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BY P. A. MOISEEV.

THE COD AND FLOUNDERS OF FAR-EASTERN SEAS.

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I N T R O D U C T I O N

The Chukotsky and Bering Seas, the seas of Okhotsk and of Japan, which was the Far Eastern Shores of the Soviet Union, cover immense areas. The multitude of animals inhabiting these seas is extremely varied. Of fish alone there are up to 800 species, among which some 200 are or can be regarded as exploitable species.

Up to the present time the salmon and herring have been of prevalent industrial importance in the Far East. The immense reserves of these fish, relative simplicity and high effectiveness of the fishing methods employed during the spawning period, simplicity of processing involved, excellence of quality of the finished product, all these factors appealed to industrial fishing, fish-processing and fish-marketing organizations. As a result, the entire fishing industry of the Far East was until recently, a passive industry - 90% of the catch was obtained by means of stationary fishing implements or fishing cordage cast from the shore

(such as seines and casting nets, etc.). Crab-fishing, whale-hunting and the hunting of other sea animals are exceptions.

It is quite natural that where fishing methods are prevalently passive and depend for their success on the intensiveness of spawning by salmon and herring, a phenomenon rarely outlasting a few days, the success of the entire fishing season depends entirely on the catches made during a very short period of time. No out-of-season catches will compensate for low catches during the season and the entire fate of the yearly fishing plan often directly depends on hydro-meteorological conditions: storms, ice, distillation of the water in the littoral zone and other factors.

Moreover, the reserves of Salmonidae are exhausted in certain fishing regions and rotation of abundant and scant generations of humpbacked salmon in all the regions produces enormous fluctuations in the annual catches of salmonidae; therefore, any considerable increase in the catch of fish in the Far East at the expense of Salmonidae must be considered as not very probable until effective methods of reproducing the salmonidae are developed and introduced into practice.

The exhausted reserves of herring in the littoral zone and near the shores of Bakhalin do not provide a basis either for planning any substantial increase in catches of this fish.

At the same time, however, the reannexation of the Kuril Islands and Southern Sakhalin to the Soviet Union, rapid population of the shores of the Far Eastern seas by permanent residents, development and technical re-equipment of the fishing industry in the Far East and the continuously growing demand for fish products on the part of the population of the Soviet Union demand rapid rise in the catches of fish in the Far East and considerable increase in the assortment of fish products.

One of the most substantial methods for increasing the catch of fish in the Far East (by several million hundredweight without intensifying the catch of Salmonidae) is the use of large accumulations of benthonic fish- cod, flounders, navaga, ruff and others, the reserves of which have remained practically intact up to the present.

During the last few years cod and flounder fishing have been somewhat intensified (particularly during the Patriotic War), however, even the maximum summary catch of cod and flounder is not as great as it might be.

Underlining the exceptionally economic importance of benthic fish inhabiting the Far Eastern seas and simultaneously noting that the scale on which the fishing of these species is conducted at present, is quite insufficient, we think it expedient to generalize the data available on the biology, distribution and industrial fishing of the most important benthic fish of the Far East which are most important from an industrial standpoint, namely, cod and flounder, and shall try to find what are the regular habits characteristic of these fish.

Furthermore, we wish to point out that the peculiar characteristics of the Far Eastern Seas have developed a number of specific features of peculiar behaviour to cod and flounder in this area as compared to the behaviour of cod and flounder in other basins.

We also wish to point out that prior to the establishment of the Soviet regime in the Far East, the biology of benthic fish was not studied at all, and the scientists working in this region limited their research for the most part to research of ichthyofauna to systematic classification.

Only after the Pacific Ocean Scientific Industrial Station for the Far East was organized in 1925, a station subsequently re-organized to form the Pacific Ocean Scientific Research Institute of Fishing and Oceanography, did the study of deep-sea fish with a view to major industrial exploitation developed on a considerable scale.

Over the course of the past year, we have collected considerable data material on the biology of cod and flounder and less extensive data on the biology of Alaska pollack navaga and other benthic fish, however, only an insignificant fraction of the results of these investigations has appeared in print (see bibliography) to clarify certain aspects of the biology of this important food and industrial product.

The present publication is a compilation of the results of the research carried out by the author and his assistants from TINRO (whose names are quoted in the text) on the industrial biology of cod and flounder in the Far Eastern seas.

The problems, hitherto either insufficiently or not at all clarified in existing literature, are discussed most thoroughly. In a series of cases the author provides extensive factual data of original character, which cannot be found in the limited literature on the fish in the depths of the Far-eastern seas.

The author admits that this work has substantial shortcomings, but believes that it is indispensable to generalize the data collected during the twenty years (1930-1950) of research.

The composite data on the industrial biology of benthic fish inhabiting those seas and the description of the main regularities of their biology will, we hope, facilitate the utilization of the considerable, but thus-far little-used reserves of fish in the waters washing the Pacific shores of the U.S.S.R.

SHORT HISTORY OF INVESTIGATIONS.

The first data on industrial fish (including the cod flounders and turbot which inhabit the Far Eastern seas were obtained by Russian seamen and explorers in the 18th century.

Russian military and commercial seamen - the courageous navigators, attentive observers and thoughtful explorers - left detailed diaries, notes and descriptions of everything they saw while navigating the North Pacific Ocean, a region previously quite unknown to Europeans.

Spanberg visited the east coast of Japan in 1739, reported he saw cod and other fish which "... we have not seen either in Europe or Asia". While navigating the packet-boat "St. Peter" with Vitus Bering in 1744, Steller, outstanding scientist, member of the Russian Academy of Sciences, visited a number of islands near the shores of Alaska and described in detail the cod and turbot fishing off the shores of Kodiak Island (Steller, 1793). Even American explorers (Kobb, 1927) were compelled to admit that "the first data on the presence of fish (in Alaska waters-p.m.) were provided by a Russian navigator in 1765, who reported that cod, perch, herring and smelt were found around the Lysiy Islands". Tikhmenov (1861) records how Russian inhabitants of Alaska coast reported: "cod and turbot were available during the summer in sufficient number, as were herring and navaga, all caught during their respective seasons".

Considerably later, in 1857, American commercial seamen, by accident, made it possible to effectively conduct commercial cod fishing in Tatorskiy strait and near the shores of Kamchatka. It is worth while noting that American cod fishing in the Pacific Ocean started and initially developed near the Russian shores. Shelekhov, one of the organizers of the Russian-American company, described the hook cordage used in cod and turbot fishing by the population of Aleutian islands in detail. Steban Krasheninnjkov, the brilliant explorer of Kamchatka (1775), listed cod and turbot among many other industrial fish species described in his outstanding work "Description of Kamchatka Land".

I. Veniaminov, who lived in Alaska for a long period of time (1840) reported in detail on the cod fishing in that area, made observations on the migration and behaviour of cod and pointed out cases of its complete annihilation and disappearance from the fishing grounds during certain years.

We could give several other similar examples, but the above suffice to show that over 200 years ago, during the period of early exploration across the Northern Pacific Ocean Russian seamen and explorers already had data on the huge potential resources of cod, turbot, flounder and other fish species along the Northwestern and Northeastern coast of the Pacific Ocean.

During the second half of the XVIII century, the period when exploration and settlement of the discovered territories of the Far East began, a number of outstanding scientists visited the shores of the Pacific Ocean.

The earliest scientific reports on benthic fish of the Eastern seas is found in the writings of Pallas and Tilesius, authors of the first fundamental studies on the fauna of the Far Eastern seas. In one of Pallas' books (1787), we find a description of *Pleuronectes Stellatus*. Considerably later, the classical work "Zoographia Rosso-Asiatica" appeared in print in 1831, (but was probably written in 1810-1811); this contains a description of Alaska pollack and two new forms of flounder *Pleuronectes asper* (*Limanda aspera*) and *Pleuronectes qualrituberculatus*, which later on proved to be the main forms of industrial flounders in the Far East together with a systematic characterization of 81 other fish species.

Tilesius (1810) provided the description of cod and navaga from Pacific Ocean.

A great many explorers (Schlegel, 1846); Bloker, 1854-1879; Bazilevsky, 1855; Guenter, 1812-1880; Steindachner, 1870-1896; Hertzenstein, 1890 and others subsequently studied the systematic classification of certain forms and composed files of the ichthyo-fauna of Japan and China including numerous representatives of Pleuronectidae and Cadidae. At the end of the 19th and beginning of the 20th centuries this research was continued by Jordan, Everman, Starks, Snider, Hubs, Tanaka and others.

Professor P. Yu Schmidt most particularly contributed to the study of the ichthyo-fauna of the Far Eastern seas. His name is associated with the beginning of the period of industrial marine ichthyological investigations in the Far East. The well known work by P. Yu. Schmidt "Fish of the Eastern Seas" is not merely an independent work on the ichthyo-fauna of the Far Eastern seas comprising description of a series of new species, but also contains detailed zoogeographic characterization of these waters. It is based on the critical analysis of the zoographic works by Shrenk, Millendorf and others, on the classical characterization of the hydrological conditions of the Northern part of the Pacific Ocean composed by Admiral Makarov and an analysis of the zoological collections gathered by the author.

The afore-mentioned zoogeographic division into zones has retained its value up to the present.

The organization and development of the fishing industry in the Far East required investigations on applied economics relating to fish. The work by P. Yu. Schmidt "Fish industry of Sakhalin" is the first publication of this type devoted to the industrial utilization of fish reserves in the Far East.

The works by Pavlenko, Brazhnikov and Soldatov marked the close of the pre-revolutionary investigations into the biology of industrial fish species and primarily into the biology of the herring, Salmonidae and Acipenseridae. The biology of benthic fish was a problem still awaiting study. We wish to mention, however, the relatively extensive investigations conducted by Marukav near the Western shores of Kamchatka (1915-1917); he collected ample material on the biology of cod and turbot, but did not sufficiently elaborate these data (Deryugin, 1928).

We can affirm with certainty that, prior to the establishment of the Soviet regime along the coast of the Pacific Ocean, no considerable ichthyological investigations and certainly not on deep-sea fish in particular were conducted in this region at all, so that data on the distribution, migration and biology of benthic fish were exceptionally scarce. The lack of special boats, underdevelopment of the industry and unwillingness of fish industrialists and of the government to organize the fishing of benthic fish, while salmon were abundant and easily caught, meant that by 1922 there were virtually no data from which the distribution and industrial reserves of cod, flounders, turbot, navaga and Alaska pollack could be estimated.

However, the cod-fishing by American and Japanese schooners near the shores of Kamchatka showed that there exist ample concentrations of cod in that area, and the successful operation of trawlers "Fedya" and "Nakhodka" in Peter the Great Bay in 1911-1915 enabled us to discover dense winter accumulations of flounders (Tyrtov, 1911; Pavlenko, 1920).

The navigations of Navozov-Lavrov and Rozov on board the cod fishing schooners in 1927-1928 (Navozov-Lavrov, 1927-1928) enabled us to observe and describe the operation of cod fishing schooners near the Karaginski and Komandor Islands, as well as collect relatively extensive data on the biology of cod and turbot.

In 1929, the first large trawlers, totalling 20 in number by 1932 and navigations of the first Soviet scientific research boat in the Pacific Ocean - the schooner "Rossinante" - enabled us to develop the investigations on biology and distributing of benthic fish. A numerous research personnel was formed comprising Okhryamkin, Polutov, Schmit, Krivobok, Shurin, Generozova, Moiseev, Demidova, Naumenko, Mishchenko and Petrova-Tychkova, who devoted all their energy to the study of the biology of benthic fish. The first cruises of trawlers and schooner "Rossinante" in the Sea of Japan had already enabled us to establish the main regularities of the vertical distribution of benthos and flounders and reveal large summer accumulations of flounders in the Northern part of Tatarski strait and high winter concentrations within the limits of the so-called "Askold Flounders shoal waters" in Peter the Great Bay (Okharyamkin, 1930; V., 1930;

Anonymous, 1930; Orel, 1931, Ivanov, 1931-1933). In 1931 Krivobok published an article with detailed analysis of conditions under which trawlers operated in Peter the Great Bay.

During the numerous cruises in 1930 and 1931 of the commercial and reconnaissance trawlers in the sea of Japan, to the shores of Kamchatka and in Bering Sea, the Scientific members of the Institute-Krivobok, Polutov, Schmit, Okhryamkin and Alperovich - collected extensive data on biology and distribution of cod and flounders showing the wide propagation of cod in the shallow waters of North-Eastern Asia; however, at that time they found no such highly-concentrated populations spread over large areas as had been expected. Nevertheless, large summer concentrations of flounders near the Western shores of Kamchatka ⁽¹⁾ were discovered. 1932 was a year of exceptionally far-reaching complex explorations of Far Eastern waters. Under the supervision of professors K.M. Deryugin and P. Yu. Schimdt and with the participation of professor I. I. Nesyatsev the collective of 50 scientists specialized in different fields of science on board six research boats conducted simultaneous hydrological, hydrobiological and industrial investigations in the Sea of Japan, Okhotsk Sea, Bering Sea and Chukotski Sea. Without going into the details of the operation and navigation of different boats of the expedition, a subject thoroughly discussed in the articles by Deryugin (1932, 1933), Schmidt (1933), Moiseev (1935) and other authors, we shall point out only that this expedition obtained

the data on regions which had been virtually unknown up until that time. They changed the existing conceptions of hydro-logical conditions and of the distribution of plankton and benthos in these seas. All these data also effected the zoogeographic division into zones of the Northwestern section of Pacific Ocean. The vast literature dealing with problems (Andriashev, 1935, 1937, 1939a, 1939b; Vinogradov, 1948; Guryanova, 1935; Deryugin, 1932, 1933, 1939; Deryugin and Somov, 1941; Kobyakova, 1936, 1937; Leonov, 1935, 1939; Ratmanov, 1937a, 1937b; Ishakov, 1934, 1940, 1949; Schmidt, 1933a, 1933b, 1935, 1948, 1950 and many others) is well known and is continually being completed by publications in which the results of the continuous development of data collected by the expeditions of 1932-1933, are presented.

In corresponding chapters of this book we shall dwell in detail on some of these data, but now we wish to mention investigations of scientific and industrial character. Serious shortcomings in the organization of the operation of the trawling fleet during the first years of its existence resulted in that the value of the industrial as well as of the exploration cruises, particularly with regard to some of the regions, was largely negligible. This circumstance affected the number of data gathered and limited the data on seasonal peculiarities, and prevented from sufficiently studying the industrial conditions of the operation of the trawling fleet. The unexplored regions attracted explorers and commercial trawlers because expeditions there had a certain novelty, but the boats did not

linger in the areas where isolated fish populations were concentrated but aimed at finding huge areas where cod-catches were consistently heavy (since cod was the main object of the search of the entire trawling fleet during the first years of its existence), and therefore moved over the vast shallow-water areas of the Far Eastern Seas with a thin grid of trawlings. Nonetheless, in spite of the aforesaid, considerable data were collected on benthic fish by 1933, and were particularly important in view of the fact that up to that time there existed practically no data on the biology and distribution of these fish in the Far Eastern waters.

Reports of the numerous researchers of TINRO from the Eastern and Western coast of Kamchatka, as well as from different points of the western coast of Bering Sea⁽¹⁾ and the trawl-caught specimens of cod, which had just completed spawning, enabled us to establish that the cod spawns simultaneously in different regions of Pacific Ocean (Schmit, 1933); this fact led us assume that separate, independent shoals of cod were present in and inhabited diverse regions of the Northwestern Pacific Ocean - and it was a fact indicating some peculiarity in the biology of cod. The methods of search previously suggested (Mesyatsev, Starostin and Maslov, 1933) and based on the experience of analogous research in Murman, proved inexpedient under the conditions prevalent in the Far Eastern seas. In a series of short articles Schmit (1933,1936) Moiseev (1934) and Andriyashev (1935,1937) draw certain deductions from the investigations on the biology of Pacific Ocean cod. We wish to add that in 1933 Prof. Suvorov participated in one of the trawling expeditions of TINRO to the shores of Kamchatka, during which he gathered a number of data which served to him as the basis for a series of publications

and manuscripts.

