proved (4, 5).

[1]Numbers within parentheses refer to items in the bibliography.

Experiments with asdic or sonar echo-ranging have demonstrated the ability of this equipment to detect sardine schools (12, 13) under favourable conditions up to 1,200 yards. Moderately rough weather, kelp beds etc., produce such confusing echoes in inshore waters in the north that the equipment is of doubtful value in scouting for herring (16). Modifications of the equipment and increasing experience of operators may make echo-ranging a practical fishing aid. After early disappointments echo-ranging has found a place in hunting whales, allowing them to be followed while sounding and thus more readily run down (11).

Among other minor aids to efficient fishing, automatic steering may be mentioned. In the troll and trawl fisheries this equipment is used effectively during actual fishing operations and in many fisheries is useful during the run in from or out to the fishing grounds.

The use of complicated equipment has increased the qualifications necessary for a competent fisherman. The increased efficiency of operations and consequent increase in remuneration which have resulted from the use of modern aids has made the fishing profession more attractive to highly-trained personnel especially since living conditions aboard fishing vessels are becoming more attractive as a result of recent developments and new design.

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Saury Lift-Net Fishing with Light

SHIGENE TAKAYAMA

ABSTRACT

Saury fishing on the north-eastern coast of Japan is conducted by the lift-net aided by electric lights which attract the fish schools. The fishing seems interesting in the application of oceanography and the particular behaviour of the fish. The fishing ground is sought, referring to the Oceanographical Chart, in the waters with temperatures ranging from 14 to 18 degrees C. Within this range of temperature the fish tend to swarm along the eastern border of the cold Oyashio current heads which penetrate into the warmer (southern) waters, from September to December.

With fully lighted electric bulbs (5 to 20 kw.) the boat scouts the saury schools at the fishing ground. When the fish schools, which come toward the surface of the water attracted by lights, are sighted, the boat stops and the lift-net is set in the water. The fish trapped in the net are lifted.

Some experiments were made concerning the characters of lighting.

INTRODUCTION

The annual catch of the Pacific Saury (*Cololabis saira*) in Japan amounts to 23,233 metric tons (1926 to 1941 average). On the Pacific coast of Honshyu, north of Chiba Prefecture, the catch of saury is about 80 per cent of the total Japanese figure, but the fishing practised in these waters is conducted according to the application of oceanography and fish phototaxis and merits some interest.

Prior to 1941, the gear used in this fishing consisted of drifting gill-nets operated during the daylight hours from September through December, and the boats used were 20 to 50 tons in size with 50 to 120 h.p. engines and ten to twenty fishermen aboard. In 1941, for the first time, electric light was applied in order to attract fish which were found to have rather strong positive phototaxis; the net used during these new operations being a drift-net supported by two bamboo poles. This experimental operation, which was satisfactory, induced many other boats to change from the old drift-nets to this pole-supported lift-net with lights. The lighting mechanism has been much improved after the end of the Second World War. At present, in saury fishing in this area, nine out of ten boats are operating with this method, and fishermen for other species of fish—sardine, mackerel and horse-mackerel—also show a tendency to adopt this new method.

The boats required for the operation of the lift-nets with light in saury fishing are the same as those used in the drift-net operation, but the requirement of net material is about two-ninths that used in the drift-net. The amount of catch per boat is nearly the same.

LOCATING THE FISH SCHOOL

The location of saury schools primarily depends on the temperature of the surface water; they are usually found in water with temperatures of from 14 to 18 degrees C (3, 1)[1]. Water with such a range of temperature in this area is rather easily located in the wide open sea, because the fishermen refer to the Oceanographical Chart published monthly by the Imperial Fisheries Experimental Station (the Station is now called Central Fisheries Station of Japan, Tokyo).

It has been generally accepted among saury fishermen in this area that the saury, within the range of the temperature above-mentioned, tend to swarm on the eastern side of the head of Oyashio cold current which penetrates into the warmer (southern) waters.

The Oyashio cold current penetrates into the warmer water, as a rule, with two heads which point south-west, the one observed farther off the coast than the other. Therefore it is usual to have two fishing centres in this region of the Pacific. In early season fishing (September) the fish schools are more frequently found in the far offshore fishing centre or ground, but the prevailing cold current over warm water often reverses the situation (4), and the better fishing ground is found at the cold water head nearer to the shore. It is usual to see the fishermen seek the fishing ground in the near cold water head only because of the economy of fuel and labour. This general rule, however, is often broken by the passing of cyclones (5) and also by the general set-up of the water temperature which causes yearly and monthly fluctuations in the formation of cold water heads and incidentally changes the fishing grounds.

FISHING BOATS, GEAR AND LIGHTING SET-UP

The ketch type boat, 30 to 50 tons in size, with 50 to 120 h.p. hot-bulb engines, commonly used in various types of fishing in Japan, is the usual vessel for present saury lift-net fishing. The quadrangle net used in this particular operation is 18 to 27 metres long both at float-line and lead-line and 10 to 15 metres deep, with mesh 1-6/8 in. stretched all over the net. The float-line is tied to a bamboo pole, called a float-bar, with the same length as that of the float-line so as to spread the net to its full length. The lead-line at the bottom of the net is weighted either by an iron chain (9 to 12 mm. in diameter) or a string of beads made of lead fastened to the whole length of the net and in addition, by five or six lead spheres, each weighing about 10 kg., tied to the line at the two ends and equidistant between them. The lead-lines starting from each sphere, made of rope or wire, are led to a cylindrical winch which is installed on the front deck of the boat, the lines running through two sets of rollers. One set, in a line, is attached to the port rail, the numbers of rollers being the same as the lead-lines, and the other set of rollers is placed on the left side of the winch. The winch, connected to the main engine of the boat by coupling gears, has ridges, also numbering five or six, and each ridge winds one lead-line, so that the winch can wind all of the lead-lines simultaneously.

[1]Numbers within parentheses refer to items in the bibliography.

Two bamboo poles, about 12 metres long and 13 cm. in diameter, are tied at their tips to the two ends of the float-bar. The net, tied to the float-bar as well as to the bottom lead-line, is stored on the port deck. At the beginning of the operation the net is pushed by hand out into the water by means of the two bamboo poles above-mentioned. The float-bar to which the net is tied is thrown overboard, and the bar is pushed away from the boat on the surface of the water by the two bamboo poles.

The electric bulb, 100 volts, 300 to 500 watts, is daylight in colour. Four bulbs are set near the distal end of a bamboo stick about 3 metres long; three or four sticks with bulbs are placed far apart on the starboard, the sticks hanging over the water so that the bulbs are placed 3 to 5 metres above the surface of water. The port stick, some 5 metres long, has two to four bulbs at the tip. The light has usually no shade, the bulbs being simply tied to the stick. Lighting is controlled by two sets of switches, one for all the port lights and the other for the starboard lights. Further, the port lights can be dimmed by means of a rheostat.

Electricity is supplied by a generator with a capacity of 110 volts, 5 to 10 kw., connected to the main engine, or to an auxiliary engine in some boats. Power is supplied in others by eighteen batteries, each with a capacity of 6 volts, 120 amperes.

FISHING OPERATIONS

Present saury fishing is usually done on dark nights. The operation, however, is possible on dimly moonlit nights if the weather is cloudy. The boat, fully lighted, scouts the schools of saury on the designated fishing ground, moving very slowly. When the school is sighted in the water or fish are seen skipping on the surface, the captain stops the engine and stands by for the operation.

Before the boat has entirely stopped she must be directed toward the wind, which is done by the two-boom spanker on the aft end. First the port lights are all turned off so that the fish are attracted to the light on the starboard, swimming toward the light underneath the boat. Meanwhile the net is set on the left side of the boat, and when the setting is completed, the left-side light is turned on and the right-side is turned off. The fish swarming under the right-side light are again attracted to the left-side light, and push themselves into the water which is now encircled by the net at bottom and front. When all the fish are sighted swimming close together under the light, the net is quickly lifted by the bottom lead-lines, and finally the fish are trapped in the lift-net. The net is then pulled in by hand by about ten fishermen standing along the rail. At the same time the two bamboo poles are drawn in onto the deck keeping pace with the moving net. The fish in the net, brought together toward the side of the boat, are transferred from the water to the deck. When the whole gear is pulled aboard, the boat starts scouting for another fish school.

The entire operation, from the location of a heavy concentration of fish to the end, takes three to four hours when the catch is about 15,000 kg. — the best that can be expected from one operation. In case fish are still present in the water after the operation, the right-side light is kept on, and a second haul is made, repeating the same procedure as the first. More than two successive operations are usually not practical, because the abundance of fish which makes

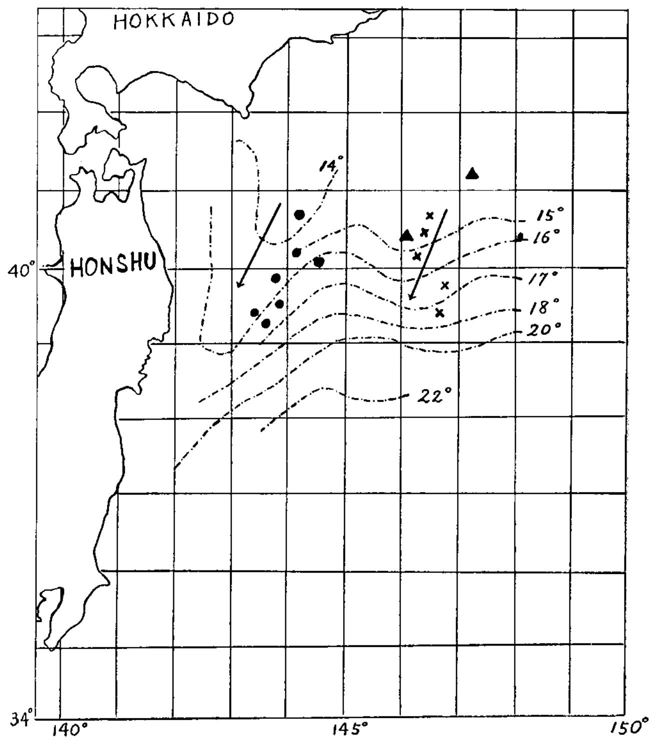

Figure 1. Oceanographical set-up and the saury fishing by drift-net in north-eastern sea of Honshu, Japan, October 1930. Broken lines show the surface isothermal lines: arrow, the moving of fishing centre during the month. Spots of fishing and the catch per boat per trip are given by triangle 200,000, cross 100,000 and dot 50,000 fishes; a trip lasts one to five days, and the catch calculated on the average of 120 boats. After Ikeda, 1933

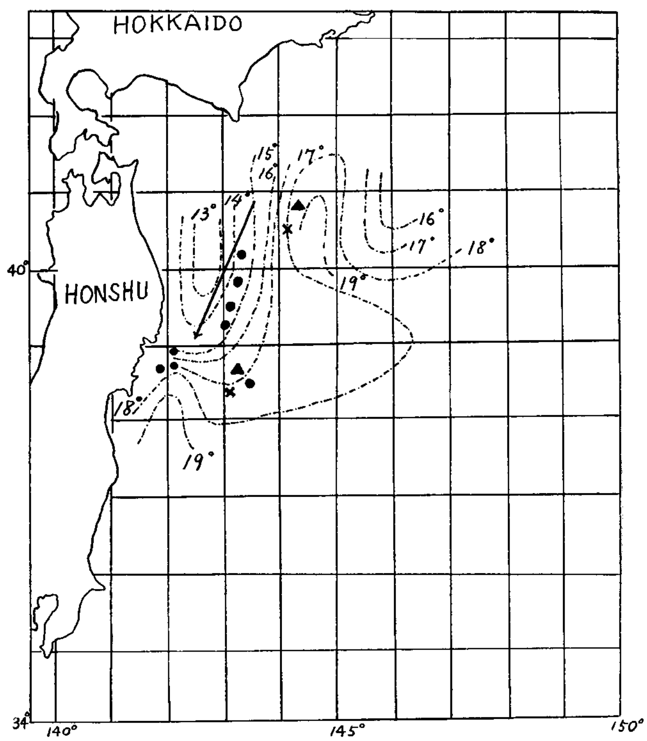

Figure 2. The same chart as Figure 1, but fishing by lift-net with light October 21 to 25, 1947. The catch figures, expressed same as in Figure 1, calculated on the average of 37 boats. Compiled from Oceanographical Chart

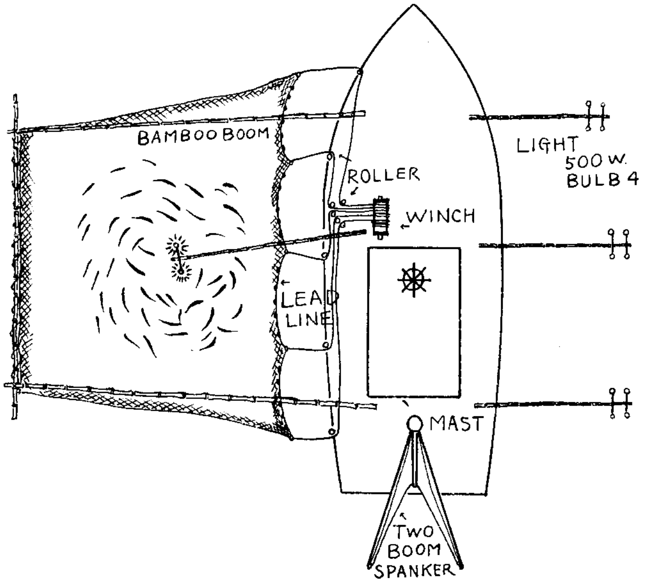

Figure 3. Top-view of a typical lift-net boat with lighting set-up. The net is lifted near the surface of water, with left side lights on

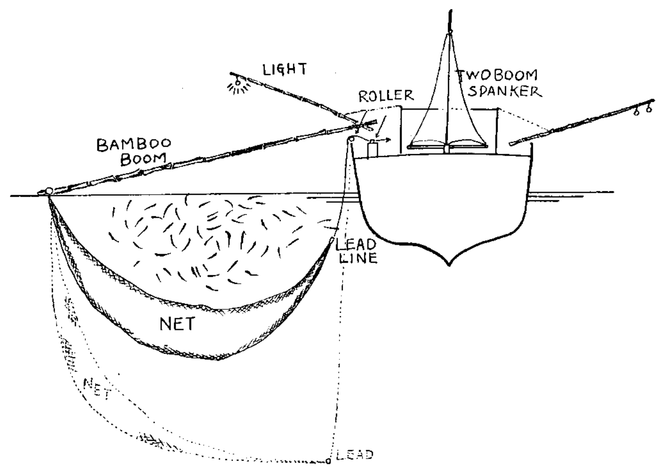

Figure 4. Cross-view of the same lift-net boat seen from the aft. The net is drawn showing two steps in operation; the net in dotted lines the first set, and the net in solid lines lifting of the net near the surface of water as in Figure 3

possible the second operation also attracts other nearby fishing boats.

The current of water as well as the wind direction often hinders the operation. The ideal operation occurs when the fish are abundant at the same time that the sea conditions are such that all lead-lines hang vertically from the boat and the two bamboo poles can be set perpendicular to the axis of the boat. The net is then inflated in the water by the current cross-wise from starboard.

SOME EXPERIMENTS

The catch analysis shows that the fish caught by the present lift-net consist mostly of three-year-old fish mixed with two-year-old and four-year-old fish. It was also noticed that small fish (one year old) are readily attracted by the light and trapped in the net together with other fish of different ages.

For the wave-length of electric light, some experiments have been made: the bulb with 4,000 A° was most effective in attracting the fish. The efficiency of 6,000 A° as used in the left light, which should be bright only near the surface of the water, was not established. In order to avoid the loss due to the reflection of light on the surface of water, the light was immersed in the upper layer of water, but this experiment did not show any satisfactory result. Various types of shades were made experimentally to give better reflection, but they are only seldom utilized at present. Other experiments show that the larger the power of the light, the more the fish are attracted, but if the light is too bright, the fish tend to leave. It was also noticed that some saury schools are not attracted at all by the light, for which no explanation is yet known.

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Technological Development in Fisheries with Special Reference to the Factory Ship in the United States

A. W. ANDERSON

ABSTRACT

Mobile vessels processing their own catches or the catches of an accompanying fleet of fishing craft have operated in the United States fisheries since early in the sixteenth century beginning with salting cod and progressing through whaling, salmon canning, freezing tuna, halibut and salmon, and reducing pilchards, herring and waste to meal and oil.

Recent factory ship developments have been varied. The Atlantic Coast fisheries are represented only by a proposed 175 ft. vessel equipped to trawl, fillet and freeze its catch, and reduce the waste. Gulf of Mexico fishery interests have built or adapted a number of shrimp trawlers to catch, package and freeze shrimp but current operations appear unprofitable.

Western Alaska fisheries have attracted an increasing number of vessels equipped to dress, freeze and transport salmon. The king crab resources also are being fished by additional craft specially built or converted to trawl for king crab, and package and freeze crab meat.

The operations of the *Pacific Explorer*, 8,800 ton factory ship, in serving as a mother ship and freezer for tuna purse seiners resulted in a series of smaller but more adaptable tuna freezing and transporting vessels for use in waters off Central and South America. *The Pacific Explorer* operation in Western Alaska produced a large pack of canned king crab but the advantages of a factory ship of its type have yet to be compared in detail with other types of operation.

Filleting is not being practised on fishing craft but tests indicate that freezing round fish at sea, thawing and filleting them on shore, and packaging and refreezing the fillets may have many advantages.

In the United States the term "factory ship" usually means a mobile vessel which processes its own catch—or fish received from an accompanying fleet—and lands a product in a condition other than fresh or iced.

This field is both ancient and broad (23, 24)[1]. Cod were salted on fishing craft off our New England Coast in the early part of the sixteenth century. Today our salt-fish operations are negligible, being limited primarily to several schooners which produce salt cod in the Bering Sea.

Production of whale oil at sea by New England fishermen began after 1715 and flourished for years. Today the United States does not possess a single whaling factory-ship.

The first salmon cannery to operate afloat was built on a scow in the Columbia River in 1867; while the first vessel to can salmon was the clipper ship *Glory of the Seas* in south-eastern Alaska in 1911. A number of floating salmon canneries continue to operate each year in Alaska, but with one exception, the *La Merced*, they are not equipped to fish or to can at sea, their operations being dependent upon adjacent shore facilities.

Mechanical refrigerating equipment was installed on a Pacific Coast halibut schooner in 1926 to keep the ice from melting too quickly. By 1930 a California tuna vessel had sufficient refrigeration installed to freeze its catch. Now practically the whole tuna fleet freezes its catch. Ice is used only by vessels operating near port or a mother ship. Floating freezers of relatively large size have operated in Alaska on a basis somewhat similar to the floating canneries. Freezing at sea, however, except for tuna clippers, is in its infancy in the United States whether by fishing craft, mother ships, or transporters.

The first floating fish reduction plant, the *Lake Miraflores*, was converted to this use in 1926 but because of state regulations did not operate off California until 1930. During the 1936-1937 season nine factory ships of this type operated with a large fleet of fishing craft and processed 239,257 tons of pilchards (22). After the 1938-1939 season, California fishing regulations prevented further profitable operations.

In Alaska several floating reduction plants operate but they too, while mobile, are dependent largely on shore facilities.

Factory-ship operation in our Atlantic Coast fisheries currently is at a low ebb. A floating fish factory advertised in the trade Press in the summer of 1948 is still in the blueprint stage (2). Its New York designers planned a 175 ft. steel vessel of the North Atlantic trawler type. The design and equipment permits trawling in the usual manner, and the cutting, packaging, freezing, and storing of 375,000 lb. of fillets. Freezing occurs as tray-loaded trucks of fillets are conveyed through a tunnel at —20 degrees F. Storage is at the same temperature. Reduction equipment processes all waste into 200,000 lb. of fish meal, fish oil, liver oil, glue, etc. Twenty trips per year were suggested as an operating schedule, the trips to be fourteen days in length with ten days' fishing.

Our Gulf of Mexico fisheries have had a number of factory-ships in operation in recent years. The *Sea Horse*, a converted 75 ft. patrol vessel, began fishing for red snapper and grouper out of Florida ports with mechanically operated lines in 1947 (1). The catch was filleted, packaged, and frozen in a shelf freezer. The shrimp fisheries, however, seem to have drawn the most factory ships. The *Arcturus*, a 108 ft. steel vessel, was constructed in 1947 to trawl for shrimp, head and pack the catch in 5-lb. cartons, freeze the cartons in an air-blast freezer, and store 140,000 lb. at 0 to +10 degrees F. (5). The *Twenty Grand*, a 132 ft. steel former government freighter, was converted in 1947 to a factory-ship equipped to trawl for shrimp, freeze and store its catch, and service other trawlers with food and fuel. It was reported to be able to freeze 2,000 lb. of headed shrimp in 90 minutes in blocks in metal containers, and to store 165,000 lb. of the frozen blocks in cartons (5).

In 1946 the *Sovereign*, an 84 ft. wooden vessel, was constructed to trawl for shrimp and fish for red snapper with

[1]Numbers within parentheses refer to items in the bibliography.

mechanically operated lines. The shrimp catch was headed, frozen in 50-lb. stainless steel baskets in eight 20,000 lb. capacity brine tanks, and after freezing, stored dry in the tanks. Thirty thousand pounds of shrimp or fish could be frozen daily and 160,000 lb. stored (4).

The *Betty Jean*, a 65 ft. wooden vessel, also entered the shrimp fishery in 1946. It acted as a mother ship for a group of trawlers which transferred their catches in 100-lb. hampers. The shrimp were headed and packed in 5-lb. cartons for freezing at —20 to —40 degrees F. in a plate freezer and stored at 0 degrees F. The freezing capacity was 14,000 lb. daily (3).

The most recent reports on the various shrimp trawlers mentioned indicate that freezing at sea, currently at least, is not profitable. Some are inactive while others have transferred their operations to foreign waters.

Freezing salmon on vessels in Western Alaska and transporting the frozen cargo to canneries in other Alaska areas or to Puget Sound is a relatively recent development (14). At least three vessels operated in this manner in 1948. The *Reefer King* is a 148 ft. wooden converted FS (freighter, small), and is equipped with air blast freezing. The *Iceland* is 100 ft. long, has two sharp freezers and carries skiffs and nets for fishing. The salmon are mechanically dressed by an "Iron Chink". It has a storage capacity of 200,000 lb. and is somewhat unique in that the refrigerating equipment is an ammonia absorption system rather than the usual compressor type. The *Nuisance IV*, a 104 ft. vessel, is similar to the *Iceland*, having an ammonia absorption system, two sharp freezers, and 240,000 lb. storage capacity. It froze salmon in the round, not having an "Iron Chink".

All of these vessels apparently operated satisfactorily. It is understood additional vessels, some considerably larger, may enter this trade in 1949. Tests of canned salmon prepared from the frozen fish indicate that freezing may have some effect on the quality as compared with regular packs. It is reported that colour and texture may be adversely affected and curd formation may be increased under long or poor storage.

Factory ship operations in Western Alaska waters, particularly for king crab, have been numerous in recent years. The area is distant from large fishing ports and markets, lending itself well to factory ship methods (12, 14).

In 1940-1941 the Fish and Wildlife Service explored these resources with several vessels, one of which, the *Tondeleyo*, a 113 ft. wooden vessel, was fully equipped to can crabs on a commercial scale (25). This vessel is no longer in operation having sunk shortly thereafter.

Prior to more extensive operations the following year, the Reconstruction Finance Corporation dispatched the *Alaska*, a 100 ft. steel trawler to the Bering Sea and the south side of the Aleutian Peninsula in 1947 (26, 27). An appreciable catch of king crabs, and bottomfish, such as cod, haddock, sole and flounders, was taken entirely by trawling, using the stern set method.

The crabs were butchered, the legs cooked in boiling sea-water, then stacked in wire baskets, and finally frozen on shelf coils in two sharp freezers at —4 to —12 degrees F. The frozen legs were stored at 10 to 12 degrees F. It was the opinion of the Fish and Wildlife Service observer on board that the *Alaska* could not fish in as rough weather as a side-set, Atlantic-type dragger, the *Deep Sea*, which was operating in the same area but that its gear took just as many crabs per drag.

The *Deep Sea*, a 140 ft. steel Atlantic-type trawler, was constructed in 1947 especially for catching king crabs and bottom fish in Alaska waters and processing, packaging and freezing the catch (10, 12, 14, 27). After butchering the catch the crab legs are cooked in steam and the picked meat frozen in trays in a vertical air-blast tunnel at —25 degrees F. Fish are frozen in a similar manner but operations have been primarily on king crabs. Crab legs are also frozen in the shell. Storage is at 0 degrees F. in a hold with a capacity of 8,500 cub. ft. or 300,000 lb. The frozen crab meat is packaged in aluminium foil.

The *Deep Sea* has operated for two years in Western Alaska and has returned to Seattle with substantial quantities of king crabs both as packaged frozen meat and as frozen crab legs. It is questionable whether the *Deep Sea* can be called an unqualified success at this time. Undoubtedly it has demonstrated it can catch and process king crabs with considerable success but problems concerning operating costs and marketing remain to be solved.

The *Chirikof*, a 70 ft. steel vessel, was constructed in 1946 as a combination vessel equipped to trawl, and to fillet, package and freeze its catch. Without much difficulty it could also be converted to albacore tuna fishing or fish-transporting. For several years it has operated on king crabs on both sides of the Aleutian Peninsula. After the trawl-caught crab catch has been butchered and cooked the picked meat is packed in friction-top gallon cans—holding about 5 lb.—in a special house on the after deck which also may be used for filleting and packaging fish in 5-lb. cartons. The packaged products are frozen on shelves in a sharp freezer at —27 degrees F. (6, 12, 14).

The *Lynn Ann*, a 128 ft. mine sweeper, was converted to a side-set trawler in 1948 and equipped to salt cod and freeze king crabs in Western Alaska (14). The king crab meat was sharp frozen in gallon friction-top cans. Eighty thousand pounds of frozen products and 400,000 lb. of salt cod could be stored.

The *Reefer King*, a 148 ft. FS (freighter, small) was converted in 1948 to a stern-set trawler equipped to buy and freeze Bristol Bay salmon and later to catch and process king crabs (14).

The *Sundown*, a 115 ft. FS (freighter, small), is being converted to a stern-set trawler and equipped to operate in Bering Sea on salmon and king crabs. Crab meat will be frozen in friction-top gallon cans in a sharp freezer with a daily capacity of 20,000 lb. Storage for 300,000 lb. will be available.

In addition to the craft mentioned there are reports of other vessels contemplating entering frozen crab and fish operations. Some plans involve sizable craft, others refer to 70 or 80 footers. For one of the latter a sharp freezer has been mentioned with a freezing capacity of 2,000 lb. daily and storage for 80,000 lb. of frozen products.

It appears that trawling for king crabs and freezing the catch, possibly combined with freezing salmon, is well on its way to becoming an established and profitable factory ship operation in Western Alaska.

The most recent experience with large factory-ships in

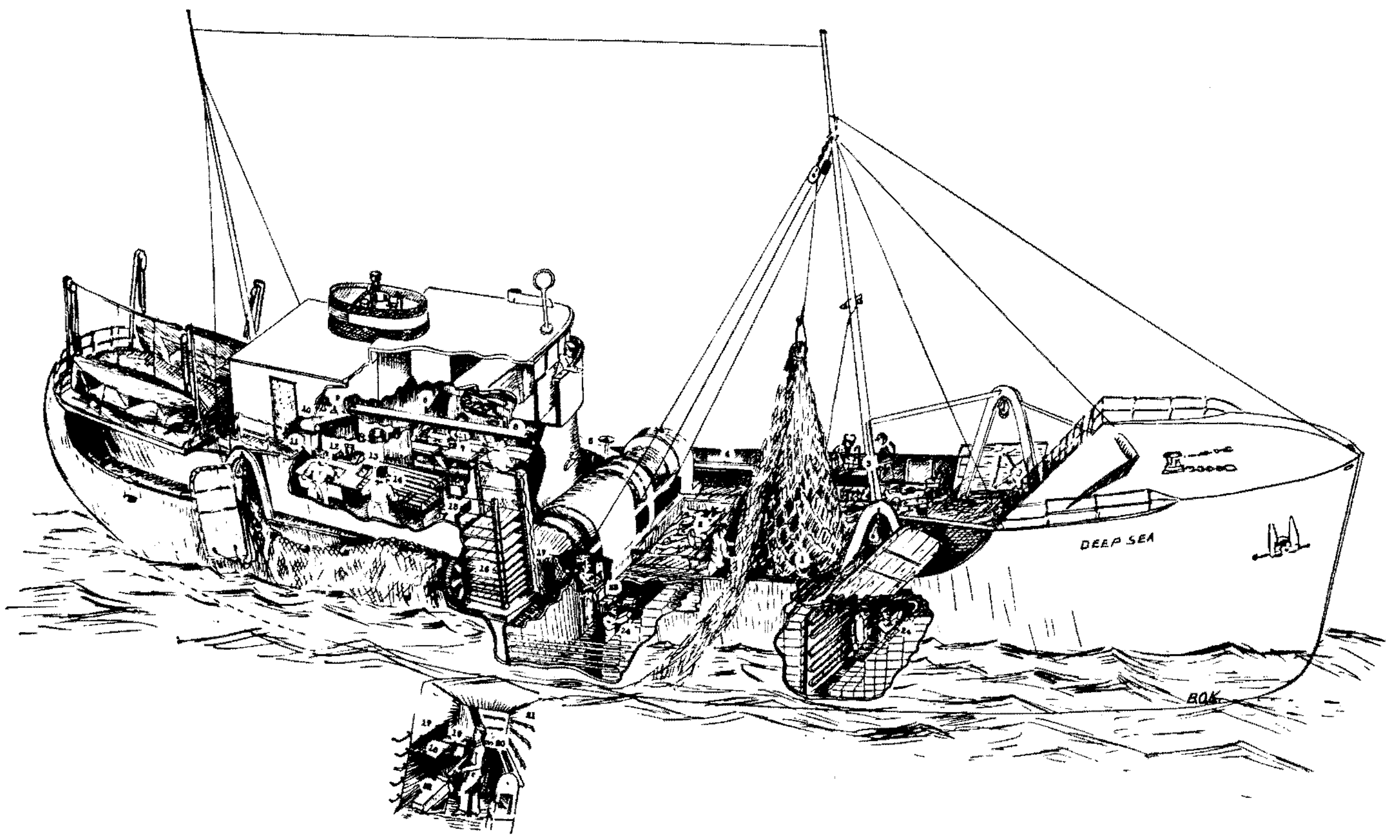

Figure 1. The recently built motor-trawler *Deep Sea* has a complete freezing and processing system on board. The cutaway view of the ship shows the various activities performed on board. These are: (1) landing the catch; (2) sorting species of fish; (3) butchering, washing, and cleaning king crabs prior to cooling; (4) sluice conveyor to cooker; (5) cooker conveyor leading to processing room; (6) chute to processing conveyor; (7) processing conveyor to filleters; (8) fish conveyed to spray washer; (9) spray washer; (10) conveyor to hopper; (11) hopper; (12) inspection table; (13) weighing; (14) packing in freezer trays; (15) chute for clean tray supply; (16) quick-freezing conveyors; (17) frozen trays; (18) defrost stage; (19) defroster tank; (20) glazing tank; (21) racks for glaze to set; (22) packing cartons; (23) full-carton conveyor; and (24) carton storage forward in ship

the United States has been with the *Pacific Explorer*, an 8,800 ton, 410 ft., steel vessel built during the First World War. Conversion of this vessel to a factory-ship began in 1945 as a means of producing additional food from fishery resources during the war period. Conversion was not completed until late in 1946. It was converted at government expense and chartered by the Reconstruction Finance Corporation, a government corporation, to an experienced commercial operating organization, the Pacific Exploration Company, Inc. The *Pacific Explorer* was designed primarily to operate in Bering Sea during the summer months, landing the catch of king crabs and bottom fish from an accompanying fleet of trawlers and tangle-net fishing-craft. During the remainder of the year it was expected to operate in other areas, possibly freezing and transporting tuna (7, 17, 27).

The *Pacific Explorer* was designed and built as a self-contained unit. Plans called for filleting, freezing, canning, salting, and by-products reduction operations. Equipment was installed to freeze 260,000 lb. of fish daily, freeze 10 tons of ice daily, can 600 cases of crab and produce 50,000 lb. of fillets in an 8 to 10 hour day, and reduce 5 tons of waste products per hour. Facilities were also provided to accommodate a crew of 240 for a 4 months' voyage and to service a fleet of fishing craft with fuel, food and other supplies.

The freezing and refrigeration system consists of four small blast freezers on the cannery deck—each with a capacity of 6,000 lb. of packaged fillets—and, on the second deck, one large and two medium blast freezers and four shelf freezers with a capacity of 38,600 cub. ft. Frozen storage space of 129,550 cub. ft. was provided. The freezers could be lowered to —40 degrees F. and the storage space maintained at sub-zero temperatures.

Four specially designed 100-ft. combination type fishing craft were built to serve as a nucleus of a fishing fleet for the *Pacific Explorer*. These vessels were equipped to operate as tuna-bait boats, otter trawlers, purse seiners, line trawlers or gill netters according to the area and resources fished. Each vessel has two large brine tanks for freezing its catch and a refrigerated hold in which fish may be stored frozen or held in ice (9, 26).

On its first trip and shakedown cruise to Costa Rica to freeze tuna the *Pacific Explorer* was staffed by a crew of 63. It left Astoria, Oregon, on 4 January 1947, and returned on 23 July with 2,250 tons of frozen tuna received from a fleet of tuna purse seiners and bait boats (8). A series of detailed reports on this expedition were prepared by Fish and Wildlife Service observers who accompanied the vessel and have been published by that agency (17, 18, 19, 20).

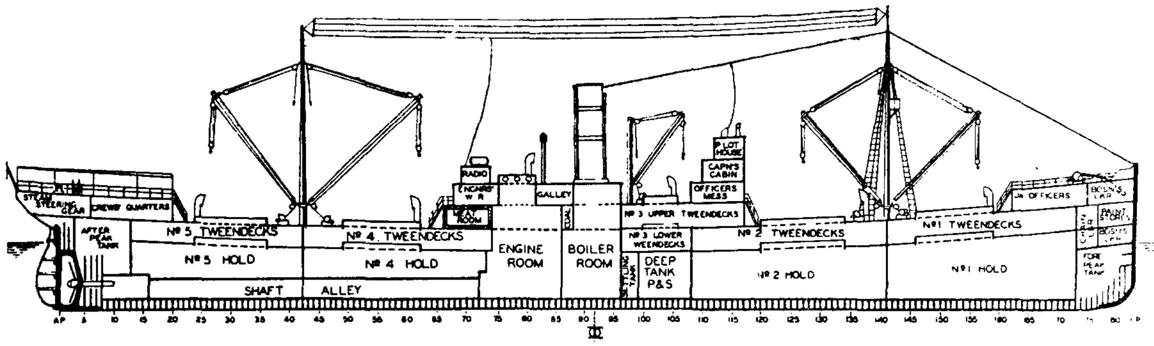

Figure 2. *S.S. Pacific Explorer* (ex-*Mormacrey*) before conversion

The trip of the *Pacific Explorer*, to Costa Rica and its service as a mother ship to a fleet of tuna purse seiners, demonstrated the feasibility of this operation and resulted in the conversion of a number of large craft to this type of service. Lessons learned on the *Pacific Explorer* expedition have been applied to the new vessels with the result that they are smaller and specially adapted to the freezing and transporting of tuna. They act also as sources of supply of fuel, food, ice, gear etc., for their satellite fleets of bait boats or purse seiners but do not carry canning lines, a reduction plant, or similar equipment.

Most of these vessels have in common the fact that they were converted from war surplus craft. Among these vessels is the *Reina Del Mar*, a 194 ft. Navy net tender, converted to freeze tuna in brine and dry-store 750 tons at 0 degrees. An A-N 53, 180 ft. long, has also been converted similarly to brine freeze and store 700 tons (11).

Much larger are the *Saipan* and *Tinian*, each 328 ft. long. The former was an LST and the latter an ARST. In 1948 they operated on an alternate schedule between Astoria, Oregon, and Central America, transporting about 4,500 tons of frozen tuna. Tuna received from a fleet of purse seiners based in the area were brine frozen in baskets holding 1,250 lb. each and stored dry at 0 degrees F. in four holds with a total capacity of 1,021 tons. All handling operations were mechanized to a large degree. Experiences on the *Pacific Explorer* were drawn on extensively in the conversion (11, 13, 15). These two vessels were later transferred to Honduran registry but are continuing to operate in the same frozen tuna trade with certain modifications in equipment and procedures that further experience has dictated as advantageous.

Continued use of this type of vessel in the tuna industry undoubtedly is on a sound basis and possibly may expand from Latin and South America to other areas. When properly equipped and operated such a vessel has a number of advantages. It broadens vastly the fishing area of those fishing craft, particularly purse seiners, which do not have great range. And it facilitates United States canning operations by making available greater supplies and permitting more uniform operating practices.

On 26 March 1948, the *Pacific Explorer* left Astoria, Oregon, for western Alaska waters and returned 18 July. In the intervening period it and a fleet of 10 fishing craft—7 trawlers and 3 tangle-net vessels—operated on the south side of the Aleutian Peninsula and in Bering Sea for king crabs and bottom fish. Almost 400,000 male crabs were delivered to the vessel and over 1,600,000 lb. of fish. About 18,000 cases of crab meat—48 ½-lb. cans per case—were packed as well as an appreciable volume of frozen crab meat and frozen packaged filleted fish. The vessel crew numbered 225 (14, 21, 28).

A detailed report on the vessel's operation has been prepared by Fish and Wildlife Service observers on the factory ship and is now in the process of being published by the Service (29).

Undoubtedly the fishing industry will analyse this report carefully and compare its findings with results that have been obtained by other operating methods in these waters. Before such a decision can be reached it will be necessary to compare the advantages of a factory ship and its accompanying fishing fleet with, firstly, a small trawler adapted to freeze its catches, secondly, a specially constructed larger vessel equipped to catch and freeze its production, and thirdly, fishing vessels delivering to shore plants, possibly to salmon canneries before and after their short salmon seasons. What the ultimate decision will be is not yet clear and well may depend on further exploration of the resources as well as future economic factors such as labour costs, transportation rates, market prices, and the availability of competing products.

Filleting and packaging fish on fishing craft has not progressed rapidly. The *Soupfin*, a 67 ft. wooden trawler, operating out of Puget Sound, filleted and froze its catch in 1943 but market conditions since then have not favoured a continuation of the practice. The *Soupfin* was equipped to sharp freeze 3,000 lb. of fillets in pans at one time on shelf coils at —5 degrees F. Ten tons of frozen fillets could be stored at 10 degrees F in addition to 50,000 lb. of iced fish in the main hold (17).

If the results of a study of freezing fish at sea, which has been underway for some time by the Seattle, Boston and College Park technological laboratories of the Fish and Wildlife Service, continue to be favourable a way will have been found to meet many of the problems of factory-ship operation, especially in the fisheries for those varieties later entering into the frozen-fish market. These studies were started because New England and Pacific Northwest vessel operators have been confronted with increasing imports of high-quality frozen fillets. The excellence of the fillets has been due in large part to the nearness of the fishing banks to the foreign processing plants. Frequently, the imported fillets have been frozen within a day of catching.

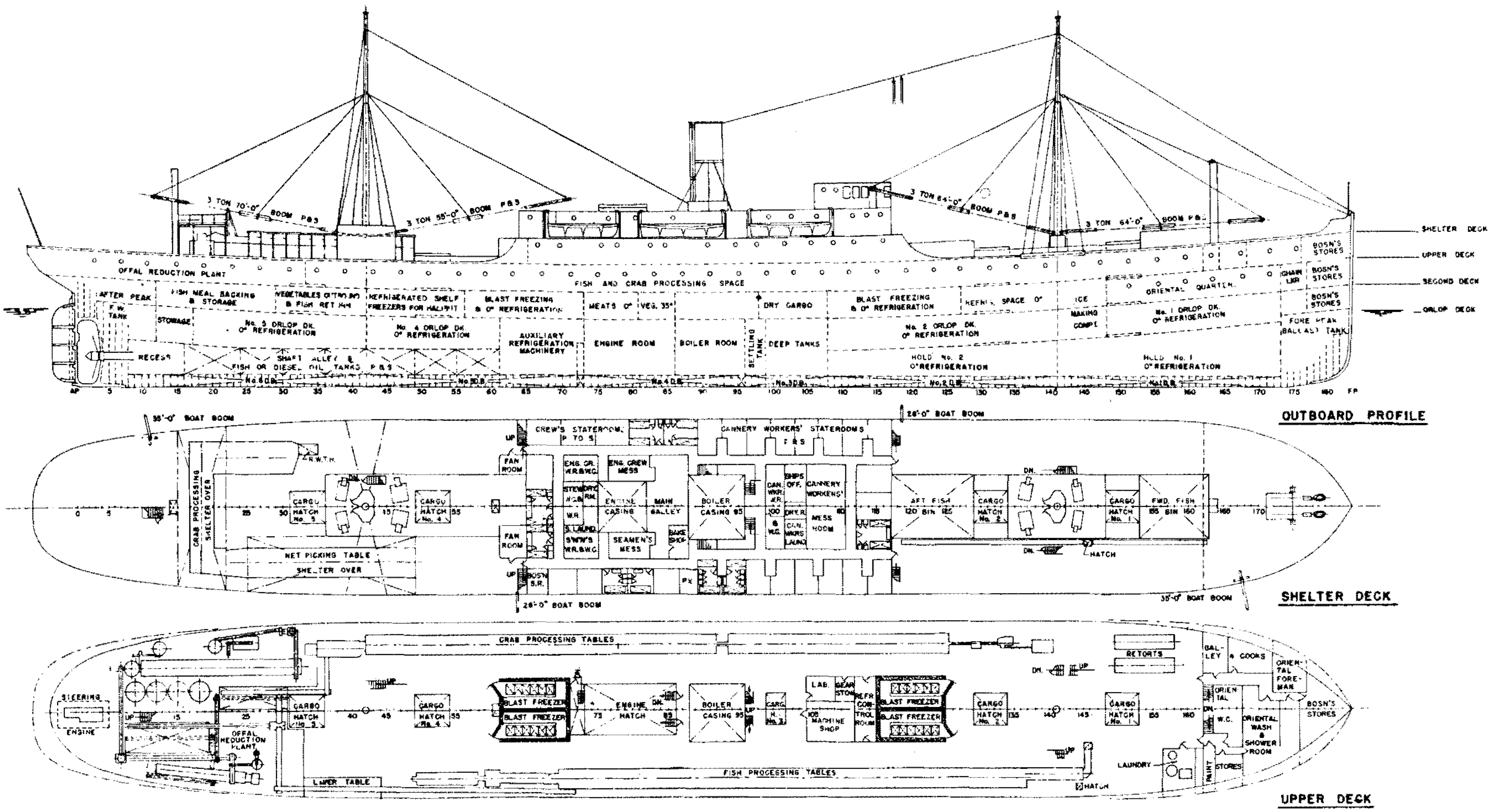

Figure 3. Outboard profile and upper decks of *S.S. Pacific Explorer*

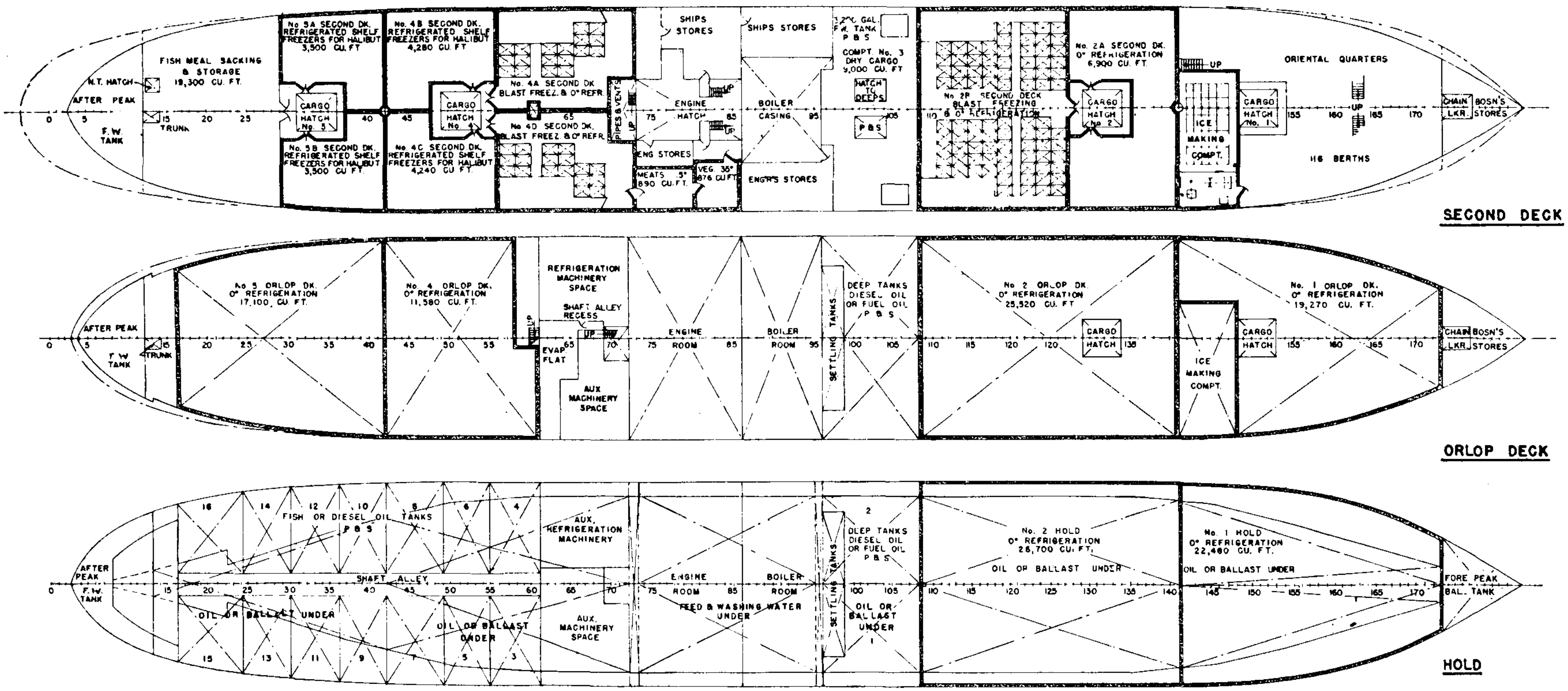

Figure 4. Lower decks of *S.S. Pacific Explorer.*

A similar situation does not prevail in our groundfish fishing ports. Filleting and freezing at sea is not feasible, at least on our present fishing craft, because of labour and operating costs, space and personnel problems, and the weather. Consequently, other means have been sought in an effort to produce the highest possible quality frozen fillets. Preliminary tests indicate that fish frozen in the round on the fishing vessel soon after catching can be landed in this condition, stored on shore for an appreciable period, later thawed and filleted, and immediately packaged and refrozen with an appreciable increase in quality over the usual product which is gutted at sea, iced, and then filleted, packaged and frozen on shore.

Final results and recommendations are not yet available, particularly with respect to equipment and refinements in techniques of handling, but the procedure outlined appears to have many advantages. It lessens the fisherman's labour at sea by eliminating all dressing of the catch. It permits the vessel to remain at sea until its holds are filled, and increases its fishing radius. Handling of the catch is simplified and may be mechanized to a considerable degree, particularly if freezing in baskets in brine wells is feasible. It may make possible the saving of trash fish, now dumped overboard, for sale to reduction plants on shore. Leaching out of nutrient materials, as now occurs in iced fish, through a combination of melting ice and pressure in heavily loaded pens, is eliminated. More efficient handling and unloading practices will prevail. Since frozen fish cannot be forked there should be no fork-holes in the fish to provide an entrance for bacteria or cause discoloured spots on the fillets.

On shore the reduction plants will benefit through an augmented supply of waste and the medicinal and industrial oil plants will again receive a full quota of livers. Processing plants and shore labour should benefit even more because an adequate supply of frozen stock will always be available for filleting. Marketing fluctuations due to either a dearth or a glut of landings should be moderated, and shore labour in the processing plant should be able to work a normal week throughout most of the year. Compared with control samples gutted and iced in the usual manner the round fish frozen at sea, according to preliminary tests, have a "sea-fresh" taste, a lesser trimethylamine content, and possibly may yield a greater recovery in fillets. Consumers should be offered, therefore, uniformly higher quality frozen fillets at no greater price and, conceivably, this may increase their consumption.

The most desirable procedures and equipment for freezing at sea, as described, remain to be worked out. It is possible a vessel may not freeze its entire catch. Economic and other considerations may dictate that freezing the first few days catch is sufficient. This, alone, would simplify the equipment necessary and reduce the space required while, at the same time, improving the quality of that portion of the catch which brings a lower price and often adversely affects the market for the higher quality catch made during the last days of fishing.

With so many apparent advantages, and with imports of frozen fillets pressing even more threateningly, it would seem that freezing at sea, and thawing, filleting and refreezing on shore may become a common practice with the accompanying effect of making our groundfish trawlers as complete converts to freezing installations as are our tuna clippers.

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The French Sea Fish By-Products Industry[1]

J. PÉRARD

ABSTRACT

The author says that the fishing by-products industry which started in France about 1900 has made great strides since then, notably since the 1940 Law on Marine Fishing.

He then proceeds to review the various methods which may be used for treating the offal from low-fat-content fish or high-fat-content fish (including the offal from the canning of sardines, tunny and mackerel) and discusses the extraction of oil from the livers of fish for medicinal or industrial purposes.

The offal after removal of the fatty substances (if any) is variously converted into meal for cattle feeding or into a greatly valued fertilizer known as fish guano.

He briefly mentions the other uses of the by-products for such purposes as the manufacture of fish paste, bait for certain kinds of fishing, tanning of the skins and others.

He concludes by mentioning that the commercial interests concerned with treating the by-products have formed a professional association with several hundred members.

About the year 1900 a beginning was made in France with the industrial treatment of the by-products from sea fishing.

Until then and even for some time thereafter this offal was used by agriculture as fertilizer, being simply spread on the fields.

At the present time, pursuant to the 1940 law on sea fishing, new factories have been established and the industry is tending to develop more and more, at least in the ports where the raw material may be collected in sufficient quantities to keep the factories in operation.

The methods of treatment vary from case to case, depending on the nature of the raw material and on the tonnage which can be collected daily.

The simplest case—and this is more particularly true of the waste products from fresh fish deliveries—is the manufacture of fertilizer for agriculture.

For this purpose the fish wastes are treated with sulphuric acid, natural phosphates being added. By this process a more or less pasty mass is produced which is piled up for a fairly long time.

By the action of the sulphuric acid the exceedingly variable substances are converted into highly assimilable nitrogenous products and the phosphates are converted into superphosphates.

Work recommences on the pile when it is thought that the reactions are completed.

The product is finely ground and occasionally reinforced by the addition of such ingredients as potassium substances; it is then sold to farmers.

This fertilizer, known as French fish guano, is greatly valued and produces excellent results.

However, this process is not very useful for treating the offal from high-fat-content fishes like tunny, mackerel and sardines, for the fatty substances are lost.

Moreover, it is more profitable to utilize the nitrogenous substances for manufacturing meal for cattle feeding.

In this case, varying according to the factory and depending on whether fresh fish waste (low-fat-content fish) or cannery waste (high-fat-content fish) are concerned, the process is entirely different.

For cannery waste (high-fat-content fish) it is possible to use extractors in which the raw material is treated by volatile solvents, such as light petrol, benzol, trichlorethylene and the like.

This apparatus exists in numerous and well-known types and hence need not be described here.

In this way, fatty, water-containing products are obtained which are usually treated in centrifugal separators; or else the product consists of a meal which, after drying, is crushed and sifted and is used either directly or with an admixture for feeding livestock, such as poultry, for fattening pigs, and similar purposes.

In other cases the method preferred is to boil up the offal in water or to steam it and then squeeze out the fatty substances.

The caked remains are then broken up and dried in double-lined steam-driers which are usually in permanent operation. The dried product is then ground and sifted as described above.

The aqueous fatty product coming out of the press is usually treated by centrifugal separators, but in some old factories the method of decanting by gravity is used. In this operation the liquid mixture is placed into large vats where it remains long enough for the oil to rise to the surface whilst the water settles at the bottom.

[1]Original text : French.

Lastly, in the case of certain products, the method preferred is to use centrifugal driers into which steam is injected. The products extracted are treated as described above.

In any event, the livers are treated separately. Some kinds of livers are used for producing oil for medicinal and veterinary purposes, others for producing oil for industrial purposes (for use, e.g., in manufacturing chamois leather, treating leather, paints and the like).

The commonest method of treating livers is to reduce the raw material to a fine pulp, then to treat the pulp in more or less warm water and, lastly, to place the magma into a centrifugal separator.

On leaving this first separator, the liquid, having been separated from its solids, enters a second separator: it is at this stage that the clear oil is produced.

Often oils intended for medical purposes are placed in a cold chamber and then filtered in a press filter in the cold chamber itself. This process yields a bright and very clear oil containing the maximum amount of vitamins.

The quality of the oil is in direct proportion to the freshness of the livers. Hence it is of advantage to treat the livers in factories situated in the actual fishing ports, or in factories as near to those ports as possible.

In France the fish by-products industry is regulated by the 1940 law on sea fishing and is under the supervision of *l'Office Technique et Scientifique des pêches maritimes.*

In particular, the species of fish whose livers may be used for the manufacture of medicinal, veterinary or industrial oils are dealt with in ministerial orders (responsible authority: Ministry of the Merchant Marine, Department of Sea Fisheries).

We would add, with more particular reference to cod, that an increasing number of trawlers engaged in deep-sea fishing off Newfoundland are now equipped to treat the livers on board ship. The oil produced in this way is only refined on arrival at the port (by such process as demargarinization).

Before the 1939 war, some trawlers, mostly from the port of Arcachon, were equipped to treat the offal from fresh fish and from inedible fish on board ship. This equipment, which was very simple, consisted of a cylindrical discontinuous double-lined steam-drier. The meal obtained by this process was later treated in a factory set up in the port where it was dried further as well as ground and sifted.

But the manufacture of oil, meal and fertilizer is by no means the only use for the by-products of sea fishing.

Manufacturers of food preserves use certain types of fish or certain parts of fish to manufacture pastes or similar products which formerly were not used or were converted into meal.

We may also mention the manufacture of bait for certain kinds of fishing, such as sardine fishing, as well as the tanning of the skins of certain fish, although admittedly this industry is barely developed as yet.

In conclusion, we would add that all the commercial interests concerned with the treatment of fish by-products have formed a professional association under the name of *Syndicat général des Industries de traitment des sous-produits de la pêche maritime;* this association already has several hundred members.

The products of this industry are so well known that we shall not give particulars of their characteristics which vary greatly according to the raw material and the treatment thereof.

For further particulars we would refer the reader to the records of the various national sea-fishing congresses, the periodical publication on professional and technical training in sea-fisheries (*Bulletin de l'Enseignement Professionnel et Technique des Pêches Maritimes*), and to Mr. Abel's paper submitted to the Seventh International Congress of Agricultural Industries held in Paris, 1948.

Summary of Discussion

The CHAIRMAN said that there were two important subjects on the agenda for that meeting: fisheries statistics and technological development in fisheries.

As most of the authors of the papers were absent, he had asked some of the members who were present to summarize the papers submitted. A greater portion of the meeting should be devoted to general discussion, and he therefore asked that the papers should be presented as rapidly as possible. Mr. Power would summarize the papers on fisheries statistics, including Mr. Bates' paper on statistics on economic features of the fisheries, Mr. Louis' paper on economics statistics on maritime fisheries, the paper on fisheries statistics submitted by the Netherlands Government, Mr. Gerhardsen's paper on statistics on economic features of the fisheries and his own paper on statistics on economic features of the fisheries of the United States.

Mr. POWER said that as he had been allowed so little time he would be unable to make a full summary of all five papers, but would try to bring out their salient points.

In his paper, Mr. Bates had described in detail the various aspects of collecting and compiling statistical data. An integrated statistical service, by eliminating duplication, reduced to a minimum the total effort involved in that work and made for better quality in the statistics themselves. The problem was simplified, of course, if all statistics were collected by a single authority, but that was seldom possible; the statistical service was often linked up to other sections of the administration. The statistical authority had also to keep in close contact with industrial and commercial circles.

Those engaged in compiling statistics should be adequately trained if really useful results were to be obtained.

All the data given by Mr. Bates, on the various aspects of the problem and the methods used for compiling statistics, were of great value and would not fail to be of interest to Governments wishing to introduce a statistical service or to improve existing services.

In his paper, Mr. Louis pointed out that fisheries statistics published by the principal countries of the world were of a national character and showed great variations. It was absolutely impossible to separate economic from biological data. Countries which had not yet introduced a statistical service could apply to the Fisheries Division of the FAO, which would furnish them with simple guiding principles.

Mr. Louis drew attention to the great value which a survey of world trade in maritime products would have in connexion with the conservation and utilization of maritime resources.

The third paper was made up in the main of statistical data furnished by the Netherlands Government on that country's fisheries and did not give rise to any discussion. It dealt also with the cost of production, marketing organization of the fisheries industry, foreign trade and home consumption.

With regard to the latter point, it was stated that in 1938 fish consumption had amounted to 10 kg. per capita and had risen to 13.3 kg. in 1947 and 12.1 kg. in 1948. Thus, there had been a rise of between 20 and 30 per cent, but there was no indication whether those figures referred to fresh or frozen fish, or to finished products. Further information was needed if the full importance of the given figures was to be appreciated.

Mr. Power considered the fourth paper, that by Mr. Gerhardsen, the most important. It was based on two years' experience in the Fisheries Division of the Food and Agriculture Organization, during which the author had been able to study statistics provided by a number of countries and to note that a great many improvements were needed in compiling statistics. There was a tendency for world fisheries statistics to become stereotyped; data which would be highly useful were not furnished, and data which were no longer useful continued to be given. It was extremely difficult to compare statistical data. The types of fish should be identified, the various processes clearly described and the standard of measurements well defined.

The author pointed out also that grave difficulties were encountered owing to the fact that national publications often appeared one or two years late. The Fisheries Division of the FAO was trying to induce the various countries to adopt a uniform method of collecting statistical data.

Mr. Power warmly recommended all those who were interested in fisheries statistics to read Mr. Gerhardsen's paper and to act on it.

Finally, he briefly summarized his own paper in which he described the methods used in the United States for the collection of statistics. In the United States it was considered the responsibility of the States to collect the basic catch and operating unit statistics. Funds at the Federal Government's disposal for that purpose were limited, and its task was restricted to co-ordinating and publishing the statistics. Unfortunately, only about half the States with important commercial fisheries made any attempt to collect statistics, and it was therefore necessary for the Federal Government to attempt to collect statistics in these States in order to arrive at an exact figure for the country's total production. Experience had shown that it was better to set up a permanent service in the most important areas rather than to undertake statistical studies in alternate years in certain areas. Federal Government services such as the Census Bureau had, on several occasions, attempted to collect fisheries statistics, but the results had proved unsatisfactory; the gathering of statistical data was a complex task requiring special knowledge.

Since 1938, the Fish and Wildlife Service had published the "Fishery Market News" which gave information on catches, prices of fish, and other relevant matters.

In spite of the progress made in gathering statistical data in the United States, biologists and economists were still handicapped by the lack of essential information.

Mr. Hora said that in India the gathering of statistical data had presented very great difficulties. Apart from one or two big centres, fishery had no commercial importance; it was practised along the entire coast in small village units as a general rule, for local consumption or for fresh fish for short-range distribution. The Indian Fisheries Conference, which had been hold in September 1948, had decided to attempt to collect statistical data on fisheries in certain areas as a pilot scheme. The results of those attempts would be examined at the next Conference, which was to take place during the current month.

He wished to know whether countries in the same situation as India, such as Java, for example, were compiling fisheries statistics and what methods they used.

Mr. Bottemanne replied that there were several fish markets in Java which made it possible to compile statistics. Those were unfortunately incomplete, as markets existed only on one part of the coast, so that other methods also had to be used. Experienced persons were sent to fishing areas; they counted the returning fishing boats, spoke to the fishermen, assessed the size of the catch, etc. In big centres from which finished products were shipped, information was supplied by the customs services. Such methods, which other tropical countries would do well to adopt, were inexpensive and gave an idea of the total production.

The Chairman said that Pakistan was faced with the same difficulties as India. Most of the coastal population fished and consumed the catch. Markets were held in some of the larger centres, but as they were held either weekly or daily they were of little use in gathering statistics. Like Mr. Hora, he would be grateful for any advice members of the Section might have to offer.

Mr. Oppedal summarized the papers, both of them on recent advances in methods of handling, preservation, processing and distribution of fish, prepared by Mr. Notevarp and Mr. Bramsnaes. He asked that Mr. Jensen, who had taken part in experiments in Denmark, should comment in detail on parts of Mr. Bramsnaes' paper.

Mr. Notevarp observed that fish began to spoil as soon as they were caught. Fish had been kept fresh successfully for four days at a temperature of 13 degrees C. If the temperature were lowered to about 0 degrees C, without, however, reaching freezing point, fish would keep for a fortnight. Mr. Reay noted in his paper that gutted "white" fish of the commoner species, for example cod and haddock, when treated and carried on board commercial British trawlers kept reasonably fresh for only a week. In his laboratory experiments he had found that under conditions of the most careful handling and stowage in plenty of ice, freshly caught fish remained reasonably fresh for no longer than 12 to 14 days. His findings agreed reasonably well, therefore, with Mr. Notevarp's. Mr. Notevarp stated that chilling on ice was still in general use, but the method of keeping fish fresh had been improved by the use of insulated holds or by mechanical refrigeration. Rapid chilling with brine gave good results. Mr. Oppedal thought that information about the results would be of interest. Experiments with an electronic sterilizer process had been carried out in New York. It had been claimed that after such sterilization fish would keep at ordinary temperatures for a considerable time; Mr. Notevarp had found, however, that reports on the results of that process had been greatly exaggerated.

With regard to the use of chemicals for keeping fish, Mr. Jensen would undoubtedly discuss the experiments carried out in Denmark and mentioned in Mr. Bramsnaes' paper.

Mr. Notevarp devoted part of his paper to the freezing of fish. Some fifteen years ago it had been said that fish must be frozen very fast in order to prevent drying or loss of taste. It had recently been found, however, that only very slow freezing could produce such effects and that the storage temperature was a far more important factor. Frozen fish would keep for three months at —15 degrees C, for four-and-a-half months at —20 degrees C and for nine months at —26 to —27 degrees C. It was certain, according to Mr. Notevarp, that freezing did not improve quality and that the fish should be absolutely fresh before being subjected to such treatment. Freezing on board, therefore, was a very considerable advance.

Mr. Notevarp then dealt with some fish products and by-products, particularly fish meal and fish oil, and noted that new methods of preventing the loss of proteins were being employed. Production of condensed fish solubles had been developed since 1940 and research in that field was continuing. Great advances had also been made in refining oil and in transforming it into edible fats and oils. Such refining, however, destroyed a considerable amount of vitamins, and efforts to remedy that defect were currently being made.

Among the new by-products of fish, Mr. Notevarp made particular mention of the fish flour to be obtained by the dehydration of fresh fish; it had only a slight fishy odour and taste. In countries where the consumption of animal protein was small, fish flour might be introduced into the diet, particularly if it were mixed with whole wheat meal. Mr. Notevarp stressed that surplus fish is the world's cheapest source of animal protein and that great efforts should be made to utilize more fish as food.

Mr. M. Graham briefly summarized Mr. Reay's paper, also on recent advances in handling and processing, in which the author described the results of several years of study and of experiments carried out at the Torry Research Station at Aberdeen, Scotland. He particularly mentioned the cod and the herring, the catches of which were very large in the United Kingdom.

Herring kept very badly; if any appreciable improvement was desired, the process of chilling on board would have to be adopted. Freezing ashore was relatively satisfactory, but the current method of packing appeared to be too expensive in labour and packaging material. Research was in progress with a view to mechanizing the whole process on the basis of a larger "glazed" unit block.

Mr. Reay then spoke of the smoke curing of herrings and "white" fish and noted that advances had been made since a new type of mechanical kiln had been put into operation.

With regard to "white" fish, as more than half of the catch was made in distant waters and owing to the perishable character of that kind of fish, freezing ashore could not give a constant and plentiful supply of a high-grade product. The only way to supply the market with fresh "white" fish was to freeze them at sea.

Mr. Reay stated that attempts at dehydration had been made in laboratories, following which the Ministry of Food had operated a small factory for dehydrated herrings in 1944 and 1945. Total production had been 85 tons. Dehydrated kipper, cod fillet and cod fillet with added hardened oil had also been produced. Those products could be made into palatable fish cakes. Although not of much interest in normal times to consumers in a country with large supplies of food, they seemed to be suitable for export to under-developed countries if the ex-factory cost could be reduced.

Mr. Graham then summarized Lieutenant Commander Renou's paper on methods of detecting fish by echo ranging and echo sounding. The paper contained an excellent report on experiments carried out in co-operation with the French Navy. The diagrams—appended only to the French text—made it possible to appreciate the accuracy of the results obtained. Those methods made it possible to chart not only the families of fish but also the configuration of the ocean bed and the speed at which the shoals of fish and the ship approached each other. Mr. Graham emphasized the importance of the methods described by Mr. Renou; they had been succesfully used in the United Kingdom also.

Mr. A. L. Pritchard commented briefly on Mr. Tarr's paper on recent advances in various technological aspects of handling fish and fish products. The paper gave general data on the research carried out at the Fisheries Experimental Station at Vancouver, Canada, a subject already dealt with in other papers. Mr. Pritchard stressed the importance of that Station's contribution to the solution of the problems of the fishing industry.

With regard to transportation in refrigerated railway cars a new experiment had recently been carried out. Further information could be obtained from Mr. O. C. Young, Fisheries Experimental Station, Vancouver, B.C., Canada.

The experiments reported by Mr. Young bore on the perfecting of a mechanical refrigeration process as opposed to the process of chilling with ice. Mr. Young had overcome the inherent difficulties and had perfected a process which made possible the maintenance of an even temperature, either lower or higher than the surrounding temperature, in transport equipment.

Mr. Pritchard summarized Mr. Hart's paper on technological advances in fishing methods. The paper was merely a summary and described the evolution of methods of catching fish from the time of sail and oars to the appearance of the petrol engine and the diesel motor, and on to the use of the radio-telephone and echo sounding—

modern methods in general use on the Pacific coast of Canada.

Mr. Hart's paper also took into account the advantages to be derived from the use of aircraft in scouting for certain kinds of fish.

Mr. Bottemane commented on Mr. Takayama's paper on saury lift-net fishing with light. That paper went into great detail; it was most interesting. Mr. Bottemane pointed out, however, that the method of fishing by using light to attract the fish was not new. It had been employed in the Java seas and throughout the tropics.

The method described by Mr. Takayama was of particular advantage in dealing with small, dense shoals. It would be interesting to find out whether such a method could be more generally used. That question could be answered only after more exhaustive investigation.

Mr. Power summarized Mr. Anderson's paper on technological development in fisheries with special reference to the factory-ship in the United States.

The United States had considerable experience with factory-ships. The vessels processed their own catch or fish received from an accompanying fleet. The United States was carrying out a programme which would soon enable it to put new types of vessels into service.

A considerable fleet of factory-ships was operating on the western coast of the United States and off the coasts of Central America. The vessels were engaged in tuna fishing and were equipped to freeze, transport and deliver their catches to the canneries. Mr. Anderson's paper listed the different factory-ships which had been put into service in the last twenty-five years and described each vessel in detail; it included a large bibliography to which those who were interested could refer.

The factory-ships which had operated off California until 1937 had been obliged to abandon that region as Californian State fishing regulations made it impossible to operate at a profit. Vessels which had been fishing for shrimps for several years had attempted to freeze their catch at sea, but the most recent reports indicated that freezing at sea was not profitable, for the time being, at any rate.

That was not the case with vessels engaged in salmon fishing off Alaska. Those vessels were equipped with installations for freezing the salmon on board ship; they moved from one fishing area to another and transported their frozen cargo to the canneries. The results of those expeditions were often profitable. Freezing on board was particularly useful when the fishing season was a short one, as was the case with salmon fishing, for example.

The United States had recently become interested in putting into service trawlers for fishing and processing king crabs and bottom-fish off Alaska and in the Bering Sea. The principal difficulty lay in the cost of labour.

The most recent experience with large factory-ships in the United States had been with the *Pacific Explorer*, a steel vessel of 8,800 tons which had been put into service off the Pacific coast. Conversion of that vessel to a factory-ship had begun in 1945 as a means of producing additional food to meet war needs.

The vessel had been designed and built as a self-contained unit. Plans had called for filleting, freezing, canning, salting and by-products reduction operations. The *Pacific Explorer* had operated in the Bering Sea during the summer months for king crabs and bottom-fish, and in other waters during the rest of the year for freezing and transporting tuna. That experiment had enabled information to be obtained which would be very valuable in the study of problems connected with sea fishing.

Vessels equipped in that way and operating off Central and South America could deliver their catch to canneries in the nearest parts of the United States and even to factories on the east coast.

Freezing of whole fish at sea appeared to offer more than one advantage. It lessened the fisherman's labour at sea; it permitted the vessel to remain at sea until its holds were filled, and increased its fishing radius. Handling of the catch was simplified and could no doubt be mechanized to a considerable degree. It might therefore be possible to save trash-fish for sale to reduction plants on shore. That procedure would eliminate the leaching out of nutrient materials which now occurred in iced fish through a combination of melting ice and pressure in heavily loaded pens.

Mr. Walford summarized Mr. Pérard's paper on the French sea-fishing by-products industry. The author began by stating that the fishing by-products industry which had started in France about 1900 had made great strides since then, notably since the 1940 law on marine fishing.

Mr. Pérard then reviewed the various methods used for treating offal by which fertilizers and oil for medicinal purposes were obtained.

He pointed out, with particular reference to cod, that an increasing number of trawlers engaged in deep-sea fishing off Newfoundland were now equipped to treat the livers on board ship. The oil produced in that way was refined only on arrival at the port, by various processes.

Before the 1939 war, some trawlers, mostly from the port of Arcachon, had been equipped to treat the offal from fresh fish and from inedible fish on board ship. That equipment, which was very simple, had consisted of a cylindrical discontinuous double-lined steam dryer. The meal obtained by that process had later been treated in a factory set up in the port where it had been dried further as well as ground and sifted.

Mr. Pérard added in conclusion that all the commercial interests concerned with the treatment of fish by-products had formed a professional association under the name of *Syndicat général des industries de traitment des sous-produits de la pêche maritime* which already numbered several hundred members.

Mr. Jensen commented on the papers read by Mr. Notevarp and Mr. Bramsnaes on recent advances in the methods of handling, preserving, processing and distributing fish; developments in utilization, new products and by-products.

He pointed out that although their use might be much restricted or quite prohibited in other countries including the United States, chemical preservatives were used in Denmark to some extent and with good results.

Chemical preservatives were of great assistance to the Danish industry in retaining and preserving the original qualities of fish products. The use of chemical preservatives was strictly controlled by the Department of Public Health. The use of such preservatives, however, and in particular of certain acids, was extremely useful in specific cases.

The preparation of fresh cod fish fillet was one of the principal industries in Denmark. Cod rarely kept fresh for more than fifteen days—even if cooled down to about 0 degrees C (32 degrees F)—during which time the fish had to be treated, boxed and sent to the consumers. It was therefore obvious that the use of chemical preservatives which would enable that period, and in particular the transportation time, to be prolonged, would be of the greatest assistance to the Danish industry; it would thereby be able to find a considerable market overseas.

"Hot-smoked" herring retained its original qualities for between three and five days. It was consequently impossible for the Danish fishing industry to export hot-smoked herring, except to a certain extent to Sweden and Germany. The problem of using chemical preservatives could easily be a matter of life and death to the Danish export of this product.

With regard to the value of using sodium nitrate for fresh fish which had been demonstrated by Mr. Tarr in 1940-1941, as stated in Mr. Bramsnaes' paper, excellent results had been obtained in Denmark by using that method.

The Danish industry also used the better-known chemical preservatives such as salicylic, formic and benzoic acids. At the present time experiments were being carried out in Denmark on the use of various new preservatives such as vanillic acid and its derivatives, hydroxylamine, and bromine derivatives of fatty acids and their esters. By treating hot-smoked herring with hydroxylamine hydrochloride the time for which they kept fresh had been increased from five days to almost four weeks. Experiments were being continued.

With regard to the use of fish by-products in the feeding of pigs, it had been admitted that that feeding must be abandoned several months before the animals were slaughtered if the flesh were not to have a rancid taste. Mr. Jensen thought that more complete results should be awaited on some of the experiments on feeding of pigs mentioned by Mr. Bramsnaes. Mr. Jensen would be grateful if the Section could hear some explanations on the use of electronic sterilization in the United States and on the utilization of fish by-products in that country.

Mr. Hora emphasized the close connexion between the economic organization of marketing fish and the perfecting of fishing techniques. Those techniques could not fail to develop if large markets were found for the fish, while ensuring that it was sold at reasonable prices.

The principal object was to ensure man his daily food and to provide him with the proteins which he needed and, if that was to be achieved, the organization of fish marketing must be studied as thoroughly as possible. He had devoted many years to ichthyology and his long experience had led him to conclude that the development of fisheries depended to a very large extent on the development of markets for the fish.

The Section had drawn up a chart showing regions where fish were abundant but which were as yet unexplored. That chart would be of undoubted use to all Governments; he thought that a table of the priorities to be given to the various factors contributing to the development of fisheries and the fish industry should also be drawn up to guide Governments.

In his opinion one of those factors consisted in ensuring for fishermen fair prices in order to induce them to produce more. In certain under-developed countries fishermen were paid no more than a twentieth or even a fiftieth of the price asked from the consumer; in India the fisherman received approximately a tenth of the price paid by the consumer. Mr. Hora thought that something should be done to ensure that the fisherman could sell his fish at about a third of the price at which it would be sold to the public; that was the case in Australia and in the United States.

Other still more important factors were the proper organization of fish marketing, the elimination of the abuses to which fishermen were often subject when they tried to sell their catch to the wholesalers, improvements in refrigeration and transport to the markets and fair distribution to the retailers. Another factor which should not be forgotten was the advantage to be derived from giving maximum publicity to the new procedures which were always being perfected and to the by-products which were being extracted from fish in ever-growing numbers.

Since fish marketing was of such importance to the development of fisheries, it was essential to organize it as well as possible; in drawing up a table of the priorities to be granted to the various aspects of that organization, the Section would certainly do an extremely useful piece of work.

The Chairman called upon Mr. H. F. Taylor, Research Professor, Institute of Fisheries Research, Institute of North Carolina. *Mr. Taylor's remarks are reproduced in full, since at the request of the meeting a verbatim record was made of his statement and given general distribution at the Conference.*

Mr. Taylor: I have attended all of the meetings of this section and have observed the presentation of papers and discussion through the eyes and ears of one engaged in the practical business enterprise of exploitation of the resources of the ocean—the fish business. I do not know whether any of the others who are participating in this Conference have ever been charged with the responsibilities of actually conducting the exploitation of the fisheries in the business sense. I might add still further that this is also from the point of view of the conduct of private competitive business enterprise such as we know it in North America. In observing the over-all results of this Conference to date a very definite contradiction appears. I have observed it before and I suppose most of us have—the contradiction of the optimistic and pessimistic.

On the one hand we have the ocean which occupies 71 per cent of the surface of the earth, in which it has been estimated that biosynthesis or photosynthetic fixation of carbon is approximately twice or even more than that of the land, and giving effect to both the higher rate of photosynthetic manufacture of organic matter and of the larger area, it has been estimated that 90 per cent of the total food manufacture of the earth occurs at sea.

Stepping now to the business aspect of it all, there is no question that fish can be produced at far lower cost than protein food can be produced on land. For example, one man-year in the North Atlantic trawler fisheries produces 200,000 lb. of assorted bottom-fish, mostly cod and haddock. On the Pacific Coast in the pilchard fishery, before the recent decline set in, one man-year produced about 500,000 lb. of pilchard. In the whole United States the entire production average of the last three pre-war years sold for just under two-and-a-half cents per lb. to the fisherman. In those same three years the average price of meat products, namely, cattle, pigs, poultry and sheep, was of the order of seven-and-a-half to eight cents per lb., from sale by the farmer to the next distributor. Fish, therefore, actually is produced and sold at about one-third of the price of animal foods produced on land. Another comparison is that between the North Atlantic trawler and the Pacific Coast pilchard fisheries, on the one hand, and, on the other, that of the most efficient production of food in our most fertile agricultural area in raising corn or maize, and feeding it to pigs. In the state of Iowa, in the Middle West of this country, one man-year produces 50,000 lb. of pigs. Therefore, the even moderately-efficient North Atlantic trawlers produce four times as much food as the most efficient of our land animal production of meat-food.

In food value we do not have accurate data with which to make the comparison. I think it may be safely assumed that fish as a class contain all of the ten amino-acids which are now considered essential to human nutrition. They certainly contain a high percentage of the unsaturated fatty acids, the assortment of trace elements, whatever they may be, the calcium and the phosphorus, and certain of the vitamins, though of course, not all of them. So, measured by any standard of fundamental food values and economic costs at the source, the ocean can certainly surpass land or agricultural production of animal food by a wide margin. Evidence has been given here that the fisheries in some parts of the world have already reached the limit of their productivity and possibly have passed it. Such, for example, is the North Sea, our Great Lakes between the United States and Canada, and possibly the Japan Sea, although the evidence there is not very convincing. These are small, almost insignificantly small, areas as parts of the total. Certainly the North American continent does not even approach in intensity of fishing as a whole the North Sea or the Japan Sea. The North Sea, having about one-quarter of the area of our Gulf of Mexico, produces almost half as much—in fact 45 per cent as much, as the entire North American continent from the Panama Canal to the North Pole, both oceans, the Great Lakes, fresh and salt water, Mexico, United States, Canada, Newfoundland and Alaska. It certainly could hardly be considered, with that little body of water producing 45 per cent as much as the entire North American continent, that by any conceivable standard of measurement the North American Fisheries are over-fished or even approached in their potentialities.

Yet with this optimistic side, with this huge area, this immense photosynthetic activity, and low cost at the source, the fisheries produce less than 1 per cent by weight of the world's food supply. The fisheries of the world produce, when measured in dietary energy, 2,800 calories *per capita* of the world's population per year, or about one day's supply of energy. From the point of view of pounds weight, we find that, in the United States at least, the weight of food consumed is approximately constant at 1,520 lb. *per capita* per year, plus or minus three-and-a-half per cent, and it has not changed during the period for which we have any records, except that in the last few years it has shown a slight uptrend mainly because of increases of the watery constituents of food and a decrease in the more highly concentrated constituents, that is, increases in milk, citrus fruits and green vegetables, and a decline in cereals, potatoes and so forth. Aside from that, the food consumption *per capita* is constant in prosperity and depression. It makes very little difference. When you think of it from the point of view of energetics it is necessarily so because, in the course of five or ten years, e.g., even one or two or three per cent too much food would result in much overweight; similarly a small percentage deficiency in food requirements would result in inanition in a few years. So that by its very nature, having regard to the amount of physical work people do, food intake must be approximately constant everywhere. Fish, in this country, is approximately one per cent of the food intake per week. In the world it appears to be even slightly less than that, around three-quarters of one per cent of the physical weight of food. Measured from the point of view of protein requirements if we estimate 70 grammes of protein, minimum requirement, per day per person, the protein content of all the fish in the world would furnish about 6.7 days' requirement for the earth's population.

From the point of view of the outtake of the water, I might say without exaggerating too much, that we do not take anything of significance out of the water. The outtake from the water is utterly insignificant as from the point of view of the world food factory. If the entire production of fish of the United States of two-and-a-quarter million tons per year was subjected to a Kjaeldahl analysis we would find about 3 per cent nitrogen. If the 3 per cent nitrogen of the entire content of fish produced in the entire United States and Alaska each year is ground up *in toto* and added to the soil it would take thirteen years to put as much nitrogen in the soil as the farmers buy and put into the soil every year in this country. Similarly, it would take forty years at that same rate to apply as much phosphorus as the farmers buy and put into the soil as chemical fertilizer annually. In the United States, the waters of the continental shelf and those of the Great Lakes cover an area of about 550,000 square miles and are less than 100 fathoms deep. Over those square miles there is about 26,000 cub. miles of water. At a moderate, conservative estimate of the amount of phosphorus and nitrogen in that water, namely 80 milligrammes of nitrate, nitrogen and 20 milligrammes of P_2O_5 (phosphoric anhydride) per cub. metre, the entire content of nitrogen and phosphorus in the annual fish production of the United States would be contained in three-quarters of one per cent of that area and of phosphorus in about two-and-a-half per cent of that area. Or to dramatize it a little more, a body of water one-hundredth of a mile deep, (52.8 ft.) and 60 per cent as large as the area of Lake Michigan, just one of our Great Lakes, would contain all of the nitrogen that is in the entire outtake of the sea by the United States fisheries, and an area about 10 per cent larger than the area of Lake Superior would contain all of the phosphorous. So, on the one hand we have the immense productivity of the world and, on the other, we have a population of the world which is growing in size and pressing more and more upon our food supply. We may ask the question: what is the matter with the fisheries? Is this all the fisheries can do? I might say truthfully, and again with little exaggeration, that while we talk about the importance of controlling the halibut and regulating the fisheries of the North Atlantic Banks and in the Great Lakes, that if the halibut totally disappeared, it would make no difference whatever and would not produce even a slight deviation in the curve of the food supply in this country. The ups and downs, the fluctuations in the North Atlantic Fisheries make no difference whatever, that is, in total food supply. They are smaller than the error of measurement of what our food requirements are. I dare say we cannot tell within 1 per cent more or less what our food consumption really is and all the food fish production is not as large as the probable error of measurement of what our food consumption is; certainly the fluctuations in any one fishery are much less. You see then that on the one hand we have a huge potential, a seemingly huge chemical manufactury that should supply the world with large amounts of its food; and yet it does not.

I might add one more point here: from the point of view of other possibilities of production, we have heard of yeast and I dare say in some of the meetings of this conference yeast production has been considered. Also, there is the manufacture of sugars from wood pulp and similar products. None of those things approach fisheries in efficiency. It has been estimated, for example, that yeast without any profit or overhead cost (direct cost for raw materials and labour in production of protein from yeast) would cost about one-and-a-half cents (U.S. money) per lb., while the total production of pilchard in this country was one-third of that, or one-half cent per lb., and the menhaden one-third of a cent per lb. So that menhaden, which is by far superior to yeast in food quality and value, can be produced at one-fifth of the cost of yeast. Other fantastic methods of producing foods such as soilless culture in water solutiosn cannot be compared with the efficiency of fish production.

What then is wrong with the fish industry? Why cannot we manage somehow to extract from the ocean a really substantially important part of the world's food requirements? Here I sound a sour note, although I do not like to be the one to sound the sour note at the end of the meeting, to point out what I think is wrong with the fish industry and the fish industries of the world. I have had to deal with the problems and the headaches in a practical way for a number of years and I think I am familiar with some of them. This chart shows that, as Dr. Walford said the other day, 98 per cent of the fish of the world comes from the Northern Hemisphere. Glancing at the map — and I glanced at the globe this morning to check up on it — it looks as if the distribution of the fish in the world and the distribution of the human population in the world are not too different. The human population south of the equator is found only in Bolivia, Brazil, Paraguay, Peru, Chile and Argentina, the countries from Kenya down to the Cape in Africa, Indonesia, Australia, New Zealand and smaller Pacific Islands. I judge just from recollections of populations that that would be about 5 per cent of the world population in the Southern Hemisphere, and about 95 per cent in the Northern Hemisphere. We know that the fish in those places are shown on the map—I do not think it is any secret—I do not think the biologists have any information that the fish industry does not already have about that. The reason why those fisheries are not exploited is that it does not pay. It would cost you more to go to Bristol Bay, the Bering Sea, the Arctic Ocean and to Davis Straits, and to these far southern areas to catch the fish than you get for it. My own company in 1928 and 1929 engaged co-operatively with an English company and a Norwegian company in fitting out a vessel, the *Northland*, later called the *Thorland*. We, ourselves, put $150,000 in that vessel and the English and Norwegian friends also put in substantial amounts which I do not remember. She went to one of the largest and richest grounds in the world—the halibut grounds west of Greenland, in Davis Straits. A great many trawlers went along and we started the enterprise with great expectation of profit and success. The thing ended in dismal failure, and our company lost every cent of its $150,000 and we wrote it off and forgot it. The headaches, the personnel problems, the mechanical difficulties, the sickness, the need of doctors, the trawling problems and the running out of gear, and the endless mishaps that a group of theorizing people would never think of! When I read Mr. Anderson's description of the *Pacific Explorer* with 225 men aboard, I immediately thanked my lucky stars that I am not responsible for the headaches that would attend an expedition like that, for months away from the home port, trying to catch fish, manufacture and make a profit, and keep everybody happy.

I am taking more time, Mr. Chairman, than I think I ought to, but to finish the point, I wish to touch on the two methods which have been proposed. First there is the factory ship or expeditionary ship like the *Pacific Explorer* for tuna purposes, which performs the function of refrigerated transport for high priced products such as the tuna or salmon—fish which yield enough margin of gross profit to pay the expenses. It is therefore merely performing the function of transportation if the volume is large enough to fill the hold of the vessel with a high value cargo and transport it from where it is to where it is wanted, and if the industry based on it is sufficiently profitable to do it. I have no doubt that in a few cases that is possible, as in the case of the tuna, and possibly the salmon. I can't think of any others right at the moment where it could be done. Most of the other fish, all of the cod fish, for example, sell for less than half the price, in fact about a third of the price of tuna. You just could not afford to do it. You would never get your money out of it.

