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INTERNATIONAL TECHNICAL CONFERENCE ON THE CONSERVATION OF THE LIVING RESOURCES OF THE SEA

Types of scientific information required for a fishery conservation programme

The Secretary-General has the honour to communicate the following paper, submitted by the Union of Soviet Socialist Republics, by Professor P. A. Moiseev, Director of the Pacific Research Institute of Fisheries and Oceanography, Vladivostok, Union of Soviet Socialist Republics.

FLUCTUATIONS IN THE COMMERCIAL FISH POPULATION OF THE NORTHWEST PACIFIC IN RELATION TO METEOROLOGICAL AND OCEANOGRAPHIC CONDITIONS, FISHERY OPERATIONS AND OTHER FACTORS

by

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25 p.

1. The North-West Pacific, including the Bering Sea, the Sea of Okhotsk and the Sea of Japan is an extensive commercial fishing area (more than 5 million square kilometres) with very varied fauna and flora.

2. Approximately 800 species of fish are found there and more than 100 of them are or could be commercially exploited. Bottom fish are particularly varied, the number of species being considerably higher than in the Atlantic.

3. These differences in the number of species are largely attributable to the fact that cod and herring are of Atlantic origin (Svyetovidov 1948, 1952) and hence, there are relatively few varieties of them in the Pacific, while the Pacific origin of the flat fish (Norman, 1934) accounts for the relatively few varieties of flat fish in the Atlantic.

4. At the same time, very similar varieties of the main commercial families - herring, cod, salmon, flat fish, mackerel etc. - are found in both the Pacific and the Atlantic. Closely related varieties of commercial fish in both oceans include: Clupea and Engraulis; Gadus and Eleginus; Limanda, Hippoglossus, Reinchardtius, Hippoglossoides, Pleuronectes and Platessa.

5. One might expect to find close similarities in the behaviour of these fish and regular fluctuations in populations, particularly as, in most instances, systematic differences are confined to the specific or sub-specific level.

6. Related varieties in both Oceans admittedly have certain characteristics of biology and behaviour in common.

7. Nevertheless, recent researches into the biology and causes of fluctuation in the fish populations of the North-West Pacific by the Pacific Research Institute of Fisheries and Oceanography have revealed fundamental differences in the biology of the inhabitants of the Pacific and Atlantic Oceans. These differences are largely due to the differing environmental conditions in the two basins and are the result of adaptation to these conditions. At the same time, however, there were very clear indications that the the fish

population is affected, first, by a number of meteorological and oceanographical factors and secondly by intense fishing.

8. In this connection, let us first glance briefly at the oceanography of the North-West Pacific and its specific characteristics, which have a considerable influence on the biological peculiarities of the fish in that area and, in many cases, dictate their number.

9. Deep valleys (4 to 6 thousand metres in depth) form the basins of the Seas of Japan and Okhotsk and of the Bering Sea and cover most of their floor; the continental shelf is relatively small, generally extending in a narrow band along the North-East shore of Asia, and beyond it the ground drops sharply to 3,000 metres or more. These characteristics distinguish the seas of the Far East from the North-East Atlantic. As much as 3 million square kilometres of the North-East Atlantic consists of broad shoals, whereas only about 1.2 million square kilometres of the North-West Pacific is shallow water. The severe continental climate and the fact that the marginal seas in the Far East are cut off from the open Pacific by a chain of islands are the main causes of the intense cooling in winter (to sub-zero temperatures) of large areas of shallow water in certain regions (the North-Western part of the Sea of Okhotsk, the Eastern off-shore area of the Gulf of Sakhalin, the Gulf of Anadyr, etc.). This cold layer is never warmed through in the warm part of the year and it covers a wide area of shallows, making them unsuitable for the majority of fish living on or near the bottom.

10. The total area of shallow water in the Far Eastern seas where conditions are suitable for bottom fish is approximately 800 to 850 thousand square kilometers. Intensive cooling (to sub-zero temperatures) in winter and considerable seasonal variations in temperature in the upper layer (particularly in the northern part of the Seas of Okhotsk and Japan) clearly distinguish the Far Eastern seas from the waters washing the North-West coast of Europe, where annual variations in temperature are negligible and there are virtually no wide areas where the temperature of the water falls to below zero.

11. Generally speaking, the permanent and tidal currents in the seas of the Far East flow much faster than the currents in the North-East Atlantic which are affected by the slow-moving water masses of the Gulf Stream (flowing at not more than 0.1 to 0.3 miles per hour). The majority of the permanent currents in the Bering Sea and the Seas of Okhotsk and Japan have a velocity of 0.4 to 0.5 miles an hour or more.