We wish to point out that by 1933-1934 the majority of explorers and industrialists became firmly convinced that the trawl-fishing of cod in the Far East promises nothing and the trawling fleet in this area is unnecessary. The latter was dissolved shortly afterwards. In the meantime, however, it was realized that the theory that trawl-fishing of cod is pointless in the Far East had been too hurriedly reached and reached without attentive analysis of reports received from the board of trawlers without thorough industrial fishing of the known shoals and that this theory was, moreover, based on data limited in scope and scant in respect of most regions. Moreover, serious methodical errors led to so prominent a specialist as Prof. Suvorov arriving at the following pessimistic conclusion while comparing the average dimensions of cod specimens caught by various fishing implements (by hook and by trawling) near the shores of the Western Kamchatka.. "reserves of cod are relatively modest" and "the explanation to the low yield of trawl fishing of cod is due to the limited reserves of cod on the one hand and dispersion of this fish over vast territories on the other hand". (Suvorov, and Shchetinina, 1935).

During the search for cod, the exploration, search and industrial ships collected ample data on the biology and distribution of many other industrial benthic fish-flounders, Alaska pollack and turbot, navaga, ruff (Scorpaenidae) and others. The data collected on biology and fishing of flounders were particularly numerous but so far have only been published in part. (Okhryamkin, Moiseev and Taranets, 1936; Suvorov, Kiseleva, Klyaritskaya and Moroz, 1937, Moiseev, 1938; Demidova, 1939). Vernidub and Panin obtained and developed a few, but very interesting

data on turbot (Varnidub, 1936; Vernidub and Panin, 1937; Vernidub, 1938). This, however, completed the first stage of the investigations conducted on benthic fish in the Far East, which constituted from 1929 to 1933. The subsequent period was characterized by research carried out on a smaller but more thorough scale.

Organization of cod-fishing by small motor-boats near the South Eastern shores of Kamchatka enabled Polutov, a member of Kamchatka branch of TINRO, to carry out observations on the migrations, distribution and behaviour of cod in this region over a number of years, as well as to establish the fluctuations in the number of this fish caused by changes in environment. The articles by the aforementioned researcher (Polutov, 1935, 1937, 1938, 1949) summarize his investigations on biology of cod in Avachinsky bay.

The Cadidae, which were at first intensively caught by trawlers, then (from 1935) from low tonnage boats by means of benthic casting nets, were studied in Peter the Great Bay over a number of years (1930-1950).

Schemes of migrations, seasonal distribution, age and dimensions, spawning periods, fertility, development of roe and young fish specimens, feeding and other biological features of the numerous Cadidae inhabiting the shallow waters of the bay were thoroughly studied (Moiseev, 1938, 1946a, Misachenko, 1938; Cvrilenko and Moiseev, 1939). Simultaneously, the changes occurring in cod shoals under the effect of intensive fishing

were observed (Tychkov, 1946; Moiseev, 1946b) and measures for the restoration of initially numerous shoals were recommended (Moiseev, 1946a).

Study on the biology of cod of the Southwestern coast of Sakhalin by the members of Sakhalin branch of TINRO (Kulichenko and Frolov) started in 1947. Alongside with the stationary investigations, expeditions worked on the biology of benthic fish, cod, primarily as did the search and development of methods for increasing trawl catches by improving trawling techniques.

In 1934, TINRO organized an expedition (Gordeev, the Head of the Expedition, Moiseev, the Ichthyologist) to the shores of Kamchatka on board the experimental boat "Lebel" all the year round (Gordeev, the Chief of the Expedition, Moiseev, the Ichthyologist).

Numerous data on the seasonal distribution of benthic fish enabled us to locate the regions in which the wintering of cod and flounders takes place and determine the periods and regions of spawning of the cod; we discovered both the summer, as well as winter periods of accumulation of cod within the limits of which we obtained high trawling catches (Moiseev, 1940a, 1940b, 1950). A series of articles on the roe and young specimens of cod and flounders (Rass and Zheltenkova, 1948) on the racial analysis of cod (Tychkova, 1949) and feeding of the cod (Logvinovich, 1948) was published on the basis of the data collected by the aforementioned expedition.

Results of the research conducted during the numerous expeditions on board the research trawler "Lebed" in 1934, 1937 and 1938-1939, the successful cod fishing during the winter near the Eastern shores of Kamchatka by commercial trawlers in 1940-1941, as well as the repeated analysis of the data gathered during preceding years and the critical evaluation of the previously drawn conclusions concerning the impossibility of successful cod trawl fishing in the Eastern waters, enabled us to judge these deductions groundless and hasty (Moiseev, 1940a, 1949, 1950; Gordeev, 1949). Moreover, the results of these investigations, and the experience gathered during the operation of the Kamchatka trawling fleet (1940-1950) clearly showed the necessity and expediency of organizing trawl fishing in the Far East and the multiform assortment of catch, where the cod occupies an important place.

The study on biology of benthic fish was conducted on an insignificantly small scale. Navaga was studied by Dubrovskaya (1933), Kaganovskaya (1949) and Frolov. While working on the data concerning cod, Suvorov and Shchetinina simultaneously reported on the basis of data obtained from the communications from trawlers and found in reports of the expeditions conducted in 1930-1933. During the last few years, in connection with the intensification of fishing of this fish species, particularly in Korean and Peter the Great Bays, we conducted special investigations some of the results of which were discussed in the article by Vedensky (1949) Kaganovskaya (1950a, 1950b), Mikulich (1949), Kizevetter (1949) and Gorbunova (1950).

The above presented description of the scientific research on benthic fish of the Northwestern part of Pacific Ocean and the articles quoted ⁽¹⁾ show that the investigations were conducted on a rather large scale, that there are contradictory opinions on certain basic problems of the biology of benthic fish and insignificant data material, which appeared in print.

We wish to point out that the overwhelming majority of published articles were devoted to the particular problems of biology and fishing and there are but a few compound works. Indeed, with the exception of the book by Moiseev on the flounders of Peter the Great Bay (1946a), a popular pamphlet by the same author on the flounders of Far East (1946), a series of writings by Polutov on the cod of Avachinski Bay and article by Kaganovskaya (1950), on the Alaska pollack of Korean Bay, no special works summarizing the data on biology and fishing of benthic fish for all the Eastern seas or at least for some large fishing region have been published as yet. The works by Vernidub and Panin (1936, 1937, 1938) on the classification and biology of Far Eastern turbot were based on rather limited data.

Despite the rather high percentage of benthic fish in the overall catch in Japan and Korea (11.4% in 1938),
(1)

We wish to add here the compilations by Schmidt (1947, 1948, 1950) and Suvorov (1948), the thorough work by Svetidov "Cadidae" (1948) and atlas on fish of the USSR containing chapters devoted to the problem, which we now discuss.

there are but a few publications devoted to their biology and fishing and in the majority of cases the published works are of a very primitive character and clarify only separate features of biology and fishing of benthic fish near the shores of Japan and Korea.

From the series of Japanese works describing the development of roe and young fish specimens of cod,..... and flounders, we wish to mention the articles by Kamiya (1916,1922,1925), Inaba(1931), Uchida(1936), Yamamoto(1939),

Apart from the widely known work by Marukava (1917-1918), the following articles detailed the distribution and biology of benthic fish in the seas of Japan and Ochotsk and near the shores of Japan; Otaki(1897), Suehiro (1934a,1934b), Hikita(1934), Uchida(1936), Kuronuma (1939, 1940a,1940b), Kanonara (1938) and Matsubara (1938,1939). Data on the biology, morphology and systematic classification of flounders inhabiting the waters near the shores of China, were presented in the work by Vu (1932).

Certain data on the fishing of benthic fish, with particular relation to benthic fish near the shores of Japan, can be found in the articles by Kishinouye (1897), Satoru(1939) and in a series of publications by various scientific-industrial stations, such as first of all the Hokkaido (Sapporo) and Tokyo stations.

However, the majority of the above mentioned works by the Japanese authors are not systematically written and are based on obsolete methods. They resemble similar works published during the past century.

The exceptional shortage of literature on the biology and fishing of benthic fish inhabiting the Pacific Ocean near North America is striking. If we exclude the relatively extensive bibliography dealing with the problem

of restoration and rational utilization of the reserves of turbot from the Pacific Ocean, reserves whose development is entrusted to a special commission, then we shall find that the number of works on biology of cod and flounders found near the shores of Alaska, Canada and United States can be counted in single numbers. The bibliography on the biology and fishing of the flounders in the Pacific Ocean waters of the American coasts comprises merely some short articles by Ketchen (1947), Manzer (1946), Mankulli (1949) and others, brief and incomplete reports on the industrial fishes of California (by Walford, 1931), of the Pacific Coast North America (Walford, 1937) and of Canada (Clemens and Wiby, 1946), all recently published and containing rather limited data on the problem considered by our research.

The bibliography on cod is almost as scant. After the publication of several works by Sean (1881, 1887, 1887a) and the wellknown report by Kobb (1916, 1927) there appeared no substantial work on the biology and fishing of Pacific Ocean cod.

By comparing the degree to which the cod and flounders of the Northern part of the Atlantic Ocean and Pacific Ocean have been studied, we became convinced that knowledge of the behaviour of the fish populations in the Pacific Ocean is much less extensive than is that of the cod and flounders of Atlantic waters. Dozens of scientific research organizations on the European and American shores of the Atlantic Ocean employing hundreds of members have studied the benthic fish (first of all the cod and

flounders over the past few decades; with the help of hundreds of small and large industrial boats and a large research fleet, working from year to year, they have collected ample data, which has become the basis for hundreds of articles on the biology and fishing of cod and flounders; the study of benthic fish is still in its initial stages with respect to the North Pacific Ocean, where pilchards, herring, salmon and other pelagic fish prevail (on both the Asian, as well as American shores).

We think that this fact underscores the need to produce a compound work on the biology and fishing of benthic fish in Far Eastern waters and first of all, on the biology of the most important industrially exploitable fish in this area, i.e. cod and flounders.

BRIEF PHYSICO-GEOGRAPHIC OUTLINE OF THE FAR EASTERN WATERS.

The north-east coast of Asia is washed by the waters of extensive marginal seas - the seas of Bering, Okhotsk and Japan, isolated from the open Pacific spaces by chains of islands.

In the North, the Bering Sea is connected to the Chukotski Sea washing the Northern shores of Chukotska, while the shores of Eastern Kamchatka and the ridge of the Kuril islands are directly adjacent to the waters of the Pacific Ocean.

The surfacd areas of the aforementioned seas covers 5212 thousand square kilometers and the length of the shore line (exclusive of the Kuril Islands) totals 22 thousand kilometers. The seas are connected with the Pacific Ocean through straits, which are shallow in the case of the Sea of Japan and deep in the case of Okhotsk and Bering Seas. Their characteristic hydrological conditions depend on the open waters of the Pacific Ocean and primarily on the Kuroshio and Oyashio ocean currents).

TRANSLATOR'S NOTE:

(All spellings based on the map of the Pacific Ocean published by the National Geographic Society of the U.S., on transliterated spellings from maps issued in the U.S.S.R. and or the Encyclopaedia Britannica, 1911 edition).

At the same time, however, the depth and width of their straits, their close contact with firm land and large "fences" of peninsulas and islands, create specific conditions considerably affecting the fauna of these waters.

Starting in the Southeast from the Philippine Islands, the Kuroshio current proceeds Northeastward to the Ryukyu Islands and branches into the Tsusim current, which passes into the Sea of Japan through the Korea Strait. The main branch continues North along the Eastern shores of the Japanese Islands, gradually turning East and moving considerably away from the shores in the region of

Inuboye Cape on Kyushu Island due to the effect of the cold stream Oyashio, which descends from the North alongside the Kuril ridge and developed from the cold water volumes of the Kamchatka stream, originating in the Bering Sea, and from the waters in the Sea of Okhotsk. The Japanese stream driven off-shore, loses its intensity, gradually turns towards the East and crosses the Pacific Ocean at between 40 and 50° of Northern latitude as the Northeastern drift (Subarctic Current).

Without entering into a discussion on the effect of the prevailing winds, irregular distribution of atmospheric pressure and other factors determining hydrological conditions in the Far Eastern Seas, we shall point out that the part played by the Kurosiwo in the North Pacific Ocean has been correctly compared with the role of the Gulf Stream in affecting the hydrological conditions throughout the North Atlantic basin. There is no doubt that the sharply-pronounced marginal character of the seas of the Northwest Pacific Ocean greatly complicates the dynamic processes and distinguishes their hydrological conditions from those in the seas situated at a corresponding latitude in the Atlantic Ocean.

Intensive cooling during the winter, vertical circulation lowering the temperature of the surface layers of the water, and the relatively weak warming-up during the summer conditions the hydrometeorological peculiarities such as: relatively low summer temperatures in the surface layer and littoral zone of the Western Bering Seas; low temperatures at greater depths during the summer; large areas in a number of regions covered by waters of intermediate cold layers. There is no doubt that the Bering Sea and particularly its Northwestern shallow part are a

cold-water basin, whereas the large deep depression communicating with the ocean through deep and wide straits is filled with waters from the Pacific Ocean whose temperatures are relatively high for these depths.

In composition of the fauna of the Bering Sea essential boreal in character, with admixtures of Arctic and essentially Arctic forms characterizing the Northern part (Andriyashev, 1939).

The vast basin of the Sea of Okhotsk which protrudes deeply into the Asiatic continent and covers an area of 1580 square kilometers is separated from the Pacific Ocean by the ridge of the Kuril Islands cut by numerous deep straits, and from the Sea of Japan by two shallow straits (Nevelski? and La Pérouse). The coast line is relatively unbroken; there are but few bays among which we wish to mention the Bay of Shelekhov, the Gulfs of Tauyski and Udski, a number of bays in Shantar archipelago (Tugurski, Ulbanski, Akademia and Nikolaus bays), bays of Sakhalin, Terpeniya and Aniwa, most of which communicate with the open sea. The depths over the 690.2 square kilometers of this sea (43.7% of total area) are below 250 meters and over 166.5 square kilometers (10.5%) - range between 250 and 500 meters.

Specifically the hydrological conditions of the Far Eastern Seas are as follows: the majority of water volumes show clearly pronounced seasonal changes in thermic indices and the extent of these indices increases with the decrease in latitude. During the winter, the temperature of the layer of large areas of Far Eastern

seas (up to 100 - 250 meters) is below zero and during the summer rises in certain regions to 20 degrees and more. The temperature of certain volumes of the Okhotsk and Bering Seas, considerable in surface area, remains below zero all round the year.

Surface horizons of the north and northwestern Sea of Okhotsk and of the Northwest Bering Sea gain little warmth during the summer.

We wish to point out that the frontiers, areas and the very existence of cold water volumes whose temperatures are below zero during the summer are subject to considerable fluctuations and this fundamentally affects the thermic conditions of different regions during certain years.

The Far Eastern sea currents are essentially anticyclonic in character and, as a rule, their velocities usually high, differ.

As a rule, no considerable fluctuations in the salt and oxygen contents within the limits of the depths between 400 and 500 meters are observed and both the salt and oxygen conditions are favorable to the existence of benthic fishes.

To understand the specific nature of Far Eastern waters, it is most important to realize their great depths and limited area of shallow continental waters. Indeed, only 25% of the entire huge area of the seas of Japan, Bering and Okhotsk constituting a surface area of 4853 square kilometers run to depths of 200 meters or less (see table 1).

TABLE 1

Surface areas (in thousands of square meters) of Far Eastern Seas with depths of 0-200 meters (following Derzhavin).