Another means has been proposed of fitting out trawlers to catch fish, fillet and freeze, and do other manufacturing operations aboard the trawler. About twenty-five years ago my company employed a firm of naval architects and engineers to investigate that very problem. They spent about two years on it, amassed an enormous amount of information, and reported unfavourably on the whole undertaking. You need here only one or two detailed reasons for it. If you give effect to the larger amount of power required to operate the freezing machinery, the room for the machinery itself, the additional fuel that has to be carried to operate both the propelling and the refrigeration machinery, the outfit that applies the refrigeration to the fish, the filleting room, and space tables and so on, packing equipment, the additional men that would have to be carried, the room required for those people to sleep, the food for them to eat and the room to prepare the food—all these things put together result in a very much larger operation and a larger ship with too little load—she would have too much freeboard and would not be manoeuvrable as a trawler. You can either make a manufacturing plant or you can have a trawler, but you can't have them both on the same vessel. It is just simply unthinkable. So that, briefly stated, it just can't be done so far as we know.

Simpler methods can be used such as chilling the fish aboard the ship. We found that the "life" of the fish could be approximately doubled aboard the trawler by merely washing the fish very carefully to remove all the blood. Blood decomposes at a much higher rate than the protein does and taints the flesh so that you think the fish is decomposed when only the blood is decomposed. The blood is all washed out with water that has never come in contact with any other fish; the fish are packed in shallow layers with little pressure and fine ice, and completely surrounded, so that they are not exposed to pressure. The "life" of those fish in edible condition is at least twice what it is in an ordinary steam trawler as now operated.

One problem in connexion with all these things always arises, namely, since the method of compensating labour in the fisheries is by means of a share in the catch and not by day wages, when there is a manufacturing operation involved you run immediately into the problem of how to compensate your labour. The labour is unionized and they will not tolerate this, that and the other, and no way has ever been found to solve even the simplest problem of better sanitation in our country without running afoul of difficulties with the labour.

I am sorry to have taken so much time, Mr. Chairman, but I hope I have contributed something of value.

Mr. Walford called attention to the fact that the chart in question contained two errors which should be corrected: there should be no reference either to the south-eastern region of Alaska as an unexplored region rich in herring, or to the western coast of India as an unexplored region rich in clupoids.

Mr. Bottemanne remarked that western chemists would be interested to hear more about the methods and chemical products used in tropical countries, especially for the preservation of salt fish.

Moreover, he called attention to the fact that modern methods of freezing and canning fish could be applied only insofar as definite markets were available. In some countries, the people could not pay the high prices demanded for canned fish.

Finally, Mr. Bottemanne pointed out that research had so far been carried out simultaneously on catching methods and the handling of fish, its processing and the chemical processes used for its preservation. In Mr. Bottemanne's opinion, catching methods should be studied separately, in close collaboration with the fishermen. He, personally, was convinced that it would be possible thus to double, in a few years, the catches of fish, even fish of the pelagic species.

A closed meeting was held at 2 p.m., which was attended by Messrs. James, Taylor, Bottemanne, Oppedal, Jensen, Seidenfaden, Walford, Power, Hora, Graham, Revelle and Ahmed.

After an exchange of views, the members present came to the conclusion that, in order to obtain a better yield and to develop the production of fish, it was necessary:

(a) *To find and make known the location of the resources, and to study the consumption, processing, distribution and marketing of fish;*

(b) *To study fishing methods, including the utilization of sonic and other procedures, and the improvement of fishing boats, equipment and gear;*

(c) *To perfect technical measures so as to increase the output of the fishing industry.*

Management and Cultivation of Fresh-Water Fish

24 August 1949

Chairman:

A. L. PRITCHARD, Director, Fish Culture Development, Department of Fisheries, Ottawa, Canada

Contributed Papers:

Pond Culture of Warm-Water Fishes
S. L. HORA, Director, Zoological Survey of India, Indian Museum, Calcutta, India

Rice-Paddy Carp Culture in Japan
Yoshio HIYAMA, Fisheries Institute, Faculty of Agriculture, Tokyo University, Japan

The Lake Fisheries of Egypt
Mohamed Kamel El. SABY, Controller of Fisheries Department, Ministry of Commerce and Industry, Cairo, Egypt

Pond Culture of Warm-Water Fishes
S. Y. LIN, Superintendent of Fisheries Research, Northcote Science Building, The University, Hong Kong

Pond Culture of Warm-Water Fishes in Indonesia
A. E. HOFSTEDE, Head of the Sub-section Inland Fisheries, Department of Agriculture and Fisheries, Batavia, Indonesia

Pond Culture of Warm-Water Fishes as Related to Soil Conservation
O. Lloyd MEEHEAN, Chief, Branch of Game Fish and Hatcheries, Fish and Wildlife Service, United States Department of the Interior, Washington, D.C., U.S.A.

Pond Culture of Warm-Water Fishes (With Special Reference to Bañgos or Milk Fish Cultivation Under Philippine Conditions)
Herminio R. RABANAL, Bureau of Fisheries, Department of Agriculture and Natural Resources, Manila, Philippines

Stocking and Rearing for River and Inland Fisheries
G. C. D. HOS, Acting Inspector of River and Inland Fisheries, Utrecht, The Netherlands

A Review of Fish-Farming in Israel
M. SHELUBSKY, Ministry of Agriculture, Department of Fisheries, Israel

Management and Cultivation of Fresh Water Fish—Principles and Practices with Special Reference to Conditions in New Zealand
A. E. HEFFORD, Formerly Chief Inspector of Fisheries and Director of Fishery Research to the Marine Department, St. Clair, Dunedin, New Zealand

The Management of Cold-Water Fish Resources in South Africa
D. HEY, Department of Inland Fisheries, Cape Provincial Administration, Stellenbosch, Union of South Africa

Fresh-Water Fishery—Artificial Insemination of Carps
Ivan JELACIN, University of Ljubljana, Ljubljana, Yugoslavia

Summary of Discussion:

Discussants:

Messrs. HORA, MEEHEAN, LEVY, M. GRAHAM, MONOD, CLARKE, KASK, BOTTEMANNE, N. AHMAD, SCHIMMEL

Programme Officer:

HERBERT SCHIMMEL

Pond Culture of Warm-Water Fishes

S. L. HORA

ABSTRACT

Attention is invited to pond-cultural practices of China, India and other Asian countries, and it is recommended that an analysis of these practices and their propagation in suitable areas should be undertaken in all warmer countries.

The role of various elements in pond-culture complex is discussed and it is indicated that all impounded waters could be profitably utilized in an over-all programme of food production. Taking fish as the basic factor in pond complex, the practices of selecting species, their stocking and cropping are discussed. It is pointed out that best results can be achieved if (i) species selected are tolerant of one another, (ii) they do not compete for food with one another and (iii), between themselves, they utilize all available food resources of the pond.

The role of organic and inorganic manures is discussed and evidence is adduced to show the superiority of organic fertilizers. The potentialities of using sewage for pond fertilization are indicated. The circumstances under which artificial feeding becomes necessary are given.

The value of fish-culture in paddy-fields and for the control of malaria is stressed. It is concluded that there is an absolute need for a new mental approach to the question of pond-culture in relation to its role as a potential food resource.

INTRODUCTION

Although effective pond-cultural practices have been in vogue in China, India and other Asian countries for many centuries, relatively very little notice has been taken of these and their exact significance is not yet fully understood. These practices have succeeded in producing high yields of valuable food per unit area (greater than can be effected by agricultural practices), and it is probable that further improvements could be effected. There are large areas in which the practices employed do not reach the higher levels of excellence observable in certain countries and in addition there are even larger areas in which practically no use is made of the available bodies of impounded water. The fullest possible development of these resources is desirable for the long-range programme of meeting world food-requirements and steps to this end are most urgently required in the present state of world food supplies. Apart from its role in food production, a programme for development of pond-culture is of deep significance in relation to peasant economy, its intimate physical relation to the structure of the village, the lower level of capitalization involved and its dependence upon the human element. A careful analysis of these practices and their propagation in suitable areas are, therefore, to be recommended to all thoughtful administrations.

ROLE OF POND CULTURE IN FOOD PRODUCTION AND ITS POTENTIALITIES

In any programme of food production, besides cereals, attention must also be paid to the production of protective foods, such as milk, eggs, meat and poultry, fish, vegetables and fruits. In thickly populated countries of south-east Asia, China and India, the *per capita* intake of meat and milk is small and fish has, therefore, special importance for their nutrition. Moreover, in the tropical and subtropical parts of the world, where the characteristic diet is rice, fish has a special role to play in balanced nutrition.

Following the example of Europe and the United States, more attention has hitherto been paid to the development of marine fisheries, and it has been generally overlooked that the inland fisheries resources of warmer countries are immense and that pond-culture, in particular, affords the best opportunities for a rapid increase in fish supplies for feeding the inland populations, specially in view of their general aversion to marine and processed fish. Small domestic ponds can play the same role as kitchen gardens. The important role that pond-culture plays in rural economy has been discussed elsewhere (*vide infra*, under "Pond Culture and Correlated Industries").

Under the term "pond", I have included small occasional ditches as well as impounded waters several hundred square miles in extent and several hundred feet deep. Small ditches can be used as nurseries while large reservoirs could serve as perennial sources of fish-supply. If run on a co-operative or collective basis, all the ponds in a village can be utilized as one productive unit. Besides the production of food, such collective fish-farms can utilize fish-wastes for the manufacture of oil from liver and entrails, glue from scales and fish-meal from bones, etc. Residual fish-wastes are good fertilizers for fruits, vegetables and crops. Bottom-silt, containing organic debris, which must be removed occassionally for the sanitation of ponds, is also a good manure.

Hickling (4)[1] gives the following data regarding fish-production in lb/acre/annum from ponds in warmer countries: South China, 4,000; Malaya, 3,500; Hong Kong, 2,000 to 4,000; Palestine, 1,200; and Philippines, 450 to 900.

In India, fertilized ponds yield 1,200 to 2,000 lb/acre/annum.

As compared with these figures, the annual production per acre of milk, eggs, poultry, meat, etc. would seem insignificant. Further, it must be remembered that ponds could be constructed in waste and marshy lands and the earth thus excavated could be used to reclaim lands for building or agricultural purposes. In the Philippines alone, it has been estimated that 500,000 hectares of low swamps and mud-flats, now lying waste, could be turned into productive fishponds. In fact, in every country there are similar extensive areas waiting utilization.

POND-CULTURE COMPLEX

In dealing with tropical and subtropical countries, it must be remembered that the standard of living of the people is low and that a great majority of them are illiterate. Further, traditions influence greatly their daily life. Thus the human element in the pond-culture complex is not

[1]Numbers in parentheses refer to items in the bibliography.

insignificant. It has been shown in another section how pond-culture can be correlated with other uses of water for raising the nutritional and economic standards of the people.

The other elements of pond-culture complex are fish, pond and farm-implements. As regards fish, a separate section is devoted to its role as the basic factor of pond-culture complex. Reference may, however, be made here to some traditional practices which experience has proved to be beneficial. For instance, baby-fish should never be planted into deeper ponds, but should be nursed in shallow, small ponds and then transplanted into deeper waters. Sometimes, two or three transplantations are necessary to improve the yield. Further, all organisms that compete with fish for food should be removed, otherwise the benefits of fertilizing the pond will be wasted. This is done by seining out periodically smaller species of fish and other fauna not directly or indirectly of any use to fish, and by uprooting vegetation and composting it on the bank for use as fertilizer. Occasional dragging of nets and raking the bottom are necessary for pond sanitation, controlling excess vegetation, giving exercise to fish, checking growth-rate and density of population, eradicating predatory fishes and for disturbing accumulations of injurious gases at the bottom.

The existing ponds are of all shapes and sizes, but with a little thought and care they can be improved for fish-culture. If, however, a new pond has to be constructed, attention should be paid to site, nature of soil and water and irrigation and drainage facilities. It is not possible to go into the details of pond-construction in this paper, but the following experiences may be of some value.

Newly excavated or desilted ponds, unless suitably manured, remain unproductive for two to three years. With the use of organic manures, colloidal mud settles down and, within a fortnight or so, the water becomes greenish in colour and suitable for fish-culture.

Excess growth of vegetation, particularly of the floating type, inhibits fish-culture. It has been estimated that Bengal loses annually 100 million lb. in fish-production, estimated at a low-rate of 280 lb/acre/annum, due to the growth of water-hyacinth. Any effective measure to eradicate this pest will lead to a great development of pond-culture industry in warmer countries. Though removal of water-hyacinth through manual labour is costly, the increased fish-production resulting therefrom has proved economical in a number of fisheries near Calcutta.

The bottom of perennial ponds becomes sickly and gradually the production falls off. For this reason, ponds that dry up occasionally or annually or can be drained are more productive. Perennial ponds can also be toned up by dewatering them, ploughing their bottom and drying them up completely. For the same reason, ponds with sloping or shelving banks are more productive, for at least a part of the bottom dries up every year.

General principles and practices of pond fertilization are discussed in another section.

As regards size, smaller ponds from one-third to three acres in extent are easy to manage. Larger ponds should be divided by raising embankments, provided the proposition is economically sound. In contiguous ponds, water and fish can be run from one to the other. In the culture of Indian carps, the areas occupied by nurseries, rearing and stocking ponds should be in the proportion 1 : 4 : 8. Distributions of farm-area into hatcheries, nurseries and rearing or stocking ponds will depend on the topography of the farm-site, the geography of the country and the kinds of fish selected for culture.

In the case of commercial undertakings, farm-implements, comprising nets, appliances for making and mending nets, baskets, floats, sinkers, rakers, scales, weights, boats, etc., are not very costly, being only about 15 to 20 per cent of total expenditure, but are necessary for emergency and daily operations. Most of them are readily available, though at present there is some difficulty in obtaining yarn.

In the case of smaller units, operated individually, fish-cultural practices become relatively expensive, but if undertaken in a village on a collective basis, the cost is considerably reduced. The use of rod and line is one way of getting one or two fish daily for domestic use but in warmer countries this pastime is not much in vogue. Without much effort a few fish can be taken with a cobweb-type of net from a pond each day single-handed. Improvements in such devices and making the working of domestic ponds comparable to kitchen-gardening would stimulate interest in the development of pond-culture.

FISH AS BASIC FACTOR IN POND COMPLEX

In pond-culture, the production of fish is the main objective and the selection of species will depend on the conditions under which the fish will have to live and thrive. For instance, the type of food available in the pond and its general biota would determine the association of fish to be introduced into it. For practical purposes, a pond can be divided into surface, midwater and bottom zones. The surface feeding species can be plankton-feeders or they can take floating vegetation. Similarly, a bottom-feeder may live on snails, worms and insects or organic debris. In selecting species, one must bear in mind the following points:

(i) The species should be tolerant of one another.

(ii) They should not compete for food with one another.

(iii) Between themselves, they should use up all kinds of available food materials in the pond and thereby contribute to the general sanitation of their environment.

It will thus be seen that proper stocking not only means selection of species but also the number of each kind depending upon the extent and nature of fodder resources of the pond. Through age-long experience, both India and China have solved many problems of fish associations. For instance, an intelligent fish-farmer in Bengal will stock his average pond with 50 to 60 per cent Catla (surface-feeder), 30 to 40 per cent Rohi (column-feeder) and 10 to 20 per cent Mrigal (debris-feeder), Kalbaus (molluscan-feeder) and Bata (omnivorous). As the means of sorting out very young fry on a commercial scale are not yet known for Indian species and there are no standards to judge the relative quality of each pond, it is usually difficult to ensure balanced stocking and for this reason the production in India is not very high. China is, however, more advanced in these respects. By applying the principle of varying O_2 requirements of different species, the Chinese fish-farmer sorts out the young into different varieties. Before stocking, he calculates the number of individuals of each species necessary to stock any particular pond.

The following table prepared by Lin (9) shows different systems of stocking ponds in China (capacity one-fifth acre):

Species	*Standard Pond*	*Pond A*	*Pond B*	*Pond C*	*Pond D*
Grass-carp (mostly herbivorous)	100	100	100	50	40
Silver-carp (plankton, all sizes)	25	20	150	50	100
Big-head (plankton, large size)	25	20	150	100	35
Mud-carp (worm-feeder)	150	400	300	0	200
Common-carp (omnivorous)	100	30	100	300	0
Black-carp (snail-feeder)	8	2	0	10	5
Bream	0	0	0	0	50

Catla in India and Grass-carp in China are the fastest growing species, whereas the bottom-feeders are useful as scavengers but not so much for food-production.

In Indonesia, varieties of carps, gouramis and perches are cultured either separately or in associations. The common-carp is the favourite fish for culture, both in ponds and rice-fields. The others are either suitable for lakes and marshes or for restricted local ponds. Tilapia is becoming a favourite fish for pond-culture owing to its adaptability to all varieties of conditions.

In Siam, common carp and Siamese gourami are used in pond-culture, whereas in Malaya fry are imported from China for cultural purposes.

Of all the species enumerated above, common-carp, which breeds in ponds, is perhaps the easiest to manage, and for this reason it has been introduced into countries all over the world where it continues to propagate and thrive. In warmer waters its growth is fairly rapid and separately cultured may yield 1200 lb. per acre per annum (1). Experiences in Southeast Asia and India have shown that the Chinese and Indian carps (river-breeders) can be readily acclimatized in other suitable warmer waters and, in spite of transporting their seed from distant places, yield very profitable fisheries.

Depending upon the varieties of fish to be used for cultural operations and the physico-chemical and biological conditions of the ponds, all types of impounded waters, however small and short-seasonal, can be used for fish-culture. While stocking, it must be remembered that each pond has its individuality and that its capacity can be altered through fertilization. Both over-stocking and under-stocking will yield low production. Exercise-netting every fortnight or so will indicate whether the stock of any particular species should be thinned or augmented. As a general rule, the following considerations should govern stocking.

(i) Nature, extent and depth of a pond.
(ii) Fertility: natural and artificial food resources.
(iii) Availability and quality, both as regards size and variety, of the fish-seed supply.

So long as food above the maintenance requirement of a fish is available, it will continue to grow. For this reason, the total production from an area of water can be increased through judicious cropping. In China, after being reared for three or four months, fishes are caught nearly every day from the larger ponds. Carp ponds are harvested twice in a year, both in China (July and December) and India (October-November and April-May). It has been suggested that the pond should be harvested occasionally in such a way that the fish production is maintained at about 70 per cent of the maximum fodder capacity of the pond.

POND FERTILIZATION AND ARTIFICIAL FEEDING

In south-east Asia and China organic manures have been used for centuries for pond fertilization with considerable success. In recent years, however, inorganic fertilizers have received great attention in the United States of America and the United Kingdom. Swingle (10) has experimentally shown that absence of CO_2 is a limiting factor in fish production, and that a combination of organic and inorganic fertilizers yields the best results. In Southeast Asia and China, organic materials are not used separately but in combinations, such as cow-dung, stable-refuse, poultry-manure, oil-cake, green grass, dry leaves, etc. (Bengal practice: Hora (7)) or cow-dung, pig-faeces, poultry-wastes, night-soil, silkworm pupae and grasses (Chinese practice: Lin (9)). Such combinations of different materials of animal and plant origin, through putrefaction, ensure CNPK balance in pond fertilization, whereas inorganic fertilizers do not provide carbon but only NPK.

As excess of free CO_2 is injurious to fishlife, the best plan is to have in the pond a reserve of readily available bicarbonate alkali so that it can give CO_2 as and when required for the growth of the plankton and for the pH balance. The traditional Bengal practices of using banana-stem juice and soap-waste are helpful in this respect. Recent analysis of banana-stem juice has shown that it contains a large amount of bicarbonate Ion.

As the organic manures use up considerable quantities of dissolved O_2 in decomposing, it may be noted that the O_2 requirements of Indian carps (Basu's private communication) show that all the principal species could live for 24 hours in waters devoid of CO_2 and containing only one mg. per litre of O_2.

Another beneficial effect of using organic manures is that organic carbon retains nitrogen in the medium for a longer period. The chemistry of this process is, however, not yet fully understood. Decrease in organic carbon will, therefore, allow nitrogen to escape in nature more freely. Thus the organic manures not only ensure sufficiency of CO_2 from the organic C but also that of N and of other elements essential for a balanced fertilization of the pond. Green grass, dry leaves and paddy straw are helpful in supplying silica and iron for the production of diatoms and other algae which form the basis of the food-chain of fishes.

The disadvantages of using organic manures are two: first, it stimulates heavy growth of aquatic vegetation which may inhibit fishing and, second, during a hot spell the rate of putrefaction may be so heavy as to deplete the entire stock of O_2 and saturate the water with free CO_2 leading to the asphyxiation of fishes. Such eventualities are, however, guarded against through pond management practices.

The use of inorganic manures on the other hand has the advantage of inducing quick growth of phytoplankton but their nutritive value is soon dissipated and the treatment has to be repeated more often. Moreover, they do not induce heavy undergrowth of vegetation.

From the point of view of costs and benefits, it may be noted that in warmer countries, inorganic fertilizers are not yet manufactured and are, therefore, comparatively very costly for any large scale fertilization of ponds, whereas organic manures can be had practically for the labour of collecting and carting them. As practised in certain agricultural farms in India, small quantities of inorganic manures mixed with bulks of organic materials may be more economical for pond fertilization.

The high production figures of 2,000 to 4,000 lb. per acre per annum in China and Malaya over the production of 700 to 2,000 lb. per acre per annum in Bengal are to some extent due to the use of night-soil in the former case. The valuable sewage-irrigated fisheries near Calcutta (2, 3) and in the East Indies (11) clearly demonstrate the great fertilizing value of human excreta. Proper utilization of sewage of large towns, particularly for fish culture, can be a very great asset in increasing the production of food.

It is sometimes necessary to stock a pond with a large number of fish or to keep them alive in small enclosures for sale. In such circumstances, they must be fed artificially so that they do not fall off in weight. Ordinarily, supplementary feeding of the fish is a question of relative cost of the materials and value of increase in fish-flesh.

POND-CULTURE AND CORRELATED INDUSTRIES

I have stressed elsewhere (8) that a village pond in a tropical country can play a great part in rural economy. Besides fish-culture, its water can be used for irrigating winter crops, watering of animals, against fire hazards, for duck rearing, sport, drainage for cattle-shed, poultry, piggery, etc., and its embankments for growing vegetables and fruits. There is, in fact, a great need to stress the possibilities of an advance in pond-use in an integrated plan for the development of a set of related enterprises. Some of these are considered below.

Paddy-cum-fish culture

In most of the countries of Southeast Asia, in suitable localities, simultaneously with paddy-crop, a fish-crop is harvested. In a majority of cases, a crop of 100 to 300 lb. per acre of natural fish is raised, but at some places fish-seed of desirable species are introduced (6) and thereby the production is augmented several-fold. Too much stress cannot be laid on the great possibilities of extending this resource.

In China, fish-breeding in paddy-fields is used for effectively controlling the most serious insect-pest, the Stem-Borer. The yields have thus been noticed to have increased by about 10 to 15 per cent. Furthermore, there are clear indications of fish eating mosquito larvae and thereby preventing the spread of malaria.

Hofstede (5) has characterized fish-culture in paddy-fields "as the highest form of pisciculture" and has reported a higher rice yield to the extent of 5 to 15 per cent. Small-scale experiments conducted by the Directorate of Fisheries, Bengal, during 1945-1946 showed an increased yield of paddy by 150 lb. per acre. The FAO Rice Conference at Baguio in March 1948 recommended the adoption of this practice in all suitable areas and the writer feels convinced that this resource is capable of great expansion for increased cereal and fish-production.

Engineering works and fish-culture

The construction of dams for multiple uses, whereby large volumes of water are impounded, provides a fruitful source for increasing fish supply through cultural operations. In TVA reservoirs, for instance, production has gone up by several hundred per cent over the original production of the Tennessee River.

Rail and road engineers in laying down their tracks make most unsightly borrow-pits which become a menace to public health as breeding grounds of mosquitoes. If these excavations could be correlated with the requirements of fish-culture, valuable areas for establishing fish nurseries and even stocking ponds could become available. The same could be said with regard to brick-fields or excavations made for building purposes or reclaiming low lands.

POND-CULTURE AND MOSQUITO-CONTROL

It is generally felt and strongly believed by some public health authorities that extension of pond-culture may lead to an increase in the incidence of malaria, a deadly disease of the tropics. This subject was discussed at the Royal Society Empire Scientific Conference and the following resolution was passed:

"In view of the great possibilities of utilizing ponds for fish-culture in various countries of the Commonwealth where malaria is prevalent, the Conference proposes that the attention of Governments of countries so situated should be drawn to the urgent need of integrating fish-culture practice with measures for malaria control."

The public-health authorities enjoin on fish-farmers in the United States to introduce certain numbers of larvicidal fish in their ponds. As organic fertilizers tend to cause the growth of filamentous algae and thereby encourage mosquito breeding, Swingle (10) has cautioned against the use of organic materials, though they help to increase the production of fish materially. Hofstede (5) has announced that *Tilapia mossambica*, a useful species for pond-culture, provides a solution for clearing long algae *en masse* from fishery ponds. His final results will be watched with interest in all tropical countries.

Though a number of efforts have been made in the countries of Southeast Asia to integrate culture of fish with the control of mosquito-breeding in the ponds, it seems to the writer an urgent necessity that a well-concerted effort should be made to solve this problem on a co-ordinated basis.

CONCLUSION

In conclusion, I wish to impress on all administrators and research workers the absolute need for a new mental approach to the question of pond-culture in relation to its role as a potential food resource. Working in tropical countries, one is constantly and painfully made aware of the prejudices and conservatism among farmers and fishermen. Against this background, evolutionary methods of improvement and development should be followed, for I am convinced that passive-infiltration methods will achieve far more lasting effects than spectacular revolutions. Western techniques may serve as a useful sourcebook for detailed research, but it is probable that the application of principles presently utilized in Europe and the United States will have little immediate use in tropical countries.

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SCIENTIFIC NAMES OF FISHES

Bata (India), *Labeo bata* (Hamilton).
Big-head (China), *Aristichthys nobilis* (Richardson).
Black Carp (China), *Mylopharyngodon aethiops* (Basilewsky).
Bream (China), *Parabramis pekinensis* (Basilewsky).
Catla (India), *Catla catla* (Hamilton).
Common Carp (China and other countries), *Cyprinus carpio* Linnaeus.
Grass Carp (China), *Ctenopharyngodon idellus* (C.V.).
Gourami (Indonesia), *Osphronemus goramy* Lac.
Kalbaus (India), *Labeo calbasu* (Hamilton).
Mrigal (India), *Cirrhina mrigala* (Hamilton).
Mud Carp (China), *Cirrhina molitorella* (C.V.).
Rohi (India), *Labeo rohita* (Hamilton).
Siamese Gourrami (Indonesia and Siam) *Trichogaster pectoralis* (Regan).
Silver Carp (China), *Hypophthalmichthys molitrix* (C.V.).
Tilapia (Indonesia), *Tilapia mossambica* (Peters).

Rice-Paddy Carp Culture in Japan

YOSHIO HIYAMA

ABSTRACT

Because Japan has only a small fresh-water area and also has an extreme food shortage, rice-paddy carp-culture has been encouraged in recent years.

This is one of the best methods of utilizing the natural fish productivity of well fertilized, warm fresh-water areas with abundant natural food. It is also a way of supplying animal protein for farmers.

By use of natural food alone, an average carp crop of 130 lb. per acre can be produced in four or five months of summer, though it will increase nearly ten times if extra food is added.

Rice-paddy carp-culture is mutually beneficial to both products but many technical difficulties await solution by scientific investigation.

Japanese scientists have made studies on the following lines:

(a) **Plankton survey and nitrogen measurement of both water and mud, and mutual effects of rice and carp;**

(b) **Construction and depth of paddy, selection of rice-strain, and proper density of carp (about 1,400 yearlings per acre without added food);**

(c) **Attempts to increase natural food supply for carp in paddy, and for the culture of other fish.**

INTRODUCTION

Japan has only a small fresh-water area available for fish-culture and the amount of fresh-water products is small compared to her large marine production. Rice-paddy carp-culture is, however, highly developed and has been improved in recent years. Though the culture has been followed in various forms for a hundred years, it presents further interesting possibilities for development.

In addition to the restricted fresh-water area in Japan, there are many rice-paddies containing water totalling about 1 million acres. When the paddies are deep and contain sufficient water, they provide excellent media for the raising of warm-water fish, usually carp.

Rice-paddy carp-culture has developed greatly in recent years for two main reasons. One is that the method utilizes the natural food growing in the well fertilized water-filled paddy. The yield of this natural food—small crustacea, molluscans, insects, worms and other forms—is more abundant in the presence of fertilizer, provided for the rice, than in unfertilized water areas. Provided the proper population density and suitable water conditions are maintained, carp can therefore be raised in paddies without additional food. This fact is of special importance at present because silk-worm cocoons, which are mainly used to feed carp, were scarce in war-time.

The other reason is that by means of rice-paddy carp-culture farmers can raise their own supply of animal protein of which there has been a shortage during recent years since the marine fishes, the usual principal source, have been difficult to obtain. Selling the excess fish produced also adds to the farmer's income.

The Japanese Government has considered the culture to be a good way of promoting production in non-utilized land-waters and many farmers have adopted it, consequently the area of carp-rearing rice-paddies was increased to 7,400 acres in 1946. Though this represents only about one-half of 1 per cent of the total area of rice-paddies in Japan, it produced 3,894,000 lb. of carp in 1946, nearly one-half of the total carp production of Japan (7,427,000 lb. according to government statistics).

METHOD OF CULTURE

Several methods are used in rice-paddy carp-culture. The first is to raise the fry from eggs in the rice-paddies, and obtain "seed carp" of 2 or 3 in. in the spring season, just after the paddies are newly filled with water.

The second is to obtain a supply of "seed carp" from a hatchery, raise them up to 6 or 7 in. in length, and harvest them in the fall when the paddy is dried up before the rice is harvested.

The third is to rear second-year carp, by the same method mentioned above, until they reach the common market size of nearly 1 lb. At times, both first-year and second-year carp of slow-growing stock are reared in mixed groups.

The type of culture differs also according to whether or not food is supplied.

Among these types of culture methods, the Government and farmers have concluded that the most efficient and adequate, in these times of food shortage both for human beings and carp, is the rearing of yearlings without added food supply.

Though the farmers can raise "seed carp" by themselves in rice-paddies, they can also get them from the hatcheries of prefectural governments or private establishments at a cost of 40 sen to 1 yen each, according to size (1948 price).

A rice-paddy which has been dried up in winter is fertilized for fish production with night soil, compost, stable manure, or chemical fertilizer, scattered and dug fully during the spring. After the paddy is well fertilized, it is filled with water. In May or June (the date is determined by the climate of the district) the young rice-plants, which have been raised in nurseries, are transplanted to the flooded paddies.

Immediately after the rice planting, "seed carp" are liberated, the number being regulated by the condition of the paddies and type of rearing. For first-year carp 800 to 2,500 individuals per acre is common in the case of no added food supply, and 3,000 to 5,000 is usual in the case of added food supply.

At this time the water of the paddy should be full of plankton, generated by the long days and warm spring weather. The young carp feed there until fall, when the paddies are dried up before the rice harvest. The period of carp-rearing in rice-paddies is therefore limited to four or five months, but these are the peak months of the growing season of carp, which can take most of their food for a year in this season of warm temperature (20 to 30 degrees C). At harvest time, the carp average up to 6 or 7 in. in total length, or 3 or 4 ozs. in weight.

While the yearlings are good for the table, most people and the markets prefer two-year-old large-sized carp, about 1 ft. long and 1 lb. in weight. Consequently some of the carp are kept alive in deeper ponds during the winter without adding any special food, as their food requirements decrease in the icy cold waters. The following year the two-year-old carp are raised to market size, by the previously described method in the water of the rice-paddies. These are sold alive to the market at a price of about 200 yen per lb. in 1948, nearly the same as that of beef of inferior quality.

The average crop of one-year-old carp when no extra food is supplied is about 130 lb. per acre. The amount of carp produced can be increased up to 2,000 lb. or more, when food is added, but the cost of food for carp is so high in Japan that feeding hardly pays in some cases.

The culture is said to be mutually beneficial to both rice and carp, since the carp eat weeds and insects which would damage the rice-plants, and the remaining food and excretion of the carp have a fertilizing effect on the rice-plants.

However, there are some conflicts between rice and carp which await solution. Rice-paddy carp-culture is successful only when both rice and carp are produced. It is necessary to control the construction or the depth of the paddies and carp density, to select the proper strain of rice and the correct fertilizer, and to prevent damage to the fish from chemicals used in insect extermination, and so on. Though this technique has long been in the hands of farmers, and carried on by traditional experience in certain localities of Japan, many minor problems remain to be solved or improved by science.

RECENT RESEARCHES

As rice-paddy carp-culture has been recommended and promoted in recent years in Japan, many researches have been undertaken to improve the method and to analyse the factors controlling success. These investigations have had inferior or incomplete results due to war-time and post-war conditions which have obstructed the work of scientists. Some of the results are as follows:

(*a*) *The relation between the yield of carp and that of rice*

No statistical survey of this problem has been undertaken on an actual farm, but comparisons of cultivation experiments indicate that the production of both rice and carp have a positive correlation, i.e., the better rice-producing paddy yields more carp, and the carp-rearing paddy yields more rice than the usual paddy (1)[1].

(*b*) *Nitrogen content in soil and water*

The nitrogen content (measured in the form of ammonia) of the mud in carp-rearing rice-paddy, fertilized in the usual way, is less at the beginning of carp-rearing, and higher at the end of the period than in the usual rice-paddy. It is thought that at the beginning of the period nitrogen is more rapidly consumed by phytoplanktons, as it is dissolved in the water of the paddy by being stirred up continuously by the fish swimming. Later the excretion of the fish increases the nitrogen originally in the mud itself, and the nitrogen next passes through the form of plankton and is finally eaten by the carp. This increase is more evident when food is supplied for the carp.

This tendency of the nitrogen cycle has no deleterious effect on the rice plants (1).

[1]Numbers within parentheses refer to items in the bibliography.

(c) Plankton reactions

The presence of carp in paddy promotes the better generation of plankton, provided that the paddy has been sufficiently fertilized. The ratio of zooplankton to phytoplankton is less in the middle and later period of carp-rearing than in the usual paddy, according to quantitative plankton measurements. This effect is also considered to be due to the stirring of the water by the carp and the feeding of the carp (1).

(d) Construction of rice paddy

The common Japanese rice-paddy has water about 2 or 3 in. deep, but to rear first-year carp the depth must be 4 or 5 in. at least, and for second-year carp about 2 in. deeper. Consequently the ridges of the paddies should be higher and must be firmly constructed. Paddies which cannot be so deep, should have a much deeper part for the carp. This is common practice now, established by previous experiments.

(e) Rice strains

Favourable water-temperature for common rice-plants is about 30 degrees C. But as the temperature is lower in deeper water and greater supply a strain of rice accustomed to cold water should be selected. In addition a strain with strong roots should be used, because carp will dig the roots out. This has been established by previous experiments.

(f) The proper density of fish

For yearling-carp cultivation without food supply, the experiments indicate 1,200 to 1,600 young fish per acre (1). If they are fed, 4,000 yearlings can be raised, and 2,000 second-year carp can be placed in the same area. This has been established by the Nagano Prefecture Fisheries Station and the experience of growers.

(g) Methods of increasing the natural diet

The natural diet for young carp in the paddies is mainly phillopoda, such as Daphnia or Moina, which are not introduced. As their amount greatly affects the production of carp, many attempts have been made to promote their generation and increase. One method is selection of fertilizer, night soil, stable manure, and other organic manures being better than inorganic or chemical fertilizer. Experiments have shown that the addition of green grass to manure has a remarkably good effect (2, 3).

(h) Natural food supply

Production of phillopodes for carp food in small ponds specially prepared for their propagation is carried on in some places. Special devices to promote their generation, such as the addition of clover-extract or other green grass extract in the water (2, 3), and heating the water by electricity or in glass-houses, have been tried in recent years. In addition, the production of earth worms in rotted forest leaves has been considered as a means of feeding carp.

(i) Utilization of rice-paddies by fish other than carp

In some districts, Japanese Crucian carp, *Carassuis auratus*, and also common loach, *Misgurnus anguillicaudatus*, are reared in rice-paddies, either alone or mixed with carp, and good results have been obtained.

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The Lakes Fisheries of Egypt

MOHAMED KAMEL EL SABY

ABSTRACT

The importance of the lakes fisheries of Egypt is shown by the fact that the total product of Egyptian fisheries is derived as follows: 60 per cent from lakes; 30 per cent from sea fisheries; and 10 per cent from inland fisheries.

Thirty thousand men and boys are habitually engaged in the lakes fisheries which annually produce 30,000 metric tons, valued at £E2 million .The four Delta lakes, which cover 550,000 acres, yield 26,000 tons. Karoun (over 50,000 acres) produces 3,000 tons. The two depressions of Port Fouad and Bardawil (200,000 acres) yield about 1,000 tons.

The Delta lakes are nearly similar in their geographical characteristics, consequently their flora, fish population and methods of capture are also similar.

The depth of the four lakes is usually less than 1 metre though the depth of Karoun reaches 9 metres in some places. Salinity and temperature vary greatly according to season.

Owing to the fertility of these lakes, they may be considered among the most valuable fisheries on record.

As a measure of protection fishing is prohibited in and around the lake-sea connexions, and also during the active period of spawning of the stationary fish, especially with regard to the Tilapia species. Also meshes are limited by law in order to protect the under-developed fish, and harmful methods of capture are prohibited.

As regards stocking, the Fisheries Service annually collects more than 20 million fry of grey mullets and eels in front of the pumps at Mex for stocking lakes Mariout, Edkou, and Karoun. *Solea vulgaris* was transferred in 1934-1935 to Karoun where the species was acclimatized; it propagated freely and grew normally.

The Fisheries Service controls three fish farms for hatching and breeding, one at Mex for marine fish, the second at Barrage for fresh-water fish and the third at Menzaleh. Experiments on methods of feeding and rate of growth are carried on in these three farms.

THE IMPORTANCE OF THE LAKES FISHERIES

To assess the importance of the lakes fisheries of Egypt, it is appropriate to set forth the following facts.

1. Although the coastal line of Egypt extends more than a thousand miles on both the Mediterranean and the Red Sea, the estimates of the annual catches of the sea-fisheries do not exceed 15,000 metric tons of fish, representing about 30 per cent of the total annual production of Egypt. This comparatively poor yield is attributed to the following reasons:

(*a*) Both the eastern Mediterranean region and the Red Sea are considered naturally poor in fish production. Moreover, the known suitable trawling grounds along the Egyptian coasts are also limited; these grounds extend about 200 miles eastward from Alexandria on the northern coast along the Mediterranean, and a little over a hundred miles from Suez southwards along the Gulf of Suez and the Red Sea coast. The comparative fertility of the northern grounds is mainly attributed to the effects of the rich annual supply of nutrient salts, contained in the Nile water during the flood season, and the formation of shallower beds confronting the Delta by the precipitation of the colloidal substances of the flood waters.

(*b*) The introduction in the Egyptian sea-fisheries of motor-propelled vessels, especially for trawling, was a very welcome development. But the personnel of this fishing fleet have not yet acquired the necessary skill, or love of adventure, to find means for increasing marine catches.

2. During the last fifty years a general policy has been carried out with a view to controlling the Nile waters in order to increase the area of land under cultivation. Consequently dams and barrages have been erected. Vast areas of agricultural lands of Upper Egypt which yearly used to be inundated for some weeks during the Nile flood, and which were considered among the best natural breeding and nursery grounds in the world for fresh-water fish, were thus irrigated by a system known as "Basin Irrigation". It has been mostly replaced by permanent irrigation, and the drainage system, moreover, has necessitated the lowering of the water-level throughout the country. These factors combined to decrease substantially the yield of the inland-fisheries. Although these fisheries comprise the Nile, its tributaries, all the canals of the irrigation and the drainage system which spreads all over the country, they do not yield more than 10 per cent of the total production of the Egyptian fisheries.

The facts mentioned above show clearly the importance of the lakes fisheries which are responsible for not less than 60 per cent of the total product of the Egyptian fisheries.

There are about 30,000 men and boys habitually engaged in the lake fisheries. The total yield of these lakes is believed to average about 30,000 metric tons, with a value of more than £E 1 million to the fishermen and something like 2 millions to the consumer. Of this total about 26,000 tons are derived from the four Delta lakes—Menzaleh, Brullos, Edkou and Mariout—which have a combined area of about 550,000 acres. The inland Karoun Lake situated in the northern part of the Fayoum depression with an area of about 50,000 acres, produces about 3,000 tons annually. The two depressions of Port Fouad and Bardawai, situated on the eastern side of the Suez Canal at the northern part of Sinai peninsula, and covering nearly 200,000 acres, produce about 1,000 metric tons of fish annually.

THE DELTA LAKES

The three Delta lakes of Menzaleh, Brullos and Edkou are alike in so far as they are either permanently (Menzaleh and Edkou) or for a number of months in the year (Brullos) connected with the open sea by a narrow strait.

Lake Mariout differs in this respect: it is permanently cut off from the sea by the Mex pumping station, which keeps the lake level at about 10 ft. below the sea-level throughout the year.

Because of their shallowness the Delta lakes can be fished easily and thoroughly. In addition the fish they contain have a rapid rate of growth. Hence the Delta lakes are for their area among the most valuable fisheries of which records are available.

The geographical characteristics of the lakes

The geographical characteristics of the Delta lakes are very similar. Except for the single narrow connexions mentioned above, they are separated from the sea by sand-bars and dunes of varying width and height; along their southern shores are somewhat marshy and bare waste-lands, through which flow the great drains. In the days before the introduction of perennial irrigation, the quantity of water discharged into the lakes must have been tens of times greater than is now released. Their annual yield of fish is still subject to very great fluctuations, determined by the amount of the flood-waters discharged into these lakes.

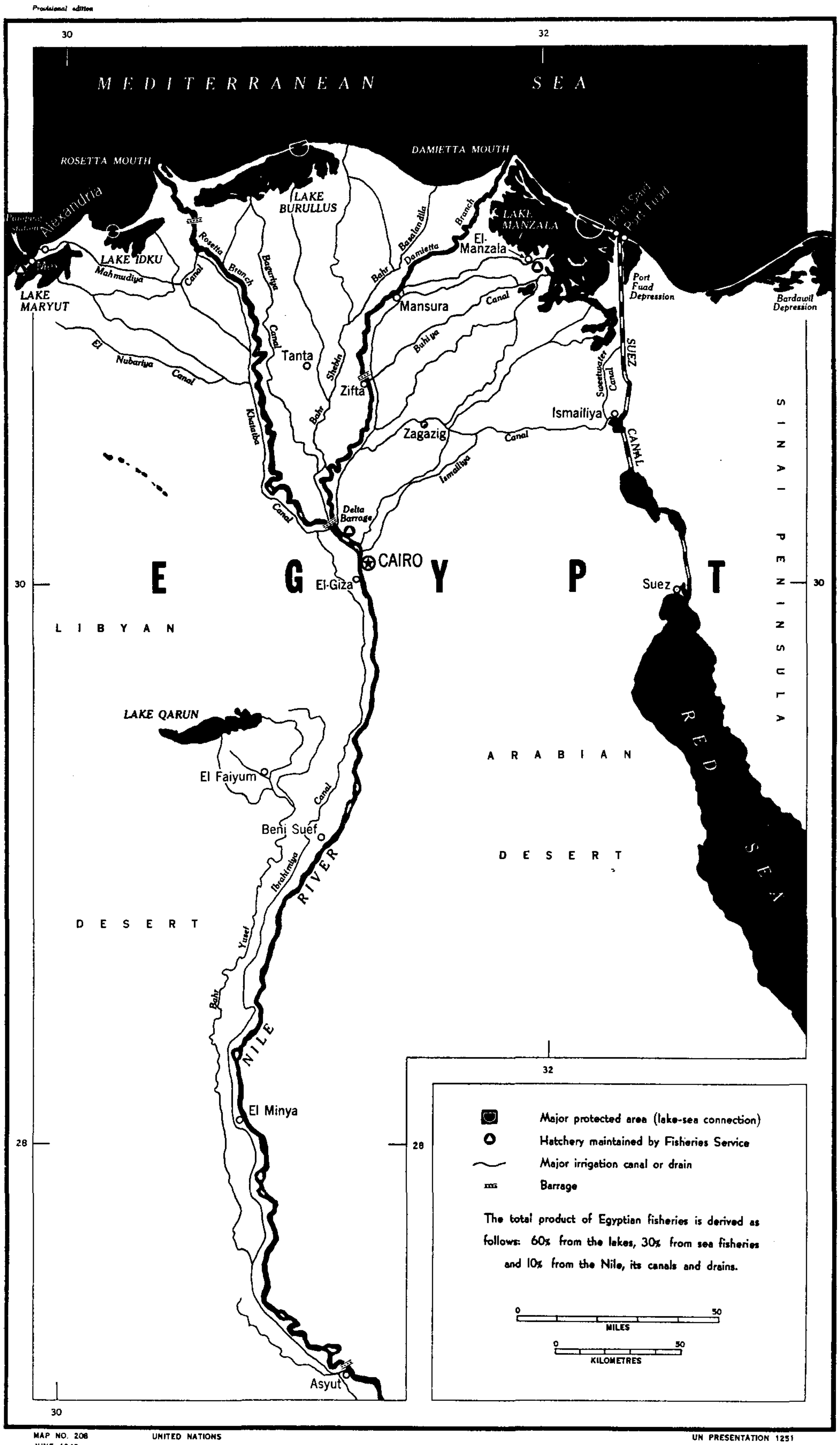
Depth. The depth of water in the four Delta lakes is almost everywhere less than a metre, and only a few centimetres over very wide areas, especially in Mariout. Persistent strong winds may completely dry off many hundreds of acres, which a day or two before were covered by water sufficiently deep for small fry, millions of which undoubtedly perish.

By comparison Karoun is about 8 metres deep at its deepest points. Although Bardawil and Port Fouad depressions are identical in that they are supplied with sea-water by an artificial lake-sea connexion, the depth of the former is in some places more than 5 metres while in the latter it would hardly exceed one metre.

Nature of bottom. The nature of the bottom in the Delta lakes and Karoun consists mainly of brownish mud, except at the south-west corner of Lake Menzaleh where some areas of the bottom contain deposits of gypsum (calcium sulphate).

The bottoms of Bardawil and Port Fouad depressions are similar and are composed mainly of muddy sand.

Salinity. There is a very wide range of salinity—from nearly fresh water to more than 50 parts per 1,000—according to season and locality. The average salinity of the lakes ranges as follows: Menzaleh, 9.5 per cent in January to 22.5 per cent in August; Brullos, 5.6 per cent in January to 18.53 per cent in August; Edkou, 4.28 per cent in January to 14.80 per cent in August; Mariout, 5.04 per cent in January to 7.97 per cent in August; and Karoun, 22.62 per cent in January to 28.51 per cent in August.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Delta Barrage
CAIRO
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E G Y P T
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DESERT
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DESERT
SINAI PENINSULA
RED SEA
LAKE QARUN
El Faiyum
Beni Suef
NILE RIVER
El Minya
Asyut
Major protected area (lake-sea connection)
Hatchery maintained by Fisheries Service
Major irrigation canal or drain
Barrage
The total product of Egyptian fisheries is derived as follows: 60% from the lakes, 30% from sea fisheries and 10% from the Nile, its canals and drains.
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The fish population in these lakes must therefore possess a very wide toleration in respect of salinity variations.

Temperature. The temperature of the lakes also varies very widely according to season and locality. The average range of variation may be recorded as follows:

Menzaleh, 19.36 degrees C in January to 26.85 degrees C in July; Brullos, 15.8 degrees C in January to 27.25 degrees C in July; Edkou, 16.3 degrees C in January to 27.1 degrees C in July; Mariout, 14.8 degrees C in January to 25.85 degrees C in July; and Karoun, 16.50 degrees C in January to 27.9 degrees C in July.

Level of water. As the three Delta lakes of Menzaleh, Brullos and Edkou are connected with the sea by a narrow strait, their water-level varies from sea-level or a little over, to a maximum of + 0.60 metre.

The water-level of Lake Mariout is always under sea-level and varies from —3.01 metres to —2.62 metres. Lake Karoun, however, is very much below sea-level and varies from —44.88 to —44.36 metres.

The flora of the lakes

According to the variations of the geographical characteristics mentioned, especially as regards salinity, temperature and depth of water, the flora of the lakes likewise undergo wide variations.

The flora include Hellophytes and aquatic, salt-marsh, and algal vegetation. The most predominant species of each type could be mentioned as follows:

A. Hellophytes:
1. *Juncus acutus*, L.
2. *Cyperus maritimus*, L.
3. *Jussiaea repens*, L.
4. *Phragmites communis*, Trin.
5. *Typha angustata*, (Bourg and Chaub)

B. Aquatic:
1. *Ceratophyllum demersum*, L.
2. *Lemna polyrrhiza*, L.
3. *Potamogeton pectinatus*, L.
4. *Potamogeton crispus*, L.
5. *Najas armata*, Del.

C. Salt marsh:
1. *Atriplex portulacoides*, L.
2. *Centauria aegyptiaca*, L.
3. *Chenopodium muralo*, L.
4. *Cressa cretica*, L.
5. *Zygophyllum album*, L.

D. Algal vegetation:
1. *Cladophora spp.*
2. *Ectocarpus spp.*

The Phytoplankton and Diatoms are relatively abundant throughout the lakes. The shores, especially near the mouths of the drains and along the islets scattered throughout the lakes, are thickly covered with vegetation, mainly with species of Typha, Phragmites, Cyperus, and Juncus. As one proceeds off-shore, Ceratophyllum, Najas, and Potamogaton, are generally abundant. The lake centres are generally clear and devoid of fixed vegetation. Around the lake-sea connexions, species of Enteromorpha, Cladophora and Ulva are common.

The fish population of the lakes

As regards the fish population of the lakes, the species of fish inhabiting Menzaleh, Brullos and Edkou, their seasonal movements and the methods adopted for their capture, are practically identical. The most important fact is that they consist of a stationary population, which breeds within the lake area, and a migratory population, which must go out to the open sea for the purpose of spawning. The former is mainly composed of the three species of Bolti (*Tilapia nilotica*, Linn., *T. zilii*, Gerv., and *T. Galilae*, Art.); the cat-fishes including the species of Clarias, Bagrus and Synodontis; also the species of Barbus, and the Nile perch (*Lates niloticus*, Linn.). The latter is mainly composed of the species of grey mullets, Bouri (*Mugil cephalus*, Linn.), Topar (*M. capito*, Linn.) and Garan (*M. saliens*, Risso.).

Actually the Telapia species represent about 60 per cent of the total catch of the three lakes, while the grey mullet species represent about 30 per cent. The remaining 10 per cent of the catch is composed of a number of species of sea-fish, mainly sea-bass (*Morone labrax*, and *M. punctata*), maigre (*Sciaena aquila*, Lacep.), sole (*Solea vulgaris*, Linn.) and prawns; the fresh-water species mainly consist of Karmout (*Clarias lazera*, C. and V.), Bayad (*Bagrus bayad*, Forsk.), Schall (*Synodontis schall*, *Bl. Schn.*, *S. serratus*, Ruppel.), Labis (*Labeo, niloticus*, Forsk.), Bynni (*Barbus bynni*, Forsk.), Ishr (*Lates niloticus*, Linn.).

In the two lakes of Mariout and Karoun the species of Bolti represent about 80 per cent of the catch and the remaining 20 per cent is composed of grey mullets, eels and the fresh-water species mentioned above. Consequently the Bolti is considered the most common fish in Egypt and represents about one-third of the total yield of all the fisheries. Its usual marketable size varies between 10 cm. and 30 cm. in length. The Bolti species breed from April to November, but principally during the early summer. They scoop out shallow basins in the soft bottom and use them as nurseries; the females have the curious habit of carrying the eggs in their mouths until the young fry are sufficiently developed to swim independently; this, of course, is a measure of protection in nature, but it has the disadvantage that every female fish, taken in the net during the critical period, brings along her whole brood, which is consequently lost.

In nature, the chief enemies of the Bolti are their own cousins, only very slightly larger than themselves and probably a month or so older. In spite of the most careful shepherding on the part of the parents, many of the young fry stray and are immediately snapped up. The fishermen finding the eggs in the mouths, are, of course, convinced that they are laid by a sort of vomiting process. That many of the fish breed more than once in the season, is proved by the not infrequent occurrence of fish with broods in their mouths and at the same time with their ovaries well developed. The chief time for catching these fish is from November to the end of February when they emerge from the marshes as the flood comes down.

Most of the fish taken are about a year old, the great majority under 15 cm. long.

The grey mullets as well as other species of sea-fish which enter the three Delta lakes to feed must all go out to sea again to spawn. To do this they must pass through the narrow straits connecting the lakes with the sea and conversely, their fry must enter the lakes at these points. Therefore the neighbourhood of the lake-sea connexions is an area of vital importance to the protection and development of the lake-fisheries.

The shoals of almost mature fish of Bouri migrate seaward during the summer months from June to September; Tobar, generally during October and November; eels, sea bass and soles, from December to the end of February. However, it has been undoubtedly proved that a good percentage of the spent fish re-enter the lake after spawning. The fry enter the lake areas as soon as they are sufficiently developed to make their way against the out-flowing currents; at this stage the mullet fry are about 18 mm. to 30 mm. long. The study of the arrival of the fry from the sea can best be made at Mex, where the pumping station, which regulates the level of Lake Mariout, is situated. The station pumps into the sea, through a canal half-a-mile long, about 4 million cub. metres of water per day. It is this current of practically fresh water which attracts the fry of grey mullets and eels from the sea; arrived at the station, they cannot proceed any farther and consequently accumulate in almost incredible numbers. The season of the mullet fry generally extends from October to the end of March with variations in the length of the fry from 18 mm. to 30 mm. according to the time when it has been hatched.

MEASURES FOR THE PROTECTION AND DEVELOPMENT OF THE LAKE-FISHERIES

1. *Means of protection:*

(*a*) As mentioned earlier, the areas of lake-sea connexions in Menzaleh, Brullos and Edkou are of vital importance. Consequently fishing is prohibited in these areas as follows:

Menzaleh: From the lake-side an area of a semi-circle 6 km. in radius, around the opening; confronting that area from the seaward side 1 km. off shore.

Brullos: A semi-circle of a radius of 3 km. on the lake-side and on the seaward side 1 km. off-shore.

Edkou: In a circle of a radius of 2 km. with its centre in the middle of the lake-sea connexion.

(*b*) As the main product of Lake Karoun is Bolti (Tilapia species), all fishing is prohibited during May and June, the active period of spawning of this fish.

(*c*) Fishing is prohibited in certain areas of the Delta lakes where stationary fish spawn. These areas are generally situated near the entrance of the big drains pouring into the lakes.

(*d*) Meshes are limited by law, in order to protect the under-developed fish and give it a chance to mature and spawn at least once. Moreover there are by-laws for the protection of the under-sized fish.

(*e*) Harmful methods which may lead to catching under-sized fish or big fish at the critical time of spawning are strictly prohibited.

2. *Stocking of the lakes:*

There is a collecting station at the Mex pumps. The fry of grey mullets and eels, swimming upstream against the current flowing from the Mex pumps and accumulating there in great quantities, are collected by the Fisheries Service and transferred as stock to Lake Mariout which has no connexion with the sea. The Fisheries Service annually collects more than 20 million of this fry.

Lake Karoun, being an inland lake, used to be very rich in the production of fresh-water fish. As its water-level gradually decreased for reasons connected with irrigation and drainage of the Fayoum district, its salinity gradually increased and consequently most of the Nile fish which were flourishing in this lake disappeared.

Since 1930 the Fisheries Service has annually transferred to Lake Karoun about half-a-million grey mullets and eels from the accumulation near the Mex pumps. Fortunately these fry have survived, acclimatized and grown to such an extent that some specimens of Bouri have been recorded as weighing 10 kg. each.

It has been noticed that the Bouri, which do not have access to the sea to spawn when mature, do not spawn in Lake Karou. Consequently the fish does not breed, for the gonads reach only half their natural growth. On the other hand, it has been proved since 1935 that the *Mugil capito* spawns in the lake. Nevertheless, the Fisheries Service is continually transferring the fry from the Mex station to stock this lake.

In this respect, an interesting experiment which the author has carried out in stocking Lake Karoun should be referred to. Fifty small specimens of *Solea vulgaris* were transferred from Edkou to this lake during the winter of 1934-1935. The fish were acclimatized, the growth was normal, and in the following years the fish spawned and propagated freely in the lake. Specimens of this species of 30 cm. are not infrequent in Karoun and the catches of sole are estimated annually at 16,000 kg.

This true salt-water fish has been established as one of the stationary species in the lake.

The Fisheries Service has at present three fish farms for hatching and breeding:

One at Mex for salt-water fish,

A second at Barrage for the fresh-water fish,

A third near Lake Menzaleh.

The principal object of these farms is to carry on experiments on normal feeding, artificial feeding, growth rate, and stocking of the lakes and near-by waters with the fry produced in these farms.

It is the intention of the Fisheries Service to extend fish farming on a large scale to the vast areas near the big drains in the north of the Delta, where thousands of acres are still bare and not yet reclaimed for agriculture and which could be easily supplied with the necessary water for the drains.

Pond Culture of Warm-Water Fishes

S. Y. LIN

ABSTRACT

Application of pond-culture depends mainly on the physical features of the land, the water-supply, the nature of the soil, the availability of suitable fishes for cultivation, food for the fishes and the development of necessary technique. The most important species selected for pond culture in warm waters belong to the carp family (Cyprinidae) with herbivorous or omnivorous feeding habits. Next come the milk fish and the grey mullets.

Fish-ponds in the delta of the Yangtze River and the West River in China and the Ganges River in India are the oldest and most extensive whilst those in Japan, Java and the Philippines are recent developments. The noteworthy feature in the Chinese method of carp-culture is the full utilization of the three dimensions (length, width and depth) of the pond by rearing several species together which results in high yields. The excellent results shown in milk fish and grey mullet cultivation in the Philippines, Java, Formosa and other countries indicate great possibilities for wide extension of pond-culture in the marshes and mangrove swamps of all maritime countries.

INTRODUCTION

The practice of pond-culture is applicable in most countries, though some places may be more suitable than others. The factors to be taken into account include the physical features of the land, the water-supply, the nature of the soil, the availability of suitable fishes for cultivation and of food for the fishes and knowledge of the technique of fish-culture. Ideal conditions for the development of pond-culture are warm climates and delta areas where the alluvial soil is extremely rich in essential elements and where the supply of fresh water is plentiful. Thus in the areas of the Yangtze River delta of Kiangsu and Chekiang, of the West River of Kwangtung and of the Ganges River delta of Bengal, pond-culture of carps began very early and is most extensively developed. But this does not mean that pond-culture in regions other than the lowlands of the delta is unpractical. It has been proved equally profitable in Palestine, Malaya, many interior provinces of China and India, the New Territories of Hong Kong, Formosa, Japan and other countries where the land is more or less hilly and in some cases where monsoon rains are the main sources of fresh-water supply. Fish, which are cold-blooded animals, grow faster in the tropics and subtropics than in temperate and cold regions.

POND FISHES

To make pond culture a worthy enterprise, the selection of species of fish for cultivation is most essential. The fundamental principle for success is a rapid and economical conversion of the organic foods on which the fish feed into forms of protein and fat suitable for human consumption. It is, therefore, preferable to select fast-growing fish with herbivorous or omnivorous feeding habits. So we find the following species to be the most suitable for pond culture in warm waters:

Family Cyprinidae

(1) The common carp, *Cyprinus carpio* (Linnaeus), omnivorous.

(2) The grass carp, *Ctenopharyngodon idellus* (Cuv. & Val.), omnivorous.

(3) The big head, *Aristichthys nobilis* (Richardson), a plankton feeder.

(4) The silver carp, *Hypophthalmichthys molitrix* (Cuv. & Val.), a plankton feeder.

(5) The black carp, *Mylopharyngodon piceus* (Richardson), a snail eater.

(6) The mud carp, *Cirrhina molitorella* (Cuv. & Val.), feeds on worms and artificial food.

(7) The bream, *Parabramis pekinensis* (Basilewsky), feeds on artificial food.

(8) The catla, *Catla catla* (Hamilton-Buchanan), omnivorous.

(9) The rohe, *Labeo rohita* (Hamilton-Buchanan), omnivorous.

(10) The calbasu, *Labeo calbasu* (Hamilton-Buchanan), omnivorous.

(11) The cirrhosa, *Cirrhina cirrhosa* (Bloch), feeds on algae.

(12) The mrigala, *Cirrhina mrigala* (Hamilton-Buchanan), omnivorous.

(13) The gold fish, *Carassius auratus* (Linnaeus), omnivorous.

(14) The tawes or barbel, *Puntius javanicus* Bleeker, a bottom feeder.

(15) The nilem, *Osteochilus hasselti* Cuv. & Val., feeds on macroplankton.

Family Chanidae

(16) The milk fish, *Chanos chanos* (Forskal), feeds on algae.

Family Mugilidae

(17) The grey mullet, *Mugil cephalus* Linnaeus, and others.

Family Osphronemidae

(18) The gouramy, *Osphronemus goramy* Lacépède, herbivorous.

In Japan a quite different technique of pond-culture in cold water has been successfully developed. The species selected by the Japanese fish culturists are (1) the eel, *Anguilla japonica*, Schlegel, (2) the trout, *Salmo milktschitsch* and (3) *Plecoglossus altivelis*, Schlegel. All these are carnivorous fishes which require animal proteins for food. The cultivation of such type of fishes would not be practical in places where animal proteins are rare and expensive. But in Japan silkworm pupae are cheap and plentiful, as also are sardines and entrails from the slaughter houses; these have made possible and profitable the culture of these species. In the following table the yield of the cold-water trout-ponds in Japan is given for comparison with the yields of fish from ponds in the tropics.

As space does not allow a full discussion of all types of pond-culture the following short notes will suffice to give a comprehensive guide to those in warm waters.

LOCALITIES FOR POND CULTURE

The most suitable locality for construction of fish-ponds is the mud flat of any delta area. In such places the embankments are easily built and a supply of fresh water is conveniently accessible from the irrigation canals and rivers. Ponds can also be constructed among rice-fields, gardens and orchards in the big plains or in wide valleys; they may be used at the same time for irrigation purposes. In front or by the side of villages, houses or temples in China, India, Siam and other countries, ponds are commonly constructed for the sake of beautifying the countryside and for bathing (particularly in India) and at the same time for fish raising. When moats are excavated around the village walls they form good fish-ponds. These homestead ponds have the advantage of collecting water rich in organic matter that is drained from the village and they become fertile with the addition of but little or no fertilizer.

CONSTRUCTION AND PREPARATION OF FISH-PONDS

Fish-ponds may be constructed by building embankments to retain water for at least a period of ten months in a year or by excavating a piece of land to about 2 metres in depth in order to collect rain-water from the surrounding areas or to tap subsoil water and to retain it in the excavated area, in which case bunds may or may not be necessary. The advantage of natural depressions in the landscape should always be considered to save labour in excavation and to safeguard water-supplies. The size of a bund varies from 1 to 5 metres in height, one-and-a-half to 8 metres in width at the base and two-thirds to 3 metres on top, depending on the size of the pond, the height of flood during the rainy season, and the spring tides. In most cases a bund is constructed with earth reinforced usually on the inside with stones, bricks and occasionally cement concrete to prevent erosion through action of the pond water. Riveting with wooden planks or bamboos laid horizontally behind wooden piles driven into the earth at regular intervals is also employed for keeping embankments in good condition.

Ponds can be classified into spawning, nursery, rearing, and stocking or fattening. The size, shape and depth of ponds vary as the physical features of the land, the purposes for which they are utilized and other individual requirements of the farmer. Two types of artificial spawning ponds are known. The first and the oldest type is for the common carp and the other for the *catla*, *rohita* and *mrigala*. As the common carp spawn in stagnant water as well as in running streams, there is no need for specially constructed breeding ponds. An ordinary fish-pond provided with

Table 1. Yields and Food Requirement of Ponds in Different Countries

Country	*Type of fish in pond*	*Food required (kg.)*	*Yield per hectare per annum (kg.)*	*Food yield ratio*
Japan	Common carp	7,500 to 9,375 (dried silkworm pupae)	3,600 to 5,400	1.87 : 1
China: Yangtze River Regions	Grass carp, big head, silver carp, black carp, common carp and bream	5,600 to 15,000 (silkworm pupae, silkworm waste, grass, snails, night soil)	2,800	3.67 : 1
China: Kwangtung	Grass carp, big head, silver carp, black carp, mud carp and common carp	6,000 to 30,000 (silkworm pupae, and silkworm waste, grass, soybean cake, goat weed (*Ageratum conyzoides*), pig manure, night soil	2,800 to 6,000	4.09 : 1
Hong Kong: New Territories	Grass carp, big head, silver carp, mud carp, common carp and grey mullet	5,000 to 20,000 (peanut cake, rice, bran, grass, goat weed, soybean dregs, pig manure, night soil)	2,200 to 3,800	4.17 : 1
Philippines	Milk fish		400 to 980	
Malaya	Grass carp, big head, silver carp, and common carp	Foods and feeding similar to Chinese method	3,400 to 5,600	
India: Bengal	Catla, rohita and mrigala	No feeding	300 to 900	
India: Bengal	Same fishes	With feeding	1,100 to 2,400	
Palestine	Common carp	With feeding	1,360	
Japan	Eel (95 per cent), common carp (5 per cent)	82,500 (fresh sardine, mackerel scad, dried silkworm pupae)	15,000	5.5 : 1
	Trout	253,120 (livers of horse and pig and mixed meals of sardine and silkworm pupae)	56,250	4.5 : 1
Indonesia	Milk fish, common carp, sepat siam, Tawes and nilem	nil	300 to 400	

plenty of aquatic plants or other suitable materials will encourage the mature carp to lay eggs on them. The spawning "tank" of *catla*, *rohita* and *mrigala* in India is quite an elaborate construction. First is selected a broad, gently sloping valley with adjacent areas of low hilly slopes which serve as water catchment areas. Next, at the lower end of the shallow valley a dam, several hundred metres in length, more than 4 metres in depth and 6 to 10 metres in width at the base is constructed to retain water during heavy monsoon showers. A deep sump more than 20 ares[1] in area and a flat spawning ground 10 to 30 ares in area are provided in their proper places. The sump is for rearing of brood-fishes and the spawning flat when covered by water to half-a-metre deep forms a rendezvous for the fishes to lay eggs.

The construction of nursery, rearing and stocking ponds is similar. A nursery pond should be small, 5 to 20 ares being considered suitable. The rearing pond is larger and the stocking pond larger still, 40 ares being regarded as an ideal size. For the rearing and stocking ponds one end or the centre should be excavated deeper than the other. A pond having an average depth of water one to one-and-a-half metres during the dry season and 2 to 3 metres in the rainy season is ideal.

On the bund, if wide enough, fruit trees, mulberries, bananas and vegetables may be grown. If pig and poultry farms are established on the embankments the waste goes into the ponds as fertilizer.

The water in the pond may be stagnant or running, the choice depends on the types of fish reared in the pond. When the fish feed directly on introduced foods, on worms, snails and crustaceans (e.g., common carp, eel, grass carp, trout etc.,) it is advantageous to keep the water running all the time. Because pollution is prevented by constant change of water, fish in large numbers can be crowded in a confined area and as a result the yield per unit of pond is greatly increased. The practice of carp-culture in Formosa and Japan, of trout-culture in Japan and of the milk-fish culture in "tambaks" in Java are good examples of this type of management. The big head and silver carp of China on the other hand live solely on plankton. They do not consume directly any stuff introduced into the pond but throughout the whole of their life feed on the floating microscopic organisms which thrive on fertilizers. The *catla*, *rohita* and *calbasu* of India, however, take partly algae, protozoa, rotifers and other organic particles suspended in water, and the young fry of all fishes are plankton feeders. In these circumstances it has been found advantageous to keep the water stagnant in the pond to avoid unnecessary loss of fertilizers after application.

For the purpose of regulating water in ponds sluices of various forms and devices are provided. Usually for one pond two sluices are constructed, an outlet and an inlet, but when a pond is adjacent to a tidal canal or stream one sluice will serve both purposes: it is kept open during the flood-tide to let water in and at ebb-tide to let water out. At low-tide it is closed to prevent water running out. With fish in the pond the water should be maintained at a depth varying from one-and-a-half to 3 metres. If the water is too shallow there will be insufficient space for the fish to grow and to excavate a pond deeper than 3 metres will not only be expensive and uneconomical but unnecessary. The water below the three to 5 metre layer changes little in temperature and is always deficient in oxygen and light and therefore poor for organic growth. This deep zone of water does not form part of the regular haunt of the ordinary fishes.

To secure the best production in a pond the water should be drained off and the bottom dried for one or two months during the dry season. The silt is removed to deepen the pond. Where it is impossible to dry up the pond, in order to maintain the correct depth it may be necessary to excavate some of the soft mud. In the preparation of a nursery pond for rearing fish fry, all such harmful creatures as predaceous fishes, insects, tadpoles and snakes must be destroyed. After the pond is refilled with clean water and enriched by the addition of fertilizer it is ready for introduction of fry, fingerlings or yearlings.

SOURCES OF FISH FRY

In China with the exception of common carp which spawn in captivity, eggs and fry of the grass carp, big head, silver carp, black carp, bream and mud carp are collected from the Yangtze River, West River, Ming and Han Rivers during the months from June to August. Through an elaborate process of sorting, the fry of each species are separated and placed in nursery ponds for rearing. After a period of from two weeks to several months the fry become fingerlings and are distributed to all parts of China, Siam, Malaya, Java, and the Philippines for stocking ponds. Grey mullet about 12 mm. in length and fry of the milk fish are collected in the estuaries and brackish water streams along the coast. The larvae or elvers of fresh-water eels are procured in the river mouths of Japan and of other countries. The fry of trout are obtained from artificial fertilization. The *catla*, *rohita*, *mrigala* and other Indian carps are collected from the Ganges River and recently to some extent from the Cauvery River in South India. It is estimated that 11,000 million carp fry are collected annually in China, and 2,000 million to 4,000 million in India. In addition there are 200 to 300 bund-type tanks in Bengal Province used for spawning of the carps. These tanks may produce, under favourable conditions, an additional quantity of 1,000 million fry per year. The gouramy breed easily in captivity but the fry of some cultivated catfish are collected from rivers and canals. The *tawes* and *nilem* of Java reproduce in captivity like the common carp.

STOCKING OF PONDS

Ponds are stocked in different systems according to the nature of the fishes. The common carp, fresh-water eels, trout, gouramy and catfish have been stocked and reared separately with profit but in the culture of grass carp, silver carp, big head, mud carp, black carp, *catla*, *rohita*, *mrigala*, *tawes*, nilem, grey mullet etc., it is more economical to grow them in association rather than separately. As a general rule, the rearing of two voracious or even one species of voracious fish in the company of herbivorous carps in a pond is inadvisable for inevitably the weak species will fall a prey to the carnivorous species. If, however, no carnivorous species is included and each kind of fish possesses a different feeding habit it is always an advantage to grow them together. In China there are

[1] 1 are = 100 square metres.

numerous systems of stocking the ponds in order to suit different individual environments. The following are some successful mixtures:

Table 2. Five Systems of Stocking the Ponds in South China

Species	Length in mm.	Numbers of fishes per hectare of pond Pond A	Pond B	Pond C	Pond D	Pond E	Pond F
Grass carp	60-150	1,200	1,200	1,200	600	480	2,400
Silver carp	100	300	240	1,800	600	1,200	300
Big head	100	300	240	1,800	1,200	510	300
Mud carp	75	1,800	4,800	3,600	—	2,400	7,200
Common carp	50	1,200	360	1,200	3,600	—	300
Black carp	50-100	100	24	—	120	60	120
Bream	75	—	—	—	—	600	—
TOTAL		4,900	6,864	9,600	6,120	5,250	10,620

The total weight of the fingerlings or yearlings at the time of introduction into the pond should be around 20 to 30 kg., although the size of the fish may vary to some extent. After one year's rearing the yield would come to a total weight of 2,200 to 6,000 kg. per hectare. In the New Territories of Hong Kong there are different systems of stocking, the special feature being the introduction of a large number of grey mullet in the association; thus to 1 hectare of pond with an average depth of 1 metre of water, which is very slightly brackish in this particular district, three systems are practised in three fish farms.

Table 3. Three Systems of Stocking Adopted in Hong Kong

Species	Length in mm.	Number of fish per hectare of pond Farm A	Farm B	Farm C
Grey mullet	25 to 45	12,000	27,360	15,000
Grass carp	50 to 100	1,524	300	700
Silver carp	75	2,208	2,568	600
Big head	75	1,536	624	600
Mud carp	50	9,600	3,120	9,000
Common carp	50	—	—	4,800
Bream	50	—	—	—

As indicated in the above tables the number of fish used to stock the ponds of Hong Kong is three to five times as many as that of the Canton delta area; moreover, the number of the grass carp is deliberately reduced to allow more space for the grey mullet in the Hong Kong ponds. The reasons for this change are apparently:

(1) The abundance of the mullet fry in the neighbourhood;

(2) The scarcity of fodder grass which is in great demand for the grass carp but not for the grey mullet;

(3) The shortage of fresh water supplies; and

(4) The slight salinity of the water in the ponds.

Grey mullet is excellent eating and fetches the highest price among all pond fishes but, unfortunately, it is a slow-growing fish, reaching at most about 400 grammes in the first year, 900 grammes in the second and one-and-a-half to 2 kg. in the third; under natural conditions a fish which grows to a size of 3 kg. in weight is rare. Grass carp will attain one to one-and-a-half kg. in the second, 2 kg. to 3 kg. in the third and more than 5 kg. in the fourth year.

Although the ponds in the New Territories of Hong Kong are stocked with three to five times as many fry as the ponds of the Canton delta, their yield is lower; the ponds in the Canton delta produce 2,800 kg. to 6,000 kg. per hectare per annum whilst those of Hong Kong produce only 2,200 kg. to 3,800 kg. This may be due to a shortage of fresh water supplies and the salinity of the water, but whether the productivity of the Hong Kong ponds could be improved by reducing the number of fish is a problem for investigation. According to Carbine (1948) the nursery ponds of milk fish in the Philippines are stocked at the rate of 120,000 to 200,000 fry per acre and the rearing ponds — 400 fingerlings per acre. The estimated mortality from fry to marketable size may be as high as 70 per cent.

The Japanese fish farmers practise pond-culture with running water and with intensive artificial feeding. In the case of common carp 20,000 to 80,000 young fry each of about 50 grammes are introduced into 1 hectare of pond; if one-year carp of 200 to 400 grammes each are used, about 2,000 suffice to stock 1 hectare. The yield will come near to the figures shown in Table 1. The technique of stocking a cold-water pond with 500,000 to 700,000 young trout fry and after one year of artificial feeding to produce 56,000 kg. of edible fish seems unbelievable but is, however, true (14).[2]

In Bengal, India, most of the big fish-ponds, each 50 to 300 hectares in area, are constructed in the low marshes or spill areas by building embankments. Into a hectare of these types of ponds roughly 500 mixed fingerlings of approximately 30 per cent *catla*, 30 per cent *rohita* and 40 per cent of *mrigala* 130 mm. in length are introduced. No artificial feeding is practised except in some cases of irrigation with sewage in controlled amounts from the main city drainage system. Homestead ponds of smaller size, one-quarter to 2 hectares in area, are better managed with artificial feeding than the spill ponds. To a hectare of these 5,000 to 8,000 mixed fingerlings, 50 mm. to 100 mm. long, of about 30 per cent *catla*, 60 per cent *rohita* and 10 per cent *mrigala* are introduced. The proportion of the different species of carps is never definitely known because the fish-fry dealers in India do not bother to sort them out before selling to farmers.

FOODS AND FEEDING

In the warm-water ponds of Asiatic countries certain species of carps have been proved, through centuries of experience, to be most profitable for cultivation. They are either herbivorous or omnivorous. The following is a list of foods employed to feed them.

(1) Foods of animal origin. To this group belong cow dung, pig faeces, poultry wastes, night soil, silkworm pupae, silkworm waste, sewage, butchery wastes etc.

(2) Vegetable foods consist of land grass, vegetables, weeds, aquatic plants, tubers, cereals (rice, bran), peanut

[2]Numbers in parentheses refer to items in the bibliography.

cake, oil-cake, soy bean cake, kitchen waste, brewery waste, soy sauce waste etc.

(3) Small organisms like small fishes, tadpoles, aquatic insects, snails, crustaceans, insects, plankton, worms and so on are valuable food for the fish. They may be grown in the pond or fall into it from the land or air.

(4) Fertilizers are organic and inorganic and include animal manures, leaves of land plants and chemical fertilizers. They are added to the ponds to accelerate the growth of plankton, aquatic insects and worms which in turn serve as food for the cultivated fishes.

The kinds and amounts of food given vary greatly according to the types of fishes, the temperature and nature of the water, and the character of the soil. Fish eat more and grow faster at temperatures between 24 degrees and 28 degrees C than either in colder or hotter conditions. If the soil is very rich in essential elements such as calcium, phosphorus, potassium and organic matter or humus, the amounts of fertilizer and food can be reduced. For plankton-feeding fishes the application of nitrogenous fertilizers is extremely important. As shown in Table 1, a running-water pond requires more food for the growth of fish than a stagnant one. The Japanese carp pond produces one unit weight of fish for 1.87 units of dried silkworm pupae, which would at least equal 5.5 units of fresh pupae. Similarly the food and fish yield ratio of Japanese eel and trout ponds (running water) is 4.5—5.5: 1 whilst that of the Chinese carp ponds (stagnant or semi-stagnant water) is 3.69—4.17: 1. The food is more expensive and higher in nitrogen content in the Japanese method of feeding than in the Chinese. These comparisons show that stagnant-water ponds are more economical than ponds with running water.

Some of the fishes in the pond reach marketable size earlier than others. It is highly desirable, therefore, after six months of rearing, to remove and market the big fish so as to provide better opportunities and more space for the smaller ones to grow. In carp cultivation the pond is generally harvested twice a year; the first crop is taken six months after the introduction of fingerlings or yearlings into the pond and the second at the end of the year. When a large number of grey mullet are raised with carps it is a general practice to catch daily or weekly. The carps are carefully handled and marketed alive in order to obtain higher prices.

EXTENT AND NECESSITY OF DEVELOPING POND-CULTURE AS AN ADDITIONAL SOURCE OF FOOD

Whilst there are no data to show the acreage of water in which pond-culture is practised and the total production in different countries at present, some idea may be obtained from reports published before or after the war. According to the report of the Central Fisheries Research Institute in Shanghai, the total area devoted to fish-ponds in China was 208,000 hectares producing 383 million kg. of fish a year. Professor Hoffman (8) estimated that Kwangtung Province possessed 81,000 hectares which produced 356 million kg., a figure which appears rather high. The silk-producing districts of Chekiang, Kiangsu and Anhwei are also very important for pond-culture. Taiwan or Formosa is the only Chinese province where milk fish is cultivated in salt and fresh-water ponds. The marshy land in Taiwan District used for construction of fish-ponds covers an area over 10,000 hectares producing 7,500,000 kg. of milk fish; in addition several hundred hectares of fresh-water ponds produce 2,720,000 kg. of carp. Java and the Philippines are also well known for their milk fish "tambaks". The culture of common carp in rice-fields has been very successful in Japan and Java in recent years. Carp-culture in ponds has been proved a success in Siam and Palestine but the practice has not yet become as extensive as in other countries.

Table 4. Area of Fish Ponds and Annual Production

Countries	*Fish pond area (hectare)*	*Production per year (kg.)*
China	208,000	383,000,000
Indonesia	100,000	30,000,000
India	90,000	54,000,000
Philippines	61,000	25,000,000
Japan	5,400	2,460,000
Malaya	200	800,000
Palestine	800	1,200,000

Montalban (12) estimated that 500,000 hectares of low swamps and mud flat which were laying waste could be turned into productive fish-ponds in the Philippines and pointed out that immediate steps should be taken to develop these areas. In India over half-a-million hectares of "tanks" in Beel, Khal, and other low marshy areas await a practical scheme to make them suitable for pond-culture. In every country there are vast areas of land which could be made productive but, unfortunately, they are mismanaged and wrongly cultivated or entirely neglected. The misuse or neglect of land and water capable of giving high returns of fish rich in protein should not be tolerated in a world where poverty and food shortage exist in so many countries.

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Pond Culture of Warm-Water Fishes in Indonesia

A. E. HOFSTEDE

ABSTRACT

In the introduction to this paper it is pointed out that fish in Indonesia are of special significance, being the principal source of the production of edible animal proteins. The special importance of the forms of fish-culture in ponds is the fact that the peasant farmer, in his mainly closed production economy, is in a position to produce fish within his own farming enterprise.

In this article a short survey is given of the brackish-water fish-pond culture, and of the fresh-water and the *sawah* culture, whilst in a postscript it is emphasized that the importance of these can be envisaged coherently only if viewed in its economic relation to the prevailing agrarian system, a thing which is very difficult to express adequately in mere statistical figures.

In Java, the most densely populated island of the Indonesian archipelago, where the shortage of animal proteins in the people's diet is the most urgent, the fish-producing ponds herein described contribute about 15 per cent to the prevailing post-war level of consumption.

INTRODUCTION

If we are to obtain a correct picture of the value of fish and fishing in the economic system of the Indonesian Archipelago and its people, we must first of all lay particular stress upon a fact that is all too rarely taken into due consideration. Yet the circumstance here referred to actually determines the nature of its fisheries and the measures that must be taken with reference to them. This circumstance can be formulated as follows:

Whereas in most of the countries of Europe and America the requirements of animal protein are primarily covered by the consumption of beef, pork etc., in Indonesia (and many other Asiatic countries) these requirements are mainly covered by the consumption of fish. Generally speaking, this signifies that for the European and American peoples the consumption of fish is a secondary consideration on the menu; that it is supplementary; a dish for those who like it, a tit-bit; whereas for the people of Indonesia it is a primary requirement.

Within the framework of this short treatise it would lead us too far afield to consider in detail the causes of this state of affairs. Therefore we must confine ourselves here merely to stating this fact. It must be further pointed out that as a consequence fishing in Asiatic countries—in many, if not in most instances—is the only source whence the people get their animal protein, and that therefore this branch of activity occupies a special place, or, to put it more emphatically, must occupy a special place.

Whereas theoretically sea-fishing can be practised along the entire coastline, inland fishing (which covers all forms of fishing within the coastline) can be pursued almost everywhere in the interior provided the circumstances be such (the principal factor being the regular presence and availability of the necessary water) that this be made possible. Since the strip along the coasts that can be regularly supplied with fresh sea fish is rather narrow, averaging as it does but a few dozens of kilometres, it will be evident that further into the interior one is dependent upon the supply of conserved fish or upon the produce of the interior fishery. We can disregard consideration of a supply of sufficient quantities of conserved fish from the sea as the yield of sea fishing does not yet reach necessary minimum requirements, nor is it likely that it will in the near future. Other conditions are also operative, for example, financial capacity, and the lesser factor (occurring in a considerably smaller degree than in Europe) of the "ready money" economy.

All this makes the inland fishery, especially in the deeper interior, a very important pursuit, for it enables the peasant farmer, within his agricultural efforts or in his spare time, to produce or catch fish, the main end of which is to meet his own immediate requirements. This was well understood by the Netherlands Indies Government a long time ago, so that the well-defined policy to increase such fish production is already old. The oldest known officially published report on this subject, which even now is still of much practical value, is dated 1865.

At the International Fishery Conference, held at Buitenzorg in October 1948, the writer read a paper "On Indonesian Inland Fisheries", in which Indonesian interior fishing was classified into the following groups:

1. *Capture operations:*

Catches in rivers, lakes, marshes and reservoirs (irrigation weirs)

2. *Culture operations:*
   - A. *In fish ponds*
     - (*a*) In brackish-water ponds
     - (*b*) In fresh-water ponds.
   - B. *Fish-culture in irrigated rice-fields*

Here, attention will have to be drawn to the culture operations under 2. Although in the Inland Fisheries Service in Indonesia a distinction is made between fish-culture in ponds and in irrigated rice-fields, these two are in essence the same, because any rice-field used for pisciculture is dealt with as if it were also a fish-pond. Also certain items pertaining to the capture operations under 1 will have to be referred to in this connexion, inasmuch as by taking specific measures one can observe quite often here also certain typical forms of pond fish-culture.

In discussing in somewhat greater detail the above-mentioned groups of inland fishery the following may be stated:

Capture operations comprise all those items with reference to which the fisherman is only in a position to catch what is naturally present. As an individual he cannot exercise any influence over the productivity of the fishing waters, and it is only by means of his fishing gear that he can in any way affect the nature and the quantity of his catch. In such cases, only a co-operative plan or a government-sponsored system can guide the yield along certain lines, such as, for instance, the production and the maintenance of a certain section of the (fish) fauna, the introduction of new vari ties and so on.

Some of the natural waters (such as lakes) or artificially laid out fishing areas (such as constructed irrigation reservoirs) can, through the application of special measures, be as fully exploited as if they were ponds. These items, therefore, are a transition to the next group, seeing that the pisciculture methods employed in reality represent a form of fish-culture.

The *culture operations* comprise those parts of inland fishery in which the production process, be it within certain limits, can be entirely governed and directed. Here one can accurately determine in advance what is to be produced and how the exploitation has to be organized in order to obtain the best results.

We shall now proceed to describe the various forms of pond pisciculture, leaving undiscussed such general factors as will serve to make such culture possible and profitable, as, for example, the water-supply and the fertility of the soil and water.

SALT-WATER OR BRACKISH-WATER PONDS ("TAMBAKS")

The ponds under this heading can be laid out on low-lying areas along the coast. They are supplied with water from branches of rivers or directly from the sea; in both cases the ebb and flood tides determine the water-supply. Here a clear understanding of the daily, monthly and annual course of the tides is of great importance, as upon this understanding the depth of the water and the dimensions of the enclosing dike will be determined.