12. Relatively fast currents carrying water masses over shallow water first and then over very deep water or water with sub-zero temperatures create conditions unfavourable to fish and other organisms with pelagic spawn or larvae.

13. Lastly, vast areas of the Far Eastern seas, and in particular, the shallow areas, are covered for months at a time by floating or stationary ice floes, whereas most of the surface of the North-East Atlantic is free from ice the whole year round.

14. These hydrological differences alone show the substantial differences in the environmental conditions of fish living in comparable areas of the Atlantic and the Pacific.

15. Other vitally important factors in the environment of many commercial fish also vary, for example the supply of food and the intensity of predation, which frequently determine the size of the fish population.

16. From a comparison of the masses of benthos and zooplankton in the Atlantic and the Pacific it can readily be seen that the benthos and zooplankton indices in many areas in the Far East seas are somewhat higher than those in the seas which wash the shores of North and North-West Europe. In most of the shallow waters of the Far East the average benthos mass varies from 100 to 500 grammes per square metre, whereas in the North European seas it varies from 20 to 250 grammes per square metre. Approximately the same relation holds good for zooplankton biomass, the figures being 160-300 mg per cubic metre and 50-140 mg per cubic metre, respectively.

Table 1

Average mass of benthos and zooplankton in the Atlantic and the Pacific
(to a depth of 200 metres)

Sea	Mass		Authors
	Benthos (in g per sq.m)	Zooplankton (in mg per m^3)	
Chukotsk	213	160	Makarov (1937) Bogorov (1939)
Bering	227	-	Makarov (1937)
Okhotsk	483 1/	300	Gordeyev (1948) Kusmorskaya (1940)
Japan	302 2/	240	Deryugin and Sômova (1941) Kusmorskaya (1948)
Kara	50	48	Zenkevitch (1947) Bogorov (1939)
Barents	100	140	Zenkevitch (1947)
White	20	100	Zenkevitch (1947)
North	244	-	Zernov (1934)
Baltic	33	-	Zenkevitch (1947)

1/ West Kamchatka
2/ Peter the Great Bay

17. This substantial difference in favour of the Far Eastern seas would probably be still more marked if we were to take into account the larger zooplankton (more particularly the Euphausiidae) which are so abundant in the Sea of Japan and especially the Sea of Okhotsk.

18. The greater mass of benthos and zooplankton in the Far Eastern seas accounts for the appearance of large, dense congregations of commercial fish and other creatures in certain areas. The heavy concentration of flat fish and King crabs off the shores of Kamchatka, pollack in the Korean Gulf, herring off the shores of Sakhalin and Hokkaido, and sardines off the Southern shores of Japan are well known.

19. An abundance of benthos or plankton alone, however, is not enough to account for the presence of commercial shoals. For example, although there is in the Gulf of Anadyr an abundance of plankton and benthos for fish food; there are no commercial concentrations of flat fish, nor are there any concentrations of cod, pollack or flat fish in the Northern part of the Bering Sea or in the whole Sea of Chukotsk, although the types of food eaten by all these fish are found there in particular abundance and the hydrology in summer is particularly suitable (for cod and pollack): the fish do not go so far from the remote regions where they winter.

20. A volumetric comparison of the food consumption of a number of the most common commercial fishes indicates that most of them feed a great deal more intensively in the Pacific than in the Atlantic. The average annual index * of stomach content of the Okhostk Sea cod, for instance, is 225 (Logvinovich, 1949) whereas for the Barents Sea cod it is only 144 (Zatsepin and Petrova, 1939). [* The ratio, multiplied by 1,000, of the weight of the stomach contents to the weight of the fish.] As a result of the greater abundance of food, the majority of Far Eastern fish have a very limited diet, although there is a very wide choice of foods available to them. The Pacific cod, for example, has more than 100 different creatures from which to select its food, but it eats only four or five varieties (Logvinovich, 1949, Gordeyeva, 1951). Similarly, the various species of flat fish and halibut, whose range of food includes more than 200 creatures, consistently feed on only a few of these (Mikulich, 1954).

21. Many Far Eastern fish greatly surpass North-East Atlantic fish in their rate of growth, average annual growth in weight and also fleshiness and oiliness. Thus, the average annual growth in weight of the Pacific cod is 1.5 to 3 times that of the Barents Sea cod, and the average weight of the Pacific cod is two to three times that of the Atlantic cod of the same age class.