Sea of Japan	Sea of Okhotsk	Bering Sea	Pacific Ocean	Total
Peter the Great Bay.16.7	Penzhinsky Bay....109.5	Mechigmsky Region.....17.8	Southeastern Kamchatka.....6.9	
Maritime Coast.....25.4	Western Kamchatka. 81.6	Anadyrski Bay.....151.5	Ayachinsky region....7.7	
Tatar Bay.....63.6	Northern Coast....133.2	Olyutorsky- Navarynsky Region.....72.3	Kronotsky Bay.....10.3	
	Northwestern Coast.....122.9	Olyutorsky Bay....21.3	Kamchatka Bay.....3.6	
	Shantarsky Region.30.3	Korf Bay and Kara- ginsky region.....33.1		
	Sakhalin Bay.....19.1			
	Eastern Sakhalin..59.2			
	Aniv Bay and adjacent areas....29.6			
	South Okhotsk shallow waters....15.3			
	Southern Kuril Islands.....8.8			
Total..... 99.4	609.5	306.8	28.5	1044.2
Total surface area of the sea.....982.6	1580.0	2290.0		4852.6

DISTRIBUTION OF BENTHOS IN FAREASTERN
AREAS.

We have included into this work a brief exposition of the distribution of main benthic groups on the shelf extending along the Northwestern coast of Asia and certain data on the qualitative indices of the marginal part of benthic biological volumes in order to better understand the regularities of distribution and formation of industrial accumulations of benthic fish in the Far Eastern Seas. Numerous expeditions and cruises on board the scientific boats, particularly frequent after 1931, enabled us to become acquainted with the main biogenetic groups characteristic of different regions of our seas and with the benthic biological volume of these water basins. The aforementioned investigations may be considered, in most cases, as reconnaissance cruises in view of the immense territory investigated, the seasonal character of research and the fact that certain areas were very little studied.

Published works by Saks (1927-1929), Deryugin and Ivanov (1939), Makarov (1937), Deryugin (1939), Deryugin and Somova (1941), Gordeeva (1948,1950), Ushakov (1930, 1934,1936,1945), Guryanova (1935), Guryanova and Lindberg (1937), Ivanova (1933) and investigations by A. V. Ivanov, A. M. Volk, K. T. Gordeeva, Z. I. Kobyakova, Zemtsova and Baranova served as the initial data for this short expose.

CHUKOTSKI SEA contains (according to Deryugin and Ivanov, 1937) six biogenetic groups, the composition of which attracted our attention by the presence of numerous amphipoda, among which the following prevail: Anonyx nugax, Stegocephalus ampulla, Ampelisca macrocephala and others. In certain sections the number of amphipoda per square meter reaches 53245 specimens (421 gr). Small molluscs are also found in great abundance (Nucula, Macoma, Cardita, Saxicava, Venus, Natica, Yoldia, Leda and others) and their number reaches 1985 specimens (345 gr) per 1 square meter. Finally, numerous Polychaeta (up to 565 specimens, i.e. 68gr), mainly from the family Maldanidae, characterize the majority of biogenetic groups as highly productive feeding regions. The aforementioned groups of living organisms from the greatest part of benthic biological volume in Chukotski sea (87%). We wish to point out the presence of crustacea, such as Chionoecetes opilio, Hyas coarctatus, Nestocrangon, brittle stars (Ophiuroidea) - O. sarsi and others. The average biological volume in Chukotski sea (following Makarov, 1937) constitutes 213 gr per 1 square meter and the food groups (Mollusca plus Vermes plus Crustacea) - 186.4 gr.

Bering Sea. The average biological volume in Bering strait reaches 500 gr. per 1 square meter, however, its content of organisms used for food is rather low and reaches only 54.7 gr. In the Southern region the biological volume is rather high (806.7 gr per 1 square meter) and consists in the main of food groups (Mollusca, Vermes, Crustacea), the average weight of which reaches 446 gr. per 1 square meter.

The average biological volume in Amadyrskiy strait is 227.5 gr. per 1 square meter and 208 gr. for the food groups; certain ocean floor scraping stations in the littoral zone showed up to 715 gr. per 1 square meter, essentially containing food groups.

Having analyzed the brief description of the distribution of biogenetic groups within the limits of the shallow waters of Chukchi and Bering seas, we may assume that certain volumes of Chukchi sea, the Northern Bering Sea and Anadyrskiy Bay have high contents of the food biological volume of benthos and from this point of view may be considered as favorable to the existence of fish.

Sea of Okhotsk. The variety of reliefs, soils and hydrological conditions in different parts of the Sea of Okhotsk, conditions therein a number of volumes differing in composition of benthic fauna and biological content. The large volume of shallow waters adjacent to the Western coast of Kamchatka and covering a surface area of 81.6 thousand square kilometers has a mean biological volume of 383.9 gr/meter² fluctuating between 229,5 (Northern part of the shelf) and 710 gr/meter² (Southern part), while the biological content of benthic living organisms having some nutritive value for benthic fishes constitutes 126 gr/meter² consisting first of all of small mollusks (66.6%). We wish to point out that a relatively small section of the Southern part of the shelf (Yavina-Kambalny) at the depths of 50 to 120 meters shows high biological volume; the main components of the overall biological volume constituting 461.5 gr/m² from which 362,5 gr/m² serve as food (essentially for flounders) are molluscs, vermes and

echinoderms. In the central section of the shelf, at the depth of 50 to 150 meters, we observed a rather high biological volume (396 gr/m^2) essentially consisting of small molluscs (34.1%) and vermes (30.5%). It is characteristic that **the nutritive biological volume** (283.2 gr/m^2) is almost identical in the central, as well as the Northern section of the shelf and its content is the highest of all the aforementioned groups of West-Kamchatka shelf.

The northwestern part of the Sea of Okhotsk is characterized by a very insignificant variety of biogenetic groups and relatively low index of the nutritive part of the biological volume.

With regard to the waters washing Sakhalin, we may assume that the shallow waters of Sakhalin Bay are relatively favorable to flounders from the point of view of the food available in this region. In Mordvinov Bay the overall biological volume constitutes 149.9 gr/m^2 and the portion of biological volume used for food - 75.4 gr/m^2 ; the depths from 50 to 90 meters have a highly nutritive benthos $-427.6 \text{ gr/meter}^2$.

Near the southeastern coast of Sakhalin at depths of 100 to 150 meters the overall biological volume fluctuates between 45 and 52 gr/m^2 and the largest proportion serves as food; this is also true of the region with the station having the maximum index of 484.5 gr/meter^2 , where we found the Leda mollusc in great numbers (284 specimens weighing 286 gr/m^2); flounders consume the latter very intensively, as they penetrate, even into the regions with low temperatures, in their search for abundant food.

In the littoral zone of Aniva Bay the biological volume is insignificant ($20-230 \text{ gr/meter}^2$), whereas in its central part the biological volume is exceptionally abundant and constitutes 843.5 gr/meter^2 . The mean biological volume of the bay reads 371 gr/meter^2 and almost entirely consists of highly nutritive groups (molluscs, Polychaeta).

Sea of Japan. In the northern part Tatarskiy strait, close to Nevelski strait, the benthic biological volume is scant and gradually decreases from South to North. The total biological volume constitutes (according to Kobyakova) only $100-120 \text{ gr/meter}^2$, although within the limits of certain biogenoses it reaches 329 gr/meter^2 and drops in the littoral zone to 19 gr/meter^2 .

Along the shores, ~~most~~ adjacent continental shallow water volumes, by virtue of their relief and character of benthic population fail to provide the food and environment required to support a considerable number of benthic fishes. The large volumes of shallow waters, in Peter the Great strait, which serves as an excellent "pasture" for flounders accumulating in heavy numbers in this region, is an exception. According to the data of Deryugin (1941), the mean biological volumes in this area fluctuated between 94 and 237.6 gr/meter^2 (see drawing 1).

TABLE 2.

Overall and food biological volume of the continental shallow waters (15-200 meters) in different regions of the Far Eastern seas

	In % according to different groups					Biological Volume		Authors
	Mollusca	Vermes	Crustacea	Echino-dermata	Varia	Overall	Nutritive portion	
Chukotski Sea	48.9	35.6	2.2	3.0	5.3	213.0	186.4	Makarov.
Bering Sea:								
Northern part	35.3	9.7	40.6	1.1	13.3	806.7	446.0	"
Anadyrskiy Bay	53.8	23.6	7.5	14.4	1.2	227.5	208.0	"
Sea of Okhotsk-								
Western shore of								
Kamchatka:								
Northern part:	31.9	42.7	11.7	2.2	11.5	668.5	140.7	Cordeeva
Central part:	48.5	26.4	5.0	6.7	13.4	342.3	218.7	"
Southern part	35.7	25.8	14.5	17.6	6.4	675.0	258.5	"
The entire Western								
Kamchatka.....	-	-	-	-	-	482.7	230.2	"
Tauysky Gulf.....	7.3	6.6	54.2	3.0	28.9	114.2	71.1	Ushakov
Central region of								
the Northwestern								
part of the Sea of								
Okhotsk.....	4.8	26.2	0.6	28.1	40.3	53.5	31.9	Ivanov, Volk
Sakhalin Bay	8.8	4.8	20.1	64.9	1.4	164.1	84.1	Ushakov
Northeastern coast	-	.9	.2	94.1	4.8	151.9	14.0	"
of Sakhalin								
Southeastern coast								
of Sakhalin.....	57.2	16.6	-	7.1	9.1	544.6	-	Zemtsova
Bay Terpeniya.....	54.7	11.6	-	5.9	17.8	371.0	371.0	Kobyakova
Aniva Bay.....								Baranova
Sea of Japan:								
Tatarskiy Strait	-	-	-	-	-	113.0	-	Kobyakova
Southwestern coast								
of Sakhalin	15.0	17.0	-	68.0	-	192.3	84.9	"
Peter the Great Bay								
depths 10-50 m	35.2	38.4	7.7	12.1	6.6	264.0	100.0	Deryugin
								and
depths 50-80 m	27.1	25.6	45.7	1.6	-	340.1	137.0	Somova
80-200 m	5.9	19.5	-	73.1	1.5	94.0	40.0	"
average.....	-	-	-	-	-	175.0	100.0	"

DRAWING 1.

Distribution of the biological volume of benthos in
Peter the Great Bay.

Drawn on the basis of data provided by K. M. Deryugin, 1931-1933.

below 50

50-100	{
100-150	{
150-200	{
200-300	{
300-400	{
over 400	{

Summarizing the data available on the character of benthic fauna in different areas of Far Eastern seas and qualitative indices of its biological volume (see table 2), we may conclude that the North Bering Sea shows the highest absolute figures for the nutritive part of biological volume (446.0 gr/meter^2) distributed within a relatively limited region reckoned on the basis of surface areas. The areas of West Kamchatka shelf also have a high nutritive biological volume (230.2 gr/meter^2) filling one of the most spacious areas of shallow waters in the Northwest Pacific.

The large biological volume (in general and nutritive) in Chukotski and North Bering Sea is hardly consumed at all by benthic fish because to reach this food supply they must pursue long migration paths. In the industrially more important regions within whose frontiers the large concentrations of flounders live, the large biological volumes are found in the shallow waters near Western Kamchatka; in Tatarskiy, at the Eastern Coast of Sakhalin and in Peter the Great Bay, the benthic biological volume and its nutritive portion in particular are smaller in proportion and more nearly equal.

The biological volumes of the aforementioned areas considerably exceed the mean indices of biological volume for the Barentz Sea (Zenkevich and Brotskaya, 1939; Idelson, 1934), and numerous regions of the Sea of Okhotsk.

In the Far Eastern Seas the nutritive portion of benthic biological volumes determines to a great extent the locale and density of the accumulations of benthic fishes. However, the mere fact that the benthic population is abundant cannot be considered as proof that industrially exploitable populations of fish requiring for their existence definite hydrological conditions are present. The rich Anadyrskiy Bay has no industrially exploitable populations of flounders neither in the North Bering Sea, nor throughout the entire Chukotski Sea were there found any concentrations of cod, Alaska pollack or flounders, although the living organisms serving as food for the aforementioned fish species are found in the said regions in exceptionally great quantities.

COD OF THE PACIFIC OCEAN.

DISTRIBUTION AND MIGRATION.

Cod is very common along the Pacific coasts of Asia and North America. Cod is found along the entire huge arc of shore line around the North of Pacific Ocean⁽¹⁾, South from Yellow Sea (Laodun Peninsula, Western Coast of Korea and from the shores of Oregon (Yaquina Bay) on the American side up to Lawrence Island in the northern part of Bering Sea).

It is quite natural that over this zone which totals almost 10 thousand kilometers, cod does not form a monolithic shoal, but is found in a great many local shoals, due to adaptation of these fish to the great variety of physico-geographic conditions in different regions of the Northern and particularly, Northwestern Pacific Ocean.

Apart from a number of differences in biology - i.e. the spawning periods and incubation of roe, rate of growth and age composition, feeding, migration and others, the cod of different regions, shows differences in the number of vertebrae, number of rays in fins, pores in the lateral line, etc. Analysis of morphometric properties enabled us to distinguish (Petrova-Tychkova, 1948) five forms of cod for the Northwest Pacific Ocean (Peter the Great Bay, Tatarskiy strait, Eastern coast of Hokkaido, the region of Aion Island and Kamchatka). Undoubtedly, further investigations will enable us to establish real morphometric differences between the cod of the Yellow Sea, Eastern Korea, Western and Eastern

⁽¹⁾ See detailed account of the distribution of cod in Svetidov's work, 1948.

shores of Kamchatka, Anadyrskiy Bay and a number of other regions of the Far Eastern Seas.

The extent of the areas where cod from the Pacific Ocean is found and development of such numerous local forms compel us to present the data on distribution, migration, and biological characteristics of cod under the headings of the different regions of Far Eastern seas.

In the Northwestern part of Pacific Ocean, cod is widely propagated within the limits of the moderate zone of the North Pacific. The Northern limits of this cod population slightly overlaps the cod area in the Arctic Region.⁽²⁾, the southern limits slightly overlap the cod area in the Indian and West Pacific Ocean regions (Vinogradov, 1948).

If we accept the scheme of zoogeographic division into zones of Far Eastern seas, as suggested by Vinogradov, we must first of all examine the correctness of classifying the cod from the Pacific Ocean with the essentially sub-arctic-boreal forms (Svetovidov, 1944), keeping in mind that the cod finds the most favorable conditions for its existence in the North-boreal regions of Far Eastern seas, and somewhat less favorable environment in the South-boreal areas and is found in inhibited state within the limits of the sub-arctic, glacial and subtropic regions. Therefore, we believe it wiser to classify the cod from Pacific Ocean with the boreal species.

Specific characteristics of the hydrological conditions in each of the above-named regions substantially

(2) Into the North Bering Sea province of Andriyashev (1939) and lower Arctic Region of Vinogradov (1948).

affect the behavior of cod and primarily their migration and seasonal distribution.

In the shallow waters of Western and Eastern Kamchatka, as well as along the Western coast of Bering Sea and to the North from the South of Anadyrskiy Bay, i.e. within the limits of the North-boreal region, cod is found everywhere in large quantities, although irregularly distributed of course. The seasonal distribution and migrations of cod have been most thoroughly studied for the waters washing Kamchatka (by Moiseev, 1940, 1950; Polutov, 1935, 1937, 1946, 1948) and are based on this work.

Ample data material collected during the cruises of research, exploration and industrial boats, as well as from the observation points on shore during the 1925-1952 period, clearly show that within the limits of the regions inhabited by this species, cod is found almost everywhere, but is distributed most irregularly.

Depending on season, region, hydrological conditions, depth, degree of maturity of the sexual products and other factors, cod-banks were found here and there. The cod was heavily concentrated in these shoals, but only lone specimens were caught either by trawl or hook over broad sea-expanses. There are many examples to show that cod is either widely dispersed or found in heavy concentrations.

During the spring and early summer (end of April-May), at the time of spawning, which occurs in the North boreal regions at a certain distance off-shore and at depths of 180-250 meters, when the temperature of littoral waters reaches 0.1 above zero, the cod of all the categories (with regard to dimension) approach the shore to feed, coming into the most insignificant depths.