Before the war, the principal products of this fish pond culture were the milkfish or *bandeng* (*Chanos chanos* Forsk.) and several prawn varieties. In view of the fact that the *bandeng*, a herring-like sea fish, cannot be made to propagate in such ponds, one can only stock them with the catch of its brood in the sea. Such catches are made along sandy shores, dependent upon the seasons in which the *bandeng* fry can be caught.

Such fry as a rule are first accumulated in smaller ponds, after which they are distributed. There are some regions where breeders concern themselves only with the rearing of young fish (about 4 in. long) which are then sold to other pond-owners for further development.

In the course of six to twelve months, such fish grow to a weight of from 300 to 800 grammes. Under very favourable conditions their weight after twelve months may even reach 1 1/2 to 2 kg. The yield of 1 hectare of pond area will annually amount to from 150 to 500 kg., a very frequent average being 200 to 250 kg.

The brood of prawns enters with the water while it is filling the pond; there are regions where the yield of prawns is increased through the system used for changing the pond water. To catch the prawns and to ensure a more or less adequate, though changeable, daily yield, special traps (fukes) are used, based upon the urge exhibited by the prawns, after they have attained a certain size, to reach the sea again.

These "tambaks", in addition, yield several varieties of other fish, the fry of which enter the pond, as does that of the prawns, with the water that is filling it. Most of these, however, are predatory fish (such as the kakap, *Lates calcarifer* Bloch) which cause the breeder a certain amount of damage. One of these other fish varieties, which enters quite frequently, though it is not a predatory fish, is the *belanak* (*Mugil spec.*).

Crabs are also quite often found in these ponds; though they are a greatly appreciated food, they can do considerable damage to the dykes.

Especially in the war years and in the course of the first post-war period of political unrest, breeders in many areas took to the cultivation of "*ikan moedjair*" (*Tilapia mossambica* Peters; "ikan" means fish, and "moedjair" is the name of the person who first discovered this fish in Java). This was a matter of necessity caused by a halt in the provision of *bandeng* fry due to the disorganization of the transportation system during the period of Japanese domination. This fish has, at any rate, the great advantage that it will maintain itself through propagation in the pond.

The principal "tambak" complexes are to be found along the north coast of Java (with a combined area of roughly 80,000 hectares) and in South Celebes (with about 20,000 hectares). The total production may be put at from 20,000 to 25,000 tons of fish, and at from 3,000 to 5,000 tons of shell-fish. Other products yielded by the "tambaks" are mangrove wood, which is planted along the dykes, and of which the leaves and the young foliage are sometimes used as green manure.

To conclude this section it is worth mentioning that before long a monograph will appear on the "tambak" system, from the pen of Mr. W. H. Schuster, an expert on this type of fishery, while attention may also be called to his paper submitted to the International Conference at Singapore in March 1949, and dealing with research on the food on which the *bandeng* subsists.

FRESH-WATER PONDS AND RICE-FIELD PONDS

Fresh-water ponds are found wherever conditions make it possible for them to exist, the principal factor being the regular supply of fresh water. They occur in the shape of "house pondlets" covering only a few square metres, wherein the food-fishes are kept for later consumption, up to large culture and breeding ponds covering a space of from 1 to 2 hectares, either scattered or combined into greater complexes.

Their chief importance lies in the fact that the farmer (whose principal and basic occupation is the cultivation of rice, the staple food of this agrarian population) can himself produce fish for his own consumption and that of his neighbouring area, a pursuit which in many instances has reached a high stage of development and has been greatly perfected.

Such culture and/or breeding establishments develop in dependence upon the prevailing local economic conditions, and the areas which they sometimes have in locally-joined ponds may reach several tens of hectares. Dr. A. L. Buschkiel described such a fish-pond centre as far back as 1929 in an address before the fourth Pacific Science Congress ("Fish culture in the District of Tarogong").

By *sawah* ponds (irrigated rice-field ponds) are to be understood such irrigated rice-fields as have been reconstructed into fish-ponds. As a rule these are so transformed for only a short period (from three to six months) in the year, when these grounds are not being used for rice planting. A combined culture of rice and fish is also carried on.

Technically, the culture in this kind of pond requires a reinforcement and raising of the small dykes so that the water can be retained sufficiently to make pisciculture possible, while in the case of simultaneous cultivation of rice and fish, care must be taken that the rice cultivation is not in any way impeded or damaged.

In fresh-water ponds, the following varieties of fish are being bred and developed:

1. Cyprinoidae ...... Carp (*Cyprinus carpio* L.)
   Tawes (*Puntius javanicus* Blkr.)
   Beureum panon (*Puntius orphoides* C.V.)
2. Labyrinthici ...... *Tambakan* (*Helostoma temmincki* C.V.)
   Gurami (*Osphronemus goramy* Lac.)
   Sepat Siam (*Trichogaster pectoralis* Regan)
3. Perciformes ...... *Ikan moedjair* (*Tilapia mossambica* Peters)

The fish most prevalent today are carp and *ikan moedjair*, and these are practically the only fish now under culture in the *sawah* ponds. In these regions the *ikan moedjair*, due to war conditions, has become a great favourite also.

The total area of this type of pond, and their numbers in Java, are more or less known. There are approximately 120,000 fresh-water ponds, covering a total area of roughly 8,000 hectares, while the *sawah* ponds cover a total of about 66,000 hectares, this being roughly 2.2 per cent of the total *sawah* area in Java used for growing irrigated rice. Their annual fish-production may be put at from 7,000 to 8,000 tons.

It is impossible within the limits of this article to give a more detailed description of the methods used for exploiting these forms of pisciculture. For a general dissertation on this subject I would once more make reference to the above-mentioned paper "On Indonesian Inland Fisheries". Side by side with very primitive systems, one may also find the most complicated forms of exploitation, which in many cases are very closely interrelated with the prevailing agriculture. Due to this, the production figures are very divergent. For fish-culture on *sawah* fields one may assume a prevailing average of about 200 kg. per hectare per annum. Fresh-water ponds under the most favourable conditions may yield as high as 8,000 kg. A yield of 2,000 kg. per hectare per annum is by no means rare, while yields of between 500 and 1,000 kg. are the lowest that should be anticipated under normal conditions. These various factors are dependent upon the fertility of soil and water; upon the possibility of the fish obtaining (in addition to their ordinary food) the remnants of agricultural produce as well; upon manuring; and upon applying to their exploitation, with a mixed population of fish, the separate constituents of which do not interfere with one another as regards the food they require.

POSTSCRIPT

The forms of inland fishing in Indonesia discussed in the preceding pages are a very complex matter; their importance cannot be expressed merely by quoting statistics. The subject can only be viewed in its economic relationship. The interior fishery occupies a definite place in the agrarian system, which in its turn is a link in the entire economy, so that this source of food production can only be viewed from all its interrelating angles.

If, nevertheless, one would wish to express the importance of pond production in figures, this may be done by starting this production in *per capita* consumption, in which case one arrives at roughly 3/4 kg. per person per annum in Java, which is equivalent to roughly 15 per cent of the total *per capita* fish consumption.

Pond Culture of Warm-Water Fishes as Related to Soil Conservation

O. LLOYD MEEHAN

ABSTRACT

The value and importance of hook-and-line fishing to the people of the United States is shown. Deterioration of the fish habitat is described as related to settling and industrialization of the country. This decrease in production has taken place while the number of fishermen has increased. Farm fish-ponds are important as a source of good fishing. Thousands are being built each year because of the good fishing which can be provided under managed conditions.

The impact of this programme on soil conservation has been tremendous. Because of the close relationship between good fishing and the drainage area around the pond, good soil-conservation practices have been stimulated. Farm ponds increase the number of stock that can be carried on the farm, provide water for irrigation, increase soil productivity because of soil conservation practices, and provide recreational facilities and revenue to farm families.

The taking of fish and game has been an inherent right of the people of the United States since early colonial times. When the country was settled, wild animals and fish were used to supplement food stocks. As time passed, these animals and fish ceased to be regarded primarily as food but became the greatest recreational value in the country.

Almost 14.6 million fishing licences were sold in the year ending 30 June 1948. In addition, many people fish without licences. These unlicensed fishermen include juveniles, those who fish within their counties, and those who fish on their own property where state laws permit such exemption. Conservative estimates indicate that this activity attracts more than 20 million individuals—or more than participate in any other single sport. This means that one out of every seven persons in this country enjoys this sport. An amount in excess of $28 million is spent each year for fishing licences, and anglers pay in the neighbourhood of $1,000 million for equipment and other expenses to participate in their favourite sport.

In spite of the importance of hook-and-line fishing, the amount of available waters suitable for fish has gradually decreased. As the country became settled, industrial and agricultural development progressively destroyed forests, soils, and natural habitats. Removal of the forests resulted in accelerated run-off and increased water temperatures. Increased agricultural use stripped the vegetative cover from the land, and unwise farming practices led to erosion. As the water-holding capacity of the soil gradually became reduced, fish habitats were partially or totally eliminated. At least, many habitats that had been suitable for the most desirable game species emerged as a type which would harbour only "scrap" fishes. Because of the loss of forest and land cover, reduction of fertility and dissipation of organic matter in the soil began to take place.

The first effect of man's destructive activities was a rapid decline in the amount of fish produced; the next was a change to less-desirable species. The climax occurred in the total elimination of desirable fish as a result of the intermittent flow of streams in the area so developed. Concurrently, we experienced periods of excessive run-off and floods.

During the drought periods in the 1930's many sections of the country which normally produced good crops and supplied a large amount of meat for human consumption lagged in production because of the lack of water. Great sections of the country would have been able to carry much larger stocks of cattle if adequate water-supplies had been available. It was natural for farm ponds to be advocated to relieve such situations. It was also natural for the American public to use these ponds to indulge in their favourite sport of fishing.

Farm ponds had been advocated during the First World War as an additional source of food supply, but at that time the ecology of these ponds was not too well understood. Most of those early ventures were failures. They did not produce fish of sufficient size for good hook-and-line fishing; so they fell into disrepute as a source of recreational fishing. Experimental work in this country since that time has shown that with proper management, good fishing can be maintained in a farm pond over a long period of years, particularly if the pond is fertilized. As a consequence, thousands of farm ponds have been constructed annually for the last ten years. At the present time there is no apparent decrease in the number being built each year.

Methods of managing farm ponds for fishing were worked out in the south-eastern section of the United States by Professor H. S. Swingle of the Alabama Polytechnic Institute. Stocking is based upon the theory that, in order to have adequate utilization of natural foods, it is essential to stock the ponds with species which will maintain a balance between prey and predator species. Bluegills, which utilize the insect fauna, are the prey species. Large-mouth black bass is the predator species. If the proper balance between the weight and number of these two species is maintained, maximum production of each may be anticipated. Based upon a theoretical weight of 4 ozs. for a bluegill and approximately 1 lb. for bass, an initial stocking rate of 100 bass and 1,500 bluegills was established.

In order to obtain maximum production, the pond must be fertilized. Fertilizer is applied weekly at the rate of 100 lb. per acre. The total amount used during a year is determined by the maintenance of a water bloom. After the water bloom has been obtained and has reached such a density that objects are visible for no more than 12 in. to 15 in. below the surface, only sufficient fertilizer to maintain this density is used. Ordinary commercial fertilizers are generally used, although Mr. Swingle makes specific recommendations on the mineral content. In many cases commercial fertilizer has been used in conjunction with manures commonly found on the farm.

Fertilization accomplishes two purposes. By maintaining a water bloom of the required density, the water is kept at maximum fertility and a crop approximating 200 lb. of fish per acre per year may be obtained. This is for hook-and-line fishing. It is known that larger crops of "scrap" species, which are not popular with the American angler, could be obtained if they were introduced. These might include carp, catfish, buffalo fish, and others. However, the production of these market fish has never been practised in the United States because people are much more interested in those taken by hook-and-line.

The other objective of fertilization is to eliminate underwater vegetation. In so doing the whole pond can be foraged by the predator species. Bluegills, upon which the bass prey, have a high reproductive potential so that if protection is afforded them they will soon overpopulate the pond. The end result will be a large population of stunted bluegills and suspension of reproduction by both species.

After elimination of all vegetation, the bass may forage at will. They may then consume the small bluegills and, as a result, will grow much more rapidly. Because the population of small fish is kept under control by predation, more food is available for the remainder and there is a much more rapid rate of growth among the bluegills. By encouraging utilization of as many of the large fish as can be taken by hook-and-line, the populations are further reduced and the growth rate further increased because of more available space and food. Under an ideal situation as outlined above, ponds have been producing for years without any indication that populations are getting out of balance. The production has held up without diminution.

In practical application on a large scale, the management of farm ponds has not worked out as described. It is very difficult to convince the fisherman that ponds must be fished heavily to obtain maximum production. For over more than half-a-century he has been educated to the idea of protection by closing areas to fishing and by regulation of size and bag limits. Consequently, public thinking cannot be changed in a short period of time.

Recent investigations in other sections of the United States have indicated that climatic differences, differences in fishing preference, and differences in rates of reproduction may alter the recommendations made for the south-east section of the country. In many areas fertilizers are not used on a large scale in farming operations and farmers are prone to neglect the fertilization of farm ponds. Little fertilization is worse than none at all, for it encourages the growth of vegetation and may defeat the very purpose for which it is intended.

It is not clearly understood by the public that there are farm ponds and farm fish-ponds. Every pond created cannot be managed for fish any more than every body of water is suited to fish. Many farmers are bound to be disappointed because a pond built for stock watering or irrigation does not produce good fishing. Extreme fluctuations in water-levels and turbidity are the two most important factors preventing proper management, although an excessive flow of water through the pond is high in importance in preventing good fishing.

Fishery management technicians and soil conservationists have a large educational job to perform. The whole fabric of thinking by the fisherman must be changed. He must be taught to utilize the available supply; he must be taught that the management of the farm pond involves principles of good fish-husbandry; and he must be made to realize that fish cannot be produced in quantity simply because water is available. This is the major problem in promoting a successful farm fish-pond programme. Additional research is also required to adapt management practices to the ecological characteristics of the land and fishing preferences of fishermen.

Naturally, the development of a farm-pond programme became closely associated with soil-conservation activities. Because a pond may be constructed at very little cost, with equipment already on the farm, and at such times as the farmer may find convenient, they have been constructed by the thousands in various sections of the country. They have become an important adjunct to the agricultural economy of the country.

The average individual who constructs a pond desires to obtain good hook-and-line fishing and to use the recreational values it will provide. In order to obtain good fishing, certain ecological requirements must be fulfilled. These ecological requirements are dependent upon activities associated with the surrounding land. If the waters are silty, the habitat is not conducive to the production of food for fish and the pond does not provide good hook-and-line fishing. The farmer may then undertake any one of a number of measures to alleviate the situation. These improvements will depend upon the type of habitat and the particular farm. Good farm practices, primarily for the reduction of erosion, are essential to the improvement of the farm pond. The pond-owner may find it desirable to adopt contour farming methods to prevent rapid run-off from the slopes. Where the run-off is somewhat slower but soils are light, his programme may include strip cropping. If the slopes are very steep, he may have to construct terraces. Where erosion is a serious problem, the farmer may undertake to control gullies on the watershed above the pond area or even on other parts of the farm. Another category of measures that may assist in the improvement of the recreational advantages of the farm pond will include increased cover about the pond area. This may involve the use of land suited primarily to timber for the production of lumber and wood for the farm; it may also include placing other types of cover on steep slopes or in the areas surrounding the pond in order to benefit wild-life and increase the value of the property for hunting.

As the farmer becomes more interested in good farm practices and the improvement of the farm pond as a centre for recreational activities, he soon begins to realize that run-off is not a problem. If the organic content of the soil is increased, more of the water will percolate through the soil and improve water conditions on the farm as a whole. Soon the farmer begins to realize also that the increase in organic matter in the soil will increase the production of farm crops.

Most of the farm ponds in this country are being constructed with the idea of increasing the carrying capacity of the farm for livestock. In general, federal and state agencies have advocated fencing farm ponds to prevent the entrance of livestock because these animals tear down the banks and roil the water to such an extent that the recreational values are materially reduced. In such areas, stock-watering devices may be constructed below the pond, and the pond area fenced and maintained for the benefit of wild-life and recreational use. These recommendations do not apply in many sections because experience has shown that access to the pond by livestock may not be an important factor where adequate cover is maintained on the watershed or where certain types of soil exist. Some of the best and most fertile farm ponds are located in grazing areas where pastures have been properly maintained and where cattle have direct access to the pond. Most of these ponds require little or no fertilizer.

Of second importance in the farm-pond programme is the production of food. If the farm pond is properly managed, it will produce 200 lb. or more of fish per acre. The fish produced may provide a valuable supplement to the diet. This indirectly improves the general well-being of the farmer.

Ponds are important to the farmer because they provide a source of recreation. They may be used for boating, swimming, skating, and other activities where the owner and his friends may relax. They are important as a source of water for irrigation; this potentiality, however, has not been fully explored.

Many state and federal organizations have come to the conclusion that if construction of farm ponds can be stimulated and accelerated to such a degree that enough ponds are built, the effect on the economy of the country will be very pronounced. With the improvement of the soil on an extensive scale, the water-holding capacity will be increased by the additional cover and an increased amount of organic matter in the soil so that more of the water will percolate to the ground-water supplies. On a large scale, this water-holding capacity will mitigate the occurrence of floods and periodic run-off.

The development of the farm-pond programme and the use of good soil-conservation measures have brought to the attention of federal and state administrators the fact that soil may be classified for certain primary uses. The development of a farm-pond programme will eliminate, to a certain degree, the use of borderline lands for agriculture and encourage the individual to maintain them for the benefit of wild-life. It has been demonstrated that any wild-life that can be maintained on the area will produce income in addition to the agricultural products obtainable from the soil. Revenues may be realized from fishing and hunting privileges and from furs obtained by trapping, thus augmenting the income of the farmer. The farm pond, perhaps, has had more influence than any other single factor on the reduction of soil erosion and the proper use of soil to provide diversified crops. It has made the farmer conscious of the fact that he is a steward of the soil with a responsibility for its conservation.

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Pond Culture of Warm-Water Fishes (With Special Reference to *Bañgos* or Milk Fish Cultivation Under Philippine Conditions)

HERMINIO R. RABANAL

ABSTRACT

The 19 million Filipinos who compose the present population of the Philippines depend for the protein in their diet principally upon fish. The great bulk of this supply is obtained by fishing from natural waters. But this source is highly fluctuating and has several draw-backs.

However, the country can look upon fish-ponds as the source of a steady supply of fish. The great potentiality of this source is favoured by the existence of almost 600,000 hectares (1 hectare equals 2.47 acres) of undeveloped fresh and salt-water swamps which if converted into fish-ponds, may be capable of producing as much as 200 million kg. of fish annually.

The giant *goramy*, *pla-salit*, and carp have proven to be suitable for pond-culture in fresh-water areas.

In brackish and salt water, the *bañgos* is a species possessing a combination of characteristics ideal for pond fish-culture. The fry are gathered in great quantities at certain seasons of the year and stocked in well-prepared fish-ponds. The technique of rearing milk fish is an industry involving the investment of about P 300 million (P 2.00 equals $1.00). The present fish-pond acreage of almost 70,000 hectares produces about 23 million kg. of fish valued at P 34 million.

ROLE OF POND CULTURE IN FOOD PRODUCTION

INTRODUCTION

The Philippines is an archipelago of over 7,000 large and small islands situated between 4° 45′ and 21° 25′ N latitude and 116° and 127° E longitude. It is at the crumpled edge of the Asiatic platform in the South-west Pacific. Because of the nature of its topography and geology, the country is essentially maritime. Its population of over 19 million depends largely on fish for the protein in their diet. This protein need is chiefly supplied from fish captured in natural waters. But this source is so highly fluctuating that even if it could be fully developed it can only barely supply the needs of the ever increasing population. Unless it is properly exploited and conserved this source of supply cannot cope with the country's need. Besides, the characteristic poverty of tropical waters in quantities of fish as well as the steep topography of the Philippine shore-line limits fishing areas.

For a steady supply of fish, that would meet the needs of the increasing population and check the expected decline in fishing in natural waters, the country looks upon the culture of warm-water fishes for its salvation. The potentiality of this source of Philippine food supply is based on the premise that there exists a very extensive acreage of fresh-water and salt-water marshes and swamps, part of the public domain now lying idle which can be converted into fish-ponds. Furthermore, the country has species of fish found very favourable for pond-cultivation. The milk fish or *bañgos*, scientifically known as *Chanos chanos* (Forskål), is ideally suited for brackish-water and salt-water ponds. In fresh waters, introduced species, particularly the giant goramy, *Osphronemus goramy*, the small goramy or *pla-salit*, *Trichogaster pectoralis*, and the carp, *Cyprinus carpio*, have been proven to have possibilities.

AREAS OF DEVELOPED FISH-PONDS AND PRODUCTION

The latest statistical records show that there are at present 69,266.14 hectares of developed fish-ponds. A conservative estimate of the annual production in these ponds is 1,000 fish per hectare. At three fish per kg., the total acreage is expected to produce about 23,088,666 kg. of fish annually, valued at about P34,632,999 (P2.00 equals $1.00). Pre-war estimates show that around the Manila Bay area alone there was an investment of about P50 million. After the Second World War, this investment increased five to ten times. New areas were opened for cultivation. Therefore, the present valuation of the annual investment in the Philippine pond-fish industry can be placed at about P350 million.

Considering that the annual *per capita* consumption of fish in this country is 31.32 kg., the present population of 19 million would need 595,080,000 kg. of fish each year. Based upon present production estimates of fish-ponds of 23,088,667 kg., there remain 571,991,333 kg. to be supplied by fishing from natural waters and by importation.

ADVANTAGES OF POND-PRODUCED FISH

Because of the constant reliance upon fish to supply the protein in their diet, the people have developed a liking for certain species of fish, especially for those in a fresh state. Even after the establishment of cold storage plants and the inflow of canned fishery products, fresh fish still maintain their preferred position in the national taste. To satisfy this desire, pond-produced fish supplies are obtained from places easily accessible to transportation facilities and can, therefore, be brought to the market fresh at all times. Besides, the catching can be stopped when there is glut of fish, and resumed when the market demand rises. There is also the possibility of more adequate sanitary precaution in production because it can be placed under very effective control by experienced fish culturists in the industry.

POND MANAGEMENT

SELECTION OF SPECIES

The Philippines, like any other tropical country, is poor in quantity, but rich in number of species, of fish. In Philippine waters over 2,000 known species of fish abound. However, there are a few native and also some introduced species which are amenable to pond culture. In no other fish than *bañgos* are the characteristics favourable for good cultivation combined. Its adaptability is based on the following considerations:

(1) Nature of food and feeding habits. The *bañgos* is chiefly vegetarian and absolutely non-cannibalistic in habit. Under cultivation it feeds on algae or *lumut* which, under favourable environment, grows in enormous quantities in brackish and salt-water ponds.

(2) Hardiness. The *bañgos* under cultivation has been found to be hardy in all its stages of growth.

(3) Availability of fry. *Bañgos* is highly prolific. A single breeder is known to produce from 3 to 5 million eggs per spawning. The eggs hatch along sandy shores and the fry are gathered in enormous quantities during certain seasons of the year.

(4) Rate of growth. The growth rate is extremely rapid so that it is even possible to harvest once to thrice a year from the same pond.

(5) Palatability and economic demand. *Bañgos* is a fish of delicate flavour and being always in fresh state when brought to the market, it demands high market value.

(6) Facility and ease of harvest. Brackish and marine ponds are usually capable of drainage so that the harvesting is not a problem. Besides, the habit of the fish of going against the current is taken advantage of for this purpose.

In fresh-water ponds, some introduced species, namely, the giant *goramy*, the *pla-salit* and the carp have been found favourable for culture. The giant goramy is very amenable as a pond fish because of its herbivorous and non-cannibalistic habits. It also breeds readily in confinement, is hardy, and possesses superior eating qualities. The *pla-salit* is a smaller and less palatable fish than the former but it is hardy and highly prolific and can, therefore, be used in stocking inland waters. The carp is omnivorous, hardy, and very prolific, and can likewise be used in replenishing depleted inland waters.

POND FERTILIZATION

In order to increase the productivity of fish-ponds, fertilization is necessary. This is accomplished either by natural or artificial methods. Under natural conditions Philippine brackish and marine ponds attain fertilization in the following ways:

(1) From the water-supply. The pond-water is periodically freshened, that is, the old stale water in the ponds is changed with new and fresh tidal water during the incoming spring tides. This new water carries a load of nutrients and micro-organisms.

(2) From the substratum. The bottom soil which is generally clayey, muddy clay or sandy clay or loam, possesses most of the nutrients necessary for the growth of the fish food organisms. If properly dried and exposed to the sun before letting in water, organic decay of vegetable matter and living organisms in the soil would renew soil fertility. Some fish-pond caretakers practise cultivation or turning over of the soil substratum in order to make the nutrients in the inner layers of the soil available to the surface layers.

(3) Drainage from dykes and from uplands. During heavy rains and floods the water that drains from the dikes and from uplands carries nutrient sediments, thus adding to the fertility of the fish-ponds.

Artificial fertilization of fish-ponds in the Philippines has not come into general use probably because of the availability of large tracts of vacant fertile areas for expansion. Besides, commercial fertilizers, either organic or inorganic in nature, are so limited in supply that all available stock is utilized to enrich soil for agricultural crops. There is also a need of knowing the chemistry of the pond-water and soil in order to execute artificial fertilization of fish-ponds most effectively and economically.

STOCKING

The stocking of fish-ponds with the fish to be cultivated must be done with the most meticulous care. At this time the tiny and delicate fry or seeds are in the most critical period of their lives. If not properly handled, great mortality will be incurred. Prior to the arrival of the seed fry, the nurseries are cleaned and dried in order to eradicate all fish enemies. Water is allowed into the nursery ponds to a depth of a few inches. The gates or inlet pipes should be carefully screened with fine bamboo screens and Manila hemp fibre cloth to prevent the entrance of fish enemies. Under favourable conditions a thick growth of the micro-benthic organisms, the natural food of the fry, develops at the bottom of the pond.

The fry are received in fish-pond centres during the fry season from the various fishing grounds. They are transported in porous earthen jars which keep them cool and vigorous even in long transit.

Prior to stocking, the fry are first sorted in order to eliminate the fry of predatory species mixed in with the milk fish. In the nurseries, thirty to fifty fry are usually stocked per square metre of pond depending upon the quantity of the food available. Stocking is generally done in the cooler parts of the day, that is, in the late evenings or early mornings, to minimize mortality. The water characteristics such as salinity, pH, and temperature of the pond and the jars containing the fry are first examined to verify any great range in these characteristics so that proper adjustments can be provided. In order to minimize the sudden change of environment of the fry which may cause heavy mortality, the containers should be tilted in the pond and the pond-water slowly and gradually allowed to dilute the water in the container. This would give the fry time to adjust themselves.

In the nurseries, the tiny and delicate fry measuring 10 mm. to 12 mm. in length, attain the fingerling stage in a period of two months or more. At this stage, they are about 40 mm. to 50 mm. long. With enough food these fingerlings can be kept indefinitely at this stunted state in the shallow and small nursery ponds. The rearing ponds which are bigger and deeper ponds are used in rearing the fingerlings to marketable size. Like the nurseries, these ponds should be drained before stocking. Then under propitious conditions, filamentous green algae, the natural food of the growing milk fish, should develop a luxuriant growth in the pond. Depending upon the amount of available food, the rearing ponds are normally stocked with 1,000 to 3,000 fish per hectare (1 hectare equals 2.47 acres) or one fish for every 3 to 10 sq. metres. Rearing ponds with plenty of fish food, stocked with an ideal number of fish, can maintain growth of fish to marketable size in a period of from three months to a year. Here the fish are left to grow without much care except occasional freshening of the water, and checking the gates and dykes for leaks. Attempts are also made to protect the cultivated species from predators composed mainly of other fishes, reptiles and birds.

CROPPING

Cropping or harvesting of *bañgos* is done with great facility. First of all the fish-pond caretaker determines when to harvest. He is guided by many factors, namely:

(1) The fish to be harvested should be large enough to demand a good price in the market (2). Ponds where food has become wanting or scarce should be cropped, if not completely at least partially (3). Harvest when convenient in relation to the tide conditions which are utilized in draining and freshening the ponds—two processes utilized in cropping methods (4). Harvest when there is market demand, as during stormy days or poor fishing days or fish demand due to local customs or beliefs.

Bañgos are harvested by utilizing the natural instinct of the fish of going against the current when fresh tidal water is allowed into the pond. Prior to letting in water for harvesting purposes the rearing pond should have its water drained to a very low level during the preceding low tide. This would expose the fish to higher temperature and other unfavourable water characteristics such as O_2-lack, oversupply of CO_2, lessened space, and turbidity. During the incoming high tide, water is allowed in and with the gate screens opened the fish go against the current through the gates to a catching pond or other prepared enclosure for temporary confinement before harvest. By these methods, most, if not all of the milk fish, can usually be harvested. The fish once confined can simply be bailed out by dip nets and loaded on boats to trucks which take them to market.

Sometimes it is desirable to empty a rearing pond completely during harvest in order to prepare this pond for a new stock of fingerlings and to eradicate fish enemies. This can be accomplished by completely draining the pond when possible, leaving water only in the catching pond which is merely a small deep pond unit near the rearing-pond gate.

Other miscellaneous species of fishes and crustaceans besides the species under cultivation usually enter the pond during their fry stage and grow there. These forms naturally provide additional income for the fish-pond. These other forms consist of several species of mullets (Mugilidae), spade fish (Scatophagidae), siganids (Siganidae), ten pounders (Elopidae), tarpons (Megalopidae), sea basses and snappers (Latidae, Serranidae, and Lutjanidae), gobies, and several others. The crustaceans include shrimps and crabs. The shrimps comprise several species of Peneaus and occasionally Palaemon. Crabs are represented by two economic species, namely, *Scylla serrata* and *Neptunus pelagicus*.

In some instances when partial harvest is to be undertaken, a drag seine or gill net is used in the pond. The advantage derived from cropping this way is that the meshes could be so regulated that only the bigger ones will be harvested by using bigger-meshed nets.

POTENTIAL POSSIBILITIES OF POND CULTURE AS AN ADDITIONAL SOURCE OF FOOD

UNDEVELOPED SWAMPS

The latest survey conducted by the Bureau of Fisheries and the Bureau of Forestry shows that there are 168,657 hectares of fresh-water swamps and 430,405 hectares of salt-water mangrove swamps thus making a grand total of 599,062 hectares of vacant lands suitable for development into fish-ponds. The fresh-water areas could be devoted to the culture of goramy, carp or some of the common native species such as the mudfish (*Ophicephalus* striatus), catfish (*Clarias batrachus*) and climbing perch (*Anabas testudineus*). Here the Government might take a hand by developing part of these lands as propagation stations for breeding the above-mentioned species to replenish depleted inland waters. This would provide the unaccounted for but constant and steady supply of fish for the common masses of the population.

The over 400,000 hectares of salt-water swamps may be developed into *bañgos* fish-ponds. When fully developed this additional fish-pond acreage is estimated to produce no less than 130 million kg. of fish. This if coupled with the expected increase in the production of fresh-water fish by the full development of available areas would amount to about 200 kg. This figure will lessen to a considerable degree the shortage in fish supply of the present population. Here is a potential source of food suited to the taste of the people. It is one which labour, capital, and the Government could go far in promoting for the desired goal of fisheries rehabilitation and fish-food self-sufficiency.

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Stocking and Rearing for River and Inland Fisheries

G. C. D. HOS

COMMERCIAL AND SPORT FISHING

In the Netherlands commercial inland fishery (carried on in polders, pools, lakes, "boezems" or systems of reservoirs for superfluous polder-water) is engaged in by from 2,000 to 2,500 undertakings, excluding the fishery in lake IJssel. In addition, some hundreds of thousands of persons indulge in sport fishing, for the fishing-rod is exclusively used, baited with fish (especially for catching pike or pike perch) and the bob (especially for catching eel).

Commercial fishery is carried on mainly by one-man businesses, only a few employ one or more hands, and these concerns are chiefly restricted to the rivers and some large pools and lakes.

About the form of organization of the commercial and sport fishermen the following observations may be stated. Nearly all commercial fishermen are members of a local or district fishermen's association. All these associations are affiliated to a superimposed national union, viz., the Fresh Water Fishery Head Department of the Nederlandse Heide Maatschappij (a Dutch reclaiming society).

Many sport fishermen are also organized in local associations, which are also affiliated to one of the two national organizations.

In the last twenty-five years the relations between the commercial and the sport fishermen have not been friendly. However, a committee established by the Government to promote co-operation between commercial and sport fishermen, in which the two groups are also represented, has done fruitful work. Hence it may be expected that if the recommendations of the committee are enacted, this will lead to a marked improvement in relations. This has, indeed, already set in.

FISH STOCKING AND REARING

With regard to the fishery, various rules and provisions have been laid down aiming at the protection of the fish stock and an increase in fish production. Particular mention may be made of the specifications as to minimum length of the fish, the closed seasons which have been fixed, specifications for various sorts of fish and fishing-gear, and the regulations regarding the minimum size of the meshes of the fishing nets.

All these measures aim at protecting immature fish and definite age-classes of the fish stock as well as at creating an adequate opportunity for the fish to propagate themselves undisturbedly, thus ensuring a sufficient egg production—in short, at obtaining naturally an optimum density of desired sorts of fish and, in consequence, a maximum production.

In addition to a fishing right, whether as owner, tenant or otherwise, the fisherman must possess a fishing—or angling—licence (according to the fishing-gear to be used) issued by the State at fixed fees which accrue to the public revenue. In excess of these fees a certain contribution towards the improvement of the fish stock is imposed. Out of the funds thus obtained are defrayed the expenses in connexion with measures of a more artificial nature, viz., the rearing of and stocking with fry or fingerlings as well as the transplanting of fish from overstocked to understocked waters.

Some sorts of fish are very well suited for transplantation, i.e., eels from 20 cm. to 27 cm. in length, montee (glass eel), roach, bream, perch, pike and pike perch. Young fry of eel and montee are mainly used for stocking such waters as cannot be sufficiently stocked by natural influx. Other sorts of fish are used for the stocking of waters which are understocked through natural causes, such as severe frost etc.

It should be stated here that small quantities of montee are imported from France. Attempts at effecting importation from England have, so far, been rather unsuccessful. Ways and means are being sought to create better possibilities in this direction.

Most used for hatching and stocking purposes are pike, carp and tench for the stocking of inland waters and salmon and sea trout for the stocking of rivers.

Hatching of and stocking with pike, carp and tench

Pike. The State has established a few modern pike-hatching houses. Near the spawning-season of the pike (generally by the end of March) the required number of ripe fish are caught. The fish are stripped, the roe and milt thus obtained are put together in a basin and stirred with a feather so as to distribute the milt evenly. Then water is added, after which the fertilized eggs are put in the apparatus in which water is kept circulating.

Regular control, systematic removal of mouldy eggs, maintenance of records of day and night temperatures as well as of further particulars (date and hour of fertilization, course of death-rate, date and hour of commencement of births etc.) are essential points to be observed in respect of every apparatus in order to ensure good results. Eggs obtained at different times are treated in different apparatus.

About the time of birth the eggs are placed on hatching-sieves (with holes of about 0.85 mm.) which are arranged in tiers in the hatching-troughs. The circulation of the water is then relaxed. As the hatching-sieves are immersed in the water of the hatching-troughs the larvae on emerging from the eggs are carried off by the weak circulation of the water in the hatching-troughs, while the egg-shells remain on the hatching-sieves and may easily be removed.

In the hatching-troughs are placed water hemlock or branches of needle-leaved trees to which the fry may attach themselves and develop further. Care is taken to maintain a circulation of water sufficiently rich in oxygen.

As soon as the fry begin to swim the time has arrived for placing them in free water. They are transported in cans and planted in shallow water near the bank preferably in a vegetated area. All stock should be disseminated as widely as possible to take full advantage of available cover and food supply. The use of a rowing-boat and a syphon hose may be of excellent service here.

Carp and tench are planted in various inland waters, a service that is financially supported by the Government. These fish are hatched in the rearing-ponds of the Nederlandse Heide Maatschappij. The head official of these rearing-ponds has made the following remarks on the hatching of carp, tench and trout.

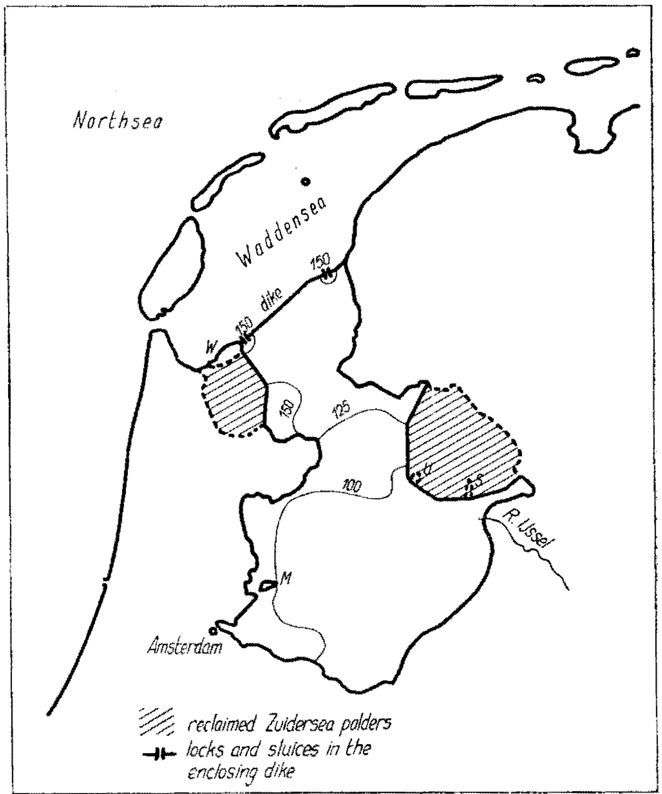
In the hatchery ponds at Valkenswaard, Bergeijk and Vaessen, fish of the carp family are annually hatched. These are transplanted as one- and two-summer-old and exceptionally as three-summer-old specimens from the hatchery ponds to the Dutch inland waters.

These fish are common carps of the Galician species, in three varieties: the mirror carp, the scale carp and the leather carp, highbacked forms which readily adapt themselves to the climatic conditions prevailing in the Netherlands. The hatching is done by the Dubisch method which includes hatching and rearing-ponds. In the ponds a four-year or five-year rotation crop is grown.

In rotation every four or five years a few ponds are drained for one year and sown with a field crop—barley, rye or oats. On the stubbles in which a clover or a grass crop has developed carp fry or one-summer-old carps are planted, a measure which ensures a better output of fry than in the case of ponds which are year-in, year-out populated with carp. A portion of the carp crop, especially the small specimens of one or two summers old which are less than 25 cm. in length is kept in the ponds till they are two or three summers old when they are placed as forage in water containing fish of prey. The sport fishermen especially show a keen interest in the hatchery product: "Common carp". Every year a combination of fertilizers is sown in the ponds and, in addition, during the summer months (May-October) a vegetable feed product rich in protein is given, e.g., lupine, beans, soya.

The total area of the ponds where fry are reared is approximately 200 hectares.

In the same way a yearly production of tench fry is attained by stocking some ponds, preferably those with a soft bottom and a dense vegetation, with tench. The indigenous Dutch tench is hardly ever used for this purpose; the massuric tench which was brought from Poland to the Netherlands in 1900 has proved to be a good pond fish.



The stocking of the Dutch polder waters (which are typical tench waters) with the two- or three-year-old specimens of this variety results in better catches, both quantitatively and qualitatively. As much as 15 hectares of the area of the ponds is used for rearing tench fry, in which, naturally, a keen interest is shown by the commercial fishermen.

The Dubisch method is not very suitable for the rearing of tench fry; preference is given to using four ponds in which some rearing-tenches propagate themselves, after which they are speedily removed. The offspring are kept in the pond for two years.

Hatching and stocking with salmon and sea trout

In former years salmon were regularly reared in the rearing-ponds at Arnhem, Vaassen and Gulpen under the international agreement between Belgium, Luxemburg, France, Switzerland, Germany and the Netherlands for the stocking of the basin of the Rhine and the Meuse with young salmon. During the Second World War this international agreement was discontinued and stocking with young salmon has not taken place for eight years past. Hence, the catches of the salmon fishers have fallen off considerably. But as soon as international conditions permit a fresh agreement (Salmon Treaty) between the Rhine States, the hatching of and stocking with young salmon may be resumed.

In addition to salmon, sea trout also are caught in these rivers. It appears that the catches of this variety of salmon can be increased through rearing them in ponds and planting them in the tributary brooks of the Meuse. Therefore, the Netherlands Fisheries inspection charges the Nederlandse Heide Maatschappij with the annual rearing of sea trout. The salmon rearing-ponds of the Nederlandse Heide Maatschappij, now reduced to inactivity, are well equipped to store the nearly-hatched sea trout eggs, and to hatch them to fry and eight-week or one-year-old trout which are then placed in the tributary brooks of the Rhine and the Meuse.

For this purpose some hundreds of thousands of embryonic sea-trout eggs are annually purchased in Denmark. The rearing-station at Gulpen especially promises well for the future, for it has two supply-pipes of calcareous water rich in oxygen, which are used alternately for certain periods. The water yields good hatching results during the winter season and ensures good growth and development in summer.

A Review of Fish-Farming in Israel

M. SHELUBSKY[1]

INTRODUCTION

Food supply, especially proteins, has become a world problem during the last few years. Food shortage became acute following the Second World War, and means were sought to overcome this shortage by new and better ways of food production. Under these circumstances, fish-farming in natural and artificial ponds assumed growing importance in national and world-supply planning.

In Israel as well, supply authorities had and still have to wrestle with this problem of animal-protein food supply to the inhabitants. Israel, at that time Palestine, had always been almost entirely dependent on foreign markets for its protein supply, and in time of war, when normal communications and commerce with the outside world are disturbed, the danger of hunger becomes imminent. Hunger became a real threat during the Second World War and the beginning of the war of independence, after the end of the British Mandate.

Special efforts were therefore made to substitute local for foreign sources by speeding up and enlarging local production. Attempts were made to breed cattle, poultry, to exploit natural fisheries and to breed fish in artificial ponds. The last solution has assumed ever-growing importance in the last few years.

Two important factors contributing to the growth of fish-farming were:

1. The existence of vast areas abandoned and undeveloped for ages, including swamps and salty lands, unfit for any other agricultural use.

2. The presence of a relatively large number of brackish water sources, containing 1,000 mm. per litre and more of chlorine, which are also unfit for any other agricultural purpose.

These areas could be settled and exploited as sources of food supply if used for fish-farming.

[1]I am indebted to Mr. M. Neutaler, the professional adviser and secretary of the Association of Fishbreeders in Israel, for his help in the collection of the data on the practical aspects of fish-farming in Israel.

STAGES OF DEVELOPMENT

Fish-farming in Israel as compared with China's millennial experience in this industry or with the centennial experience of Europe is very young. It exists only since 1938, when the first ponds were dug by settlers who learned the fundamentals of this industry in Central Europe. They brought a number of common carps from Yugoslavia, and in the spring of that same year the first spawning took place.

The first ponds were located in the Valley of Beth-Shaan (Beisan), which has many brackish water sources and marshy land not easily put to any other agricultural use.

Already in the first year climatic and other conditions in Israel proved to be well suited for the cultivation of carps, production being much higher than that usually obtained in Europe. This was probably due to the many months of growth with a relatively high average temperature and also the intensive farming methods of carp feeding and artificial fertilization of the ponds.

The area of fish-farming was rapidly expanded, and covered new grounds which were previously uncultivated. In 1938, the total pond surface was approximately 10 hectares. Annual production amounted to approximately 10 tons of fish. In 1940, the area grew to 200 hectares and today it approaches 2,000 hectares, with a yield of more than 3,000 tons of fish per annum.

KINDS OF FISH BRED

The common carp (*Cyprinus carpio*) of Yugoslav origin is the only fish grown on a commercial scale in Israel. Lately attempts have been made to breed other types of carp brought from Switzerland and France. At present, experiments comparing the new types, as to suitability and yield, with the locally-grown type are being conducted.

Attempts are also being made to cultivate other kinds of fish, such as:

1. The rainbow trout. Its cultivation is carried out in a small area in the north of Israel, where water is plentiful and has a low and constant temperature of 16 degrees to 18 degrees C.

2. Tench (*Tinia tinca*) of Swiss origin. The intention was to cultivate it together with the common carp, thus increasing pond productivity. Preliminary experiments seem to indicate that the tench is unsuitable to local conditions.

3. Grey mullet (*Mugil cephalus*). The fry of this kind is caught in a brackish river and transferred for cultivation into special ponds.

4. Tilapia. This kind occasionally appears in ponds via water-supplies from nearby natural water sources. Attempts are now being made to cultivate suitable species of this kind individually in ponds.

The cultivation of the last four kinds of fish has not as yet passed the experimental stage.

THE MAIN BREEDING AREAS

As a general rule the ponds are concentrated in valleys. The pond areas may be divided into four main categories:

1. Area receiving a supply of brackish water.
2. Marsh areas and areas not sufficiently drained.
3. Salty soils.
4. Fertile areas with a surplus water-supply.

Of the different areas in which fish-farming is concentrated in Israel, it is worth while to pay special attention to the following, owing to their specific characteristics:

1. *The Valley of Beth-Shaan (Beisan)*

This valley comprises some 15,000 hectares of which 2,400 were allotted for fish-ponds, by the competent planning authorities of Israel. The valley contains many brackish water sources of approximately 1,000 mg. of chlorine per litre, yielding some 70 million cub. metres per annum. Constant use of this water for irrigation turns the land salty, thus the only possible use of these water-sources is for fish-farming. In this area fish-farming constitutes the mainstay of agriculture, and in fact the economic existence of these agricultural settlements depends thereon.

There are other areas in Israel containing brackish water sources in which fish-farming is a basic and essential industry, as for example the Valley of Zebulun (near Haifa) with some 200 hectares of fish ponds.

2. *The Hula Valley*

It is mainly marsh-land and has an abundant water-supply. It contains today some 500 hectares of fish-ponds, which will be enlarged according to present planning by an additional 2,400 hectares. This enlargement will depend on the Hula Valley development plans, and especially on the drainage of the marsh-land.

Planning includes the utilization of a large part of the present Hula Lake as fish-pond area. It is worthy of note that partly swampy soils situated near the marshes are already being utilized as ponds, the water being supplied to these ponds from the marshes. Also here, as in the Beth-Shaan Valley, the development of fish-ponds makes possible the agricultural utilization of a large part of the area.

3. *The upper Jordan Valley*

The Valley is situated some 70 metres below sea-level. It has a high average temperature and abundant water-supply. These two factors render the area very suitable for fish-farming. For these reasons fertile soils, though suitable for other agricultural purposes, are employed for fish-farming.

4. *The Sea Plain*

The Plain contains some 200 hectares of fish-ponds, part of which were formerly marshlands.

5. *Dead Sea Plain*

This area is of special interest. Before the war of independence some 50 hectares of fish-ponds were situated in the Potash Company compound on the shores of the Dead Sea, 390 metres below sea-level. The percentage of salt in this soil is such that agriculture seemed to be unthinkable. However, successful agricultural attempts were made by an expensive process of repeated washing of the soil with fresh water brought from the Jordan.

The erection of fish-ponds in the area supplied with water from the Jordan proved successful, although the water of the ponds contained usually up to 5,000 mg. of chlorine per litre and in extreme cases up to 9,000 mg. per litre. The yield of these ponds was good even in comparison with other better-favoured areas.

In the attached Table, the amount of work invested and production obtained in different areas during the years 1947 and 1948 is summarized and compared. The figures contained in the Table were collected and checked by the statistical branch of the Fisheries Department of the Ministry of Agriculture.

Production numbers are comparatively low owing to the fact that certain areas were not fully and properly cultivated during the war.

The Productivity of Different Fish-Farming Areas in Israel, 1947-1948

Area	1947				1948			
	Total pond surface (in dunams)[1]	*Annual Production (in tons)*	*Average yield (per dunam)*	*Work kg-invested (days)*	*Total pond surface (in dunams)*	*Annual Production (in tons)*	*Average yield (per dunam)*	*Work kg-invested (days)*
1. Hula Valley	3,051½	387.2	127	25,165	2,970	469.6	158	28,178
2. Jordan Valley	1,915	375.3	196	24,397	1,859	412.1	222	24,726
3. Beth-Shaan Valley	3,838	590.0	154	38,346	4,505	760.9	169	45,655
4. Yezrael Valley	644½	87.3	135	5,676	650	130.7	201	7,842
5. Zebulun Valley	718	54.9	76	3,571	1,370	164.0	120	9,843
6. Sea-plain	1,570	194.1	124	12,612	1,944	296.2	152	17,777
7. Dead Sea plain	450	33.4	74	2,173	450	19.9	44	1,197
TOTAL	12,187	1,722.2	141	121,940	13,748	2,253.4	164	135,218

[1] 1 dunam = 1,000 square metres.

CONSTRUCTION OF FISH-PONDS

Construction of ponds as to shape, size and depth, is influenced by the general features of the country. The area of individual ponds varies between 1 and 8 hectares. Approximately 10 per cent of the area is allotted for small ponds not bigger than 0.2 hectare which are used for spawning and storing of the fish. The depth of the ponds varies between 0.5 and 2 metres, being usually 1 metre. Ponds are constructed by excavating and levelling machinery, the excavated soil being used as an embankment. In flat areas where any shape can be made at will, a rectangular form is preferred. Special water openings are constructed in order to enable the transfer and re-use of the water in other ponds.

FEEDING AND FERTILIZING

The intensive breeding of fish in Israel is based on artificial feeding and also on fertilization and manuring of the water. The fish are fed from the earliest stages. The materials usually used as food are oil-cakes, lupin seeds and also various grains.

At present some 90 per cent of the food supplied to the fish is chemically extracted oil-cake from cotton seed, containing 36 to 37 per cent protein. The yield of fish per kilogramme of this food is 1: 4-5, i.e., 4 to 5 kg. of this food are needed for the receipt of 1 kg. of marketable fish. Some 50 per cent of the oil-cake is supplied as a by-product of the local oil industry and the rest is imported.

Fertilization is carried out by using some 10 to 20 cub. cm. of stable manure per hectare per annum and in addition substantial quantities of poultry manure and chemical fertilizers.

BREEDING AND STOCKING

Spawning of the carp is carried out in special ponds, the bottoms of which are covered with branches of needle trees for the deposition of the spawn. The fish used for spawning is selected carefully, and special importance is attached to the first selection. Usually two to three male fish are introduced into each spawning pond which contains one to two females.

The spawning takes place usually in the middle of April; the usual amount of fry obtained from each spawning is 300,000 to 500,000. At the end of May the fry is transferred into nursery ponds where the fry is kept until it reaches the weight of 60 to 80 grammes. The normal stocking is 30,000 fry per hectare. From these nurseries the fry is transferred in accordance with the plans of production, into fattening ponds, until June of the following year. The density in these ponds is 2,500 to 4,000 fish per hectare, depending on the fertility of the pond and on the desired marketable size of the fish.

In many fattening ponds, which contain fish weighing not less than 300 grammes, an additional equal number of small fry up to 10 grammes in weight is introduced. This method is based on the assumption that it enables a greater exploitation of the ponds and a more complete use of the artificial and natural food.

The ponds are emptied progressively, thus assuring a year-round supply of fish. The fish taken out of the pond is stored for 12 to 24 hours in concrete storages, where they are cleansed of residues of food and mud. They are brought to the market in specially constructed tanks containing arrangements for oxygen supply, thus reaching the consumer alive. The common commercial weight of carps in Israel markets is 500 to 600 grammes.

DISEASES OF POND FISH

Losses in fish-farming in Israel, caused by diseases and parasitic organisms, were comparatively low, more especially so in light of the fact that fish are crowded and ponds interconnected, thus giving every opportunity for the rapid increase and spread of disease.

Until now the appearance of diseases was in the form of locally occurring epidemics only, and only seldom assuming large proportions. Most of the diseases and parasites which appeared in Israel are known wherever the common carp is grown, but some assumed specific local characteristics as yet undescribed.

Of the diseases and parasites known in Israel the following are important:

Of the ectoparasites, Argulus is wide-spread causing considerable damage.

Of the fungi diseases, Branchiomyces is common, appearing especially in fry and causing high mortality.

Of the local epidemics due to bacteria, the most important are infectious-dropsy caused by *Pseudomouas punctata*, and a gill disease of carps, as yet undescribed in other places, caused by *Myxobacteria*.

In some ponds in the early hours of the morning during summer months, considerable mortality results owing to the lack of soluble oxygen in the water. This is more common in ponds covered with water-blooms composed of different algae of the *cyanophyceae*.

Widespread extensive mortality with heavy losses was due to the mass development of a free-moving toxin producing *Phytoflagellate Prymnesium parvum*. During a certain period, the infected area embraced all fish-ponds in Israel with brackish water of more than 350 mg. of chlorine per litre, an area which then comprised 300 to 500 hectares in the valleys of Beth-Shaan, Zebulun, the Jordan and near the shore of the Dead Sea. This appearance of the *Prymnesium* constituted a serious obstacle to fish-farming in brackish water. A solution was found through the work of K. Reich and M. Ashner, which established the specific killing effect of ammonium on the *Prymnesia* unaccompanied by any ill effects on the fish in the ponds. In practice this was carried out by the introduction of ammonium sulphate in a concentration of 1 : 100,000 into the ponds.

Though an adequate practical solution has been found the biology and especially the epidemiology of this toxin-producing flagellate still await further research and clarification.

FISH-PONDS AND THE DANGER OF MALARIA

It has been proved by experience that if properly constructed and kept, the ponds do not constitute a contributary factor to malaria.

FISH-FARMING AS PART OF THE AGRICULTURAL ECONOMY OF THE LAND

Fish-farming was developed in Israel as one branch of the mixed farming method. Its place in the general structure of agricultural economy and the mutual influences between fish-farming and other branches of agriculture are worthy of a special note.

1. In many places in Israel fish-farming has enlarged the agricultural potential of the land by utilizing areas unfit for anything else. In many places it constituted the main and only basis for settling in the area.

2. The relatively short time needed for a profitable establishment of this branch enabled new settlements to overcome difficulties inherent in other branches.

3. As fish can be fed successfully with certain legumes such as Lupinus, this enlarges the agricultural potentialities of many places. It also combines most favourably with the need for crop rotation.

4. It is contemplated to use part of the fish-pond areas in turn for fish-farming and other agricultural uses. Thus the intensive fertilization of the pond area makes itself felt in the yield and at the same time improves the land for fish-farming in the following years.

5. Fish-farming plays an important part in the utilization of the waste products of the cotton-seed oil industry, cotton-seed being plentiful in the Middle East.

6. Fish-ponds may be used as reservoirs of water in certain areas, in which there is insufficient water-supply, by collecting water during the winter and correlating their emptying with the needs of irrigation.

7. Reservoirs, which are to be erected according to general irrigation development plans (such as the Lowdermilk plan), may be partly used for fish-breeding. This may contribute to the economic benefits of such plans.

Management and Cultivation of Fresh-Water Fish—Principles and Practices with Special Reference to Conditions in New Zealand

A. E. HEFFORD

ABSTRACT

Conditions in New Zealand are characterized by the fact that the only fish hitherto valued and utilized—mainly for recreational angling—are the naturalized Salmonidae. Results of acclimatization of exotics, and lessons derived from their success or non-success, are discussed. Hatchery and stocking techniques, operated primarily for the introduction of imported species, have followed conventional practices. Their application to waters holding established trout populations has often failed to satisfy the requirements of optimum management economy. Where there is adequate spawning ground natural reproduction meets the needs of stock maintenance. Water abstraction, obstacles to migration, erosion, land drainage and pollution have caused deterioration of some formerly excellent trout waters. The carrying capacity of a trout habitat is largely governed by the area of suitable spawning ground. Food supplies for trout, though not equal to those of earlier "virgin" waters, are generally adequate for good growth. Ways and means of economically recruiting collaborating agencies are suggested.

INTRODUCTION

Fresh-water fishery conditions in this island country of the South Pacific differ considerably from those in other parts of the world. However, the fundamental principles underlying the study of fish-life and their practical applications are as universal as the laws of Nature on which they depend.

The special characteristics of New Zealand conditions arise from: (*a*) zoo-geographical facts associated with our insular and Antipodean fauna; and (*b*) socio-political and economic factors connected with a "young", sparsely populated, and well-fed country.

The indigenous fresh-water fishes consist, with one important exception, of a few species of small-sized fish of little food value according to the standards of the British colonists. The exception is the fresh-water eel, represented in New Zealand by a long-finned and a short-finned species (*Anguilla dieffenbachii* and *A. australis* respectively) which are numerous and widely distributed and attain a large size (2)[1]. Before European settlement, eel fisheries were vigorously and skilfully operated by the native Maoris. These fisheries are still pursued in some places but with less intensity and in modified ways; and a small commercial eel fishery for a cannery has been tentatively operated in recent years; but the rich eel fauna of New Zealand at present represents a little-utilized resource of appreciable potential value.

[1]Numbers within parentheses refer to items in the bibliography.

NATURALIZATION OF EXOTIC SPECIES

Acclimatization projects were undertaken at an early date in the history of the Colony. Successfully acclimatized species are the European brown trout (*S. fario*), the "rainbow" trout (*S. gairdneri*—called *irideus* in earlier accounts), quinnat (Chinook) salmon (*Oncorhynchus tschawytscha*) and the Atlantic salmon (*S. salar*), named in order of abundance. These four species constitute nearly the whole total value (current but not perhaps potential), of our fresh-water fishery resources; but other Salmonidae have been naturalized and exist as relatively small stocks in certain waters; viz. *Salvelinus fontinalis*, *Cristivomer namaycush* and *Oncorhynchus nerka* (the last existing as a stunted lake inhabitant). Other, but little esteemed, species are *Perca fluviatilis*, *Cyprinus carpio*, and *Tinca vulgaris* (12).

In the light of present-day science it can be realized that failures or partial failures in acclimatization were due to insufficient understanding of ecological factors in the new environment and to inadequate knowledge of the habits and distribution of the species in relation to its native habitat.

The outstanding example of a foredoomed failure was the attempt to acclimatize the whitefish (*Coregonus clupeiformis*) in two South Island lakes in 1904 to 1907. Small planktonic animals are now known to be sparsely represented in most New Zealand lake faunas, and the two lakes selected as the most suitable for whitefish were very definitely lacking in the sort of plankton on which *Coregonus clupeiformis* depends for food in its young stages.

After the Chinook salmon were established in a south-eastern river sustained efforts to introduce them into other waters were unsuccessful, but by natural migration the species has distributed itself in most of the east coast rivers of the South Island. Similarly fruitless attempts were made to provide the Wanganui River (W. coast; N. Island) with a stock of Atlantic salmon from the established stock of the Waiau River system (S. coast; South Island). Our naturalized Pacific salmon are limited to those coastal waters that are of Antarctic origin and failed to acclimatize permanently when planted in rivers to the North which flow into ocean water of sub-equatorial origin. This correlation has subsequently been established by Davidson and Hutchinson (3). In all probability it also accounts for the disappearance of the Atlantic salmon planted in the Wanganui River.

It is evident that the great majority of our Atlantic salmon are non-migrants to salt-water and have adopted a fresh-water-feeding habit throughout life. A possible reason is that the small indigenous fishes, in the lakes through which the waters of the Waiau River flow and in the river itself, are sufficient to satisfy the salmon's appetite and check the urge to seek salt-water. However, it is definitely known that a few sea-run fish do return. It seems likely that a sufficiently heavy stocking of the Waiau River system, below the lakes, might result in the development of a fair stock of normal sea-running fish. It would require fresh and large importations of ova to ensure a numerous run of smolts of which the surviving fraction would provide an appreciable number of returning adults. The degree of mortality-risk during the marine phase is, however, an unknown quantity. The small number of sockeye salmon ova imported—one shipment of 300,000—would in all probability account for the negative result so far as sea-run fish are concerned. The same reason would apply to the several importations of Atlantic and Pacific salmon ova before 1900; the parcelling out to various districts would nullify any prospect of adequate survival.

The fact that appreciable success, far exceeding expectations in the case of brown and rainbow trout, has attended the introduction of exotic species in New Zealand must be ascribed to the very favourable natural conditions in this well-watered country.

There are points of view that are critical of some of the results of fish acclimatization. There is the "whitebait" fisherman's objection. "Whitebait" in New Zealand are the juvenile *Galaxias attenuatus*. The adults inhabit fresh water but descend to tidal waters to spawn and the fry spend their early phase in the sea from which they run into the rivers in dense shoals which are the object of a lucrative fishery in many rivers. These fishermen blame the trout for the deterioration of the whitebait fishery (for which there are also other causes). Trout fishermen, on the other hand, have agitated for greater restrictions on whitebait fishing in order to conserve and protect a valuable trout food. There are some who allege that the invasion of good trout rivers by quinnat salmon has spoilt the trout fishing. There is no satisfactory evidence for this, but the possibility that the earlier-hatched quinnat fry may in some waters deplete the supply of food organisms that would otherwise be available for the trout fry hatched later in the season appears to be a question that merits investigation.

Another case of competition between two exotic species is that of the brown versus the rainbow trout. Several lakes that were formerly well-stocked with brown trout are now dominated by rainbows with surviving brown trout very few in number. In some waters perch are considered to be inimical to the trout stock as food competitors and predators. There is no material evidence.

There are, as always among anglers, at least two schools of thought—some desirous of further acclimatizations; others at least dubious. And the late L. F. Ayson used to say: "You have the two best sorts of trout and the two best sorts of salmon in the world. What more do you want?"

But in the extreme north there is comparatively little water that carries even a small stock of trout. Salmon are limited to the South Island where the seawater is colder, but in some years quinnat salmon have been known to make an appearance in North Island rivers on both east and west coasts, which suggests that wide variations—on which there are unfortunately no hydrological records—occur in the character of the ocean waters round these islands. It also calls to mind that *O. tschwytscha* has a very wide geographical range which is a point worthy of note in connexion with projects for the naturalization of exotic species. A species that has a widely ranging habitat is likely to succeed where one whose natural distribution is confined within narrow limits would fail to adapt itself.

The limiting factor for trout in our northern rivers is lack of suitable spawning places rather than of suitable food or the physical character of the water. The problem of finding an exotic species, suitable for the angler as well as for the table, that could adapt itself to the conditions in such waters, is a desirable development for the future. But the first desideratum is a comprehensive knowledge of the biology of the species in relation to its native habitat and of the ecological factors that would confront it in its new environment. A number of small shallow lakes fringing the west coast of the North Island form a considerable total area of unstocked but potentially valuable fishing water. A preliminary physical and faunistic survey of some of these lakes is being undertaken to provide data which it is hoped may lead to the selection and introduction of one or more suitable exotic species.

HATCHING AND STOCKING

These fish cultural operations were essential works in the introduction of exotic species. Details of plant and working methods show local and individual variation, the results ranging from devices of original ingenuity to crude make-shifts. In general the methods and apparatus originated by American fish culturists are followed. The formerly common practice of obtaining ova from pond-fed parent fish has been abandoned in favour of trapping wild fish.

Where good and sufficient water of suitable temperature is available, difficulties are comparatively few. Probably the most common technical errors have been the tendency to overcrowd ova and alevins in relation to the supply and temperature of water, and the practice of "penning" the parent fish before they are stripped.

The planting of fry in waters where there is an established stock of trout has had little appreciable effect in comparison with what is already provided by natural reproduction which for most New Zealand trout waters has been shown to be more successful than had formerly been realized. It is concluded that much of the hatchery work has been uneconomical and that there are other activities for the maintenance and protection of trout stocks that would have produced better results for expenditure incurred (5, 6 and 7). A common cause of pointless and relatively fruitless planting has been too little regard to, or understanding of, the character of the habitat in relation to fish ecology, and the planting to satisfy the demands of ill-informed but politically influential anglers.

There is much variation from year to year in natural reproduction and survival of which all the possible causative factors are not fully known. The incidence of severe floods at critical times in the life of embryo or juvenile trout is known to have caused serious losses. A planting programme is indicated for such conditions. A lake holding a good trout stock but having inadequate spawning facilities is generally regarded as an economical source of supply of ova for a hatchery and usually provides convenient conditions for trapping. Some fish culturists here consider that ova from lake fish are inferior in quality to those of river fish. Sea-run trout are believed to give better eggs but against this the objection is raised that they would tend to produce a migratory strain and that the young fish would leave the stream too soon. On such questions there is lack of reliable evidence, and data from organized experiments are required.

The best stage at which to liberate fry or young fish is a matter upon which opinions and practices vary. It is generally after a brief period of feeding in the hatchery boxes. The cost of livers, nowadays considerably increased, is one of the deciding factors. Another question, upon which biological investigation has been local and limited, is the optimal period in the season at which to liberate. Some of our hatchery waters, derived from springs or artesian wells, are of considerably higher temperature than those of the waters in which natural spawning takes place. The incubation period is thus comparatively short. Apart from the question as to whether the rapidly hatched fry are as healthy and vigorous as desirable, there is some doubt whether the water into which they are liberated abnormally early in the season will everywhere contain sufficient food organisms to provide adequate nourishment. The observations hitherto made have tended to show that food conditions in the early season are not significantly deficient and, even for naturally incubated fry, there is certainly some potent but not precisely known factor that causes very heavy mortality in the first stages of free-swimming life in our rivers.

ARTIFICIAL IMPOUNDMENTS

The impoundment of waters by dam construction for various purposes has been the means of providing additions to fishery resources. Such artificial lakes increase the area of fishing water available and afford the necessary cover and abundant food organisms for a stock of well-grown fish provided that for the most part the depth is not excessive and the level is fairly constant; provided also that there are accessible tributary streams suitable for spawning or that a moderate amount of regular artificial stocking takes place. Their production is appreciably augmented if the dam prevents the ascent of eels, the most serious trout predators and food competitors in New Zealand waters.

Dams are harmful where they prevent the migration of Salmonidae to favourable spawning ground.

Abstraction of water for public water-works has been responsible for the deterioration of the lower parts of rivers by diminishing their normal volume and flow. The average size and number of trout have inevitably lessened in such cases. Irrigation works have had still more damaging effects by reducing stream volume as well as by the direct losses of fish which get into the races. One important trout stream (Opihi River) has an electrified screen at the main irrigation outlet, but the usual method of dealing with the situation is by salvaging the fish from the races and transporting them to safe waters.

Many of our reservoirs of potable water are potential fishery resources unutilized, access to their banks being prevented. The object is to prevent contamination, but the policy is open to criticism on biological and technical as well as economic grounds.

CARRYING CAPACITY OF WATERS AND POPULATION BALANCE

In general the carrying capacity of New Zealand trout waters is good, especially as regards the high average size of the fish. The favourable range of temperatures enables fish to feed and grow throughout the greater part of the year; and doubtless also ensures a longer succession of life-cycles for the food-organisms. Investigations on trout-food in our rivers have not brought to light any signs of insufficiency (7, 9, 10, 11). There have been exceptions however in the case of certain lakes where the large population of big trout has depleted food supplies (principally of indigenous fishes) below the limit necessary for normal growth and condition. The remedy applied was the artificial reduction of the stock. "In eight years between 1910 and 1920 more than 250,000 trout weighing about 216 tons were destroyed." (7, page 87).

The carrying capacity of waters does not admit of absolute measurement except perhaps when reduced to the dimensions of a fish-pond. Such ponds are in fact valuable means of investigating by quantitative experiments some of the factors that affect carrying capacity. In a natural habitat this value is the resultant of a complex of environmental factors, physical and biological, which may be subject to considerable periodical or incidental or even catastrophic variation, and of which some interact on others. A series of pond experiments, with controls, would appear to be one way towards their elucidation; another is by means of continuous ecological observations and correlations in respect of a natural habitat. One such correlation being studied by observations now in progress is that between the eel population and trout population in various waters.

Relevant ecological studies with regard to New Zealand trout waters have been made by Phillips (10, 11) and

Percival (9) and the subject is comprehensively reviewed by Hobbs (7). Bio-statistical relations have been dealt with by Allen (1) who is the first to have undertaken a systematic attempt to assess carrying capacity and population balance in a New Zealand trout habitat. The netting and tagging technique which he has applied to a river investigation could usually be more easily applied to a lake stock as was demonstrated by Knut Dahl in Norway many years ago.

Allen's study of trout propagation, growth and survival in the Horokiwi River was planned for three successive stages:

(1) A detailed study of existing relations in the "test stream";

(2) Artificial modifications of the density of the stock, and a study of the resulting effects on the trout population and the food supply;

(3) An extension of the work, possibly in a less elaborate form, to waters of other types.

The first phase had three principal parts: (*a*) a physical survey; (*b*) the study of the trout population; (*c*) the study of the food supply.

The final object of this phase is the determination of quantities that approximately represent (*a*) Stock, (*b*) Production, and (*c*) Crop, in order to arrive at the ratios *Production/Stock* and *Crop/Production* for application to the practical problems of fishery management.

Food supply was studied by periodical examinations of gut contents and quantitative samples of bottom fauna. For numerous food organisms determinations were made of the *availability factor* (i.e., the ratio of the percentage of an animal in the total food ingested and its percentage in the fauna at the same time and place). This is found to vary for the same animal with the age of the trout and with the time of year. Associated with the general investigation in this stream is a study of flood effects on bottom fauna. A method of assessment of the amount of change in bottom composition and contour has been developed for correlation with qualitative and quantitative variations in the fauna.

Hobbs (7, pages 115-122) has discussed *environment improvement* under the heads: (*a*) chemical, (*b*) biological, (*c*) physical. Reference is made to pollution as, even under the generally favourable New Zealand conditions, an existing but remediable factor.

The possibility of improving carrying capacity by the introduction of nutrients for the basic flora of waters is deemed to be very slightly applicable to our fisheries and much too costly in respect of the most important trout habitats. With regard to a "nutritional chain" culminating in the production of the desired fish flesh (trout in this case), the ecological requirements of the intermediate organisms in the series are emphasized: e.g., that there may be limiting factors in the physical environment which may nullify any assistance obtainable from optimal chemical factors.

No scientifically directed trials have yet been completed in New Zealand but monthly analyses of nutrient salts, phyto-plankton and zoo-plankton have been made over the past two years in two neighbouring and physically similar lakes, to be followed by a fertilization experiment in one, using the second for control observations. There is at least a possibility that the naturalization of exotic forage fishes would supply a missing link that would enable large trout to benefit from small invertebrates at present unutilized, the propagation of which might be increased *via* increased flora *via* increase of requisite nutrient salts in the water.

The essential conditions to be satisfied before undertaking any project for the introduction of new fish, or fish-food organisms, or artificial nutrients, are the ensuring by biological prognosis that the modified ecological association would not be unfavourable to useful indigenous organisms (7, page 122).

EFFECTS OF VARIOUS RATES OF CROPPING ON PRODUCTION

As yet no systematic investigation has been made upon this question in New Zealand. Exploitation is confined (if one excludes poaching) to amateur rod-fishing which is subject to various restrictive regulations (e.g., closed seasons, size-limits, daily catch limits and prescribed baits and lures). In a detailed discussion based largely on records of catches from a limited number of waters over the last sixty years, Hobbs (7, page 43) concludes that, "While the number of anglers has increased greatly, individual anglers today, on some waters, still take much the same weight of fish per unit angling effort as others did last century. In other waters the catch of the individual angler is now less; but nowhere is there evidence that it has dropped in inverse proportion to the increase of total angling effort. Thus present evidence does not show that abstractions have yet generally reached the maximum that should be possible without threatening the continued well-being of stocks."

The difficulties of such estimations as Allen's *Stock/Production* and *Crop/Production* ratios will vary according to the character and extent of the habitat. "Redd"-making trout and salmon are convenient subjects because of the comparative ease of estimating the "run" of spawners to the breeding-grounds and in many cases of actually counting the number of "redds", thus giving a direct picture of both stock and production magnitudes.

The composition of the stock according to size or age-groups, periodically determined, is a long-recognized method of assessing the effect of abstractions by fishing—though the occurrence of other depreciating factors must also be borne in mind. A further indicator is the *immature/mature* ratio.

A significant correlation of such criteria of the condition of the stock with the crop figures will depend upon the approximation to accuracy with which the latter figures have been ascertained, due allowance also being made for the quantitative effects of causes of mortality other than the human predator. Our fresh-water fisheries, with the exception of the commercial taking of quinnat salmon, are exclusively a matter of amateur sport. It is not expedient to prescribe compulsory returns of catches to provide data for fishery statistics. Through collaboration with Acclimatization Societies and Angling Clubs individual anglers are encouraged to keep fishing diaries. These are periodically submitted to the department conducting research in order that the data may be extracted and analysed. Much of the information and many of the conclusions in the report already quoted are based upon such data.

WAYS AND MEANS

An important economic consideration is the question of finding and making the fullest use of available helpers and facilities. With our exiguous departmental staff we have found this a more vital problem than the acquisition of technical information which is obtainable through publications.

The essential ecological research is a task for trained biologists. In New Zealand the harvest (of problems to be elucidated) was plentiful, bur the labourers for a long time were few.

Collaboration from academic scientists was obtained through contacts with university biological departments—researchers, teachers and students. Various gaps in our knowledge of fundamental aquatic biology have been filled by this means. In some cases "grants-in-aid" have been allocated for such work.

Associations with other State Departments concerned with applied science may also provide useful data and collaboration in developmental work: e.g., meteorologists (for climatic data), soil conservationists (in respect of environment improvement), hydro-engineers (for flood, river-flow and lake-level data) and chemists (for water analyses etc.).

Local bodies concerned with fishing—in New Zealand Acclimatization Societies and Angling Clubs—are another class whose co-operation is essential, whereby it is possible to secure valuable data: e.g., systematic records of catches made by individual fishermen and collection of biological material such as scale samples and fish stomachs.

In addition to the value of the data collected, it is an important means of educating the fishing community in conservation and rational utilization of resources, and as to the necessary methods of providing a sound basis for these objects.

We have received assistance from industrial technologists (both departmental and commercial) towards the solution of such problems as the utilization of material that is obnoxious from the fishery standpoint: oil chemists and cannery experts in respect of eel utilization; and with regard to sawdust, a frequent cause of river polution, its increasing utilization as fuel, its use in horticulture and in the construction of building material are examples.

Isolationism, much too prevalent in the past with both metropolitan and provincial bodies, is a most serious obstacle to progress.

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The Management of Cold-Water Fish Resources in South Africa

D. HEY

ABSTRACT

There are no cold-water fish of economic or sporting value indigenous to Southern Africa. Experience is therefore confined to the exotic Salmonidae, in particular to Brown trout *Salmo fario (trutta ?)* and Rainbow trout *Salmo irideus*.

The first attempt to acclimatize Salmonids in the Cape Province was in 1867. After repeated failures they were eventually established at the Jonkershoek Hatchery in 1892.

The trout waters of South Africa are limited to the winter rainfall area of the southern coastal belt and certain mountainous areas where rain falls in summer. Trout are living under what might be termed borderline conditions. The water temperature approaches the lethal limit in summer and in the former area this is accompanied by a reduction in stream-flow.

The percentage of eyed ova produced at the hatcheries was not considered satisfactory and four years of intensive research on the subject was commenced in 1937. As a result thereof, hatchery and cultural techniques were improved.

A description is given of stocking and management methods, which although based on standard practice have been modified to meet the peculiar climatic and ecological conditions obtaining in the country.

While natural trout water is limited, the potential acreage is likely to be appreciably increased by the development of water resources in South Africa.

INTRODUCTION

The term "cold-water fish" is usually applied to the Salmonidae, but in some cases may also be extended to the Percidae and the Small-mouth bass *Micropterus*. For the purposes of this paper it is interpreted as referring only to the Salmonidae, and particularly to trout.

There are no cold-water fish indigenous to South Africa and experience is therefore limited to the acclimatization of exotic species. The first step in this direction was taken in 1867 by the promulgation of legislation "encouraging introduction into the waters of the Cape Colony of fishes not native to such waters". Several attempts were made by private individuals between 1867 and 1883 to acclimatize Salmonids at the Cape but all consignments were lost in transit; and in 1884 after successful hatching of fry from British brown trout ova, all the fish were lost from inexperienced handling (12[1]—Report No. 1). In 1890, the Cape Government agreed to provide funds for further attempts to be made on a larger scale. In 1892 some 200,000 ova were imported and hatched and the fry released in four rivers of the Western Province. In 1893 a hatchery was established at Jonkershoek under Ernest Latour. He was succeeded by John L. Scott, who took the first eggs from trout reared in South Africa in June 1895. Subsequently a second hatchery was established at Pirie, near King William's Town. From that time onwards, thousands of eyed ova have been distributed throughout Southern Africa from these hatcheries. The species concerned are the European Brown trout (*Salmo fario* (*trutta*?)) and the American Rainbow trout (*Salmo irideus* (*gairdnerii*?)). An early spawning and supposedly non-migratory strain of Rainbow (*Salmo irideus* (*gairdnerii*?) *shasta*), was imported and acclimatized early in 1938.

A number of attempts between 1896 and 1906 to introduce Atlantic salmon to the Cape of Good Hope met with success in the initial stages. They were hatched and reared to the migratory stage in twelve months, but disappeared after being released in the rivers. The number of smolts released in each case, however, was too small to justify these experiments being pronounced decisive. The acclimatization of the Pacific salmon in South Africa has not been attempted.

While there was little difficulty in establishing trout in South Africa, and they grew faster than in their native countries, yet it soon became apparent that our trout waters were limited. Except in a few mountainous areas such as the Drakensberg range, the trout waters of South Africa exhibit borderline features, particularly as regards temperature. This also applies to the rivers of the South Western Province, the majority of which are at an altitude of less than 1,000 ft. The existence of trout in certain rivers of the Eastern Cape, Natal, Rhodesia, Transvaal and Basutoland is only possible because of the high altitudes and even here summer temperatures border the lethal limit. Trout may be found in waters with a mean summer temperature of over 20 degrees C and individual maximum surface temperatures of 27 degrees C.

Another very serious limitation to the establishment of the exotic trout in the mountain streams around the southern coastal belt of South Africa is that the majority are too heavily peat-stained (visibility Secchis disc = 4 ft.) and acid (pH 4.0 to 6.0) for these fish. Trout have been established in the Steenbras reservoir where the acidity may rise to pH 4.5, but are unable to propagate in this water owing to the lethal action of the acid water on the milt (8). Such waters are also poor in trout food. These factors, however, do not apply in the Eastern Province of the Cape, Natal or further inland.

Two additional characteristics of South African rivers which seriously affect trout are the high fluctuation in water-level and the heavy silt-load resulting from erosion in the catchment areas.

PRINCIPLES AND PRACTICES OF HATCHING

The methods employed at the hatcheries of this department were, until recently, largely based on those developed in Europe towards the turn of the century. Adult trout are held in large stock ponds and fed on a diet of minced liver, sea fish and salmon-egg meal. This is augmented, when possible, by live food. At the commencement of the spawning season, which is in May and June in the case of Brown and Rainbow trout respectively, the spawners are transferred to the spawning ponds. From here they are trapped or netted and the ripe fish stripped. The hens do not ripen at the same time and consequently the season may extend to the end of August for both species. The females are stripped into a basin and milted and allowed to stand for a few minutes when a small quantity of water is added. The surplus milt is washed from the eggs in rotary washing jars (12—Report No. 3) where they remain until they are no longer tacky.

The eggs are placed on glass grilles in hatching troughs, while development proceeds to the "eyed stage". At the mean water-temperature of 10 degrees C this requires fourteen days for Rainbows and twenty-one days for Brown trout. Throughout this period they are examined daily and all dead eggs removed. By doing so losses from disease are nil as our acid water (pH 6.8, A.R. 0.3) is not conducive to fungal infection.

At the eyed stage the eggs are washed under a strong jet of water, when all infertile and many weakly developed eggs turn white. After their removal, the balance is examined under a strong light when any defective ova can be eliminated. The ova are despatched in various types of containers. For journeys of less than five days' duration wooden boxes containing damp moss are an effective and economical method of packing. For long rail journeys special ice boxes are used.

The percentage of eyed ova produced at the Cape hatcheries was under 60 per cent of the eggs stripped. With the object of increasing this, intensive research on the hatchery and stripping techniques and climatic factors affecting trout was commenced in 1937. This work has been fully described elsewhere (4, 5, 6 and 7) but the more important findings were:

1. That the life of both eggs and sperm in water is limited thus establishing the basis for the dry method of impregnation.

2. There is a period of optimum fertility at which stage eggs should be stripped. Eggs taken prior to this will have a low fertility due to under-ripeness whereas those stripped

[1]Numbers within parentheses refer to items in the bibliography.

later will be over-ripe. The efficacy of stripping therefore depends on the judgment of the stripper in taking the eggs at the correct time.

3. Eggs which are very over-ripe have a white or opaque disc lying on the yolk. The ovarian fluid associated with such eggs causes the immediate coagulation of the milt. Consequently if an over-ripe fish is stripped together with other hens, it will result in the loss of the entire batch of eggs.

4. The eggs produced from hatchery fish are inferior to those from wild fish. The higher the proportion of natural food included in the diet of the brood fish, the better the quality of the eggs.

5. At a water temperature of 11 degrees C, the maximum mortality of any one batch of eggs can be expected on the fifth to the ninth day after impregnation in the case of Rainbow and Brown trout respectively. This fact is of practical application in estimating the yield of ova from a batch of eggs.

6. Ecological conditions at both the Perie and Jonkershoek hatcheries of this department are borderline, particularly stream-flow and water temperature which at times approach the lethal limit. Consequently it cannot be expected that the quality of eyed ova produced under such conditions should equal those from the native habitat of trout.

7. By applying certain modifications of cultural technique the mean fertility was increased to 80 per cent with individual batches as high as 98 per cent. By utilizing circular rearing tanks, rearing losses to the fingerling stage do not exceed 33 per cent.

The findings of Hobbs (9) in New Zealand, that the operation of hatcheries is not justifiable and that the results are inferior to natural spawning, do not apply in South Africa. There are very few rivers in which natural spawning is adequate to maintain the trout population. Even in the best trout streams of the Eastern Cape Province and Transvaal, periodic "hail water" kills occur which may eliminate the entire trout population. When the water temperature is high, a sudden rush of ice cold water resulting from a hailstorm, falling perhaps miles away, is lethal to fish. Lethal conditions for trout also result from severe droughts, silting of river-beds and pollution. In addition predators and poachers take a toll of stock-fish.

Therefore where trout are living under borderline ecological conditions and in addition have to survive in the face of the adverse factors mentioned above, restocking with hatchery-produced ova or fingerlings is essential.

STOCKING OF WATERS

When stocking with trout, eyed ova, fry, fingerlings or adult fish may be used as experience dictates. Each has certain advantages. Eyed ova are economical and easy to transport. Planted in Chaplin hatching tins or floating hatching boxes, they can be used with excellent results in stocking virgin waters where risk of losses from predators is low. For restocking depleted waters the use of fish is preferred. The larger the fish used the higher the percentage survival. They are distributed from the hatcheries by road using a special transportation unit.

As a result of the great advances which have been made in our knowledge of the life histories and habits of aquatic fauna and the ecology of communities, the stocking of waters need no longer be a matter of trial and error. The first step is a thorough investigation of conditions existing in the particular water, such as maximum and mean temperatures, pH, alkaline reserve, turbidity, oxygen content, declivity, stream-flow and food supply. Having determined the nature of the water and with a knowledge of the requirements of each species of fish, it can be predicted with reasonable accuracy which are likely to thrive and the most suitable can be selected.

In waters which are already stocked care should be exercised to ensure that the population balance is not upset. This will happen unless an ecological niche is available for the new species. Fish which are likely to compete for food supply should not be introduced into the same water, but species with divergent feeding habits can be combined to advantage. Although the food of fish covers a wide range, no species is so catholic in feeding habits as to be able to utilize the entire variety of aquatic food. In some South African rivers, trout must compete with indigenous fish of the *Barbus* family. In rivers of the Western Province, the whitefish (*Barbus andrewii*) and the yellowfish (*Barbus capensis*) occur. In Natal, the scaley (*Barbus elephantis*) abounds. These fish are inferior to trout from the sporting aspect and have little table value. Not only do they compete for the food supply, but also affect the natural spawning of trout. They shoal during the late winter and ascend the rivers during spring, arriving at the spawning grounds shortly after the trout ova have hatched. They disturb the spawning beds and in addition consume quantities of ova and alevins (2).

Waters with an established population of coarse fish cannot be stocked with Salmonids until the former have been eradicated. Many methods have been employed for this purpose such as the use of dynamite, chemical poisons, electricity, etc., but all are of limited application or efficacy. As many South African waters are infested with exotic carp, means of eradicating them have been very thoroughly investigated. The results of research undertaken in this department to date, indicate that fish can be effectively eradicated from any water by the use of powdered *Tephrosia* seed at a concentration of 10 to 30 parts per million. Furthermore such fish are edible and will recover from the effects of the poison if placed immediately in fresh water. The food organisms are not adversely affected and consequently the water can be restocked after two weeks by which time the poisonous element in the *Tephrosia* seed has decomposed (1).

RATE OF STOCKING

The number of fish required for stocking a water is dependent upon the potential productivity and the survival rate. Potential productivity is determined from the abundance and nature of the food supply, (Biogenic Capacity), and the area of water. The Biogenic Capacity (10) is determined from quantitative and qualitative sampling for food including both benthonic and planktonic forms, and is expressed as a numeral between B1 (very poor) and B10 (very rich).

In lakes the productivity can be estimated from the modified formula of Leger:

$$K = B \times \frac{Na}{10} \times X$$

where K is productivity, and Na is the area of the water in ares. In the case of rivers the productivity is expressed in kg. per km. by the formula $K = B \times L \times X$, where L is the breadth of the river in metres, and X a factor with a value of 1 to 3.5 (11).

The survival rate of Salmonids to adult stage in South African waters which are already stocked is considered to be 1 in 100 for fry and 1 in 10 for fingerlings. To estimate the number of fry or fingerlings required for stocking, the productivity figure is multiplied by 100 and 10 respectively.

THE MANAGEMENT OF WATERS

Once waters have been adequately stocked they must be correctly managed if they are to yield consistent results. Management practice differs with the type of water.