22. The interspecific relations between commercial and non-commercial fish exercises a very real effect on the numbers and behaviour of the commercial fish population, but as yet this factor has been little studied. The number of species (166 in the Pacific as compared with 48 in the North Atlantic) and the abundance of Cottidae, Agonidae, Hexagrammidae, Liparinae, Blenniidae and other bottom fish, which often have a diet similar to that of the commercial fish and feed intensively on the spawn and young of the latter (and sometimes even on mature fish) undoubtedly leave their mark on the biology of many commercial bottom fish and often reduce their stock considerably.

Table 2

Number of species of non-commercial bottom fish in the Pacific and Atlantic Oceans

Family or Order	Bering Sea (Andriyashev, 1939)	Sea of Okhotsk (Schmidt, 1950)	Sea of Japan (Lindberg, 1937)	Pacific coast of America (Schulz and de Lacy, 1935)	Atlantic, Barents Sea (Knipovich, 1926)
Cottidae	73	50	36	38	14
Agonidae	16	15	15	15	4
Hexagrammidae	6	5	4	5	-
Cyclopterinae	9	23	10	13	3
Liparinae	22	+	-	-	4
Blenniidae	40	55	37	29	23
TOTAL	166	148	102	100	48

23. Other types of fish too are known to be affected in this way by natural predation; in the case of salmon, for example, there are instances where up to eighty per cent of the young of the pink salmon are eaten by loaches, young coho salmon and other fishes even before they descend to the sea (Semko, 1953).

24. These are the fundamental differences in the environment of commercial fish in the North-East Atlantic and the North-West Pacific which make it possible to determine that there are characteristics which are peculiar to the topography, oceanography and population of the Far East seas. This specificity of environment is largely responsible for some of the distinguishing biological characteristics of the commercial fish in the North Pacific and it produces sharp fluctuations in the stock of several commercial varieties.

25. Such fishes as the pollock (Theragra chalcogramma), the Pacific herring (Clupea harengus pallasi), the Pacific salmon (Oncorhynchus) and others are extremely widespread and abundant in this area. The pollock is a nekto-benthic rather than a demersal fish; it ranges freely through the middle water and feeds mainly on plankton and nekto-benthic crustacea and much more rarely on benthos. It has little tie with the comparatively narrow continental shelf, withstands low and sometimes sub-zero temperatures relatively well and not infrequently rises to the surface in search of its food.

26. The Pacific salmon (Genus Oncorhynchus) take as their spawning grounds the wide basins of the rivers which empty into the Northern Pacific, where the eggs and larvae can develop in the conditions most suitable for each species. Later on, when the young salmon migrate to the sea and begin to feed intensively on the concentrated bio-masses of the open sea, their environment is particularly favourable and they grow rapidly and ensure a high level of stock recruitment.

27. The Pacific herring, having penetrated to the North Pacific from the North Atlantic in one of the interglacial periods, has settled very widely there; it has taken over extensive areas of the off-shore shallows as spawning grounds and, feeding on the abundant pelagic food supplies of the Far Eastern seas, has become very numerous.

28. Similar examples could be given for a number of other commercial fish.

29. The overwhelming majority of the creatures inhabiting the Far Eastern seas, and particularly such creatures as salmon, herring, cod, flat fish, navaga, pollock and king crab, have formed a number of isolated and often independent populations, which have settled in various regions of the Far Eastern seas and adapted themselves to living in varied conditions.

30. The localised nature of the present habitats and of the large concentrations of these commercial fish, having regard to their wide distribution throughout the Far Eastern seas, together with the existence of biological and morphological differences in most of the varieties which now have their habitats in several regions, indicates that we are dealing with a fauna which is now compartmentalised and isolated in a number of comparatively detached areas, though sometimes widely scattered all along the North-East shores of Asia.

31. The geological history of the countries of the Far East and, more especially, the distribution of fresh-water fauna in North East Asia (Yale, 1929; Lindberg, 1937, 1948) provide conclusive evidence that successive advances and withdrawals of the sea took place on the shores of Eastern Asia during the quarternary period and that enormous upheavals occurred beneath what are now the marginal Far Eastern seas. The distribution and biology of the marine fish carry this theory further and show that not only the fresh-water fauna but also the typically marine fauna, and in particular the fish of the Far Eastern seas, which were at one time comparatively uniform, are now split up into local populations.