Near the shores of Western Kamchatka the cod appear off the Northern and Southern regions as early as April and, as a rule, form concentrations of considerable density.

At the beginning of 1932, on board the trawler "Plastun", Polutov obtained heavy catches of cod in the region of Moroshechny. During the first half of June 1939, the expedition on board the trawler "Lebed" discovered, in the same region, a heavy concentration of cod at depths of 50 meters and less, and catches during three hours of trawling over this school reached 13 centners (Moiseev, 1950).

Approximately within the same periods of time there occurs the post-spawning migration of cod to the shallow waters off the shores of South-Western Kamchatka⁽¹⁾, in the region of Ozerbo-Yavina, where at the end of April, May and June 1930-1933 industrial trawlers and in 1934-1939 research boats of the TINRO made heavy catches (up to 8 to 10 centners per trawling-hour and in certain cases even considerably heavier from the depths of 25 to 120 meters.

During the second half of May 1930, the trawler "Balkan", commanded by captain Kostrubov caught, from the depth of 50 to 60 meters, in three successively launched trawls (No. 18-20) from 10 centners to 30 centners of cod in each trawl; trawl no. 3, which was launched somewhat further out in the open sea, from a depth of 90 meters, brought in 25 centners of cod, which was intensively feeding on herring. On June 2 in the region of Opala the same trawler lifted from depths of 55 to 75 meters 5 to 25 centners of cod.

Observations from the shore-points and from the boats conducting littoral fishing showed that during the spring season (May-June) cod lives in the central part of the

West Kamchatka Coast in a relatively narrow littoral warm zone avoiding cold, deeper regions.

While the littoral cod fishing in the region of Ozernoy-Bolsheretsk starts during the first half of May, in the region of Vorovskaya-Icha the first catches are usually taken during the second half and near Kolpakovo during the third decade of May.

Thus, between the end of April and the beginning of June there occurs the first migration of cod into the shallow waters of the Northern (Oblukovina-Khariuzov) and Southern (Ozernaya-Koshegochek) regions of West-Kamchatka shelf.

Undoubtedly, the high concentration of cod during the spring in the Southern and Northern regions of Western Kamchatka is due to the fact that the fish which have completed spawning leave the spawning region and proceed towards the shallow waters for feeding; the largest concentrations consist of cod feeding on herring, which also approach the shores during this period.

Having approached the Northern and Southern sections of Western Kamchatka coast (and avoiding the central cod regions and as the water grows warmer gradually in the littoral zone, the cod begin moving along the shore into the central parts of the shallow waters region. Thus, the cod already appears at the end of May and in June to the North from Ozernaya and to the South from Moroshechnaya within the limits of the depths that do not exceed 60 to 80 meters. During this period of time the littoral catch in this region is intensified and diurnal catches reach 1000 specimens and more per

motorboat and areas with high concentrations of fish are found. Thus, during the first few days of June 1930, the trawler "Balkan" near Kikhchik at depths of 35 to 60 meters caught from 5 to 10 centners of cod within an hour of trawling. On the 12th-13th of June 1939, the catch from the trawler "Lebed" at shallow depths in the region Vorovskaya-Kolpakovo came to 320 specimens of cod per three hours of trawling. Undoubtedly, the first appearance of cod in the littoral zone of the Southern and Northern regions of Western Kamchatka is followed by the gradual migration of cod along the shores towards the off-shore central regions of West Kamchatka with the simultaneous approach of new shoals of fish from great depths to the shallow waters.

We made no observations on the behaviour of cod directly following the spawning (i.e. in April), however, we have reasons to assume that, during the past spawning period, near the shores of Western Kamchatka, the cod remain for some time, in the spawning-grounds, above the depths of 100-150 meters and over until the littoral waters grow warmer.

In July-August the migration of cod along the Western shore of Kamchatka begins and the majority of northern schools move southwards, while the majority of Southern concentrations move northwards. This migration leads to the displacement of the best fishing regions to the central section of the coast-line; it is well-known that the beginning of May and June, cod-fishing from the hook from motorboats in the Ozerney

region gradually moves northwards.

The specimen of cod, which was marked on June 8, 1939, on Moroshechnaya reaverse, was caught 60 days later on Muukhin traverse, i.e. 230 farther to South, which confirmed anew the theory that migration of cod near the shores of Kamchatka occurs in both directions.

In July we observed increased concentrations of cod at depths of 40-50 meters off the Southern half of the central and northern half of the Southern regions of Western Kamchatka over an extension of 70 miles. Certain catches consisted of 400 specimens of industrial-weight cod totalling 5.1 centners. In the Southern region (Ozernoy-Opala) there were no accumulations of cod at that time, nor in August 1938 did we find cod in the Northern region. There can be no doubt that migration of cod to the central part of the coast of Western Kamchatka is in the main completed by the middle of August. The spring and summer migrations of cod in the northern and southern directions are essentially directed to feeding grounds. Investigations by Gordeeva (1948) showed that the central part of the West-Kamchatka shelf has a high nutritive biological volume of benthos. In the spring this region is, as a rule, covered with a mighty layer at low temperature, which prevent the penetration of the majority of industrial fish, cod included, into this region. As the area covered by waters of low temperature gradually recedes the migration of cod into volumes freed from cold waters begins, that is northern shoals moves south, southern shoals move north.

Right at the end of the spawning period the cod begin intensive feeding, mainly on benthic invertebrates (Logvinovich, 1949).

Let us now examine the behaviour of cod during the spring and summer seasons near the shores of Western Kamchatka and along the western coast of Bering Sea.

The pattern of migrations presented in drawing 2 has been drawn on the basis of data collected by Polutov (1937, 1946, 1947), research conducted by the author (Moiseev, 1940), observations of Japanese fishermen (Bogdanov, 1946) and data provided by certain members of TINRO.

From the spawning region, which, as proved by the work of the expedition on board the "Lebed" in 1939 (Moiseev, 1940) and observations made during the cruises of commercial trawlers in 1940, is situated near the southeastern extremity of Kamchatka above the depths of 150 to 250 meters, the cod proceed towards the shore and along the shore in both northern and southern directions. The spawning occurs in March-April and commercial accumulations of cod in the region Utashud-Sopochny were found during these months. As the littoral zone grows warmer, the cod approach the shore and in April-May appear in the region of Lopatka and near the southeastern coast of Kamchatka. Simultaneously, the fish migrate northward, along the relatively narrow continental zone of shallow waters near Southeastern Kamchatka; at the end of May the cod reach the shallow waters situated in the southern part of Avachinski Gulf, where successful fishing from the hook begins.

The shoals of cod continuously arriving complete this concentration, which moves towards the North. In July, the fishing is most successful in the direct proximity of Avachinski Gulf and in August-September, the highest concentrations of cod are found in the northern part of the Bay (Bichevinski Bay).

Simultaneously with northerly migration, the cod move from the spawning-grounds near the south-eastern shores of Kamchatka southwards, to the eastern, then to the southern shores of the North of Kuril Islands, i.e. Synnusyn and Paramushir. Cod is successfully fished in this region initially (in May-June) near the eastern shores, later (in August-September) south from Paramushir Island, of the small island Shirinka. Throughout this entire period from the moment when cod has completed spawning, while it feeds intensively, its distribution is conditioned by the distribution of its food and by temperature.

In September cod leave the shores and begin migrating into the wintering grounds. The shoals leaving the northern part of Avachinski Bay during these periods somewhat exceed in number the density of concentrations in the region of Avachinski Gulf, but, are found, however, at great depths.

In October-November there are hardly any cod specimens left near the shores and they can only be found at the depth of about 100 meters. Simultaneously with the migration of the main bulk of cod from Avachinski Bay in a southern direction and from the shores of Paramushir in a northern direction, we assume that a certain amount of cod does not proceed

towards the wintering and spawning grounds, near the southeastern extremity of Kamchatka, but drops to greater depths and remains throughout the entire winter in the direct proximity of the regions where cod accumulate during the summer. This assumption is confirmed by separate cases of heavy catches of cod in October-November in the Northern part of Avachinski Bay at the depths of 100-140 meters.

We wish to point out that from the results obtained by marking cod specimens, an experiment carried out by Polutov, a small number of cod seem to penetrate into Kronotski Bay and in the opposite direction. In all probability the cod inhabiting the area near the Eastern and Western shores of Kamchatka only occasionally penetrate through the straits between the Northern Kuril Islands.

Polutov assumes that a special shoal of cod inhabits Kronotski Bay. It spawns in February-March at considerable depths in the central part of the bay. The tracts of migration of this shoal are not sufficiently clear as yet, however, there exist certain data enabling us to assume that the plan presented in drawing 3 is correct. During the winter high trawling catches were obtained at depths of 180-230 meters with mean catches ranging between 8 and 10 centners per trawling-hour. In June, apart from the littoral zone, the cod inhabit the depths of 60 to 120 meters.

In Kamchatka Bay the trawling cod investigations were rather limited. During the summer (June-July)

small catches of cod (up to 5 centners) were obtained within a large range of depths: from 20 to 180 meters. During the autumn cod approaches the mouth of Kamchatka river in great numbers and feeds then on young specimens of Salmonidae.

In the shallow waters of Commander islands, where we also observed the spawning (Crebnitsky, 1897; Redko, 1926-1927; Smit, 1933), the cod migrates in the spring to depths of 10 to 20 meters and remain there throughout the entire warm season. During the winter the cod move farther out into the open sea, at depths of 60 to 100 meters, but usually do not sink deeper. Catches of cod at the depths of 30 to 80 meters did not exceed 5 to 6 centners. The most successful catch on the hook was in June-July at the depths of 30 to 40 meters.

The region adjacent to Karaginski island, including the Litke strati and Korf Bay, is rather cold. However, even here the cod are found in considerable numbers. During the spring starting from the mid of May with the rise of temperatures in the bays and gulfs, the cod follows herring shoals on which it intensively feeds and enters Korf Bay (Bogaevsky, 1928), then appears in the harbours of Skrytaya, Skobeleva and Sibir at the depths of 3-5 and more meters, where it remains until September feeding and after the herring move away, it feeds on navaga, smelt and crabs (fig. 3). The trawling catches in the southern part of Litke street reached in September 5-9 centners. Near the eastern coast of the island, at depths of 70 to 110 meters the catches of cod did not exceed 5 centners per trawl; in July-August the

most successful catch on the hook was obtained from the depths of 12 to 24 meters. In Olyutorski bay (to be precise, in its southwestern part), the cod, which completed spawning, appear in great numbers in mid May at depths of 25 to 60 meters and remain here during the entire warm season frequently forming large shoals of great density where the catches run up to 60 centners.

The spawning-grounds of the cod in Anadurski Bay have not been established as yet, but undoubtedly are in the wintering-grounds, which are situated at depths of 170 to 250 meters to the Southeast from Cape Navarin. Probably during the spring, due to cool temperatures, the cod proceed here from the large volumes of shallow water in Anadyrski Bay in order to spend the winter in higher temperature volume. After spawning (March-April?) the cod proceed towards the shores and as early as in May-June are found in abundance in the section extending from Cape Navarin to the Anadyr river, as well as in two other littoral areas. We wish to point out that the large post-spawning spring migrations of cod from deep waters to shallow water occur precisely to the region of Anadyrski Bay and extend over from 200 to 250 miles (see fig. 4).

Thus we may see that throughout the entire volume of waters along the north-eastern shores of Asia from Penzhinski Gulf along Western and Eastern Kamchatka, and near the western shores of the Bering Sea, following winter of early spring spawning occurring from February to May (more seldom until June), the cod start migrations,

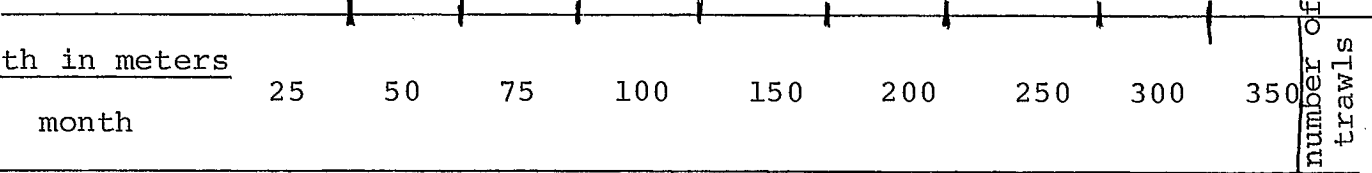
in their search for food, towards the shores, in both northern and southern directions. The migrations within the shallow-water volumes and formation or disappearance of dense concentrations or of isolated shoals occur depending on the hydrological conditions and primarily on the distribution of waters at temperatures below zero, as well as on the distribution of food.

Let us examine more thoroughly the distribution of cod, during the summer, at different depths. As outlined by a series of researchers (Polutov, Alperovich and others), during the summer season, the cod near the shores of Western Kamchatka are encountered within a large range of depths, however accumulations of a high density are found only between the limits of two parallel zones extending along the shore line. The first zone of high concentrations found by the so-called "littoral" shoal, is situated in the summer at depths of less than 50-60 meters, the second "deep" shoal concentrates within the limits of 80-90 to 120-140 meters. This distribution is particularly well pronounced in the central and northern regions of Western Kamchatka in June, partly July-August.

Apart from the differences in depths and other conditions, the above-named shoals differ from each other in sex composition. The "littoral" shoal consists of a great number of small and medium size fish specimens (with a small admixture of large fishes), among which the females prevail, whereas the "deep" shoal is characterized by larger fishes among which the

number of male specimens prevails. Table 3 shows the distribution of cod according to different depths over the year. We may see that the curve of the catches of cod in June shows two summits.

TABLE 3.

Depth in meters month									
	25	50	75	100	150	200	250	300	350
June	40.0	67.1	19.0	52.1	19.0				74
July-August	4.2	49.3	16.0	2.1	6.2	2.0	1.0	-	145
October	-	1.2	3.0	5.4	7.5	5.7	-	-	47
December	-	-	3.2	20.6	28.0	10.5	-	-	53
January-Febru.	-	-	-	.5	1.5	21.4	27.8	3.0	72
March.....	-	-	-	-	5.2	1.0	4.5	1.0	41
Number of trawls	13	101	80	59	78	70	26	5	432

When analysing the composition of the "littoral" and "deep" shoals, the aforementioned prevalence of large female specimens in the "littoral" shoal attracted our attention (table 4).

Table 4.

The number of cod female specimens of varying dimensions found in the shallow waters of Western Kamchatka in August 1939 (in %).

Length of the fish	Opala-Utka	Bolsheretsk	Muukhin-Mykum-cheshin.	pymta-Kimchey	The entire Western Kamchatka.
Below 60 cm	54.7	49.4	65.8	52.3	53.6
60-80 cm	58.4	58.8	55.3	50.8	52.0
Over 80 cm	75.0	66.7	84.4	76.0	76.0

When we simultaneously observe increased concentrations of fish at small depths in direct proximity to the shore, as well as at the depths of 100 meters and over, we may assume that the spring and summer distribution of cod into different zones is due to the slow sexual development of certain cod specimens, which is discussed in the chapter on sexual maturity. The data on the state of sexual products in cod inhabiting different zones confirm this supposition. Thus, during the research conducted by the expedition (which took place between July 22 and August 1), in Olyutorski Bay in 1931, (V. Shmit), we observed considerable increase in catches at the depths of 100 to 200 meters; at the same time, successful fishing of cod on the hook was carried out from near the shore at depths below 30-40 meters. The state of sexual products of the cod found in shallow waters showed that the spawning period had been recently completed, as the sexual glands

were inflamed in the majority of fish examined (stages VI and VI-II), while the fish specimens caught at the depths of 100 meters and over exhibited sexual products in the II and III stages of maturity, i.e. in quiet state, and we therefore assumed that no spawning had taken place during that year. The catches of cod near shore consisted in the main of fish specimens that were visibly exhausted, with sharply protruding joints of the skull-bones, low weight of liver (which is usually pink or brownish), and feeding intensively on fish (salmon, herring, navaga etc.). Within the limits of the deep zone the cod is rather well fed, the liver is large and of light yellow colour, the feeding is in the main on benthic invertebrates.