South African rivers fall into two climatic groups, those in the summer rainfall area and those in the winter rainfall area. Conditions in the two differ very markedly. Rivers in the summer rainfall area become low in winter, and the temperature drops. Ice may form in the backwaters. During the summer the flow is normally good but the water temperature is relatively high. Periodic droughts and occasional hailstorms affect the fishery adversely. Conditions in the rivers of the winter rainfall area are almost the opposite. During winter the stream-flow is high and numerous floods and spates occur. The flow drops progressively throughout the summer and the temperature rises, with the result that by the autumn the rivers are appreciably reduced in size. Today conditions in the Eerste River, once one of the best trout streams, are so bad that the survival of the Rainbow trout is attributed to their periodic migrations to the sea.

There are very few natural lakes or artificial impoundments suitable for trout as the water temperature is too high in summer.

The improvement measures usually applied to waters include the provision of adequate spawning grounds, the development of food supplies, the prevention of pollution, control of predators, and the regulation of fishing.

PRODUCTIVITY AND REGULATION OF FISHING

In South Africa trout waters are developed purely as a recreational asset. Consequently no statistics of productivity are available, the only criterion being whether the water is yielding consistent baskets. In all the provinces trout fishing may only be done by licensed persons using the artificial fly. There are size limits, daily bag limits and a close season during the winter months.

CONCLUSION

The mileage of natural trout water in South Africa is very limited in comparison with the size of the country. There are no natural lakes and few artificial impoundments suitable for trout and the latter are chiefly small municipal reservoirs. With the imposing programme for the development of aquatic resources in South Africa, however, this potential acreage is likely to be greatly increased.

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Fresh-Water Fishery—Artificial Insemination of Carps

IVAN JELACIN

ABSTRACT

Yugoslavia abounds with resources of fish, which up to now have not been sufficiently utilized. The annual output of fresh-water fishery amounts to approximately 14,000 tons. Of that 3,200 tons are the output of carp ponds, and 10,800 tons the output of open waters. The surface of carp ponds will be enlarged ten times by next year. The natural increase in carp consists of an average of 400 kg. per hectare which, through good care and the use of fertilizer, is increased 100 per cent.

Corn, which is very well utilized (coefficient 1 : 4) is mainly used as an additional food. Well equipped fisheries have an average annual increase of 1,200 kg. per hectare, and a two-year economic system is employed.

After two years of experimentation, artificial insemination of carps was successfully carried out this year at the "Etchka" State fishery. The exact method employed is described in this paper. This method of insemination can be used on a large scale without special installations, and it can therefore produce a quick development of the raising of carp.

All waters which are of importance for fishing are continuously stocked with young fish of various kinds.

Fishing in open waters is carried out by State fishing enterprises or fishing co-operatives. Fishermen employed by State enterprises receive, besides their regular monthly pay, a percentage of the value of the fish caught and a bonus for the careful handling of tools and equipment. The co-operatives engage in fishing under their own management.

Besides the wealth in fish, some waters abound with great quantities of excellent kinds of crabs weighing up to 300 grammes.

Through the employment of protective measures and stocking of fish, the wealth of open waters is steadily increased.

In addition to other sources of natural wealth abounding in Yugoslavia, fishery represents a significant economic branch. Owing to the backwardness of the country in its technical development, its resources are insufficiently utilized and they therefore represent a basis for a great future economic development. The abundant resources in fish have not been sufficiently utilized because this economic branch was not given adequate attention in the past.

The annual output of fresh-water fish amounts to approximately 14,000 tons (1948—13,991 tons) of various fish, mainly used for consumption by the population, which means an annual average of about 1 kg. per person.

Of the total of fresh-water fish, 3,200 tons are the output of carp ponds, and the other 10,800 tons river and lake fish. The potential possibilities of fresh-water fishery are very large and can be doubled by applying adequate technical means without undertaking biological measures for the improvement of the output in open waters.

Even greater possibilities of fresh-water fish production lie in ponds and therefore the Five Year Plan provides for a tenfold increase of the surface of fish-ponds.

The total surface of carp ponds already being utilized amounts to 5,600 hectares, while large surfaces are now under construction; one part of them, about 2,000 hectares, will be ready for use early next spring, and the remaining larger part in the course of the following years.

Owing to the favourable climatic conditions, the possibilities of a natural increase are very good and amount to an average of 400 kg. per hectare. In well-equipped fish-ponds where fertilizers, especially with superphosphate are applied, the natural increase reaches 100 per cent.

Corn is mainly used as an artificial additional food for carps, and, to a smaller degree, various residues from the oil industry, especially residues from sunflower seeds. Carps do very well on corn as an artificial food and it has been established through investigations carried out at the "Etchka" fisheries that 4 kg. of corn are needed for an increase of one kilogramme. Making use of all the measures for a rational utilization, certain fisheries on large surfaces reach an average annual increase of 1,200 kg. per hectare, and in specially good years (e.g., 1947) an increase of up to 1,700 kg. of fish per hectare.

All the well-equipped fisheries apply the two-year economic system so that after two summers fish is brought to market for consumption.

In order to increase the production of ponds, special attention is being paid to scientific investigations with the aim of finding new methods for fish breeding and of throwing light upon particular stages of the process of living.

After two years of investigation of artificial insemination of carps, which met with great difficulties—for carps eggs are, as is well known, very gluey and completely mature only for a certain short time—this year we succeeded for the first time in Yugoslavia to carry out artificial insemination of carp eggs and to successfully produce carps fit for life. Insemination was carried out in the fishery "Etchka" within the natural spawning time. Neither experimental breeding-ponds nor special premises in institutes were available and thus it was proved that artificial insemination of carps can be carried out in any fishery without considerable auxiliary means.

Artificial insemination was carried out in the following way:

On 8 June this year an exceptionally scaled carp (female) weighing 10 kg. and an exceptionally scaled carp (male) weighing 5 kg. were caught with a net in the breeding-pond at the beginning of the spawning time. The eggs of the female could easily be pressed out into a tin container. The ripe eggs were clear and bright, while unripe eggs looked dark and whitish. The sperms of the male were directly poured into a glass test-tube. The insemination itself was made in china plates, five to ten minutes after the pressing out of the eggs, in the following way:

1. The plate was filled with water 2 cm. deep;
2. About one-half a teaspoon of milt was put into the water and stirred with a hen feather;
3. Immediately after this the eggs of the female were, with the use of a spoon, put into a plate and they were

equally divided, as far as possibile, in the bottom of the plate, and stuck immediately. During this process the liquid of the sperm was continuously stirred to and fro with a hen feather so that the spermatozoides of the male could penetrate everywhere;

4. One to two minutes later the liquid of the sperm was poured out and the eggs remained stuck on the bottom of the plate. Thr life of the sperm after water was added lasted 120-140 seconds. The pH value of the sound sperm amounted to 7.3 to 7.6 and the pH value of the unsound and over-ripe sperm amounted to 7.2 to 6.0;

5. Immediately afterwards, this fresh water was carefully poured in;

6. After twenty-four hours, and in one case only after thirty-six hours, fresh water was substituted, always of the same temperature, and all the rotten eggs were removed with light nippers.

The further development of the artificially inseminated eggs proceeded as follows:

Plates with eggs were, for the purpose of further development, brought into a closed room and were placed on a window-sill where they were in the shade in the morning and exposed to the sun in the afternoon.

1. After twenty-four hours, there appeared a dark ring in the transparent inseminated eggs, whereas a few eggs which were not inseminated looked white and dim;

2. After two days, embrions could be clearly discerned; one could easily see large points in the place of eyes. When the eggs were touched with nippers the embrions moved within the eggs;

3. Three days later the first fry (about 10 per cent) came to life;

4. Four days later all the fry from inseminated eggs, at least 98 per cent, came to life.

Until 10 June the average temperature of the water was 18 degrees C. After that came very cold and rainy weather. The weather did not affect the development of eggs kept in the room. The result of the insemination of eggs and of the production of fry in plates was considerably better than in the breeding ponds, in May and July, where on 8 June fish also spawned, but in a natural way. Fry with two heads, two tails or other defects, as often happens with artificially-bred trout, were not observed. The young carps were very strong and full of life which was shown by the fact that none of them perished when water was changed once in the course of three days.

Artificial insemination of carps has great advantages in comparison with the natural spawning. These advantages are the following:

By a general introduction of artificial insemination of carps, a complete change in carp-breeding will take place as was the case earlier with artificial trout-breeding. Once it is introduced, the great annual cost for natural spawning will be reduced and all the breeding of young carps will be put on a more rational basis.

The selection of various kinds of carp will then be easily carried out because information as to exactly which female carp crossed with which male carp will be available.

Investigation into the qualities of particular carps will then be executed in the shortest time because it will be possible to inseminate the eggs of one and the same female with the sperms of various males and, vice versa, eggs of many females could be inseminated with the sperm of one and the same male.

Every male can be used for artificial insemination without direct contact with the female and this can be done several times in the course of the same year[1].

The development of the eggs in containers and indoors removes the dangers of the weather and the destruction by parasites and through diseases.

According to the experience gained up to now, artificial insemination of carps can be carried out on a large scale in conveniently large containers and in corresponding rooms. The only difficulty is that the eggs are fit for insemination only during the honeymoon journey of the female. Here, further investigation is necessary; it should be possible to discover what hormones can be injected to make the eggs of the female fit for insemination. After this is discovered, artificial insemination of carps will be possible to a large extent in the same way as that of trout or with even less effort.

In carp ponds, perch-pikes and sheat-fish are mostly bred as subsidiary rapacious fish because they have proved most suitable owing to their quality. For the production of fish in open waters artificial spawning ponds are arranged in convenient places along the rivers where the young carps are reared up to fifteen days, and after that they are let into the main water-streams of the Panonian plain, i.e., the Danube, Sava, Drava, Tissa and Morava. Besides carp, these waters receive fish by means of the introduction of perch-pikes by transplanting of eggs from the nest. The present capacity of the carp-breeding ponds is 10 million young, and in 1948, 930,000 perch-pikes were transplanted.

For the re-population of trout waters, artificial breeding ponds are used and every year tens of millions of young trout are let into open waters. Over 10 million young are let every year into Lake Ochrid alone, with its special kind of trout (*Trutta ochridana*).

Fishing in open waters is carried out by fishermen in brigades in accordance with the Regulations on the Protection of Fish. These fishermen are either State employees or belong to fishermen's co-operatives.

Fishermen employed by the State hand over all the fish caught to State fishing enterprises, and receive for the work their regular monthly pay with an additional percentage of the value of the fish caught, so that each of them is paid according to his work. Since all fishermen receive the necessary technical equipment for fishing from the State, they are given special rewards for the careful handling of tools and other equipment on the basis of amortization quotas.

Fishermen in co-operatives provide themselves with the necessary fishing tools and equipment and sell fish on the market on their own account. They are under obligation to sell certain quantities of fish as determined by the plan and at prices fixed by the State. The quantity of fish which each co-operative has to sell at fixed prices is determined for every co-operative separately, according to the quantity

[1]Sperm kept in a refrigerator can be used for insemination even after seven days.

of fish available in the water region. They are under no other obligations towards the State, which takes care of the implementation of measures for the promotion of fishing.

In small trout waters which are of significance for sports, members of the co-operatives take care of the production of young trout.

Such organization of the management of fish resources in open waters makes planned utilization possible and at the same time guarantees that the fishermen will take care of the promotion of fishing on their own initiative, because they are constantly interested in an increased fish catch.

In addition to the wealth in fish, certain waters in Yugoslavia abound in large quantities of excellent varieties of crabs which are caught at 100 grammes each. In these waters only male crabs are caught while female crabs are left for further breeding. Females are caught only in order to be transported to other waters where these excellent kinds of crabs are used to increase the stock and thus enrich the wealth of open waters.

Summary of Discussion

The CHAIRMAN emphasized the importance of the pond culture of fish because of the possibilities which that type of breeding offered as a food supply.

He announced that in the absence of the authors of several of the papers which had been presented Mr. Hora had kindly consented to make a general statement on the subject and that he would stress the main points of the papers relating to tropical areas.

Mr. HORA said that pond-culture of fish could play an important role in meeting food requirements and in raising the standard of living of the population, particularly in tropical regions. As early as 1942, the Government of Bengal had decided to create a Fisheries Department. Since marine fishery had been halted because of the war, that department concentrated exclusively on standardizing pond-culture methods and on stimulating the interest of the population in that industry. Mr. Hora pointed out that during a war, marine-fish supplies failed and that inland fisheries, particularly pond-culture, might prove very useful. During the previous two wars, fresh-water fish had been the staple food in many countries.

Mr. Hora stated that the inland population of south-east Asia preferred fresh-water fish to marine species and on that account pond-culture played a special role in their food supply. Mr. Hora also mentioned as an important factor the fresh state in which fish were sold to the consumer. Provision was made for keeping them fresh in fish markets of the Far East, where live fish brought a much higher price because of the certainty that they would not cause poisoning. Pond-culture made the consumption of fresh fish possible.

Mr. Hora had been glad to note that the construction of reservoirs was playing a very important role in the soil conservation practices in the United States. A thousand pounds of fish per acre could be raised each year in those reservoirs which showed that fish, in that country as in the tropics, could become a staple food if circumstances required.

Mr. Hora pointed out that a pond which was dry during a part of the year was usually more productive than perennial ponds. Therefore, the use of the water for irrigation did not interfere with fish-culture. The soil on the beds of perennial ponds in the course of time became filthy and gradually productivity fell off. Therefore, it was advisable to drain the ponds every three or four years. The bed silt containing decaying organic matter made an excellent fertilizer.

Although the construction of reservoirs in the United States was very expensive, in tropical countries there were large natural ponds which could be developed. In south-east Asia only a small part of this natural resource was already being used, but in Africa and Latin America they had not even begun to be used. A pond might appear tiny when compared to the sea, but its importance in rural economy was considerable, and pond-culture might be called upon to play a decisive role in the proper feeding of peoples in hot climates.

Considerable capital was being spent in tropical countries in applying European and American methods of developing marine fisheries when, in the opinion of scientists (Mr. Hora then quoted a passage from Mr. Harold Thomson's work, "Latent Fishery Resources") fish populations were less dense and the organization of fishing for commercial purposes presented serious difficulties. If 10 per cent of the money, materials and labour employed in developing marine fisheries in the tropics were spent on improving ponds for fish-culture, Mr. Hora was certain that the results would be much more satisfactory. Scientists of advanced countries who did not understand local conditions, should not give advice on the development of natural resources in the tropics; very often their advice retarded the development.

By the application of indigenous practices and their improvement in the light of modern scientific knowledge, any reservoir or pond could be developed either as a hatchery or as a nursery. Unfortunately, there were no statistics available to show the extent of such reservoir areas country by country, but it was known that they were very extensive. In the Philippines according to estimates there were 600,000 hectares of undeveloped swampland capable of producing 200 million kg. of fish per year. In Bengal it had been established that 100 million lb. of fish were lost annually because of water hyacinth. In hot climates public health organizations obliged the farmers to clear their ponds to prevent the breeding of mosquitoes and the spread of malaria. In Mr. Hora's opinion, the farmers could not be urged to keep their ponds clean unless they obtained some advantage, and pond-culture might thus induce them to do so.

Regarding pond-culture practices, Mr. Hora repeated that indigenous methods should be improved, not by replacing them by western methods but by studying carefully the ancient and well-tested methods used by the Chinese and Bengalis. He thought that an exchange of views on the practices in use in different countries would be very useful.

In recent years, great interest had been shown in the use of chemical manures for pond fertilization and, in the case of cold waters, their use had greatly increased productivity. Mr. Hora had dealt with the advantages and disadvantages of using organic and inorganic manures in his paper and he would like the subject to be discussed somewhat fully. There was no doubt that organic fertilizers were far superior for increasing the productivity of ponds, provided certain disadvantages could be eliminated. Mr. Hora felt sure that modern scientists would succeed in doing that.

Pond-culture could be encouraged either for sport or for the production of food but the methods would differ according to the objective. In most of the warm countries where the objective was an increase in food production, mutually tolerant herbivorous and omnivorous species were raised, and by introducing a number of species with different feeding habits an attempt was made to utilize all the food resources in the pond. It was obvious that pond culture practices would greatly depend on the variety of fish to be raised and on the nature of the fertilizers used for the manuring of ponds. The nature of ponds should always be properly studied when stocking them with fish. Breeding and fish crops would depend on that.

From the point of view of culture practices, the fish used for pond-culture could be divided into two categories: pond-fish and river-fish. The most productive species of China and India belonged to the latter category and very interesting and ingenious methods had been evolved in both countries for collecting river fry, and transporting and rearing them. The Chinese carp (*Cyprinus carpio*) had been found to be the easiest to rear and had therefore been introduced all over the world.

Mr. de Vries and Mr. Bottemanne in their study on "Latent fishery resources and means for their development" had made some interesting observations on inland fisheries in Indonesia and had referred to the various practices there. They had dealt with fish-culture in ponds and in rice-paddies. They pointed out that the most intensive type of cultivation was that of fish in the rice-paddies. Young fish were introduced at the time of planting and gathered in during first weeding six weeks later. In some cases even three successive crops of fish could be had to one rice crop and the animal protein was a useful supplement to the essentially vegetarian diet of the peasant. Needless to say to make such breeding possible the water must be of good quality and available in adequate quantities.

Japan had been the first country to practise fish-culture in paddies and a debt of gratitude was owed to Mr. Hiyama for his paper on such an important subject. Mr. Lin, Mr. Hofstede and Mr. Hora himself had spoken on that procedure in their papers and had shown that fish-culture in paddies made it possible to increase rice production by more than 10 per cent. Mr. Hiyama's contribution indicated along which lines further research could be undertaken to increase fish productivity in rice-fields even more. The importance of that resource could only be realized by those who had seen the vast paddy-fields in the deltaic regions of Bengal where, by proper embankment, a water-depth varying from 1 ft. to 3 ft. was maintained. The most productive fish was the *catla* which grew to a length of 12 in. to 15 in. in two or three months and to a weight of 2 lb. to $2^1/_2$ lb. Even if those fish could not be further fattened for lack of suitable ponds in the immediate vicinity of paddy-fields and could not be marketed, the carp always provided food for the farmers and their families. Mr. Hora felt that the great possibilities in increasing such resources could not be over-emphasized.

With the construction of embankments low-lying areas near the sea coast and in the estuaries could be made very productive. They could be gradually converted into fresh-water ponds and finally rice-fields.

Regarding programmes of pond-culture in new countries, a knowledge of practices in China and India would be a first necessity and then experiments would have to be carried out on the cultural possibilities of the indigenous species and their feeding and breeding habits and yields. If no fast growing species were available, then exotic species would have to be imported. In Africa the Cichlidae could be suitable for *Tilapia mossambica* was becoming a favourite fish in Indonesia. If other species failed, the common Chinese carp (*Cyprinus carpio*), was sure to give satisfactory results on account of its high adaptability to all types of habitats.

In conclusion he wished to say that pond-culture and agriculture were allied practices. Pond-culture was a type of husbandry used intensively in tropical areas where highly developed agriculture, fertile soil and an adequate water-supply made the practice a lucrative industry. As Mr. de Vries and Mr. Bottemanne had put it, pond-culture should become an important element in the production of tropical lands and in the feeding of their dense populations.

Mr. Meehean, in presenting a summary on farm-ponds in the United States, pointed out that the question of pond-culture of fish was viewed in a different light: fish-culture was carried on primarily to meet the requirements of recreational fishing and was concerned chiefly with raising certain species such as the large-mouthed black bass (*Micropterus salmoides*), the bluegill (*Lepomis macrochirus*) and the catfishes, whereas in tropical countries the emphasis was placed on the breeding for commercial purposes of fish generally used as food.

Mr. Meehean remarked that the production of tropical species amounted to from 1,000 to 4,000 lb. per acre while United States ponds produced only about 175 lb. per acre of game species.

The importance of constructing artificial ponds as a factor in the food economy, however, was recognized by the United States as early as 1934 when there had been severe droughts, especially in the Middle West. The farmers, forced to sell their stocks of cattle on account of the inadequate water-supply, had felt that ponds on their land would provide a solution to their difficulties. Furthermore, the Soil Conservation Service also recommended the construction of ponds as a means of preventing erosion and of regulating floods. Those considerations as well as the attractions of fishing as a sport had led many states to encourage farmers to construct and maintain ponds on their land.

All ponds, however, did not contain fish; in fact, only a small percentage of them were suitable for fishing. Until the last ten years, fishing had been subject to strict regulations in the United States. However, investigations had shown that, as far as warm-water species are concerned, it was impossible to exhaust the supply in impoundments or lakes by hook-and-line fishing. That fact had brought about a real revolution in the attitude of Americans toward management of fisheries resources, the importance of which was constantly increasing.

It was difficult to evaluate the methods of stocking and managing farm-ponds and the production obtained. Climatic factors in different sections of the United States, as well as fishing preferences by those engaged in angling, had considerable effect upon the production, stocking and management procedures, as well as on the success of recommendations developed by research workers. A great deal of research on species, species combinations, and methods of management would be required before high production could be expected from farm-ponds in all parts of the United States.

The danger from the malaria-spreading Anopheles was not acute in the United States where inorganic fertilizers, which control aquatic vegetation, were used more than any other kind. In certain regions of the south-east where malaria was prevalent. precautions such as stocking with Gambusia and the destruction of vegetation along the banks was practised. An advantage of inorganic fertilizers was that they were produced on a large industrial scale and were, consequently, moderately priced.

The CHAIRMAN announced that Mr. Jelacin, who had arrived from Yugoslavia since the opening of the conference, was a welcome addition to the experts present. He asked Mrs. Levy, of the Yugoslav delegation, to read aloud Mr. Jelacin's paper.

Mrs. Levy read the paper by Mr. Jelacin.

The CHAIRMAN thanked Mr. Jelacin for the detailed explanation he had given of the new and interesting experiment on the artificial insemination of carps, which had just been carried out successfully in Yugoslavia.

He then opened the general discussion.

Mr. M. GRAHAM drew Mr. Hora's attention to the fact that the pond-culture of fish as practised in China and in India was an art based on traditions dating back thousands of years rather than a science, in the real meaning of that term, which might be applied in other parts of the world. For example, the Chinese analysed water by tasting it; it was difficult to see how such an empirical method could be of any use to a pisciculturist in Africa, for instance. Mr. Graham expected greater results from systematic studies carried out by the different governmental services concerned, like those in the British Ministry for the Colonies.

Mr. Graham then drew attention to a fish of the Tilapia species which was found in streams and lakes in Africa as well as in South America; it was a highly edible fish, the commercial production of which might prove to be very profitable.

Mr. Graham was deeply interested in Mr. Lin's observation on the method whereby different species were mixed in the same pond in order to obtain the maximum benefit from the nutritive elements in the water.

In conclusion, Mr. Graham wished to correct an erroneous impression which had perhaps been given by a film shown on Monday, 22 August, relating to certain experiments in the fertilization of sea lochs in Scotland carried out by a British scientist. The film, which was excellent in itself from a scientific point of view, had shown the effect of organic fertilizers on vegetal and animal plankton, on aquatic fauna and so forth. The sound track, however, had given the impression that the method in question was of some immediate practical value. Mr. Graham doubted that statement, feeling that it might cause disappointment for which the British Government could in no way be responsible.

Mr. MONOD confirmed Mr. Graham's observations regarding the importance of fish of the genus Tilapia, which was fully appreciated in Africa. In the Belgian Congo, for example, Belgian pisciculturists had begun to raise that kind of fish in the region of Elizabethville. In the Sudan, in French West Africa, in the basins of the Senegal, of the Niger and of Lake Chad, there were a certain number of species of Tilapia two of which—the *Tilapia nilotica* and the *Tilapia galilaea*—might grow to a length of 42 cm. and a weight of 1,500 grammes. The culture of those fishes raised certain technical problems, however, for their diet was limivorous and microphagous like that of the limivorous Characids. At the time of buccal ncubation, it seemed easy to take the eggs and hatch them away from their natural setting. The fry seemed extremely hardy; Mr. Monod himself had transported them in a lorry.

Mr. Monod pointed out that experiments in the culture of other species had also been made in the region of the Niger, especially with the only African Osteoglossid, the *Heterotis niloticus*.

With regard to pisciculture in rice-fields, the chief obstacle—in French West Africa—was that in the waters of the region, where the rice-fields were open and fed by the swollen waters, there were certain herbivorous characids which cut rice shoots for their food and thus caused great damage to the rice-fields. That situation was perhaps peculiar to French West Africa; the indigenous inhabitants attempted to remedy it by shutting off the entrance to the channels, but they had not had much success.

Mr. CLARKE observed that Dr. Gross, the British scientist who had made the experiments in the fertilization of sea lochs in Scotland, about which Mr. Graham had spoken, was engaged on research work at the Woodshole Laboratory in Massachusetts, which the members of the Section were invited to visit on Sunday, 28 August.

Dr. Gross seemed certain that his method could be applied commercially. Mr. Clarke asked why Mr. Graham seemed to think that those experiments would not be fruitful.

Mr. M. GRAHAM replied that he did not deny the scientific value of the experiment, quite the contrary; but for the time being it seemed that the facts known were not sufficient to contemplate their immediate practical application, without running the risk of giving erroneous guidance to the layman. So far, no areas had been found with conditions necessary to ensure the complete success of the new method.

Mr. CLARKE said that in Dr. Gross's opinion the flow of water, causing the loss of the fertilizers used, was not a factor of sufficient importance to nullify the validity of the experiment as Mr. Graham seemed to fear. Moreover, the experiments carried out at Woodshole confirmed that observation.

The method might doubtless be applied profitably to the culture of crustacea, which was one of the most valuable resources of the coastal region of New England for example. One might easily visualize the culture of crustacea in basins which were shut off during the period of fertilization. Attempts along that line had been made that year in the fisheries at Woodshole and members of the Section would have the opportunity to learn, on the spot, the results thus far obtained.

Mr. Kask thanked the preceding speakers for the clear outline they had given of the importance of pond-culture of fish as a source of food supply. Recognizing the value of that resource and the improved methods in that field used in the Far East, the United Nations Food and Agriculture Organization had recently requested the services of Mr. Lin of the Fisheries Research Department of Hong Kong. The methods used in the Far East had hitherto been empirical and it was therefore difficult to disseminate information about them. Mr. Lin had been appointed so that a scientific study of those methods could be made, as well as plans for sending information about them to South America, the West Indies and Africa.

Mr. Bottemanne said that he had lived for a long time in Indonesia, where he had been interested in the pond-culture of fish. He was surprised at the statement made by Mr. Hora that the Indonesians preferred fresh-water fish to sea-water fish. He himself had found that, for the most part, the fish consumed in Java were sea-water fish.

He was also surprised that no one had mentioned the fact that pond-culture of fish in Java required the investment of considerable capital. In Indonesia pisciculture was carried out either in irrigated rice-fields or in brackish water or fresh-water ponds. In 1940, salt marshes had been converted into brackish water ponds for fish-culture at a cost of between three and four thousand guilders per hectare, and had therefore required a capital investment far higher than for marine fishing. The cost of preparing fresh-water ponds or rice-fields was not so high, but the fish still cost more than sea-water fish.

Mr. Bottemanne drew attention to another method used in Borneo and Indo-China. In those countries there were large ponds which were filled during the wet monsoons and half empty during the dry monsoons and in which great quantities of fish could be produced at a low cost. In Indo-China especially, fish were produced in those ponds in such quantities that before the war almost 20 million kg. of fresh-water fish had been exported to Java.

In reply to the observations made regarding the use of Tilapia, Mr. Hora pointed out that he had mentioned that fish in his paper. India was quite prepared to acclimatize new species of fish like Tilapia or even to replace certain species by others if their culture proved to be profitable.

Mr. Graham had mentioned the mixing of species as a means of using the resources of a pond to better advantage. That was in fact one of the best methods used in China as well as in India; but whereas in China a method had been found for making a selection from among the very young fry and thus improving the production, in India the selection of species of very young fry had not been carried out so successfully.

In reply to Mr. Graham's observations concerning the respective value of European or United States methods and those used in the Far East, Mr. Hora stressed that he had merely pointed out the futility of sending students from the Far East to the United States or the United Kingdom to learn methods of pisciculture as the conditions were entirely different in those countries and the students could observe the improved methods in use in their own countries.

With regard to fish-culture in irrigated rice-fields in the Sudan in Africa, Mr. Hora thought that the presence of harmful species was no reason to condemn the technique in itself. A way must be found to choose species which were not dangerous to the rice crops. The experience of countries in south-east Asia had shown that fish-culture, far from harming the crops, was beneficial to them.

Mr. Bottemanne had said that the conversion of salt marshes into brackish water ponds for fish-culture cost three to four thousand guilders per hectare. He had not mentioned, however, the profits that could later be obtained from those ponds. In India such profits had proved to be considerable. In general, it had been necessary at the beginning to convince the pisciculturists of the value of that method; but after a few had tried it, the method had soon been widely adopted. It was true that in certain cases the yield had decreased after five years of exploitation—that had been particularly true in Bengal—but an investigation had revealed that the pisciculturists had merely closed off the pond without providing a new supply of water from a fresh-water source. After five years, the salinity had greatly increased and the production of fish had diminished considerably. It was therefore necessary that pisciculturists should always be advised to make provision for a supply of fresh water to renew the water in brackish water ponds and thus to avoid excessive salinity.

Speaking of artificial insemination, Mr. Hora mentioned the recent experiments undertaken by an Indian institution in the Punjab in which attempts had been made to inject into carp hormones extracted from the pituitary gland in order to induce ovulation. Those experiments had not been successful. In that connexion Mr. Hora referred to the very interesting experiments made by Professor J. Hammond on the influence of light and darkness on the fecundity of sheep and goats. Professor Hammond had observed that darkness was an important factor which stimulated ovulation. Moreover, as it had been noted that carp reproduced at high-water—in other words when the waters were muddy and therefore dark—Mr. Hora thought it might be suggested that the institute carrying out the experiments in the Punjab should undertake new experiments concerning the darkness factor in artificial breeding.

Finally, with regard to the draining of the Dead Sea by the Jews, Mr. Hora observed that the Jews had noted that fish-culture in the marshes which were to be drained provided a means of fertilizing the soil.

Mr. N. Ahmad asked whether there were any methods of combating aquatic vegetation in fish-culture ponds.

Mr. HORA replied that the question was very important; if vegetation became too rank, fish breeding was impossible. In certain ponds near Calcutta, vegetation had been removed by hand, which had been possible in spite of the expense involved because the ponds yielded large returns. In other regions, however, returns were not so high. The question arose particularly in the western part of Bengal where water hyacinth was a ubiquitous scourge. Large chemical companies, such as Imperial Chemical Industries, were currently experimenting with a view to producing certain chemicals which would destroy such aquatic growths without harming the fish.

Mr. Hora suggested that it would be useful for FAO to initiate concerted action in that field as the question was of interest to all tropical countries. Any measure designed to destroy water hyacinth and other aquatic weeds would make it possible to increase considerably the production of fish in warm countries.

Mr. SCHIMMEL asked whether there were any general statistics on the production of fish in fresh-water ponds as compared with the returns from sea-water fish.

Mr. HORA replied that in India the production of sea-water fish was double that of fresh-water fish. It should be borne in mind, however, that all fresh-water fish were not sent to market, as some were consumed locally; but the value of fresh-water fish sent to market was twice that of sea-water fish.

Mr. KASK said that during his travels in south-east Asia he had observed that the production of fresh-water fish was certainly as important as a source of food supply as the production of sea-water fish. In Malaya, for example, a kind of herbivorous fish was bred which could live without oxygen and which reproduced easily in muddy water. That fish was not only consumed in large quantities locally but was exported to neighbouring countries.

Mr. Kask thought that if appropriate species were chosen, fish-culture might be introduced in other regions and serve to increase the food supply.

Mr. SCHIMMEL suggested that the method might first be tried out in the Caribbean area where *per capita* consumption of protein was very low.

Mr. BOTTEMANNE said that before the war the production of fresh-water fish in Indonesia had amounted to 100 million kg. and the amount of sea-water fish caught had been about 300 million kg. He felt that those figures could be doubled. Account must always be taken, however, of the cost price of the fish, as the largest part of the population could not buy fish which sold at too high a price.

Research in the Conservation and Utilization of Marine Resources

1 September 1949

Chairman:

S. L. HORA, Director, Zoological Survey of India, Calcutta, India

Contributed Papers:

Changes in the North Sea Stocks of Fish
Michael GRAHAM, Lowestoft Research Laboratory of the Ministry of Agriculture and Fisheries, Suffolk, England

Research on Use and Increase of Fish Stocks
A. G. HUNTSMAN, Consulting Director, Fisheries Research Board of Canada, and Professor of Marine Biology, University of Toronto, Toronto, Ontario, Canada

Research in Fishery Conservation (Techniques used in Studying Fisheries; and the Integration of Hydrological, Biological and Other Studies in a Well-Rounded Marine Fisheries Research Programme in India)
H. Srinivasa RAO, Chief Research Officer, Central Marine Fisheries Research Station, Madras, India

The Utilization of Marine Algae
Philip JACKSON, Deputy Director of the Scottish Seaweed Research Association, Musselburgh, Scotland

Utilization of Algae
Emil ÖY, Chemical Engineer, Stavanger, Norway

Marine Algae
P. SCHANG, *Vice-Président du Syndicat national des producteurs d'iode*, Paris, France

Summary of Discussion:

Discussants:

Messrs. M. GRAHAM, N. AHMAD, A. L. PRITCHARD, BOTTEMANNE, ENGLE, WOODWARD, ROUSSEAU, BONNEFIL, SEIDENFADEN, REVELLE

Programme Officer:

HERBERT SCHIMMEL

Changes in the North Sea Stocks of Fish

MICHAEL GRAHAM

ABSTRACT

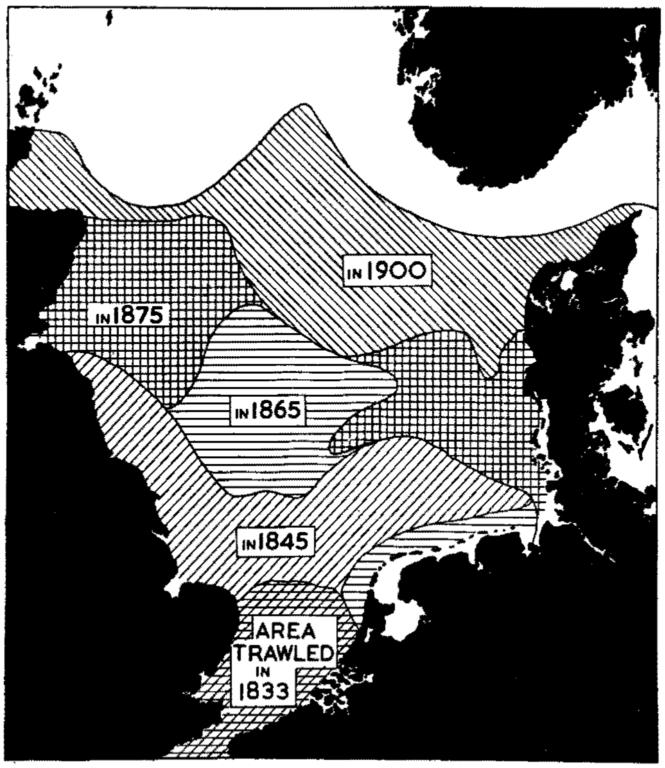
Although the yield of fish from the North Sea has remained remarkably steady, this has been accompanied by changes for the worse in the stocks. The fishing power is evidently the main factor governing density of stocks of plaice, haddock, and cod, which are the three staple demersal species. The herring stock, so far, seems to be virtually independent of fishing.

This review attempts to show quite crudely the bulk effects of large changes in fishing of a hard-fished stock. Information on overfishing, or on finer changes in the fish stocks, can only be obtained from special studies, some of which have been published.

The North Sea was opened up to trawling in stages during the last century, in the last two decades of which the turnover from sailing to steam trawling took place (Figures 1 and 2). The herring fishery, which is by drift net and located mainly within 30 miles of the British coasts, increased gradually up to 1913 (Figure 3) and also turned over to steam.

English fishing statistics were not on a good basis until 1906 (Edser-1925); Scottish statistics are older.

In 1913 the principal species in the English fishery were herring, haddock, cod and plaice. Other species include: skates and rays, (*Raia sp.*), whiting (*Gadus merlangus*), dab (*Pleuronectes limanda*), turbot (*Rhombus maximus*), soles (*Solea vulgaris*) and dogfish (mainly *Acanthias*). The fish



SPREAD OF ENGLISH TRAWLING IN THE NORTH SEA DURING THE 19TH CENTURY.

Figure 1

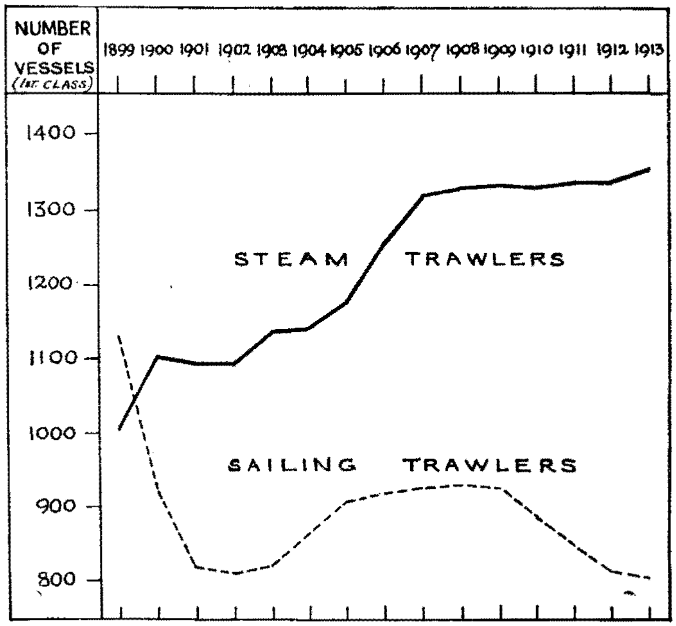


Figure 2. Number of trawlers registered in England and Wales—1899-1913

populations on the two sides of the North Atlantic are therefore not dissimilar in general.

The North Sea fishing is complicated both by the numbers of countries participating (Figure 4), and by differences in the methods, markets, and customs, in fisheries of each of those countries.

Certain important events have occurred since 1906: a reduction of fishing by about 75 per cent in 1914-1918; an increase of fishing by about 30 per cent due to the introduction of the Vigneron-Dahl trawl and heavy gear in 1924-1928; a reduction of fishing by more than 50 per cent (provisional estimate) in 1939-1945. There remain the following periods when the rate of fishing was not changing rapidly: 1906-1913. Pre first war; 1919-1922. Post first war; 1929-1938. Post Vigneron-Dahl; and 1945-1946. Post second war.

General information on the yields and the stocks is given in the following table. Figure 5 may also be consulted.

Period	*Average international annual yield*		*English landings per days absence Demersal (tons)*
	Herrings (tons)	*All other species (tons)*	
1906-13 Pre 1st War	684,917	428,082	0.82
1919-22 Post 1st War	541,804	503,788	1.22
1929-38 Post V-Dahl	848,594	413,399	0.55[a]
1946-47 Post 2nd War	—	—	1.08[a]

[a] Reduced by 25 per cent for Vigneron-Dahl factor.

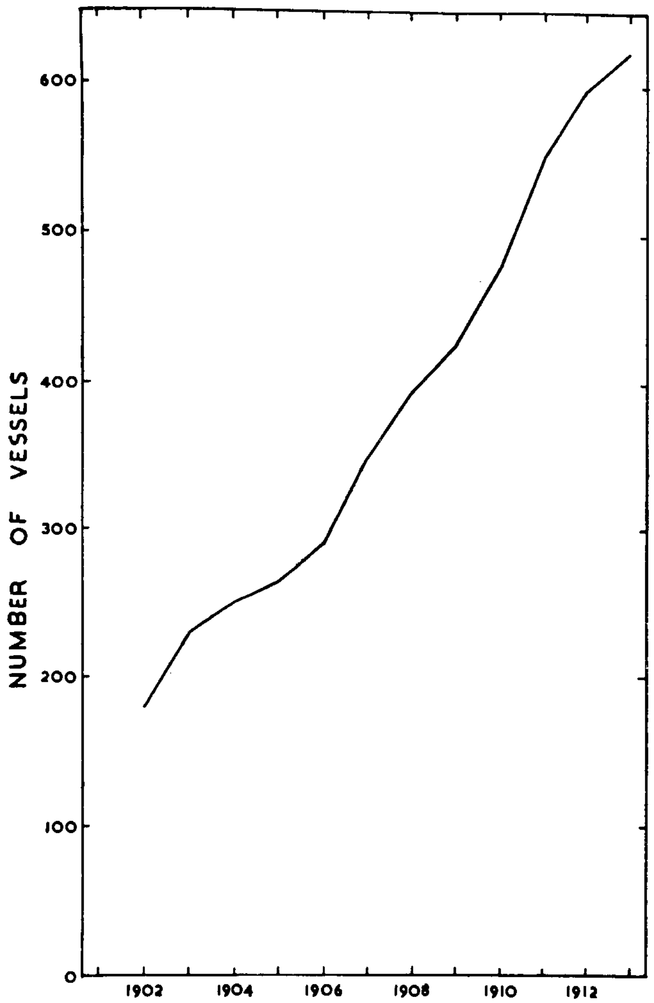


Figure 3

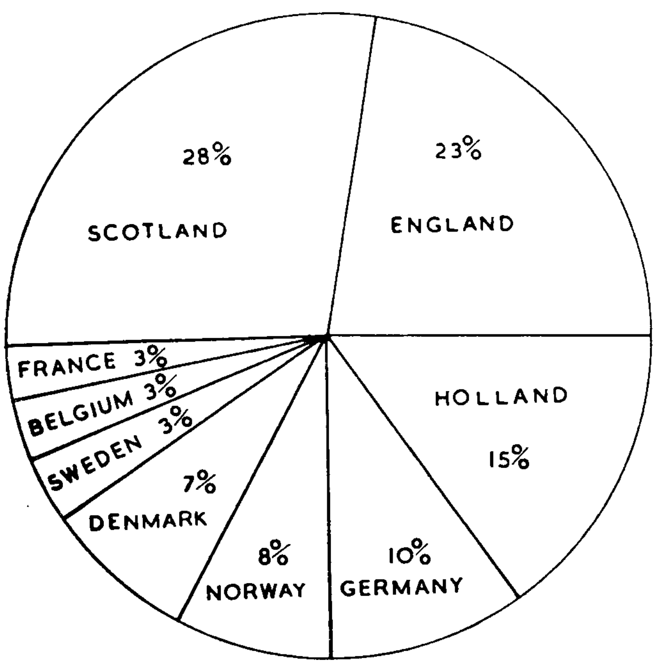


Figure 4

It appears that fishing has had no effect on the herring stock, but enormous effects on demersal species, shown in the last column.

The relative reactions of the stocks of the three staple demersal species, when fishing was reduced, are shown in the following table:

Landings per days absence (tons) pre-wars and post-wars.

	Pre 1st War	*Post 1st War*	*1919 percentage of*	*Pre 2nd War*	*Post 2nd War*	*1946 percentage of*
	1913	*1919*	*1913*	*1938*	*1946*	*1938*
Plaice	0.10	0.22	*220*	0.12	0.42	*350*
Cod	0.22	0.26	*118*	0.18	0.59	*328*
Haddock	0.15	0.79	*527*	0.13	0.21	*162*

To bring the account up to date, the demersal stocks in 1947 were only a little heavier than in 1938, having fallen rapidly and continuously since 1945 (Figure 6).

The largest query outstanding is whether the apparent insensibility of the herring stock to fishing is not due to hard fishing of demersal species, nearly all of which are its enemies. Another important question is whether the haddock stock in the inter-war period lost some of its resilience.

For the future, the only hope lies in the International Agreement of 1947 to set up a committee to regulate fishing, following the convention of 1946 in which size limits and minimum mesh regulations were agreed upon.

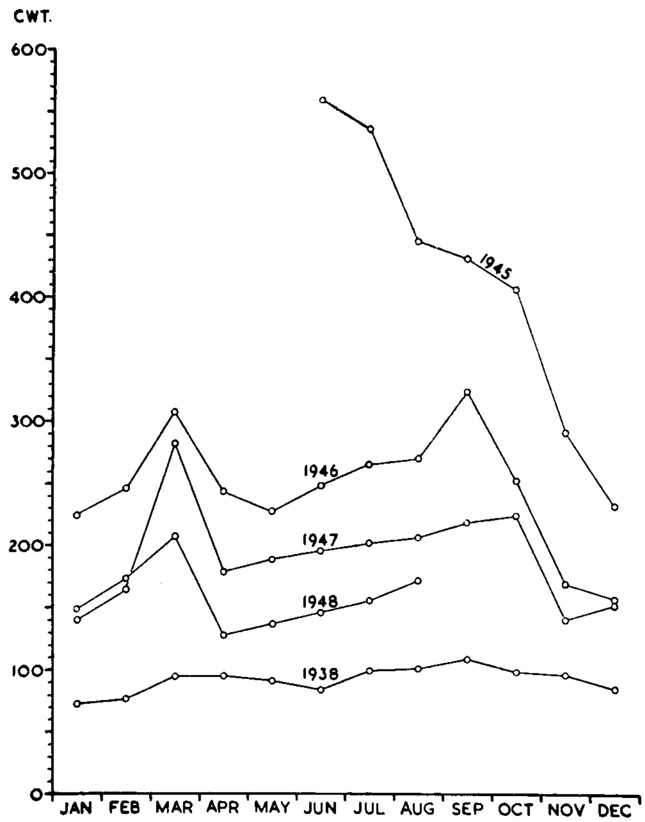


Figure 5. Catch for average 8-day trip of a Grimsby North Sea steam-trawler

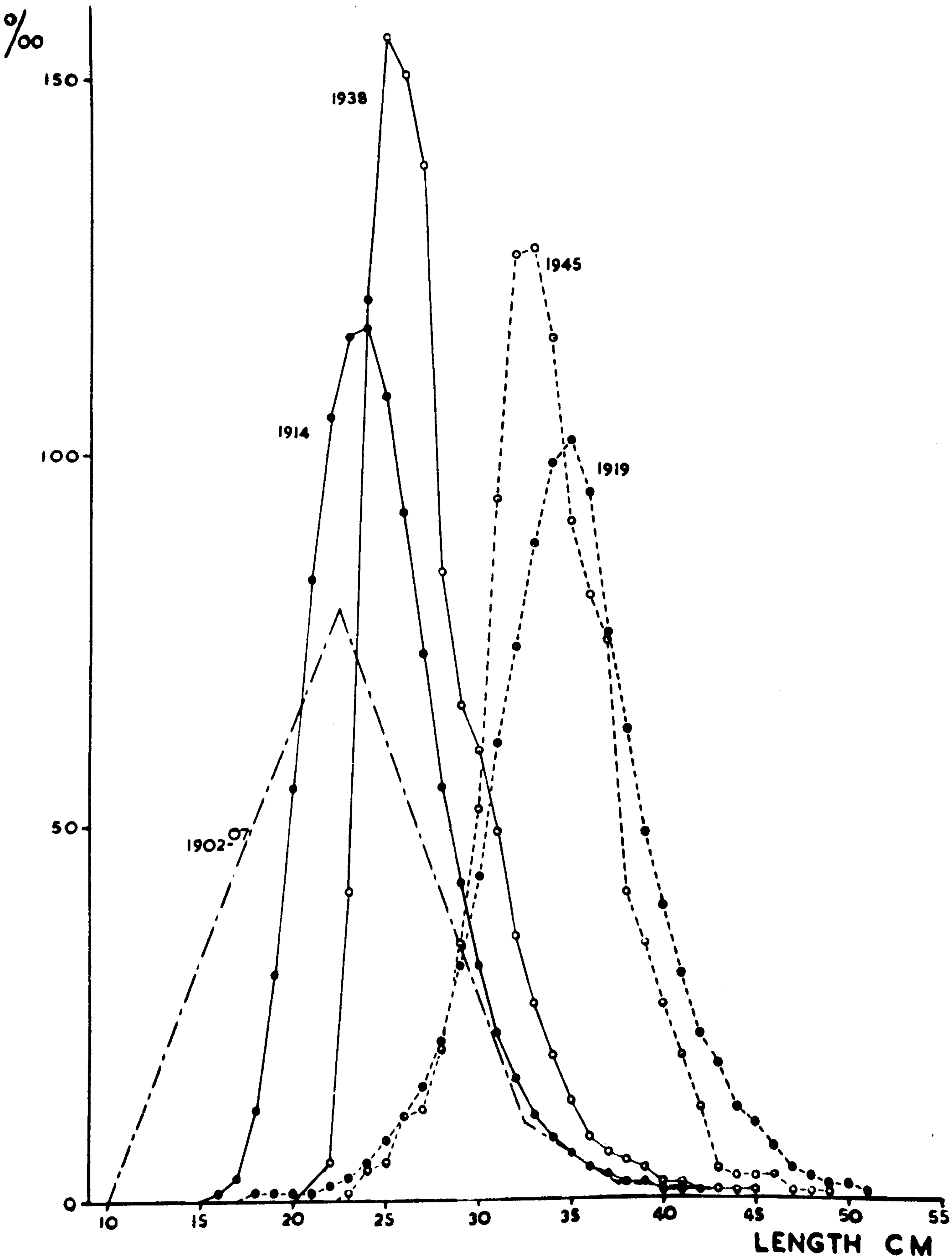


Figure 6. Length distribution (per mille) of plaice from the southern North Sea

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Research on Use and Increase of Fish Stocks

A. G. HUNTSMAN

ABSTRACT

With lack of clear proof that overfishing leaves too few spawners, restriction of fishing to help reproduction lacks a sound basis. This holds also for restricting the taking of small fish to get more pounds of these later. Natural fluctuations in stocks need study for varied reasons. Main research should be on most economical use of accumulated stocks that otherwise go to waste. The extent to which different fisheries depend upon the same fish needs elucidation before taking common action in economical management. Differences in conditions may make common action undesirable.

Costly attempts to introduce fish into waters lacking them should be made only after careful determination of the conditions required and of whether they occur. Attempts to increase existing fish stocks should be based only on knowledge of what actually limits their numbers, seeing that their reproductive powers are so great. For greater use of stocks there should be research on improvement in gear and technique and on location of stocks. For each valuable species there should be rather full knowledge of the factors governing its distribution and abundance, that is, affecting its movement, survival, growth and reproduction. The common environment should be investigated in this connexion.

USE OF STOCKS

As long as there is great fear that future supply will be less through overfishing leaving too few fish to spawn, research to settle this matter should come first. Proof is yet lacking for such overfishing except for salmon in a Scottish river (1)[1] where a trap could remove every ascending fish. No other case has come to light in the five years since a request for such was published (14). Aquatic mammals (walrus, seal, whale) may be in a different category through being more vulnerable than fishes. Even in confined waters, such as small lakes, scientists have been finding it difficult to eliminate undesirable fish by any means, as witness more individuals of the same kinds being obtained by poisoning after two years (16) than in the first poisoning (18). Also it is questionable whether Governments will be able to keep down as being objectionable the stream-spawning lampreys and smelts now established in the upper Great Lakes. The technique required to reveal an overfishing effect on the next generation is to stop the heaviest fishing abruptly and to ascertain carefully whether more spawners will produce more offspring as shown by age determination of samples of fish taken in later years.

It is sometimes argued that it pays to let small fish become large, that, although some die, the others becoming larger will be more valuable. Proof is needed. This argument does not apply to fish such as pink salmon (*Oncorhynchus gorbuscha*) which are taken only when about to spawn and die. Nor has it been shown for Atlantic salmon which may survive spawning that it pays to let grilse perhaps double in weight in a year. Proof has not yet been furnished that it pays to conserve the young of halibut that grow rather rapidly for many years. The proper technique is to mark the young to discover whether those actually taken when older are more valuable.

Decreased catches through the years are commonly attributed to overfishing, but may merely reflect decrease in natural fluctuations in abundance (7, 8, 4). To prevent wrong inference, natural fluctuations should be studied. If their causes are discovered, means of control may be found possible. Also, knowledge of fluctuations should permit prediction of changes in a fishery for the guidance of fishermen. The research technique is to study statistics of the takes, determine the year-classes of the fish taken, and attempt correlation of changes in abundance with causative factors.

Fish can be taken economically only when and where they either become concentrated or roam and reach fishing gear. Stocks are limited and represent accumulations of fish grown over longer or shorter periods, perhaps many years. Intensive fishing reduces stocks more or less rapidly and may make fishing unprofitable. Overfishing is clearly over-effort for the stock available. It is a continuing economic problem to ensure sufficiently high take per unit of effort for profitable fishing. The highest take is not necessarily the best. The take should be increased only as long as the extra cost is offset by the added revenue from sales. Not only markets but possibility of other employment will determine when and how rapidly the accumulated stock of fish should be taken by industry. From the fishing standpoint, over-removal of accumulated stocks giving decreased take per unit of effort has been clearly described by Graham (5, 6), Thompson (19), Russell (17) and others. When operating under more or less peculiar conditions, each fisherman may have to decide whether his take warrants further fishing. For any large, homogeneous fishery, research can well be directed toward economic capture of available stocks. To discover whether there should be common action in limiting the take, the take per unit of effort should be followed accurately and other factors to affect it than the fish removed should be eliminated.

For no purpose should it be assumed that fish taken at different times and places belong to a common stock. The extent to which two or more fisheries depend upon the same fish can be determined. Fish taken in one fishery can be marked or tagged and released to discover to what

[1]Numbers within parentheses refer to items in the bibliography.

extent they enter the other fishery (11). There is an extensive literature on the marking and tagging of fish.

The possibility of common stocks becomes even more important when different fisheries involve different uses of the fish, as for fertilizer, oil, bait, food or sport. In this matter, in addition to determination of the extent to which the fisheries depend upon the same stock, there is the task of assessing the comparative values of the fish for different uses. Only the most superficial attempts have yet been made to solve the complex problem for society that such assessment involves.

Until we have one clear case for fish in large, open waters, such as lakes or ocean, of over-removal reducing total take through the years, such a reason for limiting take of fish lacks a sound basis. Accordingly, research can well be directed toward reducing cost of capture so that society may have more food that it may badly need. To permit more economical harvesting of the crop that otherwise goes to waste, there needs to be research for improving gear and technique and for locating unused stocks. Practically unused stocks of highly prized salmon occur, whose economic capture for food presents a difficult problem. Interested persons should continue their more or less intelligent attempts to locate and capture the fish, but in addition there should be research on the biapocrisis (15) of each kind of fish, how it responds in movement, survival, growth and reproduction to what it faces. Such responses, which have not been studied systematically for any kind of fish, determine how the kind can be captured and where and in what abundance it will be found.

INCREASE OF STOCKS

In small waters where the requisite conditions are under control, stocks of fish may be increased to the limit set by the conditions. In such fish-culture, practice is guided by known success or failure. The many attempts made to increase stocks of freely moving fish in open waters, where they are without protection and from which they may wander, do not justify regular practice with results still doubtful or quite unknown.

Introduction of kinds of fish into waters lacking them have sometimes been clearly successful. Introduction may be by transporting the fish or by eliminating obstacles to their migration. Any major attempt at introduction should be made only with the knowledge of how it can be successful. This knowledge will come from systematic research on the biapocrisis of the species (15).

The hope that hatching and planting fish would increase existing natural stocks in open waters led in the nineteenth century to extensive development of "fish-culture", particularly in North America. That hope is now after eighty years being seen as almost wholly vain (20, 21, 3, 12). It failed to take account of the basic fact that, with enormous reproductive powers, fish will be few only when conditions limit their numbers.

The problem of increasing an existing natural stock of fish is a difficult one. Primarily there should be research to reveal what limits its numbers, and this may involve knowledge of the whole life history. The technique required is assessment of the numbers present at each stage and analysis of the situation. While it is natural to start with spawning of the eggs, time may be saved by going backward from the large fish, since large numbers of any size of fish necessarily mean adequate spawning, hatching and survival of young to the size found numerous. The local "bottle-neck" that limits numbers of salmon in eastern Canada varies greatly from river to river: Falls, dams, low water, lack of freshets, lack of suitable spawning bottom, lack of plant nutrients, lack of suitable cover, fish predators, bird predators, high temperature. When the local "bottle-neck" is discovered, the questions arise as to whether or at what cost it can be removed, as to how effective such removal will be in increase of numbers of fish caught, and as to whether the value of the increase will warrant the cost (9, 10, 13).

An alternative to removal of the "bottle-neck" is to plant fish beyond the stage so affected. This action is justified only if the conditions will permit the planted fish to survive and grow to the desired size. To plant successfully knowledge is needed first of the biapocrisis of the species and second of the pertinent conditions in the water. That knowledge can be obtained directly by experimental planting under widely varying conditions and by detailed and accurate determination of the results and analysis of the associated conditions (12, 13).

The requisite biapocrisis of a species is so detailed that research on it should start with fish in a water so small that they and the conditions they face can be readily and steadily followed. This is important basic knowledge for all management of the species. The soundest plan is to start with small fish in a small water and work up to large ones.

GENERAL PROGRAMME

Research reveals difficulty in keeping the crops of fish from going to waste, even in an artificial reservoir (2); yet there continues to be a great fear of too few fish being left for spawning.

(*a*) If demanded, there should be research on whether or not more spawners are required for maintenance of stock.

The idea that small fish should not be taken is firmly established in men's minds, but without proof of its effectiveness. (*b*) If demanded, there should be research on whether or not it pays not to take the smaller fish so that they may be taken when larger and more valuable, if enough survive.

Planning should include the following:

1. Investigation of each of the more important fish as to most economical use of the accumulated stocks. Determination of the take per unit of effort that will be economical, taking into account all the factors that enter into the situation. In recognizing overfishing, the effect on the take of previous removal of fish should be distinguished from the effects of other factors.

2. Determination of the extent to which different fisheries depend upon the same fish, with a view to common action in economical management. Assessment of comparative values for different uses of fish taken by different fisheries (commercial and sport) from the same stocks.

3. If productive waters lack valuable kinds of fish, careful determination of whether or not the conditions are suitable for the kinds before making costly attempts to introduce them.

4. If there should be evidence that from most standpoints a valuable kind of fish could be much more abundant, investigation to discover for each body of water what limits its numbers with a view to using remedial measures if economic.

5. For increased takes, research on improvement in gear and in fishing technique and on location of unused stocks.

6. To provide a background for solving problems in capturing and managing a valuable species, systematic investigation of its biapocrisis, that is, of its response in movement, survival, growth and reproduction to what it faces.

7. Study of the fluctuations in abundance of each valuable species (*a*) to avoid wrong inferences for fishery management, (*b*) to discover possible remedial measures, and (*c*) to predict what the fishery will be.

8. Study of the common environment for the fishes of each region, concentrating on the factors governing the distribution and abundance of the important species. Water movements, temperature, salinity, food organisms, competitors and enemies are clearly important factors.

9. Improvement of techniques for accurate determination of the results of particular fishery actions. Experimental action is useless without a known result. Accurate assessment of the fish taken, particularly of those that are of known origin as having been marked or tagged, is very important. Also, there is the very difficult matter of assessing the stocks of fish.

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Research in Fishery Conservation (Techniques Used in Studying Fisheries; The Integration of Hydrological and Biological and Other Studies in a Well-Rounded Marine Fisheries Research Programme in India)

H. SRINIVASA RAO

ABSTRACT

The geographical, climatological and other features of the country are briefly described which serve to show that the environment for fishery development is generally favourable and that consequently the exploitable resource must be considerable. The need for improving the instruments of exploitation—namely, the fishing communities and their craft and gear, and the need for incurring considerable expenditure on technical development and administrative measures are emphasized. Marine Fisheries of India are stated to constitute a problem in the methods of exploitation rather than in those of conservation in the immediate and near future, but the steps that the Government of India has already taken to obtain sufficient scientific data, on which to base future development schemes and measures for regulation of the Marine Fisheries of the country with a view to conserve and stabilize them, are of a long-term nature. The methods adopted for fishery investigation are those that have been employed elsewhere in more advanced countries with slight modifications to suit local conditions. The investigations have been commenced only recently and are still in the preliminary stages. Consequently, no report of actual results achieved is included.

INTRODUCTION

The report presented here on the subject given above may be studied with advantage against the adequate and admirably clear background provided by three recent reports by the FAO Regional Representative for Fisheries in Singapore: (1) Fisheries in south-east Asia (July 1948); (2) Fisheries of Pakistan, India and Ceylon (August 1948); (3) A programme of socio-economic research into the fisheries of south-east Asia (September 1948). A fuller bibliography is given at the end of this paper.

RESOURCE

In the second report cited above which concerns India, it is stated that amongst other measures to improve fisheries, substantial programmes of investigation bearing upon the resource and environment of the fisheries are necessary. So far as marine fisheries are concerned, the resource judging from the size and geographical position of the country must be deemed to be considerable. The long coast line (3,200 miles) of India, the numerous perennial rivers and silt-laden streams which discharge enormous quantities of organic and inorganic matter along both the coasts during the monsoon rains spread over an aggregate period of six to seven months in the year, the wide arms of the Indian Ocean (the Bay of Bengal and the Arabian Sea) and the smaller gulfs like the Gulf of Manaar, the Gulf of Cambay and the Gulf of Cutch, and the Palk Bay which are influenced directly or indirectly by currents from the adjacent oceanic waters, the two hundred odd oceanic islands of the Andamans and Nicobars and the atoll-girthed Laccadive Islands with innumerable creeks, bays, mangrove swamps and extensive reefs, and the considerable extent (115,000 square miles) of the continental shelf from the shore to the 100-fathom line—all point to the resource being not only considerable in extent and size, but also in production.

CULTURABLE WATERS

To this extensive fishable area of open sea must be added the not inconsiderable culturable, but at present barren, tidal estuaries, backwaters and swamps scattered along the entire coast line of India. No estimate is available of the extent of these, but on a rough computation made for the purpose of this paper the area is approximately 2,000 square miles in extent. An acre of salt-water in the fish farms of France and Italy and in the Philippines has been known to yield in one year an average of 500 lb. of fish without the addition of manures or fertilizers, but the recent experiments in Scotland of fertilizing enclosed arms of the sea show that yields can be multiplied many times with proper care and maintenance of such enclosed waters and regulation of fisheries. On the basis of production indicated above, the 2,000 square miles or 1,280,000 acres of swamps, estuaries and backwaters of India may be expected to produce anything up to 640 million lb. of fish per annum without much initial capital outlay.

The utilization of suitable brackish water ponds on our coasts for the culture of fish would appear to be within the collective financial resources of our fishing villages aided by our Provincial and State Governments. These ponds are of various sizes, shallow, and protected on the seaward side by long sand spits parallel to the coast, and are connected with the sea by, more or less, temporary channels. A very rough estimate of cost (made for the purpose of this paper) of constructing a sluice with sliding screens to regulate the inflow and outflow of tidal waters, of raising a protective embankment on the seaward side and strengthening it by turfing with suitable binding grasses, etc., and of excavating, where necessary, ponds of the desired dimensions and depth would amount to Rs. 10,000 (approximately $3,000) per square mile as the unit. If at least a fourth of the area of coastal salt-water pools or ponds is suitably prepared and made available for fish-culture, the cost would work out to half-a-crore of rupees. The advantages of utilizing these backwaters are many. The fishermen, with a little training, can manage the ponds and sluices and embankments, the maintenance costs being low; they will have a subsidiary occupation to sea-fishing nearer home; the culture ponds will provide them with their daily food and earnings by sales; and the fishermen will have no need to go far out to sea to earn their daily bread when the weather conditions are not favourable. Above all, the capital investment will be within the means of their co-operative societies.

The estimated total annual production of sea-fish is 116.7 lakhs of maunds (933 million lb.) or 8,118 lb. per square mile of fishable area. Taking the number of adult fishermen in the maritime provinces only which may be estimated to be one-third of a total of 550,610 for the whole of India, the catch per man works out at 2,500 lb. per annum or less than 7 lb. a day. This low production was to be expected considering the means of exploitation restricted to frail craft which can operate only small gear within a very limited radius from the coast. It is actually a case of the fish inviting fishermen to catch them in the latter's operational field rather than fishermen pursuing fish in the sea. It is fairly obvious from what has been stated above that resource estimation is by itself a formidable, if not an impossible, task in India under the existing circumstances. The main and immediate problem of Indian marine fisheries is, therefore, one of intensive and extensive exploitation rather than conservation.

Exploitation must be based primarily on the efficiency of the human element and of the instruments employed for exploitation. The socio-economic position of the fishermen and the lack of adequate facilities for transport and marketing, and the present financial situation in the country make it extremely unlikely that the exploitation process can be quickened appreciably in the near future.

The need for biological, hydrological and other studies as a means of stabilization and conservation of fisheries had been realized for some years, but it was not until the food supply situation in the country became serious that action was thought of in several directions. The first steps taken to initiate these studies include subsidies from the Central Government to Provincial and State Governments to augment their administrative and research machinery for effectively carrying out the general plan of fishery development. The realization that estimation of resources and research must precede large-scale exploitation, and that results of research do not become available for practical application until many years later led the Government of India to establish as a first step (1) a deep-sea pilot fishing station at Bombay, one of the biggest centres of fish assembly in the country, (2) a marine fisheries research station in Madras, and (3) an inland fisheries research station at Calcutta. The initial difficulties of securing trained personnel and a minimum of suitable equipment may be said to have been partially overcome, and any sustained work on the estimation of the resources and on the nature of the environment will, it is clear, be possible only on the basis of a liberal policy of progressive development in marine fisheries supported by ample financial resources.

As has been stated above, our main aim at present is exploitation on a large scale firstly to provide the much needed food to our starving masses, and secondly to utilize the opportunities thus created for estimating our fishery resources and for studying the physical and biological environments which support our fisheries. This large-scale exploitation will not be possible until power-craft and bigger and improved nets begin to operate in off-shore waters up to a depth of about 100 fathoms under the supervision of senior fishermen well acquainted with the habits of Indian pelagic and midwater fishes. In a recent booklet by U. Shanker Rao (1948) entitled "The Rao Plan: Deep Sea Fishing as a Cottage Industry", the suggestion has been made that the services of the Navy and the merchant fleet may be enlisted in the study of movement of shoals of commercial species of fish in Indian waters; and that the fishermen or groups of them can be assisted with bare-boat charter terms. If every 1,000 of the adult fishing population of 5-1/2 lakhs is provided with a power fishing boat on the terms mentioned in the booklet, the Government will have to build 550 power vessels at a cost of 2-3/4 crores of rupees at the rate of one-half a lakh of rupees per boat.

The very low socio-economic status of the workers in the fishing industry, the lack of local capital for investment owing to the novelty of the venture and uncertainties of adequate returns in the present deplorable state of the country's inflationary finance, make it extremely difficult to modernize all at once fishing, processing and marketing. To establish the industry on a sound and permanent basis, simultaneous action at many different points is urgently required.

The Marine Fisheries Research Station of the Government of India, with which this report deals, is organized in several mutually complementary sections and consists of a main station and three substations. The location of the main station at Mandapam in the extreme south of India on the East Coast at the head of the Gulf of Manaar is in reference to the necessity of studying pure marine conditions under which sea-fisheries thrive. A long chain of reef-girt island running parallel to the coast from Mandapam to Tuticoris provide protected waters for safe navigation of small vessels. Oceanic currents from the Indian and other oceans have presumably a profound influence on the fish and fisheries of the area. As the West Coast of India has somewhat different meteorological, physical and biological conditions, it was deemed necessary to study them also in detail. A small team of marine and fishery biologists is studying at the Calicut Substation the peculiar fishery problems of that coast. Herring, anchovy, mackerel and perch constitute the bulk (55 per cent) of the sea-fisheries of Indian coasts, while shell-fish (prawns, crabs and lobsters, and oysters and clams) form only a fifth of this quantity. A large assortment of miscellaneous fish (some prime and others commercially important like sharks and rays) constitutes roughly 24 per cent of the Indian production. Herring and mackerel provide the most important fisheries of the west coast, the latter being concentrated around Karwar where a substation has been established to study the biology of the mackerel. The sardines, more particularly the oil sardines, which provided an extensive fishery on the west coast several years ago, are now commercially non-existent. The study of the biology of sardines constitutes therefore an important item of investigations at Calicut. At the temporary headquarters in Madras, a team of workers is engaged in studying the biology of sharks and rays, ribbon-fish, oysters and clams, prawns and crabs, sea-weeds and the early development of various species of commercial fish.

The Marine Biology section which consists of a team of planktologists, algologists, bacteriologists and biochemists works in close co-operation with the fishery biology section covering both the coasts.

The Physiology section at the headquarters of the Station is concerned mainly with the study of the adaptive faculties of certain species of fish and prawns, the young of which migrate in enormous numbers in certain seasons into the backwaters and river estuaries. The differences in the osmoregulatory functions of these forms are expected to provide a clue as to which of them would be most suitable for purposes of culture on a large scale in the many thousands of acres of the at present relatively unproductive brackish waters of the Indian coasts.

The Fishery Survey section consists of a Fishery Survey Officer, a Statistical Officer, and twelve Survey Assistants. The first two are stationed at Bombay, being central in regard to approach to fishing centres on both the coasts, and the Survey Assistants in eleven different centres (six on the east coast and five on the west coast) distributed over the twelve zones into which the entire coast line of India between West Bengal and Cutch has been divided for convenience of survey. The Survey Assistants after carrying out a rapid preliminary survey of the fishing industry in individual zones for a period of about six months covering all general information about the fishing populations, craft and gear, fish landings and other conditions, are now in a position to conduct more detailed surveys in the more important fishing centres.

A summary of the methods and techniques adopted in the study of the problems outlined above is given below.

PROBLEMS STUDIED AND TECHNIQUES EMPLOYED

1. Taxonomy of commercial species of fish from different centres of collection.

2. Distribution of commercial species along the coasts of India. Qualitative analysis of catches of fish at the major centres of fishing, and qualitative and quantitative determination of the catch per day per unit of craft and gear and men employed.

3. Biology of commercial species of fish food (qualitative and quantitative estimation); age in relation to size, maturity and growth as studied by the majority-size-group method, examination of gonads and artificial fertilization, and growth as indicated by scales, otoliths etc.; spawning period, mortality.

4. Standardization of gear and methods in the study of planktology and hydrology. Determination of planktonic elements in the sea at different seasons and their distribution at different levels in different centres and in different seasons; qualitative estimation of the same by Lea-Gibbon's subsampler and filtration methods.

5. Correlation between zoo-plankton and phyto-plankton and between these and the physio-chemical factors (salinity, oxygen, phosphate, nitrate, silicate, currents, rain and wind) both in quality and quantity.

6. Survey of fish populations, craft and gear, fish landings and other conditions covering fishing and fishermen along both the coasts of India.

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The Utilization of Marine Algae

PHILIP JACKSON

ABSTRACT

Certain red seaweeds form a source of agar, the uses of which in bacteriological work and the fish canning and other industries, are well known. A quantitative survey of these weeds growing round the British coastline was carried out during the war and revealed adequate quantities to satisfy Britain's own requirements of agar at that time. These resources were utilized and Britain did, in fact, become self-supporting in this field.

The organic constituents of the common brown algae today find wide application in all the major industrial countries in the world, but many of the problems associated with the harvesting and processing of this natural raw material have yet to be solved. The Scottish Seaweed Research Association, assisted by many university scientists, government departments and industrial concerns in Britain, is actively investigating these problems and substantial progress is being made.

The paper outlines the techniques which have been developed for, and successfully applied to, the quantitative assessment of inter-tidal or littoral and totally submerged or sub-littoral seaweeds. Scottish waters have been found to support adequate quantities of both types of seaweed to justify commercial exploitation.

Reliable methods for the routine quantitative estimation of the known organic constituents of these weeds have also been developed and used in the analyses of many thousands of samples of the common Scottish species. As a result, the chemical composition and variations in this composition with season of the year, age of plant, depth of immersion and so on are now known with considerable accuracy.

The most difficult problem in the commercial utilization of the common Scottish seaweeds is undoubtedly the design and development of economic means of harvesting the sub-littoral weed, and the establishment of a thriving seaweed industry in Britain is largely dependent on the solution of this problem. Three possible methods which are being investigated are briefly described.

Seaweeds can be divided into four main groups according to their characteristic colours, red, green, brown and blue.

Certain red seaweeds form a source of agar, the uses os which as a culture medium in bacteriological investigationl and in the fish canning and other industries, are wels known. Before 1939 the bulk of the world's agar supplief came from Japan, and with the entry of that country into the Second World War, the supply position became acute. As a result, investigations were initiated in Britain, as in many other countries, to examine the possibility of a local source of supply. A survey of Britain's red weed resources, sponsored by the Ministry of Supply, and carried out by a team of workers under Newton (1) revealed adequate quantities of the species of red weed suitable for agar production to satisfy Britain's own requirements of agar at that time. These resources were utilized and Britain became self-supporting in this field. A full account of the chemical and botanical work done is being published.

From the point of view of commercial utilization, the brown seaweeds common to Scottish waters are conveniently subdivided into inter-tidal or littoral seaweeds, which are exposed at low tide (cf. *Fucaceae spp.*), totally submerged or sub-littoral seaweeds (cf. *Laminariaceae spp.*), and cast weeds or seaweeds in the second sub-classification which have been dislodged from the sea-bed by storms and cast onto the beaches.

The Scottish Seaweed Research Association, which was set up at the instigation of the Scottish Council on Industry and several interested government departments and industrial concerns, is, amongst other things, examining the possibility of utilizing these seaweeds, and has already made substantial progress in resource surveys, chemical analyses and harvesting and processing techniques.

Previous attempts to exploit the brown seaweeds commercially as a source of soda, potash and iodine failed with the discovery of cheaper sources of these inorganic materials. The investigations commenced in recent years by the association are, however, aimed at utilizing the organic constituents, carbohydrates, proteins and the like, which today find wide application in all the major industrial countries in the world and on which it is fairly certain that a permanent and thriving seaweed industry can be based.

[1]Numbers within parentheses refer to items in the bibliography.

So far alginic acid is the only organic constituent being used commercially on a large scale. While the acid itself is used in the manufacture of fibres, thickeners, protective colloids, insulating materials, etc., its real importance lies in the fact that it is the starting point for the production of alginates, which are used extensively in the food, textiles and paper industries, and in the manufacture of pharmaceutical, medical and surgical preparations. Mannitol, another important organic constituent, is used as an inert filler in foodstuffs, as a dusting powder for chewing gum, in the manufacture of varnishes, coatings for fancy papers and leathers, shoe polishes, soldering fluxes, pharmaceutical products such as metal complexes and colloidal suspensions, and so on. Laminarin and fucoidin are yet to be fully investigated, but it is fairly certain that new uses for these constituents will be developed when they become available in commercial quantities.

A suitable technique for surveying littoral seaweed beds quantitatively has been developed and successfully applied to the Scottish coasts, which have been found to support 180,000 tons of this type of weed growing at a density suitable for commercial exploitation. The technique used, which has been fully described by Walker (2), consists briefly of dividing the coastal areas into sections determined by changes in width, substratum, weed density, species, etc., and determining the average density in each section by cutting and weighing the weed within chosen quadrats. Using this technique, a survey of 4,250 miles of the Scottish coastline was completed by three botanists in twenty months, the results being correlated and analysed by a fourth, and senior, botanist.

The quantitative assessment of the totally submerged or sub-littoral seaweeds is more difficult. Aerial photographs are useful only to give a preliminary, and largely indirect, indication of the presence or absence of weed in the sub-littoral zone, and even for this limited use considerable experience is necessary before the results can be interpreted with confidence. It is difficult to pass on this experience. The possibility of using echo-sounding apparatus has been examined, but the present indications are that while seaweed reflects supersonic sound, the method gives no information on density or species. The "View Box-Spring Grab" technique (3), though somewhat laborious and time consuming, gives all the information required with a reasonable degree of accuracy. This method, which is applied after an area has been selected from a study of Admiralty charts, aerial photographs, and the general nature of the coastline, consists briefly of first observing the sea-bed through a view box fitted to the side of a boat to obtain an indication of whether or not a quantitative assessment would be worth while. In the original technique the quantitative assessment was made by taking samples at fathom intervals along transects from the coast. The samples were weighed and the average density of weed growth calculated and applied to the area under consideration to give the total quantity of weed growing in the area. It has since been found, however, that sampling along transects at measured depths can be replaced by random sampling with little if any, loss of accuracy, and a considerable time saving. It has, in fact, been estimated that the time required to survey an area using the modified technique will be only a quarter of that found to be necessary using the original technique. A specially designed spring grab which is closed automatically by a trip mechanism as soon as it hits the sea-bed and collects all the weed growing within the half-a-square yard which it covers, is used in the sampling operations.

During the past two years, the original technique has been applied to a survey of sub-littoral seaweeds growing in Orkney waters. Of the 180,000 acres of sea-bed between 0 and 10 fathoms around the Islands of Orkney, 90,000 acres were originally estimated to be worthy of consideration as potential sub-littoral seaweed beds. Of this 90,000 acres, preliminary surveys eliminated 50,000 acres as unworthy of more detailed survey or too dangerous for the application of the "View Box—Spring Grab" technique. The remaining 40,000 acres have been surveyed in detail using a 30 ft. 0 in. motor-boat and a crew of three.

From the results of this survey, it has been possible to estimate that the sub-littoral seaweed resources of Orkney in areas where harvesting would be profitable, amount to 1,200,000 tons, growing at a density of 20 tons/acre, mainly between 1 and 6 fathoms.

It has also been found that in strong tidal waters such as prevail around the Islands of Orkney, the density of seaweed growth, the weed cover and the depth at which the weed grows are related as follows:

$$\sqrt{\frac{d_t}{C}} = \alpha - \beta f \qquad (4)$$

where d_t is the average weed density of the total sampling operations,

C the weed cover, i.e., the number of samples with weed expressed as a percentage of the total sampling operations,

α, β constants for the particular survey area.

f the depth at which the weed grows.

Large quantities of sub-littoral seaweeds are dislodged from the sea-bed by winter storms and cast onto the beaches each year. Two factors must be taken into account in any scheme to utilize this weed. First, if it is not removed quickly, there is a considerable risk of its being reclaimed by the tide, and second, if left in the "packed" state in which it has been cast, it is susceptible to bacterial attack. If economic means of overcoming these difficulties can be devised, cast weed would undoubtedly form a very valuable source of raw material. Partly for this reason, and partly to obtain information on the location of sub-littoral seaweed beds, about thirty beaches in Scotland and the Outer Hebrides were kept under observation during the winters of 1945-1946 and 1946-1947. During each of these two winters about 100,000 tons of seaweed were cast, but little is yet known about the conditions of "casting". This is a profitable subject for further investigation.

Suitable methods for the routine estimation of the main organic constituents of the common Scottish brown seaweeds have been developed (5). Two methods have been developed for the quantitative estimation of mannitol, the first based on the quantitative extraction by a suitable solvent such as n-butanol, and the second involving the use of periodic acid. The extraction method is, however, unsuitable for routine analysis since at least four extractions of 10 to 12 hours are necessary. The periodic method is based on the fact that 92 per cent of the mannitol is oxidized in 60 seconds, while the other oxidizable constituents are unaffected.

The estimation of alginic acid is based on the extraction of the acid from the seaweed with sodium carbonate solution, the seaweed having been previously treated with dilute mineral acid. The sodium alginate so obtained is then converted into calcium alginate, followed by acidification to give the free acid, which is estimated by determining the amount of acetic acid liberated from a calcium acetate solution.

Laminarin is hydrolyzed to glucose, which is then estimated with the Shaffer—Somogyi reagent.

Fucoidin is estimated by hydrolysis to fucose, which is oxidized by periodate, and the liberated acetaldehyde determined by the method of Nicolet and Shinn.

Using these methods the chemical composition and variations in composition with age, season, and depth of immersion of some of the sub-littoral seaweeds common to Scotland have been determined (6). Monthly samples of *Laminaria Cloustoni*, *L. digitata*, *L. saccharina*, and *Sacchoriza bulbosa* have been collected for a period of two years, the plants divided into stipe and frond and analysed separately for total ash, organic nitrogen, iodine, mannitol, laminarin and alginic acid. The results indicate wide seasonal variations in composition which are due almost entirely to variations in the composition of the fronds.

The seasonal variation of the above constituents in the common littoral seaweed *Ascophyllum nodosum* over a period of two years has also been studied (7).

Algal celluloses have been prepared from *Laminaria Cloustoni*, *L. digitata*, and *Fucus vesiculosus* and have been shown to be fundamentally similar to the cellulose of the land plants (8).

In the extraction of alginic acid on a commercial scale, the remaining organic constituents of the weed are being wasted. This means that for every ton of alginic acid produced approximately three tons of potentially useful chemicals are at present being lost. Processes for the extraction of these chemicals are being investigated.

In the first attempt to harvest sub-littoral seaweed mechanically (9), the weed was cut by rotating cutters driven by under-water oil motors. The cut weed was entrained in water pumped from the vicinity of the cutters to conveyors on the deck of the surface craft, the water then being returned to the sea and the weed conveyed to the hold tanks. During trials under actual operating conditions continuity of harvesting was seriously interrupted by (*a*) the jamming of weed between the blades and the cutting plates, (*b*) the draping of frond over the cutting head with consequent "blinding" of the suction ports, and (*c*) damage to machinery by stones adhering to the entrained weed. These troubles were, to some extent, overcome, but an examination of the system has revealed serious faults which must be investigated before this principle can be developed as a practicable method of harvesting sub-littoral seaweed. With this object in view, work is proceeding to:

(*a*) Obtain additional fundamental information on the cutting of sub-littoral seaweed stipe,

(*b*) Effect the entrainment of whole plants to facilitate separation of stipe and frond for the subsequent drying and processing operations,

(*c*) Increase the weed-water ratio in the entrained mixture.

The use of specially designed grapnels for harvesting sub-littoral seaweed from motor-boats has been developed with the primary object of providing a simple method requiring inexpensive equipment for use by crofters and fishermen in part-time employment. In trials using a single grapnel and hand operated winch, a rate of over one ton an hour has been achieved, which brings the method within reasonable reach of commercial exploitation. Experiments to date have indicated that the weight of weed harvested in a given time increases, although at a diminishing rate, with the size of grapnel, the latter being limited only by the maximum weight that can be conveniently handled.

Further improvement is anticipated from tests at present being conducted with grapnels of a modified form which will traverse a track of greater breadth on the sea-bed. In actual harvesting operations two or more grapnels with power operated winches would be used and the weight of weed collected correspondingly increased.

While supplies of seaweed from crofters and fishermen working part-time would form useful additions to a main source of supply, they could not, in themselves, be expected to support a large industry. Some form of high capacity mechanical harvester is necessary for this purpose.

Because of the encouraging results from trials of the single grapnel method of harvesting, an attempt is being made to employ this principle in a continuous system. The most effective form, angle of incidence etc. of grapnel member has been investigated and a first prototype equipment designed and constructed for use under actual operating conditions. The equipment consists essentially of two side chains with steel mesh stretched between to form a continuous belt. Short hooks are mounted at suitable intervals. The object of the steel mesh is twofold, first, to compact the weed in front of the hooks and second, to cause the trailing end of the gear to ride on the surface of the weed-bed and thus prevent fouling of the hooks. By this means, the equipment can be of a much lighter form than would otherwise be possible, an important point in navigation. The downward thrust of the trailing end on the sea-bed is reduced in the prototype equipment by means of cork floats.

One of the main practical difficulties in operating equipment of this type is the anchoring of the hooks or chains on awkward obstructions on the sea-bed, and, in an effort to overcome this difficulty, the belt has been designed to operate in the reverse direction to the travel of the boat.

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Utilization of Algae

EMIL ÖY

ABSTRACT

The development of the seaweed industry from the kelp burning to the modern utilization of the organic constituents, e.g., alginates, mannitol, fucoidin and laminarin is discussed.

Schemes for the seasonal composition of *Laminaria digitata* and a suggested method for the production of the main constituents of this seaweed are given. The difficulties in connexion with the harvesting and storing of an adequate mannitol-rich raw material are mentioned.

Some essential problems of special interest in the use of seaweed meal as animal feed are also discussed. Thus the accumulation of trace elements in seaweeds is explained by regarding the alginic acid as an ion exchange material. Some experiments by the author on the organic iodine compounds in seaweeds are mentioned. The peripheral parts of the stipe of *Laminaria cloustoni* are very rich in organically bound iodine. The extract of this iodine-rich material after hydrolysis with barium hydroxide gave a positive Kendall's test indicating the presence of diiodotyrosine.

The negative digestibility of the proteins of some seaweeds is explained by the presence of a high molecular substance which has an adverse effect on the pepsin. The effect of several seaweeds is demonstrated by artificial digestibility experiments with casein in pepsinhydrochloric acid.

UTILIZATION OF SEAWEEDS IN NORWAY

The kelp burning and the production of iodine from kelp had a certain economic importance in some of our coastal districts until 1933 when Chilean iodine as a by-product of the nitrate industry undercut and drove the kelp out of the market; only small vestiges of the industry remained until the outbreak of the Second World War. In 1932, the export of kelp ash reached 4,800 tons and the combined value of exported kelp and iodine was 1.2 million kr.

In order to revive the industry and utilize the kelp resources, the Norwegian Department of Commerce sponsored research work during 1935-1940 at the Research Laboratory of the Norwegian Canning Industry which for the most part was conducted by the author. As regards the utilization of the raw material, the kelp-burning industry was very primitive. In Norway alone about 10,000 tons of organic material was burnt each year and in addition 25 to 50 per cent of the essential element—iodine—was volatilized and lost. Hence the research work was carried out to investigate methods for utilization of the organic compounds of the seaweed and to use seaweed meal as animal feed. A comprehensive analytical survey of the most common weeds was made, and the different organic constituents were studied and appraised as commercial products. A typical scheme for the seasonal composition of the fronds of *Laminaria digitata* is given below.