32. It may be presumed that the movements of the sea and, more particularly, the chasms which formed in the region of the present marginal Far Eastern seas led to the contraction of the continental shelf, to the appearance of large areas of great depth, to the development of regions with markedly varying oceanographic conditions, and, perhaps, to an increase in the speeds of currents. All this led to the break-up of the once continuous populations of fish and other creatures of many kinds which had been inhabiting this area, and to their separation, as indicated, into isolated groups which acquired distinct biological features and, with them, certain related morphological differences.

33. Instead of the very extensive and protracted horizontal migrations of herring, cod, pollack and other fish which occur in the Atlantic Ocean, we find that in the Northern Pacific there occur comparatively short seasonal migrations of the majority of fish and other creatures, principally from deep to shallow water and back, which are due both to the sharp seasonal changes in hydrographical conditions in the upper layer of water (to a depth of 200 metres) and to the location of food supplies and other factors (Polutov, 1948, 1951, Moiseev, 1946, 1950, 1953). This sharp seasonal change in hydrographical conditions has led in the case of most commercial fish to the evolution of single spawning, to the shortening of the incubation period, to the occurrence in a number of fish (flatfish, for instance) of protracted periods of enforced winter-fasting (combined with a sharp decline in activity) and so forth. Only a number of pelagic fish, (mackerel, sardine, anchovy, saury, etc.) in the North-West Pacific undertake fairly longthy feeding migrations, which are longest during their periods of maximum population density.

34. As has already been observed, one of the most important characteristics of the Far Eastern seas and one which sets its mark on the nature, the number and, more especially, the biology of the creatures inhabiting them, is the complex of currents which are relatively constant and at the same time fast-moving.

35. In view of the narrowness of the continental shelf, the vast extent of the great depressions and the markedly varying hydrological conditions even in areas situated close to each other, the high speeds of the currents in the Far Eastern seas are extremely unsuitable for many of the creatures living in them which have pelagic spawn. It is easy to see that eggs and larvae, and also later the young fish which wander into the currents, will be carried far away from the spawning area and will then in most cases have to contend with conditions unfavourable for their further development.

36. The simplest reckoning will show that if the eggs and larvae of, say, flatfish remain for 15-20 days in the open sea where the speed of current is 0.5 miles an hour, the young fish will emerge 180-240 miles from the spawning ground, which usually means outside the confines of the region which is a suitable habitat for them.

37. Consequently, fish which have pelagic spawn have evolved ways of avoiding the most harmful effects of fast-moving currents in order to ensure reproduction in sufficient numbers. Flatfish, for example, in regions with very fast-moving currents, come right in to the shore to spawn and deposit their eggs in inlets and bays where there is little movement of the water. Furthermore, a plaice, (Pseudopleuronectes yokohamae) has developed a sticky, benthonic spawn (Pertseva-Ostroumova, 1954). It is very probable that certain other types of flatfish (Pleuronectes obscurus and Pl. pinnifasciatus) have developed similar spawn which is deposited under the ice. No large concentrations of flatfish are found in areas of shallow water with strong currents and only slight indentation of the shoreline, whereas they are being found in greater and greater numbers in regions where there is little movement of the water (Western Kamchatka, the Tatar Straits, the South East coast of Sakhalin).

38. The Atlantic cod has pelagic sawpn, but the cod found in Far Eastern waters has benthonic spawn (Uchida, 1936), which is not carried away to any large extent by the currents and is able to develop in areas with the most suitable temperatures. In addition, benthonic spawn is not exposed to the harmful effects of the floating ice which covers much of the spawning areas during the cod's spawning period.

39. The pollack, which has pelagic spawn, comes close in to the shore, to areas with slow-moving currents, to deposit its eggs (Vedensky, 1949; Gorbunova, 1954). Its main spawning grounds in the Korean Gulf, Peter the Great Bay and off the South West coast of Kamchatka are in areas of relatively still water.

40. At the same time, fish with demersal attached eggs (the Pacific herring, and certain members of the Cottidae, Blenniidae and Rajidae and other families) find that the Far Eastern seas offer the most favourable conditions for their development and are found there in great numbers or in a great variety of species.

41. The Pacific herring has demersal attached eggs and, unlike the Atlantic herring, deposits them as near the shore as possible, thus ensuring that large numbers survive even in regions with extremely strong currents (the Shelikhov Bay, the Northern Coast of the Okhotsk Sea).

42. The currents in the Far Eastern seas greatly influence the behaviour and numbers of pelagic fish. Such typical inhabitants of these areas as the sardine (Kaganovsky, 1935), the mackerel (Vedensky, 1951) and the yellow-tail Seriola quinqueradiata and other fish come close in to the shore to spawn and deposit their eggs in inlets and bays.