The relatively small prevalence of females among the fish less than 80 cm in length overlaps the sharp prevalence of females (2 to 4 times) among the cod specimens of large size (over 80 cm). In the "deep shoal" region large males outnumber the females, however, this disproportion is less pronounced. Nevertheless, considering the fact that males do not reach the maximum linear dimensions attained by females, even the slight prevalence of males over females 80 cm and more in size shows that the specific weight of males within the limits of the region of "deep shoal" is higher than usual.

Migration of cod from the shores of Western Kamchatka towards greater depths begins in the second half of September and becomes well pronounced in October, particularly in November.

In October the cod is hardly found at all at depths of less than 40 meters and the first more or less regular catches are obtained from the depths of 50-60 meters and more. Both "shoals" meet and remain at depths between 50-60 meters and 200-230 meters.

The highest concentrations are observed within the limits of depths from 100 to 150 meters and the curve of the distribution of cod according to different depths has one apex only. The prevalence of large females over males continues to be sharply pronounced (table 5.) even in the second half of October, although both "shoals" have already come together. Percentage of males of medium and small size considerably increased.

TABLE 5.

Number of cod females of different dimensions in the shallow waters of Western Kamchatka in October 1939 (in %).

Length of fish	Koshegochek-Bolsheretsk.	Kungan-Kekhta	The entire Western Kamchatka.
Below 60 cm	32.5	-	33.5
60-80 cm	35.5	54.6	37.7
Over 80 cm	60.6	83.4	66.7

We wish to point out that the prevalence of females among the large cod, which is particularly pronounced during the summer season in shallow waters and persists throughout the autumn, shows a feature characteristic for almost all the fish species: i.e. the percentage of males decreases among the older age groups.

November and December are marked by further migration of cod to gradually greater depths and the largest concentration of fishes was observed in the central region, i.e. the region of Kekhta, where the catches per trawling-hour reached 100 specimens.

Under the effect of intense autumn-winter vertical circulation during this period, the area suitable for cod becomes reduced, the fishes accumulate within a smaller area and their concentration increases. Analysis of December trawl catches indicates that migration of cod from the shores becomes intensified and concentrations of these fishes at the depths of 100 meters and over in the central region (Krutogotova-Kekhta) and from 70 to 90 meters in the northern region (the region of Sopochnaya) increase. Large females continue outnumbering the males, however the number of small and medium size males is greater than the number of females of similar dimensions.

In January-February, then in the early half of March the cod begin migrating towards gradually greater depths and move farther and farther away from the shores to the depths of 270-300 meters.

Undoubtedly, the migration of cod and particularly specimens that are not sexually mature away from the shore is considerably stimulated by the increasing vertical circulation.

At the end of January the increased concentration of fish was observed in the central region (Kikhchik-Pymta) at the depths of 180-230 meters. In March, in the southern part of the central area, as well as near the south-eastern extremity of Kamchatka, we found no considerable accumulations of cod. On the contrary, we noted a decrease in the density of cod population at all the investigated depths between 100 and 300 meters. This decrease in the density was clearly visible in February and by March the cod had almost entirely disappeared from the southern region of Western Kamchatka. In the central region the cod was found in shoals more frequently, however, in single specimens only.

The number of cod found in benthic horizons sharply dropped. At the same time we noticed that starting from October the cod of medium size, medium weight and the percentage of sexually mature cod specimens caught continuously decreased. When analyzing the composition of cod catches in depending on degree of readiness to spawn during the winter of 1938-1939, we obtain the following table (table 6):

TABLE 6.

Percentage of cod prepared to spawn during the winter 1938-1939 near the shores of Western Kamchatka.

Month	Sexually immature	Sexually mature	Overall number of fishes.
June 1938	42.9	57.1	1588
October-December '38	45.2	54.8	890
January-February '39	82.2	17.8	913
March 1939	81.7	18.3	71

Starting from December, we observed a decrease in the catches of the relative number of fish specimens that do not spawn during the given year (51.5%), which reached 82.2% in January-February and remained at the same level in March.

The same regularity was observed in proportion between separate groups of cod of different dimensions according to different months. From October until March the number of cod specimens of small dimensions found in catches increases, while the number of large cod specimens decreases accordingly. In the first decade of June (1939) the number of medium and large fishes sharply increases (table 7).

TABLE 7.

Proportion between the number of cod specimens of different dimensions found in trawl-catches near the shore of Western Kamchatka in 1938-1939. (in %).

Month	Below 60 cm	60-80 cm	Over 80 cm	Mean length (in cm)	The number of fish specimens that have been measured.
June 1938	21.1	53.1	25.8	70.15	764
August 1938	3.2	40.3	56.5	79.75	186
October-					
November '38	17.0	43.0	39.9	74.10	216
December '38	29.4	50.9	19.7	67.45	961
January-					
February '39	34.7	60.7	4.6	63.10	1070
March 1939	55.2	36.5	8.3	56.80	96
March 1939	28.5	57.3	14.2	66.65	3060

The above data lead us to assume that while during the summer and autumn months (June-November) we observe in catches a considerable prevalence of fish over 60 cm in length (71.5-96.8%) and a high percentage of fishes that will spawn during the coming winter (54.8-57.1%), the number of cod that will not spawn in the coming winter (82.8%) prevail in the catches during December and particularly in January-February, and the number of large fish specimens (65.3%) decreases. Furthermore, the percentage of non-spawning cod remains almost unchanged until March

(81.7%) and the relative number of large fishes decreases even more (up to 44.8%). Undoubtedly the sexually mature cod specimens that are ready for spawning drop out of the trawl catches with the beginning of winter. However, single specimens of sexually mature cod with sexual products in a state close to spawning were caught by trawl in January-February over the entire extension of the Western shore of Kamchatka. The cod with liquid sexual products or with the products in the V stage of maturity was caught in the early half of March in the southern region of Western Kamchatka, as well as to the South-East from Cape Lopatka.

The aforesaid leads us to assume that the approach of the spawning period and intensified development of sexual products in the West-Kamchatka cod is accompanied by migration of fishes ready for spawning in the current year away from the ocean floor and their concentration in the intermediate horizon, where the spawning occurs.

Naturally, this theory requires a thorough verification, but we believe that this is the only, theory enabling us to explain the almost entire disappearance of cod prepared for spawning from the trawls launched in the regions of their wintering, and the appearance en masse of the large cod that have completed spawning as early as April-May (perhaps even earlier), in the southern part of Western Kamchatka and approximately at the same time in the North, in the region of Moroshechnaya. In this respect the cod of Western Kamchatka probably behave analogously to Atlantic cod, which, as is known, rises from ocean floor to shallower depths during the spawning period.

The catch in February and March of single specimens of sexually mature cod probably occurs during the recovery of trawl, when the latter passes through the water thickness.

The cod of the Atlantic Ocean is a prebenthic and not a benthic (at least during certain seasons). Mesyatsev (1930) indicates that the most successful catch was obtained by means of fishing nets launched at 18 meters above the ocean floor, whereas the nets situated directly over the ocean floor or in higher (over 18 meters) horizons obtained considerably lower catches.

Results of the investigations by means of sounding device, during which we succeeded in fixing on the ribbon the location of cod shoals, as well as a number of other observations (Sung, 1938) allow us to affirm that Atlantic cod remain during certain seasons at 2-15 meters above the ocean floor. At last, a series of experimental trawls in the Barentz Sea in 1949 by means of a two-stage trawl proved that catches obtained by the upper trawl, the lower plank of which passed at 3-5 meters above the ocean floor⁽¹⁾, were 2-3 times higher during certain seasons than the catches obtained by the lower trawl. We shall not discuss the well-known fact that the results of trawl-fishing considerably increase when the vertical opening of the trawl is enlarged. This, however, also shows that the cod dwells in prebenthic horizons, not on the ocean floor.

(1) Investigations were carried out by V.D. Gordeev.

Distribution and migration of cod near the shores of Western Kamchatka in April and May have not been thoroughly studied as yet and juxtaposition of certain data alone enable us to assume that the intensive post-spawning approach of cod to the shores, in search of food, takes place in April and at the beginning of May; there are also grounds to believe that high concentrations of cod are formed precisely during that period of time..

Summarizing the aforesaid concerning the distribution and migration of the West-Kamchatka cod, we may suggest the following scheme of migrations of this fish.

Having appeared simultaneously in the northern (Moroshechnaya-Spochnaya) and southern (Sivuchy - Koshegochek) regions of Western Kamchatka in April-May, the cod spread in June along the shore line northwards (from the southern region) and southwards (from the northern region) toward the central region of Kamchatka, where we observed large concentrations of these fishes and their intensive feeding in July and August. At the end of September the cod leave the shores and migration continues until March inclusively. Simultaneously with the migration of cod into the depths, we observed the disappearance of the sexually mature fish specimens from catches, probably caused by the migrations of spawning cod into intermediate horizons. The spawning of cod starts in the middle of March and in all probability continues until the end of April⁽¹⁾ in the region, the limits of which

(1). We are talking of mass spawning.

are still unknown; however, we may assume that during the spawning the cod do not move far away from the shores of Kamchatka and the spawning takes place within the borders of the region marked with a dotted line in the map (fig. 3). After the spawning has been completed, the migration towards the shores begins and the cod appear first of all in the northern and southern regions of Western Kamchatka.

Examining the scheme of migrations we may conclude that the season between April and July, occasionally including the early half of August should yield best results for cod fishing (as it does), since the relatively energetic post-spawning migrations of fish proceeding to the shallow waters in search for food occur during this period of time. In shallow waters the cod are found in the heaviest concentrations, although by the end of the summer the density of shoals gradually decreases. Another period, during which we can expect high catches, is December-January, i.e. the period of the most intensive migration of cod away from the shores and its concentration over a continuously diminishing area. During this period of time the large non-spawning fish specimens still remain at the ocean floor.

According to the observations of Moiseev in 1939 and Polutov in 1940, near the south-eastern shore of Kamchatka, the cod sink during the winter to the depths of 150-200 meters and form in February-March considerable concentrations in the region of Utashud-Sopochny. In March in the same region, as well as somewhat farther to the South, the cod spawn and then begin moving towards the North along the coast reaching the slight depths (30-50 meters) and simultaneously approaching the shores.

In August the cod approach the northern part of Avachinski Bay, where in August-September we observed in the region of Bichvinski Bay concentrations of large shoals of cod, which can be successfully caught on the hook. When the temperature of the prebenthic horizon reaches maximum, the cod turn in the opposite direction - southwards - and drop towards somewhat greater depths.

Apart from the observations carried out in Kronotski Bay, we have no data obtained through observations conducted all the year round in the migration of cod in the north-western part of the Bering Sea, however, the extension (with the exception of the region of Anadyrski Bay) of migrations is rather small and depends first of all on the hydrological conditions under which a given shoal exists. The almost simultaneous appearance of cod which have recently completed spawning along the entire western shore of the Bering Sea shows that there is a great number of spawning-grounds and therefore, the length of migration paths of cod is rather short.

The distribution of cod according to the depth in the North Bering Sea (in the region of the exterior part of Anadyrski Bay) shows features similar to the same distribution near the shores of Western Kamchatka. Analysis of the operation of the trawler "Chayka" in August-September 1932 enabled Starostin to compose the following (table 8).

TABLE 8
Distribution of cod catches in the Northwest Bering Sea
in August-September 1932.

Depth in meters	25	50	100	150	200	225	Number of trawlings
Mean catch per hour of trawling in centners	1.43	1.87	3.02	4.92	.88		104

We observed a distinct increase in the catch at depths of 150 to 200 meters. Certain catches within the limits of shallow waters (at depths below 75 meters) reached 20-30 centners, and in the region of the 200-meter depth contour reached 25 centners.

The distribution of cod according by different depths in Olyutorski Bay is analogous to the afore-discussed. We wish to point out that near the shores of Western Kamchatka, as well as in Anadyrski and Olyutorski regions, the littoral zone is characterized by an abundance of small and medium size cod (there were also found large specimens), whereas in the deep zone the medium-size and large cod prevail (65-80 cm).

Along the southern borders of North-boreal and within the limits of the South-boreal regions of the moderate zone of Northern Pacific Ocean the cod is found in considerable quantities near the Southern Kurils and eastern shores of Hokkaido and Maritime coast in Peter the Great Bay and near the eastern and western shores

of Korea. Despite this propagation of cod in the South-boreal region, the living conditions in this area are not sufficiently favourable, i.e. the hydrological conditions are unsuitable and areas covered by shallow waters are mostly small and therefore, the behaviour of fish is rather specific and dimensions and density of concentrations limited. The overall number of cod found in this area is also considerably less than that in the waters of Kamchatka and Bering Sea. Here, as well as in northern seas, we find a great number of local cod shoals among which the following: the cod of the Southern Kurils, Eastern Hokkaido, South-Western Sakhalin, region of Nelm Bay, Peter the Great Bay and eastern shores of Korea. The complete lack of data on the cod of the Yellow Sea with the exception of statistical data provided by Tarasov (1950) makes it impossible for us to discuss the distribution and migrations of these cod.

In Tatarskiy strait the cod inhabit the waters washing Sakhalin and continental shores. During the winter the fish migrate away from the shallow waters. During the April cruise of the trawler "Askold" (1932) no cod was found anywhere with the exception of two specimens caught in the traverse of Pilvo. No cod was found near the continental and Sakhalin shores during the winter either.

The cod spawns in February-March (less frequently in April) at depths of 80 to 200 meters. It is interesting to note that near the shores of South-Western Sakhalin the cod which sank to the depths of 200-250 meters

during the summer in the pre-spawning season (December-January) began to approach the shores and reach depths of 80-120 meters, and there spawned. (Kulichenko and Frolov). Spawning-grounds near the continental shores and behaviour of cod during the winter are unknown.

In the spring, the cod which have completed spawning approach the shores and reach depths of 15 to 40 meters, where intensive feeding begins. Near the South-Western Sakhalin it coincides with and is stimulated by the

April spawning migrations of herring, herring being the main food for cod during this particular season.

After herring leave the shores after spawning, the cod migrate away from Southwestern Sakhalin towards the depths of 200-250 meters, where they remain from August until October.

Migrations along the shores are insignificant and the map presented in drawing 5 shows the limited migrations of this particular shoal of cod.

Near the continental shores of Tatarskiy strait the migration of cod to the shores occurs in April-May. Here, during this period of time we observed intensive feeding of cod and occasional high catches of cod (up to 15-20 centners), the guts of which are filled with herring.

Simultaneously the cod proceed in the northern direction, reach De-Kastri Bay in considerable numbers and move further to the North from Aleksandrovsk remaining at the depths of 3-40 meters.

It is obvious that mainly small and medium size cod penetrate to the most northern part of Tatarskiy strait. Thus, in October 1930, in the region of De-Kastri, the catches of cod contained specimens from 35 to 75 cm long on an average 51.75).

During the summer experimental catches of cod on the hook cordage in the region of Soviet Harbour, Datt Bay and Takhobe Bay yielded good results (up to 50 centners per boat per day).

The advent of autumn and the drop in temperatures of the littoral waters compel the cod to migrate to greater depths that are not affected by vertical winter circulation.

Let us consider the data of Krivobok in the bathimetric distribution of cod near the shores of Maritime and Tatarskiy strait during different seasons (table 9 on page 39).

The low concentrations of cod and consequently, the low trawl-catches somewhat reduce the clarity of bathimetric characteristics for different months, but we may nevertheless establish beyond any doubt that in April, when conditions closely approximate winter conditions, most cod remain at the depths of 100 to 400 meters.

In May the cod move closer to the shores and appear at the depths of 25 to 40 meters. During the period from June to October inclusive, the cod along the Maritime shores and in Tatarskiy strait, (with the exception of waters washing the southwestern coast of

Sakhalin) remain at the depths of 25 to 75-100 meters.