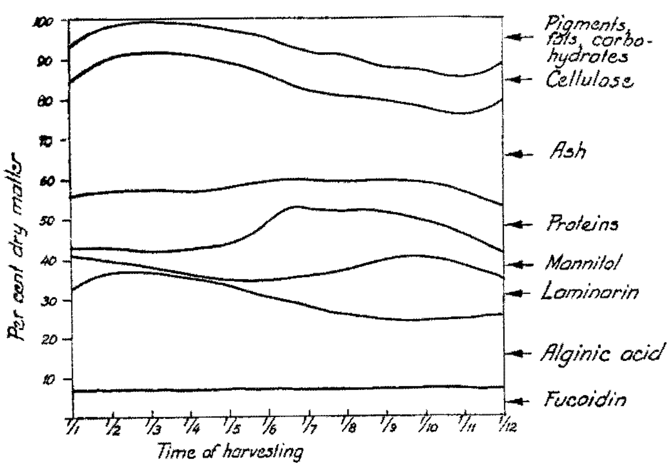

Figure 1. Seasonal composition of *Laminaria digitata*

The carbohydrate-rich raw material in the autumn was intended to be used as cattle-feed while the raw material harvested in June-July and relatively rich in mannitol and alginic acid was meant to be used for a complex process according to the following scheme:

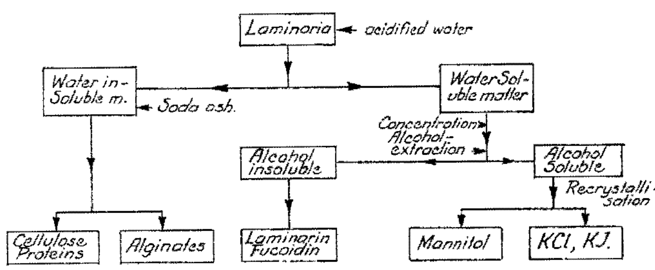

Figure 2.

The cellulose and proteins are of little value; besides, these products contain large quantities of water which makes the drying too expensive. The fucoidin is so slimy that the seaweed has to be leached with acidulated water which partly destroys its valuable colloidal properties as it is very sensitive to chemical and physical interference. Thus the difficulties lie in the harvesting of raw material adequately mannitol-rich to make the process profitable. The perennial stipe of the *laminaria* contains little mannitol and during our difficult weathering conditions some mannitol may be washed out or destroyed by bacterial activity. Also, some mannitol is lost by insufficient extraction.

The following table shows the analysis of a relatively mannitol-rich weed and the aqueous extracts after the above-mentioned process.

	Dry matter	Ash	Alginic acid	Laminarin	Fucose	Mannitol	Proteins
L. digitata				Per cent			
July 2, 1937	100	21.2	20.7	4.7	4.5	17.1	7.4
Extract:				*Grammes per litre*			
I	148	50	1.4	24	—	38	4.6
II	249	83	2.0	30	6.5	80	6.0
III	240	78	2.0	28	6.0	70	6.0

The mannitol content of the extracts which amounts to 30 per cent of the dry matter seems sufficient for practical utilization, but owing to the above-mentioned difficulties the method has not hitherto been further developed. Black (1)[1] has shown that the mannitol content of *Laminaria cloustoni* increases with depth of immersion. If effective harvesting and drying methods for such raw material were found, the possibilities exist for a complex utilization of seaweeds.

Preliminarily the seaweed industry is limited to the production of sodium alginate and carragheenin of high quality but in rather limited quantities. The planned harvesting of raw material for 1949 is as follows: 1,500 to 2,000 tons for seaweed meal; 1,000 tons for sodium alginate; and 150 tons for carragheenin.

Thus the utilization of algae has reached its former economic importance and is believed to be of increasing value, though great difficulties have been met with and are to be foreseen in the future.

THE ACCUMULATION OF TRACE ELEMENTS IN MARINE ALGAE

Cornec (2), Wiesner (3), Vernadsky (4), Jones (5), Williams and Whetstone (6), Bertrand (7), Ter Meulen (8) and the author (9) have investigated the properties of marine algae in accumulating trace elements from seawater. The following table represents the approximate accumulation of several elements:

Elements	*Species*	$n = \frac{\text{Element in fresh algae}}{\text{Element in sea water}}$
B	Different	4
B	Gigartina	10
F. Ca, K, S	Different	10
Au, Pb,	Different	100
Cu	Laminaria	200
Cu, Sn, Si	Different	300
Mn	Laminaria	300
P, As	Laminaria	500
Cu	Rhodymenia	1,000
Fe, Cr	Different	3,000— 5,000
I, Mn	Fucus	3,000— 5,000
I	Laminaria	20,000—30,000

The mechanism behind the phenomenon is obvious if one considers the alginic acid as an ion exchange material. The alginic acid is distinguished from other high-molecular carbohydrates such as cellulose and starch by having basic molecules which have, besides the two groups through which they are united in the chain, a third reactive group, carboxyl. This allows a further linkage and hence the formation of a three-dimensional super-molecule.

[1]Numbers within parentheses refer to items in the bibliography.

Thus the alginic acid chains are linked together across the carboxyl groups through multivalent cations, especially calcium, forming a more or less cross-linked, gelling structure which also induces physiological differentiation between the several parts of the plant. Analysis of holdfast, stipe and leaf of *Laminaria cloustoni* indicate the following ratio between equivalents of alginic acid and equivalents of calcium.

Holdfast: 0.5 to 0.6 eq. Ca per uronic acid unit
Stipe : 0.4 to 0.5 eq. Ca per uronic acid unit
Frond : 0.3 to 0.4 eq. Ca per uronic acid unit

Thus the holdfast has a stronger gel structure through denser cross-linking than the looser and more flexible gel structure of the frond while the stipe forms an intermediate structure. The perennial holdfast and stipe contain more of the other multivalent cations to which physiological importance must also be ascribed.

Other cation binding substances in marine algae are the carbohydrate-sulphuric acid esters, e.g., fucoidin and carragheenin. The seaweed colloids are also osmotic buffers which partly explains the accumulation of alkali chlorides and other soluble salts.

The accumulation of boron has been explained by the formation of boric acid esters of polyhydric alcohols; these alcohols also have metal complexing properties which may have certain effects. The organic arsenic compounds in algae are little known; likewise the minerals occurring in certain pigments. Sirahama (10) has isolated a glycerine fatty acid phosphorous compound through alkaline hydrolysis of seaweed.

As feeding experiments have indicated a certain effect of seaweed meal against animal diseases, the question concerning the amount of trace minerals in seaweeds has an economic importance for the seaweed industry; but further studies are necessary for the evaluation of seaweeds as mineral feed. The manurial value is due to the organic constituents which provide bulk for the soil, as well as to the mineral salts (11).

THE ORGANIC AND INORGANIC IODINE COMPOUNDS IN SEAWEED AND THE PROBLEM OF ENDEMIC GOITER IN EUROPE

The iodine in seaweeds occurs partly in organic combination as shown by Kylin (12), Closs (13) and Masuda (14, 15). Hercus and Aitken (16) and Toryu (17) claim to have found diiodotyrosine in *Cystophora retroflexa* and *Laminaria ochotensis* respectively. Jacques and Osterhout (18) have shown that the iodide concentration in the cell sap of halicystis is 1,000 to 10,000 times higher than in the surrounding sea-water.

The insolubility of the organic iodine compounds is shown by the following experiment with *Laminaria digitata*.

Composition of dry matter *(Laminaria digitata)*

	Iodine	*Ash*	*Proteins*	*Mannitol*	*Laminarin*
			Per cent		
Before leaching	0.40	21.2	7.4	17.1	4.7
After leaching	0.18	17.5	11.5	1.9	3.4
After algin extraction .	0.22	—	24.0	0	0

Thorough leaching with water removed 73 per cent of the iodine while the rest, after algin extraction, was enriched in iodine and proteins. The red algae *Gigartina mamillosa* contained 0.05 per cent iodine; after the extraction of carragheenin the dry matter contained 0.11 per cent iodine and 32.5 per cent proteins.

The bark or the outer, coloured layer of the stipe of *Laminaria cloustoni* was richer in iodine and proteins than the inner part of the stipe. The bark was cut off and leached in 1 per cent sodium carbonate which loosened the inner alginate-containing material. The composition in percentages is shown in the following table:

	Proteins	*Organic iodine*	*Iodine in proteins*
Inner stipe	5.7	0.04	0.70
Outer ,,	7.8	0.09	1.15
Bark I	28.6	1.65	5.80
,, II	28.7	1.83	6.40
,, III	29.3	1.83	6.24

The organic iodine follows the proteins and the presence of iodine containing amino-acids seems possible. Kylin (19) has shown that the seaweeds contain iodine oxidase which liberates free iodine, while Mazur and Clark (20) have shown the presence of tyrosine amongst other amino-acids. Hence the chemical assumption exists for the building of diiodotyrosine as follows:

Iodide + iodine oxidase   iodine
Iodine + tyrosine   diiodotyrosine

The seaweed fronds also have an outer layer which is rich in iodine and proteins and which probably is the seat in which are built organic iodine compounds.

An attempt to isolate diiodotyrosine after the methods used for thyroid glands by Harrington and Randall (21), Leland and Foster (22), Ludwig and von Mutzenbecher (23) was not quite successful. The extracts gave Kendall's reaction which may indicate the presence of diiodotyrosine, but the crystallization of the final solution of organically bound iodine after the barium hydroxide hydrolysis has hitherto been unsuccessful and deserves further studies.

The iodine question is of major importance for the seaweed-meal industry. As seaweeds are not palatable for the population of the western hemisphere, the indirect method of feeding seaweed meal to animals must be recommended. McClendon (24) has stated that Japan, where seaweeds are commonly used in the diet, is the only country which is free of endemic goitre and cretinism. According to Cauer (25), Jesser and Thomae (26) who have made an analytical survey of the iodine content of te airh in Central Europe during and after the kelp burning period, the mean value of the iodine content fell to a fraction of the original value when kelp burning ceased. The following figures show the variation from 1932 to 1941:

Iodine in the air of Central Europe according to Cauer, Jesser and Thomae

Year	*Iodine in air*
1932	20.0 gamma per 100 cub. metres (kelp burning)
1937/38	3.6 gamma per 100 cub. metres (kelp burning ceased)
1941	2.3 gamma per 100 cub. metres (kelp burning ceased)

During the kelp burning in the coastal districts 25 to 50 per cent of the iodine was volatilized and transported to Central Europe by means of western winds. Thus Central Europe is now deprived of an iodine supply in the atmosphere. The iodine had significant biological consequences and will need to be replaced in other ways. The only European sources are the seaweeds which contain iodine in more valuable forms than the usual iodine salts.

THE DIGESTIBILITY OF THE SEAWEED PROTEINS

It is known that the proteins of some seaweeds show a poor digestibility. Through feeding experiments with pigs, Ringen (27) found a negative digestibility of the proteins in *Ascophyllum nodosum* while the proteins in *Laminaria digitata* showed positive digestibility. As large amounts of seaweed meal cause loose stools it was thought that this might induce a loss of nitrogen-containing material from the intestines of the animals. In order to investigate this matter, artificial digestibility experiments were conducted with casein in pepsinhydrochloric acid by means of the usual technique with and without seaweed meal added. The results, in percentages, for several species of seaweeds are shown in the following table:

	Digestibility of casein		
	Casein	*Casein + 0.2 g. weed*	*Casein + 0.5 g. weed*
Laminaria digitata	93.3	92.4	89.5
Laminaria saccharina	93.3	89.6	88.2
Laminaria cloustoni	93.3	84.0	78.0
Fucus serratus	93.3	90.5	86.9
Fucus vesiculosus	93.3	84.5	79.4
Ascophyllum	93.3	85.1	80.8
Alaria esculenta	93.3	90.3	90.9
Cold water extract *Ascophyllum*	93.3	88.5	88.2
Warm water ,, ,,	90.9	88.8	88.0
Washed *Ascophyllum*	90.1	86.6	82.9
Cold water extract *L. cloustoni*	90.1	87.5	85.0
Warm water ,, ,,	90.1	87.0	82.0
Washed *L. cloustoni*	90.1	89.3	85.9
Seaweed meal (*Ascophyllum*)	92.0	—	78.7

The findings are closely parallel to those of the feeding experiments by Ringen (27) in which the *Laminaria digitata* proteins showed far better digestibility than those of *Ascophyllum* and in which *Ascophyllum* proteins showed negative digestibility. It is also interesting to note that the results are in agreement with the experience of the population in our coastal districts which prefers alaria (cattle weed) *Laminaria digitata*, *Laminaria saccharina* and *Fucus serratus* to the inferior species *Fucus vesiculosus*, *Ascophyllum* and *Laminaria cloustoni*.

One hundred grams of *Ascophyllum* were extracted twice with boiling water; to the combined extracts was added basic lead acetate solution. The precipitate was washed, decomposed with hydrogen sulphide, filtrated and concentrated. The filtrate from the lead acetate precipitate was dialyzed against distilled water for four days; the dialyzed solution was finally concentrated. Amounts corresponding to 2 grammes of dried weed were added to casein. The artificial digestibility analysis showed the following results:

Casein	*Casein + dried extracted weed*	*Casein + lead acetate prec.*	*Casein + filtrate*	*Casein + dial. filtrate*
90.3	74.1	88.0	84.8	84.9

Hence the active substance is moderately soluble in boiling water. It is not quantitatively precipitated with basic lead acetate and does not pass a semi-permeable membrane.

Accordingly it seems to be a highly molecular substance which would be difficult to separate from the laminarin and impossible to wash out of the algae with simple means. It may perhaps be classified as an enzyme poison, and it presents a serious obstacle to the utilization of some of our commonest seaweeds for animal feed.

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Marine Algae[1]

P. SCHANG

ABSTRACT

The seaweed which grows along the cost of Brittany may be classified into a large number of families.

The principal families are the following:

Fucaceae, shore algae rich in potassium, nitrogen and phosphoric acid, which are mainly used in agriculture (soil improvement.)

Laminaria, sea-bed algae, rich in iodine, potassium and alginate.

The first species is cut above low-tide mark in spring and in autumn, and the second is cut from boats at low tide.

Utilization of products extracted from seaweed: Iodine, pharmaceutical and photographic products; Potassium salts, fertilizers and manufacture of chemical products; Alginate, dressing of textiles, adhesives, stiffening, loading in soap manufacture, paper and leather industries, and surgical dressings.

Algae are extremely simple plants and, like fungi, are thallophytes.

They are classified according to their colour, in the following four divisions:

1. Chlorophyceae, green algae;
2. Cyanophyceae, blue algae;
3. Phaeophyceae, brown algae;
4. Rhodophyceae or Florideae, red algae.

Mention should also be made of eel grass (*Zostera marina*), a plant which grows in the sea and resembles land grass, and is used as material for packing, padding, upholstery and so forth.

HABITAT OF ALGAE

Algae live on sea-washed shores at a depth of less than 50 metres.

Owing to its purity and temperature, and to the currents which bring it to especially smooth sea-beds, the water on the shores of the Channel and of the Atlantic coasts of Brittany has always appeared extremely favourable to the development of these algae, which may be classified in many families, roughly divided as follows:

(*a*) Shore algae, sometimes submerged and sometimes dry;

(*b*) Sea-bed algae, always covered with sea-water.

SHORE ALGAE, OR FUCACEAE OR FUCOIDS

These algae are extremely important in agricultural economy.

They may be found on all rocky and shingle beaches. They readily leave the shore and penetrate up rivers as far as the tide carries enough salt to enable them to live. In such extreme conditions their development is limited and their forms often differ.

In the sea they grow near the shore and never at a great depth. Amongst the best-known species it has been observed that the nearest, in order of distance from the shore, are *Pelvetia*, *Fucus vesiculosus*, *Ascophyllum nodosum*, *Fucus serratus*, *Himanthalia lorea*, *Halidrys siliquosa*, *Cystoseira fibrosa*, and the *ericoids*.

Thus the vegetation zone of the fucaceae is very extensive, but it may be said that the limit of their full development is approximately 2 metres above low-water mark.

Fucaceae cover the rocks with a thick brown mantle at low tide, but stand erect at high tide, owing to the bladders

[1]Original text: French

filled with nitrogen which are scattered all over their surface and which lighten their weight.

There are many types of fucaceae, the chief being *Himanthalia lorea*, *Pelvetia caniculata*, *Platicarpus* and especially *Fucus vesiculosus* and *Fucus serratus*, which are rich in potassium, nitrogen and phosphoric acid. The following tables give the composition of the fresh and the dried plants:

	Chemical composition: Fresh plant (Per cent)	Chemical composition: Dry plant (Per cent)
Water	71.860	
Dry matter	28.140	100
Total ash	6.240	22.200
Soluble chlorinated ash	6.890	24.500
Nitrogen	0.684	2.430
Phosphoric acid	0.129	0.458
Sulphuric acid	1.670	5.940
Calcium	0.292	1.038
Magnesium	0.181	0.644
Alkaline chlorides	4.720	16.800
Potassium chlorides	2.400	8.550
Potassium	1.517	5.400
Sodium Chloride	2.320	8.330
Soda	1.230	4.380
Iron and aluminium oxides	0.240	0.855
Iodine	0.008	0.028

The plants are between 0.4 metres and 0.5 metres long, sometimes longer.

Ascophyllum nodosum

Although this fucoid is less salty, it is rich in fertilizing substances. Products useful in the textile dyeing industry may be obtained by hydrolysis.

Chondrus crispus

This small alga is very abundant in Finistère. It is also called carrageen lichen or white seaweed.

It forms a jelly in lukewarm water and produces consistent viscid solutions.

Its use in pharmacy, in cooking and as a thickener is well known.

It is exported mainly to Germany (for the preparation of preserves) and to America (for the manufacture of edible creams).

SEA-BED ALGAE

Laminaria are brown algae, the largest on the Breton shores, and include some highly important species.

They grow between cartographic zero and the 30-metre line.

They are attached to the rocks by highly-developed suckers and consist of a more or less rigid stalk with supple fronds which stand erect in the water and subside as the level drops.

The main species may be classified as follows:

Laminaria cloustoni. This plant has a stiff, solid stalk 0.8 metres long, which annually develops a frond 0.7 metres long, divided into strips; the old frond falls off towards the end of spring.

This alga is used in large quantities, being either washed up by the sea or cut from boats by professional seaweed cutters.

The chemical analyses are given in the following table:

Composition of whole Laminaria cloustoni

	I Percentage of dry matter	II Proportion of the fresh plant for each 23 grammes of dry matter (grammes)
Ash	30.30	7.27
Ash insoluble in water	4.29	,,
Chlorinated ash	27.93	6.70
Nitrogen	1.50	0.36
Phosphoric acid	0.09	0.02
Sulphuric acid	2.64	0.63
Calcium	1.65	0.39
Magnesium	0.37	0.08
Alkaline chlorides	19.18	4.60
Potassium	7.47	1.79
Potassium chloride	11.84	2.83
Sodium chloride	7.34	1.77
Iron peroxide	2.06	0.47
Aluminium	4.56	1.04

The quantities of iodine vary, but the average is approximately 1 gramme per 1,000 grammes of green matter.

These algae are very rich in minerals and in alkaline chlorides; next comes calcium, partially combined with sulphuric acid and accompanied by considerable quantities of iron and aluminium oxides, which are actually obtainable from the plant. These oxides are usually most abundant in old plants and especially in old stalks.

The proportions of nitrogen and phosphoric acid are low, and *L. cloustoni* seems to be an especially abundant source of potash.

Laminaria digitata and *L. flexicaulis*. The first has a short stalk, 0.1 metres long; the second has a long stalk, between 0.6 and 0.7 metres long; both bear fronds divided into strips, the length of which often exceeds 2 metres.

As the stalks are small in diameter, and extremely flexible, the bearing of the plant varies according to the water level.

The chemical analysis is given in the following table:

	Chemical composition: Fresh plant (Per cent)	Chemical composition: Dry plant (Per cent)
Water	73.07	
Dry matter	26.92	100
Organic matter	21.95	81.70
Total ash	4.96	18.40
Ash insoluble in water	1.10	4.08
Nitrogen	0.29	1.07
Phosphoric acid	0.10	0.41
Sulphuric acid	0.56	2.08
Calcium	0.27	1.02
Magnesium	0.28	1.04
Total alkaline chlorides	3.36	1.25
Potassium chloride	1.79	6.67
Potassium	1.12	4.17
Sodium chloride	1.57	5.85
Soda	0.83	3.08
Iron and aluminium oxides	0.15	0.55

The iodine content varies according to the development of the plants and the time of the year between 0.7 grammes and 1.7 grammes.

These algae are thus rich in alkaline chlorides and, like *Laminaria cloustoni*, contain little nitrogen or phosphorus.

Their industrial value lies in their iodine and potassium-salt content.

Laminaria saccharina. This alga is shaped like a long ribbon, fluted at the sides with a corrugated surface. The stalk is short and the frond is sometimes over 2 metres long Its sweet taste, which gives it its name, is due to its mannitol content.

	Chemical composition of Laminaria saccharina	
	Fresh plant	*Dry plant*
	Per cent	
Water	69.24	
Dry matter	30.76	100
Ash insoluble in water	2.05	6.54
Chlorinated ash	14.57	47.46
Nitrogen	0.23	0.73
Phosphoric acid	0.20	0.65
Sulphuric acid	1.69	5.50
Calcium	0.73	2.37
Magnesium	0.28	0.91
Alkaline chlorides	9.56	31.30
Potassium chloride	4.92	15.98
Potassium	3.11	10.12
Sodium chloride	4.64	15.10
Iron and aluminium oxides	0.54	1.75

These algae have a small iodine content, of approximately 0.3 grammes per kg. of green matter.

Laminaria saccorrhiza bulbosa. These algae are even larger than the preceding ones. They have long sacculated stalks of elliptical section and ending in large fronds.

	Chemical composition of Laminaria saccorrhiza bulbosa			
	Fresh plant		*Dry plant*	
	Per cent			
Water	89	440		
Dry matter	11	560	100	
Ash insoluble in water	1	020	8	830
Chlorinated ash	,,		,,	
Nitrogen	0	189	1	638
Phosphoric acid	0	044	0	383
Sulphuric acid	0	235	2	030
Calcium	0	242	2	090
Magnesium	0	191	1	660
Alkaline chlorides	4	980	45	300
Potassium chloride	3	878	33	420
Sodium chloride	1	375	11	880
Iron and aluminium oxides	0	082	0	752
Iodine	0	007	0	068

There are other species, but they are relatively unimportant.

Having given the chemical composition of the various species of algae, we will not study them further but will consider their practical utilization.

CULTIVATION, HARVESTING AND PROCESSING

CULTIVATION

The cultivation of seaweed has never been considered in France, since generous nature provides an ample new supply every year, both washed up on the beaches by the winter and spring storms for collection, and growing on the shores and shallow sea-beds for cutting at low tide.

HARVESTING

The two main methods are as follows:

1. Collection of the seaweed washed up on the shores by winter and spring storms, sometimes in enormous quantity and consisting mainly of the *L. cloustoni* variety, sometimes the stalks, sometimes the fronds and sometimes both together.

2. Cutting the fucoids above tide mark twice a year, in accordance with decisions of the local authorities, since these weeds are mainly used for soil improvement.

3. Cutting laminaria with long-handled sickles and reaping hooks from boats manned by men registered for naval service.

Whichever method of harvesting is used, the seaweed is dried in the fresh air, and the sun and wind soon extract most of the water. It is thus easy to obtain seaweed containing only 30 per cent of moisture instead of the 80 per cent or more it contained when it was harvested.

Seaweed with a 30 per cent moisture content can be perfectly well preserved in stacks, even in the open air.

The part of the seaweed called "sea wrack", which is not used for cultivation and is dried as has just been described, is then burned, and the ash is the raw material from which iodine and potassium salts are extracted. Cut and dried laminaria may be used in the following ways:

Raw, in the manufacture of alginates and iodine.

Burning of sea-wrack to ash, for the extraction of iodine and potassium salts.

TECHNIQUE AND EQUIPMENT

The technique described below may be used either in the collection of sea wrack; or in the cutting of laminaria where they grow.

In laminaria cutting, boats approximately 7 metres long, weighing from 3 to 5 tons, manned by two men and propelled by sail or motor, go at spring ebb-tide to the seaweed beds, where fronds of *cloustoni*, *digitata* and *flexicaulis* soon appear.

The seaweed gatherers pull up or cut the laminaria with long-handled reaping hooks or sickles and haul them into the boat. The boat when loaded returns to port on the flood-tide.

On reaching the beach, boats are unloaded into carts waiting for them along the shore, and the weed is spread over grassy or rocky fields to dry sufficiently for keeping.

In the evening, in order to avoid the night dew, it is advisable to stack the weed temporarily, and on the following morning to spread it out again until it is sufficiently dry.

Attempts have been made to find more efficient methods of collecting laminaria than with reaping hooks or sickles, but the problem of mechanization is rendered very difficult by the irregularity of the sea-beds.

The people of the coast are skilled in this work, the men in the boats and the women and children on land. Its maintenance is a social necessity, since the community has no other adequate means of subsistence.

UTILIZATION AND DERIVATIVES OF SEAWEED

FOOD

In some countries, for example Japan, seaweed is eaten. Brittany seaweed has not yet been used much in this way. In hard times, such as the 1914-1918 war, attempts were made to feed horses and cattle with more or less processed seaweed but were never carried very far.

On the other hand, suitably-selected, dried and pulverized seaweed has been found to possess certain properties as a vitamin-containing condiment in the preparation of food for children.

It should be added that certain products based on alginate, extracts of natural seaweed, are used in America for human food. There is therefore no reason *a priori* why this idea should not be applied in France and elsewhere in Europe.

INDUSTRY

The uses of products extracted from seaweed ash are as follows, in chronological order:

Iodine and all its derivatives: pharmaceutical and photographic products, electric cells, potassium salts, potash fertilizers and manufacture of chemical products.

Then come a number of new products extracted from natural seaweed in the form of alkaline alginates, and other metals, the use of which is daily becoming more extensive.

In the textile industry, for the dressing, dyeing and printing of fabrics, and soon probably for the actual manufacture of fabric.

In soap manufacture and perfumery.

In paper manufacture and leather dressing.

In all preparations requiring the qualities of emulsions, agglutinants, stiffeners, loaders and coatings (e.g., in textiles, highway maintenance, and cryptogamic products).

In medical and surgical dressings.

The normal annual consumption of iodine in France is approximately 80,000 kg., which can be obtained from seaweed.

AGRICULTURE

Seaweed has always been gathered in Brittany for soil improvement. Its richness in potassium and nitrogen and its organic content (see the tables of chemical composition) have made an important contribution to the light soil of Brittany and have made it possible to cultivate first-class early vegetables and fruit (cauliflower, potatoes, peas, strawberries etc.) in sandy soil.

Substances washed away by rain are restored to the soil in seaweed.

Potassium salts extracted from seaweed ash have also helped appreciably in the cultivation of the soil of the interior.

PRESERVATION OF SEAWEED

As has been pointed out, the mere exposure of seaweed to sun and wind dries it sufficiently to ensure that it will keep perfectly even in the open air.

The seaweed industry therefore makes an important and valuable contribution to the life of a country.

Summary of Discussion

The CHAIRMAN pointed out that three papers had been presented on Research in Fishery Conservation: Mr. Graham's on "Changes in the North Sea Stocks of Fish"; Mr. Huntsman's on "Research on Use and Increase of Fish stocks"; and Mr. Rao's on "Research in Fishery Conservation—Techniques Used in Studying Fisheries, and the Integration of Hydrological, Biological and Other Studies in a Well-Rounded Marine Fisheries Research Programme in India".

As two of the authors were absent, Mr. Graham had agreed to summarize the three papers concerning research in fishery conservation and to answer any questions put to him. Mr. Woodward, the programme officer, would, moreover, review papers on the utilization of algae.

The Chairman recalled that the first question was connected with other problems which had already been examined at previous meetings, in particular those of 22 August and 25 August which had dealt respectively with changes in abundance of fish populations and fisheries statistics. The debate which was about to take place would therefore be based on previous discussions.

He also stated that the Water Section would that morning deal with a related question, namely the protection of fish and wild-life, in connexion with the study of the utilization of hydro-power. That meeting would take place at noon to enable members of the Wild-life and Fish Section to attend it.

Mr. M. GRAHAM stated first that the three papers were somewhat heterogeneous. Since the conclusions of his paper were opposed to the thesis supported by Mr. Huntsman, he thought the summary which he was to give of the three papers would be more coherent if he began with Mr. Huntsman's.

Mr. Huntsman indicated first that there was lack of clear proof that overfishing left too few fish to spawn and that restriction of fishing to help reproduction did not seem necessary. He then said it was sometimes argued that it paid to let small fish become large, and that, although some died, the others becoming larger would be more valuable. Proof was needed of that fact. That argument did not apply to fish such as the pink salmon, the Atlantic salmon and the young of halibut. In his opinion, the proper technique was to mark the young to discover whether those actually taken when older were more valuable.

Mr. Huntsman opposed the biologists who based their conclusions on the graphs of profits drawn up by commercial undertakings. So many other factors came into play that those graphs should not be the only criteria for biologists.

Mr. Graham pointed out that the programme of action suggested by Mr. Huntsman could give rise to no objection. In the interests of the conservation of marine resources, the author thought greater attention should be paid to scientific research.

Mr. Graham said the paper was very valuable and he would advise his staff to read it. He had read it, however, with a certain feeling of impatience. During his whole career, he had noted the disastrous consequences of overfishing from the economic as well as from the social point of view, and if Mr. Huntsman stressed the need for scientific research, he, for his part, would state the plain facts to show what had happened during the previous generation and what was currently happening in the North Sea.

There were several tables, figures and information in his paper which showed the position in the United Kingdom.

He thought that Mr. Rao's paper was of undeniable interest but he had not been able to obtain any information from it which was of world significance.[1] Mr. Rao visualized the adoption in India of the methods used in fisheries research in western countries with some slight modifications to take account of local conditions. He pointed out that research was still in the preliminary stage.

The CHAIRMAN declared the meeting open to general discussion. In Mr. Graham's paper it was pointed out that "The largest query outstanding is whether the apparent insensibility of the herring stock to fishing is not due to hard fishing of demersal species, nearly all of which are its enemies." That would imply that demersal species were harmful to pelagic fish. He wished Mr. Graham would clarify that point.

From the summary of Mr. Huntsman's paper it appeared that conservation measures were useless, that there was an urgent need for fisheries statistics and that it was most important to improve the techniques for evaluation of the results of certain measures relating to fishing.

In connexion with Mr. Rao's paper, the Chairman remarked that, so far as fisheries were concerned, India was half-way between the highly-developed and the under-developed countries. Since the aim of the Conference was to enable an exchange of views to take place, he would like members of the Section to study the programme being carried out in India and to state their opinion on it. If that programme gave results it might be undertaken in other tropical regions. It was important to know whether the methods adopted in western countries could be applied in tropical regions, taking into account the fact that marine resources there were not similar. In the northern hemisphere, for example, there were many demersal species whereas pelagic species were abundant in tropical regions.

Mr. N. AHMAD pointed out that in the first sentence of his paper Mr. Rao said that the geographical, climatological and other features of the country served to show that the environment of fishery development was generally favourable and that consequently the exploitable resource must be considerable.[2]

In Mr. Thompson's paper, on the other hand, it was said that those who had had experience of exploratory research in the warmer seas had on the whole been forced to the conclusion that fish populations were less dense there than in the higher latitudes of the northern hemisphere, and that, although the water masses were enormous in extent and must in the aggregate contain great quantities of fish, the catching of those economically in commercial quantities presented certain difficulties. Those two statements were contradictory. In Pakistan, for example, where primitive methods were still in use, the fisheries were as yet of little commercial importance.

He shared Mr. Thompson's opinion but wished to hear the views of other members on the question.

Mr. A. L. PRITCHARD, commenting briefly on Mr. Huntsman's paper, stated that the latter declined to draw a distinction between the economic and the biological exhaustion of marine resources, and said that he was right. When the yield from a fishing zone ceased to be economical because the fish stock had diminished that zone was abandoned and there were therefore no definite grounds for stating that overfishing had actually caused biological depletion.

He was sure that if Mr. Huntsman were given convincing proof that overfishing might have harmful results, he would be ready to change his opinion. Mr. Pritchard had personally succeeded in making him admit that stocks of pink salmon and Atlantic salmon might be exhausted if they were overfished.

Mr. BOTTEMANNE made some brief observations on Mr. Rao's paper. The latter stated that the way to develop fisheries in India was to undertake biological research, adopting the methods used in western countries.[3] Basing his views on the experience he had acquired in Indonesia, he did not share Mr. Rao's opinion. It should not be forgotten that in western countries fisheries were already highly developed when research was begun, and it could be based on the results already obtained. It was not the same for tropical regions. The first thing necessary there was to discover fishing zones. Fishing was more difficult there than in western countries because the water was clearer and the fish swifter. Biological research was certainly useful, but the fisheries themselves should be developed first and then corresponding research, which would probably give useful data, could be undertaken.

The CHAIRMAN asked Mr. Bottemanne to put his interesting observations in writing, as he wished to transmit them to the Indian Government.

Mr. ENGLE thought that Mr. Rao over-estimated the potential production of the 1,280,000 acres of swamps, estuaries and backwaters of India when he stated in his paper that they might be expected to produce anything up to 640 million lb. of fish per annum. In making such estimates, it was not possible to take as a basis the optimum results obtained from experimental fishing carried out under the best possible conditions.

There was an additional reason for caution in making assessments: when attempts at culture are made in a region so extensive as that of which Mr. Rao was speaking,

[1] The following is an excerpt from a communication from Mr. Rao: "The paper states that herrings (sardines, etc.), anchovy, mackerel and perch constitute the bulk of the sea-fisheries of the Indian coasts. These are of wide-spread occurrence, particularly the mackerel, in the South-East Asia region, and are therefore of wider significance".

[2] *Ibid.*: "The general concept is that tropical waters support less dense populations of fish than colder waters. But many exceptions are to be found in the areas subject to cold oceanic currents or welling up where rich fisheries exist. Even if the resources are not as rich as the fishing grounds of the North Atlantic, the fisheries have an added importance as they serve areas where the diet of the people is deficient in proteins. In the author's opinion, neither the exploratory research nor the exploitation of the fish of the warmer seas has been on a scale comparable to that of temperate waters, due probably to the low economic condition of many countries of the tropics".

[3] *Ibid.*: "It is not claimed that biological research alone would contribute to development of fisheries; that is only one aspect of the problem. There is, admittedly, need for developing fishing by the use of mechanized craft and gear so as to bring off-shore waters within the operational field and to discover fresh fishing zones, as is clearly stated in the paper, but it is difficult to concede that preliminary research of whatever kind should await mechanization, for one of the aims of exploratory research is to find out the extent of resources to justify the more intensive mechanized fishing."

due attention must be accorded to the possible incidence of infectious diseases and other unforeseeable factors which might have disastrous effects on the stock of fish.[4]

The CHAIRMAN requested Mr. Engle to draw up a report for transmission to the Indian Government, for its information.

Mr. M. GRAHAM replied to the questions put to him. In the present state of knowledge, it was difficult for him to reply positively to Mr. Ahmad. Mr. Ahmad had cited the terms into which Mr. Thompson had translated the classic conception that the dense fish population of temperate waters was due to the fact that those waters were inhabited by certain highly productive species, whereas tropical waters contained a large number of species with a low rate of production. According to traditional thought, that fact was due to the low plankton content of tropical waters. Mr. de Vries and Mr. Bottemanne, however, in their recent paper took a more optimistic view of the possibilities of fishing in tropical waters. The question remained unsolved and deserved exhaustive study.

He pointed out to the Chairman that in nature no very clear line of demarcation existed between the zones inhabited by deep-sea fish and by the pelagic species. It was therefore possible to conceive of the existence of neutral zones in which the two species met and gave free rein to their rivalry. That had been observed in the case of the cod, which certainly fed upon herrings in the North Sea.

Mr. Graham drew attention to the fact that certain experts believed that one of the most harmful consequences of overfishing was the reduction of spawners. That argument had been advanced by the Scottish scientist Raitt. Although two members of Mr. Graham's laboratory at Lowestoft, who were currently studying that argument, were inclined to acknowledge that it was well founded, considerable controversy continued and no final scientific conclusion had yet been reached on that subject.

Returning to Mr. Huntsman's paper, Mr. Graham emphasized the great difficulty of supplying at short notice the positive and historical proofs demanded by its author. It was an incontrovertible fact, however, that, whatever the cause might be, certain stocks of fish were in danger of disappearing, and it was clear that the fishing industry could not stand idly by, while awaiting the completion of exhaustive scientific studies. That was why, in certain countries, including the United Kingdom, investigations were being based largely on practical considerations and the fisheries were taking an important part in the organization of the biological and oceanographic studies requisite for the development of their activities. Mr. Graham thought that the maritime countries would find it to their interest to be guided by the system applied in his country, which had proved to be of considerable use, both from the scientific and from the purely commercial point of view. The United Kingdom had set up an Advisory Commission composed of the directors of the various services engaged in research on fishing, representatives of the administrative services concerned, members of universities interested in that question from the scientific point of view and representatives of the fishing industry. The last-mentioned were usually the owners or managers of fisheries; but they naturally took into account the opinions of the commanders of their fleets, so that the Commission represented as fully as possible the opinion of all the circles directly concerned, and its conclusions were based on the entirety of their pooled experience. Mr. Graham had no doubt that the application of any development programme of the kind envisaged by Mr. Rao would be furthered by the adoption of that method, which had had successful results in the United Kingdom.

Mr. BOTTEMANNE said that although it was true that very many different species of fish lived in tropical seas, very few of them had any attraction from the point of view of commercial fishing.

He thought, however, that those species were more productive than was generally supposed. His long experience of fishing in Indonesia led him to conclude that the principal factor in augmenting the volume of catches in tropical regions would be the motorization of the fleet. Those regions had remained in the age of sail. He recalled the revolution which the introduction of the steamship had brought about in the North Sea Fisheries. The introduction of motorboats and the transformation of the indigenous coastal fisher into the deep-sea fisher would not fail to have a similar effect on the fishing industry throughout the Far East.

At the invitation of the CHAIRMAN, Mr. WOODWARD outlined briefly the existing status of phycology—a new and relatively unexplored field of knowledge. Algae were divided into four main groups according to colour: green, blue, brown and red. The only algae of any commercial value were the red and the brown, the latter being in great preponderance.

He would not dwell upon the red algae, as only agar could be extracted from them—a product which, although finding increasing use in industry, had only limited uses. In that connexion, he pointed out that the Second World War had shown that many of the countries on the coasts of which red algae grew (cf. U.S.A., Great Britain, South Africa, Australia, New Zealand, etc.) became self-supporting in their production of agar.

Turning to the brown algae, the largest group, he pointed out on a world map the regions in which it was estimated that a quantity existed large enough to be of commercial value—regions which supported more than 100 tons of algae per mile of coast. The non-buoyant sub-littoral algae were found in greatest profusion in western European countries, Norway, Eire, the White Sea, the United Kingdom, France, and along the eastern coast of North America. The buoyant sub-littoral brown algae, the principal species of which was the giant kelp *Macrocystis Pyrifera*, were found mainly in British Columbia, California, Peru, Chile, Cape Horn, the Falkland Islands, around the Cape of Good Hope, in Tasmania and New Zealand.

Mr. Woodward then gave a summary of quantitative estimates of brown algae, emphasizing the fact that the

[4] *Ibid.*: "The estimate is based on known production figures in Europe and the Philippines without the use of fertilizers or manures, but as far as India is concerned, even half the reported figures would meet its food requirements to a considerable extent. More field data are certainly desirable and caution in making assessments is necessary as has been pointed out. Knowledge of the environment and the organisms concerned from the physical and biological points of view would help in coping with unforeseeable adverse factors like infectious diseases, etc."

data which he would give could not be regarded as absolute, as few methods had yet been developed for surveying seaweed beds, and such as had, had only been applied in a few areas. With regard to the buoyant sub-littoral brown algae, it was estimated that there were approximately 45 million tons in the North American Pacific region, 17 million tons in the Falkland Islands, 500,000 tons in Tasmania and 50,000 tons in New Zealand. It was probable that at least equal amounts existed in regions such as South America and the Southern circum-polar area, about which insufficient data were available for accurate estimates.

With regard to the non-buoyant sub-littoral species, it had been possible, owing to lack of data, accurately to assess only the amounts available in Scotland—about 10 million tons. It was known, however, that there was an abundance of such algae in Norway, Eire, in the White Sea, in Japan and in France. Mr. Woodward observed that Mr. Jackson's paper on the utilization of marine algae contained a description of methods developed at the Institute of Seaweed Research in Scotland to discover algae and assess them quantitatively. The best methods developed depended upon new aerial photographic techniques and a novel "View Box-Spring Grab" method; echo-sounding apparatus had not been found applicable.

Methods at present used for harvesting the brown algae, with one exception, depended upon manual labour. The oldest method, the one still used in Eire and Scotland, consisted simply of picking up the seaweed washed up on the shores by winter and spring storms. In the North American Pacific, where the buoyant types are used, mechanical harvesters are employed, which, on the average, bring in 300 tons of algae per boat per day.

In the waters of the Western Hemisphere, where very severe difficulties are encountered, due to the non-buoyant nature of the weed, grapnels and dredges are being experimented with, although they are not yet in general use. In addition, a method based upon a combination of the principles of the vacuum cleaner and the lawn mower shows some promise. The variety of these methods could be attributed to the diversity of the conditions prevailing in various regions, but, whichever were chosen, it appeared probable that harvesting should be carried out in the same region only one year in three, if the algal resources were to be properly conserved.

All the brown algae, wherever they grew, were of the same general chemical composition. That could vary considerably, according to the season, species, location and part of the alga examined but, in general, the composition of the brown alga comes within the following limits:

		Per cent
Water		70—90
Dry content		
Carbohydrates	Mannitol	6—20
	Alginic acid	14—26
	Laminarin	0—24
Proteins		6—13
Lipoids		0— 3
Ash		20—45

The exploitation of algae had been undertaken in western Europe since the year 1700. It had been based mainly on the utilization of the mineral elements contained in them—soda, potash and especially iodine. They were no longer exploited for their soda and potash content. Only in France and Japan were they still utilized as a source of iodine whereas modern industry was principally interested in the extraction of their carbohydrates.

Mr. Woodward drew attention to the considerable commercial possibilities offered by algae carbohydrates, of which the four principal ones were alginic acid, laminarin, mannitol and fucoidin. Of those, only alginic acid was currently being commercially prepared, particularly in Norway, France, the United Kingdom and the United States of America, where it was used in the textile, food and pharmaceutical industries. As for the other products, they were still in the laboratory stage. Laminarin, which it was hoped would soon be available to the public, was expected to play a role in the field of surgery and medicine in providing a new source of glucose.

The Chairman, opening the general discussion on the utilization of marine algae, observed that the tropical regions were practically without resources in that field. During the war, attempts had been made in India to produce agar but it had been found to be of a very poor quality. He wondered whether that result was attributable to a poor choice of methods used or to the inherent nature of tropical algae.

Mr. Rousseau questioned Mr. Woodward regarding the economic possibilities offered by the utilization of algae from the Sargasso Sea.

Mr. Bonnefil inquired about the application of phycology to the synthetic textile industry.

Mr. Seidenfaden asked on what data the triennial cycle for the harvesting of algae was based.

Finally Mr. Revelle wished to know whether there were any plans for employing under-water photography in estimating world algae resources.

Mr. Woodward, replying to each of the four questions in turn, said that he had discussed the question of Sargassum weed with biologists and oceanographers cognizant with that area. From those conversations he had gathered the impression that the volume of seaweed available there was being greatly over-estimated. The total surface area of the Sargosso Sea was in fact only 200 square miles and the algae brought into the area by the currents were found on the surface and did not represent any great tonnage.

As for the textile industry, the possibilities offered by the new science were very great and it would take up too much time to list them all. Alginic acid was being used particularly in textile size and as a raw material for the manufacture of soluble yarns.

Mr. Woodward observed that triennial harvesting seemed to provide the greatest margin of safety from the point of view of conservation of algae resources. Nevertheless, a definite rule could not be established; in certain specific areas, for example, two or three harvests took place yearly without any apparent bad effects.

Lastly, Mr. Woodward stated that no substantial study had yet been made of the possible use of under-water photography. He had taken advantage of his stay in the United States of America to look into the matter, and he hoped in the future to be able to apply the techniques developed at the research laboratories at Woods Hole.

Game and Fur Conservation

26 August 1949

Chairman:

Abelardo MORENO, Professor of Zoology, Director of Museo Poey, University of Havana, Havana, Cuba

Contributed Papers:

Wild-life on Croplands
Edward H. GRAHAM, Chief, Biology Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C.

Game Conservation on Croplands in Great Britain
A. D. MIDDLETON, Biologist, Imperial Chemical Industries, Game Services, Fordingbridge, Hampshire, England

Recreation and Wildlife Problems Peculiar to Rangelands of Western United States
J. V. K. WAGAR, Head, Department of Forest Recreation and Game Management, Colorado A. & M. College, Fort Collins, Colorado, U.S.A.

Game and Fur Conservation on Rangelands in the Western United States
D. I. RASMUSSEN, In Charge of Wildlife Management Intermountain Region, United States Forest Service, Ogden, Utah

Ecological Aspects of Deer Production on Forest Lands
A. Starker LEOPOLD, Assistant Professor of Zoology, Museum of Vertebrate Zoology, University of California, Berkeley, U.S.A. Cal.

Summary of Discussion:

Discussants:

Messrs. E. GRAHAM, LINCOLN, DAHLBECK, VOGT, F. DARLING, M. GRAHAM, ORPEN, RASMUSSEN, G. SWANSON, BREWER, WAGAR, LEOPOLD. H. D. FISHER, MUNNS

Programme Officer:

G. E. BREWER, Jr.

Wildlife on Croplands

EDWARD H. GRAHAM

ABSTRACT

On farms and ranches in the United States certain lands, such as marshes and odd areas, are best used when they are managed for furbearers, water-fowl, or some other kind of useful wildlife. Most agricultural land produces wildlife as a by-product, for it is used primarily to produce a cultivated crop. Some land-use practices developed and encouraged by the Soil Conservation Service, as a part of soil and water conservation operations, are particularly beneficial to wildlife. Chief among them are: use of *Lespedeza sericea* and *Lespedeza bicolor* for field border plantings; use of *Roza multiflora* for hedges or living fences; stabilization of streambanks by use of appropriate vegetation; establishment of wind-breaks that include tree and shrub species of value for wild-life food and cover; management of ponds for fish production (large-mouth black bass and bluegill sunfish); and the planting and protection of pond areas for furbearers, waterfowl, game and other wildlife. Such practices are applied to the land first because they are good for the land itself and therefore of value to those who operate the land. They are the habitat improvement measures that are being applied to cropland to make it permanently productive of wildlife.

Some wild vertebrate animals are considered harmful, a great many seem to have no economic value, and a number are considered useful because of sport, their fur, or other values. Wildlife also has important aesthetic and ecologic values, but such values in practical agricultural programmes are usually given little weight.

Along with cultivated crops, domesticated animals, grass, and trees, wild animals are a basic biological resource. Wildlife cannot rightly be separated from "land resources" as it has been separated in the agenda of this Conference. Wildlife is as much a product of the land as any other living resource.

The management of wildlife is different from that of all other living resources in some fundamental respects. Wildlife in the United States is not owned by the person on whose land it occurs. As an inheritance of English law, American wildlife belongs to the State, not as proprietor but in its sovereign capacity for the benefit of all the people. Therefore, while a man may sell his cultivated crops, domesticated animals, livestock, trees and other land products, he cannot sell the wildlife which his land produces. He can, however, sell hunting privileges to those who have obtained a hunting licence from the State. He may also, under State law, sell furs which he obtains from animals he has trapped on his own or other lands.

Wildlife also differs from many other living resources in that, for the most part, it is a by-product of lands which are used primarily for the production of other crops. Although some land in the United States is devoted exclusively to the production of wildlife, such as public refuges and extensive marshes, most wildlife comes from land that is used for cultivated crops, livestock, and wood products.

Because of the nature and ownership status of wildlife, operations on private cropland intended to increase the production of wild animals are most likely to succeed if they have land-use values in addition to their wildlife values. The things that are being done for wildlife benefit on cropland in the United States can be separated into two groups. First are operations on land that has as its chief value the production of wild animals. Secondly, there are land-use operations that produce wildlife on land used also for other purposes.

It has been estimated by the Soil Conservation Service that there are approximately 100 million acres of land in the United States that are not adapted to the production of cultivated crops, livestock or trees, the most suitable use of which is wildlife production. Approximately one-third of this acreage is on farm land. One type of land suited best to wildlife is the marsh which it is not physically desirable or economically feasible to drain. Both coastal salt-water marshes and inland fresh-water marshes have been given special attention for the production of furbearers, especially muskrat, and for migratory water-fowl. The specific things done to marshland for such purposes are: fencing, to control cattle grazing; ditching, chiefly to provide wildlife travel lanes; control of water-levels to manipulate vegetation; controlled burning to manage vegetation; and seeding and planting of desired plant species.

Other agricultural lands that can be devoted exclusively to wildlife are odd areas. These are usually small, such as inaccessible corners of cultivated fields, gullies, rough and rocky sites, highly eroded spots. Odd areas are managed for wildlife production by protecting them from fire and grazing. They are frequently planted to trees and shrubs that provide wildlife food and cover. Although individually small, the total acreage of odd areas is very large—amounting perhaps to something like 10 million acres in the United States.

In addition to the development of lands such as marshes and odd areas that are best used when they are managed exclusively for wildlife, there is a group of practices that produce wildlife as a by-product of cultivated crop production. One such practice is the field border planting. In many regions the margin of a crop field, where it adjoins woodland, produces little or no growth of crop plants and frequently erodes into an unsightly and unproductive area. Because of the shade and root competition of the adjacent trees and the infertile nature of the soil, most plants make poor growth on field margins. After considerable trial the Soil Conservation Service found that two perennial legumes would grow well under such conditions. These two plant species are now used a great deal in revegetating crop field borders. The larger shrubby species, *Lespedeza bicolor*, is planted next to the trees in a band 15 or 20 ft. wide. Beside the bicolor on the field side of the border the smaller wand-like *Lespedeza sericea* is planted in a band of comparable width. Sericea serves as a turn-row for team and tractor and for wildlife cover. The seed of bicolor provides A-1 bobwhite quail food and the flowers are an important source of nectar for honey-bees. Millions of bicolor plants and thousands of pounds of seed of bicolor and sericea lespedezas are produced for field-border plantings in the United States each year.

The hedge is a land-use practice on crop-land that is becoming more and more popular in the eastern United States, and to some extent in the humid West. The plant most used is multiflora rose (*Rosa multiflora*), which grows to a height of 8 or 10 ft. and a width of 10 or 12 ft. It is not big enough to shade crops or to provide root competition and it does not spread into adjacent land that is in use. Multiflora rose hedges were first used in conservation operations as contour guide lines and as barriers against erosion and swift run-off of water on steep slopes. The stems of the plant are stiff and very thorny, and it is now being used as a living fence because it will turn livestock if plants are set a foot apart in the row. Multiflora rose fences are used to separate crop fields from pasture, and to protect gullies and other odd areas from grazing cattle. The hedges provide excellent wildlife cover and contribute to a permanent land pattern of value to wildlife. The present demand for multiflora rose far exceeds the supply available from both public and private nurseries.

The revegetation of streambanks is receiving increased attention by both soil conservationists and wildlife managers. Stabilization of streambanks not only protects cropland through which the stream runs, usually very productive bottomland, but it also produces excellent wildlife cover of desirable pattern in terms of strips of vegetation across crop fields. Since the most desirable plant species for streambank stabilization have proven to be shrubs or plants of shrub-like form, their cover value is considerable. Protection of eroding streambanks also improves the stream for fish and other aquatic life by reducing sedimentation. Streambank stabilization, combined with the soil conservation programme necessary on the watershed to supplement and make secure the work on the streambank itself, is one of the major contributions to improvement of stream habitat. In the United States such work has proved that it can convert muddy streams to a good condition suitable for trout.

Throughout the central United States wind-break plantings of trees and shrubs have been used a great deal, especially to protect farmsteads and crop fields from damaging winds. Considerable attention has been given to the selection of trees and shrubs in wind-breaks for their wildlife value, because such woody plantings in otherwise treeless areas can be of great importance to wild creatures. Frequently a row of conifers is included in a wind-break to provide winter shelter for wildlife. The margins of wind-breaks are planted to shrubs that produce fruits and seeds that provide food for wild birds and mammals. The establishment of some 7,000 miles of field wind-breaks contributes much to the improvement of cropland for wildlife.

A land-use devise on crop-land of value to both fish and other wildlife is the farm pond. Farmers and ranchers, receiving technical assistance from the Soil Conservation Service alone, during the past fifteen years have constructed more than 125,000 ponds. These ponds are built on selected sites with a design that renders them a permanent part of the farm set-up. They are frequently used to provide water for livestock, for irrigating small gardens, spraying orchards, or some other agricultural purpose. Nearly half of them, however, have been carefully stocked with the correct number of large-mouth black bass and bluegill sunfish ("bream") to permit their management as fish-ponds. Many of these ponds are fertilized with commercial fertilizer and are producing about 200 lb. of palatable fish per surface acre per year. A great many of the ponds that have been constructed are fenced, protecting them from livestock. The area within the fence is often planted to trees and shrubs which help to make the pond and the fenced area around it a particularly valuable small refuge for furbearers, water-fowl, and game species, as well as fish.

The management of marshes, odd areas, ponds, and streambanks, and the establishment of wind-breaks, hedges, and field borders on land used primarily for the production of cultivated crops can make cropland excellent wildlife habitat. Such practices are applied to the land first because they are good for the land itself and therefore of value to those who operate the land. Because of this they are the most permanent and important things that can be done to agricultural land to make it productive of wildlife.

Many other things can be done to improve cropland for wildlife. Unless such measures can be assured a permanent place in the agricultural scheme of things, however, they cannot be depended upon for long to produce the wildlife that agricultural land can make possible. Since more than half of the land acreage of the United States is in farms and ranches, and since something like 80 per cent of the hunting and much of the fishing is done on agricultural lands, it is evident that in the United States we must depend upon such lands for much of the useful wildlife we are to produce. We believe that the things that have been done through soil and water conservation work in the United States have pointed the way toward the most permanent and productive use of cropland for wildlife. The practices described are being applied. They are producing wildlife in America. As we husband our land more and more carefully in the future wildlife will take an important place along with the other crops that the land produces.

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Game Conservation on Croplands in Great Britain

A. D. MIDDLETON

ABSTRACT

The British system of intensive game management on crop lands is described. The shootable crop of partridges and pheasants depends largely upon the increased survival rate and density due to protection from natural mortality factors and the maintenance of a favourable environment. It is suggested that this object is best achieved by the employment of gamekeepers covering small areas. Carefully regulated shooting of the game crop is an important factor in the management of fluctuating populations. This should be based upon census data and knowledge of the productivity and carrying capacity of the land for game. Artificial propagation plays little part in British game conservation at the present time, and good results are obtained on suitable range by management of the wild stock.

INTRODUCTION

The two important game-birds on cropped land in Britain are the grey partridge (*Perdix perdix*) and the pheasant (*Phasianus* spp.). The red-legged partridge (*Alectoris rufa*) is also common in some areas, especially in the south-eastern section. Hares (*Lepus europaeus*) and rabbits (*Oryctolagus cuniculus*) are not generally regarded as game in Britain, but are shot incidentally with game. This paper gives some data on the British system of game management on farmed land, with typical results obtained from it. Britain differs fundamentally from many countries, including North America, in that the right to kill game is vested solely in the ownership of land. The State gives legal protection to game-birds during the close season and safeguards the rights of landowners, but there is no Government game conservation department and no State-assisted propagation of game or research. Game shooting licences (at £3, averaging about £150,000 per annum) are a direct local taxation, and no portion is allocated to game conservation. The only overhead assistance, recently started, is a research and advisory service operated by a large commercial organization having an interest in the manufacture of sporting ammunition (Imperial Chemical Industries, Game Services).

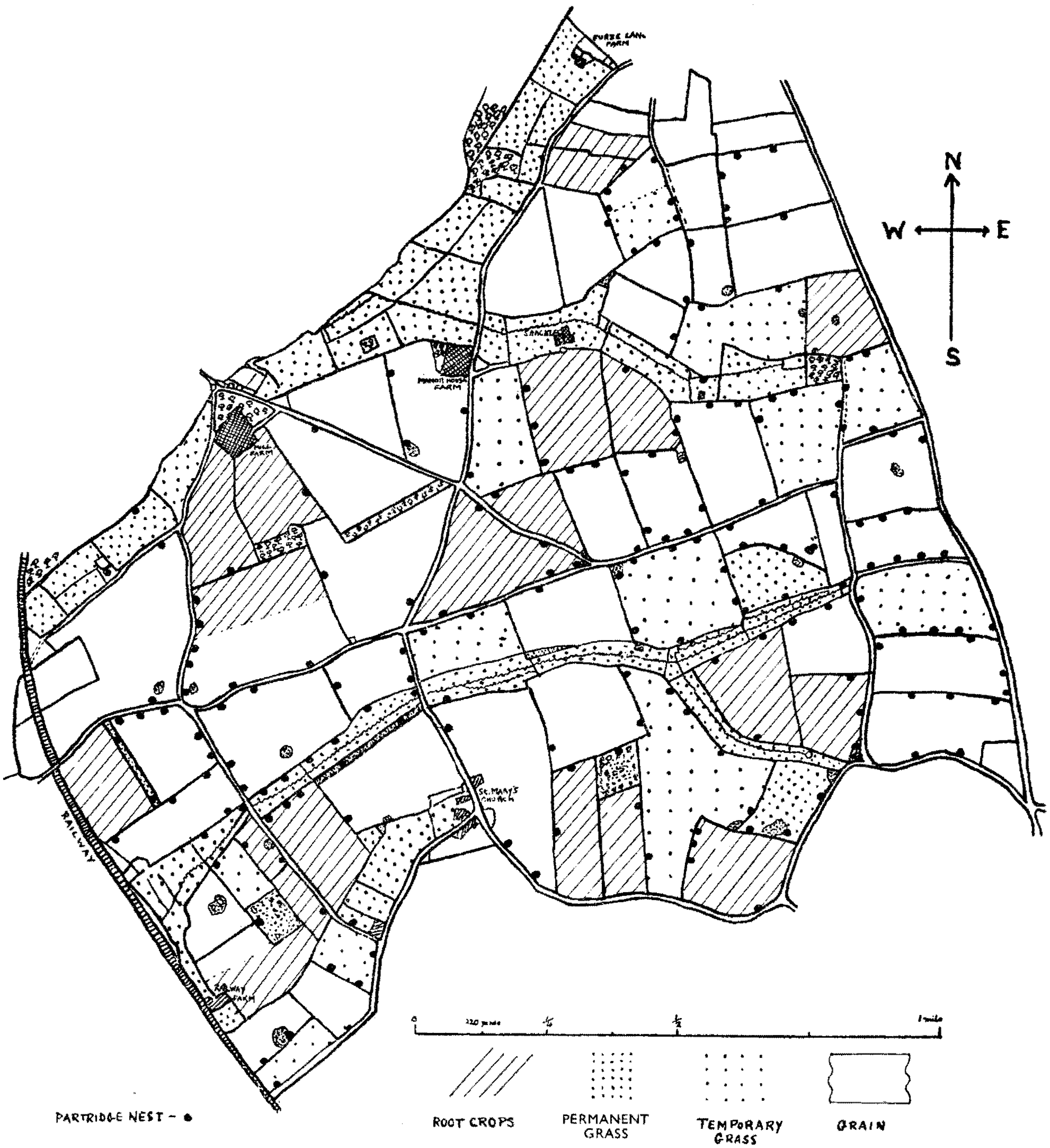
SHOOT MANAGEMENT

A shooting area or estate under one ownership or management may be anything up to 20,000 acres of agricultural land, but a common size is about 3,000 to 5,000 acres. Since the British system of shooting driven game demands a high density of birds, the best results are obtained by intensive management and preservation over a limited area. This entails the employment of gamekeepers to carry out adequate predator control and reduce natural game mortality by every possible means. Experience has shown that the best results are obtained by employing one keeper for about 1,000 acres when a mixed population of pheasants and partridges is maintained. At the present time, however, very few owners can afford to employ keepers at this density, and the average area covered by a keeper today is at least 2,000 acres, while much potential game land is unkeepered.

Practically all game shooting on keepered estates is done by driving the birds over a line of guns, normally six or seven in number. This entails the use of a line of beaters varying from ten to forty. In partridge driving, an area of between 100 and 300 acres may be taken in one drive. Pheasants in woodlands are either driven out or over gaps in the wood. By this means, a large proportion of the game is killed in a single day. (See records in the table below). Even in good years, the same ground should rarely be driven on more than three or four days during the season if the stock is not to be depleted.

A normal arrangement by many estate owners is to let the shooting to another person or a syndicate of shooting men. In some cases, the owner retains the keepers and is responsible for the management, while in others the syndicate simply rents the shooting rights and makes its own arrangements for keepering and management. Land which has a good game history will provide a rent of from three to five shillings per acre for shooting rights alone.

The cash value of game killed on a productive estate forms a considerable contribution towards the keepering and other expenses. For example, at present-day values, the crop of game recorded in the table below from 4,000 acres would yield about £1,520 as an annual average. This would cover the wages of three keepers and their housing (approximately £800), rates and taxes on the sporting value of the estate (say £200), beaters' wages (possibly £120), leaving about £400 towards other shooting expenses and general estate maintenance. Alternatively, a revenue of something between £400 and £600 could be obtained by letting the shooting rights alone, and probably a very much higher one by running a well-managed syndicate.



GREAT WITCHINGHAM, NORFOLK

Figure 1. Map of one keeper's beat, showing crops in fields and positions of partridge nests in 1936. Approximately 1,300 acres, 195 nests found by keeper (estimated total 215).

A TYPICAL GAME AREA

Most of the important points in the management of game on crop-lands can be shown in a study of one good estate. Great Witchingham in Norfolk, an area of about 4,000 acres, was carefully managed by one owner over a period of forty years. Three gamekeepers were employed, each being responsible for a "beat" of about 1,300 acres. Of the 4,000 acres, 230 are woodland, broken up into about 30 units varying from 1 to 20 acres, with 40 acres of uncultivated heath and marshes. Permanent grass pasture totals about 160 acres; and the remainder is arable land cropped on a rotational system for grain, roots, and grass or clover for hay. The interspersion of these crops in a normal year is shown on the map of part of this estate.

The farming is carried on independently by tenant farmers. Although most of the farmers and their workmen try to avoid destruction of game, no special crops are grown or deliberately sited for the benefit of game.

The owner relies solely on wild stocks of partridges and pheasants for his production, with no artificial rearing or other methods of increasing the population. Partridges have always been regarded as the important game crop, but the measures taken to protect them also maintain a considerable pheasant population. The records of numbers killed over a twenty-year period are given below. Some woodcock, snipe and wildfowl, with large numbers of wood-pigeons, are also killed each year.

Game killed at Great Witchingham, Norfolk, 1911—1930

Year	*Partridge*	*Pheasant*	*Hare*	*Rabbit*	*Best day (Partridge)*
1911	2,431	2,617	284	2,457	879
1912	3,137	2,199	435	2,755	802
1913	1,734	2,268	339	1,789	630
1914	3,891	2,809	551	1,736	880
1915	3,030	601	234	2,728	826
1916	174	488	173	835	—
1917	1,538	1,851	171	1,016	—
1918	1,438	1,126	125	897	—
1919	488	1,117	185	913	—
1920	1,321	1,133	164	1,418	—
1921	794	1,128	329	1,412	401
1922	751	1,415	269	1,651	221
1923	1,521	959	273	1,369	479
1924	2,063	1,190	207	1,129	687
1925	755	1,152	248	1,139	403
1926	635	901	280	1,022	253
1927	69	528	302	1,619	—
1928	1,272	1,455	411	1,858	561
1929	1,517	1,728	318	1,637	578
1930	3,540	1,715	369	1,984	1,102
Total 20-years	32,099	28,380	5,667	31,364	
Yearly Average	1,605	1,419	283	1,568	

ENVIRONMENT

Probably the most important requirements of partridges and pheasants are as follows:

1. Suitable safe nesting cover, correctly interspersed over living range.
2. Summer cover and feeding range for young broods.
3. Favourable weather during early life of chicks.
4. Winter feeding range and escape cover.
5. Freedom from predators.

In Britain, the field hedgerow is the nesting site for the great majority of partridges. Pheasants also use hedgerows, but find the heavier cover of woodlands and belts equally suitable. The partridge prefers a fairly open site with rough grass, nettles or other ground vegetation as the direct nest shelter. The rank herbage on the margin of a small trimmed hedgerow appears to be ideal. Comparisons of field sizes, bounded by suitable nesting hedgerows, on different estates indicates that the optimum is about 17 to 20 acres. The field pattern at Great Witchingham is not as suitable for this requirement as on some estates in Britain, but, as will be seen from the map, the majority of the cropped fields are near to the above figure. It will be seen that practically all the partridge nests are on the hedgerows, which may be taken as an indication that nesting cover in them is adequate in relation to the field range. Partridges do not grow well in very small fields, possibly due to a protective instinct of avoiding proximity to cover likely to harbour predators. If the fields are too large, partridges cannot make full use of the area without nesting in the growing crops. In practice, very few grain crops in Britain provide adequate nesting cover by the end of April (the start of the laying period), while nests in grass, clover, lucerne etc. are very vulnerable to destruction when the crop is cut before or very soon after the normal hatching date 10 to 20 June. On open areas, such as downland, where hedgerows are few and nesting cover is a limiting factor, the holding capacity of the land can be improved by the erection of nesting "pens", which are simply small units (about 20 × 2 yards) fenced against grazing and left uncropped to produce a dense growth of grass and other herbage. They can be erected conveniently along wire fences or crop margins with little or no interference with farm cultivation. Such a "pen" provides nesting accommodation for a pair of partridges (occasionally two pairs will use the same enclosure).

The most critical period in the life of any game bird is the first few weeks after hatching. The cover, food and weather conditions at that time largely determine the survival of the shootable surplus. There is little doubt that the optimum would be a complex mixture of different crops and weeds for food, with intervening local open spaces for sunning and dusting, while escape cover for protection from predators must be constantly available. These conditions exist at certain points on the average farm in Britain, but there is a considerable element of chance in the choice by the partridge of a nesting territory which will later provide good conditions for the survival of the brood. For this reason, the most productive game areas are those on which a mixed cropping pattern is usual. The cropping pattern on the Great Witchingham map for 1936 is fairly typical of present-day conditions in eastern England, where sugar-beet is an important root crop. In many other areas grain or grass are more dominant, with fewer root crops. Since the young partridges eat animal food (mostly insects) almost entirely for the first three weeks, (1)[1] a growing grain or grass crop, mixed with weeds, provides abundant food. The insect food on a field of sugar-beet or other roots in June is very sparse, with constant exposure owing to lack of cover. The general practice is for a partridge brood to go straight into a nearby grain or grass crop after hatching, but if the nest is in a hedge between two sugar-beet fields, this is not possible and the brood has less chance of survival.

Local weather conditions play a vital part in the survival of young game broods. Neither partridge nor pheasant chicks can resist prolonged exposure to cold or wet, but they thrive in sunshine. Very heavy summer rainstorms will literally drown young broods in exposed conditions, in spite of the protection afforded by the parents, but the most destructive weather is a period of two or three cold, sunless days with enough rain to make the vegetation continually wet. The variation in summer weather conditions, influencing the survival of young birds, is certainly one of the most important factors causing the violent fluctuations in numbers so well known in game species.

Sample counts of partridges in early August, distinguishing old and young, have been carried out at Great Witchingham for a number of years. The ratio of young

[1]Numbers within parentheses refer to items in the bibliography.

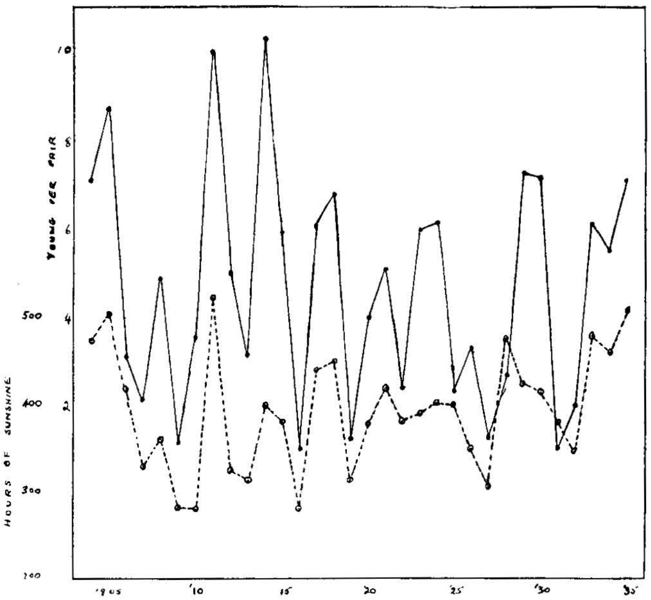


Figure 2. The production of young partridges per pair of old at Great Witchingham, Norfolk, correlated with the aggregate hours of sunshine in June and July

to old obtained by this means gives a direct measure of the productivity for the season—the average number of young surviving up to August per pair of old birds. In Figure 2, this figure is correlated with the amount of sunshine during the early life of the chicks.

The cropping pattern and interspersion of hedgerow and woodland is equally important during the autumn and winter for holding a population of partridges and pheasants, as well as for convenience in shooting. Pheasants, hatched in the hedgerows and reared in growing crops, require thicker cover such as woodland, scrub or thick hedges for the winter. In some areas devoid of such cover, pheasants will use the heavy forage crops, such as kale, as their winter home. The partridge remains throughout the winter, feeding and roosting in the open fields. During autumn it lives mainly on grain and weed seeds left after the grain harvest; but in the late winter 90 per cent of its food is green leaves, particularly grasses and clovers (2). The distribution of grassland, either permanent or temporary, in the farm pattern is therefore of great importance in winter and early spring. Root and forage crops, such as swedes, mangolds, sugar-beet, turnips and kale, form the principal escape cover for partridges during winter, so their interspersion is equally important—and incidentally a great aid to organized shooting. In the average British winter there is adequate food and cover on normal arable farmland up to the end of December, but January, February and March can be very difficult months for the survival of a partridge population. With most of the root crop harvested and nearly all fields ploughed, both feeding range and cover are severely restricted. At Great Witchingham in the early months of 1936, for example, the only reasonable feeding range would be in the grass-fields stippled on the map.

The main function of gamekeepers on British estates is the control of predatory animals known or likely to destroy game at various times of the year. It is very difficult to define the result of predator control, since the employment of gamekeepers is naturally supplemented by more general protection and conservation than would be normal on unkeepered land, protection of nesting cover and limitation of numbers shot, for example. On the average crop lands in England, the principal predators are fox (*Vulpes vulpes*), stoat (*Mustela erminea*), rat (*Rattus norvegicus*), badger (*Meles meles*), rooks and crows (*Corvus* spp.) and various species of owls and hawks, particularly the sparrow hawk (*Accipiter nisus*). Domestic dogs and feral cats are important nest destroyers, while farm operations, particularly grass cutting, are also responsible for the loss of many nests. The following is a fairly typical list of predators killed during two years on about 4,000 acres in Hampshire by four keepers:

	1947	*1948*
Sparrow hawk (*Accipiter nisus*)	82	41
Carrion crow (*Corvus corone*)	80	42
Rook (*Corvus frugilegus*)	60	152
Little owl (*Carine noctua*)	192	141
Jay (*Garrulus glandarius*)	81	65
Magpie (*Pica pica*)	240	254
Grey squirrel (*Sciurus carolinensis*)	9	20
Stoat (*Mustela erminea*)	178	136
Weasel (*Mustela nivalis*)	82	106
Rat (*Rattus norvegicus*)	451	753
Cat (*Felis domesticus*)	22	10
Various	249	222
TOTAL	1,726	1,942

As foxhunting is a parallel sport to shooting in many parts of Britain, the number of foxes killed by keepers is not usually recorded. The normal practice is for keepers to leave sufficient foxes for hunting, but to control them to a minimum to prevent damage to game.

Disease due to parasitic worm infestations and other causes is often a serious factor affecting game. Young pheasants and partridges are very susceptible to gapeworms (*Syngamus trachea*). This parasite is common to many other birds, and in some areas causes heavy mortality among game. Strongylosis (*Trichostrongylus tenuis*) occurs in periodic outbreaks among partridges, especially on densely stocked areas, where it has caused very heavy losses. Coccidiosis and enterohepatitis are protozoan diseases of

Figure 3. A typical English partridge environment in Hampshire

sporadic occurrence in game, and it is likely that other diseases and parasites, not so well known, may be important mortality factors.

CENSUS AND PRODUCTION DATA

The management of an area of cropped land to produce the maximum crop of game resolves into three main headings:

1. The maintenance of a suitable environmental pattern on the land.

2. Detailed protection to reduce the effect of all mortality factors.

3. Carefully controlled shooting to allow the survival of an adequate breeding stock from year to year.

Of these, the latter is least understood or appreciated by the average shooting man. It is obvious that the shootable population should be simply the surplus not required as breeding stock for the next year, after allowing for all natural mortality and local emigration.

Three figures are of fundamental importance in census and assessment of the shootable crop: (*a*) The number of breeding birds at nesting time; (*b*) the ratio of young to old in late summer—the "production ratio"; (*c*) the natural mortality and emigration loss from the census area between the summer count and the following nesting period. On many British estates, with the help of close observation by keepers, it has been possible to obtain fairly accurate nest censuses checked by pair counts for partridges (3, 4, 5, 6, and further unpublished work). The holding capacity of different areas varies greatly, and the factors limiting the nesting density of partridges are very elusive. The highest recorded density over a large unit is 720 nesting pairs on 3,000 acres (one to 4.2 acres) in Norfolk in 1936. In general, an average density of a nest to between 5 and 10 acres can be regarded as a high population. In 1936, the average taken from fourteen well-keepered estates totalling 39,730 acres was one nest to 7.6 acres. Great Witchingham with 6,662 nests in eleven years gives an average of 6.6 acres. The potential production from nesting stock is reduced by nest losses through predators and accidents (average 22 per cent of all nests), by 7 per cent eggs unhatched, and by a variable chick mortality mostly dependent on weather conditions soon after hatching (average over 50 per cent).

A sample count, recording the proportion of young to old in August, is the second basic census figure which incorporates all the nest and juvenile losses (see Figure 2), and makes possible a direct calculation of the total population:

Total number of old birds (nesting stock) $\times$ ratio of young to old in August $+$ number of old $=$ total population.

Recent work indicates that a normal high mortality among old hens from nesting to August makes a correction necessary, reducing the total obtained by the above calculation by approximately one-sixth in an average year.

The calculation of the number of partridges which can be shot off any area to leave an adequate breeding stock is complicated by a high loss between late summer and the nesting time (April—May). The loss varies on different areas between 10 and 70 per cent of the total, excluding those shot, and on a normal well-managed estate 40 to 50 per cent must be allowed for. This means that, if 100 nesting pairs are wanted, 400 partridges must be left after shooting. The causes of this "winter wastage" are so far little understood. Although some natural mortality occurs all through the winter, there is evidence that more than half of the loss takes place suddenly at the time the coveys break up for pairing (January—February), and it seems logical to assume that it is due to a complex shuffling movement or emigration. It is undoubtedly the most important uncontrolled factor in partridge management on a limited area.

Comparison of nesting stocks with kills gives a useful index of cropping. At Great Witchingham, over eleven years, 6,662 nests yielded a bag of 22,804, or 3.4 per nest. The highest figure was in 1930 with 6.1 killed per nest. In 1933 and 1934 the average for a group of seven estates was 2.9 and 3.1 respectively.

Comparable production data for wild-pheasant populations are not yet available. The normal procedure on an estate, such as Great Witchingham, is to shoot cocks and hens equally during the early part of the season but cocks only during the latter part of December and January. It is generally agreed that cocks should be reduced to leave a breeding proportion of one cock to four or five hens, but in practice cocks are rarely killed down to this level. The stock of hens left for breeding at Great Witchingham to produce the bags shown in the table above is estimated at 600 to 700 in a normal year.

ARTIFICIAL PROPAGATION

Since 1940, the artificial propagation of game birds for shooting has been forbidden by law, owing to food scarcities. Before the war, forty-two game farms produced about 1,500,000 pheasant eggs and 400,000 poults annually for sale to private estates. In addition, many of the larger estates penned pheasants for egg production and rearing. It was fairly common for keepers to rear and release any number up to 5,000 or more pheasants on an estate for shooting. There was also considerable importation of partridges and eggs from Central Europe, mostly for restocking depleted areas rather than shooting in the same season. This too has stopped. Partridge rearing on game farm lines, and penning for egg production, has so far proved too difficult to become a commercial proposition, but it would certainly be a very useful method of increasing the stock on depleted estates, and experiments are in progress with that object. Practically all pheasant hatching and rearing in the past has been done with domestic fowl foster-mothers rather than incubators and artificial brooders.

As a result of the restrictions on rearing, more attention has been given to wild game management, with very good results on most keepered estates. It seems likely therefore that artificial propagation will be mainly used for restocking rather than for the direct production of large numbers of birds for shooting.

CONCLUSION

I have tried to show that the British system of game production on cropped lands can be both productive and economic when efficiently managed. The detailed conservation carried out by gamekeepers on limited areas results in a much greater local density than the open range procedure adopted in the United States and some other countries. It is more costly, but considerable revenue can be derived from the game produced, both as meat and sporting value. The essential point in practical game conservation is the production of a shootable surplus each year above the survival requirements of the population. Without this man-made surplus, continued shooting must reduce the population level over a period of years.

Much of the land in Britain is now unkeepered, and there is no doubt that a considerable decline in general game density has occurred, largely due to lack of protection and indiscriminate shooting over the war period. The areas where game is still carefully preserved have probably arrested this decline to some extent, while an apparently unsatisfied demand for good shooting should give a stimulus to increase game conservation when financial and other post-war conditions in the United Kingdom become stabilized.

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Recreation and Wildlife Problems Peculiar to Rangelands of Western United States

J. V. K. WAGAR

ABSTRACT

Most travellers unconsciously recognize rangeland landscapes, but do not understand the forces which produce, change and endanger such areas. The effects of precipitation patterns, altitudes, strong winds and mountain barriers are shown as they affect vegetation, wildlife, people and professions.

Once-scarce species including bison, pronghuck antelope, mule deer and wapiti are now restored. Too numerous jack rabbits and prairie dogs respond to control. Publicly-owned rangelands, much abused before 1934, come increasingly under intelligent management. National parks, forests and ranges provide great inspirational, hunting and fishing playgrounds for the people.

The three principal or key problems in the management of wildlife and recreation upon rangelands are : (1) the status of bears, (2) conflicting land and wildlife ownership, and (3) the obvious need for a universal understanding of ecology, now that most remaining wildlife and human problems are ecological.

Zoning seems the best solution for the bear problem. Abandonment of the myth of "absolute" ownership of private land, while recognizing the rights of landowners and state-owned wildlife upon it, is the solution for land-wildlife ownership problems. More intelligent and informed citizens are needed to permit maximum application of wildlife science.

Is it not true that wherever arid and semi-arid rangelands cover the earth there are land-use problems? It is equally true that rangeland problems always are great and vexing. Upon rangelands there can be few half-hearted things, animals, people—or measures. All is far, high, deep, dry, swift or powerful. Here recreation and wildlife problems deal with superlatives. If we solve them, we can solve the problems of gentler lands.

Rangelands which I discuss are the arid and semi-arid grazing lands of the western United States, watered with as little as three inches of moisture annually, and rarely with more than twenty. Problems which rise upon the dry interior regions between the Mississippi River and the Pacific Ocean represent those in other arid lands, for they involve fundamental conflicting uses of rangelands by people, livestock, wildlife and vegetation. All people have like physical needs, though they differ greatly in their philosophies. Soils and climates marking treeless or semi-forested rangelands in all parts of the world stem from the same circumpolar chemical and physical processes. Vegetation and animals in all lightly-watered lands are related in structure, physiological functions and fundamental responses to an environment increasingly dominated by man's desires, intelligence and bungling.

It is easier to recognize the open rangelands of western United States than to understand them. Most travellers readily identify in picture or actuality the mesas, buttes, canyons, natural bridges, sparse and yet seasonally luxuriant vegetation, unusual plants and awesome distances which distinguish these lands. But most observers do not realize that features which compose each landscape are more than static accidents. They only vaguely sense the dynamic forces which shove scenes and actors to and fro upon the stages of these rangelands. They do not recognize the ecological processions of evolution and succession at work. They know neither the beginnings nor the probable ends of these processions. Yet of all lands on earth, these need great understanding.

Western rangelands are unruly, violent, temperamental lands with soils, snow and plants always ready to move off by wind, water or gravity. Consider the wind. In this region are many chinook winds, the foehn winds of other mountainous regions of the world, which make living tolerable. But there are also a Wind River, the "dust bowl" of 1934, and blizzards which devastated Colorado in 1884–1885, Montana and Wyoming in 1886-1887, and much of the West in early 1949. The Great Sand Dunes are blown against the east side of Colorado's San Luis Valley. Grotesque rocks are chiselled by wind-driven sand. Tumbleweeds loosen their hold upon soils which need their protection and move toward the horizons.

Snow and rain fall in a capricious pattern which defies ready understanding and prevents widespread, approved land-use practices. Summer rains gently soak the mountain meadows scattered through lodgepole pine forests at high elevations and latitudes within this region. Deep winter snows blanket the ground. Soils are fine-textured and well-covered by plants. Little erosion results. Yet not far below, at 6,000–8,500 ft. elevations in the Pike's Peak region, ponderosa pine forests upon coarse granite soils are visited by torrential summer rains and dry, warm winters. Coniferous trees, well established in early spring, winter-kill upon the drier sites. Vegetation wanes under grazing or logging practices tolerable within other regions. Severe erosion results.

Rangelands at the lower elevations between the mountains are marked by low rainfall and high evaporation. There is little continuous, protective turf. Bunch grasses drain moisture from greater soil areas than are covered by visible tufts of grass. Bare spots separate them. Brush lands similarly are covered by dominating but non-continuous plants. Succulent plants sprout and flower with the advent of short wet seasons, quickly complete their growth and seed production, and lapse into long periods of dormancy giving little protection to the land. Plants like the cacti store water, transpire it sparingly, and poorly protect the soil. Many plants are poised precariously upon the brink of oblivion, vanish under careless use, and leave behind less desirable species—or vegetational voids. Erosion begins, or increases, where the plant mantle is removed or impaired. This region flows water—and soil—through the Grand Canyon of the Colorado, a world-famous example of erosion.

Great extremes in elevation typify this country and govern its phenomena. The Colorado River, which enters the Gulf of California at sea-level, rises high in Colorado, which has an average elevation of 6,800 ft. and fifty-one peaks towering above 14,000 ft. in elevation. In California, a depression 280 ft. below sea-level in arid Death Valley lies less than 100 miles from 14,495-ft. Mt. Whitney, tallest peak in the United States. In sailing 50 miles across the Olympic Peninsula in north-western Washington, rain clouds drench coastal forests with 142 in. of annual precipitation, maintain the glaciers atop the 8,000-ft. Olympic Mountains, and leave but 15 in. of moisture upon the north-east corner of that area, where farmers must irrigate.

The Cascade Mountains of western Washington and Oregon divide luxuriant coastal rain forests from arid deserts and dry, open-timbered mountains. Let strong winds blow east across the Cascades from the warm Japan current in the nearby Pacific, and forest fires can scarcely be started with a blow torch. Let them blow west across the Cascades from the dry interior of these states, and fierce forest fires rage.

East of the Continental Divide which splits western rangelands, summers are comparatively wet and winters dry. West of that barrier summers are dry and winters are the wet season. Only a few miles and the Coast Range separate the redwood fog belt lying within 30 miles of the Pacific, wherein redwoods can carry moisture to their tops more than 300 ft. in the air, from the arid Central Valley of California.

Temperatures often vary 40 degrees F. daily upon western rangelands. They vary greatly from the Lower Sonoran zones of most southern plains to alpine tundras occurring at high elevations in every mountainous state within this region. Here are the largest glaciers in the United States, and the hottest, driest deserts. Record temperatures range from —66 degrees F. in Yellowstone National Park to 134 degrees F. in Death Valley.

Bison, bighorn sheep, mule deer, prongbuck antelope and wapiti have migrated farther in this region—as seasons, elevations and scant food per acre dictate—than their counterparts have in less contrasting lands. Coyotes, mountain lions and jack rabbits have cruised more extensively than related beasts of humid lands.

Here bison herds became noted for vast numbers, nearly irresistible stampedes, and sustenance for Indians who understood their use. This was the land of the grizzly bear. It also was the land of the rattlesnake, the prairie dog, the horned toad, the Gila monster, and other unusual creatures which learned to live within it.

Despair among men from other lands who did not understand this land, or love among those who did, suggested names which picture the tensions and violence of place. Here are the Grand Canyon, the Grand Teton, Mount Massive, Death Valley, Devil's Tower, Hell's Canyon, the Great American Desert, Bonneville Salt Flats, Great Salt Lake, Red Desert, the Badlands, Hell's Half Acre, the Great White Throne.

This is a land of human tensions. Men who live or seek recreation within these rangelands (where not modified by ditch, highway and town) are strong men, and strong men can be violent. The emotions and outbursts of vigorous men in an unstable country gave lustre to the writings of Emerson Hough, Owen Wister, Theodore Roosevelt, Stewart Edward White, Francis Parkman and Zane Grey. Current stories about this land, written by contemporary authors James Warner Bellah, Ernest Haycox and Luke Short employ the same ingredients of vast space, tormenting aridity, dangerous beasts, shrewd Indians epitomizing all the threats of the land, and strong men in frontier military posts, striving for understanding of and adjustment with their over-all environment. In story or theatre, those who portray western people employ violence fully as much as broad hats, tanned faces and white foreheads, spurs, high-heeled boots, and sounds and smells of cattle and horses. Recreationists come to this country, hoping to find places where with validity they can wear these brave trappings, and indulge in whatever freedoms can be maintained against spreading pressures which destroy them.