43. All the foregoing explains why the vast majority of fish with pelagic spawn deposit their eggs near the shore, why fish with benthonic spawn deposit their eggs in their home ground and why fish with demersal attached eggs are found in great numbers and a great variety of species in the Far Eastern seas.

44. Owing to the abundance of predators in the North West Pacific many fish have armed themselves with strong anal rays, well-developed opercular spines and so forth.

45. The greater fecundity, by comparison with closely related Atlantic varieties, of the majority of the fish inhabiting the Pacific Ocean can be ascribed largely to the gradual reaction of the species to local oceanographic conditions and to the somewhat greater influence of the predators native to Far Eastern waters.

Table 3

Fecundity of some Pacific and Atlantic Ocean Fish

(in thousands of eggs)

Types of Fish	Pacific Ocean	Atlantic Ocean
Ground and Demersal:		
Cod (Gadus)	411-763	170-250
Navaga (Eleginus)	25-210	6.2-6.3
Limanda:		
L. aspera	626-1,133	-
L. punctatissima	162-528	-
L. limanda	-	80-140
Hippoglossoides:		
Hip. elassedon dubius/37-42 cm. in length	211-241	-
Hip. platessoides limandoides/47-49 cm. in length	-	241-336
Pelagic		
Moiva (Mallotus)	15.3-39.9	6.2-13.4
Mackerel:		
Pneumatophorus japonicus	400-800	-
Scomber scombrus	-	350-450
Anchovy:		
E. encrasicholus	-	30
E. japonicus	35	-
Herring (Clupea)	39.9-92.4	14.8-23.3

NOTE: The fecundity of the cod stated above is for 1 kg. of fish.

46. The above shows the importance of a knowledge of the oceanography of the Far Eastern seas for an understanding of the generally established principles of the biology of fish common to those seas.

47. Of special importance are the changes which have occurred over a period of years in the Kuroshio current in determining the oceanographical details of the north-west section of the Pacific Ocean and all the Far Eastern seas. The changes observed over the last forty years have led to changes in the distribution of warm and cold masses of water. Two warming periods and one cooling period occurred in that time. Such alternations or disturbances in the Kuroshio considerably affect the oceanographical characteristics of a number of regions in the north-west section of the Pacific Ocean which in turn influence the distribution and quantity of a number of commercial fishes.

48. Such are a few of the biological characteristics of the fish population of the north-west Pacific which, feeding on the highly-nutritive benthos and plankton in the Far Eastern Seas, are found in relatively large numbers notwithstanding the comparatively small area of the continental shelf.

49. The rational organization of the fisheries for salmon, herring, cod, pollack, flounder, halibut, mackerel amd other fish, taking account of the size of the shoals and of the conditions of reproduction in the north-west section of the Pacific Ocean, may lead to highly stable conditions and considerably higher catches.

50. At the same time the fact that commercial fishes are localised, that they spawn near the shore and that the fry remain in shallow waters makes it essential to develop the industry strictly in accordance with the quantity of each commercial species, taking into account its biological characteristics and, at the same time, taking measures to increase its rate of reproduction.

51. The above-mentioned particulars concerning the biology of several Far Eastern fish, the changes in metereological and oceanographical conditions and the influence of commercial fishing are important factors in causing fluctuations in the quantity of a number of commercial fishes in the north-western section of the Pacific Ocean.

52. We shall give a few of the most characteristic examples.

53. Pacific Salmon. The three main species of Pacific salmon (ONCORHYNCHUS) fished in the Far Eastern waters are the pink salmon, the chum salmon and the sockeye salmon. Before 1940, up to 400,000 mt. tons of salmon were caught along the north-eastern shores of Asia; subsequently, as a result of the intensive sea fishing by the Japanese, who failed to take into account the size of the fish population, and also of the unfavourable metereological and oceanographical conditions, the size of the catches dropped considerably, amounting at the present time to 100,000 - 250,000 mt. tons.

54. The current catches of salmon fluctuate in accordance with the intensity of the fishing and with the productivity of each generation, which depends on a number of natural factors such as the freezing in some years of the spawning grounds, the devouring of the spawn and larvae by predators and changing of the water level at the spawning grounds.

55. Considerable fluctuations in the population sizes of the most numerous species of salmon - the pink salmon - as well as a decline in the populations of other species of pacific salmon such as the chum and the sockeye salmon - have been noted.