TABLE 9.

Distribution of cod catches (in number of specimens per an hour of trawling) in the northwestern part of the Sea of Japan in 1933.

Depth	0.	25	50	75	100	150	200	300	400	The number of trawlings.
April	0	0	1.5	2.5	6	10	7	5		54
May	0	2	9	11	5	11	-	-		33
July	0	17	9.6	6	-	-	-	-		34
August	0	11	4	3	5	5	1	-		58
October	.5	3	5.6	3	-	-	-	-		56

In Peter the Great Bay the seasonal distribution and migration of cod are almost identical with those near the Maritime shores. At the end of the spawning, which takes place in February-April above the depths of 100-150 meters, the cod approach the shores and reach the shallow waters measuring less than 50-75 meters in depth, where they feed intensively. After the littoral waters warm up, the cod leave the shores and proceed towards the depths of 50-100 meters, where they remain throughout the summer. The cold temperatures of autumn and winter produce further migrations of the concentrations of cod within the limits of the depths of 150-250 meters.

In the shallow waters of South Kuril Islands, near the shores of Hokkaido, Eastern shores of Korea, etc. i.e. within the limits of the South-boreal region, we observed great changes in the annual migration cycle of cod as compared with those observed for the cod of the Bering Sea and waters washing Kamchatka.

High summer temperatures of littoral waters compel the cod to remain throughout the warm season at depths of 100 meters and over (100-200 meters near the Eastern shores of Korea, 150-250 meters near the Southern Kuril Islands and 200-450 meters near the shores of Hokkaido). With the advent of winter the cod approach the shores at the depths of 15-50 meters, when during this season the water temperatures reach minimum annual figures. The spawning occurs here in December-February. In March-April the fish already begin migrating away from the shores because of the rapid warming-up of the surface layers of water. Following the migration of large specimens of fish, leaving the shores when the temperature rises, the young specimens also move away (fig. 6).

Such is the general scheme of the distribution and migration of cod from Pacific Ocean within the limits of the northern and southern-boreal areas. The cod inhabiting Tauyski gulf and the region of Ayan Bay is in a visibly inhibited state, as may be seen from the very low rate of growth, high mortality rate (V. Rozovy observed great numbers of dead cod thrown out during the winter in the region of Ayan Bay) and low catches.

The cod inhabiting the Yellow Sea, i.e. the subtropic regions, became sufficiently adapted to conditions unusual for this fish species, as may be judged from the fact that annual catches reach 15-16 thousand centners. We have no data on biology of these cod.

The limited extension of paths of migration of the cod from the Pacific Ocean, which we discussed above, as well as the existence within the boundaries of the Far Eastern waters of a great number of separate local shoals of cod are sufficient evidence to show that the systematic classification of cod in the Pacific Ocean, as set by Svetovidov (1948) was correct and that, in morphological features, the large-headed cod from Pacific Ocean resembles ~~most~~ **most** closely the littoral Greenland cod (*Gadus morhua ogac Rich*).

From this we may conclude that cod, which have migrated from the shores of Greenland to the shores of the North Pacific with its numerous extensive volumes of shallow water all differing vastly from each other formed a number of shoals with varying morphological and biological features somewhat modified by the effects of the new habitat, although characteristics peculiar of the original form, have been preserved.

Having discussed the distribution and migrations of cod, we wish to dwell on the ability of cod to form concentrations.

During the expedition on board the trawler "Lebed" in 1938-1939, apart from the research works we carried out in a number of regions of the West Kamchatka shelf,

experimental-industrial trawls which aimed at locating and fishing large industrial accumulations of cod. The great number of different investigations conducted by the expedition made it impossible to carry out industrial trawl on the desired scale, and, the data obtained are of unquestionably great importance.

At the beginning of June (June 4-10), 1939, 35 operations using a symmetric trawl constructed in a manner as to prevent various invertebrates and flounders from penetrating inside (see Moiseev, 1950), were carried out in the northern part of the West-Kamchatka shallow water region in the proximity of Moroshechnaya-Sopochnaya.

The first 21 trawling operations during which the trawl was tested and concentrations of cod were located were of experimental character; subsequent trawling operations were of industrial nature. An accumulation was found in the direct proximity of the shore at depths of less than 50 meters (mainly between the depths of 12 and 40 meters) and this greatly complicated the use of the trawl, since this equipment is difficult to launch at small depths. This compelled us to use the trawl on a varying course, during which the trawler with the trawl was directed at small depths, but at the moment when the trawl was lifted, the boat was navigated to the depths of 40 meters. The trawling lasted for 3 hours.

Results of the afore-discussed trawls enabled us to clarify the dimensions and character of concentrations and results of this small industrial fishing.

It is obvious that in this case the summary results of fishing are rather modest. During the thirteen trawling operations which lasted three hours each, 1655 specimens of cod weighing 50 centners were caught. Among the cod caught the medium size (50.8%) and large fishes (38.3%) prevailed. On the other hand, considering the arrangement of trawls and their catches, we may see that in the region investigated the cod formed an accumulation extending over 25 miles along the shore and 5.6 miles wide, within the limits of which we obtained high catches of cod.

Considerably farther to the South, in the Kolpakov and Uda River regions, we discovered on June 12-13, 1939, at the depths of 22-30 meters, another accumulation of cod which resembled the afore-described in its configuration.

The latter concentration also extended, over 30 miles along the shore. The small number of trawls, carried out in this region (8 trawlings) made it impossible to fully determine the boundaries of this concentration, however, we were able to establish that the cod occupied a rather large water volume. During the 8 three-hour trawls 908 specimens of cod were caught weighing about 32 centners. Two trawls provided 16.3 centners of cod. In these catches the medium sized (48.5%) and large (38.4%) cod also prevailed.

During the first half of August (from August 1, until August 7, 1939) the expedition carried out a series of trawls associated with the search for crabs, in the central section of West Kamchatka shallow water region from Bolhaya River to the Kekhta River. The total

number of one-hour trawls performed in this region reached the total of 69.44 making a catch of less than 50 specimens of cod, 14 trawls caught 50 to 100 fishes, 7-from 100 to 150 and 3- over 200 cod specimens. Moreover, one of the trawls brought back 396 fishes weighing 7.9 centners. Having shown on the map the trawls which made the most considerable catches, we shall see that in August there is a zone extending along the shore, and in this zone the density of cod distribution is high and made up of concentrations of considerable extent (including the gaps of up to 40 miles, chiefly caused by the high benthic biological volume (Gordeeva, 1948) in this region.

It is well known that dimensional composition is most important for evaluating the degree of uniformity of composition of the industrial accumulation of its different sections, since it has been established that different elementary accumulations bring together fishes of similar dimensions (Lebedev, 1940; Tokarev, 1949).

Let us compare the dimensional composition of cod in different trawls launched within the borders of the aforescribed concentrations. By comparing the dimensions of cod caught by trawls NoNo 611, 612, 620 and 621, i.e. within the limits of littoral concentrations situated somewhat to the South from the mouth of Moroshechnaya river, we may see that not only the mean dimensions of cod in these trawls were close (63.2; 62.1; 63.5, and 60.3 respectively) to each other, but Peterson's curve for the four trawls also had a similar character.

Comparison of the dimensional composition of cod catches in trawls NoNo 716, 748 and 755 (mean dimensions 55.1; 56.4; 65.0) and their graphic presentation also show that the fishes caught by the above-named trawls within the limits of the concentration situated between the rivers Kikhchik and Utka resemble each other.

Comparison of dimensional composition of cod from the trawls NoNo 732, 741, 747 of the most southern accumulation situated between the mouths of rivers Bolshaya and Ozernaya, i.e. their mean dimensions (50.3; 60.0; 58.0; 57.3), as well as graphically presented length of their body (fig. 7.), proves anew that the catches obtained by the aforementioned trawls consisted of fishes of uniform dimensions.

It is quite clear that in all the three cases we dealt with accumulations considerable in dimensions and uniform in composition.

The above exposed results of the trawls conducted by the expedition on board the research trawler "Lebed" showed that near the shores of Kamchatka, in a series of regions of considerable surface area, there are formed during certain seasons high concentrations of cod within the limits of which the catches (trawl catches included) noticeably increase.

The aforesaid compelled us to re-analyze the results of the trawling operations conducted on board a great number of research and industrial trawlers in 1930-1934 on the basis of which it had been assumed that distribution of cod in Pacific Ocean is rather diffusional and the cod do not form concentrations during the summer.

Indeed, if we closely analyze the communications received from the majority of trawlers, the lack of systematic organization of work during the search for industrial accumulations of cod becomes apparent. In the overwhelming majority of cases the trawler launched successively several trawls, recovered them on board the ship and moved to another section of the region investigated, without thoroughly and methodically fishing in the horizon which provided the highest catch. Less frequently, the trawlers lifted one trawl after another along a line that was often of considerable length, without stopping and conducting thorough reconnaissance in the region where the catch appeared to be the highest. Undoubtedly, the majority of explorers, trawler captains and supervisors of fishing organizations were under the hypnotizing influence of the Japanese scientist Marukava who maintained that cod fishing in the shallow water regions of Western Kamchatka are the richest in the world. In view of this, catches of 10, even 15-20 centners obtained within an hour of trawling, which, however, were not preceded by a great number of trawls, were usually given little attention.

Let us quote several examples confirming the aforesaid. During the first cruise of the trawler "Balkan" to the shores of Kamchatka in 1930, Captain Kostrubov lifted during the second half of May in the region of Ozernaya-Yavino 10 centners of cod per trawl within three successively launched trawls (NoNo 18, 19 and 20). Thus, a concentration of at least 10 miles in length

(or in width) was intersected, but he launched no more trawls within the limits of this concentration, although it was obvious that he had located an accumulation of fish sufficiently large to permit effective cod fishing. The same occurred at the beginning of June in the region of the river Opala, where 25 centners, then 5 to 20 centners of cod per an hour of trawling were caught. However, the boat proceeded south without stopping to continue fishing in the area where the concentration had been located.

At the end of August, in the region of Cape Ginter, Anadyrski Bay, the trawler "Balkan" caught during 9 trawls 143 centners of cod and about 45 centners escaped through a tear in the net. However, even there, in spite of effective results, no industrial fishing in the area of large concentrations was organized. Examples of trawlers ignoring the most elementary rules of fishing are even more striking.

The trawler "Plastun" in 1932 launched four trawls No. 74-77 in Anadyrski Bay in the region of Ginter from South to the North, and obtained catches of 15, 10, 25 and 5 centners respectively and left for another area although the mean catch per trawl reached 14 centners.

Similar examples can be quoted in great number, however, the above said suffices to refute the theory maintaining that the cod from Pacific Ocean do not form well outlined, regularly accumulated concentrations.

The data presented enable us to assume that the cod from the Pacific Ocean form, within the limits of the inhabited areas, local shoals that cover consider-

able surface areas during definite seasons. During the spring and summer (May-September) near the shores of Sakhalin, Eastern and Western shores of Kamchatka, and northwestern part of the sea of Bering, these concentrations are situated in the regions with rich benthic biological volume. Changes in the hydrological conditions produce displacements of the concentrations of cod to the areas with high contents of nutritive biological volume.

We wish to point out that it is erroneous to believe as did many employees of the fishing industry in the Far East, that there exist in Barentz Sea exceptionally large areas, within the borders of which the trawl catches of cod are constantly high.

In reality, as was clearly proved by Mesyatsev (1937, 1939), the industrial accumulations of cod consist of small fish shoals, containing, as a rule, fish specimens of similar dimensions. These shoals consist of several hundreds of fishes, migrating within the limits of their grounds and which form temporary industrial concentrations, readily disaggregated and reunited anew. As may be seen from the numerous maps presented by Mesyatsev, the dimensions of concentrations with catches exceeding 10 centners usually do not exceed 10-12 miles in width and 15-18 miles in length (i.e. 150-220 square miles) and the navigating personnel must be highly skillful to remain within the limits of this relatively small area and obtain in the course of a prolonged period of time high catches of fish.

When comparing these data with the dimensions of accumulations of cod, which were observed in the Far Eastern Seas, it is easy to see that skilful fishermen were able to accomplish effective fishing within the limits of numerous cod accumulations that have been located.

As mentioned above, the cod from the Pacific Ocean or the majority of specimen ready for spawning migrate during the pre-spawning period to some intermediate horizon, where the spawning occurs. It is possible that during the spawning period the cod from the Pacific Ocean or a considerable part of the specimens forming part of a given shoal, do not remain on the ocean floor, but inhabit somewhat higher horizons. Feeding may, indirectly confirm the aforesaid. The development of data on the feeding of cod gathered by the expedition of 1938-1939 by Logvinovich (1948) showed that large cod feed essentially on fish, mainly on Alaska pollack and secondarily on herring, navaga and young cod. It is natural to assume that while hunting for these benthic and nectic fishes, the cod leave benthic horizons. Moreover, it is well known that average cod caught on hook cordage near the shores of Kamchatka, are as a rule larger (by 8-10 cm) than cod caught in trawls in the same area. We may assume that while small cod specimens remain in the benthic horizons in view of the fact that objects on which these fishes feed are almost entirely of benthic character, the feeding of larger specimens does not require these fishes to remain directly on the ocean floor, since the trawl catches consist essentially of specimens smaller than those caught

on the hook, and the trawls are thrown, as a rule, close to the ocean floor.

Migrations of Atlantic cod have been studied by a number of researchers and the existing patterns of migrations are based on the vast factual material and, first of all, on the results of mass spawning. It suffices to mention that by 1937, 13500 specimens of cod were marked in the Northern part of the Atlantic Ocean. Results of the markings were summarized and migration of Atlantic cod was discussed by Schmidt (1936, 1947), Tening (1937), Maslov (1944) and others.

The Arctic-Norwegian shoal of cod makes regular seasonal migrations from Northwest Norway into the Bering Sea, descends to the North from Spitsbergen and moves eastwards to the shores of Nova Zembla penetrating as far as Kara sea. These migrations are essentially in search of food, while migrations in the opposite direction are produced by the drop in temperature of the waters of the Barentz sea during the fall and return of the cod to the spawning regions. The overall extension of migration paths of this shoal reaches 200 kilometers and more. An approximately equal extension (up to 200 kilometers), though somewhat less regular, has been observed for migrations of Greenland cod shoals moving from the southwestern shores of Greenland to the shores of Iceland and back.

Thus, the Atlantic cod (with the exception of a few local forms, i.e. Baltic cod, White Sea cod, etc.) are characterized by migrations of rather long distances

and relatively well localized spawning regions.

Summarizing the above presented data material on the distribution and migration, we may see that the cod from the Pacific Ocean are widely propagated within the limits of the North Pacific Ocean temperate zone and are mainly found in the North boreal regions. In the subarctic and subtropic, as well as in cold regions the cod are found in a limited number and an inhibited state.

Inhabiting a large range of depths (from 5 to 350-400 m) within the limits of North-boreal regions the cod remain during the summer in the areas of shallow waters (below 100-120 meters), where the temperature ($2-9^{\circ}$) and feeding conditions are particularly favourable to the existence of these fishes.

In the North-boreal regions, together with the widespread summer distribution of cod over the vast territories of the Northwest Pacific Ocean, the cod form well-outlined concentrations, the density of which increases during the winter, i.e. during the pre-spawning period.

In a number of regions (Tatarskiy Bay, Western Kamchatka, Litke strait, Olyutorski and Anadyrskiy bays), the summer distribution of cod in the shallow waters especially depends on thermic conditions in these regions.

In the North-boreal regions of the Northwest Pacific Ocean, the cod show two well-pronounced seasonal migrations:

The spring feeding migration occurs after the spawning has been completed and is from the deep regions of wintering up to shallower depths, where the cod find the most abundant food and begin intensive feeding; and the autumn-winter wintering migration from the summer-grounds in the shallow waters to the regions of great depth dependent on the autumn-winter drop in temperatures of the littoral waters.