Western rangelands of the United States, interspersed with forests, brought tensions to the profession of forestry. Wildland management first developed as a dependable, applied science called forestry in western Europe, wherein gentle, adequate rains fostered protective turfs and forests. In England, France and Germany, the forest became an area managed for timber, game, and pasturage. The forester, *le forestier*, or *der Förster* was in charge. Forestry was imported to the United States by those most impressed by its timber production concepts. The first American forestry schools, established at Cornell, Yale and Michigan universities before creation of the United States Forest Service, were surrounded by wildlands in which timberlands were the dominant type and logging and milling the dominant wildland industries. But when the first national forests were set aside in Regions 1 to 6, in the area between Montana, New Mexico, California and Washington, foresters trained in eastern forestry schools were placed in charge of wildlands wherein rangelands were inseparably interspersed through forests.

Within these western rangelands, foresters had to discover and develop the scientific principles of range management. National forest grazing fees for years totalled more than stumpage fees, though charged at less than commercial rates. Upon the Wichita National Forest, foresters re-established one of our most successful bison herds and other wildlife, and fostered a museum herd of longhorn cattle. They co-operated with state game and fish departments to create refuges, to enforce game laws, to stock barren lakes, and to manage big-game herds.

Yet today paralleling professions are suggesting that the management of western wildlands be scattered among a number of newly specialized professions. The Society of American Foresters, among the oldest of American professional societies dealing with the ecological management of wildlands, is under tension. Some suggest that its name be changed to that of the Society of American Wildland Managers, lest its membership be scattered through many weak, small societies (some confined rather much to this region), each with its seldom published, thin journal.

This region knows human tensions caused by space. Points of departure and arrival are far apart. It was not western Oregon or California's gold-fields that made traversing the Oregon and Santa Fe trails magnificent adventures. It was space between outposts of law and order and of culture. Most travel and settlement within this expanse did not occur until trans-continental railroads and telegraphs shortened travel and communication time across these lands, and repeating rifles made it safer. Even today space plays an important role. People in automobiles and airplanes hurry across this land to unusual scenes and pleasures preserved by space from over-use and defilement by men. They then return to relate how they, too, along with the pioneer great, conquered the terrors of space.

In this land is more spaciousness per dollar than in most places in the world. White (4)[1] wrote of it: "... thar is more cows and less butter, more rivers and less water, and you kin see farther and see less than in any other country in the world." To many this is waste land, but people come to it for relief from all the crowded places of the earth. They seek in it a semblance of the spaciousness of the frontier. Old and weary men tell us that new frontiers can be found in test tubes and microscopes, but we may wonder if man can adjust to a lack of space by the time all of it has vanished. He seems to need sunsets. The most stable governments seem to be situated within generous space and peopled by those who like it. We know what man's needs for food and fibre are, but have not fixed his need for space. We should determine it before this expanse of spaciousness has been shattered.

ACCOMPLISHMENTS IN RANGELAND WILDLIFE AND RECREATION

I have dwelt long upon the peculiarities of this region, but understanding of it is necessary for the solution of its problems. It is well to list these problems, that we may consider them against solution.

Considering all problems, we have progressed. The American pronghorn antelope, which faced extinction in the early 1920's, now has reached safe numbers. In many states, it is harvested systematically with no danger of chance diminution. The North American bison, though sentimentally mourned for vanished numbers, now fills all ranges which can be spared it. Local residents of north-western Wyoming believed in the late-teens that wapiti would eventually become extinct and be in part supplanted by the moose, which was less exacting in respect to winter range. Today the wapiti fills most of its former range from which settlement has not evicted it. In some areas hunters can shoot their own choice of sexes. Reduction programmes beyond the harvest of regular seasons take care of surpluses. When live-trapping and transplantation is suggested for removal of wapiti from the national parks one hears the question: "Where can we find room for them?"

Mule deer, once unsuspecting and faced with extinction, have increased to enormous numbers. Problem areas appeared but yield to increasingly scientific management. Beavers, whose rich fur prompted much of the first exploration of this region, are successfully live-trapped and moved to streams lacking them. Surpluses are systematically cropped. They have been re-established on most streams where they can be tolerated. Other furbearers, including marten, became re-established.

Jack rabbits, killed in spectacular "drives" two decades ago, now rarely occur in epidemic numbers. Prairie dogs have responded to poisoning. Few extensive "towns" now exist. Some game managers worry lest they be killed off to an extent adversely affecting the cottontail which is now achieving "game" status distinguished by a closed season in many western states.

Wolves are extinct over much of the West. Mountain lions in many areas are not numerous enough to afford good hunting. Many western national parks lack both.

[1]Numbers within parentheses refer to items in the bibliography.

Indiscriminate grazing upon public lands of the West ended in 1934, at which time 142 million acres of public domain awaiting settlement was withdrawn from homesteading and placed under orderly management. Freedoms of the open range are lamented, but not its abuses. To this national rangeland was extended (*a*) definite allotment of grazing by area, in capacities commensurable with the landowner's ability to carry herds through winters on his own lands, (*b*) range water improvements, and (*c*) reseeding of deteriorated pastures. Grazing experiment stations have been established to discover trends of plant succession which may be employed in grazing management, and to determine the relative merits of different patterns and procedures of stocking, seasonal use and grazing intensities. Many cattlemen adopt these measures for use on their own lands in accordance with their understanding and need.

Within western rangelands were established the first national parks of the nation and the world. Today within this region are seventeen national parks and many national monuments, open to the public, and preserving quite well, despite inadequate appropriations, many outstanding scenic features, and acting as game refuges which have contributed importantly to the re-establishment of the bison, the preservation of grizzly bears in Montana and Wyoming, and the satisfactory status of the wapiti.

In greater area than the national parks, the national forests include most of the forest lands related to semi-arid rangelands of the West. Though they lack scenic wonders which bring people in greater numbers to individually more prominent national parks, they are vast hunting, camping, fishing, and wilderness-exploration lands open to the public.

State game and fish departments within this area increasingly employ research as the basis for good wild-life management. Increasing co-operation with federal agencies brings wildlife ranges and herds into desirable balance.

United States Public Law 732 (79th Congress—1946) requires (*a*) the study of biological values lost or gained, and (*b*) programmes for their preservation whenever engineers plan to impound or divert waters for irrigation, water-power or flood control.

UNSOLVED PROBLEMS

Such successes indicate that many rangeland wildlife and recreation problems approach solution. Simple problems in wildlife biology do, but increasing human populations and ease of transportation add three great problems involving human ecology which, unless solved, may destroy valuable game animals and recreational practices essential to our individually free type of democracy. Let us consider these in turn.

CAN WE PRESERVE ALL RANGE WILDLIFE?

A key problem of rangeland wildlife and recreation is the undecided status of bears. Some ranchers call them predators and kill them despite protective laws. Poison apparently had been set for bears even before they were proved predaceous as asked by law. The United States Forest Service and National Park Service protest against indiscriminate bear killing. The United States Fish and Wildlife Service, which gains financial support from stockmen for rodent and predator control, sometimes favours the rancher when doubtful issues concerning bears are raised.

Universal interest in bears has not given them adequate protection. In Colorado the last few grizzly bears are endangered to protect the local business of a few cattlemen, while tourist bureaus assure visitors that the West is still wild but no longer dangerous. The University of California has for its emblem the extinct California grizzly bear.

Sportsmen desire that bears be protected as game, but in some western states, bear-control men kill more bears than sportsmen do. State game departments which protect bears as game animals are financially liable for livestock damaged by bears. If they rule bears predators to be killed upon sight, bears may be destroyed by summer hunters when least valuable. They may even become extinct.

Zoning seems the obvious solution. In lands more adapted to stock raising than to bear production, term the bear a predator and treat him as such. Upon intermediate lands where both bears and livestock can be tolerated, and where both do well, only predatory bears should be killed, and only by landowners whose animals they molest. In lands better adapted to bear production and recreational hunting than to livestock raising, eliminate cattle and sheep and vigorously protect the bear.

THE PROBLEM OF LAND AND GAME OWNERSHIP

Problems of land and wildlife ownership have tormented many nations. From Magna Carta on, lessons learned in securing their equitable distribution have in many countries prepared the way for better laws and government. Among old nations, changes related to these problems occurred over too many centuries for a clear view of all facts concerned. Upon western rangelands—which awaited settlement based upon railroads, repeating rifles and free lands—a few decades brought into sharp and unmistakable focus all human and wildlife factors involved.

The western states gave land ownership under federal laws to new citizens, while retaining ownership of wildlife. Little conflict occurred at first. Game laws were few and poorly enforced. Landowners harvested wildlife in keeping with their rights as they interpreted them. Big-game herds melted away before damage to crops was serious.

Settlers, assured of their importance by free lands, and prompted by their own desires and promises of demagogues, felt that they deserved whatever could be harvested from their own and adjacent lands. In this region, ownership of waterholes gave assured use over vast areas of public domain. Here, in a boom land, railroad crews and hordes of miners lived upon wild meat. Farmers demanded, and got, free of charge, irrigation water from public watersheds. Rail transportation made possible greater shipments of meat, hides and grain to greater and more distant cities than had existed before. For all this, wildlife was a subsidy, largess flung about in payment for settlement.

Today, wildland and wildlife management have brought back the game herds. Modern industry and transportation have brought recreationists. Cattle and sheep, long important in western economy, compete with wapiti and deer (which are increasingly important in the new recreational economy) in degrees varying with species and rangelands. Stockmen ask to buy public lands which their herds share with wildlife. City hunters in mounting numbers are hunting upon rangelands used by both livestock and big game. Public hunting lands upon national and state forests and Taylor grazing lands, in places can be reached only across ranches whose owners increasingly exclude the public in accordance with frontier "waterhole" traditions.

Wealthy people from adjoining states are buying Colorado ranches especially for their hunting and fishing values. Many of these new ranch owners complain vehemently about paying high non-resident fees for hunting state-owned game upon nationally owned forests, and vigorously keep Colorado residents off their newly acquired properties.

Ranchers ask to own and control beavers upon their properties, and promise to handle this fur resource intelligently. State game departments oppose granting such ownership. If beaver management failed under rancher ownership, it would be expensive for states to buy back the beavers. Landowners can legally exclude fishermen from their properties, but many western states refuse to stock with state fish, and keep streams closed to the public.

All factors involved in the ownership of land and wildlife upon western rangelands seldom have been listed. Some landowners claim the full capital valuation of their lands based upon a production unimpaired by the presence of state-owned wildlife. Thus they believe themselves entitled to full payment for damage done by wildlife. Some claim payment in money. Others take their toll of wildlife upon the pretext that they feed it. They ask fair treatment from the state. It would seem equally fair for landowners who graze livestock upon adjacent public lands to pay full value for such grazing instead of the more common cost of administration. It would seem fair only if those who use irrigation water and electricity developed by water flowing from public lands would pay for that water in addition to payments for water rights and distribution systems. We may someday compute the greater timber and forage production possible if water is spread upon lands which shed it.

A fair viewpoint is that game was present before the land passed into private ownership; that the landowner never received title to the wildlife and was not expected to reduce its numbers beyond limits provided by law. Under this premise a certain amount of wildlife damage must be expected upon lands privately owned within game areas. Capitalized values and taxes should be proportionately lower. The landowner could expect an adjustment in charges which the public might ask for his use of public property.

Let us consider the significance of trends governing private ownership of western lands. Though zealously disposing of the better agricultural lands through various homestead laws from 1862 on, the people of the nation reserved national parks from 1872 on, national forests from 1891 on, and national rangelands in 1934, wherever special values warranted public ownership. Constitutions of Colorado and other western states permit necessary passage across lands of one owner to lands of another, and construction of ditches for flowing irrigation water across lands of intervening owners.

The 1920 Surface Rights Act gave the homesteader the agricultural and pastoral rights he requested, but retained for public ownership rights to coal, oil, and other subsurface riches. The process of eminent domain is used increasingly to gain right-of-way for highways and other public works. It will not be long before the nation, which pays for various reclamation and flood-control impoundments, will claim for free public use adjacent lands upon which recreational values are enhanced.

Absolute ownership of land apparently is a myth, however valuable private land-ownership is in developing self-reliant citizens. Yields from many acres go only to payment of land and income taxes. Taxes normally take a far greater toll of ranch production than does state-owned game. However, taxes are tolerated because they provide direct returns like schools and roads, while returns from wildlife, except to the dude-rancher, are indirect. In contrast, the rancher's control of taxes is indirect, while his control of game can be direct.

With increasing demands for hunting and fishing, it seems desirable to retain public recreation rights upon tax delinquent or other publicly-owned wildlands which are sold for agricultural and grazing uses. This is only the reverse of purchases with public funds, of fishing rights upon private property. We should not be surprised in the near future to see trespass, upon lands bought by non-residents primarily for the enjoyment of state-owned game and fish, punished only when actual damage to property has occurred.

PUBLIC IGNORANCE OF ECOLOGICAL MANAGEMENT

A third unsolved problem is the difficulty with which the wildland or wildlife manager gains public support. This problem, too, reaches its climax in western United States.

In the West, houses often are built by carpenters of lumber sawn by men from trees which grew in some forest or other, probably naturally. The farmer obviously grows his crops in rows or in weed-free fields of exotic grains, upon land from which he removed by ploughing whatever natural vegetation was present. Automobiles occur naturally nowhere in nature, though their performance depends entirely upon natural laws. The atomic bomb likewise violates none of the laws of nature, but mercifully does not occur naturally within it. Dams and ditches control fluids flowing naturally, but are unnatural in form. Even animal husbandrymen receive credit for herds they breed, for fences normally enclose only the animals they select, and their cattle closely resemble no wild creatures.

Few men are so ignorant that they question existence of houses, fields of wheat, motor cars, atomic bombs and white-faced cows. Yet most pool-hall and barber-shop loiterers feel qualified to challenge recommendations of wildlife experts. A prominent veterinarian (1) reputedly stated, from his unfamiliarity with ecological sciences, that foresters in charge of western rangelands are trained "in ritual and not in science". Some stockmen understandably but not always excusably challenge the recommendations of range scientists.

A very free Press has erroneously claimed that range and wildlife decisions are laid down as edicts from arm-chair bureaucrats in Washington, thus showing ignorance of the ecology of government. Only general policies are set in Washington, by men who began in the West as field men. Decisions governing wildland and wildlife upon western public lands are made in the field by scientists trained in our best schools.

Scientists who deal with wildlands and wildlife study in college the same chemistry, physics, algebra, trigonometry, statistical methods and logic as do automotive engineers and atomic scientists. They study the same botany, soils and zoology, as do agronomists and veterinarians. In experiment stations they work with experts from other sciences, and use the same methods for setting up scientific experiments and obtaining unbiased results. Wildland and wildlife managers miss credit due them because upon low value lands they can afford to use only natural forces instead of artificial structures and intensive treatments. Their ends are the goals of nature—more grass and browse, denser forests, more wildlife—and ignorant men in doubt give nature the credit! Leopold (3) stated that the enjoyment of wildlife is directly proportional to its naturalness, but did not warn wildlife managers that nature usually would receive credit for its production.

Only in old states and nations wherein all timber products come from managed forests, much grass comes from meadows once impoverished, and most wildlife comes from herds dependent upon man's intelligence and sufferance, do those who manage wildland and wildlife come into their own. Time helps, but in the West changes occur so rapidly that resources can be lost before their values and management are understood.

TOWARD GREATER UNDERSTANDING

A forest educator (2) advised foresters to get off corral poles, where they sat swapping tales and tobacco with local residents, and to learn to talk with women's clubs. Similarly our western ranchers, despite traditions of boots and spurs, guns and range wars, need to learn the gentler art of public relations. Happily, I know many ranchers who intelligently teach their viewpoints, needs and outdoor skill to city hunters, and many city hunters capable of adding to one decent man's respect for another. No one can equal a landowner in teaching the values, rights and responsibilities of private land-ownership.

All management of lands by men, wildlife by men, and man's relationship to men is government. Government can be by whim, by hypothesis, by emotionally stirred resentment of change or the proximity of strangers; or it can be based upon ecological verities measured and established by science; upon ecological relationships long shown to be fair and good to all concerned.

Men can use western lands *and* wildlife through centuries to come only when they learn all interrelated ecological factors involved. Western ranchers, wildland and wildlife managers, and recreationists can save all wildland and wildlife values only when they learn and observe all rights and needs of others using the same lands.

We are met at this conference because increasing transportation ease makes imperative a better understanding and co-operation between once distant nations. We of the western United States must despair of better international relations if we cannot erase tensions which develop when city people notorious for their ignorance of rural conditions come in contact with ranchers famous for vigorous if not always diplomatic action. We of the world must despair of the continued existence of this civilization if we cannot develop superior citizens capable of thought and understanding beyond matters limited to personal whims or desires. If we cannot learn to think with the honesty and completeness necessary to understand all of human ecology, we may need to discard everything and start over again.

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Game and Fur Conservation on Rangelands in the Western United States

D. I. RASMUSSEN

ABSTRACT

This report deals with experiences in the field of wildlife management on rangelands in the western part of the United States.

These western rangelands were first utilized by white men about a hundred years ago for the grazing of domestic livestock, and for many years this was considered to be their sole value. Only in comparatively recent years has their value for other uses, including watersheds, wildlife productiou and public recreation received recognition.

The turn of the century saw the general low point in the wildlife resource of the western ranges, particularly in the big game and furbearer populations. Inauguration of protective measures resulted in very marked increases in a number of big-game species. This increase in turn has resulted in the development of problems of over-population of big game, and it conflicts with livestock use on the ranges and the need for new techniques and programmes of wildlife management.

Three examples of the increase in western big-game herds are cited.

(1) Mule deer in Utah increased from an estimated 8,500 in 1916 to a herd that provides 60,000 to 70,000 animals annually for Utah deer hunters.

(2) Wyoming antelope were nearly extinct in 1909 but now this game species is each year supplying 10,000 to 15,000 animals for Wyoming hunters.

(3) Colorado elk totalled less than 1,000 in 1910; in 1948 there was a legal kill of 10,273 animals in that State.

Experience and observations have provided three general principles applicable to successful management of big game on western ranges:

1. **Big-game numbers must be balanced with the available forage supply.**
2. **As a general rule, both sexes must be regularly harvested to stabilize healthy big-game herds at desirable levels.**
3. **Actual competition between big game and domestic livestock for native range forest is not direct, it is far less than generally supposed, and big-game herds and domestic livestock can, as a rule, both be successfully managed on the same rangelands in a multiple land-use programme.**

This report will deal with experience in the field of wildlife management on rangelands in the western part of the United States. Rangelands inherently refer to lands that are principally devoted to the production of domestic livestock through the grazing of natural vegetation. These lands consist not only of grasslands but also include areas of desert and semi-desert shrubs, pinon-juniper and chaparral woodlands, and open forests.

According to Renne (1)[1], "Only 5 per cent of the more than 750 million acres in the eleven western States is used for crops. About 90 per cent of this extensive land area is usable mainly for grazing purposes, and livestock production is the basic industry in the two hundred counties of these range States." He also states that less than half of the nearly 750 billion acres of rangeland in the eleven western States is in private ownership. The Federal Government owns 54 per cent of the total land area of these States (406 million acres). The United States Forest Service and Bureau of Land Management administer three-fourths of the Federal lands, or 42 per cent of the total land areas of these western States.

About 200 years ago white men entered this area attracted by the natural resources, primarily the pelts supplied by the native furbearers, which they proceeded to exploit to their near elimination. Only the last 100 years have seen the entry of any number of white men into the western range region, and the establishment and expansion of a range livestock industry dependent upon the native forage resources.

[1]Numbers within parentheses refer to items in the bibliography.

Early fur-trappers and pioneers found a varied and locally abundant wildlife resource consisting of game animals and birds, both upland and water-fowl, furbearers, and native fish. After the settlement of these western areas those wildlife species that were attractive as food, that provided desirable raw material or interfered with man's agricultural endeavours, were hunted, pursued and destroyed. Even those that were valuable were given no legal protection. It was apparently assumed there was an unlimited supply.

MULTIPLE USE OF WESTERN RANGES

The western rangelands when first utilized by white men were considered valuable solely for the grazing of cattle, horses, sheep and goats. Full and complete utilization of the forage resources by domestic livestock, without consideration for other values, was the accepted practice. Only in comparatively recent years have the values of these rangelands for uses other than livestock grazing received recognition.

Large parts of the rangelands are valuable as watersheds. In fact, this is their greatest value in many parts of the arid and semi-arid West. Excessive livestock grazing is often the limiting factor to proper watershed management.

The wildlife resource of the rangelands and the public recreation it provides is an asset and an extremely important business in the West. Public recreational needs should be provided, especially on public lands. Big game and domestic livestock both consume forage, and when both classes of animals are present on an area conflicts, sometimes real and sometimes imaginary, often occur. Erosion caused by overgrazing at times results in deposition of sand and silt in streams and cutting of stream channels until it adversely affects the fisheries resource. Valuable and harmless furbearers are sometimes destroyed in programmes intended to eliminate animals that prey on domestic livestock.

To manage and co-ordinate all the resources and values of rangelands requires a programme of multiple land-use. The objectives of such a programme have been ably stated by Olsen (2): "This does not mean that every acre would be subject to multiple use by loggers, cow-punchers, sheep-herders, campers, fishermen and big-game hunters. It does mean that lands will be so managed that public needs as to water, timber, forage, recreation and wildlife will be provided to the fullest extent that the resources under proper and equitable use will permit."

WILDLIFE MANAGEMENT IN THE MULTIPLE LAND-USE PROGRAMME

The turn of the century saw the general low point in the wildlife resource of the western ranges, particularly in the big game and furbearer populations. Recognition of this was responsible for the inauguration of protective measures and programmes of restrictive harvests. These measures were effective and, associated with certain beneficial habitat changes, resulted in marked increases in a number of big-game species, especially deer, American elk or wapiti and pronghorn antelope, and also in certain furbearers such as the beaver. Protection did not bring about similar increases in the case of big-horn sheep generally, or in a number of species of native game-birds and furbearers. Serious conflicts between the grizzly bear and wolves with domestic livestock made restoration of these species definitely undesirable on rangelands utilized by livestock. Also, the intensive agricultural development of the grasslands that constituted the original range of the American bison made restoration of large herds of this species unfeasible.

Increase of big game animals

Three of the outstanding, but not necessarily unique, examples of the increase in big-game animals to a level permitting heavy annual hunter harvest at the present time follow:

Mule deer in Utah. The first record of mule deer numbers in Utah was made for the year 1916 when 8,500 were estimated to be present in the national forests of that State. Deer hunting was prohibited from 1908 to 1912 and a buck law became operative in 1913. The total annual deer kill in Utah was estimated to be 600 in 1913 and 800 in 1920, the first two years for which we are able to find any records (3).

In contrast, the legal Utah deer kill in 1942 was 63,600 animals. Slightly smaller numbers were taken each season between 1942 and 1948. In 1948, the legal kill reached an all-time high of 68,895 animals. This included 53,526 bucks killed on a regular buck licence, and 13,147 antlerless deer and 2,222 bucks killed on special permits (4). The author believes that the 1948 kill was not excessive for the Utah deer herds generally, and that a number of large areas were actually under-hunted.

Pronghorn antelope in Wyoming. The pronghorn antelope was almost extinct in Wyoming by 1909 when it was given statutory protection. In 1945, a record number of 17,000 were taken by hunters in a general open season. An aerial census in 1946 showed 48,000 pronghorns remaining on Wyoming ranges. The 1945 kill was believed to be a larger harvest than the herd was able to stand, and as a result the Wyoming game administrators have in the following years restricted the number to be taken annually. Under an efficient and carefully regulated system of harvesting, about 10,000 animals of both sexes were taken by hunters in 1946 and 10,500 in 1947. A state-wide census early in 1948 showed approximately 65,000 animals, and that year 16,000 permits were issued and 15,912 antelope were killed. The Wyoming Game and Fish Commission now reports, "In spite of hunting pressure, droughts and blizzards the pronghorn continues to thrive" (5).

American elk or Wapiti in Colorado. The total number of elk in Colorado was estimated in 1910 at 500 to 1,000. That state's legislature established a closed season on elk from 1913 to 1929 and elk were reintroduced to a number of suitable areas. In the early 1940's when there were an estimated 20,000 to 25,000 elk in the state it became apparent that the emphasis would have to be placed on better utilization and management rather than on additional restoration (6). Liberal regulations during the past three years have permitted the legal hunter harvest of 23,494 animals, including animals of both sexes, a number greater than in any other state for this period. In 1948 the total elk kill was 10,273 animals, the highest in Colorado's history. The 1949 elk-hunting regulations are even more liberal than in 1948 and provide for a general open season for either sex. This is the desirable harvest programme to properly manage their elk herds as determined by the capable and qualified technical personnel of the Colorado Game and Fish Department.

Principles of good game-range management

Increases in the number of big-game animals on western ranges, as in the three examples cited above, have also occurred at least in local areas in every western State. This has caused both stockmen and sportsmen to become alarmed over the possible range conflict between game animals and domestic livestock. Big-game herds must be fed. They utilize range forage, and there is a natural limit to the total quantity of food that these western ranges produce. Stockmen at times blame big game for range damage caused by livestock; likewise, sportsmen have been known to excuse range overuse by big game as due to livestock. A complete understanding of the interrelations between big game and livestock on western ranges has not been reached at the present time. Neither is there agreement between all interested parties of the proper place of big game on these lands.

Even though the wildlife range resource has not been understood in the past, and is still subject to misinterpretation, enough knowledge has been acquired to provide certain guides for good game-range management. Experience and observations have given us three general principles applicable to successful management of big game on western ranges:

1. *Big game numbers must be balanced with the available forage supply.* Overuse of a range results in reduced yield, and worse, a decreasing capacity of the land and vegetation to produce desirable forage. For example, *Purshia tridentata,*

a desirable browse species for deer, antelope and elk, cannot be maintained in a vigorous condition and produce adequate seeds if the annual twig growth is utilized by more than 60 per cent (7). Failure to recognize overuse brings its own cure in wasteful reduction of the herds by disease and mass starvation, as in the famous Kaibab deer herd (8). Even on areas where no livestock graze, game numbers must be limited and the herds managed on the basis of available natural feed.

In the West winter range very often limits the size of the big-game herds. It is on these areas that food shortages are most apt to occur. Attempts to supplementally feed oversized big-game herds during winter shortages is a highly questionable method at best. Experiments in Utah (9) and Colorado (10) have shown the fallacy of trying to maintain large mule deer herds by supplemental winter feeding. Indications are that feeding programmes are equally unsuccessful in the case of antelope and moose. Elk or Wapiti respond more favourably than deer to supplemental feeding of hay and concentrates, but observations show that winter elk feeding generally is also of doubtful value. Such feeding programmes (*a*) result in the destruction of the native forage plants and cause serious damage to winter ranges at and adjacent to the feeding areas, (*b*) are very questionable from an economic standpoint, and (*c*) do not always prevent abnormal losses in the herd.

The author believes that all too much reliance is being placed on the questionable and expensive programmes of feeding hay and supplements as a game management practice, rather than herd reduction and maintenance of numbers at the winter range carrying-capacity.

2. *As a general rule, both sexes must be regularly harvested to stabilize healthy big-game herds at desirable levels.* Every western state has found it necessary to issue hunting licences permitting the killing of female deer and elk. The State of Idaho, alone among the western states, has always had an either-sex or hunter's choice law. Big-game herds have increased and Idaho continues to have good big-game hunting under this system. All too often the female deer, elk, antelope and moose have been and are considered sacrosanct. In most western states the public has been so sold on the "buck law" that proper and desirable harvest of surpluses has not been possible.

In Colorado a few years ago, over-populations of deer and elk made it necessary to issue permits for the taking of antlerless deer and elk in addition to the bucks and bulls killed under their "buck law". This did not prove satisfactory and an either-sex hunt on the regular licence for certain districts was tried. Each change permitted the total legal kill to increase to new highs, but not enough to obtain the desired removals. In 1949 officials report, "This year's conditions even more critical than last . . . demand that we sell a state-wide either-sex season on deer and in almost one-third of the deer areas of the state permit the killing of two deer per licence" (11). This is a realistic deer management programme based on good field information of actual game range conditions obtained from studies by district biologists. Colorado is the only state that has authorized such a liberal hunting programme in an attempt to base its management on a biological basis.

It has been shown that western elk and deer herds can under careful management be maintained with hunting removals of animals of both sexes to the extent of 20 to 25 per cent of the number of animals in winter herds (12). Illustrative of this fact is an elk herd on the Nebo range in central Utah. This herd was established by a transplant of 48 animals onto an unstocked range in 1914. To date this herd, under a system of carefully planned and supervised management, has provided sportsmen a total of 4,397 animals of both sexes during 21 hunting seasons and an additional 173 animals for the stocking of other areas. At present there are about 600 animals remaining on this range.

The States of Wyoming and Idaho have demonstrated that antelope herds can be maintained with sizable annual removals consisting of both sexes, and that such removals are necessary to hold the herds to an optimum size.

Wyoming has also found it necessary to issue hunting licences to kill a limited number of cow moose on some areas to hold their numbers at desirable levels.

Despite repeated demonstrations that healthy big-game herds can be maintained under a system permitting the removal of both sexes, and that this as a rule is a necessary management procedure, either-sex hunting has not yet received universal public acceptance. Unfortunately, many sportsmen and some administrators assume that the killing of females is only justified as a measure for reducing herds on overstocked ranges. The fact that some female big-game animals can be regularly harvested by hunters under sustained yield management programmes, and thereby provide additional game animals for more hunters, is neither understood nor appreciated.

In parts of the West we still cling all too firmly to traditional programmes of protection aimed at restoration of big-game numbers. Unfortunately, it is not acknowledged that in many cases restoration has been accomplished and our present-day problems are, in the main, those of more efficient harvest.

Restrictive laws and seasons are limiting the take of deer from some western herds to 4 or 5 per cent or even less of their total numbers. At the same time other herds are annually producing 20 per cent or more of their population for hunter harvest. Losses on certain overstocked ranges in different western states annually exceed the legal hunter take.

3. *We know that actual competition between big-game and domestic livestock for native range forage is not direct and is less than generally supposed.* To assume that no competition exists is erroneous, but certainly the maximum productivity of land can result from multiple use. Big-game herds and domestic livestock can, as a rule, both be successfully managed on the same rangelands in a multiple-use programme without serious conflict.

There are three important aspects to the problem of appraising the conflict in the range forage use between big game and livestock. These are (*a*) the food and forage habits of the different animals, (*b*) the degree to which they occupy and utilize the same areas, and (*c*) the actual food requirements of the various kinds of animals.

Big-game animals eat numerous plants normally unpalatable to livestock, including certain poisonous species. They do not equally relish those eaten by livestock. Grasses, for example, make up only a minor part of the mule deer's year-long diet. Big game use parts of the range not grazed by livestock, such as steep and rocky slopes and areas far from water. Livestock, likewise, make use of certain areas that are not attractive to big-game animals because of the forage type, lack of cover or terrain. Without the presence of both big-game and domestic livestock certain areas would remain unused.

Schwan (13) says, "When ranges which are well adapted to domestic stock (and) are properly . . . stocked, there will still exist . . . a definite capacity for game animals".

The food preferences of deer and cattle differ markedly, but deer and domestic sheep relish many of the same forage species. It is true that elk eat many of the plants preferred by cattle; the same also applies to antelope and domestic sheep. There may, therefore, be localized areas of heavy use when definite competition for forage exists. On the other hand, mountain goats generally utilize inaccessible areas that are valueless for domestic stock and moose use both areas and forage species that have little or no value for livestock.

At times it is necessary in sound range-management programmes to reduce livestock use on ranges where only a small number of big-game animals are present, as well as on areas where there are many game animals. Also, it is sometimes necessary to reduce big-game populations where there is no livestock grazing or where the livestock grazing need not be changed. "Usually, severe misuse of rangeland results from either big game or livestock, seldom from both. Range inspection will show which animal is overusing the range. That animal should be reduced in numbers until forage and numbers balance and stability of the range is assured" (14).

RANGELANDS AS PUBLIC HUNTING AND FISHING AREAS

It is the range and forest lands of the West that furnish practically all of the big game and native upland game-bird hunting, and most of the trout fishing and fur-trapping. Of the western upland game species only the introduced Chinese pheasant is primarily dependent on cultivated lands. Two other successfully established exotics, the Hungarian and chukar partridges, are essentially inhabitants of the rangelands.

It has always been considered that hunting and fishing available for all is a part of the American tradition. If at all possible, we want to see this continued. However, the increased hunting pressure and demand for fishing and hunting territory has resulted in large areas of privately owned western rangelands being posted against public use. This has been especially true near large centres of population. Within the different states various methods and systems have been used by the fish and game administrators and sportsmen groups in an attempt to counteract and discourage the practice of posting private lands. The author believes (regardless of arguments for or against such a practice) that the future will see more and more privately-owned rangelands closed to public use. The public will be admitted to private lands only where the landowner (*a*) does not care or (*b*) feels the need of public hunting to remove big-game animals in conflict or competition with his operation, or (*c*) is offered sufficient financial or other incentives which he feels will justify permitting hunters and fishermen on his lands.

A major hope for continuing our American tradition of public hunting and fishing lies in the millions of acres of publicly-owned range and forest lands in the West. Here big game, game-birds and game-fish can be produced as a part of a multiple land-use management programme and in sufficient quantity to supply recreation in the form of hunting and fishing for millions of Americans.

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Ecological Aspects of Deer Production on Forest Lands

A. STARKER LEOPOLD

ABSTRACT

In common with many other game species, deer seem to be primarily a product of sub-climax plant successional stages on forest land. Influences such as logging, fire, and locally even livestock grazing, which produce a stand of young brush concomitantly produce a stand of deer. Climax forest, mature chaparral or grassland supports few deer.

Moderate browsing of the brush by deer during the early stages of a successional cycle may appreciably improve the range by inducing sprout growth. On an understocked range the woody forage species quickly grow out of reach of deer and carrying capacity declines more rapidly than if the brush were kept pruned. On the other hand, deer can weaken or kill the forage plants on an overstocked range, causing a premature drop in carrying capacity followed by decimation of the herd. Regulation of deer numbers to the finely balanced point of optimum stocking is an essential element of management.

Over and beyond local regulation of deer numbers, there exists the possibility of manipulating plant successional cycles to maintain high productivity of local ranges. At present the ecological forces of land clearing which produce good deer forage are vicarious rather than planned specifically for deer. Intensive management of deer habitat might provide for rotational clearing of key areas of range (usually localized winter ranges) to initiate new growth stages of young brush and tree reproduction. Controlled burning is one of the most usable tools for this purpose. Livestock grazing likewise can be used to the advantage of deer on some grass and brushlands. Such local manipulation of vegetation must be accomplished without inducing soil erosion or causing undue sacrifices to other forest uses such as timber production, watershed protection or general recreation.

It is axiomatic that deer are one important crop of forest lands whose other products may include saw logs, water, livestock, other species of game and fur, and general recreation. Since deer populations may be influenced for better or for worse by almost all other uses to which forest lands are put, the game manager of necessity must understand the ecology of the forest as a whole. This paper explores some ecological principles that seem to underlie deer production. The following observations, which concern specifically the white-tailed deer (*Odocoileus virginianus*) and the black-tailed or mule deer (*Odocoileus hemionus*), may also apply in some degree to elk, moose, and perhaps other types of forest game.

Many species of North American game appear to thrive best in the sub-climax stages of vegetational succession which follow such land disturbances as cultivation, logging, fire or grazing. Thus, the second-growth following logging or fire in coniferous forests generally supports much denser populations of both small and large game than did the virgin forest. Weedy and brushy fringes of crop lands likewise are better populated with small game than the original woodland or prairie which they replaced. Even on the Arizona desert, jack rabbits were found to be more numerous on heavily grazed desert ranges, where the sparse climax ground cover of bunch-grasses had been replaced by a sub-climax stand of weeds and annual grasses, than on undisturbed desert (5)[1]. Deer definitely follow this pattern of increasing when the plant succession is set back to early stages, decreasing as climax vegetation is restored.

DEER IN RELATION TO PLANT SUCCESSIONS

The closed canopy of a dense forest precludes growth of deer food plants and hence of a deer population. When the mature forest is removed, either by logging or by accidental burning, there springs up on the ground a cover of herbs, brush and young trees which will support deer. In almost any type of forest, the plant species represented in early successional stages include many good deer foods, and from the spruce forests of Maine to the chaparral of California's coast it is well known that deer populations tend to build up rapidly during the "new brush" stage following clearing. But as time passes, forest reproduction emerges from the brush and gradually a new canopy is established. The browse species again are shaded out, and the carrying capacity of the range for deer once more drops to a low level. This "normal" successional cycle in deer carrying capacity is designated by curve *a* in Figure 1.

More forest canopy is opened by commercial logging than by any other agency. Logging yields an immediate crop of lumber and creates conditions for a future crop of deer. The dual benefits derived from proper silvicultural practice exemplify the highest type of "multiple use" of forest lands. To be sure, the forests of North America are currently being cut faster than they are being grown, despite the continuing efforts of foresters to put all timber lands (private as well as governmental) on a sustained yield basis.

Preservation of the forest itself is basic to national welfare, and long-term plans of forest game management must be premised on ultimate universal adoption of balanced silviculture.

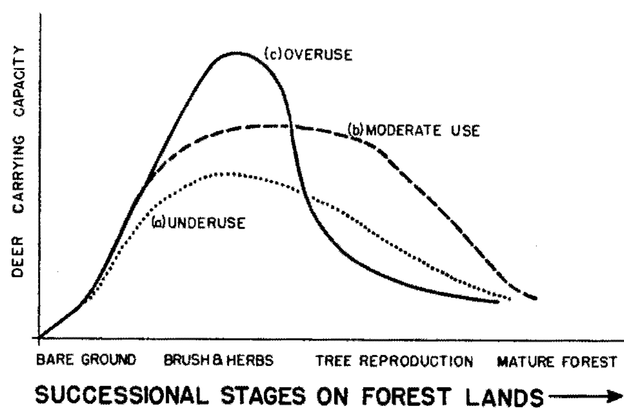

Figure 1. Effects of different degrees of deer-use upon range carrying capacity through stages of a plant-successional cycle. Total productivity is highest when the range is browsed moderately as in curve *(b)*

[1]Numbers within parentheses refer to items in the bibliography.

Unfortunately, wild fire is the second most important influence in opening forests. Fire creates great areas of temporarily productive deer range but at an exorbitant cost in timber and watershed destruction. The gradual reduction (and hoped-for final elimination) of extensive fires will result in more closed forest canopy than exists now and hence in stabilization of deer carrying capacities at something below the present level. Compensation is possible by more intensive management of localized portions of the forest, especially winter ranges, which are the key areas in maintaining deer numbers. Fire, which is a devastation when out of control, still may be one of the most useful tools in managing key areas of deer range, as will be mentioned again later.

Whereas fire and logging are the two most important influences which initiate successional cycles on forest lands, grazing by domestic livestock may act in the same manner on climax grass and brushlands. Deer and livestock compete for forage, often to the detriment of each other and of the range. At the same time, some livestock grazing may raise the carrying capacity for deer on certain ranges by maintaining the vegetation in a sub-climax successional stage in the manner of fire or clearing.[2] For example, in northeastern California (and elsewhere in the Great Basin) considerable numbers of deer winter in foothill areas now well grown with such shrubs as Bitterbrush (*Purshia tridentata*) and Common Sagebrush (*Artemesia tridentata*). These shrubs have invaded a predominantly bunch-grass range following heavy livestock grazing. The climax grassland wintered relatively few deer. Presumably the livestock, imported in great numbers in the late 1800's and early 1900's, caused an ecological disturbance of the bunch-grass type and induced an increase in shrubs which nowadays support a large population of deer. Although overstocking of both livestock and deer on the bitterbrush-sagebrush range is evident in many areas, it remains a fact (not often acknowledged by those interested solely in deer) that the complete removal of the stock probably would result in ultimate shrinkage of the deer population as the range reverted toward the climax bunch-grass. Again in southern Texas, grazing has led to growth of great areas of mesquite and scrub oak (with high deer populations) on former deerless prairies. Grazing as an ecological influence may therefore create deer range, just as in excess it can destroy the range.

It is a safe though regrettable generalization that the very factors which have contributed to the present high carrying capacities of our deer ranges are all being overdone from the long-term standpoint of resource conservation. Forests are being overcut and overburned; western ranges are on the whole much overgrazed. Future deer management will have to be keyed to a programme of more conservative land use. Deer range, in the form of extensive brushlands produced vicariously by man's careless and profligate exploitation of the forest, must be reduced to lesser acreages, which, however, if intensively and specifically managed for deer, may have fully as great productive capacity in some areas and nearly as great in others.

[2]Conversely, the deterioration of cattle range is often judged by the degree to which the climax vegetation has been altered by grazing, the best grass ranges being those most nearly approaching climax (Dyksterhuis, 1949). The principles governing range management for game are not necessarily synonymous with those applicable to livestock.

EFFECT OF DEER UPON THEIR OWN RANGE

Whereas the carrying capacity of the forest for deer is primarily a function of plant successions and ecological disturbances, it may be profoundly influenced by the deer themselves.

Deer may modify the carrying capacity of their own range during a successional cycle. Moderately heavy browsing of the woody species during the early and middle stages of the cycle will cause the individual plants to produce adventitious sprouts, thereby increasing the volume of available food and further raising the carrying capacity for deer. The palatability of the sprouts is higher than that of unbrowsed twigs and there is reason to believe that the nutritive value may also be higher (3). Likewise the sprouts are within reach of the deer; their regular consumption prevents the plant from growing out of reach and assures another crop of available forage for the next year. In this manner the deer can improve their own range. The carrying capacity curve designating a "moderate" degree of use is shown as *b* in Figure 1.

Not infrequently a deer herd will continue to increase beyond the stage of moderate or balanced range use and will follow a pattern which has come to be called "irruptive" by U.S. game managers (2). A deer irruption often follows insufficient harvest of the deer during the upswing of a successional cycle. Excessive use of the forage by too many deer may stimulate the browse plants to produce more and more sprouts, temporarily raising the volume and nutritive quality of the forage to an abnormal level but ultimately causing physiological exhaustion and even death of the plants. During irruptive peaks, fawn production and fawn survival often remain high, which would indicate adequate nutrition for the does. But when the volume of food falls off because of overbrowsing, or when the food is rendered temporarily unavailable by deep snow, the deer herd is left literally in excess of its food supply. At this point the herd inevitably suffers mortality—sometimes wholesale starvation, at other times gradual decrease following lowered reproductive success. In warmer climates (such as the coastal mountains of the Pacific coast or in Texas) actual decimation often results from parasitism or disease, but the underlying cause is still inadequate nutrition. There may be a series of recurrent ups and downs in some irruptive deer populations, reflecting year to year fluctuations in food conditions. The curve designated as *c* in Figure 1 depicts only the simplest range situation resulting from a violent irruption and consequent collapse of the food supply. The various modified and recurrent effects of range overuse are not graphed.

At times excessive numbers of deer consume tree reproduction along with brush species, a fact which may delay the formation of a forest canopy or favour reafforestation with undesirable species that happen to be unpalatable to deer. This interferes seriously with efficient silvicultural practice. Likewise hungry deer frequently invade agricultural lands and cause extensive damage to crops, orchards or vineyards.

From the foregoing comments, it should be obvious that optimum deer production is not attained by permitting either overstocking or understocking of the range. Greatest production will be derived by maintaining a moderately heavy deer population such as will keep the food plants well browsed, thus stimulating sprout growth, without leading to their rapid decline by overuse. This applies to ranges stocked solely with deer and to combinations of deer and livestock. It must be remembered, however, that on cleared forest lands the key forage species often are transient products of the plant succession and that they soon will be replaced by forest growth regardless of how lightly or heavily they are browsed. Thus there is no advantage in ultra-conservative stocking of such brush ranges.

Admittedly, most U.S. deer ranges are currently more prone to be overstocked than understocked. Fifty years of education of the American public in the gospel of conservative use of game resources has had its effect upon public thinking, and sportsmen are slow to accede to increasing the deer harvest for the purpose of reducing a population. During the game "restoration" era of the recent past, most deer states adopted legislation permitting only bucks to be killed; yet it is impossible to regulate deer numbers unless some females can be harvested as well. Under the buck law, yields will vary from 2 to 10 per cent of the herd per year, whereas annual production in a healthy herd on good range is usually 20 to 25 per cent. Chronic undershooting, often coupled with unnecessary predator control, has permitted countless local irruptions of varying degrees of severity—an inexcusable waste of game and range resources as well. The most immediate objective in the field of American deer management is to work out more flexible hunting regulations so that the full annual crop can be harvested. Until this is accomplished other aspects of deer management seem futile. There is no incentive to produce deer only to see them starve.

MANAGEMENT OF DEER AND DEER RANGE

As I see it, the future of American deer management will involve the following three steps:

(*a*) Reduce logging, grazing and careless burning of forest and rangelands so as to put these lands on sustained yield and assure their perpetual productivity. Unless the basic resource is preserved there is little hope for game production. Much progress is being made in this regard.

(*b*) Perfect the legal machinery for harvesting the full annual crop of deer so as to maintain a favourable balance between deer and their range at all times. Most of the states are groping in this direction now, but there remains much to be learned. Proper herd regulation is perhaps the most immediately achievable step in deer management.

(*c*) Deliberately and purposefully manipulate plant successions to maintain high range capacities for deer. Habitat management, over and beyond the present accepted practices of good forestry and good range management, might well adopt such tools of land clearing as controlled burning, chemical plant poisoning or mechanical brush-cutting, to stimulate deer food production on critical sites not adapted to timber production. The controlled use of fire has been established practice for years in managing game habitat in the south-eastern United States (4) and game and livestock range in northern California (3). Current studies being conducted in California seem to show that judicious, rotational burning may be both safe and effective in improving certain types of range for deer. Other areas need reseeding, fertilization, closer regulation of livestock or development of water sources. The point to be emphasized here is that intensive management of local units of deer range often will pay for itself in increased production.

Obviously the selection of areas to be so intensively managed will have to be made with due regard for other forest values, particularly timber production and general recreation. The areas where such investment is justified need not be large in terms of the forest as a whole. Much can be accomplished on small, critical areas. For example, on the west slope of the Sierra Nevada in California, most of the deer winter on the lower fringe of the good timber belt, and limited areas of winter range could be managed in brush without appreciably reducing timber production or rendering the forest less attractive for general recreation. There is more than enough summer range in the higher zones. Likewise in parts of the north-eastern United States the deer winter in limited "yards" (often swamps) which should be devoted principally to growing deer food. Assuming that the legal machinery for fully harvesting the deer crop can be perfected, a high return is possible by investing in habitat management of key areas in the forest.

Manifestly, management methods must be applied in such a manner as to preclude soil erosion or long-term deterioration of the site. Any form of forest clearing is dangerous unless used with discretion. But only by such intensive and deliberate ecological controls can the maximum potential crop of deer be produced on forest lands.

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Summary of Discussion

The CHAIRMAN announced that several papers had been received on the topic to be discussed. The paper submitted by Mr. Vaughan-Jones on the "controlled area" system in relation to game management on rangelands in Northern Rhodesia would be considered at the following meeting, on Monday, 29 August, which would deal with the subject of wildlife resource management. He called on Mr. E. Graham to introduce his paper.

Mr. E. GRAHAM introduced his paper on the subject of "Wildlife on Croplands".

Mr. LINCOLN wished to stress two important points brought out in Mr. E. Graham's paper. The author had pointed out that most of the hunting and fishing in the United States of America took place on croplands. In view of the fact that over 10 million hunting licences were issued, enough game would have to be maintained to supply the needs of hunters. It was necessary, therefore, that land which could not be adapted to the production of cultivated crops, the rearing of livestock or the planting of trees, should be reserved for wildlife production.

Mr. Lincoln pointed out that the methods recommended by Mr. E. Graham with a view, in the first place, to soil conservation were also practised by the United States Wildlife and Fish Service. Over 300 refuges covering more than 4 million hectares of land provided cover for migratory water-fowl as well as for other types of fowl and wildlife. Those practices had proved successful.

Mr. DAHLBECK observed that wildlife in Sweden was a secondary product of the land and was an important factor in farm economy.

The right to hunt was vested in the estate owner and, since he derived some revenue from hunting, he was very much interested in wildlife production. As to the damage which wildlife might cause to crops, it was for the estate owner himself to decide whether such damage exceeded the profit he obtained from hunting.

In Sweden that practice did not create any difficulties and wildlife production on croplands was considerable.

Mr. VOGT, who had recently completed a trip through the United States in which he had covered over 5,000 miles, declared that he had been struck by the scarcity of hawks. He wished to know whether the Fish and Wildlife Service was taking steps to prevent their destruction.

Mr. E. GRAHAM commented that the Soil Conservation Service recommended practices which did not apply specifically to wildlife but concerned land-use in general. The planting of hedges and borders on cropland, for instance, had made wildlife production possible as a by-product of cultivated crop production. The plants used, such as *Rosa multiflora*, provided excellent wildlife cover. The practices recommended by the Soil Conservation Service would in the first place benefit the land and in the second place would contribute to wildlife production. The Service was doing nothing to cause either an increase or a decrease in the number of predatory animals.

Mr. VOGT observed that in the United States hunters themselves were responsible for the extinction of predatory animals; yet those animals had their useful points. Hunters should be made to understand the need for the preservation of a reasonable number of such animals.

Mr. F. DARLING considered Mr. E. Graham's paper extremely important. The author's work on "Natural Principles of Land Use" was well known in the United Kingdom, where the principles enunciated in that book should be applied more widely.

The problem of the ownership of wildlife was of major importance. In the United Kingdom, the game on a property belonged solely to the owner of that property, and he made careful use of it. That practice, unfortunately, placed all wildlife resources at his mercy, and he was in a position to do as he pleased with them. Although some wildlife was admittedly plentiful, the effects of the practice were often disastrous for agriculture. The weasel, the stoat and the badger were killed in large numbers, thus leading to an alarming increase in rodents detrimental to cultivation. Wheat in the braird suffered extensive damage, and the same was true of forest nurseries. By the time a coniferous plantation was 10 to 15 years old, it was full of wood-pigeons which were impossible to destroy; although pine martens would be the natural check. Wood-pigeons would certainly not cause such extensive damage to clover-fields and cruciferous crops if some predators, the magpie for instance, were spared.

The usefulness of predators was beginning to be recognized in the United Kingdom. There was reason, moreover, to hope that conservation measures would lead to encouraging results.

The CHAIRMAN observed that in Cuba the planting of the sugar-cane had required the tearing down in these areas of all the hedgerows which provided cover for wildlife. As a result, wildlife had been tremendously reduced in the sugar-cane plantation regions.

The Chairman requested Mr. M. Graham, in the absence of Mr. Middleton, to present a summary of the latter's paper on the subject of "Game Conservation on Croplands in Great Britain".

Mr. M. GRAHAM observed that numerous points in the paper were of local interest. The purpose of a conference such as the one under way was to consider problems which, while peculiar to the United Kingdom, for instance, might some day have to be solved by other countries. In the United Kingdom, intensively cultivated lands were situated in the vicinity of populated and highly-industrialized areas. Shooting rights were the exclusive property of estate owners, and the preservation of game was maintained under the strict supervision of gamekeepers. The practice described in detail in Mr. Middleton's paper had hitherto proved efficient; despite the increase in population, game conservation had been possible.

Mr. M. Graham felt, as did Mr. F. Darling, that the extinction of predatory animals was dangerous to farming, yer it was the only way to maintain game in sufficient quantities. It appeared, indeed, that a *modus vivendi* had been reached between estate owners and farmers, who also hunted for sport. Both were responsible for the protection of wildlife from the industrial populations living near croplands.

Mr. Middleton, in his paper, also described the conditions required for the survival of wildlife.

Mr. M. Graham added that he had been very much interested in Mr. E. Graham's paper, which linked soil conservation with wildlife conservation.

He agreed that some points in Mr. Middleton's paper might prove a source of useful study for all countries wishing to conserve their wildlife resources.

Mr. ORPEN wished to know whether the United States and the United Kingdom had enacted any legislation for the protection of predatory birds such as hawks and owls.

Mr. LINCOLN replied that in the United States, the Bald Eagle, emblem of the country, was the only bird protected by federal law.

Hawks and owls were protected by state laws only; most of those laws were based on a model drafted by the American Ornithologists' Union, which provided for the protection of all birds with the exception of the sharp-shinned hawk (*Accipiter velox*), the cooper hawk (*Accipiter cooperi*), the Goshawk (*Astur atricapillus*), the duck hawk (*Falco peregrinus*), the greathorned owl, the crow, the blue jay and the European house sparrow. Although the laws existed, they were rarely enforced in view of the aversion of hunters for predatory birds.

It was hoped that a federal law would be enacted for the protection of the owls and the hawks, since that would make it possible for federal agents to enforce the law in the various states. Experience had shown that the enactment of the federal law for the protection of the bald eagle had led to excellent results.

On the other hand, the United States Fish and Wildlife Service and, before it, the Biological Survey, had for many years conducted a campaign to convince the public of the usefulness of hawks and owls. But their efforts had unfortunately proved more or less in vain.

Mr. F. DARLING stated that in the United Kingdom, existing legislation for the protection of birds was being thoroughly revised with a view to increasing its effectiveness. Although laws existed, they were not strictly enforced. Gamekeepers merely protected game required for shooting and killed other predatory wildlife indiscriminately. The golden eagle was protected by strict laws which, however, were not always observed. Since the introduction of sheep to the deer forests, many of those birds had been killed, particularly in the deer-forest lands where they had previously been allowed to live.

Mr. VOGT wished to know whether the increase in income tax and death duties had adversely affected wildlife conservation in the United Kingdom.

Mr. M. GRAHAM replied that in view of the increasing taxation to which estate owners were subjected, the practice described by Mr. Middleton was falling into disuse![1] As a result of the social revolution which was taking place in the United Kingdom, the number of estates on which gamekeepers could be employed was progressively declining. It would thus become necessary, in the light of the social changes, to devise a new method for the protection of wildlife.

Mr. F. DARLING pointed out that in Scotland, where there were extensive deer forests, higher death duties had resulted in the cutting up of large estates. That circumstance made it difficult to maintain the former practice whereby wildlife was protected by estate owners. It was to be hoped, therefore, that the national wildlife conservation agencies would gradually take over that responsibility from the estate owners.

Mr. VOGT wished to know whether the Labour Government in the United Kingdom, in mapping its general programme, was considering that possibility.

Mr. M. GRAHAM replied that the House of Commons was considering a law on national preserves which would ensure wildlife conservation. Moreover, two committees on conservation of natural resources had been appointed recently, one for England, the other for Scotland. A White Book had also been published on the subject.

Mr. WAGAR summarized his paper on "Recreation and Wildlife Problems Peculiar to Rangelands of Western United States".

Mr. RASMUSSEN summarized his paper on "Game and Fur Conservation on Rangelands in the Western United States".

Mr. ORPEN felt that Mr. Rasmussen should be congratulated on the results achieved in Utah. He wished to know, however, whether, in addition to the official figures Mr. Rasmussen had quoted, he could give some idea of the amount of game killed illegally. He also asked whether there were large beasts of prey in Utah as there were in the Union of South Africa.

Mr. RASMUSSEN replied that some poaching did occur in western United States, but he had no reliable data on the amount of game taken. It was his opinion it was of only minor importance.

Mountain lions were the only large beasts of prey now found in Utah. They were hunted by livestock owners and game administrators because of the belief that they are harmful to both livestock and big game. Coyotes were present but their influence on deer herds was little known.

Mr. G. SWANSON found Mr. Rasmussen's account of the problem of management of big game in the states of the Western United States thoroughly satisfactory. The figures he had quoted for Utah merely illustrated the situation; comparable figures could be given for other Western States.

One of the most outstanding results achieved in the United States was the increase in the population of big game. Unfortunately, it had not been possible, at the same time, to educate the public. As a result of public misapprehension there was seldom a rational and adequate utilization of big-game resources in the United States.

Mr. BREWER wished to know to what extent the antelope herds in the Western States had suffered from the rigours of the previous winter.

Mr. RASMUSSEN replied that the effects of the previous winter's blizzard on antelope herds had been greatly exaggerated. Some antelope herds caught in the blizzards had moved across country until their movement had been restricted by roads and railroads where serious local losses occurred that were easily observed. That explained much of the publicity regarding the events.

Mr. WAGAR explained that in Colorado the antelope hunting season had not been opened until the results of the aerial census of antelope herds after the blizzard had become known. The census had shown that the losses had

[1]The following is an excerpt from a communication from Mr. A. D. Middleton to the Editor: "Although many of the larger estates have been broken up and the number of gamekeepers reduced, a very large proportion of these areas are now shot over by groups or syndicates who still employ gamekeepers and carry out the system of game preservation described in my paper. All the evidence we have indicates that game management of this kind is now being strongly revived after the severe setbacks of the war period. This revival is due solely to the enthusiasm of individual sportsmen, rather than to any interest shown by the Government".

been very low and that they had been local rather than general.

Mr. LEOPOLD introduced his paper on the "Ecological Aspects of Deer Production on Forest Lands".

Mr. M. GRAHAM pointed out that by approaching the problem of deer conservation from the ecological point of view, Mr. Leopold had indicated the course to be followed in the conservation of all wildlife, for the principal factor in any effective management should be the utilization of environmental influences on the species. Game management agencies had a tendency to introduce considerations, based for instance on agricultural or geological factors, which did not directly affect the development of wild fauna. In order to be truly effective, game management should be based principally on a thorough ecological and biological knowledge of the species so as to retain the balance essential for the regulation of deer numbers.

Mr. F. DARLING congratulated Mr. Leopold on his interesting paper, which opened up new vistas for all concerned with the problem of deer control.

He noted that when surveys were made of human population, demographers based their conclusions not on the number of men within a given group, but on the number of women of an age to bear children. But when a census was taken of game, and especially of deer, attention was devoted exclusively to the male of the species and the importance of the female was underestimated to the point where, for irrational sentimental reasons, the female was shielded from the dangers of the hunt. Yet it was a proven fact that in order to check the constant increase in the number of deer in the world, it was essential to destroy not only the males, but also the females.

To support that argument, Mr. Darling cited some facts on deer hunting in Scotland. Stalking of the male deer was customary between 15 August and 15 October, and stalking of the female between 15 November and 15 January, after the birth of the fawns. But only hinds without a calf at foot were killed. Deer were killed at the rate of 5 per cent, 2½ per cent of each sex; but at this rate the herds would increase.

Moreover, the gradual disappearance of the brush forests of Scotland caused the herds to invade the low grounds where they wreaked havoc among the crops.

The problem was therefore a real one and it could probably be satisfactorily solved by putting into effect the ecological methods practised by Mr. Leopold.

Mr. H. D. FISHER was sorry that the Section had not yet received a Canadian paper on game management which had been prepared for it.

As was well known, Canada was primarily concerned with fur game. Of a total area of 3.5 million square miles, less than 8 per cent was under agricultural cultivation; the remainder was composed largely of forests of which 3 per cent was private property and 89 per cent belonged to the State. There were more than a million square miles of national parks, game reservations and hunting areas. Intensive ecological and biological research was being carried out on those vast regions.

The Canadian authorities were faced with two big problems: on the one hand, they had to take steps to check the overpopulation of their national parks; on the other hand, they were attempting to alter popular notions, especially with regard to predatory animals. The mountain lion was still extant in the provinces of the West, as well as the bear and the wolf, but their numbers in the past had been constantly decreased, while the number of certain game animals greatly increased until overpopulation resulted. The policy in force on federal reservations now was that every animal there should be protected unless it was proved that it threatened the existence of another species. Moreover, the reward formerly offered for the destruction of predatory animals had been withdrawn. The Canadian Government hoped that those measures, together with the ecological and biological research under way, would help to correct conditions.

Mr. ORPEN said that in South Africa the public was permitted to visit the national parks only by automobile and was not permitted to leave the roads. In that connexion, he stressed the difficulties encountered in Canada in disciplining visiting crowds. In his opinion, the only effective way to protect game would be to set up reservations from which the public would be positively excluded.

Mr. VOGT explained that the very strict regulations enforced in the national parks in South Africa were necessary owing to the presence of dangerous animals such as lions, elephants, buffaloes and crocodiles.

Mr. DAHLBECK gave an account of game conditions in Sweden, where fur game were an important resource. The red fox was the most important game in Sweden next to the moose.

He considered that one of the main methods of conserving game was by stimulating public interest; that was how in Norway the reindeer and the beaver, which had been threatened with extinction, had been preserved.

Steps had been taken to protect the bear and the lynx. The same had not been done for the wolf and wolverine; however, it was prohibited to poison them or to trap them without special licence. The State paid compensation for any damage done by big predatory animals to livestock: Mr. Dahlbeck estimated that the annual expenditure for that purpose amounted to approximately 50,000 Swedish crowns ($10,000).

Mr. Dahlbeck then commented on the practice of introducing a foreign species into the wildlife of a country for the purpose of improving the native species. He pointed out that the effects of cross-breeding were often disappointing, as witnessed by the introduction of the Hungarian partridge and the Carpathian red deer into the Scandinavian countries. They could not become acclimatized and had almost caused the extinction of the local breeds. In Finland, the American black fox had been introduced in the hope of improving the fur of the wild red fox, and a hybrid species known as the Samson fox had been created. Those were ugly animals and their fur generally grew in tufts. Samson foxes seemed to have crossed over into Sweden, for a few had been found there in the past two or three years.

Mr. Dahlbeck wished to know whether other countries had experienced similarly unfortunate results.

Lastly, he drew attention to an aspect of fur-game breeding which was not given enough consideration in comparing game production with deliberate breeding of fur game. The fact was lost sight of that in fur-game farming, the animals had to be fed and that they ate not only what was often expensive food but, in many cases, food which was of great value to man. For example, minks were often fed chicken eggs.

Mr. MUNNS confirmed Mr. Dahlbeck's remarks on the inferior quality of hybrid breeds: the American beaver introduced into Poland no longer bore fur as beautiful as in his natural habitat.

In view of the fact that the laws in force governing the protection and control of birds of prey were not correctly applied, Mr. ORPEN would welcome an appeal to the Governments concerned to take the necessary measures.

Mr. BREWER remarked that the best procedure would be to communicate the views of the Section on that matter to the International Union for the Protection of Nature, which was in a position to make recommendations to Governments.

Management of Wildlife Resources

29 August 1949

Chairman:

Nils DAHLBECK, Honorary Secretary and Executive Member of the Swedish Society for the Protection of Nature, Stockholm, Sweden

Contributed Papers:

Management of Wildlife Resources
E. B. WORTHINGTON, Scientific Secretary, Office of the East Africa High Commission, Nairobi, Kenya, East Africa

Game Control in Kenya Colony
A. T. A. RITCHIE, O.B.E., Game Warden, Nairobi, Kenya, East Af-ica

The "Controlled Area" System in Relation to Game Management on Rangelands in Northern Rhodesia
T. G. C. VAUGHAN-JONES, Director of Game and Tsetse Control, Lusaka, Northern Rhodesia

Scientific Work of the National Parks Institute of the Belgian Congo
V. VAN STRAELEN, *Directeur de l'Institut royal des sciences naturelles de Belgique*, Brussels, Belgium

Management of Wildlife Resources
Jean-Paul HARROY, *Secrétaire général de l'Institut pour la recherche scientifique en Afrique centrale et Secrétaire général de l'Union internationale pour la protection de la nature*, Brussels, Belgium

On the Conservation of Bird Resources
Jean DELACOUR, President, International Committee for Bird Preservation; Research Associate, American Museum of Natural History, New York City, U.S.A.

Management of Bird Resources
J. Dewey SOPER, Dominion Wildlife Officer, Alberta and the Territories, Dominion Wildlife Service, Lands and Development Services Branch, Department of Mines and Resources, Ottawa, Canada

Peruvian Management of Bird Resources
Enrique AVILA, Ornithologist, *Compañía Administradora de Guano*, Lima, Peru

Management of Bird Resources
R. A. FALLA, Director, Dominion Museum, Wellington, New Zealand

Management of Bird Resources
Gustav A. SWANSON, Head, Department of Conservation, Cornell University, Ithaca, N.Y., U.S.A.

Administration of Big Game Resources in the United States
Albert M. DAY, Director, United States Fish and Wildlife Service, Washington, D.C.

Administration of Game Resources
M. GOUILLY-FROSSARD, *Directeur général honoraire des eaux et forêts, Président honoraire du Conseil supérieur de la chasse*, Paris, France

Management of Wildlife Resources
A. URBAIN, *Directeur du Muséum nationale d'histoire naturelle*, Paris, France

Problems of Conservation in Great Britain as Illustrated by the Status of the Red Deer (*Cervus elaphus*) and the Atlantic Seal (*Halichoerus gryphus*)
F. FRASER DARLING, Director, West Highland Survey, Scotland, The Old Rectory, Lilley, near Newbury, Berkshire, England

Problems in Connexion with Imported Species of Animals
The Ministry of Agriculture, Buenos Aires, Argentina

Summary of Discussion:

Discussants:

Messrs. HARROY, VAN GRAAN, R. C. MURPHY, DAY, R. POUGH, LEOPOLD, ORPEN, DE VOS, G. A. SWANSON, DELACOUR, SEELE, DE LA TORRE, F. DARLING, HEIM, BREWER, RASMUSSEN

Programme Officer:

Mr. George BREWER Jr.

Management of Wild Life Resources

E. B. WORTHINGTON

ABSTRACT

In countries with much wild fauna, including many of the African territories, the conservation of game and the control of undesirable elements in the fauna must go forward hand in hand, bound together into a common policy. The increase in human population indicates an increasing need for both conservation and control of wild animals. Many game administrations as at present constituted may be inadequate to meet the needs of the future.

Except in a few cases of rare or local animals or in restricted environments, it is not yet possible to estimate the fluctuating populations of game with any degree of accuracy.

The value of protected areas depends more on the imponderables, such as educational and scientific and tourist values than on the direct financial return.

The International Conventions of 1933 and 1937 on the protection of the fauna and flora of Africa have provided an important stimulus to conservation. There are international problems of control, especially concerning the effect of game in the spread of diseases.

In less-developed continents, such as Africa, there is much need for public relations and education in conservation, but success will be best achieved by presenting a balanced picture with due weight given to the control of animals as well as to conservation.

INTRODUCTORY NOTE

This paper, which refers mainly to conditions in Africa, has been prepared under stress of time and there has been no opportunity to refer to more than a small fraction of the extensive literature on the subject. The main publications referred to have been East Africa High Commission Paper No. 1 "Fauna of British Eastern and Central Africa (Proceedings of the Conference held in Nairobi on 8th–9th May 1947)" Nairobi 1948; my book "Science in Africa" Oxford Press. 1938, Chapter 8; and various reports by game departments and individuals, chiefly from the British administered territories in Africa. The rest has had to be supplied from my personal views and memory.

BASIC CONSIDERATIONS

There are two main facets to the administration of game and fauna resources, one is concerned with conservation and the other with control. Lack of appreciation that conservation and control must be combined into a common policy has lead to some loose thinking and writing on the subject, particularly in recent years. Conservation implies the preservation in perpetuity of a reasonable quantity of game and wild fauna on account of their educational, scientific, economic, recreational and aesthetic value. Control implies the need, which is growing as human population increases, to keep the population of game and wild fauna within reasonable bounds, so that the animals do not conflict unduly with the use of land for production purposes. Any authority responsible for the administration of game resources in countries where large game animals are still numerous, must clearly take both aspects into full consideration, in order to serve the human community at large.

There is still an impression in some quarters that Africa and other continents rich in game and wild fauna still contain great uninhabited spaces where game is dominant and that the wild fauna will survive without special precautions being taken on their behalf. Unfortunately for the game, this is no longer true. As an example, in the territories comprising the East African region—one of the main strongholds of the unique Ethiopian fauna—recent evidence points to a multiplication of the human species at a rate much greater than anticipated, and consequently the use by man of much land which has formerly been dominated by game is becoming inevitable. The census of British East Africa undertaken in 1948 shows that the human population is already nearly 18 millions, more than 3 millions greater than was thought, and the rate of increase of the human species is likely to be much greater than current calculations have suggested.

In the administration of game resources, as of human beings, it is necessary to look forward a considerable period; fifty years is by no means too long. In half-a-century's time it must be anticipated that, in the particular example of British East Africa, the human population will be two or three times as great as at present, and in consequence the competition for available unused land will have become acute. It must be anticipated that nearly all the usable land will by then be required for purposes of agriculture, forestry and other human activities, and that the larger wild animals will be eradicated, or at least heavily persecuted, nearly everywhere except in restricted areas which will be devoted exclusively to their well being. The areas of conservation, including national parks and reserves for fauna and flora, may then have to be surrounded by fences. Such areas will need management under scientific control, to make them carry the maximum of wildlife and to reduce the tendency for animals to spread outside. It will be necessary, for example, to maintain the right balance between herbivores and carnivores, to provide permanent water-supplies and even to improve the carrying capacity of grazing land. Special arrangements may have to be made in these areas for species which are less capable of standing the hurly-burly of competition. Outside the national parks and reserves and other conservation areas, it must be assumed that most species of game will, during the next fifty years, require heavy control measures to avoid their depredations, and their spreading of disease to domestic animals.

There are of course exceptions to this realistic, if unromantic, forecast in cases where game animals take a useful place in the agricultural or other human use to which the land is put. Such has already occurred by long experience and tradition in countries like Great Britain where the sporting value of game has considerable influence on systems of land use and on land values. In the less developed countries, such as Africa, most of which must be given over primarily to production from the soil, the sporting and recreational value of game outside conservation areas will inevitably diminish.

It must be admitted that, with such a future in view, the present systems of game administration in most parts of the world are inadequate to deal properly with either conservation or control. The deficiencies are in three main areas, detailed below.

Firstly, there is an inadequate background of scientific knowledge and research. The problems of game administration are primarily scientific problems of balancing the wild populations with the environment, but the effort devoted to gaining the requisite knowledge is in most parts of the world very small in relation to the problems at issue. There are exceptions to this, for example, in the Wildlife Services of the United States, and in the new Nature Conservancy in Great Britain, but certainly in Africa, where the problems at issue are in many ways greater, the scientific effort is far too small.

Secondly, in the aspect of conservation, there is urgency in selecting, demarcating and administering areas to be devoted to permanent national parks. Progress has of course been made in certain countries, notably in America. In inter-tropical Africa it may be said that the Belgian Congo is probably in advance of other countries in the administration of its *Parcs Nationaux* comprising areas of remarkable scenic beauty and faunal multitude and variety. In the British countries of inter-tropical Africa considerable progress has likewise been made. The proportion of land area at present given over to national parks and game reserves ranges in the British territories from under 4 per cent to nearly 10 per cent of the total land area. Perhaps in the ultimate picture of developed Africa fifty years hence, an average proportion of nearly 5 per cent of land area may be suitable for fauna and flora in the interests of the public at large. The conserved areas would not for the most part be in lands with a high productive capacity for agriculture, and so they would represent a percentage very much smaller than 5 per cent of the total land value. For comparison, a proportion of 10 or 20 per cent is generally regarded as suitable in African territories for land to be maintained permanently under forest cover.

The third way in which present administration appears inadequate is in the control of game in those areas which are not scheduled for conservation. For control to be successful, unrestricted shooting or trapping will not suffice because such methods reduce game populations only to a certain limit and that limit is often not far enough. Whereas the direct depredation of the larger animals on agricultural land is considerable in Africa, far more important is the insidious and often masked effect of wild fauna in spreading disease through the agency of a wide variety of insects and other vectors. Even though a population of game may be reduced to as low as 10 per cent of the original, there may well be sufficient left to provide the necessary link in the spread of diseases such as rinderpest and trypanosomiasis, from one herd of cattle to another and in the case of some diseases, from one human group to another. This implies that the control of undesirable wild fauna should generally be undertaken by trained men under the control of game departments.

The rest of this paper is devoted to comments on the sub-headings of the section of the agenda on the administration of game resources.

POPULATION APPRAISAL

Whereas in some national parks or particular areas under close observation it may be possible to estimate game population with some degree of accuracy, it cannot be said that this is as yet possible in most parts of the world, particularly perhaps in Africa. Again there are exceptions, in the case of particular species to which special study has been devoted on account of their rareness or local distribution. Such a case is the White Rhinoceros, restricted to a few small areas of Africa of which the West Nile district of Uganda is one. The species was in danger of extermination and a close estimate of the surviving population, almost to a count of individuals, was made some years ago at the time when the species was completely protected. A recent estimate indicates that the population has increased very considerably. Another example of a different kind, also from Uganda, relates to the elephant population: the game warden has arrived at an estimate of the total number of elephants and of their rate of reproduction, and the number of elephants killed annually in control operations is related approximately to the estimated annual increase. For most species of animals, however, game administration is not yet sufficient to provide estimates of numbers, nor have the methods for population appraisal as applicable to African conditions yet been established.

It must be emphasized that the appraisal of the population of any particular species at any one time is of very little value by itself. It is more important to have some idea of the fluctuations of populations, which are often large, and of the balance of populations between one species and another. An example of this, illustrating the relation between predator and prey, may also be taken from Eastern Africa. The leopard has in the past been subject to considerable persecution on account of the high value of its skin, and in consequence two species of vermin which constitute an important part of the leopard's food, the baboon and the bush pig, have increased so alarmingly as to require heavy measures of control in agricultural areas. Consequently in a number of territories the leopard is now on the list of species which are completely or nearly completely protected, and it is hoped thereby that a system of biological control of baboon and bush-pig may readjust itself.

SYSTEMS OF ADMINISTRATIVE REGULATION

I suppose that practically all countries have a game ordinance providing a legal basis for game administration, but the methods by which such ordinances are administered vary greatly. Again, my examples come from Africa. The territories of British East Africa (Kenya, Tanganyika and Uganda) have each had a separate game department operating for many years. Though small in size, and sometimes criticized in periods of financial stringency as luxury departments, they have performed a most important function in the steadily evolving process of colonial development. In future they are likely to have to perform even more than they have done in the past, especially perhaps in connexion with game control. With the constitution of national parks it has become usual to hand over the administration of such areas to special boards of trustees, independent of the game departments.

Further south, Northern Rhodesia administers its game by a department which is responsible also for fisheries and tsetse-fly control, a combination which has advantages in that the activities in regard to game are brought more directly into line with other branches of progress. The same system, though on smaller scale, applies in Nyasaland.

Southern Rhodesia has a small game department, and in the Union of South Africa prominence attaches to the National Park Administration.

The British West African colonies, with larger human populations, have less room for game. There are no special departments devoted to game, but game ordinances are administered by other departments of government.

The Belgian Congo provides an important example in game administration. The extensive National Parks have an independent organization which not only provides for administration but also for scientific research and already an impressive series of scientific publications on the national parks has appeared. In addition there is a separate game administration for the rest of the country operating as part of the large government agricultural department.

VALUES OF PROTECTED AREAS; COSTS AND ECONOMIC VALUES; NATIONAL BENEFITS

The values of protected areas are generally difficult or impossible to assess in terms of money, because they depend to a large extent on educational, aesthetic and scientific values, as well as obscured economic values from tourist traffic, and direct returns from entrance fees and the like. It is understood that in certain cases, such as the national parks in America and the Kruger Park in the Union of South Africa, protected areas pay for themselves handsomely. Such is not yet the case with the national parks of inter-tropical Africa, though it may become so in course of time. But so far as is known, in no case are the economic returns from national parks or other protected areas commensurate with the economic returns which might be obtained if the same land were put to other uses, such as agriculture or forestry. The case for extensive national parks and protected game areas therefore depends in large measure on the educational, aesthetic and scientific values, which in Africa at least are not yet appreciated by the very great majority of the indigenous human population.

INTERNATIONAL AND INTER-TERRITORIAL PROBLEMS

The International Conventions of 1933 and 1937 concerning the protection of the fauna and flora of Africa provided an important stimulus to modern conceptions of game conservation. In certain cases where the most appropriate areas for national parks or reserves happen to lie along international frontiers, as for example, between Uganda and the Belgian Congo, suitable arrangements have been made on a local basis. The control aspect of game administration likewise involves a number of important international problems. For example, the possible spread of rinderpest through the agency of wild fauna presents a risk to the countries of Southern Africa and to the Belgian Congo, a risk which has not yet been overcome.

In British East and Central Africa a system of inter-territorial consultation on matters of game and fauna administration has recently been instituted by the East Africa High Commission and the Central African Council. A first conference of game wardens and other authorities concerned, from Kenya, Tanganyika, Uganda, Northern Rhodesia, Nyasaland, Southern Rhodesia, the Anglo-Egyptian Sudan and the Union of South Africa took place in May 1947 at Nairobi. The resulting report (East Africa High Commission Paper No. 1 printed in Nairobi 1948) provides a quantity of comparative data for nearly all the British administered territories in Africa. This first conference was followed by an informal conference between heads of game departments of East and Central Africa held in May 1948 at Lusaka, and it is expected that similar conferences will be held in the future at approximately annual intervals.

In addition, several of the international African technical conferences held in the last year or so have devoted special attention to certain aspects of game administration. This was the case particularly with the International Conference on Tsetse and Trypanosomiasis held early in 1948 at Brazzaville, and the African Rinderpest Conference held in October 1948 at Nairobi. Thus, for Africa at least, there is now in being a system for international and inter-territorial consultation among those authorities who have greatest knowledge of and are most concerned in the administration of game resources.

The several national and international societies and associations concerned with the preservation of nature have likewise done much work, especially in bringing before the public the pressing needs of conservation. The various recommendations made by such societies have not always been accepted readily by Governments and other authorities responsible for action in these matters, partly because the societies have concentrated on conservation and have generally excluded control from their purview. The balanced view is however gaining weight, and as an admirable example, reference may be made to a recent publication by the Society for the Preservation of the Fauna of the Empire (Captain K. Caldwell, "Report on a Faunal Survey in Eastern and Central Africa", January—April 1947).

PUBLIC RELATIONS AND EDUCATION IN CONSERVATION

In the highly developed countries such as Great Britain or the United States, perhaps it could be claimed that the problems involved in this heading are to some extent overcome. The existence of the famous national parks of America and the recent Act of the British Parliament to establish national parks in Great Britain are sufficient evidence of this. In the less-developed countries such as Africa it cannot be said that public relations and education in conservation have yet made much progress, except in the case of the white immigrant populations which comprise but a very small proportion of the whole. Indeed, there appears to be great need for public relations work in this subject, but it is suggested that public relations and education in game conservation will not be a success in Africa unless a balanced picture is presented with due weight given to control as well as to conservation.

Game Control in Kenya Colony

A. T. A. RITCHIE, O.B.E.

Game preservation has recently been accorded its fair share of interest and attention, and this in spite of man's urgent preoccupation with desperate problems of his own survival and sustenance. It may be that the care of "the beasts of the field" has provided some degree of escapism; or perhaps the insecurity of life has made him more sympathetic towards his lesser brethren. It may even be that the obligation of the present to preserve for posterity things of interest and beauty has become more fully recognized and acknowledged.

Be that as it may, it is the fortunate fact that game preservation has been written about and discussed in the Press, and in conferences and conventions, to an extent that provides a striking contrast to the indifference of a decade or two ago. Game laws have been revised and made more drastic, national parks and sanctuaries have been established far and wide wherein wildlife can remain safe for all time; and men of good will everywhere have interested themselves in the policy and practice of game preservation.

While there is thus a reasonable general knowledge of the world's fauna and what direct steps the world is taking to retain it, there is only the most confused idea of the nature of the various complementary activities, repressive and often destructive, that must accompany preservation to make such retention possible. It will be the object of this paper to put forward—alas, it can only be in briefest outline!—some account of what these activities are, and why they are necessary.

"Game control" in this paper has a clear-cut meaning: it is the sum total of measures that must be taken to prevent any animal which we desire to preserve from coming into serious conflict with man and his legitimate activities. Thus, while game preservation means in effect the shielding of game from man and his instinct to kill, game control means the shielding of man from the depredations of game; and the work of a Game Department—in Africa at least—must comprise in equal degree these two activities. The reason for this dual role is not far to seek. Wildlife can enjoy effective protection only with the good will and co-operation of the human community with which it coexists; and it will not keep good will, nor expect even tolerance, if the loss and damage it occasions is severe. Masochism is as dead as the Dodo, and idealistic altruism is fast following it into the limbo.

During the last twenty-five years, game control has been required in Kenya Colony to perhaps a greater extent, and certainly in more varied forms, than anywhere in the world. For during that time, vast areas of upland country lying between 5,000 and 10,000 ft. above sea-level hitherto populated only by countless herds of plains game and a handful of pastoral nomads, have been taken up by immigrant settlers and subjected to more or less intensive farming, with crops, or stock, or both. Other very considerable areas of land not previously used, much of it at lower altitudes, have been opened up and developed by native enterprise inspired and assisted by an administration always anxious to improve the economic status of its people. The Colony has thus undergone, in many parts of it, a complete metamorphosis in the last quarter of a century; and a vast natural zoo has given place to a populous countryside busy with man's bucolic preoccupations.

Now it is obvious that the change-over from the rule of nature—and nature in very positive and possessive form—to the rule of man cannot, in so short a time, take place without most serious and persistent clashes; and the fact that zones of human activity alternate with areas that remain, and in all probability always will remain, undeveloped, make it unhappily certain that there will long be "frontier incidents", if no worse.

The conflict between man and the indigenous fauna is of two main types. The first results from the actual material damage done by animals to human person or property; the second is caused by the ever-present threat of what may be called biological danger from the indigenous fauna acting as reservoirs and foci of diseases and epidemics. This latter class of trouble becomes more evident in a reasonably mature agricultural economy; the former, which makes insistent demands for active intervention during periods of rapid extension of development, is the one that we have naturally been chiefly concerned with during the period under review.

It is not easy to summarize the faunal problems that, in Kenya, beset the incursion of human activity into virgin country, since they are so very diverse, but they may for convenience be grouped under two major headings:

1. The disposal of displaced animals; and,
2. The troubles arising from the upset of the balance of nature.

DISPOSAL OF DISPLACED ANIMALS

The problem of displaced animals is most serious with regard to the animals of the open plains, since it is there that the numbers involved are greatest. Further, all or almost all of the plain-dwellers—zebra and the various antelopes, wildebeest, hartebeest, oryx, eland, Grant and Thomson gazelle—are nomadic or semi-nomadic and move in great waves to follow rain and grazing. Thus a farm which has been cleared of game today by the efforts of an energetic settler, may be invaded a few days hence by herds and herds of beasts which know, or care, nothing of his jealous claim to ownership, or of his prowess with rifle.

And the damage that vast herds can do to a newly-established farm is of course appalling; if there are crops they are eaten and trampled; young grass is grazed to the earth; water-holes are drunk dry or puddled into mud; fences, if put up, are broken night after night, for the animals of the plains are prone to stampede at night—often with good reason, be it said—and a fence has no chance of remaining intact, or indeed of remaining at all, unless it has screening, a ditch or parapet or other obstacle, to check the momentum of a terrified mob.

It is worthy of note that, while the game of the plains will move of its own volition, no amount of persecution, by shooting alone, will expel it from an area. Shooting merely drives animals a few hundred yards at a time, and they return again in a few hours at most. To induce them to move out we have found only one effective measure: one must combine persistent harrying from motor vehicles with shooting.

Many of the bush-dwellers also prove difficult to deal with when their habitat is invaded, but for the most part the problems they present are due rather to their psychological idiosyncrasies than to their numbers. Thus, the intransigent nature of the rhinoceros which utterly rejects the possibility of a compromise with mankind, the conservatism of the elephant, the refusal of the giraffe to recognize danger, the "j'y suis, j'y reste" attitude of certain antelopes, particularly waterbuck, bushbuck, duiker and impala, the buffalo's midnight maraudings and his daylight retreat to the most impenetrable thickets when he is molested, these are some of the characteristics that complicate our problems.

Unfortunately, for it is an enthralling study, time forbids here any description of how we have to deal with these beasts of the bush, but I can give a few clues. Rhino cannot be moved, and if an area inhabited by them is required for human occupation the animals must be killed. A few years ago, when some 30 square miles of bush country had to be cleared for the use of a native tribe, we had to shoot 163 rhino. Elephants, provided we do not try to cut their migrational circuit, will learn where they cannot go; but it takes a long time, and the lethal lesson must be repeated *ad nauseam*. Giraffe, unfortunately, are not amenable to any discipline, and it is a terrible thing to see the inevitable end of a fence-breaking herd: one is shot, and the other eleven stand and look at it; two are shot and the other ten stand and look at them; eleven are shot, ... and the survivor still stands with a perplexed and questioning gaze. There surely, if you are an animal lover, you have fitting material for a Grand Guignol nightmare! Buffalo, a pest when they remain in enclaves in the centre of settled areas, can up to a point be hunted successfully in their dense fastnesses with the aid of dogs. I say "up to a point", for after a time they refuse to stand to dogs, and all that one sees of them is a glimpse of black receding rump, or a pair of horns a bare rifle-length from one's chest. They are a difficult and dangerous quarry.

As I have already said, the main object of game control is to provide a buffer between the indigenous fauna and the legitimate activities of man; but there is one consideration that must temper all our efforts: it is, that not more animals shall be killed than is absolutely necessary to achieve our purpose. The wildlife of Africa is decreasing, alas, at a rate that must shock every lover of nature. It is sometimes the case that the circumscribed habitat of an animal makes it necessary for the natural increase to be destroyed at regular intervals in order to prevent overcrowding and its attendant troubles. But, except in such conditions, and when poisoning vermin, we must count every beast saved on the credit side and every beast killed on the debit.

Where the element of haste is absent, the wastage of life will normally be less. Ecological methods of control can often then be adopted, such as the provision of alternative areas, and the betterment of these areas by grass-burning or clearing or other means, the provision of water where none exists and the gradual inducement by "peaceful persuasion", if one can so describe bloodless harrying, to move away from contested zones. Unfortunately, the very rapid development which has been the lot of Kenya has granted few possibilities for such forbearance, and the most drastic measures have been called for, and have perforce at times been adopted.