56. One of the reasons for the marked decline of the salmon population in some areas has been the unfavourable climatic conditions. The sharp drop of winter temperatures and the decrease in winter precipitation frequently cause extensive freezing of the spawning grounds. By means of repeated year-round observation of the development of the salmon spawn in winter weather in various areas of Kamchatka and in the Amur Basin it was possible to establish the effects of hydrometeorological factors on the number of the young with sufficient certainty (Semko, 1953; Krogius, 1954; Birman, 1954 and others).

57. A typical example is the marked drop in the number of chum in the Amur basin where, as a result of the extensive freezing over a period of four years - from 1911 to 1914 - of the spawning grounds of the summer chum salmon in the most sheltered areas, there was a considerable drop of the population, further aggravated by the intensive fishing. As a result, the catch which was 21.4 million fish in 1910 dropped to 0.2 million in 1920 and has remained low since (Nikolski, 1954).

58. The Pacific salmons inhabit different areas at different times and as a rule return for spawning to the basins of the streams where they were hatched. That is why a decreased salmon population in one area cannot be supplemented with salmon from a neighbouring, more productive, area. Once a catch declines, it usually continues to be low for a long time and can be increased only by means of long-term and costly measures for the conservation, reclamation and culture of the fish.

59. Since the commercial salmon fisheries have shrunk, fishing has become more intense; it has become particularly intense during the past years as a result of Japanese salmon fishing at sea; and the number of salmon reaching the spawning grounds is definitely inadequate in some areas. For example, in 1954, of the main school of sockeye salmon moving to deposit their spawn in Lake Kurill in Kamchatka, only 320,000 fish reached the spawning ground, instead of the 2 to 2.5 million fish normally needed to fill the spawning ground, while 3.8 million salmon were caught at sea by Japanese vessels. With such intense fishing, the number of Kamchatka sockeye salmon will soon decline disastrously. There is the well-known example of the population of sockeye salmon in the Kamchatka river basin; as a result of intense sea fishing, the catch rapidly dropped from 23 to 24 thousand mt. tons, in 1937-39, to 200-300 hundreds mt. tons and numerous conservation measures have failed to raise it.

60. With the methods developed to forecast the number of Pacific salmon on the basis of data concerning the survival rate of the spawn, larvae and the fry it is possible to predict the nature and number of the spawning runs with some accuracy. The number of fish that may be caught in the different regions should be established in accordance with the scientific recommendations for the permissible size of the catch. The Soviet Union is doing extensive work to provide better conditions for the natural spawning of Pacific salmon and to improve the spawning grounds. Fish conservation measures are strictly complied with. The size of the permissible catch is determined each year on the basis of the age composition of the spawning stock. Extensive salmon culture operations are being carried out. In view of the depletion of the Pacific salmon population, even greater efforts are needed to conserve and increase it. Naturally, steps must first be taken to ensure the effective regulation of salmon fishing otherwise measures of fish conservation and culture will be of no avail and the number of salmon will rapidly dwindle.

61. It therefore goes without saying, that the countries interested in keeping up the Pacific salmon population must participate both in the regulation of the size of the catch and in the culture of the fish.

62. PACIFIC HERRING, though it occurs almost throughout the coastal waters of the Far Eastern seas, forms several localized stocks which live in limited areas and do not migrate long distances. The largest concentrations are known to exist off the coast of Sakhalin and Hokkaido and along the north-western shores of the Sea of Okhotsk. Considerably smaller populations occur in the Shelekhov Bays along the north-eastern coast of Kamchatka. Between 1925 and 1935 the total catch of herring in the north-western part of the Pacific Ocean was almost one million mt. tons and in recent years it dropped to 200 to 300 thousand mt. tons. The number of Pacific herring fluctuate considerably, according to the sizes of the various generations which are to a large extent determined by oceanographic conditions and the intensity and nature of the fishing.

63. It has been observed that the very numerous, generations of herring that spawn along the north-west shore of the Sea of Okhetsk are those which were hatched in years when there were no ice floes in the littoral zone, while the sizes of the broods are reduced to levels of no practical significance for stock replenishment in years when spawning occurs in an unfavourable ice régime. In view of the fact that not more than two or three age groups are fished, the failure of one of them tells very materially on the results of the fishing.

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64. The very considerable fluctuations in the number of herring in the Sakhalin-Hokkaido stock (in the last twenty years, catches have declined from 900 to 100 thousand mt tons) are due to somewhat different causes.