During the spring migration and during the summer period, the migrations to shallow waters coincide with simultaneous migrations towards the shores and along the shore line.

The specific hydrological conditions and underwater relief of the Far Eastern seas condition the existence of a great number of local shoals of cod in the Northwest Pacific Ocean inhabiting limited areas and migrating within the borders of these areas. The extension of seasonal migrations of cod in the Far Eastern waters is relatively small: near the shores of Kamchatka and in the southwestern part of Anadyrski Bay, where migrations are on the largest scale, their extension rarely exceeds 150200 miles in the same direction.

Within the limits of the South-boreal regions (Southern Kuril Islands, Hokkaido, Korean shores) the seasonal distribution and seasonal migrations of cod are diametrically opposite to those in the North-boreal regions. As the littoral waters warm up during the summer, the cod sink to the depths of 200-300 meters and more with minimum temperatures and during the winter (December-March) approach the

shores to spawn.

Thus, the numerous local shoals of the cod from the Pacific Ocean substantially differ ecologically depending on the living conditions, although their morphological differences are rather slight.

LENGTH AND WEIGHT.

Prior to discussing the data on linear dimensions of cod, we wish to point out that, as we already mentioned while discussing the flounders (Moiseev, 1946), the mean size can be obtained only after comparing a great number of fish specimens (at least several thousands), which were caught by means of identical fishing cordage in the same area and from the same depths, or in different areas (while comparing the fish of different regions), but under otherwise identical conditions (depth, fishing period, etc.).

Under conditions of the Far East, we cannot lay down conditions for any fish species, since we deal with a relatively small number of measurements, different means of fishing or identical fishing implements, which vary in dimensions of mesh, depths to which sunk, and periods at which sunk, location of the place where a given fish was caught and a number of other factors reflected in the resulting average length. Therefore, the use of average length for benthic fish can be effective only under conditions of mass material available and when the means of fishing are either identical or at least analogous. The example of Prof. E.K. Suvorov's theory maintaining that the cod

reserves near the shores of Western Kamchatka have decreased, a conclusion at which the author arrived on the basis of analysis of the mean dimensions of cod found in the catches of 1929-1933, is well known (Kaganovsky, 1938).

The data presented here on the length and weight of cod are designed to show the extreme fluctuations in the weight and length of the cod and contents (in %) of different dimensional groups in the catches, differences in dimensional composition of cod catches in different regions, fluctuations in mean length and weight according to seasons, years and changes in the weight in dependence with the length.

The maximum dimensions of Pacific Ocean cod encountered in the Far-Eastern waters do not exceed 115 cm in length and 18 kg in weight. Thus, the maximum dimensions of cod from the Pacific Ocean are considerably lower than the dimensions of Atlantic cod, which, as it is well known, is often 120-130 cm in length (Maslov, 1944) and occasionally reaches 160 cm in length at 40 kg of weight (B., 1940). Since the most thorough seasonal changes in the dimensional composition of cod have been studied most thoroughly near the shores of Kamchatka during the expedition that took place in 1938-1939, let us dwell on the data provided by this expedition.

TABLE 10.

Length of cod of Western Kamchatka in 1929-1939.

Length in cm.	15	20	25	30	35	40	45	50	55	60	65	70
Number of specimens	3	9	8	113	304	524	1075	1109	1294	1707	2004	

TABLE 10,
continued.

Length in cm	70	75	80	85	90	95	100	105	110	M	n
Number of specimens	1857	1317	776	529	262	96	25	3		78.9	13089

Table 10 shows dimensions of fish caught by means of different implements; symmetric large-meshed trawl, finely meshed otter trawl, etc., which had varying selecting capacity.

Let us proceed now to the analysis of data on the length of cod according to different months, where we shall use the dimensions acquired during the first seven

cruises of the expedition on board "Lebed" (from June 14, 1938 to June 18, 1939) where only a symmetric trawl was used, in view of which the data of these particular cruises are most suitable for comparison (table 11).

TABLE 11.

Dimensions of the West-Kamchatka (in %).

Dates	Length in cm.											
	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75
June 14-24 1938	-	-	-	.2	.4	2.4	5.2	4.0	9.0	13.7	18.2	10.6
August 11-20 1938	-	-	-	-	.5	-	-	-	2.7	6.5	7.5	7.5
October 15-24-1938	-	-	-	.4	.4	3.7	4.2	6.0	2.3	5.1	14.8	12.1
December 3-16-1938	-	-	-	-	2.1	4.2	6.7	6.0	10.6	12.8	17.5	12.5
January 24 Febr. 11, '38	-	-	-	.4	1.3	2.0	4.7	11.7	15.3	23.7	21.5	10.8
March 4-11 1939	-	-	1.6	1.6	7.8	17.2	7.8	9.3	7.8	17.1	14.1	4.1
June 4-18 1939	.1	.1	.1	.5	.9	4.4	5.1	8.0	9.5	13.6	17.0	17.1
Total number of specimens	2	1	2	20	72	234	327	479	643	937	1116	886
Percentage	.03	.01	.03	.3	1.1	3.7	5.1	7.5	10.1	14.8	17.6	14.0

TABLE 11 (Continued)

Date	Length in cm.										
	75-80	80-85	85-90	90-95	95-100	100-105	105-110	n	M	s	+6
June 14-24-38	10.6	10.3	9.2	4.8	1.0	0.4	-	764	70.15	.47	13.10
August 11-20-38	18.8	24.2	21.0	8.6	2.7	-	-	186	79.75	1.15	15.65
October 15-24-38	11.1	10.7	18.1	5.1	4.6	1.4	-	216	74.10	1.01	14.95
December 3-16-38	8.1	5.7	7.3	4.5	2.0	.2	-	961	67.45	.42	13.20
Jan. 24-Feb. 11, 1939	4.1	1.6	1.3	1.1	.5	-	-	1096	63.10	.12	13.30
March 4-11, 1939	4.7	4.7	1.6	-	-	-	-	64	56.80	1.73	13.90
June 4-18, 1939	9.7	6.3	4.3	2.3	.7	.2	.1	3060	66.65	.23	12.90
Total number of specimens	563	414	364	203	69	13	2	6347	67.0	.15	12.50
In percentage	8.9	6.5	5.8	3.2	1.1	.2	.03	---	---	--	---

TABLE 12

- 84 -

The weight of West-Kamchatka Cod (in %)

Date	Weight in kg.									
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
June 14-24, 1938	0,8	9,2	11,3	17,2	13,0	13,4	8,4	9,6	6,7	4,6
Aug. 11-20, 1938	0,6	2,9	8,1	8,7	9,3	16,3	18,0	12,2	11,1	5,2
Oct. 15-24, 1938	3,4	16,8	1,7	13,6	13,6	10,1	8,5	5,1	8,5	6,8
Dec. 3-16 1938	9,3	14,7	11,4	13,9	12,1	10,4	7,7	5,0	4,6	3,3
Jan. 24- Feb. 11, 1939	5,1	20,2	23,3	19,1	9,6	7,9	4,8	2,4	1,7	1,4
March 4-11, 1939	27,7	24,6	9,3	13,8	19,9	16,2	3,1	1,5	1,5	1,5
June 4-18, 1939	5,0	6,2	9,3	15,2	19,5	15,8	8,7	7,7	3,4	4,4
Total number of specimens	102	208	205	252	213	198	140	106	81	60
Percentage	6,1	12,6	12,4	15,1	12,9	11,2	8,4	6,3	4,9	3,6

TABLE 12 CONT.

	10-11	11-12	12-13	13-14	14-15	15-16	n	M	m	σ
June 14-24, 1938	4,2	0,8	0,4	-	0,4	-	239	5,26	0,17	2,68
Aug. 11-20, 1938	5,2	1,8	0,6	-	-	-	172	5,28	0,18	2,45
Oct. 15-24, 1938	8,5	-	1,7	1,7	-	-	59	5,59	0,42	3,24
Dec. 3-16, 38	3,5	1,7	1,4	0,6	0,4	-	518	4,62	0,13	3,11
Jan. 24-Feb. 11, 1938	2,1	0,7	-	1,4	-	0,4	293	3,77	0,15	2,65
March 4-11	1,5	-	-	-	-	-	65	2,58	0,26	2,16
June 4-18	1,5	1,5	0,3	0,9	0,6	-	323	5,07	0,14	2,70
Total number of specimens	55	21	11	11	5	1	1669	4,80	0,06	2,48
Percentage	3,6	1,3	0,6	0,6	0,3	0,1	----	- - -	- - -	- - -

The figures expressing the mean dimensions of cod, and graphs shows that the number of large fishes increases in catches and returns to the summer norms in June with subsequent increase in the mean dimensions by August.

Fish specimens between 50 and 90 cm prevail in catches. There were found but few fishes less than 50 cm or more than 90 cm in length. Over 11% of fish specimens caught in August and October, 1938, measured over 90 cm in length; however, this was an exceptional case.

In March, 1939, on the other hand, 36% of catches comprised small fishes (less than 50 cm). In the catches made during other seasons, however, only 6.2% of cod were over 90 cm in length and not more than 13% of cod were below 50 cm in length. It must be kept in mind that the large mesh (as wide as 125 mm in the wings) of the trawl used on this occasion did not retain small fish.

Fluctuations in the mean weight according to different seasons and percentage of fishes belonging to different weight groups (see table 12) confirm the results of analysis of the dimensions of cod. Seasonal fluctuations observed in the mean weight of cod are considerable: from 2,58 kg. in March the mean weight of cod rises to 5,59 kg. in October.

Similar seasonal fluctuations in dimensions of cod have been observed in other regions as well. Thus, according to the data of Kulichenko, winter fishing on the hook (near the southeastern coast of Sakhalin) yielded catches consisting almost exclusively small sexually immature cod specimens, which naturally reduced the figure showing mean dimensions of the fishes caught (table 13).

TABLE 13.

MEAN DIMENSIONS OF COD CAUGHT NEAR THE SOUTH-WESTERN
COAST OF SAKHALIN AND SOUTH-EASTERN KAMCHATKA

Region	M o n t h s									the data provided by:
	II	III	IV	V	VI	VII	VIII	IX	X	
Southwestern Sakhalin, 1947:										
Length in cm.	58,6	60,7	62,1	65,2	67,9	83,0	72,5	-	61,7	Kulichen- ko
Weight in kg.	2,05	2,18	2,81	3,89	4,30	5,80	5,30	-	3,11	
Southeastern Kamchatka:										
Length in cm:	-	-	-	73,8	74,2	72,4	71,2	73,1	-	Polutov

Large sexually mature cod specimens feed very little and do not bite during the pre-spawning and spawning periods. Moreover, it is obvious that during these periods the majority of these fish slightly rise above the ocean floor. After spawning has terminated, the large fish begin to approach the shore feeding intensively and more and more frequently become the prey of fishermen.

As a result the mean dimensions of fishes caught also increase, but begin gradually decreasing in the late fall when the cod prepare for winter spawning.

Let us present a table showing correlations between the length of the body and weight of cod found in coastal waters of Western Kamchatka (table 14).

We noticed considerable fluctuations in the weight of large cod specimens. Thus, fishes 90 to 95 cm in length, weight 6-18 kg.

In order to obtain a clearer notion of the increment of weight in the young, sexually immature cod specimens, let us draw a **correlative** grid with class differences of 250 gr depending on the length of body and weight of the fishes 65 cm and less in length (see table 15).

It is much more interesting to calculate the mean weights for all the dimensional groups from the correlative grid (see table 16).

Mean weights presented in table 16 have been calculated according to the summary variation line there being for large fish specimens (over 65 cm in length) a class difference of one kg. and for small fishes - 250 gr, in view of which they somewhat differ from the mean dimensions of small cod for different seasons that have been calculated according to variation lines with class differences of one kilogram.

The mean weight of the majority of the dimensional groups shows a general tendency to increase from June to March, due to the improved feeding conditions and to an even greater degree, by the increase in the weight of the sexual products, which will be discussed further on (see table 46).

At the end of the spawning the mean weight decreases, as the roe constitutes about 20-26% of the general weight of the fish.

Let us proceed to a brief exposition of the data on length and weight of the cod from the Pacific Ocean in different regions of the Far East.

TABLE 14.

-88-

Correlation between the length and weight of the West-Kamchatka cod (male and female specimens) caught between June 14, 1938 and August 4, 1939.

Length in cm.										Weight in kg.										
	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	n	M			
25	1															1	0,50			
30	5															5	0,50			
35	34	1														35	0,57			
40	67	6	1													74	0,60			
45	14	94														108	1,38			
50		98	5													103	1,54			
55		39	84	2												125	2,21			
60		3	117	65												185	2,83			
65		1	10	180	74	2										267	3,74			
70			1	28	144	79	7									259	4,74			
75				2	30	100	68	9	1							219	5,75			
80					5	25	56	56	16	1						159	6,85			
85					1	4	18	45	52	29	16					165	8,27			
90							3	5	12	28	33	13	8			102	10,00			
95									2	3	8	9	4	9	2	37	11,71			
100											1	1	1	4	1	8	12,75			
105															2	2	14,50			
110																				
n	121	242	218	277	254	219	152	115	83	61	58	23	13	13	5	1854				
M	41,10	51,25	60,25	66,94	71,90	76,40	80,60	84,50	87,40	90,20	91,30	94,90	94,75	99,00	102,50					

TABLE 15.

Correlations between the length and weight of sexually immature cod (male and female specimens) of Western Kamchatka (June 23 1938-March 11, 1939).

Length in cm	Weight in grs.								
	0-250	250-500	500-750	750-1000	1000-1250	1250-1500	1500-1750	1750-2000	2000-2250
25	1								
30		2							
35		2	26	1					
40			5	44	5				
45				4	36	29	2		
50				1	3	23	28	13	3
55						1	4	14	24
60								2	4
65									
n	1	4	31	50	44	53	34	29	31
M	27,5	35,0	38,3	43,0	47,3	49,9	52,8	53,7	57,7
Table 15, contd									
Length in cm	2250-2500	2500-2750	2750-3000	3000-3250	3250-3500	3500-3750	3750-	n	M
25								1	0,125
30								2	0,250
35								29	0,550
40								54	0,875
45								71	1,225
50								71	1,597
55	19	10	3					75	2,200
60	17	24	25	21	5	7	1	106	2,825
65									
n	36	34	28	21	5	7	1	409	-
M	59,9	61,1	62,0	62,5	63,0				

TABLE 16.

Mean weight of West-Kamchatka Cod depending on the dimensions and season (in kg.).

Length in c m	June-August 1938	October-December 1938	March 1939	June 1939	Annual mean figs	Number of specimens mens.
25					0,125	1
30					0,375	3
35	0,50	0,50	0,57		0,61	33
40		0,53	0,60	0,83	0,81	62
45	1,50	1,46	1,45	1,14	1,08	80
50	1,83	1,50	1,14	1,45	1,60	79
55	1,97	2,10	2,37	2,10	2,10	91
60	2,70	2,90	2,86	2,89	2,87	130
65	3,06	3,92	3,74	3,52	3,74	252
70	4,60	5,04	4,87	4,56	4,76	235
75	5,57	6,11	6,13	5,38	5,76	214
80	6,64	7,45	7,00	6,53	6,36	156
85	7,99	8,70	9,19	7,81	8,38	163
90	9,48	10,53	11,68	9,72	10,00	102
95	10,80	12,18	12,90	10,17	11,70	34
100	12,50	12,50	13,50	14,00	12,88	8
105					14,50	2
110						
Mean weight per season	5,66	4,77	4,07	5,07	4,97	1645

Having amalgamated in the composite table (table 17) the data available on linear dimensions of the cod caught by trawls and on the hook, we may see that the cod in the Sea of Japan are usually smaller than the cod inhabiting the Sea of Okhotsk and Bering Sea. In the Sea of Japan the catches mainly contain fish specimens of 45 to 70 cm in length (71.3%), whereas in the sea of Okhotsk, near the shores of Western Kamchatka, the fishes reach as a rule 45 to 80 cm (79.8%) in length. In the waters washing the Eastern shores of Kamchatka the fishes of 55 to 90 cm are found in a prevailing number (94.6%) and finally the length of the cod from Bering Sea fluctuates as a rule between 55 to 95 cm (94.1%). The weight of cod varies accordingly. From 2.43 kg in the Sea of Japan it rises to 4.65 kg. in the Okhotsk sea and reaches 4.42 kg. in the Bering Sea (table 19). Undoubtedly, the number of medium size cod decreases, while the specific weight of the groups of small dimensions increases in the catches as we gradually approach the Southern borders of the area of the propagation of cod. This is particularly evident in table 18 summarizing the mean dimensions of cod from different regions.