TROUBLES ARISING FROM THE UPSET OF THE BALANCE OF NATURE THROUGH MAN'S ACTIVITIES

It would be platitudinous to speak of the delicate equilibrium that nature has achieved through her countless aeons of trial and error, of adaption and improvization, of survival and extinction. Suffice it to say that when new factors and impulses impinge on a balanced ecological entity, violent reactions ensue, the ultimate repercussions of which none can with certainty foretell.

As is inevitable in these circumstances, a number of complications very directly and obviously attributable to such interference are now present in Kenya: it must suffice to mention the two most outstanding and troublesome, one the result of the killing off of leopards, and the other partly caused by the disappearance of lions from settled areas.

With regard to the former, the facts are as follows: some fifteen years ago fashion decreed that leopard-skin coats should be worn by really smart women. The vogue originated, I believe, in the United States and quickly spread to Europe. Leopard skins in Nairobi promptly jumped from 20 or 30 shillings to £15 or £20. This tremendous stimulus to trapping had disastrous results on the leopard population. Leopards were not then protected under the Game Ordinance, and the Government was for some time reluctant to make them game animals, believing that to do so would invite countless claims for compensation from those who had—or who would say they had!—lost sheep and goats from their depredations. By the time it was agreed that leopards should be protected, the damage was done; for they are a very easy animal to trap, and in some parts of the Colony they had been almost exterminated. The result was tragic. Baboon and bush-pig, two of the most destructive animals in the world, have increased to an extent that constitutes them a devastating curse to the husbandman, and a greater source of loss probably than all other faunal marauders combined. Baboon are very difficult to destroy, at least after the first attempt against them has "educated" them, and bush-pig are even more so. I speak with feeling, since on my Game Control Officers falls the unpleasant duty of organizing the poisoning campaigns by which alone we can combat these and certain other vermin. We are paying dearly indeed for not protecting the one and only natural enemy of these two pests; and it will be several generations before the rigid protection of leopard on the one hand, and all-out warfare against baboon and bush-pig on the other, redress the balance: "the sins of the fathers . . . ."

The other bitter trouble which I must mention is with regard to hyaena and here we cannot be held guilty of stupidity or negligence. This, in brief, is what happened. When great areas of plain country were taken up for cattle ranches, the first thing the settlers did was to hunt and kill off the lions. Now the hyaena is by nature partly a scavenger

—he plays the role of Lazarus to the lion's Dives—and partly a hunter, a rather dirty hunter perhaps, being very partial to the newly-born and to mothers when calving. The killing off of lions and the decrease of game in settled areas, taking place simultaneously, deprived him there of his normal sources of food supply, with the result that he has become an intrepid and almost unbelievably cunning marauder, and attacks full-grown cattle, making invariably for the udder and other soft underparts. He kills freely but mauls—hideously—many more than he kills. He appears to have as good an eye for a beast as any judge in the show ring, and invariably picks the best; he is usually too clever to return to his kill; he very soon knows all about strychnine when a campaign is under way; and altogether he is an appallingly difficult—and expensive—customer. It will, I fear, take years to exterminate him from these scenes of his misbehaviour.

So much for Game Control. It has a hundred aspects and a thousand facets; and on its successful prosecution depends the hope of survival of much of the larger indigenous fauna of Africa.

To conclude, here are a few points I wish to stress:

1. Game preservation, in such conditions as obtain in Kenya, must involve game control, which indeed should properly be regarded as an integral part of game preservation.

2. Game control needs exact knowledge and experience, and cannot, without courting possible failure of purpose and the certainty of unnecessary waste of life, be left to casual effort. It should be organized by the authority which directs the work of preservation, and should include pest-destruction, pest here meaning vertebrate vermin.

3. Game control, where necessary, must be undertaken ruthlessly and with courage, disregarding—I speak from bitter experience—the taunts and curses of many enthusiastic but uninstructed nature-lovers.

4. Those concerned with the care of indigenous fauna must be perpetually watchful for the possible repercussions that may be caused by the upsetting of the balance of nature, and must try to devise and apply remedial measures in anticipation.

5. The poisons today available for vermin destruction (arsenite of soda for vegetarian animals, and strychnine for carnivorous animals), are both loathsome substances in view of the agony that precedes death. The necessity for the use of poison is unfortunately very great. Requests have been made that certain scientists, and vast industrial concerns, in a position to do so, should experiment with a view to discovering an effective, painless, mammal poison. I should like to close by repeating that request—indeed, I would make it a prayer!

The "Controlled Area" System in Relation to Game Management on Rangelands in Northern Rhodesia

T. G. C. VAUGHAN-JONES

ABSTRACT

In Northern Rhodesia an attempt is made with the "Controlled Area" system to compromise between the clashing interests of wildlife and livestock on rangeland. The territory carries a rich fauna typical of Central Africa. Wildlife conservation is patterned on the assumption that, with the hoped-for conquest of tsetse, most of the still empty rangeland could be used for livestock.

The system presupposes the potentially permanent economic value of wildlife. In a "Controlled Area", demarcated according to the land's ecological suitability, selected desirable species may be specially protected, persons not resident may be prohibited from hunting except under permit ; and general protective regulations may be applied as necessary. A typical "Controlled Area" is described.

Reduction of buffalo eased the incidence of trypanosomiasis, but "control" in this sense may mean virtual extermination and should be carried out under strict and competent technical direction.

The appeal in the "Controlled Area System" is to the local people : incentives given are pride of possession in their fauna, gain from licence and permit fees. With balanced conservation, under suitable conditions, a "Controlled Area" should pay for itself.

At present the main issue rests between wildlife and livestock ; but compromise on a scientific basis may still be possible.

The writer's experience lies in the organization of wildlife management and preservation in the Central African territory of Northern Rhodesia. This paper will deal with one aspect of that work which represents a conscious attempt to meet the difficulties inherent in the conservation of game, particularly the larger and more vulnerable species, on rangelands which are at the same time open to the normal activities of economic rural development. Though, for reasons which will appear later, relatively little of the total area of the territory is yet used for livestock range, the pattern of wildlife conservation is built on the assumption that all land not otherwise classified, whether for agriculture, forests or unequivocal game preservation, must in the course of time be so used.

The territory's wildlife comprises most of the larger animals for which central Africa is famous: elephant and buffalo, lion and leopard, hyaena and jackal, zebra, and antelope of numerous species from the lordly eland to the tiny blue buck. This rich fauna, backed by the tsetse flies (chiefly *Glossina morsitans*) which collectively always carry trypanosomes lethal to stock, and in some areas also those fatal to man, fights back in various ways against man's intrusion, but cannot hold out for long against increasing populations and modern weapons. To preserve it for its valuable features entails active conservation measures; but the inherent clash with mankind and his rural activities renders quite impracticable its preservation at large and without regard to locality.

Cattle populations are as yet localized and, in total, average no more than one beast to every 100 acres of tsetse-free land, which itself is less than half the total potential range area of the territory. It is thus easy to assume now that these livestock areas must be freed of virtually all game, and the game itself eventually segregated in confined areas classed as National Parks or Reserves. From the livestock aspect alone there are good reasons for such a thesis: the stock cannot afford the competition for grazing and (in rare cases) water, or the risk of diseases—trypanosomiasis, helminthiasis, rinderpest, foot-and-mouth and others—in which game may be implicated as a carrier. But it is arguable whether, in the light of further scientific knowledge and experience of practical game management, it should in the end be necessary to destroy so much of the territory's natural heritage of fauna; perhaps some compromise could be reached.

The "Controlled Area" system is an attempt to pave the way for such a compromise. It is essentially a fluid system, because it must meet all contingencies arising from the endless combination of the three dominant factors: the needs of man, the needs of wildlife, and the ecological features of any given area which determine its capacity to sustain life. The system aims at providing a category intermediate between fully developed lands and wildlife sanctuaries, acknowledging that, certainly for the present and perhaps for always, wildlife has a useful part to play in the economy of the land. Though important furbearers, such as the leopard and otter, are scarce, game generally provides meat and hide to the people in tsetse areas which carry no livestock, and sport or other pleasure to all.

How does the system work? Take a typical tribal area in Northern Rhodesia, the Kaonde-Ila of the Mumbwa District. The pattern of local government is simple: the District Commissioner as combined administrator and magistrate guides and instructs the tribal "Native Authority", i.e., the council of Chiefs, towards self-government based on the pattern of the old Chiefs' authority adapted to modern conceptions. The population averages three to the square mile, spread about in groups of smallish wattle-and-daub villages each under the control of a headman. Some keep cattle, some do not, and some cannot because of tsetse fly; but all are hunters by tradition. Of the District's total area of some 8,000 square miles, roughly a third has, as a Game Reserve, been closed to habitation.

The District's broad ecological pattern is relatively simple. To the south and east lies the cattle country comprising the wide flood-plains or "flats" of the Kafue River with their margins; then a belt where primitive agricultural clearings have been made in the "tsetse-bush" and where contact between the fly and cattle chiefly occurs; finally to the north and west the tsetse-infested wilds typical of the Kafue Game Reserve. The region as a whole presents a typical and quite complete set of the territory's problems in wildlife management. Amongst the cattle used to roam great herds of buffalo, lechwe and other game, competing for the grazing during the dry season and bringing tsetse to the margin of the flats in their passage to and from the "fly-bush". In the hinterland sleeping-sickness had made its appearance where the people came in contact with the tsetse at high density in the big-game habitats. But those same people relied on that game for their hunting and their meat; even those who had stock, traditionally kept it as a form of wealth and prestige rather than for meat; and by common consent of responsible opinion the fauna of the area was held to be a magnificent asset.

At first the district was open to all. It was annually invaded by sportsmen and hunters from the European farming area to the east; the game slaughtered was sometimes carried away in lorry loads or, at worst, left to rot in the bush. The native Africans objected strongly to this, not for sake of any feeling against slaughter as such, but in resentment at the white man's intrusion and greed at their expense. The sporadic slaughter did nothing to drive off game and tsetse permanently: it merely scattered both, probably increasing contact between the fly and native cattle and so worsening the incidence of trypanosomiasis. At any rate a decline in stock numbers set in, and it was estimated in 1945 that, through this disease, the number of cattle in the area had been reduced by more than half over the previous fifteen years.

Setting aside the Game Reserve area, the problems to be tackled might be summarized thus:

(*a*) The breaking of contact between the stock and the game-fly complex;

(*b*) The conservation of the game primarily for the sake of the native population and on the general principle of preserving a valuable asset;

(*c*) The control of hunting by persons not resident in the area, to the advantage of the local authority and its people.

As a comprehensive step towards solving these problems the District was declared a "Controlled Area".

In law the "Controlled Area" :

(*a*) Provided for the specific protection of any animal needing protection in the area;

(*b*) Provided that no one not resident within the area should be allowed to hunt therein without special permission from the appropriate authority; such permission might be conditioned in any manner thought desirable, and be contingent on the payment of a fee;

(*c*) Provided that any or all of the provisions of the law relating to Game Reserves might be applied to the area or to any part of it for a specified time.

Administratively, the geographical definition given to the area enabled a small conservation staff to concentrate its work to best advantage, a point of importance in a territory where effort can so easily be dissipated in the vastness of undeveloped lands.

The breaking of contact between stock and the game-tsetse complex involved chiefly the reduction in numbers of buffalo. As a start, in 1943 and 1944, a scheme had been undertaken by a skilled European hunter with a staff of six African hunters and the necessary labour force: in those two years over 700 buffaloes were killed, their meat and hides saved and sold at reasonable prices. The scheme was economic: on the basis of a price of 6d. per lb., for the dried meat at a centre some 120 miles distant, a small profit was made each year, but for climatic reasons the work had to be confined to a limited five months' season, and would not have been profitable as full-time employment.

At the close the big buffalo herds had been broken up and the remnants were difficult to hunt. The tsetse had diminished, and the operation had been simple enough, but the experience underlined the need to undertake such work with skill and under close control. This could not have been achieved by individual free-lance hunters, who usually cease to find the work paying or interesting long before it is advanced enough to produce results from the point of view of scientific control. To achieve the removal of game from a given area, it must be attacked consistently and efficiently in and near that area over a considerable period. There is no rule as to the amount of time or effort required, much depending on the habits of the species, on the attractiveness of the area to it, and on the practicability of its moving elsewhere. To talk of "driving game away" in relation to large areas of land in Central Africa is a wishful euphemism; the fact is that if the game needs that land it will continue to return to it until it has been exterminated.

Further work, fencing off the cattle zone, clearing of bush and continued game control, is required to consolidate the initial success against the tsetse, but with the aid of trypanocidal drugs such as the new "antrycide", to protect stock near the "fly-front", there is every hope that the trypanosomiasis problem will be solved. The solution of one problem usually uncovers another: competition for grazing and incidence of game-carried diseases, helminths and so forth, will next be to the fore. From a constructive view, the issue resolves itself into a search for compromise between the essential needs of livestock and wildlife respectively, not necessarily the whole original fauna, but a selection of species made with due regard to habits and adaptability to the new regime. In practice most European ranchers regard the antelopes on their ranges as an asset well worth the sacrifice of some grazing and the vague risk of diseases which may in any event persist in stock alone; but the destructive or dangerous elephant, buffalo, lion and the like are seldom welcome.

In the Mumbwa area, as everywhere, the ultimate future of wildlife will depend upon its appreciation by the people who live there. Nothing which is amenable to human control can survive for long unless it commands the people's emotional respect, or appeals to the personal pride or cupidity of those who maintain it. Unfortunately abstract respect for wildlife is unknown to most African natives; the "Controlled Area System", therefore, aims at providing two other incentives. First, pride of possession, because a man is more likely to look after that which is his own, for which he is responsible, than that over which he has no control. Secondly, monetary gain from game licences generally and from hunting permits issued to visitors, because once the local governing authority has handled additional revenue won through wildlife conservation, it is more likely to promote the activities and enforce the laws involved. There are signs, from Mumbwa and elsewhere, that these incentives will work, but the process will inevitably be slow.

The "Controlled Area System" is still too new to enable an accurate balance sheet to be drawn up for it. Each area should ideally operate under its own control, and with balanced conservation pay for itself from licences and fees. Theoretically if, notwithstanding expert guidance, it cannot support itself, something must be wrong, either the land, or the people on it, or both; but the desirable equation is obvious. Other aspects of wildlife, recreation, indirect revenues, aesthetic values and so on, should all follow on the credit side once the correct balance has been found.

For the rest, it is plain that under local conditions recreation must take its cue from economic necessity; it must accord with what that necessity allows. There can thus be no clash between it and the system outlined. Problems of watershed protection have scarcely arisen yet, and in any event are most logically catered for under Natural Resources or Forestry legislation. Where a watershed protection area can be co-ordinated with a game reserve a double advantage accrues, but the ecological issues are too complex to enable it to be said that every watershed should be a game reserve. From the conservationist's point of view, the main issue on Northern Rhodesia's range lands rests between wildlife and livestock; but the pattern of rural development is still in the making and it is too early yet to be definite as to the final outcome.

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Scientific Work of the National Parks Institute of the Belgian Congo[1]

V. VAN STRAELEN

The essential work of the Institute of National Parks is directed towards the protection, on purely scientific lines, of nature in all its forms.

The rapid advance of civilization towards the virgin areas of Central Africa made it essential to safeguard some parts of that unique nature, threatened in its remotest fastnesses by the brutal methods employed by the white man in his conquests.

The conception and execution of the idea of creating absolute natural reserves mainly devoted to the study of nature removed from all human influences was due to the liberal and enlightened mind of King Albert.

[1]Original text : French

Protective measures were called for first of all on the ridges and slopes of the tectonic faults of the great African *graben*, especially on the Virunga volcanos, where excessive deforestation would have resulted in formidable erosion. Owing to their altitude these regions enjoy a climate which would inevitably have encouraged European occupation and thus the recession of the natural environment. These were the principal reasons for the creation of the Albert National Park, but its establishment was also hastened by the need for saving from extermination the last families of gorillas which had sought refuge on the extinct volcanos of Mikeno, Karisimbi and Visoke. This Park, which was originally a reserve of 25,000 hectares, has covered since 1935 an area of 809,000 hectares. From south to north it includes, over a distance of 300 kilometres, the range of active and extinct volcanos, the great game plain of the Rwindi and Rutshuru rivers, the Belgian waters of Lake Edward, the valley of the Upper and Middle Semliki and the slopes, under Belgian administration, of the mighty Ruwenzori massif, whose snow-caps rise to 5,119 metres.

The following were established in succession: the Kagera National Park, situated north-east of the mandated Territory of Ruanda-Urundi; the Garamba National Park on the Congo-Nile ridge; and the Upemba National Park in the heart of the Katanga. The Belgian Congo National Parks cover a total area cf 27,250 square kilometres.

Despite the already large reserved areas under its management, the Institute cannot confine itself to its present scope. Only one per cent of the Belgian Congo territory is subject to the regulations governing strictly-controlled natural absolute reserves. However, the creation of other parks, particularly in the form of re-stocking reserves, for the protection of natural environments which it is essential to preserve is being considered.

CONDITIONS UNDER WHICH THE NATIONAL PARKS WERE CREATED

The establishment of each of the existing parks was conditioned by the urgent need for the preservation of gravely threatened areas, the orography of the region, the wealth of its fauna and flora, and its population density. In order to fulfil the proposed purpose—that is, the elimination of the human factor—it was essential that the reserved areas should be uninhabited or sparsely populated so as to minimize their encroachment on native customary laws. This was one of the greatest obstacles which the Institute had to overcome, and the solutions found for it are still not entirely satisfactory. From the date of their creation the management of the National Parks was an awkward and complicated task which too often encountered lack of understanding of the importance of its aims.

In some instances, as in the Albert National Park, the beauty of the protected places was so great that mankind could not be deprived of such sources of emotion, delight and splendour. Accordingly it was decided to admit visitors to certain strictly-limited parts, although this concession was inconsistent with the objective execution of the Institute's plan.

To ensure strict protection it is essential to avoid any interference in the free play of the organic forces. The introduction of elements foreign to the native fauna and flora may have repercussions whose consequences cannot be foreseen.

The formula adopted for the Belgian Congo National Parks therefore combines the definitions of "National Parks" and "absolute natural reserves" laid down at the International Conference for the Protection of African Fauna and Flora held in London in 1933.

The first and most urgent step was to keep intact the territory, hydrography, fauna, flora and geography of the lands placed under the management of the Institute. This programme looked as though it would occupy the Institute for several years to the exclusion of all other activities. It did not do so, however, because the foundations of the Institute's constitution in its present form had scarcely been laid when the scientific programme was embarked upon. Since that time this programme has been interrupted only by six years of war conditions. The work was actively resumed when the economic situation improved and regular communications were re-established, and the Institute distinguished itself by sending one of the most important missions ever to work in Africa.

THE INSTITUTE'S TWO TYPES OF ACTIVITY

(a) *Methodical investigation on the site*

The scientific programme of the National Parks Institute of the Belgian Congo provides for two types of activity. However, although it has made a determined start on its programme, the Institute cannot for the time being embark upon the whole of its projects, as its initiative is restricted by human and material limitations. The permanence and continuity of observations requires the presence on the site of experienced observers whose observations, continued over long periods, will reveal the determining factors in the maintenance of the biological equilibrium, of which little is yet known. In future this work will be entrusted to scientific conservators, real field naturalists, who will study continuously those problems which alone will elucidate methodical and continuous observations of those associations. The field of investigation here is vast and—apart from study of the rhythm and nature of variations in associations—observations of climatic influence, persistency of migration, animal psychology, processes of plant restoration, synecological influence of bush fires, volcanology, seismology and many other problems of general or particular scientific interest make the Belgian Congo National Parks a vast undertaking in experimental ecology. In this spirit, and despite their very burdensome functions as organizers and supervisors, the members of the Institute's staff in Africa are already taking part in this section of the programme by means of the environmental observations which they collect during visits to the reserves. All the observations gathered are analysed, classified and transmitted to the scientists concerned with a view to publication. The conservators sometimes go deeply into a subject and prepare reports on their observations. Thus in 1939 the Institute published a report on the morphology of the Nyamuragira volcano by Colonel R. Hoier, Conservator of the Albert National Park; and in 1947 a paper by Major E. Hubert, Deputy Conservator of the Albert National Park, on the growth of the fauna of the large mammals in the Rwindi-Rutshuru plain since its total protection.

Similarly, it is proposed to establish laboratories which will not only provide the permanent observation staff with the essential means of research but will also enable scientists who are passing through the Congo, or who have gone there expressly for research purposes, to study their special subjects on the spot. Thus a first laboratory was set up in 1939 on the summit of the Nyamuragira volcano in order to observe its activity in all its phases.

(b) *Inventory of the fauna and flora of the reserves*

In 1933 a start was made on the second part of the Institute's programme of scientific activity. The essential and basic studies are to lead to the preparation of an inventory of the fauna and flora of the reserved areas. For this purpose naturalists are sent to the sites on temporary missions and with a definite object. They systematically explore a specific area within the scope of their own branch of science.

The age of fragmentary sampling must be resolutely left behind if progress is to be made towards knowledge of biotic concepts and ecology. Hence, the missions' programme includes the compilation of large collections of specimens of the various zoological and botanical categories. These missions, which consist of one or more members, have already obtained results far exceeding previous contributions to learning, which were generally made as circumstances and opportunities permitted. The importance of the specimens they gathered and the observations they made show how little progress had previously been made in the scientific exploration of Central Africa. The specimens collected by the missions are either placed in preservative media, prepared by native taxidermists, or merely packed, according to their classification, and then sent to Belgium. The Royal Belgian Institute of Natural Sciences is responsible for the reception and preservation of these specimens. The insects, several million of which have already been collected, are prepared, mounted and labelled (with the place and date of capture) by a team of specialized assistants paid by the Natural Parks Institute of the Belgian Congo. When the various categories have been classified, specialists in all parts of the world are invited to co-operate in studying them.

Although at first the specialists were sometimes discouraged by the unusual size of the series submitted for their inspection, they were soon unanimous in declaring that the provision of so large a volume of material enabled and indeed compelled them to revise, often from an entirely new standpoint, the very bases of their knowledge of the group in which they had specialized.

The findings and conclusions of these scientists are subsequently published by the National Parks Institute of the Belgian Congo in its scientific record "Exploration of the Belgian Congo National Parks". The collections studied are divided between the national scientific institutions responsible for the preservation of the types and the scientist carrying out the study. The latter is provided with the co-types which he wishes to retain for purposes of comparison in his subsequent work.

There will thus be a grouping of data which will provide a picture of life in each national park at a given time. In this way it will be possible to analyse a biological spectrum whose gradual variations, caused by the constant oscillations in the equilibrium of the fauna and the flora, will slowly appear during centuries of observation. This aspect of the Institute's work will be particularly favourable to the progress of certain branches of science which are of prime importance.

The qualitative aspect is today the essence of biology. But it is becoming more and more necessary to supplement it by quantitative observations which will no doubt one day become predominant. The greater or lesser, and more or less constant, abundance of the species, their interrelations and interferences, their relations with the microclimates and macroclimates, and all occurrences in which the time factor is predominant, are phenomena whose expression requires the use of figures.

In the end these studies will only be possible in the natural reserves, for if they are based on observations made in biotopes upset by human influences, their results are vitiated by systematic errors. Some parts of these researches will be an important factor in nature protection, which is a branch of applied biology. Fluctuation in the density of animal and plant populations is a phenomenon whose determining factors are little or poorly known. Any decrease in the number of large mammals in the natural reserves, a decrease which is very easily noted by chance observers, causes concern. Many of these oscillations are undoubtedly part of the normal cycles and have no harmful effect on the biological community if it covers a sufficient area.

THE EXPLORATORY MISSIONS

The first exploratory mission sent to Africa by the National Park Institute of the Belgian Congo was the one directed by Mr. G. F. de Witte, a naturalist with great experience in the collection of zoological data in warm countries, who was then Deputy Conservator of the Belgian Congo Museum at Tervuren and is now Conservator of the Recent Vertebrates Section of the Royal Belgian Institute of Natural Sciences and Head of the Scientific Section of the National Parks Institute of the Belgian Congo. From 1933 to 1935 Mr. de Witte was responsible for the exploration of the southern sectors of the Albert National Park, mainly from the herpetological point of view; however, he simultaneously extended his researches to other zoological groups and to the flora. Working with a method and care which probably had no previous equal, he made remarkable collections of annelida, batrachia, reptiles, insects, fish, mammals, birds and plants; and as a result scientific knowledge of the areas between Lakes Edward and Kivu is greater than that of any other area of Africa. Nearly one million insects were collected, and their preparation required ten years' work. The collections of batrachia and reptiles numbered 28,900 and 3,800 specimens respectively, the collection of arachnids some 80,000. These figures are quoted merely to show the importance and scale of the studies undertaken in this way by the Institute and the amount of work required to carry them out. The scientific results of this mission have been reported in sixty-five papers and the research material is still far from exhausted.

In 1935 and 1936 Mr. H. Damas, professor at the University of Liège, was engaged on a hydrobiological mission during which he paid particular attention to determining the living conditions of the microfauna of Lakes Edward and Kivu. During that mission he compiled a depth chart of Lake Kivu and also made several zoological collections.

In 1936, Dr. L. Van den Bergh, professor at the Prince Leopold Institute of Tropical Medicine (Antwerp), investigated the parasites of vertebrates and the parasitic helminths in the Albert and Kagera National Parks.

The Institute's scientific programme is not strictly limited to the study of fauna and flora. From 1933 to 1936 Father P. Schumacher, an ethnologist specializing in the study of the Kivu and Northern Ruanda pygmies, was commissioned to study the anthropology of the Batwa clans permitted to stay in the remote depths of the vast forests within the boundaries of the Albert National Park.

In 1935-1936 Mr. L. Hermans was commissioned, with the financial assistance of several national institutions and departments, to prepare a magnetic map of all the Congo territories east of longitude 22 degrees East. He spent fifteen months on survey work in the Albert and Kagera National Parks.

The problem of bush fires, which cover a large part of tropical Africa every season, is one of the most controversial biogeographical problems, and the Institute therefore had to make it one of the main points of its programme. The policy of non-interference which it pursues can alone clarify, by comparison of observations made in the burnt and unburnt areas, the actual synecological influence of periodic bush fires on plant associations. During his mission in 1937-1938 Mr. J. Lebrun, scientific secretary of the Belgian Congo Institute for Agronomic Studies, took up the study of this problem, probably a fundamental one for the future of the great continent, which is in process of drying up. Besides making many observations this botanist collected in the Albert National Park a large number of plants which enabled him to prepare an important paper on the plant associations and plant geography of the alluvial plain south of Lake Edward. During that mission he carried out a first exploration of the Kagera National Park.

In 1937 S. Frechkop, mammalian zoologist and deputy conservator of the Royal Belgian Institute of Natural Sciences, was commissioned to visit the Albert and the Kagera National Parks to observe the mammalian ethnology. He brought back from his mission a very large number of documents of great interest.

During 1938, Mr. A. Gilliard, a geophysicist, was entrusted with the study of the tectonic movements of the mountainous massifs of the great African *graben* between Lake Albert in the north and Lake Kivu in the south. It has not yet been possible to publish his conclusions. When the Nyamuragira volcano south of the Albert National Park erupted in January 1938, the National Parks Institute of the Belgian Congo, in conjunction with the Jacques Cassel Fund of the *Université Libre* of Brussels, sent Mr. J. Verhoogen, a geological engineer specializing in volcanology, to observe its activity. He remained there until November 1938 and in 1939 returned to continue his observations on the volcano, which was still erupting, but the war interrupted his work. His observations were reported in a paper supplemented by films taken during the eruption.

All the scientists sent out on missions brought back a large number of photographs in support of their observations. The photographs are filed and catalogued at the Institute's metropolitan headquarters, where they are used for publicity and illustration. This collection now contains more than 20,000 photographs. However, it was essential to supplement it by films, which enable biological observations of special interest to be recorded. For this purpose Mr. A. Denis-Roosevelt, an American scenario-writer of Belgian origin, was entrusted with a cinematographic mission in 1934. Accompanied by four assistants, he travelled by car to the Congo across the Sahara and French Equatorial Africa. In 1935/1936 he stayed in the various sections of the Albert National Park, where under Mr. G. F. de Witte's advice he filmed aspects of the vegetation and characteristic scenes of the life of the large and small fauna. This material was supplemented by scenes from the life of the pygmies, some of which, such as those showing the circumcision rites, are of unique value. He also made several recordings of native music and chants.

THE SECOND WORLD WAR AND THE POST-WAR PERIOD

The Second World War interrupted the scientific work of the National Parks Institute of the Belgian Congo. However, the Institute used those years of inactivity to prepare a large mission, which was sent, after the cessation of hostilities, to explore the Upemba National Park.

In view of his experience in this field Mr. G. F. de Witte was appointed leader of this new mission, which may be regarded as the most important natural-history mission yet sent to Central Africa. It includes Mr. W. Adam (malacologist), Mr. A. Janssens (entomologist), Mr. L. Van Meel (botanist), and Mr. R. Verheyen (ornithologist). It started work at the beginning of 1947 and is due to finish at the end of 1949: it has already obtained results of considerable interest. The Upemba National Park provides an especially favourable field for research, as this reserve includes vast areas with very varying environments. High plateaux, representing outliers of peneplains of the former continental shelf, have characteristic vegetation bearing witness to their antiquity, whilst water channels, clearly linked to the recent geographical cycle, cut into this massif in deep ravines where very special climatic conditions prevail. Then again, in the depression of the Kamolondo *graben*, which is partially filled in with alluvial deposits, there is a liberal formation of old lake beds, of which Lake Upemba is the largest. These formations gave rise to bioclimates rich in varied species whose importance had not been previously determined by research. The results of this exploratory mission are therefore likely to contribute greatly to knowledge of African fauna and flora.

Another mission was organized during 1948. The programme of this mission, which was staffed by Mr. H. Hediger, director of the Basle Zoological Gardens, and Mr. J. Verschuren, an assistant, consisted chiefly of the study of the psychology of the large mammals. It went to the Garamba, Albert and Kagera National Parks and carried out observations which are supported by some 10,000 photographs and a large number of film scenes.

A further mission is now being organized to work in the Garamba National Park. This reserve is situated on the southern slope of the watershed between the Congo and

Nile drainage basins and its fauna and flora are still little known. It continues to harbour a certain number of white rhinoceros.

Apart from its publications on the scientific results of the missions sent to the national parks, which now comprise 113 reports, the Institute has published special works such as the monographs on the vegetation of the national parks, the biogeographical territories of the Albert National Park, and the flora of the spermatophytes in the Albert National Park. This last monograph, which is unusually extensive although limited to this reserve, is an important contribution to knowledge of the flora of the whole eastern and mountainous region of the Belgian Congo and Ruanda-Urundi except the Upper Katanga.

The National Parks Institute of the Belgian Congo has also endeavoured to promote a movement for the protection of animal species threatened with extinction. For this purpose it published in 1936, 1941 and 1947 a copiously-illustrated handbook on the animals protected under the International Convention signed in London in 1933, setting forth all the legislative measures relating to hunting and fishing in the Belgian Congo.

For publicity purposes the most impressive of the photographs are reproduced as enlargements and on postcards. When the subject is suitable, the Institute's publications contain copious illustrations of phases of the natural environment of the National Parks.

CONCLUSION

Such is the scientific work of the National Parks Institute of the Belgian Congo. It is already considerable despite its relatively recent growth and limited resources.

When the Institute began its work it enjoyed the support of the National Fund for Scientific Research in carrying out its scientific programme, and an endowment from a Belgian patron led to the creation of the Foundation for the Promotion of Scientific Study of the Belgian Congo National Parks. This foundation's objects consist not only in financing missions to the Belgian Congo National Parks but also in financial support for the scientific study of those reserves, provided in the form of travelling fellowships, grants for the study and preparation of scientific material collected, or any other action calculated to support the Institute's scientific work.

During future years the National Parks Institute of the Belgian Congo will pursue its programme with special emphasis on developing the analysis of the biological complexes. Broad foundations have already been laid for their study and knowledge of them will contribute much to the advancement of the pure and the applied sciences.

Management of Wildlife Resources[1]

JEAN-PAUL HARROY

ABSTRACT

This note applies only to inter-tropical Africa, where the position of wildlife is of a very special nature. As the fields of human activity continually expand, the areas left free for wildlife grow smaller year by year.

In many territories veterinary science, besides making possible a large increase in domestic cattle—to the detriment of wildlife—has made it a legal obligation to exterminate wildlife in order to control sleeping sickness and other epizootic diseases.

In conjunction with the two factors noted above, the need to provide food for workers and the native populations has in many cases resulted in the wholesale slaughter of African wild animals. The view is increasingly accepted that wildlife in Africa will disappear except in certain special reserves organized for the purpose.

The second part of the note enumerates the requirements such reserves must satisfy if they are to be adequate. The note concludes that these requirements cannot be easily satisfied within the framework of a Game Service, the resources and the men required being generally beyond the means of such official services.

Let me begin by stating the problem. I have been asked to discuss, in the light of experience, the management of wildlife resources. The status of expert with which I have been honoured is valid only for Central Africa, not even for Africa as a whole.

In this particular geographical region, the position regarding wildlife is such that the authorities are giving much more thought to organizing its destruction than to regarding it as a resource which should be husbanded.

Little more than half-a-century ago, inter-tropical Africa was covered with forests or prairies, most of which were the home of abundant big game, and where human settlements were few, small and scattered and of little economic importance. There was little agriculture or stockbreeding. Hunting consumed, so to speak, the interest on the game resources and left the capital intact.

But colonization has upset the balance. In accordance with processes that have often been described, human occupations—commercial crops grown by the natives, European plantations and the expansion of stockbreeding—cover a much greater area.

The areas in which game can find a habitat are being steadily reduced. Where man has introduced agriculture, the herbivorous animals—particularly some, such as the elephant, the zebra, and the wild pig—become nuisances. The carnivora, in turn, particularly in places where their usual herbivorous prey is scarce, become dangerous to human beings and to domestic animals. On the pretext of defending persons and property, the areas surrounding human settlements are systematically cleared of almost all their large fauna.

Veterinary science, an item which the colonizer places on the credit side of the African balance sheet, has become a source of many dangers to wildlife in the dark continent. Epizootic diseases formerly decimated herds of cattle, and prevented their increase. Today epizootic diseases are often successfully controlled. As a result the number of cattle in

[1]Original text: French

Africa has increased since the beginning of the century, in some cases tenfold. The area of grazing ground left free for herbivorous wildlife has decreased in proportion. Overstocking has resulted in a lowering of the quality of the pasture land and of the number of permanent waterholes it affords, which means that the wildlife is pressed further back towards it last areas of refuge. But the situation has deteriorated most tragically where veterinary authorities have decreed that the best method of controlling epizootic diseases such as sleeping sickness or rinderpest is the systematic extermination of most of the larger species and even of the small wild mammals. This terrible decision has been taken in several African territories, with results described as good by those responsible, but still disputed by many experts.

The colonizer has set millions of Africans to work and is now obliged to feed them. A simple solution was at hand; and the meat supply for workers, soldiers and porters was provided, wherever possible, at the expense of the local wildlife. Upon the pretext of obtaining food supplies, and with the protection of crops or livestock as an additional excuse, wholesale slaughter was and still is tolerated if not encouraged. Where game laws make an official attempt to counteract the harmful consequences of the frequently ill-considered distribution of firearms among the indigenous population the local representatives of the authorities rarely apply them strictly.

Much might be written on the unrestricted hunting in which traders of all sorts are now engaged, to the detriment of the last remnants of big game in Africa, the authorities remaining apparently unmoved.

There you have the problem stated in all its tragic simplicity. At the highest level, it is thought desirable that the big game of Africa should be exterminated, because extermination would "make room" for human beings and might "perhaps" solve the problem of this or that epizootic disease. At the local level, it is easy for an administrative officer to increase his popularity among the inhabitants by turning a blind eye and tolerating slaughter which brings about a temporary but immediate solution to certain administrative difficulties.

Under these conditions, one might refer to a phrase in the Progress Report (31 December 1943) of the Game and Tsetse Control Department of Northern Rhodesia which, in my opinion, sums up the whole alarming situation and which describes it as being in an evolutionary stage "between the present, when game has its uses, and the future, when under a fully developed agricultural system it will on the whole no longer be wanted except in areas especially set aside".

In Africa no thought is being given to the husbanding of wildlife resources. All that is being done is that in some provinces an attempt is being made to organize the extermination of wildlife in such a way as to turn it to some economic advantage to the human community. How many animals shot to protect crops or in a "tsetse control" campaign are left to the vultures?

There can be no question in this short note of analysing the underlying causes of such a state of affairs, nor the means of changing the course of development. Only a transition in Africa from the phase of extensive to one of intensive human occupation can restore to the natural native habitats the living space which is now being torn from them piece by piece. And the best if not the only method of curing the urge felt by most Africans today to kill any animal within range without thought for the morrow even if it is female or newly-born, is the provision of more plentiful sources of protein by means of stock-breeding and pisciculture.

Let us now pass to the question of what is being or should be done to constitute these "areas especially set aside", where African wildlife might still be allowed to live.

Disregarding the excellent attempts at nomenclature put forward in various quarters, I shall divide such areas in Africa into two main classes: supervised reserves and other reserves.

There is no need to repeat how deceptive and dangerous are those maps, with a patchwork of black and grey, demonstrating for the greater satisfaction of national self-esteem, the abundance of laws and regulations establishing natural reserves or national parks, of which nobody on the spot has ever heard.

In Africa, it cannot be denied, most maps of this kind are still window-dressing. But in exoneration of those responsible for this position, it should also be pointed out how delicate a task it is to maintain an African region effectively under a regime for the strict protection of its natural communities.

From personal experience, I think the principal requirements needed to ensure that such sanctuaries offer real protection, can be listed as follows:

1. A protected area of sufficient size to permit the herds of herbivorous animals to make their seasonal migrations without having to leave the area.

2. A boundary as nearly circular as possible so as to reduce the ratio of perimeter to area, and consequently the risk of outside interference, to the minimum.

3. Boundaries well defined by topographical features. The ideal boundary is a major watercourse. A hypsometric curve, a meridian or a straight line between two points are the least desirable boundaries, and are certain sources of dispute, whatever efforts may be made to mark the boundary.

4. Human settlement and movement should be reduced to a minimum inside the reserved area. In a country where everyone, even the game warden, is a born poacher, it is practically impossible to prevent anybody permitted to live or to travel in the region from occasionally killing game and escaping the penalty. The ideal formula, which was applied in the national parks of the Belgian Congo, is the legally effected evacuation, subject to the payment of fair compensation and the provision of new land for the evacuées, of the entire population of the reserve area, generally chosen because of its low density of population. A policy of this kind can be carried out only at great expense and after complicated and often protracted formalities.

5. The immediate neighbourhood of the protected area should have a relatively sparse native population, with few colonial development projects. Otherwise, the game outside the reserve is soon exterminated, and there are continual complaints contrasting the shortage of meat for the native population and the workers on the projects and the tantalizing abundance of "useless" herds of animals which are kept—or have taken refuge—in the reserved

area. Besides the complaints, which always result in encroachments on the reserve, such a situation leads to poaching which the local authorities, for easily understood reasons, punish very lightly.

6. The maintenance of active and continual supervision of the protected area. This requires a trained body of native police and a minimum European staff. A team of two or three native wardens can, on an average, supervise a sector of 200 to 400 sq. km. One European, moving about continually and making frequent unexpected visits of inspection to all the wardens' posts in the reserve, is absolutely necessary to ensure a minimum of efficiency on the part of the native staff, who are not unduly conscientious by nature and are exposed to many temptations. A reserve controlled from a distance by an administrative official, whose main work lies in other fields, may be dismissed as illusory; there would be no serious obstacle to the activities of poachers or even traders.

In conclusion, it must be admitted that a reserve of sufficient size to constitute an effective biological sanctuary —and in Africa one can hardly allow less than 4,000 to 5,000 sq. km.—involves heavy expenditure, easily exceeding twenty thousand dollars a year. Expenditure on such a scale and the provision of the men to plan and execute such programmes are inconceivable without a suitable organization, whether its basic purpose is primarily sport and tourism, as in the Union of South Africa, or scientific as in the Belgian Congo or the Nimba natural reserve, administered by the *Institut Français d'Afrique Noire* in Guinea. But a subdivision of a game service, however good its intentions, has neither the financial means nor the brainpower to carry out such a task. It is here that one must seek the causes of the indifference with which, almost everywhere in Africa, wildlife resources, far from being husbanded, are being gradually exhausted without hope of restoration.

On the Conservation of Bird Resources

JEAN DELACOUR

ABSTRACT

The general principle for the conservation of bird resources is that no indiscriminate exploitation can be attempted without causing the disappearance of the species involved. Only birds produced by means of artificial breeding or of rational propagation methods can be used for human consumption as food on a scale of economic importance.

Only a few wild species, in very special circumstances, are of any direct economic importance as food for man or as producer of fertilizers. But birds are of tremendous significance from the scientific, esthetic, sporting and recreational viewpoints, and also as maintainers of the balance of nature and as destroyers of harmful animals and plants.

Intelligent and co-ordinated efforts, often on the international level, are necessary to keep at a proper level the bird populations of the world.

As the president, and in the name of, the International Committee for Bird Preservation, I may be forgiven if I recall briefly here the general principles of bird preservation.

1. Birds, as most other wild animals, cannot be subjected to unrestrained hunting without eventually disappearing and becoming extinct, nor can they be commercially exploited unless measures of protection and propagation are taken to ensure the replacement of destroyed individuals.

2. The number of species of wild-birds of direct economic importance to man as a source of food is very limited and such use is confined to a few undeveloped regions with small human populations.

3. As producers of fertilizers, certain sea-birds are of great value, but only a few species are involved and they are confined to a few small islands.

4. Birds' greatest values to man are non-economic. Their scientific interest for the study of life and evolution is such that it is literally a crime to destroy species. Their aesthetic and recreational value is enormous. Bird-hunting is a popular sport and it is harmless if it is held within the limit of the supply that is annually produced through adequate measures of protection and propagation. However, the food supply produced by sport hunting can be only of incidental value. This has long been recognized in the United States of America where the sale of birds has long been prohibited. Poultry as a food supply can only be produced on an important scale by intensive natural or artificial breeding for that purpose; this applies to the domestic breeds, and also to wild species, and it could be extended considerably. The same principle applies to other bird products, particularly feathers used for millinery and other purposes, and to the trade in live birds. Ignorance of the above principles has already caused the extinction or a great diminution in numbers of many species. If many of the present destructive practices are not totally and immediately stopped, the greatest part of the species involved may have disappeared within the next century. The destruction of special habitats necessary to birds, such as forests, can cause their extinction as easily as direct killing, and a balanced conservation of birds along with other natural resources is indispensable for man's future.

5. Birds have a tremendous indirect value to man as they play a great part in preserving the balance of nature, particularly in checking the increase of insects, other invertebrates, and some vertebrates, the over-population of which often causes great damage and threatens man's food supplies, and sometimes his very life. Many birds are decidedly beneficial in these ways, while others are also of great value in the dissemination, propagation and control of plants.

If the supply of birds for all purposes useful to mankind —scientific, aesthetic, recreational and economic—is to be maintained, intelligent and well co-ordinated management by scientifically trained technicians is essential.

Many game-birds are migratory and inhabit different countries at the various seasons of the year. It is necessary that international measures be discussed, adopted and enforced so that no one commercially exploits them to the detriment of the others, or takes more than his proper share. An excellent example of what can be accomplished in that way is that of the Old World migratory quail, *Coturnix coturnix*, a bird that breeds in Europe and winters in North Africa. For many years quails were netted in Egypt during the winter and the early spring and sent alive to London, Paris and other large cities, where they were fattened and sold at high prices as a great luxury in the food market. At the same time, quails were shot indiscriminately in Algeria and other parts of Africa. Thirty years ago quails became scarce and their extinction was in sight; measures had to be taken to ensure their survival. The I.C.B.P. took up the matter, and with the co-operation of the *Conseil International de la Chasse*, protective steps were soon taken. Egypt passed a law prohibiting netting in spring, in February, 1936, Egypt passed a law prohibiting export of live quail between 15 February and 30 June, in May 1936, and this came into force in 1937. Great Britain, to support Egypt's action, passed a law prohibiting import of live quail between 15 February and 30 June (1937). Prohibition of netting in the French territories in North Africa came in 1937, and France also prohibited the import of quail. As a result of this co-operation, quails have increased all over western Europe, and at the meeting of the C.I.C. in Brussels in 1949, the Netherlands delegate reported that, although quail did not occur in that country before, they are now abundant there. A valuable game-bird has thus been restored to Europe.

Water-fowl constitute everywhere highly prized game-birds, and most of them are migratory. Their extinction is being threatened unless they are properly safeguarded on the breeding grounds in the north, along their migration routes, and on their wintering grounds. This has been achieved satisfactorily in North America. In Europe, where the situation is rendered more difficult by the number of nations affected, some progress is being made. Various countries, particularly Britain, Belgium and the Netherlands, have undertaken helpful protective measures, and a special Wildfowl Enquiring Committee of the I.C.B.P. is hard at work at the present time.

Besides long-domesticated birds such as chickens, geese, ducks, pigeons, turkeys etc., which for centuries have been reared for the eggs and flesh, other birds are successfully reared in large numbers, and released to provide sport shooting. The common pheasant is an excellent example of such acclimatization successes in Europe, North America and other countries.

During nearly forty years of personal experience with birds in all parts of the world, I have seen the gradual dwindling of their numbers practically everywhere. Whenever species have been commercially exploited without strict regulations and proper measures for their propagation, their disappearance has been rapid and their status has soon become so precarious that they lost all their economic value to man. This cannot be tolerated.

I have spent many years studying and collecting birds in various parts of the French Union, particularly in Indo-china and Madagascar, also visiting French Occidental Africa, Somaliland, the West Indies and Guiana. I found that much inconsiderate destruction has taken place, particularly on small islands and in densely populated areas, without any real benefit for the inhabitants. The plumage trade did bring in some money, but at the price of the local extermination of several species, which promptly caused its discontinuation. Nowhere could I see that any durable advantage could be derived from any commercial exploitation of wildlife.

My recommendation is that measures be taken to ensure everywhere the conservation of all species in proportion to their influence on the life and well-being of mankind and of other forms of life, and that those of direct economic value should be propagated expressly for the purpose of their exploitation.

Management of Bird Resources

J. DEWEY SOPER

ABSTRACT

Modern conditions make the science of wildlife management increasingly important. Factors that produce this result include a constantly expanding civilization, with a greatly increased human population; reduction of breeding environment suitable for wildlife; and much increased gun pressure. Preservation of bird resources becomes an exacting responsibility and a perpetual challenge to game administrations.

Numerous small migratory birds of great value to agriculture and forestry are protected throughout the year. The larger game birds require special investigation and management. As a result of this need, techniques for appraisals of populations and detection of population trends have been developed. Results of the annual research influence the character of game legislation with respect to bag limits, length of open season and other restrictions on hunting.

For discovery of seasonal trends in game bird populations, reliance is placed on various techniques, especially unit area counts and extensive territorial transects traversed chiefly by means of motor vehicles and aircraft. These methods have been used for research relating to water-fowl and to upland game-birds. Water-fowl population data are also obtained in North America by means of a co-operative midwinter inventory.

A knowledge of major migrational flyways, continental distribution with respect to breeding and wintering grounds, sex and age ratios and rates of reproduction is also necessary for effective waterfowl management. Sound legislation must also provide for creation and rehabilitation of water areas and bird sanctuaries, law enforcement personnel and conservation publicity. International management and protection are becoming increasingly important.

In this modern day and age the science of wildlife management assumes a role of mounting importance. As time advances, an increasingly more positive attitude toward conservation is required. This arises from the operation of several factors. Among these are the obvious ones of a constantly expanding civilization, with a vastly augmented human population; associated shrinkage of suitable breeding environment; and greatly increased hunting pressure.

As compared with the early period of settlement and its abundance of game, the present era demands more vigorous methods of management for the preservation of valuable wildlife resources. The significance of the issue is not only practical and economic, it is also ethical; it is our duty to conserve, to keep the world enriched with living forms of indigenous fauna, and to fight vigorously against the threatening increase in the number of vanishing species.

The management of birds represents but one part of the constant effort to safeguard all forms of wildlife. Birds are of many sizes and types and have different management requirements. In relation to unwarranted human encroachments, for instance, some need a greater degree of protection than others. A host of small insectivorous birds, of much value to agriculture, are relatively inconspicuous and unmolested; nevertheless, they are safeguarded by various acts and regulations providing protection throughout the year. Game-birds, on the other hand, are comparatively large and are actively sought by hunters; consequently, these birds as a class need ceaseless and careful management on the part of game administrators.

Because of this necessity, special fact-finding techniques have been and are being evolved. The character and aim of these are manifold. Of basic importance, however, is the determination of population levels. Lacking this information, reasonably exact and scientific management of game-birds is scarcely attainable. The manager of game-birds also needs to know not only the percentage of the kill by gunners, but also such elements as natural cycles of abundance, drought, disease and lead poisoning. It is clear that without data on these various factors, it is difficult, or impossible, to deal intelligently with such matters as bag limits and length of open season.

One of the early techniques for determining population levels of game-birds and other species is that of sampling by unit areas. A unit area is one in a single locality which is carefully defined as to size and on which the aggregate population of one or more species is ascertained as precisely as possible by actual count. The larger the territorial range of any given species, the greater the number of such sampling areas of average habitat that should be established.

Total population estimates are arrived at by ascertaining the ratio of the total area of the sample units to the total range of the species concerned and then multiplying the sample population figure to complete the proportion. The sample areas may vary greatly in size, depending upon the species selected for study. In the case of small passerine birds, for example, relatively small unit areas suffice. On the other hand, much larger ones are imperative for upland game-birds in order to secure fairly reliable population data per square mile. In applying the method to water-fowl even larger tracts are needed for a good average sample. For all practical purposes the same method may be used on both breeding grounds and wintering grounds.

Discovery of biological tendencies is not necessarily dependent upon calculated total populations for any given major expanse of territory. In fact, the population trend, which is of great importance to administrators, is normally to be detected in evidence derived from the unit areas alone, essentially independent of other considerations. Needless to remark, the same unit and technique must be employed every year, during a similar period, to secure figures of comparative value. From these data the population trend, upward or downward, is calculated. It is generally expressed as a per cent. This acquired knowledge —perhaps in conjunction with supporting information from other sources—is then utilized for management purposes.

A more recent technique that has been developed for population appraisals and determination of trend, chiefly of water-fowl, is known as the transect method. Within the last two years, especially, it has been employed widely in the United States and Canada. It is notably effective in the region of shortgrass plains, prairies and aspen poplar "parklands" between the Rocky Mountains and the eastern forests. Its great recommendation lies in the fact that numerous geographical areas of wide extent can be effectually appraised simultaneously by many crews in a moderate amount of time and in a uniform way.

The open country transect method is carried out by means of motor car and aeroplane. The standard transect comprises a strip of territory one-quarter of a mile wide. There is one-eighth of a mile, or 220 yards, on each side of the road, or in the centre of the selected air-strip. These transects are previously plotted on a map of the territory that includes the projected field of operations.

Transects of the width mentioned are the most useful for several reasons. This width is found to permit the desired data to be obtained rapidly and in the most efficient and economical manner by observation through binoculars. Since the ground-strip on which observations are made is one-quarter of a mile wide, one square mile of sample is examined in the course of every four miles travelled along the centre line of the strip.

It has been the practice of the Dominion Wildlife Service and the United States Fish and Wildlife Service, when running such transects, to continue the survey without a break for long distances and to record on separate forms of special character, bearing a corresponding identification number, the data obtained. Transects are so plotted on a detailed map as to traverse collectively all existing soil types and other environmental types in the selected region. Often a survey crew of two men in an automobile and another crew of two men in an aeroplane run transects in close co-operation. In the course of a period of many weeks, thousands of miles are thus examined. As a double check, the transects are usually run twice in the same water-fowl breeding season. Since few broods are hatched in the early part of the season, most of the production figures are tabulated during the period when the transects are being examined for the second time.

As previously intimated, the purpose of these surveys is to obtain reliable quantitative sample data on a broad scale. The method described is not applicable to rough or forested country, but on open prairies it may be used for sampling populations of either water-fowl or upland game-birds. It provides, year after year, comparative data from which may be obtained a knowledge of relative abundance, numbers of breeding pairs, population trends, annual production, water areas and other features.

Surveys of selected unit areas and the broader transect system with machines can be used for the appraisal of game-bird populations either separately or jointly. Each method has its advantages and disadvantages, depending in part upon the nature of the territory and of the wildlife to be studied.

In the case of ducks and geese, selected sample areas will naturally be chiefly lakes and marshes. Quantitative and other data will be gathered by a ground crew, utilizing a boat or canoe, with or without the co-operation of air observers. In the great northern forests, where roads are completely lacking, the most practicable method to be used on a large scale is that of observation from aircraft. Indeed, without the use of aircraft, large and important tracts of the arctic, sub-arctic and northern coniferous forest could not all be investigated in a single season.

A winter technique for population appraisal of water-fowl has been developed by the United States Government and is now used throughout North America in the "Mid-winter Water-fowl Inventory". This operation is conducted during the month of January. The resulting data are employed in conjunction with data acquired in the previous summer and during the autumn shooting season to ascertain the percentage of kill, sex and age ratios, and other population information that could not be secured in any other manner.

An inventory of this kind requires an extensive co-operative effort on the part of Federal, state and provincial administrations and a host of qualified private citizens. Most of the results are obtained by count and by piecemeal estimates on the wintering grounds in the United States and Mexico, where wildfowl are concentrated. A high percentage of birds, in flocks large and small, resort to coastal plains and adjacent areas at sea; others are scattered across the continent in lakes, marshes and streams. The desired data are gathered by the combined use of aircraft, motor-car, boat and canoe, and by travel on foot.

A knowledge of wildfowl migration routes and flyways is another necessity for general management purposes. By long-continued field observations and much banding work the major North American waterfowl migration routes have been plotted and named the Atlantic, Mississippi, Central and Pacific Flyways.

Large numbers of waterfowl, of mixed species, follow these flyways northward and southward. Some species depart more or less from the routes adhered to by the majority. Ross's Goose, for example, migrates north-east and south-west between California and Perry River, Northwest Territories, Canada. Knowledge of these specific migration routes enables legislators to apply special regulations in given districts, or regions, should one or more species associated therewith require additional protection. Lacking such information, expedient restrictions could not be imposed with as much understanding and effectiveness.

Hand in hand with a comprehension of local and continental flyways goes a knowledge of the distribution of the various species of ducks and geese. It is useful to know the full extent of breeding and wintering grounds, as well as the intervening territory covered during the migrations. Of these, a knowledge of the total summer range ranks high in importance in connexion with the total breeding population and the annual increase. All such information is valuable for general management and administration of game laws.

Laborious gathering of faunal data constitutes but one of the techniques of modern wildlife management. Foremost among related activities is the logical application of the acquired facts to a wise course in game legislation. Another is good enforcement of the law by an adequate number of trained officers, without which the finest regulations are of comparatively little avail.

Valuable features in conservation are the bird sanctuaries and refuges that have been set aside in large numbers in North America. To these may be added the very extensive National Parks, where all forms of wildlife are carefully managed at all times. Especially during the past two decades, many thousands of small and larger bodies of water have been created on the drought-susceptible plains of the West; these have gone far to stabilize and preserve the wildfowl population. Rehabilitation of deteriorated lakes and marshes by building dams and diverting water is an important link in the chain of activities on behalf of wild-fowl welfare and perpetuation. Adequate publicity, for the purpose of educating the public to the great need for wildlife conservation, is another useful tool of management.

Not least among the aids to bird life is the application of international management and protection. In this respect North America has been fortunate in having developed international migratory bird treaties to one or more of which Canada, the United States and Mexico are parties. The actual and potential value of such co-operative measures for the conservation of a continent's bird life is perhaps beyond reckoning, but that it is very great there can be no dispute. The benefits of international protective co-operation accrue especially to all those species of water-fowl and waders that are classed as game-birds.

Peruvian Management of Bird Resources

ENRIQUE AVILA

Field work on the Peruvian guano islands has brought to the fore a considerable number of problems. This paper has been written to call the reader's attention to some of those that have engaged the writer's interest during the last few years. An endeavour will be made to present the issues in an orderly manner, although such an objective cannot be fully attained, since most of the background has to be passed over if the paper is to be kept on a concrete level.

Let us begin with a statement that will prove very useful in the understanding of the sound management of the

Peruvian guano bird. The guanay cormorant (*Phalacrocorax bougainvillii*, Lesson) which numerically far exceeds the other two species: "Piquero" (*Sula variegata*, Tschudi) and "Alcatraz" (*Pelecanus occidentalis thagus*, Molina), originally belonged in the category of stenochthonous species (i.e., a species found only in a limited area). Its present quasi-eurychthonous position, that is, its considerable dispersal and high population level, was made possible by the intervention of man on the one hand and the greater degree of tolerance to human interference by the species itself on the other. One can therefore say that, in a sense, the guanay has artificially outnumbered the other species. Furthermore, parallel to this numerical increase, the guanay, a bird of Antarctic origin, slowly expanded its breeding range to more and more northerly islands, following the cold waters of the Peruvian Current.

Two rather obvious conclusions can be drawn from the foregoing statements, namely: (1) the guanay is a highly vulnerable species to hydro-biological disruptions along the Peruvian coastal waters, and (2) the management effort should be so aimed as to create the best conditions to bring the species back to its previous population level in the shortest possible time once the ecological set-back is over.

It is well known that the Peruvian Current is subject from time to time to more or less serious disturbances, such as local or generalized changes accompanied by a considerable rise of the water temperature. Some authors even speak of a "periodic" occurrence of the abnormalities, but the truth is that if such a periodicity does exist, we still are ignorant of the time interval involved. However, the thing to bear in mind is that, ordinarily, the hydro-biological disruptions advance from north to south. Now as it is under the influence of man that the guanay has expanded its breeding range to the northernmost islands, the guanay, if the disruptive wave progresses southward, will therefore be hit by its effects in a similar latitudinal sequence. And this knowledge provides the ground for the first management recommendation offered here. The Peruvians should conduct their guano-harvest campaigns in such a way that not all the meridional islands off their coast should be exploited in the same year, and much less so when the ecological set-back is in full operation. This policy would ensure the swift replenishment of the species, because the southernmost islands would behave as nursery centres except in extremely perturbed years, when the disruptions reach the Peruvian islands of the highest latitude.

That the birds do move to the south in the presence of these hydro-biological anomalies, is sufficiently proven by the results of past "banding" operations. This brings us to the second point in the discussion.

The guano birds move annually in relatively large numbers down to the northern half of the Chilean coast. Under ordinary conditions, this movement takes place when the breeding season is over, i.e., around February. It is a moot point whether this movement should be termed a migration or an irruption. In our opinion, the guanay is not migratory *strictu sensu*, but the mere fact that quite a few thousands of them do travel south upon the completion of their breeding cycle, raises an important question: How much guano does Peru lose on this account?, or, if you prefer, How much guano does Chile gain? Unfortunately, available banding data are not sufficiently significant statistically to answer this question quantitatively, and therefore it is important that the banding operations continue until this concrete problem may be fully elucidated.

It has been established that the best method of banding in the islands is to take the numbered metal rings to the field, and capture the young birds (about one month old) with the help of a crew of eight to ten men to handle a strong and closely-knit net. The wrapping of the bands around the tarsus should proceed at the fastest possible rate. Night banding proved extremely inadequate and harmful. Needless to say that besides solving the above question, tagging would also provide data concerning the longevity of the three guano bird species under natural conditions, their "migration" routes, their turnover rate, age at sexual maturity, homing instinct, group behaviour, etc. Banding, then, constitutes the second management recommendation, and for its implementation to be of the greatest value, Chile, Peru, Ecuador and possibly Colombia should work in close co-operation.

Not totally disconnected with this problem is that of census taking. So far methods have been devised only for gross estimates of only the adult and economically active population. One of the most interesting, and probably the most reliable up to date, is that devised by William Vogt; this consists essentially in weighing the guano accumulated in a certain number of square metres, dividing the total weight by the product of the number of nests included in the area multiplied by two (since each nest contains two adults), and finally dividing this figure again by two if the guano harvested corresponds to two years' accumulation. The resulting figure is a rough estimate of the amount of available guano produced by each adult bird in one year. It was found that each adult bird produces 15.8 kg. of available guano per year. Therefore, to estimate the total number of economically active adult birds in a particular year, one need only divide the total weight of the guano harvested that year by 15.8; the result, as pointed out elsewhere, may not be very accurate but it certainly is an acceptable estimate. In this way, for instance, if an estimate is wanted of the economically active adult population of birds for 1947, divide the number of metric tons of guano harvested, (converted into grammes), by 15.8 kg. (also converted into grammes). Thus, for 1947 we would get:

$$\frac{160{,}433 \times 10^6}{15{,}800} = 10{,}153{,}987 \text{ birds.}$$

Naturally, the figure is only arithmetically accurate; for all practical purposes it should be interpreted to mean roughly 10 1/2 million economically active adult birds.

To obtain reliable data about the whole population, that is, adult and young together, especially as the numbers fluctuate throughout the year—or years—no better way can be suggested than the use of aerophotography correlated to exact knowledge of the islands' topography and area, in addition to data on the average number of birds per square metre at different phases of their life cycle. This suggestion presupposes patient and diligent work, but the equipment for such a study is not wanting. The aerophotographs should not be taken at exactly the same calendar dates from year to year, but rather at the same phenological dates. This is, in our opinion, very important if valid comparable data are to be secured. Furthermore, the picture-taking should be done as simultaneously as the phenological condition makes it possible in all the islands, and at each of them from a constant altitude and angle.

As happens with most administrations of long standing, that of Peru's guano islands has developed through the years certain stereotyped policies, to which routine practices have become adjusted. One must readily grant that in such cases it is very difficult to alter the ordinary ways, even in the presence of indubitable reasons to alter them. However, if the reasons for alteration in method survive the negative force of mere habit or custom, the change is finally welcomed. To the writer's mind, one such change must take place in the exploitation of the Peruvian guano islands. Up to this day the traditional practice survives of harvesting the guano almost to the last speck in any island open to exploitation. Hundreds of labourers are put to picking and sweeping the islands until their granitic cores become exposed. This rough method of harvesting as well as insufficient transportation means and poor disbarking facilities take time and the result is that the guano-harvesting campaigns are unduly prolonged, with the deplorable consequence that the birds are interfered with in different degrees depending on the length of each campaign.

The argument usually advanced to support this policy is twofold:

(1) Peru's agriculture needs every ounce of guano that can be gathered, and (2) Since the exploitations are carefully timed not to take place when the birds are breeding, the fear of human interference is simply the understandable product of too great caution. Yet the writer believes that such reasoning is entirely fallacious. In the first place, Peru's coastal agriculture is already confronted with an annual deficit of guano amounting to about 60 per cent of the total normal guano production per year—a situation that would not be perceptibly worsened by a slight drop in the amount of guano made available to the nation, especially if the cause for the decrease was not to remain operative more than two years. In the second place, it is time to realize that any wild animal population must not only be undisturbed during the breeding season but equally during the preceding phases—most of which not only take place without detectable outward signs but even without our knowing of their existence. This is a chapter for the animal psychologist, too often disregarded, we are afraid, on no other grounds than anthropomorphic misconceptions.

Here, then, is another recommendation. The islands, especially those with a craggy and jagged surface, should be left with a crust of guano to smooth up the whole breeding area, thus facilitating for the next year the rapid mechanical extraction of the guano layers by using tractors and bull-dozers of the right size, and what is more important, presenting the birds with an island more congenial to their ecological requirements. It is the writer's belief that such a policy would cut by half the duration of the campaigns and prove in the end most beneficial to the welfare of the birds.

Finally the writer would like to recommend the fostering of research on the possibilities of expanding the guano industry by transplanting the Peruvian guano bird species to other suitable geographic regions. We are staunchly opposed to any blind tamperings with established species, but we also believe that if scientifically sound investigations prove that no ill results will come from the transplantations, the Peruvian Government should extend a helping hand so that international covenants could eventually be reached, whereby an enduring benefit would come, directly or indirectly, to the peoples of the contracting States. The difference between our proposal and those formulated by other people in the last decade or so, is that we ask as an indispensable prerequisite the carrying on of a thorough scientific investigation—even if it takes many years.

Management of Bird Resources

R. A. FALLA

ABSTRACT

The insular, restricted and isolated nature of the New Zealand archipelago affects the bird resources in several ways.

(1) There are practically no migrants except pelagic sea-birds, aud shore-birds from the northern hemisphere, and for these New Zealand is a terminal area.

(2) The indigenous avifauna has a high proportion of endemic and archaic forms to the preservation of which conservation resources have in the past been mainly directed.

(3) Native water-fowl and game-birds which in most countries sustain organized shooting pressure, have been to a large extent replaced by naturalized species.

Discussion of population studies of economic significance are, therefore, restricted to:

(1) Penguins and petrels, of which the former were historically a source of oil and the latter of food. They may be regarded as marine resources, and their gregarious habits make population studies practicable.

(2) Gannets and cormorants, as potential guano producers, but of relatively small importance in an area of high rainfall.

(3) Gulls, an increasing element of value as scavengers and potential egg-producers on a small scale.

(4) Inland water-fowl, with examples of interaction between native and naturalized forms.

(5) Game-birds, of which the naturalization has followed a pattern of rise and decline in several species.

INTRODUCTION

The position and nature of the New Zealand archipelago are such that an experience paper based on work in this area will have certain limitations in its general applicability, but at the same time it will have some relevance to problems of the bird resources of insular areas in the temperate zones. It may be mentioned at once that migrant birds are not a large proportion of the total avifauna, and for those that do occur New Zealand is a terminal point in migration whether as a breeding or a wintering ground. The scientific and aesthetic value of many endemic primitive forms such as the kiwi (*Apteryx*) calls for special measures of absolute protection and improvement of habitat, and so far this has been the main concern of conservation practice. The relatively few kinds of birds for which economic value may be claimed may be grouped as follows:

(1) The oceanic, colony-forming penguins; once used as a source of oil.

(2) The oceanic petrels breeding in immense numbers on off-shore islets. These still are a factor in the food supply of the Maori section of the population.

(3) Gennets and shags of coastal waters, potential producers of guano, the deposits of which, however, do not accumulate owing to the high rainfall.

(4) Gulls and terns.

(5) Island water-fowl, mainly ducks, not in great numbers or density, which are of some importance as game-birds, and to a lesser extent as food. Naturalized swans in the same category still are in the process of extending their range and numbers.

(6) Game-birds. All introduced species.

For several reasons it is not possible to offer from New Zealand experience any well-tested techniques related to such resources. The country, perhaps unfortunately, has never felt much need for husbanding natural resources either for internal use or export; and the habit of destructive exploitation associated with pioneering phases still is very strong. As many parts of New Zealand are thinly populated and imperfectly explored, and until 1945 no field biologists were employed in government departments responsible for wildlife administration, there is insufficient basic data on distribution and population levels of most of the birds. In this paper, therefore, a selection has been made to cover those aspects of the matter in which New Zealand experience appears to offer examples not so likely to be covered elsewhere.

DETERMINATION OF POPULATION LEVELS. MIGRATION ROUTES AND FACTORS AFFECTING WELFARE OF STOCK

Penguins

These present no problems of technique beyond the difficulty of getting to the islands, e.g., Macquarie Island, 600 miles, and no sheltered anchorage. The breeding season being known, the birds may be counted at the peak of the season, the colonies (of *Eudyptes schlegeli*) being so densely packed that the number may be estimated by surveying the total area and calculating from the average number of breeding birds in a sample small area of known size. Using this method the breeding population of *Eudyptes schlegeli* on Macquarie Island was estimated in December 1930 by Falla[1] as over one million birds. In addition, all yearlings which come ashore to moult in February can be similarly counted and a record of survival rate at the end of the first year can thus be obtained. This was the age group that was exploited by an oil industry between 1894 and 1918. Using similar methods J. H. Sorensen (M.S.S.) estimated the population of *Eudyptes crestatus* at Campbell Island as 5 million; and further surveys are projected at Snares, Antipodes and Bounty Islands.

Ultimately, it should be possible to assess with more accuracy than the nineteenth century oil-hunters achieved, the takeable surplus of certain penguins, although the exploitation of penguins must be considered both repugnant and unnecessary so long as other sources of fat and oil remain to be exploited fairly and economically.

Petrels (Sooty shearwater or New Zealand muttonbird, and short-tailed shearwater or Tasmanian muttonbird)

The species mentioned are similar in appearance and habits and are sources of supply for local industries (known as "mutton-birding") in both Australia and New Zealand. Some population study of the short-tailed shearwater is being undertaken in Australia, but the present notes relate to the position of the sooty shearwater in New Zealand. The breeding population is distributed in many island-inhabiting colonies, some of immense size. No complete estimate ever has been attempted; but the number of young taken in the regular season from some five small islets has been 300,000 annually for some years past. Only one chick or fledgling is found in each occupied nesting burrow; and the numbers taken from certain measured areas are on record. Such numbers can be used in estimating nesting density. A preliminary assessment of birds present in the breeding season on an island on which they are not disturbed recently was made at the Snares. The method was to assess the area over which burrows occurred, to make sample counts of the density of burrows in typical sample areas, and finally to determine the proportion of burrows actually occupied in sample areas. Owing to incomplete coverage of the whole island the final estimate of one million plus was regarded as conservative. An independent investigator, using an area and density comparison with a very small islet of known population about 80 miles further north, offered an estimate of 800,000.

There still are a number of unknown factors such as age at maturity, length of breeding life, and migration route. Migration is trans-equatorial and appears to be clockwise round the greater part of the coastline of the North Pacific Basin, but as the area is not a good one for "recoveries", the very limited banding experiments have so far shown only evidence of site tenacity on the breeding-grounds. However, the empirical evidence of a now ancient native industry shows that under certain conditions breeding stocks are exploitable without evident depletion. When all the factors have been evaluated it should be possible to establish firm criteria for the safe exploitation not only of sooty shearwaters in New Zealand and elsewhere, but for allied species which are abundant in several oceanic areas. The food value of muttonbirds is high in proportion to their size, and, ultimately, there must be discovered uses for such by-products, at present wasted, as stomach-oil, surplus fat and feathers. Conservation at the present time presents no problems except those involved in preventing undue disturbance of nesting habitat both in and out of season. International aspects would arise only if great mortality in migrant flocks were to occur off the coasts of Japan, the Aleutian Islands, British Columbia and south to California; but there is no evidence of this at present.

[1] *B.A.N.Z. Exp. Birds.*, 1937, page 110.

Gannets and cormorants

Although western South America and South Africa are the only parts of the world in which the climate allows fresh guano deposits to build up at an appreciable rate, there are guano-producing birds nesting in considerable numbers on and off the New Zealand coast. The gannet (*Morus serrator*) nesting, with the exception of one small colony, north of the subtropical convergence, forms colonies similar to those of *M. Bassana* in the northern hemisphere. The well-established techniques already developed for population estimates of these birds elsewhere have been applied recently to a complete survey of all colonies, including photography from the air in the case of a few inaccessible ones. There is sufficient reliable historical data from some of the colonies to indicate an over-all increase in numbers over the last thirty years. Gannets are not molested and the largest accessible colony at Cape Kidnappers has a warden. While it is true that high rainfall prevents any accumulation of guano there always has been sufficient to encourage sporadic gathering from accessible rookeries. It has not been done during recent years in which chemical fertilizers have become fashionable, and if ever resumed would, of course, have to be controlled so that visits were made only after the departure of breeding birds in March.

South of the convergence the best guano producers are several species of sub-antarctic cormorants. Owing to high rainfall on the nesting islands about Foveaux Strait and in the sub-antarctic, most of their rich product is lost. There is, however, some accumulation in places, and it will be greater when senseless slaughter in the supposed interests of fisheries ceases. For some years it has been illegal, and it is hoped that the legal protection will gradually become effective through information and education service in that direction. At present this is effected through simple illustrated circulars, but it needs more personal dissemination among the fishermen concerned.

Gulls

One of the results of offal discharge from meat works in New Zealand has been a remarkable increase in the population of two species of gull that are regular scavengers. The larger is the southern black-backed gull (*Larus dominicanus*) and the smaller the red-billed gull (*Larus scopulinus*). The former nests in colonies of some hundreds and in more dispersed units along the coasts, the latter in compact colonies of some thousands. While such conditions last there is no doubt that if ever urgently needed a calculated supply of eggs could be taken once a year. As gulls will lay a second time the stock would suffer no setback if the first laying should be gathered by properly authorized and supervised collectors. It would be a condition of such policy that all indiscriminate and illegal collecting should be firmly suppressed.

Water-fowl

Pollution, erosion, drainage and over-shooting have reduced water-fowl to a level at which the present status as a renewable resource is not high. To some extent the decline has been offset by successful introductions. Unfortunately, these "successes"—for example, *Branta canadensis* from North America, *Caenopis atrata* from Australia, and *Anas boschas* from various sources—have not only filled empty niches but have displaced many of the surviving indigenous ducks. Most of the naturalized water-fowl still are in the phase of range extension, and in consequence all conservation practice and population study has been devoted to native species. As a result of nesting survey, trapping and banding in a sample area, officers of the Department of Internal Affairs have established that the native duck, *Anas poecilorhyncha*, has an eccentric dispersal in its first year both north and south at least 500 miles, thus covering practically the whole extent of the country. It also is apparent that native ducks are less successful in finding safe nesting sites in areas modified by settlement. It would seem in these circumstances sound policy to decrease the shooting pressure on native species and extend the season and bag limit for mallard and black swan in addition to continuing supervised egg collecting in the case of the swan.

Summarizing New Zealand experience in this matter, it may be said that the present-day population of native water-fowl is quite unable to stand up to modern shooting pressure and that in default of any satisfactory method of stimulating the increase of native ducks, introduced species that will neither hybridize nor compete unduly with the native must be looked to for provision of future game supply. It should be added that the first alternative—encouragement of the native species—still is being investigated.

Game-birds

There are no native game-birds, a small quail having become extinct about 1870. Four introduced species have been established, and one of them, the Australian brown quail, has settled in unobtrusively like a native and maintained equilibrium in northern districts. Two others, pheasant and Californian valley quail, have successively flourished and declined to a comparatively low level of numbers. A fourth, the Chukor, is a more recent introduction and still is in the extension phase. As the factors involved in these changes are not yet understood it is clear that further introductions are undesirable.

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Management of Bird Resources

GUSTAV A. SWANSON

INTRODUCTION

My introduction to the broad subject before us for discussion will be based necessarily chiefly on my experience in the United States and Canada, although some examples have been drawn from other countries. It is hoped that in the "experience papers" and discussion which follow, specific treatments will come out which will be of practical value to us all. Under the heading of "management," I interpret it that we include the control of bird populations where that is necessary or desirable, as well as the encouragement of the valuable species which we are interested in producing in larger numbers. Because of the international character of this meeting, it seems appropriate that the greater part of our time be devoted to the management of migratory birds which know no political boundaries, and are, therefore, international themselves. It is recognized, however, that the arts and sciences are universal, and that management techniques developed for one species in one country may be adaptable to other species elsewhere. While the greater part of my time, therefore, will be devoted to a consideration of the methods being employed and developed for encouraging the production of migratory game birds, brief consideration will be given to the other important phases of this broad subject.

The difference in the legal status of wild birds in different parts of the world should be mentioned. In the United States, and also in Canada, the sale of migratory birds or their eggs is prohibited. The value of both the migratory and resident game birds as a source of recreation has been recognized to such a degree that it far transcends the very considerable value these birds also have as food, and it is the recreational values primarily with which the public wildlife conservation agencies in the United States and Canada are chiefly concerned. In remote areas of the far north, as, for example, Alaska and northern Canada, the native people are permitted to collect the eggs and to take certain wild birds for food throughout the year, but elsewhere these forms are protected seasonally for their value as game.

Through the enactment of treaties binding first Canada with the United States, and later Mexico with the United States, the protection of the migratory species of birds in North America has become primarily a Federal responsibility, though the states and provinces co-operate fully. Protection of the resident forms, however, remains a responsibility of the individual states in the United States and the provinces in Canada. By far the greater part of the attention of both the Federal and the state agencies is paid to the game species, among birds, the ducks and geese (Anatidae), the woodcock and snipe (Scolopacinae), and the pheasants, partridge and quail (Gallinae).

The great value, therefore, of bird resources in North America is primarily a recreational value. There are a few instances of direct economic values, such as the management of eider duck populations in the Canadian Atlantic coast islands for the collection of eider-down by residents, but the primary purpose for which the tremendous machinery of migratory-bird management has been developed is to foster the continued production of these birds as game.

An indication of the fact that the recreational value is very considerable lies in the total number of hunters who are licensed to shoot migratory birds in this country. In the United States the estimate of this number is relatively accurate because all hunters of migratory birds are required to purchase a Federal "duck stamp", which is not required for the shooting of resident game species such as partridge and pheasant. The sale of the Federal duck stamp, therefore, is a relatively accurate index to the increasing importance of duck hunting to the United States sportsmen. In 1936 there were less than 500,000 purchasers of these duck stamps, while in 1948 the number was in excess of two million. The economic value of such an important recreational resource is, of course, obvious, because duck hunters in the United States are estimated to spend more than $300 million each year in pursuit of their sport.

The outstanding importance of the migratory game birds demands, I believe, the larger proportion of my time, but I should like first to consider briefly that important aspect of bird management dealing with the control of certain bird populations to avoid serious damage to crops or property.

CONTROL OF BIRD POPULATIONS

In many types of situations birds become a nuisance or sometimes a serious economic problem because of their depredations upon crops. A large amount of research has been conducted into methods of limiting these depredations either through reducing the numbers of the birds themselves, or in some manner preventing them from doing the damage. I shall mention briefly examples of only a few types of damage, and a few techniques for control which have been used.

Ducks and geese have caused very serious depredations in fields of small grain and rice in the western United States during the past few years. Several methods have been used to combat these depredations. Where the damage is acute, the Fish and Wildlife Service has frequently assigned experienced pilots with small airplanes to harass the birds and drive them from the fields of rice or other grain. This method is expensive, not always effective, and is frequently dangerous to the operator, but it is a method which must apparently be continued as a permanent part of the waterfowl restoration programme, because wherever waterfowl refuges are established and large populations of birds are encouraged in agricultural areas, conditions arise sooner or later where the concentration of birds causes damage to agricultural crops, and this means of harassing them must be used. Frightening measures, including mechanical frightening devices, as well as pyrotechnics and firearms, are used to some extent, but are only locally effective. The most promising long-range measure for the prevention of excessive depredations by ducks upon rice-fields, particularly in California, appears to be the acquisition of special areas as "management areas" where rice will be grown especially for the ducks in order to entice them from the neighbouring rice-fields.

Blackbirds, starlings, cowbirds, grackles and sometimes other birds, are very gregarious in fall and summer, and they frequently cause excessive damage to crops, particularly maize and rice. The damage to the rice-fields in Arkansas and Texas from these species has increased so greatly during the past few years that the Fish and Wildlife Service has been persuaded to initiate a full-scale investigation for the purpose of developing control measures if possible. Because these birds are wintering and have come from widely scattered parts of North America, it seems unlikely that any reductional control measure, such as poisoning the birds, will be satisfactory. That method was used with some success on a resident species of blackbird in California, but dealing with migratory birds is, of course, a much more complex problem. In the present instance, no proved control measures have yet been devised, but it appears that the most promising ones are ecological manipulations, to make the area less attractive to birds, so that the tremendous aggregations will not develop in the immediate vicinity of the rice-fields.

The introduced starling is becoming a widespread problem since its numbers and range are still increasing rapidly. In some of their roosts, such as public buildings in large cities, the birds simply constitute a nuisance by defiling the buildings with their excreta, where they roost in large numbers. In other areas, such as the small fruit-growing sections of New York, they are a serious economic problem, because of the quantity of cherries they destroy. On some public buildings in large cities the starling roosting problem has been considered so important that expensive high voltage electrical circuits have been installed, and success has been reported, at least in the initial trials. Unfortunately, the successful systems are very expensive. The obvious cure, to design the buildings so that they lack roosting places, is being practiced now by some architects.

In various parts of the world gulls, frequently herring gulls (*Larus argentatus*), have become so troublesome as to require reduction in their numbers. This has been the case for several years along the coast of Maine, and more recently in the Canadian maritime region. When unduly numerous, herring gulls prey excessively upon the eggs and young of various beneficial species, and their numbers in some sections have become too great for the populations of other birds in the same general area. Along the coast of Maine, representatives of the U.S. Fish and Wildlife Service have developed a technique which has been very effective in reducing the population of herring gulls, and since this problem is widely distributed, and particularly since the technique is certainly applicable to other colonial species, a brief description of it seems appropriate.

The method consists in spraying a very light oil upon the eggs in the nest. The oil seals the air pores in the egg shells, thus killing the embryo in the egg. The parent birds continue incubating the eggs for some weeks, and do not renest as they do if the eggs are collected or destroyed. The U.S. Fish and Wildlife Service, in co-operation with the State of Maine, has conducted this type of control measure since 1940. Their records show that in the years 1940 through 1948 a total of over 450,000 herring gull eggs have been sprayed, and over 90,000 double-crested cormorant eggs have likewise been sprayed since 1944. The 1948 report of these activities showed that a substantial decrease had been effected in the numbers of the herringgull since 1944, but that the cormorants had not yet been reduced. In regions where the eggs of gulls and other wild birds are utilized as food, the method described here would, of course, not find favour.

Following the second World War, there was a tremendous interest in the use of radar and supersonic sounds in bird control. Both have been investigated to some degree by the U.S. Fish and Wildlife Service, but there is no convincing evidence at present that either supersonics or radar can be of the slightest possible value in the control of bird populations, despite the exaggerated claims which were frequently heard following the war.

PRODUCTION OF MIGRATORY GAME BIRDS

Because of the tremendous value of the migratory game birds, such as ducks, geese, and swans, woodcock, snipe etc., the Federal Governments of the United States and Canada have conducted both intensive and extensive investigations into the methods which are practicable for increasing their numbers. A review of the chief techniques used for these purposes will be made.

It cannot be denied that the effect of hunting by from a half-million to over 2 million sportsmen in the United States, and smaller but significant numbers in Canada and Mexico, is a very considerable and significant mortality factor operating against these birds. The most serious efforts, therefore, are expended in determining the current status of the population so as to adjust the liberality of hunting regulations according to the current supply of birds. This means that methods of estimating the breeding population of waterfowl with reasonable accuracy must be developed, and while experiments into more accurate and practical methods are still in progress, it is appropriate to describe those which have been used with some effectiveness for several years.

Midwinter inventory

Since January of 1935, the Fish and Wildlife Service has been conducting an annual midwinter inventory of the North American waterfowl population. It is known that in January the waterfowl are most concentrated on their wintering ground, most stationary in their movements, and it is then easiest to estimate their numbers. Even at this season, of course, the task is a herculean one, and has been attempted only with the assistance of several hundred voluntary co-operators. For some years, the Fish and Wildlife Service attempted to translate the annual January inventory into an estimate of the total North American population of wintering waterfowl, but such an estimate cannot, of course, be very accurate, and it has been concluded that it is best to express only relative figures, with the trend from one year to the next indicated, but with no attempt to estimate the total numbers. The basic assumption that at this season the birds are most easily located and therefore most easily counted, is certainly correct. Even in January, however, the North American population of waterfowl is scattered over such a wide territory that it is a practical impossibility to make any accurate total estimate. It is so important, however, to secure the best possible measure of the status of birds at that season that the Fish and Wildlife Service, together with the Dominion Wildlife Service of Canada, is continuing the attempts to secure the most accurate possible inventory in midwinter.

A number of methods are employed. Airplanes, and in a few instances dirigibles, are employed to secure the estimates from overhead. In some cases, large flocks of birds are photographed, and the counts later made from these photographs. This, of course, makes it possible to secure a thoroughly accurate count of the birds in the photograph, but there are so many conditions under which aerial photography is not feasible that it cannot be looked upon as the completely practical solution. The use of the airplane, however, makes it possible for a relatively few trained observers to cover much greater portions of the waterfowl wintering areas, and this does tend to make the results more and more accurate. Since January 1947, the Fish and

Wildlife Service has been conducting a very extensive aerial survey of the main water-fowl breeding ground of coastal Mexico, and for two years aerial surveys have been made of the more important wintering areas in the West Indies. These, together with the more intensive coverage of the water-fowl wintering areas in the United States, Canada and Alaska, which are still being conducted with the aid of some 1,200 to 1,300 volunteer observers, do constitute a tremendous mass of information which, though not thoroughly accurate in a statistical manner, does furnish the best available means of estimating the status of the entire North American population of Anatidae.

The methods employed upon the breeding grounds are entirely different, and while they have been improved year by year, they appear already to have a reasonable degree of reliability. In the United States these efforts have been made with the full co-operation of the State game departments and the Fish and Wildlife Service, while in Canada the U.S. Fish and Wildlife Service, the Dominion Wildlife Service of Canada, and the game branches of the provincial governments have worked in close co-operation. All agencies concerned deserve due credit for their efforts to develop the very important techniques of estimating breeding populations. Only if the relative population and reproductive success of water-fowl can be determined with a reasonable degree of accuracy during May, June and July, are the results practicable for application in determining the degree of liberality which will characterize the hunting season in Canada and the United States during the ensuing autumn. Substantial crews of water-fowl biologists are, therefore, engaged during the period from late April through early July in making intensive studies throughout the important water-fowl breeding grounds of the number of breeding birds which are occupying the various types of habitat. Quantitative methods have been developed which depend upon conducting an accurate count of the number of breeding water-fowl observed on a strip one-quarter of a mile wide as it is traversed by the observer, whether he be travelling by automobile along the roads, or whether he be flying by light airplane over the roadless areas. Both methods are employed and some 30,000 to 100,000 miles of these sample strips are traversed each year. As far as possible, the same routes are studied year after year, and the relative number of water-fowl observed on them provides a reasonably accurate index to the status of the population, and permits the administrators of the Fish and Wildlife Service or the Dominion Wildlife Service to recommend a hunting season which will be based upon actual measurements of the population.