65. The rise in the temperature of the Sea of Japan which began in the years 1922-1924 created unfavourable conditions for the reproduction of the Sakhalin-Hokkaido herring, especially near Hokkaido, where by 1930 the catches had been reduced by one-half as compared with 1920. Later (in the period 1933-1938) the catches also began to decline gradually off the shores of Sakhalin, and had fallen to minimum proportions by 1938 (Svetovidov, 1953). When the temperature of the Sea of Japan began to fall (after 1938) the catches gradually began to increase, and high-yield generations appeared in 1939, 1940 and 1942; they constituted the bulk of the catches for nearly twelve years. One generation alone, that of 1939, yielded catches of over 700 thousand mt tons. However, the number of these high-yield generations was substantially reduced and the reproduction of the herring limited by the intensive fishing of small, sexually immature herring, of which about 150 thousand mt tons a year were caught in 1940 and 1941 (Probatov, 1953).

66. It is interesting to note that, as a result of the intensive fishing and of the improvement in feeding conditions, some increase is observable in the fecundity of fish of certain size, and also a rise in the growth rate (Piskunov, 1952).

67. Owing to the change in oceanographic conditions and to irrational and intense fishing, the numbers of the reproductive population have declined sharply, the area of the spawning grounds has contracted and the catches have fallen. In order to increase the reproduction of the Sakhalin-Hokkaido herring population the catching of young fish must be completely stopped, offshore fishing regulated and the underwater vegetation in the spawning grounds protected.

68. There is a large number of species of flat-fish (twenty-eight) in the Far Eastern seas, of which only a few, which predominate in the catches, are of primary importance to the fishing industry. Far Eastern flat-fish are scattered as a large number of local, distinct and in some cases relatively small populations living within the confines of a shelf where the oceanographic and feeding conditions are favourable. The biggest concentrations of flat-fish are found in the coastal waters of western and south-eastern Kamchatka, near the Kurile Islands, in the Tatar Strait and off the Soviet coast of the Japan sea and Sakhalin.

69. Their migrations are limited to a movement from the relatively deep regions where they winter to the coastal shallows where they breed and feed, the total distance of migration rarely exceeding 80 to 100 nautical miles, except in the case of halibut.

70. The specific distribution and biology of flat-fish makes them particularly vulnerable to fishing and if this is not regulated the stock may easily be over-fished.

71. It is possible to show the effect of intense fishing on the flat-fish stock of Peter the Great Bay (Sea of Japan) by an example of a similar kind; the study of this influence began simultaneously with the organization of the fishery, a circumstance which has enabled many changes in the population to be established almost from the first months of their appearance.

72. The flat-fish population of Peter the Great Bay was practically unfished until 1929, but a rapid increase of the catch to 8 thousand mt tons (in 1932-1933) led to a number of striking consequences. The average catches, and therefore the total take, declined rapidly in the four years following the organization of intense fishing, and the areas inhabited by the winter concentrations shrank from 2000 km^2 to 150 km^2.

73. At the same time a change occurred in the composition of the catches through a sharp decline in the number of Limanda aspera, the main species fished. The quantity of the oldest age-groups in the population diminished and the proportion of young, sexually immature fish increased considerably. The average size of flat-fish of all ages are increasing; for example, the length of year-old males of the species Limanda aspera has increased by 77 per cent (Moiseev, 1946). Sexual maturity also comes earlier in such rapidly growing fish. Statistics show that, on account of the more rapid rate of growth of the flat-fish population of Peter the Great Bay decimated by industry, there was a markedly quicker increase in the live weight (Moiseev, 1946). In the following years a complex of fishery protection measures was adopted - the catching of young fish was prohibited, the mesh-sizes of fishing gear were controlled, prohibited fishing areas were defined and a limit was set to the annual catch, which resulted in stable fishery conditions.

74. The example of the flat-fish population of Peter the Great Bay shows that it is relatively easy, if fishing is intelligently regulated, to obtain stable catches and to achieve the most efficient use of the populations for a long time. At the same time it is easy to see that the over-fishing of flat-fish can easily lead to a sharp decline in the population, and some time is required for its rehabilitation.

75. It is easy to see that the great isolation of the flat-fish population of the Far Eastern Seas makes them much more liable to capture than those in the seas of the north-eastern part of the Atlantic Ocean, where the level of flat-fish fishing is large enough and well known (Jensen, 1947; Margetts and Holt, 1947).

76. Cod are widely distributed in the coastal waters of the north-western Pacific. It is known that there are substantial concentrations off the shores of Kamchatka and in the Anadyr Gulf, near the northern and southern Kurile Islands and off the shores of Sakhalin and in the Japan Sea. The Pacific cod does not make the extensive migrations peculiar to the Atlantic cod. In various areas of the Far Eastern seas it forms local populations which make small seasonal migrations, usually not exceeding 200-300 nautical miles. The isolation of the different populations of cod makes them highly sensitive to a change in oceanographic conditions and to the effects of commercial fishing. Observations of the cod populations along the eastern coast of Kamchatka have shown beyond a doubt that the size of generations of cod increases in periods of rising temperature, which is explained by the more favourable living conditions for the young fish. A specially marked influence on the numerical strength of the population was noted for the particularly strong brood of 1934, which appeared for ten years in the catch.

77. On the other hand, very intense commercial fishing of cod in some areas has led to a decrease in the average sizes, and to a sharp decline in the size of the catch. Thus, on the coast of southern Sakhalin the cod catch amounted to 54 thousand mt tons in 1912-1913, but the number of cod inhabiting this area then declined markedly, and the catches fell to 15-20 thousand mt tons in 1931-1940.

78. There is no doubt that the fragmentation of Pacific cod into a large number of distinct populations makes them much less resistant to the effects of commercial fishing than, for example, the Arcto-Norwegian stock of cod, which inhabits a wide area, is numerous, and offers great resistance to the effects of intense fishing.

79. Major changes in the abundance of cod of the Arcto-Norwegian stock usually occur, not through the effects of commercial fishing, but under the influence of fluctuations in oceanographic factors (Rollesfsen, 1949).

80. The foregoing shows that, in addition to a survey of the oceanographic conditions and the determination of their influence on the numbers of Pacific cod, the particular nature of their biology urgently calls for strict regulation of the intensity of fishing in accordance with stock levels of each population.

81. The king crab (Paralithodes camtschatica) is widely distributed in the north Pacific, but the most important concentrations are found along the coast of Kamchatka, the northern and southern Kurile Islands, Sakhalin and Japan Sea. These concentrations represent separate, isolated populations which make comparatively short migrations. There are no data on the influence of protracted changes in the oceanographic conditions on the numerical size of crab populations, but the effect of intense fishing on the supplies of particular, very heavily fished populations has been shown most clearly.

82. Thus, the crab fishery on the coast of south-west Kamchatka organised in 1916 soon (in 1922-1924) began to land as many as 2.5 to 3 million crabs, which very quickly led to exhaustion of the supplies in this area (Miyake and Matsuro).

83. The rapidly developed crab fishery off the south-west coast of Sakhalin, which yielded over 5 million crabs in 1917, also resulted in a reduction in the population, a sharp reduction in the size of the crab caught and a diminution of the catches, after which a number of regulatory measures were adopted, resulting in the catch becoming stabilised at 1.5 to 2 million units. There is no doubt that the specific nature of the biology and distribution of the king crab in the north-west Pacific calls for the same attention to the organization of a rational exploitation of the resources as in the case of most commercial fish inhabiting this basin.

84. All the above data on the living conditions of sea fish and animals in the north-west Pacific, which to a considerable extent determine the peculiarities of their biology, distribution and abundance, and also the examples given of the effects of too intense fishing on the individual

populations of salmon, cod, herring, flat-fish and king crab, are sufficient proof that all the aforementioned fish may soon be caught if fishing is carried on without regard for the biological peculiarity and abundance of each individual population.

85. All this, in turn, bears witness to the need for agreement between the States concerned on the rational exploitation of the natural resources of animal populations suitable for commercial fishing, the areas of distribution of which are within the limits of coastal waters and of the high seas adjacent thereto, with a view to securing the largest possible catches while maintaining the populations at a high level.

86. Without co-ordinated efforts on the part of the countries of the north-west Pacific for the conservation and rational exploitation of the natural resources, those resources may be exhausted within a very short time.

87. At the same time, there are very abundant fishery resources in the extensive open spaces of the north-west Pacific, permitting rapid development of ocean fishing and substantial increase in the catches.

88. Several species of tunas sauries, swordfish and many others, are already being harvested to a great extent, and there is every reason to believe that the catch of these fish can be considerably increased without any reduction in their number. Their wide area of distribution in the extensive open waters of the Pacific, the great length of their migratory routes, their great number and the fact that they spawn in the open sea, make these fish considerably less vulnerable to commercial fishing than those which live in coastal water and which concentrate for spawning on small areas in the shallows, or in rivers.

89. While about 9 million mt. tons of fish and other marine animals are even now being caught in the north Pacific, which is more than in any other basin, there can be no doubt that there are great opportunities for further intensifying the exploitation of the natural resources of this area of the world ocean through the development of ocean fishing.

90. This method is the one that offers the best prospects from the point of view of the utilization of the natural resources of the north Pacific..

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