The establishment of refuges as a water-fowl management technique is one which has long been practised in the United States, but particularly during the past fifteen years. There are now about 200 Federal water-fowl refuges totalling nearly 3,125,000 acres, and the number of such areas established by the various states is probably equally high. On a few of the Federal refuges portions are open to hunting by the public, but the majority are closed to all hunting. These Federal and state refuges are an important factor in maintaining a stock of breeding water-fowl, particularly during years of drought.

Control of important water-fowl diseases is difficult, but merits attention. One of the most important single causes of water-fowl mortality in North America was the botulism (western duck sickness), which sometimes killed hundreds of thousands of ducks in single years near the north end of Great Salt Lake, in Utah. Fortunately, the research on this problem by the U.S. Fish and Wildlife Service has developed reasonably successful methods of preventing these losses in areas where control of the water levels is possible. The duck losses from botulism in Utah have been reduced to a small fraction of their former importance. At present, there appear to be no satisfactory techniques, or even promising possibilities, for controlling two other important water-fowl mortality factors in North America, lead poisoning and fowl cholera. Active research, however, is in progress on each at several centres.

The banding, or ringing, of water-fowl constitutes a most important research technique which has thus far been used only very little on problems of management. To be sure, banding has been employed as a method of bird study for many years, but almost entirely for aspects of ornithology, having little to do with management. To be of real value in management, banding must be conducted in quantity and the results analysed statistically for validity. In North America, where a single banding system has been employed by the United States and Canada, and where a clearing house is maintained in Washington for all recoveries of banded birds, the opportunity for such statistical studies exists; but even here, until very recently, banding had not been utilized to the extent desirable to yield management information. A few of the important types of data which banding can yield should be mentioned:

1. The total population of water-fowl in even the continent of North America might theoretically be calculated, as proposed by Frederick Lincoln (the "Lincoln index") if we had an accurate measure of the total number of birds taken by hunters—by the ratio, total population: total birds shot: total birds banded: number of banded birds shot and reported. Having three parts of the equation, we could easily solve the fourth, but unfortunately, we have not been able to secure accurate data on the necessary three.

2. The proportion of ducks taken by hunters each year, for example, should be indicated clearly in the proportion of banded ducks returned. If an attempt is made to reduce hunting pressure, as has frequently been done, by shortening the season, reducing the bag limit, or prohibiting certain effective aids to hunting, those restrictions should be reflected accurately in the proportion of duck bands returned during such seasons, as compared with other seasons. Unfortunately, it is only recently that such studies have been initiated even in North America where nearly 700,000 Anatidae have been banded, and over 100,000 recoveries have been reported.

3. The total kill of ducks by the tremendous army of 2 million duck hunters in the United States is a problem difficult of solution, but banding may eventually solve it. If the kill of any large area or sample, as for example, one State, can be determined with reasonable accuracy, then band returns in sufficient quantity could theoretically make the precise information from the one area or sample applicable elsewhere. To use an over-simplified hyphotetical case, suppose that on 100 public hunting areas scattered throughout the United States a careful record is kept of the total number of ducks taken, and the number of banded

ducks in that total. Unless there are qualifying circumstances, the ratio of banded birds to unbanded birds taken on these few hunting areas should be the same as the ratio on other areas. If, therefore, on the hunting areas sampled a thousand unbanded birds are taken for each banded one, then it follows that the total number of banded ducks recovered by hunters in the whole United States needs only to be multiplied by 1,000 to produce an estimate of the total duck kill in the country. This assumes that we have banded ducks evenly scattered throughout the continental duck population, which is not yet true, of course, although that ideal is being approached.

4. The degree to which water-fowl segregate themselves into distinct populations, or to which they use distinct migration routes or "flyways", can be revealed only by banding, and the importance of this information to management is great. If, for example, it is certain that populations maintain themselves so distinct that changes in the population of one group or "flyway" of birds does not materially affect that of another, then our management measures must be adjusted accordingly. This aspect of water-fowl research has been studied extensively, but despite this, our concepts are still subject to change. When the banding returns for a species of duck or goose are studied in detail, it is frequently found that its movements do not conform closely to the traditional flyways which have been popularly accepted for some time in the United States in an over-simplified form. It still appears, however, that the concept of the flyways is, in general, a useful one, particularly in management.

5. The rate at which any water-fowl population disappears—the population turnover—is another important aspect available only through mass banding. Fortunately, several detailed studies of this kind are in progress on different water-fowl, and the results have or are being reported. These data are of inestimable value in management.

Many other examples of the value of banding in management could be cited but for lack of space. The causes preventing the full employment of such a valuable tool cannot be considered in detail here, but it is hopeful that in many parts of the world, including North America, there is an increasing recognition of its value, and it seems clear that the next few years will see tremendous strides in this field.

Limitations of space have prevented consideration of many aspects of the "management of bird resources" which are of outstanding importance. It is to be hoped that they are considered in other papers and the conference discussions. I should like to emphasize that while I have selected my examples largely from North American problems, I am not unmindful of the excellent progress in management in many other countries as well. Game research has progressed during the past decade to a degree hitherto inconceivable. The broad programmes of wildlife research now in progress in Britain, Scandinavia, Finland, Netherlands, South Africa, New Zealand, and the USSR, to name only a few, give much promise for the future management of bird resources, but it must still be emphasized that both research and management are far behind the need.

Administration of Big Game Resources in the United States

ALBERT M. DAY

ABSTRACT

The total United States population of big game mammals is estimated at about seven and three-quarter million animals, of which about two-thirds are white-tailed deer. Other animals present in some abundance are the mule deer, Columbian black-tailed deer, elk, antelope, peccary, and black bear. Relatively scarce animals are the desert and Rocky Mountain big-horn sheep, mountain goat, moose, bison, European wild boar, grizzly bear, and caribou.

A period of extreme depletion was reached for many of these species about the end of the nineteenth century ; the general trend at present is upward. Most available habitat is now occupied, and for the more abundant species, especially deer and elk, the available winter range has become a factor limiting the further growth of populations.

The administration of the principal game-mammal resources has passed beyond the stage of indiscriminate efforts to build up the populations, and has become, instead, a management problem designed to preserve a balance between populations and food supply. This end can be achieved only through extensive and continuing collection of data on the state of these populations and their relation to their environment. Supplementing this research, the public must be educated in the fundamentals of game conservation in order to gain the necessary support for the programme.

The total United States population of big game mammals is estimated at some seven and three-quarter million animals. By far the most abundant and widely distributed species is the white-tailed deer, which comprises only a little less than two-thirds of the total population of big game. A related species, the mule deer, ranks second in abundance, and makes up about 19 per cent of the total. Other reasonably abundant large game mammals in the United States are the Columbian black-tailed deer, elk, antelope, peccary, and black bear. Relatively scarce animals, on the other hand, are the desert and Rocky Mountain big-horn sheep, the mountain goat, moose, bison, European wild boar, grizzly bear, and caribou. We have less than 20,000 of any of these last-named species; and in the extreme case of the woodland caribou, there are only a few individuals.

Comparing the present time with the early years of this century, the general trend of the big-game mammals in the United States is upward. It is probably true that ir no case, with the possible exception of the white-tailed deer, does the population of any of these species approach the great abundance of primitive times. With the spread os pioneering settlers into the wilderness, the growth of townf and cities, the conversion of millions of acres to agriculture and grazing lands for domestic stock, and the industrialization of other vast areas, the habitat of most of the wild mammals shrank. From these causes, coupled with wasteful killing, the big-game mammals had declined by the end of the nineteenth century to a point where many persons predicted their virtual extinction.

Space does not permit a review here of the conservation efforts which, for most species, happily reversed this trend. For some, the conservation movement came too late. Caribou are, for all practical purposes, gone from the United States. We must still practice extreme vigilance and care to prevent loss of the picturesque big-horn sheep. Probably we must be satisfied with preserving token populations of the bison and grizzly bear. But for most other species—especially deer and elk—we have reached the point where it is necessary to think in terms of managing the existing populations rather than attempting to bring about further increase in their numbers.

Only a small fraction of the original habitat of these large mammals remains. With few exceptions, most of the suitable range is now occupied. For most species the amount of winter range is critically small. Our western mountains, for example, in general could provide an abundance of summer feeding for larger game populations than now exist. But the former winter ranges now are largely occupied by farms and ranches. In the northern and eastern sections of the country there is plenty of summer food for deer, the only game mammal remaining in the east in any considerable numbers. The adequacy of the winter deer range varies greatly from one section to another, and also with the severity of the winter, and winter starvation of thousands of deer has become all too common.

The available winter food supply, then, has become the condition which rigidly determines the limit of most big-game animal populations. The populations must be kept in balance with available range and forage. If we as wildlife administrators fail to manage the resource to maintain this balance, Nature does it for us. But Nature's method is both wasteful and inhumane. The death of thousands of animals through starvation is not pleasant to witness. Furthermore, its consequences are far-reaching. Before a herd is thus drastically reduced, it has overbrowsed its range, not only using up all food immediately available, but so seriously damaging and destroying the browse plants that it is many years before the range can recover enough to support any sizable population of animals.

The aim of good management, therefore, must be to detect over-population before it has reached serious proportions, and to take appropriate measures to balance populations and food. Habitat improvement through modifications of timber-management or grazing-management practices can be made to increase game-carrying capacity. Basic to any management measure, however, is an accurate knowledge of the size of the population and of yearly changes in its size. Without such knowledge, the wildlife manager is working blindly.

We in the United States have given much thought and attention to the problem of big-game inventories. Except for some interruptions during the recent war, an inventory of the populations of 15 groups and races of big-game animals has been compiled each year since 1937. The data have been collected by various State and Federal agencies, and have been assembled and compiled by the Fish and Wildlife Service.

To be successful, the method of enumeration must be closely adapted to the topography of the land, the climate, the amount and kind of cover, the habits of the species, the season of the year, and the equipment and man-power available for the undertaking. In a country like the United States, we are confronted with a great variety of conditions, and so have necessarily used a variety of methods.

In making direct counts, we use airplanes extensively for many game species. Ten of our western states are using the aerial census method for antelope, having found it to be cheaper, less time-consuming, and more accurate than the various ground-count methods formerly used. It is possible to evaluate seasonal movements from summer to winter ranges much more accurately from airplanes. Several mid-western States are applying the method with some success to censuses of white-tailed deer. In general, airplane counts are best used in country where the topography is not too rough, in areas without coniferous cover, and in deciduous forests in winter. To an increasing extent, we are supplementing direct observations from planes by aerial photographs, from which actual counts often may be obtained.

In heavily forested areas such as we have in north-eastern United States, airplane counts seldom are practicable, and recourse must be had to ground counts instead. Drives have been used to obtain an accurate count of deer in the dense cover of the north-eastern forests. In these there are two essentials: adequate man-power, and careful selection of the "drive area" so that it may be representative of the region to which the figures are to be applied. A modification of the drive method has been used for mule deer in the more open and shrubby country of the West.

With migratory species such as caribou (and, sometimes, mule deer and elk) counts are made at favourable points along the seasonal migration routes. During deep winter snows, deer are counted where they congregate in "yards", or an indirect count is made from the tracks when the animals first move into the yards. Track counts are often used along roads, shores, or fire lines. Where small areas are involved and animal populations are low, this type of count is fairly satisfactory for all species.

Sometimes it is necessary to attempt an estimate of populations as a substitute for the direct count. The indirect method is, of course, less accurate, but is less expensive and can sometimes be used where direct counts cannot be made. One example of an indirect count is a browsing survey. After a reasonable amount of experience in an area, a good observer can estimate, from the degree of browsing, the size of the animal populations per unit area.

Whatever the method used, regularly repeated censuses must be the basis for intelligent management of the game resources. The census not only indicates what we should do, but provides a measure of success by which to judge the system of management we have adopted.

If a given area is found to be overpopulated—in the sense that the animals are out of balance with the food supply—a reduction must be effected promptly by one or more methods. During the past decade we have done a considerable amount of transplanting of big-game animals from areas of over-abundance to areas of scarcity. Such transplants often are effective in building up herds in new areas; they seldom solve a problem of overpopulation. Sometimes, where winter food is the critical factor, it is possible to provide the necessary winter range by acquiring lands to be devoted to this purpose. A number of our western states have such land acquisition projects under way. The Elk Refuge at Jackson Hole in Wyoming represents an attempt by the United States Government to provide adequate winter range for the herd of elk that summers near Yellowstone Park.

Particularly in the case of deer and elk, it is becoming more often necessary to supplement these methods by a controlled reduction of certain herds in order to prevent over-population, destruction of browse plants, and certain starvation of the animals. Such reduction usually is effected by controlled hunting, except in the National Parks, where, if reduction becomes necessary to save the habitat, it is accomplished by Park personnel. Reduction by public hunting, in order to accomplish the necessary population adjustment, must include the taking of female animals. Over much of the country, public sentiment is opposed to the shooting of does, based on traditions of many years' standing. Some State Game Commissions lack authority to permit the killing of does. There is need for education of the public so that they may understand that the control of the game population is actually in the interest of conservation.

In the United States, regulations concerning the taking of game are almost entirely the responsibility of the various states. The notable exceptions are such public lands as the National Parks and the National Wildlife Refuges. But by far the greater part of our big-game animals are on public domain or in the National Forests, where state regulations prevail. There are, however, certain unifying forces which tend to reduce the diversity in methods of game management which otherwise would exist. Such mediums for the exchange of opinion and experience as the annual North American Wildlife Conference and the International Association of Game, Fish, and Conservation Commissioners are examples.

An even more potent force for unity is the great co-operative program for the restoration of wildlife in which the Federal Government and the various states have been engaged since 1938. This is known as the Federal Aid to Wildlife Restoration programme. It provides for a pooling of Federal and state funds to finance a variety of projects, all directed toward improving conditions for wildlife and toward increasing the populations of game-birds and mammals. The Federal funds are derived from an 11 per cent excise tax on the sale of sporting arms and ammunition. The Federal Government provides from this source 75 per cent of the cost of any approved restoration project; the state contributes the remaining 25 per cent.

Many of these co-operative projects are investigations designed to give administrators the specific facts they need in order to regulate the game resources properly. Other projects have been concerned with such practical work as the transplanting of animals; or the improvement of habitat for game. A considerable percentage of the funds have been spent to acquire lands for such purposes. The program began in a modest way a decade ago but has so thoroughly justified its existence by its splendid accomplishments that it has acquired considerable momentum, and the last two years have seen a phenomenal increase in these activities.

In summary, the administration of the principal game mammal resources of the United States has passed beyond the stage of indiscriminate efforts to build up the populations. It has become, instead, a management problem designed to preserve a balance between populations and food supply. This end can be achieved only through the most complete and accurate knowledge we can obtain as to the state of these populations and their relation to their environment. Such basic research must be complemented by education of the public so that it will support the programme.

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Administration of Game Resources[1]

GOUILLY-FROSSARD

ABSTRACT

Population appraisal

Live game. **Maps have been drawn to show the distribution of the principal species of game in France.**

Dead game. **Before the war the number of game killed annually in France was estimated at 35 million. The statistics for 1946 showed that the numbers of dead game sold in the large towns in that year did not exceed 4 million. Although the scale of black market activities and family consumption could not be ascertained, the disparity of 31 million between the two estimates given above shows that the stock of game in France has not yet reached its pre-war level.**

System of Administrative Regulation

There are two main laws governing hunting and game-shooting:

(1) A *police law*, **of 3 May 1844, established, as its name indicates, the penalties applicable where the provisions laid down by it were infringed. It contains : (*a*) rigid provisions applicable to the whole of France, (*b*) more flexible provisions adaptable to the different areas and giving rise to ministerial or prefectoral decrees.**

(2) *A law on the organization of hunting and shooting :* **The Law of 28 June—27 December 1941 associates sportsmen in the work of game conservation by the payment of a special obligatory contribution, and automatic membership of the departmental branches of the Federations of Sporting Societies. These are controlled by the** *Conseil Supérieur de la Chasse*, **which is the technical adviser to the Ministry of Agriculture in the matter of regulations.**

Value of protected areas

There are in France five national parks, two fully protected areas, four wildlife sanctuaries and more than a million-and-a-half hectares of game reservations.

Costs and economic values

The annual cost of game conservation in France, under the control of the *Conseil Supérieur de la Chasse*, **may be estimated at approximately 500 million francs (1,800,000 sportsmen contributing 300 francs each)—the expense of private shoots has not been included.**

Before the war it was estimated that game-shooting accounted for an annual turnover of 1,939,640,000 francs.

This sum represents about 30 milliards at the present value of the currency.

National benefits

In addition to this important economic benefit, game-shooting is a not inconsiderable element of social progress, since it brings the different classes of society into closer relation.

International problems

The moral tone of game-shooting should be raised by imbuing those taking part with the sporting spirit. Game-shooting need not be a massacre.

Effective protection should also be provided for migratory birds. Every nation should be prepared to make the necessary sacrifices to that end.

Prophylactic measures should be taken to avoid the transmission of infectious disease-germs by game imported alive from abroad.

Public Relations and Education in Conservation

In France, the *Conseil Superiéur de la Chasse* **maintains close relations with sportsmen through the Federations and the gamekeepers employed by the latter. These receive suitable technical training at the Gamekeepers' School at Cadarache, and are qualified to teach the most rational methods for the repopulation of reserves and the conservation of game. The** *Conseil Supérieur de la Chasse* **tries to reach the masses more effectively by means of broadcasts, for the education of the public in sporting matters is far from complete.**

A civilized sportsman should not indulge in needless slaughter. He should contribute to the maintenance of the biological equilibrium in nature. His education should be started during his schooldays.

Any wild animal, whether fit for food or not, naturally living in a state of freedom and generally hunted, is defined as "game" in French legal terminology.

The present note makes no mention of birds of passage, the study of which constitutes the special subject of other papers being presented at this meeting.

POPULATION APPRAISAL

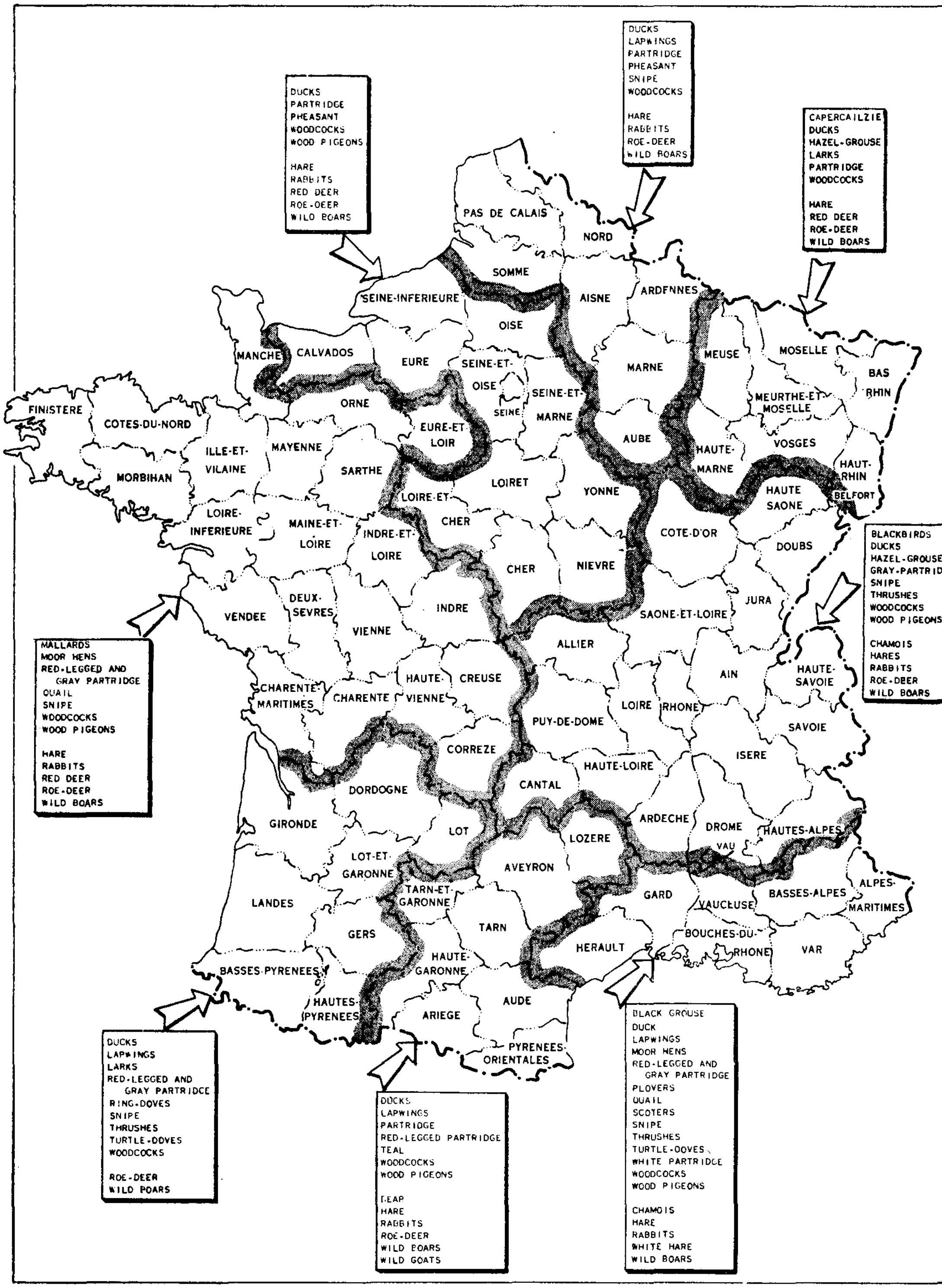
Live game. Save in very exceptional cases, the appraisal of the wildlife population of a region of any size is almost impossible owing to the mobility of small fur and feather game. Only the numbers of the larger game animals, (except the wild boar, owing to its nomadic habits), can be ascertained, provided that operations are restricted to a comparatively small area, and that a large staff with an adequate knowledge of wildlife is available.

The larger animals are in the first place not very numerous and they leave traces on the ground which make it easy to identify the species, the sex and even the number of animals.

In the State forests particularly, it is often possible to arrive at a fairly exact estimate of the numbers of red deer

[1]Original text : French

Provisional edition



FRANCE: ZONES OF DISTRIBUTION OF THE PRINCIPAL SPECIES OF GAME

Source: Sketch map provided by the author

MAP NO. 21x UNITED NATIONS UN PRESENTATION 1278 and roe deer. Many of the State forests possess a network of forest roads which makes it easier to count the animals by the isolation of individual areas. Further, the supervisory staff employed by the Waters and Forests Administration includes gamekeepers who have acquired from long experience a thorough knowledge of the habits of these animals.

It has thus been possible to establish the fact that in large leafy forests bounded by arable land, it is only possible to allow two head of deer per 100 hectares without damage to the rural economy. But these censuses are exceptional. Generally speaking, all that can be done is to determine the zones of dispersion of the principal species of game. It has thus been possible in France to prepare a series of maps divided into sectors containing several departments, or sometimes a single department, and showing the different species of game to be found there.

Conventional signs indicate whether the species are very common, common, infrequent or rare.

In the *Pavillon du Bois* at the 1936 International Exhibition in Paris, there was a wall map which showed at a glance the distribution and density of wildlife in France. The attached map gives a sufficient general idea of this distribution.

Very detailed studies of this type have been made concerning certain species by specialists in the biology of wild animals.

Thus, Dr. Couturier, of Grenoble, in his remarkable work on the chamois, has made an extremely detailed study of what is termed the "*chorologie*" of the chamois, that is to say the geographical distribution of this "typical denizen of the Palæarctic region".

The *Conseil Supérieur de la Chasse* is associated with these studies. On the proposal of its Commission on Scientific Studies it recently established models of ear-marks and rings to be used on game introduced for repopulation purposes with a view to ascertaining their habitat by tracing their movements.

Dead game. Although, with the reservations quoted above, live game manages to escape any really accurate census, the numbers of dead game can be estimated with fair precision.

Before the war, for example, all game brought into the large towns was subject to a toll duty. The toll statistics made it possible to ascertain the quantities brought in. The tolls having been abolished, this source of information has disappeared. But the Commissariat of the *Halles Centrales* of Paris continues as in the past to keep statistics of the numbers of game sold in the markets.

It was estimated in normal times that the sales of game in the markets of the capital were about one-tenth of the sales of game in the principal provincial towns.

The statistics for 1946 showed that 410,000 head of game were sold in Paris. It may be deduced from this that during the same period the total amount of game sold in the large towns of France, Paris included, was more than 4 million head, excluding the black market and family consumption.

Whatever may be the importance of the two elements last mentioned, which it is impossible to estimate, we are still very far from equalling the numbers of game estimated as killed in France in an average year before the 1939-1944 war. These were estimated at 35 millions divided as follows:

Wild boar	20,000
Roe deer	10,000
Stags and hinds	3,000
Hares	1,000,000
Rabbits	16,000,000
Partridges	4,000,000
Pheasants	500,000
Birds of passage (including water-fowl)	3,500,000
Total	35,503,000

These figures show that the amount of game in France has not yet reached the pre-war level.

SYSTEMS OF ADMINISTRATIVE REGULATION

Game, being a source of wealth, is protected by the public authorities. The French legislation contained two principal laws on hunting and game-shooting: the older of these is dated 3 May 1844, and is a police law on hunting. It has been amended ten times since its promulgation to keep it up to date. In France written law has taken the place of customary law.

The most recent is the Law of 28 June—27 December 1941 on the organization of hunting and shooting.

Police Law on Hunting and Shooting

The Law of 3 May 1844, as its name indicates, consists only of police regulations. Some are rigidly fixed and are in force throughout France. Others are more flexible, and lay down general principles, the application of which is left to the discretion of the executive.

In a country like France, where there is such a diversity of climate, soil, relief and hydrography, and therefore of crops, the wildlife is also very varied, and it was logical to take such a step to allow adaptation of the regulations to the conditions in different regions.

Amongst the regulations valid throughout France, mention should be made of the sportsman's obligation: to obtain a game licence whenever he wishes to hunt or shoot elsewhere than in his "possessions adjoining a dwelling and surrounded by a continuous fence preventing any communication with neighbouring estates, and entirely preventing the passage of men and fur animals"; and only to shoot, or to hunt "*à courre, à cors et à cris*" according to the old expression used in French venery,[1] or with nets and ferrets in the case of rabbits. Any other methods of hunting, including aircraft and motor-cars, even for beating, are prohibited.

Amongst the more flexible rules, the application of which is left to the discretion of the executive, may be noted the fixing by Ministerial Decree of the opening and closing dates of the hunting or shooting season, which necessarily varies according to the regions. It is necessary to pay due regard to the harvest and the state of development of the game. (The open season lasts as a rule for about four months).

The Prefects, by delegation of the Chief of the Department of Agriculture, may issue decrees to forbid hunting or shooting when there is mow on the ground ("to prevent

[1]Before the war there were sixty packs for hunting deer or wild boar, with 2,000 hounds, and twenty packs for hunting roe deer, with 600 hounds.

the destruction of birds or to promote repopulation"), or to authorize the holder of a game licence to catch certain types of game even with prohibited devices in order to release it for purposes of repopulation. The second clause allows them to prohibit the shooting of certain types of game-birds which are becoming scarce or dying out.

It may be noted that French law takes care to distinguish between hunting proper and the destruction of harmful animals, especially in the closed season, because these two activities have not the same purpose in view.

The chase is a form of diversion, and is undertaken purely for pleasure. The destruction of harmful animals, on the contrary, becomes a necessity for the owner of land, who is entitled, and indeed bound, to protect his crops or stock against the incursions of predatory animals.

Law on the Organization of Hunting and Shooting

The law of 1941 deals with the organization of hunting and shooting. It is based on a very original principle, namely, that sportsmen are directly associated in the work of game conservation: (*a*) by the compulsory payment of a special contribution for this purpose at the same time as the licence fee. The procedure of collection ensures that this money cannot be used for any other purpose than game conservation; and (*b*) by automatic membership of the departmental branch of the Federations of Sporting Societies. The Federations are controlled by a central body, the *Conseil Supérieur de la Chasse*, which collects the fees mentioned above for distribution subsequently among the Federations.

The *Conseil Supérieur de la Chasse* is under the chairmanship of the Director General of Waters and Forests, and includes amongst its members a majority of the Presidents of Federations.

Its functions are administrative, technical and advisory. As regards regulations, it acts as technical adviser to the Ministry of Agriculture.

Need for a Game Conservation Law

Before the French Revolution hunting and shooting were reserved for certain privileged people and under the July Monarchy they were the prerogative of the rich, but after that they became progressively more democratic. Thus the police law of 3 May 1844, which applied to 125,000 sportsmen, rapidly became inadequate, particularly after the First World War, owing to the increase in the number of sportsmen from 617,000 in 1913 to 942,000 in 1919, an increase which was not compensated by a corresponding increase in wild game.

The association of the sportsmen with the work of game conservation, under the Law of 28 June—27 December 1941, constituted a notable step forward. But this is no longer adequate and something more needs to be done.

The next stage would be a rational game conservation programme without which 1,800,000 French hunters might be obliged to lay down their arms for lack of game. Since its establishment, the *Conseil Supérieur de la Chasse* has been working to prepare such an essentially democratic law, and it is to be hoped that the problem will soon be solved.

To sum up, the police law, the law on organization and the law on conservation constitute the steps in the inevitable evolution of hunting legislation in France along democratic lines under the pressure of numbers.

VALUE OF PROTECTED AREAS

The *Conseil Supérieur de la Chasse* encourages as much as possible the constitution of scientific or game reservations by granting cash subsidies to non-official bodies managing them.

It has adopted the following classification for these reservations:

National parks, open to tourists, for the purpose of popular scientific education.

Fully protected areas, where no human interference is allowed, to render possible the study of the behaviour of the fauna and flora exposed only to the influences of the biological forces of nature.

Sanctuaries, where certain types of game, the extermination of which is feared, are completely protected.

Game reservations, the purpose of which is to promote the breeding of game solely for sporting purposes. They include national, inter-departmental, inter-communal and communal reservations.

In order to be of real use, a game reservation must fulfil certain conditions: it should preferably be situated in the centre of the hunting area the population of which it is to regulate, should consist of ground corresponding to the habitat of the game, be of sufficiently large extent, have natural boundaries easily distinguishable by the game, and be sufficiently distant from traffic highways and pasture land, in view of the danger to the game from sheepdogs. Young game returns to the reservation from inherited instinct when in danger, and full-grown game spreads to neighbouring grounds when it becomes too numerous in the reservation.

Game reservations are of great importance in countries where there are large numbers of sportsmen.

The annexed table shows the distribution in France of national parks, fully protected reservations and sanctuaries.

It may be added that in 1939 the game reservations covered 1,775,678 hectares and were marked by more than 80,000 signs.

They have been fully reconstituted and are even on the increase.

COSTS AND ECONOMIC VALUES

The annual cost of game conservation in France may be estimated at about 500 million francs, excluding private expenditure which is difficult to assess. This corresponds to the compulsory contributions for game conservation payable in addition to the fee for the game licence as indicated above (approximately 1,800,000 sportsmen pay 300 francs each for this purpose). With these funds the *Conseil Supérieur de la Chasse* and the Federations are undertaking the restoration of game areas by releasing game on the reservations, trapping and supervision. In 1938, for example, the following were released: 19,261 grey partridges (pairs); 2,595 cock pheasants; 8,001 hen pheasants; 20,327 hares; and 39,452 rabbits.

In relation to this sum of 500 million francs, an attempt must be made to estimate the value of hunting, both in

Distribution of Reservations in France

Department	*Name*	*Area in hectares*	*Protected Species*	*Managing Organization*
		National Parks		
Isère	Le Pelvoux and La Bérarde:	22,000 ha.	Chamois, grouse, ptarmigan, white hare	Administration of Woods and Forests
Haute-Savoie	Les Bauges	10,000	Chamois, roedeer, grouse	Administration of Woods and Forests
Basses-Alpes	Lauzanier	3,000	Chamois, grouse, ptarmigan, marmots	National Society for Acclimatization
Basses-Pyr.	Néouvieille,	2,200	Grouse, ptarmigan, white hare	National Society for Acclimatization
		Natural Reservations		
Bouches-du-R.	Camargue,	10,000	Migratory birds	National Society for Acclimatization
Ariège	Montvallier,	8,000	Izard, bear, white hare, capercailzie, ptarmigan, partridge	Ariège Federation
		Sanctuaries		
Morbihan	Sept-Iles,	Island in the sea	migratory birds, particularly puffins	National Society for Acclimatization
Basses-Pyrénées	Pic du Midi d'Ossau	10,000 ha.	Izard, bear	Basses-Pyrénées Federation
Ariège	Burrus Reservation	3,700	Izard	Ariège Federation
Alpes-Marit.	Borréon	3,500	Chamois, ibex	Ariège Federation. Alpes Maritimes Federation
		Hunting Reservations		
		Ad memorium		

receipts for the French Treasury and as a means for circulating wealth.

The review of the *Comité National de la Chasse* published a study on this question, details of which are given in the annex, in 1938. This document shows that at that period hunting was bringing into the State and communal treasuries a sum of 264,940,150 francs, and was creating, by sales of game, special resources amounting to: 17,700,000 francs.

Lastly, it was contributing to an increase in the circulation of wealth (manufacture of cartridges, weapons, breeding of game, hounds and horses, clothing and gamekeepers' wages to an amount of 1,652,000,000 francs; making a total of 1,934,640,150 francs.

Bringing these figures up to date by using a conversion co-efficient of 15, this sum would now correspond to at least 35 milliard francs, taking into account the increase in the fee for game licences. We have intentionally taken the co-efficient 15 instead of 19[2] to make allowances for factors which could only be accepted *mutatis mutandis*.

NATIONAL BENEFITS

To the economic advantages which we have just indicated should be added social advantages, the importance of which should not be under-estimated. Hunting provides its 1,800,000 devotees with healthy pleasure and beneficial recreation.

In touch with nature, under the stimulus of difficulties to be overcome, differences of opinion lose their acuteness, the remembrance of partisan conflicts grows dim and gives place to a truer understanding of affairs and of relative values. Brought together by sport, men of feeling learn mutual esteem and seek rather to draw closer to each other than to be divided.

Hunting and shooting are thus an element of wealth both from the economic and social points of view.

INTERNATIONAL PROBLEMS

Amongst the international problems arising in this field, the two most important are, in our opinion, those having reference to the establishment amongst the masses in each nation of a hunting or sporting spirit and the effective protection of migratory game-birds.

To create a hunting or sporting spirit—and we shall return to this point in the section on education—means to inspire a popular feeling that certain actions held to be lawful should nevertheless be repudiated by any civilized sportsman. Sport does not consist of taking a defenceless animal as a target for the pleasure of using firearms. To hunt in a true sporting spirit is to seek out and pursue a wild animal which is given a sporting chance. To act in any other way is mere slaughter.

The second problem concerns the protection of migratory game-birds.

It may be recalled that the International Convention of 1902 for the protection of birds useful to agriculture is due for revision, principally because the concept of the harmfulness of animal species no longer corresponds to the present data available to science concerning the idea of biological equilibrium in nature.

It is to be hoped that at the international conferences on this subject, each country represented will sacrifice unreservedly its preferences, its customs, even its traditions or economic interests, in favour of international regulations ensuring the effective protection of migratory birds for the benefit of the community of nations.

[2]The index figure of retail prices in 1938 being taken as 100, the figure for February 1949 was 1,850, and that for wholesale prices 1,950. This means that the co-efficient for both is approximately 19.

As regards sedentary game, the only question to be borne in mind is that of prophylactic measures to be taken to avoid the introduction of contagious disease germs by the importation of foreign live game. Such germs might include bird plague, which decimates whole flocks of domestic birds, or tularemia, which may be transmitted to man.

Another problem of a more specialized nature may be mentioned: that is, the issue of game licences to aliens passing through a foreign country. An international agreement on the subject should be concluded.

PUBLIC RELATIONS AND EDUCATION IN CONSERVATION

We have described the satisfactory method whereby the sportsman is associated with the work of game conservation in France. The *Conseil Supérieur de la Chasse*, which acts as technical adviser to the Ministry of Agriculture, keeps in touch with all the sportsmen in France through the Federations to which they are affiliated and through the keepers employed by the latter organizations. These, having received suitable technical training at the Gamekeepers' School at Cadarache, which is under the Council's supervision, are qualified to teach the most rational methods for the repopulation of hunting grounds and the conservation of game. In order to reach the heart of the masses, and to obtain a wider audience amongst sportsmen, the Council frequently has recourse to broadcasts, for the sportsman's education, although it is making progress in France, is far from complete; there are many hunting problems to which the majority have not given a moment's reflection. To observe the letter of the law is certainly, socially speaking, an excellent thing in itself, but the law does not contribute to the improvement of the individual himself, who may think that he can do what he likes as long as he keeps the law. Does the average sportsman think of the abuse of the law, or of the moral duty incumbent on any civilized man to distinguish between hunting and indiscriminate killing, of the necessity of sparing animals still too young to reproduce their species, of avoiding the infliction of needless suffering, and of refusing to engage in mass slaughter without definite purpose?

How many sportsmen have given a thought to the question of the equilibrium between living beings established by nature, and to the damage which may be done, owing to the instability of this equilibrium, by thoughtless acts committed by sportsmen?

While sportsmen must be acquainted with the extent of their legal rights and obligations, they are also bound to conduct themselves like civilized beings, by submitting their behaviour as hunters to the test of their moral responsibility towards the harmless animal, in order to contribute to the conservation of the species.

A crusade to raise the moral tone of hunting should begin at school, because knowledge acquired in childhood remains, if not always present to the mind, at least within easy recall.

Management of Wildlife Resources[1]

A. URBAIN

ABSTRACT

The management of the wildlife resources of Nature should not be confused with the question of the protection of Nature. Further, it is necessary to give a precise, but broad definition of what is meant by the word "game", classifying under this heading both mammals and birds hunted for food, or for commercial, industrial or sporting purposes.

The administration of furbearing game resources, i.e., mammals, can only include a relative appraisal of population in a well-defined area. The administrative regulations which govern these inventories are dependent on local hunting societies, regional federations of the societies or higher bodies established in line with them ; on State organizations, bureaux or administrative offices of the animal industries, under scientific control, which have at their disposal all the necessary documentation and draw up the regulations. The management of wildlife is linked to national economy. It raises international problems which can only be settled by international conferences, and it presupposes special education of the public.

The management of winged-game resources depends on the same general considerations as those noted above, but the migratory movements of birds, owing to their power of flight, make it difficult to estimate the number of birds and may cause great changes in their geographical distribution. The establishment of ornithological stations and the method of banding in certain regions are the only possible means of settling these questions. The conservation of birds as destroyers of harmful insects or producers of useful products (guano and phosphates) is a matter for special regulations.

The management of wildlife resources should be established upon scientific bases, as regards breeding, numbers, length of life and geographical distribution, habitat and the diseases to which birds and animals are subject. The classification and nomenclature of the mammals and birds that constitute game should be in accordance with the most recent data of zoology. The establishment of biological stations in areas abounding in game would make it possible to carry out the necessary studies preliminary to drafting wise hunting regulations.

Though the question of the "management of wildlife" has been raised during the last twenty years in various regions of the world, it is still far from covering all territories and has thus been only very inadequately resolved.

It must be said at once that this question does not always present the same aspect, that the conditions in which it appears are various, that the methods of study or the technical procedure in connexion with it cannot always be the same, and are thus extremely varied.

Generally speaking, this question of the management of wildlife has been dominated for the last twenty years by solicitude for the "protection of Nature", particularly protection of the fauna, and the real problem, which is that of faunal inventories of the mammals and birds of certain

[1]Original text: French

regions, and the study of the variations observed in these animal populations, has in many cases been distorted by the problem of the protection of Nature. More attention has been paid to "natural reserves" than to "hunting reserves", though the latter are more important in the management of wildlife. It must, however, be admitted that stricter and more numerous regulations have been drafted in many countries, but they have not always been very rigorously applied and the results have not generally been as good as might be hoped.

Any summary of the questions relating to the management of wildlife resources should start, to avoid confusion, with a precise definition of the word "game". Game should include all creatures, both mammals and birds, which are hunted for food. Birds cannot be excluded from this definition, as witness the well-known expressions "fur-bearing game" (mammals) and "winged-game" (birds), "water-game" (seagulls, terns, scoters, ducks, teal, snipe etc.), "migratory game" (migratory birds, bustard, woodcock, plover, wood pigeon, turtledove etc.).

Perhaps consideration could be given to the suggestion that the sense of word "game" (*"gibier"*) should be widened to include other species of mammals and birds which are not hunted exclusively for food.

Many species are killed for industrial purposes, to obtain certain products such as fats, hides and leather, and fur, such as for example certain Cetacea (whales and Balaenoptera, dolphin and porpoises), and certain marine carnivora (seals of various types, sea-otter), and these are certainly game.

All the ungulates of the genus Bovidae, bovines properly speaking, various species of antelope, large and small gazelle, which are killed entirely for sporting purposes and for the trophies they provide rather than for the food obtainable from them, are also undoubtedly game in the real sense of the word.

Thus, in any international conventions on hunting, it would be necessary to make a zoological definition of the word "game" (*"gibier"*) as soon as possible in the interest of clarity in the texts to be established.

The administration of furbearing game resources, that is to say mammals, should include first of all a population appraisal of the different species in a given region. This appraisal is difficult and will always be relative. It will of course be easier on a reserve where the constant supervision of animals in a limited area makes it possible to count them fairly accurately and to divide them into male, female and young. This counting will generally be impossible in non-protected areas, where the animals have complete freedom of movement and can disappear from one region and reappear in another, sometimes appearing among other species, though without intermingling.

The systems of administrative regulation which govern such inventories vary in their nature. They are very often private organizations, such as local hunting societies, and regional federations of these societies, most frequently associated in a higher national body controlled by the State which, under the existing laws, controls the distribution of game, deals with the establishment of game reserves, decides upon necessary repopulation with certain species which have become scarce in some regions and determines the conditions for hunting within the framework of the existing laws. Such organizations exist in western Europe, particularly in metropolitan France, and their importance as shown by the results obtained in the conservation and improvement in the condition of game cannot be denied.

In another form of regulation, the authority is vested under the law, in regularly constituted state organizations which bring together those representatives of scientific establishments, of hunters and of the administration best qualified to prepare regulations concerning the state of game at any given moment, its conservation and hunting. Such an organization is the *"Conseil Supérieur de la Chasse pour la France d'Outre Mer"*, founded in 1945, whose authority is exercised by an Inspector-General of Hunting in the Colonies and by regional inspectors who work in given areas. In other cases the management of wildlife resources is carried out by the bureau or administrative officer of the animal industries, with a scientific or administrative staff specially detailed for the purpose. This Anglo-American method is certainly the best, as it facilitates the assembling of documentation derived from the sources themselves on the condition of game in the principal regions of the territory or upon the evolution of certain species, documentation which is particularly valuable when drafting hunting regulations. It is to be hoped that this method of organization, an essential characteristic of which is the establishment of services and the provision of a specialized staff, will become general in all countries.

The advantages of wildlife management properly understood are very important for the national economy of a country. Game is a very useful food resource and in certain regions and at certain times of the year, it assumes considerable importance. It is, however, necessary that game should be constantly supervised, in order to achieve a rational exploitation which will depend upon its evolution and consideration for the future.

Wildlife management poses certain international problems, which are sometimes of great importance, both for the economies of adjacent countries and for the protection of certain species (concordance of hunting regulations, establishment of international reserves in forest areas, etc.). The establishment in Europe of an International Hunting Council has already shown how important this matter is. Further, the international conventions for protection, such as the International Convention relative to the Preservation of Fauna and Flora, signed in London in 1933, the International Convention of 1902, between the United States, the United Kingdom, Russia and Japan regulating the hunting of seals in the North Pacific, and the establishment of the International Office for the Protection of Nature by the International Conference at Fontainebleau in 1948, are welcome signs of progress in the field of international co-operation in the study and preservation of world fauna.

The provisions enacted nearly everywhere in the world for the purpose of wildlife management will not, however, assume their proper importance until the public becomes really interested in these matters, and this raises the question of the pressing need to educate the public. This education, which, generally speaking, starts at school with the children, and which is now greatly assisted by documentary films of good quality, must be directed more and more towards the masses in the home country and the indigenous masses in the territories of the various Unions. It must be definitely of a scientific, technical and juridical nature, so that the citizens of all countries may become as conscious of their duties as of their rights in respect of hunting and wildlife management.

All the considerations set forth in the preceding paragraph in respect of game in general and furbearing game in particular are applicable to bird management, that is to say the management of winged game. However, certain special features of bird-life, particularly the large-scale migrations rendered possible by their powers of flight, make it more difficult to estimate their numbers than in the case of mammals, and are an obstacle to studies on geographical distribution. Knowledge of the migratory habits of different groups of game birds, (most of which are migratory), is of the utmost importance to hunting, as is knowledge of wintering places, the flyways followed by the birds in their migration, and breeding conditions, a knowledge which has considerable bearing on the very future of hunting. In this connexion, the establishment all over the world of large numbers of ornithological stations for the study of migration, whose activities are ceaselessly expanding, is making available information of considerable interest in relation to wildfowl management. Among these results particular mention may be made of studies recorded in the Old World on the subject of starlings, Corvidae, herons, Anatidae, quail and the white storks of North Africa.

Large-scale research programmes have been drawn up in connexion with the migration of other species, particular attention being paid to the future of game introduced for the repopulation of certain regions. It is thus desirable that the number of research stations working on migration and the general biology of birds should be increased, and that all necessary material and financial means should be granted them to extend their means of study. To this end, the experimental method of banding birds, introduced in recent years, should be made general. This method consists of placing an aluminium ring bearing identification marks on the leg of a migratory bird. This banding, carried out when the bird is still in the nest, or when it has been captured in the course of its wanderings, enables its movements to be followed. This method, however is only effective when subjected to a strict control by scientists capable of collecting and interpreting the information obtained.

The problem of the conservation of useful birds is closely linked with that of hunting and consequently with the problem of bird management. In addition to the need for safeguarding as far as possible birds useful to agriculture, the conservation of birds producing useful products, particularly fertilizers, should also be considered. In addition to the guano produced on the Pacific Coast of South America, which has long been so usefully exploited, the transformation of guano in regions with humid climate, as in the Paracel Islands, provides very valuable reserves of phosphoric matter. Thus special protective laws should be drawn up to protect birds producing this type of natural wealth.

The management of wildlife resources, both animals and birds, can only be established upon a scientific basis. The biological conditions of bird life strictly govern reproduction, that is, their numbers, and their geographical distribution, which in its turn is closely linked with food needs and with migration. All these problems have for thirty years been the subject of close research by zoologists, who have made very important contributions to our knowledge of birds, with a view to the organization of hunting.

In particular, the knowledge acquired of biological environments and the biological equilibrium of these environments, of the sexual cycles of mammals and birds, on length of life, of epizootic diseases which may be contracted by game, has all been of great value in the rational organization of game exploitation and the establishment of suitable regulations on hunting, such as dates for the opening and closing of the hunting season, hunting areas and reserve areas, lists of protected species and species which may be hunted, proportion of the sexes to be maintained etc. In this latter connexion, hunting regulations must strictly follow the progress achieved in the systematic classification of mammals and birds, and in the nomenclature used, and to this end the services for hunting management maintain close liaison with the leading scientific establishments working on natural sciences. The documentation which has been assembled during the past few years by the zoologists of these scientific establishments throughout the world and which serve to clarify and define hunting problems more accurately, are of considerable importance.

The bases and details of a modern classification of mammifera have been established in a most remarkable document by G. G. Simpson, of the American Museum of Natural History, New York. The same work has been done in respect of birds by Peters of Harvard College, Cambridge.

Further, many scientific works on African fauna, both mammals and birds, have been published by G. Allen of Harvard College, Cambridge, and by Prunier and Bigourdan, Maibrant, Jeannin, Rode, and Dr. Gromier of the National Museum of Natural History, Paris; on the birds of Indochina by J. Delacour, associate of the Museum of Paris, and by Jabouille; on mammifera and birds of Madagascar by Delacour, Grandidier and G. Petit; on furbearing animals of California by Grinnell, Dixon and Linsdale of the Museum of Vertebrate Zoology of the University of California; on extinct or rare mammals of the Old World by F. Harper of New York Zoological Park.

The scientific establishments have always been conscious of the part they are called upon to play as regards the application of zoological sciences to hunting, and they have played that part whenever their advice has been sought. They can, however, only advise and teach on this subject; they cannot organize. The action taken by these establishments is of primary importance. It can only achieve its full effect, however, through the establishment, in all the regions having a special interest in hunting, of biological stations to study animals in their proper environment, the variations in population, and migrations, and thus to provide precise details for a wise exploitation of game resources.

Problems of Conservation in Great Britain as Illustrated by the Status of the Red Deer *(Cervus elaphus)* and the Atlantic Seal *(Halichoerus gryphus)*

F. FRASER DARLING

ABSTRACT

Game preservation in Britain has undergone considerable modification in the last half-century with repercussions on wildlife. The large deer forests are now being broken up and the ground is increasingly going to hotel and syndicate shoots. There are $2^1/_2$ million acres of deer forest in Scotland which should not carry more than 100,000 deer. There has been heavy and wasteful slaughter and much poaching since 1939, and a policy of conservation is urgently needed to make sure that this valuable wildlife resource is properly used.

The Atlantic seal has much increased in the last thirty-five years under absolute protection at the breeding season. The stock is estimated at perhaps 15,000 head. Unfortunately, the island nurseries are now being raided with much waste and disturbance. These seals represent a valuable wildlife resource which should be conserved as an economic asset rather than preserved sentimentally and ineffectually.

The role of such factors as social behaviour, sex ratios and stocking capacities are discussed and the suggestion is made that by taking advantage of the two-week starvation period of the young seal after weaning, new colonies of these animals could be established on empty islands with suitable shore-lines.

The status of wild mammals and birds in Great Britain liable to be killed for food, oil, skins or feathers is undergoing considerable change at the present time and there is urgent need for new attitudes of mind and methods of conservation. We have passed through two centuries of so-called game preservation, the effects of which should be understood in relation to the present state of change and the future that it is possible to envisage.

Game preservation created artificially high populations of grouse, partridges, pheasants and mallard duck, and actively depressed such predators as stoat, weasel, otter, wild cat and badger, as well as raptorial birds of all kinds and owls, crows, magpies and jays. Even dippers were shot as they were considered to eat salmon-ova and trout-ova on the beds of streams. This considerable deviation from equilibrium had other consequences affecting agriculture and forestry. The rabbit and wood-pigeon greatly increased and annually cause much damage, and wood mice (*Apodemus*), which cause damage when present in large numbers, were the subjects of but little natural predation. Game preservation caused the planting of many woods and coppices and there can be little doubt that the small-bird populations of wood-edge species have benefited, because the regression of former forests was much restricting their habitats. The drainage of marshes and fens for agriculture reduced the populations of water-fowl and wading birds which had formerly been quarry, but many game preservers were actively creating artificial lakes which attracted duck. These ponds and lakes enabled some species to hold on and maintain varied distribution.

Sport was the privilege of the well-to-do. Poaching was punished by heavy penalties and the ratio of keepers to poachers was relatively narrow. There were strictly kept dates when the shooting of game species opened and closed and there was very strict etiquette in shooting. Birds were not shot sitting, nor were they taken in traps or snares.

The red deer in Scotland were never given the title of game and therefore have never had a close season awarded by law. But this scarcely mattered because a rigid code of etiquette imposed certain inviolable conventions. Deer forests increased to a total of 3 million acres in the nineteenth century, the total now being about $2^1/_2$ million of sub-arctic-alpine moorland of *Calluna, Scirpus, Carex* and *Eriophorum*. The deer herds were carefully watched in a countryside extremely difficult of access (and conversely of egress) and forests (in the old connotation of waste places) were large (30,000 to 100,000 acres). The stags were shot between 15 August and 15 October, and hinds from 15 November to 15 January. Care was always taken in the choice of stags to be shot and the number to be shot was strictly regulated. The maintenance of deer forests allowed sanctuary for many species, such as the golden eagle and the pine marten, which would otherwise have been lost.

Throughout this period, potential wildlife resources, such as the Atlantic seal and the gannet, were having varied fortunes. Gannets were being taken when young by coastal peoples from several gannetries, but though any considerable increase was prevented, very few gannetries were wiped out. The Atlantic seal was much preyed upon by coastal peoples (as it had been since the time of St.Columba in the sixth century), the skins being used for sea-boots and the oil for burning and cattle-feed. The seals were most wastefully exploited and the species came near to extinction. But the end of the nineteenth century had seen the emergence of paraffin oil and the rubber boot, which undoubtedly saved the Atlantic seal, and food was constantly becoming easier to obtain. Even food habits were changing, and only one gannetry is visited for the purpose of taking young birds for food. The result has been a great increase of both Atlantic seals and gannets, but both these oceanic species repair for breeding to a few remote islands where they congregate in large numbers. That is the danger, but it is not so great for the gannet because many have their nests on inaccessible ledges. Also, this resource is as yet scarcely touched.

The position in Britain today is quite unlike that either before the 1914-1918 war (the golden age of game preservation) or that of the inter-war period (the era of cheap food). Rich men are few and fewer still are able to keep together large estates with a unified game policy. Shooting has probably become more popular than ever and syndicate shoots on rented ground are now common. Both game and wildlife are apt to suffer under the syndicate system. Gamekeepers are fewer and poachers on a commercial basis much more numerous. There is now no artificial rearing of game. The recent war and the present timber shortage have necessitated the felling of much timber, so that the habitat of certain species has regressed. Mechanized farming and the earlier cutting of grass have further upset the open-ground birds.

The red deer of the Scottish Highlands are a first-class wildlife resource, but whether the species is to be so treated or wastefully exploited depends on a vigorous conservation policy. The large, carefully-stalked deer forests are fast being cut up into smaller lots and deer ground should never be in small lots. Shooting lodges are becoming hotels, often kept by people with no knowledge of forest management. The guests pay dear and expect to get their stag. The strict regulation and etiquette of the private owner are gone, there are many wounded deer about, and as there is no legal close season, deer are being shot far outside the period of the old "gentlemen's agreement". This legitimate sport is dangerous unless law and conservation policy step in, but the greatest danger to the deer and the valuable resource they represent is in the organized commercial poaching and the admitted out-of-season killing of deer in poor condition. The roads of the Highlands are much better than they were and motor-cars and trucks can get about the country quickly.

Britain is definitely meat-starved, which means that high prices will be paid for indifferent quality, so a far-run stag after the rutting season is still saleable, though to kill the framework of a carcass after the fat has been run off it for that season is rank waste. It is still worse to kill half-starved and young deer roaming the low ground in the depths of winter, but the sausage machine makes it worth while nowadays.

There is one other plague that has fallen on Britain—that of greyhound racing. This form of sport is immensely popular with the masses and a large population of dogs must be fed. Horses are few now so there is no plentiful supply of knacker meat there; wild animals are being slaughtered instead to feed the dogs. Deer are being poached wholesale for this purpose, sea-birds are being shot and seals are being attacked.

It is at a moment like this that the Atlantic seal is once more in great danger, despite legal protection between 1 August and 1 December. We know that raids are taking place on the island nurseries. Since the seals have increased it is now worth while for the unscrupulous to raid in a big way.

Let me repeat: both these animals, the red deer and the Atlantic seal, are a valuable wildlife resource, and I as an ardent conservator would welcome controlled exploitation of them. We can the better conserve if a resource is valued economically rather than purely sentimentally.

As this is an "experience paper" I will confine my remarks to red deer and Atlantic seals for I have made protracted studies of them. My main interest to begin with was social behaviour and this in itself is a keystone in conservation policy. Serious disturbance of the social factor in a gregarious species will destroy it. Both red deer and Atlantic seals are polygamous, but careful study of the life history shows that this general fact does not mean there are large numbers of surplus males, for each male is active for a relatively short time and retires for resting periods. But if treated as a wildlife resource some males could be taken at the onset of the breeding season without disturbing the herds. It is also noticeable in both these widely different species that reduction of gregariousness, and therefore of males, to a low level results in much less thorough overt, pre-coital sexual behaviour, and females are apt to be left barren. Indeed, in some species of animals there is a threshold of numbers below which breeding will not take place. This concept of social stimulation to successful breeding was first elaborated from my studies of gull flocks, but it has now been found to apply to several big-game animals which are potential wildlife resources.

A study of stocking capacity is essential to proper conservation of deer and other herbivores. It is far from being an easy thing to establish. The country may well appear to carry a big stock successfully, but attention must be given to the time factor and the consequences of grazing such a stock through a century or two. For example, it is certain that the red deer stocks in Scottish forests have been too high for well over fifty years. The practice was begun of feeding stags artificially on the low ground in winter. The increased stock put too great a strain on the wintering ground with resulting regression of cover, and there has been constant complaint in winter of deer coming out of the forests onto agricultural land. Before the Second World War the stock was probably a quarter of a million. Now it is possibly half that, and if the deer are to be a resource yielding meat and skins without interfering with farming and pastoralism they should be kept down to 100,000. Such further reduction in no way justifies wasteful killing out of season or without regard to the sex ratio. One more point must be made about the red deer of the Highlands as a wildlife resource: they are biologically adapted to use portions of an environment more economically than domesticated cattle and sheep, and should be considered as a necessary complement to cattle and sheep in utilizing the grazing potential of mountainous ground in Scotland.

As for the seals, this is a resource of oil, meat and skins which needs the utmost measures of conservation. The stock on British and Irish shores is about 15,000, certainly not more, possibly less. The number of considerable breeding stations is less than twenty. Some of these approach conditions of overcrowding and this causes losses in the calf crop. The Atlantic seal consumes rock fish of low commercial value and may therefore be looked upon as an additional gleaner from the sea and not a competitor for the supply of saleable fish. There are several vacant groups of islands the coastal waters of which could profitably be fished by a stock of Atlantic seals, and the shores would provide suitable breeding ground. But there is no stock there. The curious phenomenon of starvation which plays such an important part in the life history of this species could be taken advantage of in stocking new stations. The calves are deserted by the mothers after two weeks, by which time the calves are very fat and about to change their long white birth-coat for a short, sea-going blue one. This process takes another fortnight, and even then the calf seems in no hurry to go to sea though it is starving.

Obviously the animals have no tradition of home ground, never having been in the sea, and they could be moved quite easily in the starvation period to stock new island groups to which they would probably return as breeders.

Great Britain has recently established a Nature Conservancy. If it manages to incorporate results of its own researches and of others into a legal code for conservation of wildlife resources, it will do something which has not been done in Great Britain before, and which never needed doing more urgently than now. Protective measures in the past have been either by convention or law for protection of certain species. Our need is for legislation on the basis of Theodore Roosevelt's dictum of "conservation through wise use", and the indications are favourable.

Problems in Connexion with Imported Species of Animals[1]

BY THE MINISTRY OF AGRICULTURE OF ARGENTINA

The thoughtless introduction of exotic species into native faunas has in many countries created problems that are difficult to solve. In the particular case of Argentina, special mention should be made of experience with the European hare (*Lepus europaeus*) and the wild boar (*Sus scrofa*). The former spread rapidly and was declared a pest as from 1907. The latter, though its area of distribution is smaller, is infiltrating and proving a very unfortunate acquisition, owing to the depredations it is causing in stock-raising.

Both species were introduced through the whim of certain stock-raisers and country dwellers, perhaps in order to add a new game animal to the local fauna. There was not the slightest scientific or other advantage which might have seriously justified such an action.

Most unfortunately, both species, in particular the hare, have met with factors favouring their adaptation and have become serious nuisances to agricultural and stock-raising production.

These examples should be duly borne in mind by consulting experts of the State agricultural and stock-raising bodies in the countries concerned, so as to avoid, by means of a real scientific criterion, the importation of species which might be economically prejudicial to national interests.

In this connexion, it should be noted that it is often desired to introduce foreign species into a country in order to start biological conflicts attested by technical experiments in other countries. Such experiments have much merit, to be sure, but, in the reasoned opinion of experts, the purpose could be served by using native species of similar habits without running the risk involved in the importation of fauna which eventually might have undesirable repercussions in the course of years.

Argentine experts therefore report: That experience gained in Argentina points to the need for submitting to the consideration of experts any plan for introducing exotic wild species, whenever their unimpeded multiplication might cause an unbalanced state detrimental to the local fauna or might more or less seriously prejudice the agricultural and stock-raising economy.

[1]Original text: French.

Summary of Discussion

The CHAIRMAN said that in view of the number of papers submitted on Management of Wildlife Resources they would be divided into three groups, one on the management of wildlife resources in Africa, the second on the management of bird resources and the third on the ecological problems of the management of game and bird resources. Each group of papers would be introduced by a competent person who would summarize the matters dealt with in the papers.

The CHAIRMAN invited Mr. HARROY to introduce the following papers:

Paper by Mr. Worthington on the "Management of Wildlife Resources";

Paper by Mr. Ritchie on "Game Control in Kenya Colony";

Paper by Mr. Vaughan-Jones on "The 'Controlled Area' System in Relation to Game Management on Rangelands in Northern Rhodesia";

Paper by Mr. Van Straelen on "The Scientific Work of the National Parks Institute of the Belgian Congo";

Paper by Mr. Harroy on the "Management of Wildlife Resources".

He recalled that the paper by Mr. Vaughan-Jones had originally been listed for discussion at the meeting on Game and Fur Conservation but had later been included for discussion at the present meeting.

Mr. HARROY pointed out that the first three papers were evidence of a tendency which was at variance with the theories he had defended for a long time. Those papers stressed the growing conflict between the interests of the human population of Africa and those of the African wildlife. According to Mr. Worthington's paper, the development of agriculture and of stock-breeding had limited the areas available to wild beasts. The conflict was constantly growing on account of the increase in the human population. Mr. Worthington calculated that within fifty years the population of Kenya would have tripled and the conflict between man and beast would therefore have increased. The result would be defeat for the animal groups and would necessitate conservation of African wildlife wherever possible. The greatest difficulty lay in the complete absence or paucity of data necessary to establish a coherent policy for conservation and control.

Mr. Worthington discussed the difficulties involved and pointed out that, as an accurate estimate of animal groups could not possibly be made, it was hard to launch an attack on the various species thought to be harmful to man without running the risk of upsetting the natural equilibrium. In fact, the destruction of certain predatory animals enabled other species to increase rapidly. Mr. Worthington mentioned the classic example of leopard hunting, which had resulted in the rapid increase of the baboon and the wild pig, both harmful to agriculture.

Mr. Ritchie's paper brought out clearly the dilemma of man, who realized that animals had a right to life but that it was absolutely necessary to slaughter them in large numbers, as in the case of the rhinoceros and the giraffe, in order to protect agriculture. Mr. Ritchie also stressed the danger of upsetting the natural equilibrium and he mentioned, in addition to the problem of the leopard, the problem of the hyena; that animal had become much more harmful to human activity since the extermination of the lion, whose kills had supplied the game on which it fed, and the disappearance of certain other species from which the hyena had formerly eaten.

In his paper, Mr. Vaughan-Jones dealt particularly with the attempt made by the Government of Northern Rhodesia to reconcile the opposing needs for conserving big game and for protecting cattle in open pastures. That attempt had led to the establishment of supervised zones. Livestock was separated from the big game in order to protect it from herbivorous animals infected with sleeping sickness. The system had had excellent results.

The conservation of big game as set forth in those three papers seemed to depend upon the establishment of areas to which man would not be freely admitted and where game could exist in as large numbers as possible. The management of wildlife resources was carried out by playing a sort of trick on nature the purpose of which was to increase the number of animals within the reserve areas.

In the Belgian Congo, on the contrary, the problem was viewed differently, as was shown in the two final papers. National parks were not established in order to become sanctuaries for as many animals as possible. The basic belief was that man, in all his activities, made crafty use of the laws of nature but that he did so clumsily, for he did not know those laws. It was therefore necessary to have areas where those laws could flourish unhindered by man.

For that reason, no human intervention designed to change the equilibrium of nature or to increase the number of animals was permitted in the national parks of the Belgian Congo. The reserves were natural, self-contained and clearly demarcated areas in which all settlement by mankind was prohibited.

Mr. Harroy had himself managed the Garamba National Park, which covered almost 500,000 hectares and where no human being was allowed except the warden, the investigators and the general supervisory personnel.

Mr. Van Straelen said in his paper that the National Parks Institute had undertaken a systematic study of those areas. In the immediate future, an important ecological mission would visit the Garamba National Park, where the only survivors of the white rhinoceros and the Congo giraffe were to be found. Similar missions had already undertaken the exploration of Albert National Park and the Upemba National Park, and the results of their observation had been published by the Institute of the National Parks of the Belgian Congo.

Mr. VAN GRAAN thought that the point of view of most of those who had taken part in the discussion on the conservation of wildlife was too pessimistic. He himself thought it possible to reach a compromise between the development of human activity and the conservation of wildlife. The experience in that connexion acquired in the Union of South Africa was very interesting. In early days, wildlife resources had been considered almost inexhaustible and animals had been relentlessly hunted. That attitude had lasted until it had appeared that the land was sufficiently free from wild animals to be suitable for agriculture and stockbreeding. Then, however, farmers had realized the usefulness of big game, especially herbivorous animals, and had asked that the latter should be put back on their lands. The Government was now trying to meet that request.

That evolution—destruction followed by restocking—was not necessarily the same everywhere. Generally speaking, however, the public should be taught to understand that while beasts of prey could be killed, wild herbivorous animals were a very important resource. It was wrong to believe that the development of civilization was necessarily accompanied by destruction of big game and that wildlife could be preserved only by creating reserves or parks. Such were the conclusions which Mr. van Graan thought that the current conference should reach.

Mr. MURPHY asked Mr. van Graan whether he thought it was possible to have abundant and healthy herbivorous fauna in the absence of predatory animals.

Mr. DAY, discussing the history of game management in the United States, explained that at first many important big-game species had been hunted in forest lands but that the situation had since changed. A study made by the Wildlife and Fish Service a few years ago showed that most game was to be found on crop land. Furthermore, the herds of deer were currently more numerous than they used to be as a result of the thinning of forest lands.

In his opinion, herbivorous fauna could exist without the presence of predatory animals and he cited the example of the States of New York and Michigan where wolves and mountain lions had been eliminated many years ago. He concluded by saying that the task of the future was the mutual adjustment of game conservation and the needs of agriculture.

Mr. VAN GRAAN, in reply to Mr. Murphy's question, said that he thought that game could be preserved without predatory animals. During visits to the national game preserves of the Union of South Africa he had been able to observe that the springboks had lost none of their speed and were in perfect health despite the fact that for a period of sixteen years they had not been pursued by lions.

Mr. R. POUGH did not think that healthy wild fauna could exist without beasts of prey. Indeed, it was not enough to take the short-term view since the equilibrium of nature assured by beasts of prey operated over the long term. In his opinion, the existence of excessively large herds of deer in certain regions of the United States where predatory animals had been exterminated was proof that nature's equilibrium could not be maintained without the latter.

Mr. LEOPOLD was of the opinion that it was necessary to divide game species into two groups. One group could be conserved only if conditions maintained for them were exactly similar to those of their original wild state; for example, mountain sheep and grizzly bears. For such species, which were relatively few in number, large preserves had to be provided where natural conditions were retained without modification.

The second group of species, including most North American forms, could be preserved and managed on lands that were being used for production of agricultural crops, livestock or timber. Such was generally the case with small game and furbearers, and most ungulates.

Predatory animals likewise could be divided into the same two categories. Some, like the wolf and grizzly bear, could be retained only on wild lands because of their depredations on livestock. Others, like foxes, coyotes, bobcats and mountain lions, were useful in maintaining balanced game populations and with moderate regulation could be retained on lands developed for grazing, forest production and even on some agricultural lands.

Thus no sweeping generalizations were applicable to all predators under all conditions.

Mr. ORPEN pointed out that in the Union of South Africa it was impossible to conserve predatory animals where there was livestock. But in national preserves, such as Krueger Park, an effort was made to maintain the balance of nature without the interference of man.

Mr. DE VOS emphasized that the exact role which predatory animals played in game conservation had been poorly assessed. For example, in the Province of Ontario, there had been an increase in range and numbers of deer despite the presence of wolves in the area. This shows that it is important to study specific cases before reaching any conclusion on the subject.

Upon the invitation of the CHAIRMAN, Mr. DELACOUR presented his paper, "On the Conservation of Bird Resources". He also presented three other papers: one by Mr. Soper on the "Management of Bird Resources"; one by Mr. Avila on "Peruvian Management of Bird Resources"; and one by Mr. Falla on "Management of Bird Resources".

Mr. G. A. SWANSON summarized his paper on "Management of Bird Resources".

Mr. DELACOUR explained that the position with regard to water-fowl in Europe was not as favourable as in North America. The shooting seasons were very long and the birds were not sufficiently protected. The European section of the International Committee for Bird Preservation was giving active consideration to the question. It had established an international wildfowl research institute which was undertaking accurate studies of all questions relating to water-fowl and was attempting to obtain for them protection similar to that which they enjoyed in North America. The problem was obviously more complicated in Europe as the migratory birds only passed a few weeks every year in each country and an international agreement would be necessary. He stated, however, that duck resources were still considerable.

Mr. DAY pointed out that in North America the protection of migratory birds was possible because of the close co-operation between the Canadian and United States authorities. An attempt was also being made to obtain the co-operation of Mexico and to standardize the general principles governing regulations on the subject.

Ringing would play an ever-growing part in estimating the number of fowl and in establishing shooting laws. It would not only make it possible to follow the movement of birds but also to determine the number of birds killed in the shooting season. In the United States a system for regulating shooting based on the flight routes of birds had recently been adopted. Under that system, sportsmen on the Pacific Coast had been given more freedom than sportsmen on the Atlantic Coast. The regulations had been drawn up on the basis of the data collected as a result of ringing.

Mr. SEELE noted with astonishment that there was a general tendency to consider that wildlife should be conserved and protected solely in the interest of sportsmen. It seemed to be forgotten that besides the 2 million sportsmen in the United States there were several million photographers and nature lovers. He would like the competent authorities to stress still further that aspect of the conservation of wildlife and he would like a programme of education to be instituted.

He pointed out that there were very few birds which were harmful to man.

Mr. DAY stated that it was the administration's job to retain the balance between the quantity of game and the number of sportsmen. That state of affairs was due to the fact that in the United States most of the money necessary for establishing reservations came from the sale of hunting licences. It was regrettable that no allocations were forthcoming from other sources.

Mr. DE LA TORRE emphasized that the issues pertaining to management of game resources should not be divorced from the solution of its economic problems. In Mexico and in other Latin American countries having a similar standard of life an important problem arose in connection with the protection of migratory animal life. Very little progress had been made in this respect on account of the lack of education on the subject. A systematic educational programme should therefore be put into effect with the co-operation of all Governments. A committee of the United Nations should carry out an appropriate plan in conjunction with a committee of technicians appointed by the local governments in each of the countries concerned. An extensive campaign, of circularizing appropriate literature, and by the use of the radio, the cinema, and through school courses, and technical missions, should be carried out in order to enlighten the public on the methods and importance of protecting wild animal life. Also new laws protecting migratory game should be enacted.

As for the necessary funds to carry out successfully such a programme, which would benefit not only the underdeveloped countries but all the countries of the world, they would be provided by a permanent organization created by the United Nations similar to the Bank.

The CHAIRMAN pointed out that the International Office for the Protection of Nature was considering those problems and that it was in touch with UNESCO and the Food and Agriculture Organization of the United Nations.

The CHAIRMAN said that the third and last topic to be discussed concerned the ecological problems of the management of wildlife and bird resources, which were set forth in the following five papers: "Administration of Big Game Resources in the United States", by Mr. Day; "Administration of Game Resources", by Mr. Gouilly-Frossard; "Management of Wildlife Resources", by Mr. Urbain; "Problems of Conservation in Great Britain as Illustrated by the Status of the Red Deer and the Atlantic Seal" by Mr. Darling; and "Problems in Connexion with Imported Species of Animals" by the Ministry of Agriculture, Argentina. The latter paper had been received too late to be reproduced for distribution at the Conference.

He asked Mr. Darling to discuss the topic on the basis of those five papers.

Mr. F. DARLING observed that the five papers, which had been presented separately and which dealt with conditions in various countries, all stressed the same point, namely, the connexion between agriculture and the conservation of wildlife. The papers also showed that the scientific application of ecological principles was equally important with their purely theoretical formulation. Furthermore, the various authors agreed that a compromise could be reached between the use of land for agriculture and the management of wildlife resources, as the two were not incompatible.

Mr. Darling stressed the necessity of teaching the principles of ecology in schools and of spreading knowledge about them through the Press and other means. Knowledge of Theodore Roosevelt's maxim, "Conservation through wise use", should be more general.

Mr. DAY observed that the problems to be faced were largely the same in all countries. Everywhere the area of land used for agriculture was increasing, and the habitats were almost completely occupied. In the case of the deer, for example, it was more important to ensure the preservation of the existing stock than to attempt to increase it further. In many countries, however, public opinion was traditionally opposed to the killing of the female. The public must understand that regulating the abundance of animals was done in the interest of preserving them.

With regard to other species of big game, the size that the herds could reach was determined by the supply of food in winter. The mountain sheep and the grizzly bear had become very rare in the United States, and the Federal Government was taking steps to prevent their complete extinction.

The management of wildlife resources in the United States was designed to preserve the balance between the animal populations and the available food supply. That purpose could be attained by accurate knowledge of the situation of the herds and the conditions in which they lived. Moreover, an attempt must be made to explain to the public the full economic importance of wildlife.

Mr. HEIM summed up the contents of the paper presented by Mr. Urbain, who was not able to be present.

Mr. BREWER recalled that at the previous meeting it had been said that the methods used in the United States had proved successful in conserving the wapiti, mule deer, white-tail deer and antelopes. He wondered what the situation was with regard to the caribou and moose.

Mr. MURPHY, referring to moose, compared the situation in certain areas in the north-eastern part of the American continent with that in northern Europe. In Maine, for example, there might be a total of from fifty to a hundred moose, whereas in Sweden, which was four times as large as Maine and had a population five times greater, the herds of moose were constantly growing, even though about 14,000 animals were killed by hunters each year. That situation could be explained by the fact that the exploitation of forests had been controlled in Sweden since the beginning of the seventeenth century, and it furnished undeniable evidence of the part played by the habitat in determining the size of herds.

With regard to beasts of prey, Mr. Murphy said that, after having listened to the discussion that had taken place, he felt certain that such animals fulfilled a useful function in preserving the balance of nature, and, in that respect, man was more dangerous for wildlife than the great mammals he hunted so relentlessly. Beasts of prey attacked the weakest example but man generally attacked the strongest; when beasts of prey hunted, they were guided solely by their desire to trap their prey, whereas man was discriminating and sometimes hunted only the male of the species. The result was that man's activity might be a much greater factor in upsetting nature's balance.

In opposition to those who thought that the presence of birds of prey had a very adverse effect on the bird population of a given area, Mr. Murphy mentioned the case of the Azores. Nowhere in the world, except perhaps in the Galapagos Islands, was there so large a number of hawks of the buzzard family; yet nowhere were there so many different species of birds, from quail and woodcocks to starlings, blackbirds and other small species.

The CHAIRMAN confirmed that there were some 40,000 to 50,000 head of moose in Sweden. On the other hand, caribou and wild reindeer had completely disappeared, a fact which was doubtless due to the intensive development of the domestic reindeer, which numbered about 250,000 and used all the available pasture area.

Mr. DE VOS mentioned two localities on the American continent where there was an overpopulation of moose, namely, the Isle Royale National Park in the United States, and St. Ignace Island in Canada.

Mr. RASMUSSEN pointed out that the moose were not as plentiful in the western part of the United States as the deer, antelope and the wapiti. However, recent increase in the numbers of moose had begun to raise problems of management in certain areas in eastern Idaho and western Wyoming.

He agreed with Mr. Van Graan that it was possible to raise wildlife, especially certain ungulates, in regions devoted particularly to agriculture. As proof he mentioned the fact that large numbers of antelope, deer and wapiti lived in the extensive range areas of the western part of the United States where there was also large-scale domestic livestock grazing. He felt that joint or multiple use of western United States range lands by big-game animals and domestic livestock was preferable, as a practical procedure, rather than to attempt to maintain big-game herds for hunting in this region by establishment of a system of hunting preserves.

He stressed the necessity of providing not only for the protection but also for the control of wildlife numbers. In practical management programmes it is usually necessary to remove or harvest female as well as male big-game animals, both when there is need for stabilizing herd numbers as well as when there is an overpopulation.

Mr. VAN GRAAN stressed that wild animals, and particularly herbivorous animals, did not suffer from a lack of their natural enemies; the contrary was the case. In support of that statement he mentioned the case of the ostrich, the number of which had considerably increased in South Africa during the preceding fifty years. He also mentioned the turkey as a striking example of what man could achieve in developing a species outside its native habitat. The problem of the management of wildlife must be viewed in the light of the experience acquired and of existing conditions.

Mr. DE LA TORRE associating himself with the desire expressed by Mr. Urbain that a definition should be given to the word "wildlife", asked the conference to define also the terms "hunting reserves" and "game reserves" in order to establish a clear distinction between them. He considered a hunting reserve to mean an area in which hunting was controlled, where a species not found elsewhere could be hunted under certain conditions. On the other hand, a game reserve was a controlled conservation area, or an area devoted to restocking game, and was therefore strictly closed to hunting.

Mr. LEOPOLD pointed out that the problem of regulating beasts of prey was complex. No general principle applicable to all species could be laid down. While it could not be denied that lions could not live side by side with cattle in South Africa, any more than the native wolf could be tolerated in Iowa, it was still true that beasts of prey undoubtedly play an important and valuable role in the ecology of wild regions, such as the western United States.

In recent years there had been a general tendency to eliminate beasts of prey; that means of assuring protection to wildlife had unquestionably been abused. It was becoming more and more evident that protection should be essentially a matter of preserving the habitat through better biological and ecological knowledge of the species.

The CHAIRMAN observed that certain beasts of prey were more valuable economically than others. That was true in Sweden, particularly with regard to furbearing animals such as the martin and the linx, which were very valuable and had to be protected.

In reply to a request by Mr. DARLING for his views concerning the effect of introducing into the fauna of a country a foreign species with a view to improving the native species, Mr. LEOPOLD said that the turkey could not be taken as a conclusive example, as it was a domestic species. Experience had shown that the domestic variety as well as the hybrids which resulted from cross-breeding could not easily become adapted to new conditions of existence. Cross-breeding might cause the disappearance of the native species and it could not be done without running a great biological risk.

Mr. DE VOS asked whether the fact that large beasts of prey had not existed in Scotland for centuries had had any effect on the herds of deer in that country.

Mr. F. DARLING replied that there was still one beast of prey in Scotland, namely, a fox longer on the leg than the English fox, that attacked fawns less than one week old and thus caused a certain reduction in the herds.

Certain other factors such as loss of shelter had a greater influence on the individual size and type of the species than the action of beasts of prey.

Mr. ORPEN pointed out that the purpose of the meeting was to discuss the management of wildlife from the point of view of the benefit that man could draw from it. That question should not be confused with the question of the protection of nature. In national parks all animals, including beasts of prey, naturally had a right to the same protection. The same could not be true in agricultural regions where the protection of crops for the use of man was of primary importance.

In reply to a question by Mr. Orpen, Mr. F. DARLING confirmed that the number of deer in Scotland, which ten years previously had been about 250,000, was now about 125,000. This figure was approximate but seemed fairly reliable. Only about 100,000 deer could live comfortably on the 2,500,000 acres of rough land in the highlands of Scotland. The size of the deer population therefore had to be reduced if the unfortunate effects of overgrazing were to be avoided.

In reply to another question by Mr. Orpen, Mr. Darling said that there were only several hundred deer in England; they were semi-domesticated and lived in parks, or were on Exmoor and in Cumberland. During the nineteenth century English deer, which were larger and had larger antlers, were crossed with the Scottish deer; but the aim of the experiment had failed. That cross-breeding had not, however, had an irreparable effect on the Scottish deer because of their great numerical superiority to the few English stags introduced.

The Scottish deer were quite well adapted to the rather poor conditions of their habitat. Mr. Darling thought that the figure of 20,000 animals killed during the hunting season of 1942, mentioned by Mr. Orpen, although fairly high, was probably correct. Although the normal proportion of animals killed should not be so high, the figure was justified because the herds already numbered more than the 100,000, beyond which there was overpopulation. It was not the number of deer killed annually in Scotland that was regrettable, but rather the conditions under which some of them were destroyed, for example, by shooting outside the customary seasons, and the increase of poaching on a large scale, etc. Mr. Darling was afraid that if that situation could not be improved it would in the long run cause the extinction of the species.

LIST OF CONTRIBUTORS TO FISH AND WILDLIFE RESOURCES SECTION

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ABOU SAMRA, IBRAHIM, Director of Fouad I Institute of Hydrobiology and Fisheries, Alexandria, Egypt *44*

AHMAD, NAZIR, Deputy Director of Fisheries, Comilla, East Bengal, Pakistan 111, 117, 118, 163, 184

ANDERSON, A. W., Chief, Branch of Commercial Fisheries, Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C., U.S.A. 103

AUDIGOU, L. J., French Supply Office, 1800 Massachusetts Ave., N.W., Washington, D.C., U.S.A. 62, 64

AVILA, ENRIQUE, Ornithologist, Compañía Administradora del Guano, Casilla 2147, Lima, Peru *231*

BATES, STEWART, Deputy Minister of Fisheries, Ottawa, Ont., Canada *68*

BLEGVAD, H., Director, Danish Biological Station, Secretary-General, International Council for the Exploration of the Sea, P.O. Box 20, Charlottenlund Slot, Charlottenlund, Denmark *51*

BONNEFIL FILS, LÉONCE, Chef de la section d'entomologie, Ministère de l'Agriculture, Port-au-Prince, Haiti 186

BOTTEMANNE, C. J., Former Head of Institute of Sea Fisheries of the Indies, Batavia, Indonesia, c/o Dr. E. DE VRIES, Ministry of Overseas Territories, The Hague, The Netherlands 24, 25, 26, *39*, 63, 65, 66, 112, 114, 118, 163, 164, 184, 185

BRAMSNAES, FRODE, Director of Research, Technological Laboratory, Ministry of Fisheries, Copenhagen, Denmark *90*

BREWER, GEORGE E. JR., Vice-President, The Conservation Foundation, 30 East 40th Street, New York, N.Y., U.S.A. 209, 211

CLARKE, GEORGE L., Marine Biologist, Woods Hole Oceanographic Institute, Woods Hole, Mass., U.S.A. 162

DAHLBECK, NILS E., Honorary Secretary and Executive Member of the Swedish Society for the Protection of Nature, Maestersamuesgatan 3, Stockholm, Sweden 208, 210, 252, 254, 255

DANNEVIG, ALF, Director, The Flødevig Sea-Fish Hatchery, Flødevigen, Arendal, Norway *57*

DARLING, FRANK F., Director, West Highland Survey [Scotland], The Old Rectory, Lilley, Newbury, Berkshire, England............................. 208, 209, 210, *251*, 256

DAY, ALBERT M., Director, U.S. Fish and Wildlife Service, Washington, D.C., U.S.A. *239*, 254, 255

DELACOUR, JEAN, President, International Committee for Bird Preservation; Research Associate, American Museum of Natural History, New York, N.Y., U.S.A. *228*, 254

DE LA TORRE, LUIS ROJAS, Representative of The National University of Mexico, 50 East 42nd Street, New York 17, N.Y., U.S.A. 254

DE VOS, A., Biologist, Ontario Department of Lands and Forests, Toronto, Ont., Canada 254, 255, 256

DE VRIES, EGBERT, Professor of Tropical Rural Economics, Agricultural University, Wageningen, The Netherlands. Counsellor to Ministry of Overseas Affairs, The Hague, The Netherlands *39*, 64, 66

DUNLOP, HARRY A., Director of Investigations, International Fisheries Commission, Fisheries Hall, No. 2, University of Washington, Seattle 5, Washington, U.S.A. *16*

EL SABY, MOHAMED KAMEL, Controller, Fisheries Department, Ministry of Commerce and Industry, Cairo, Egypt *126*

ENGLE, JAMES B., Vice-President, National Shell Fisheries Assoc., R.F.D. 1, Annapolis, Md., U.S.A. 184

FALLA, R. A., Director, Dominion Museum, Wellington, N.Z. *233*

FISHER, H. D., Associate Biologist, Fisheries Research Board, Department of Fisheries, Ottawa, Ont., Canada 210

GERHARDSEN, G. M., Chief Economist, Fisheries Division, Food and Agriculture Organization of the United Nations. Recent address: Viale delle Terme di Caracalla, Rome, Italy *79*

GOUILLY-FROSSARD, M., Directeur Général Honoraire des Eaux et Forêts, Président Honoraire du Conseil Supérieur de la Chasse, Quai d'Orsay, Paris, France *242*

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HARROY, J. P., Secrétaire général de l'Institut pour la recherche scientifique en Afrique centrale, 42, rue Montoyer, Brussels, Belgium 226, 252

HART, J. L., Director, Pacific Biological Station, Fisheries Research Board of Canada, Nanaimo, B.C., Canada. *99*

HAVINGA, B., Director, Government Institute for Fisheries Investigations, Amsterdam, The Netherlands...... 1

HEFFORD, A. E., Formerly Chief Inspector of Fisheries and Director of Fishery Research to the Marine Department, 22 Ravenswood Road, St. Clair, Dunedin, New Zealand *150*

HEIM, ROGER, Professeur au Muséum national d'histoire naturelle, Paris; Membre de l'Académie des Sciences, Paris; Vice-Président de l'UIPN, aux bons soins de l'Académie des Sciences Coloniales, 15, rue Lapérouse, Paris XVI, France 255

HEY, DOUGLAS, Director of Inland Fisheries, Cape Provincial Administration, P.O. Box 152, Stellenbosch, Union of South Africa *154*

HIYAMA, YOSHIO, Fisheries Institute, Faculty of Agriculture, Tokyo University, Tokyo, Japan *124*

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Printed in the Netherlands
Price : $ 2.50 (U.S.)
(or equivalent in other currencies)
38873—April 1952—4,000