While the mean dimensions of cod in different volumes of the Bering and Okhotsk seas and along the Eastern coast of Kamchatka are rather proximate and fluctuate within the limits of 70-75 cm. and 3.7 - 5.3 kg, the mean dimensions of cod inhabiting the Sea of Japan substantially differ. According to the data provided by Krivobok, the dimensions of cod in the northern part of Tatarskiy strait (excluding De-Kastri, where only

TABLE 17.

LENGTH OF COD FROM PACIFIC OCEAN (in cm).

Region	Year	Fishing means	Number of specimens and %	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100	100-105	105-110	110-115	M	n
Bering Sea	1928-	Multistage fishing net	No					25		1	37	104	324	659	682	364	177	58	27	5				72,55	2438
	1930		%							0,04	1,57	4,26	13,20	27,03	27,36	14,93	7,25	2,37	1,19	0,20					
	1931-	Trawl	No		1	3	19	25	29	54	120	294	156	110	723	111	808	461	185	73	25			75,70	3197
	1933		%		1,02	0,07	0,45	0,60	0,69	1,29	2,86	7,00	3,72	2,62	17,22	26,47	19,25	0,98	4,41	1,75	0,60				
	1928-	Trawl and multist. fishg net	No		1	3	19	25	29	55	157	398	480	769	1405	1475	985	519	212	78	25			74,05	6635
	1933		%		1,02	0,05	29	0,38	0,44	0,83	2,37	5,99	7,23	11,57	21,17	23,22	14,86	7,82	2,20	1,18	0,38				
East-ern Kam-Chatka	1934-	Multistage fishing net	No				1	31	234	644	1107	2957	5416	8104	9617	7909	5636	2772	1260	453	72	12		72,35	46232
	1948		%					0,07	0,50	1,40	2,4-	6,40	4,71	17,53	20,80	17,10	12,19	6,01	2,72	0,98	0,16	0,03			
Sea of Okhotsk (Western Kam-Chatka)	1929-	Multistage fishing net	No						1	4	17	62	109	188	270	210	109	42	14	4	--	1		72,40	1031
	1950		%						0,09	0,39	1,64	6,01	10,57	18,25	26,19	20,38	10,57	4,07	1,36	0,39		0,09			
	1931-	Trawl	No	3	9	8	113	304	528	1071	1092	1232	1598	1890	1587	1107	667	487	248	92	25	2		64,55	12063
	1939		%	0,02	0,07	0,06	0,94	2,52	4,34	8,88	9,06	10,21	13,24	15,73	13,15	9,17	5,53	4,04	2,06	0,76	0,21	0,01			
	1929-	Trawl and multistage fishg net	No	3	9	8	113	304	524	1075	1109	1294	1707	2018	1857	1317	776	529	262	96	25	3		65,10	13029
	1939		%	0,02	0,03	0,06	0,86	2,32	4,00	8,21	8,47	9,89	13,04	15,88	14,19	10,06	5,92	4,04	2,01	0,73	0,2	0,02			
Sea of Japan	1944	Multistage fishing net	No					7	27	38	40	28	23	26	42	37	22	6	6	2				62,55	304
			%					2,30	8,89	12,49	13,15	9,21	7,57	8,56	13,82	12,17	7,28	1,97	1,97	0,66					
	1932-	Trawl	No	73	5	24	77	119	134	228	249	284	255	245	132	57	21	8	7	4				54,65	1922
	1933		%	3,80	0,26	1,26	4,00	6,19	6,97	11,86	12,95	14,78	13,26	12,74	6,86	2,96	1,09	0,42	0,4	0,20					
Foreastern seas	1932-	Trawl and Multistage fishg net	No.	73	5	24	77	126	161	266	289	312	278	271	174	94	43	14	13	6				55,80	2226
	1944		&	3,28	0,22	1,08	3,46	5,66	7,23	11,97	12,70	14,00	12,48	12,17	7,88	4,82	1,98	0,56	0,52	0,27					
	1928-	Multist. fishing net	No.				1	38	262	687	1201	3151	5872	8977	1060	8520	5944	2885	1307	467	72	13		73,25	9457
	1948	Trawl	%					0,08	0,52	1,37	2,40	6,30	11,74	17,95	21,22	17,03	11,88	5,78	2,62	0,94	0,14	0,03			
		Trawl	No.	76	15	35	209	448	686	1353	1461	1810	2009	2245	2442	2275	1496	956	440	169	50	2	1	66,40	8178
			%	0,42	0,08	0,19	14	2,46	3,77	7,44	8,04	9,96	11,05	12,35	13,43	12,56	8,22	5,26	2,42	0,93	0,27	0,01			
		Trawl & Multist. fishing net	No.	76	15	35	210	486	948	2040	2662	4961	7881	11222	13053	10795	7440	3841	1747	633	122	15	1	70,15	3183
			%	0,11	0,02	0,05	0,30	0,68	1,30	3,00	3,90	7,18	11,56	16,69	19,14	15,84	10,91	5,63	2,56	0,93	0,18	0,02			

Small and medium size cod penetrate during the summer) are the largest for the entire basin of the Sea of Japan, however, but still are only 61,8 cm in length and 2.96 kg. in weight. As we gradually move towards the South along the Maritime Coast, the mean dimensions of cod gradually decrease and reach the minimum (52.4 cm and 1.98 kg) in Peter the Great Bay. Keeping in mind that the maximum dimensions of cod in the Sea of Japan (table 17) as well as the rate of its growth differ little from those of cod from the seas of Okhotsk and Bering, we may assume that as a result of the unfavorable conditions in the Sea of Japan, the cod are not only few in number, but subject to a considerably higher rate of mortality.

We wish to point out that in the Okhotsk and Bering seas we found only 3.0 - 3.9% of fish specimens over 90cm in length and in the Sea of Japan only 0.9%

Increase in the weight accompanying the increase in linear dimensions of cod is very similar for all the Far Eastern seas (table 20). However, a comparison of these data with analogous figures for the Barents sea showed that the cod from Pacific Ocean gain weight much more rapidly with the increase in dimensions. The difference noticed in fish 30-35 cm in length rapidly increases and at 90-100 cm the mean weight of the cod from Pacific Ocean exceeds the weight of the cod specimens of corresponding dimensions from the Barents Sea by 2-2,5 kg. The cod from the Pacific Ocean are

characterized by a large head (21,5% of the overall weight of fishes between 65 and 75 cm in length).

TABLE 18.

Mean dimensions of cod (length in cm and weight in kg) in 1930 - 1940

Regions	Trawl fishing		Fishing on the hook.	
	length	Weight	Length	Weight
<u>Bering Sea:</u>				
Eastern Section.....	72,65	4,93		
Northern Section.....	67,88	3,86		
Anadyrski Bay.....	71,3		73,3	
Olyutorski Bay.....	71,44	4,70	75,3	4,1
Korf Bay.....			70,8	
Region of Karaginski Island	72,25		66,7	3,7
Region of Komandor Island..	68,85			2,47
<u>Eastern Kamchatka:</u>				
Kamchatka Nay			68,4	
Kronotski Bay			73,35	4,4
Avachinski Bay	72,54	4,50	64,4	3,8
<u>Sea of OKHOTSK:</u>				
Region of the Northern			76,4	
Kuril Islands			73,5	5,3
Ozernaya-Nolshaya			71,5	4,8
Kikchik-Vorovskaya				4,5
Moroshechnaya-Khariuzovo	64,2	3,71		
N. E. Coast of Sakahlin	67,5	4,15		
Southern Kurill Islands			78,4	4,99
<u>Sea of Japan:</u>				
De-Kastri	51,75			
Pilevo-Aleksandrovska	61,80	2,96	62,9	
Nevelsk-Uglegorsk	58,30	2,59		
Nelma	57,90	2,48		
Povorothy-Olimpiada	53,70	2,01		
Peter the Great Bay	52,40	1,98		

TABLE 19.

Weight of cod found in Far Eastern waters.

Weight in kg.	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11
Bering Sea	22	92	163	249	262	166	99	66	38	20	5
Sea of Okhotsk	125	271	396	533	585	452	276	169	110	68	64
Sea of Japan	253	365	316	225	134	48	12	6	4	4	--
Summary	400	728	875	1007	981	666	387	241	142	92	69

Weight in kg.	11-	12-13	13-14	14-15	15-16	16-17	17-18	Mean	n
Bering Sea 3		1						4,42	1186
Sea of Okhotsk	21	13	12	5	1			4,65	3101
Sea of Japan	1	1	-	-	-	-	1	2,43	1369
Summary	25	15	12	5	1	-	1		5656

When calculating the mean weight we excluded from the variation line the fish specimens weighing over 17 kg.

TABLE 20.

Weight of cod of varying dimensions (in kg.).

Length in cm.									
	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70
Sea of Japan	0,16	0,37	0,67	0,81	1,24	1,66	2,18	2,78	3,50
Okhotsk Sea	0,13	0,38	0,61	0,81	1,08	1,60	2,10	2,87	3,74
Bering Sea					1,40	1,57	2,20	2,70	3,47
Barents Sea 1936, Maslov	0,18	0,29	0,51	0,75	1,02	1,33	1,67	2,11	2,58

TABLE 20 contd.

	Length in cm.									n
	70-75	75-80	80-85	85-90	90-95	95-100	100-105	105-110	110-115	
Sea of Japan	4,34	5,09	6,58	7,25	9,25	11,25	12,40		18,00	1471
Sea of Okhotsk	4,76	5,76	6,36	8,38	10,00	11,70	12,88	14,50		1645
Bering Sea	4,40	5,70	6,54							3158
Barents Sea	3,12	3,93	4,75	5,79	7,18	8,95	11,34	12,79	13,57	

Let us examine the degree of fattening of cod in different regions of Far-eastern seas (table 21).

TABLE 21.

Degree of fattening (according to Clark) of the cod from different regions of Far Eastern seas.

Region	<u>Degree of fattening</u>			Year of observation	The data provided by
	From:	To	Mean		
<u>Bering Sea:</u>					
Unimakski region	1,090	1,147	1,119	1932	Chmit
Central section of the zone	1,105	1,246	1,244	1932	"
Navarinski reg.	1,077	1,195	1,137	1932	"
Olyutorski reg.	0,930	1,283	1,117	1932	"
Eastern Kamchatka	1,110	1,290	1,171	1934-39	Polutov
Eastern Coast of Hokkaido	0,925	0,936	0,930	1938	Matsubara
Barents sea	0,80	0,90	0,85		Dementyeva

It is easy to notice that Northern fishes inhabiting the Bering Sea, eastern and western coasts of Kamchatka are best fed, while the cod near the eastern shores of Hokkaido, i.e. inhabiting the southern extremities of their propagation, are the most undernourished. The conditions under which the cod live in the northern waters, however, are hardly more favourable for the existence of this fish species. It is interesting to note that the cod from Barents Sea are rather undernourished, which depends (apart from other factors) on the exterior of these two species.

Intensiveness of feeding of the cod is rather high all the year round as may be seen in the fact that the degree of fattening of cod at different seasons (see table 22) varies but little.

TABLE 22.

Degree of fattening of the cod from Avachinski Bay (following the data provided by Polutov).

Months	1934	1935	1936	1937	1938	1939
May	1,10	1,10	1,13	-	1,14	1,33
June	1,27	1,13	1,17	1,15	1,16	1,29
July	1,16	1,14	1,13	1,12	1,15	1,29
August	1,17	1,09	1,13	1,11	1,14	1,26
September	-	1,02	1,15	1,16	1,17	-
Mean value	1,17	1,11	1,16	1,13	1,17	1,29

Thus there are but small fluctuations in the degree of fattening of cod during the warm season of the year. At the same time we wish to point out that the degree of fattening of cod over a number of years (1934-1938) also varies but very little; it was only during 1938, one in the six year-observation period that any substantial increase in the mean monthly and mean seasonal degree of fattening was noted.

Let us discuss the proportion of groups of cod of different dimensions found in the catches. Let us divide the fishes caught into the following dimensional groups:

small (less than 50 cm), medium size (from 51 to 70 cm) and large (over 71 cm in length). Near the shores of western Kamchatka as we already mentioned in the chapter on distribution and migrations, we observed a greater number of large fish in trawl catches between June and August, after which their number in the catches gradually decreased reaching minimum during the spawning period, i.e. in March (table 23).

TABLE 23.

Proportion between the number of small, medium-size and large cod specimens in trawl catches obtained near the shores of western Kamchatka in 1938-1939 (in %).

Season	Small (up to 50 cm)	Medium (51-70 cm)	Large (over 71 cm)	Number of specimens
January-Febr.	8,4	72,2	19,4	1096
March	36,0	48,3	15,7	64
June	8,2	34,9	56,9	764
August	0,6	16,7	82,8	186
October	8,7	28,2	63,1	216
December	13,0	46,9	40,1	961
Annual figure	10,2	50,0	39,8	6347

Simultaneously we observed that the percentage of large and medium size fish in the catches attained by trawl and multistage fishing net catches was relatively high. Despite the fact that in the Barents Sea the longevity of

cod and their maximum dimensions are considerably higher than in the Far Eastern waters, the catches obtained in this region by trawl usually contain medium size cod and the correlation between the number of small and medium size cod in the catches obtained by the Nurmansk trawling fleet is almost the same as in Far Eastern waters (table 24). We may assume that intensive fishing in the North of Europe reduced the number of older fish specimens in these waters while in the Far East intensive fishing occurred only in the region of Avachinski Bay where indeed cod fishing was initiated 20 years ago.

TABLE 24 .

Correlation between the small, medium size and large cod specimens in Far Eastern seas (in %).

Region	Year	Small (up to 50 cm)	Medium (51-70 cm)	Large (over 71 cm)
Bering Sea	1928-1933	2,01	27,16	70,83
Eastern Kam- chatka	1934-1948	1,97	31,04	59,99
Okhotsk Sea (Western Kam- chatka)	1938-1939	15,75	47,28	37,17
Sea of Japan	1932-1944	32,85	51,35	16,00

Table 24 .CONT.	Number of specimens	Means of fishing employed
Bering Sea	6,635	Trawl and multistage fishing net
Eastern Kamchatka	46,232	Multistage fishing net
Okhotsk Sea (Western Kamchatka)	13,029	Trawl and multistage fishing net
Sea of Japan	2,226	Trawl and multistage fishing net.

Systematic observations on the dimensions of cod in catches from Avachinski Bay conducted between 1934 and 1949 and organized by Polutov, enabled him to establish beyond doubt - the influence of the fertile and infertile generations as well as fishing on the correlations existing between groups of different dimensions and ages found in catches.

Figures in table 25 show that the make-up by dimensions of the catches that were taken over 15 years of fishing substantially changed. The specific weight of the small sexually immature cod (from 0.5-6.9 to 13.0-18%) considerably increased and percentage of the large fish (30.6-36.0 to 22.9-29.0%) dropped accordingly.

TABLE 25.

Correlations between dimensional groups of cod in the catches obtained by means of the multistage fishing net in Avachinski Bay (in %). (following Polutov).

Year	Small (below 50 cm)	Medium size (51-70 cm)	Large (71 cm and over)	M	n
1934	0,72	29,95	63,13	72,3	5768
1935	0,16	21,50	75,40	75,9	6205
1936	0,0	14,12	85,39	77,7	3902
1937	0,04	63,15	33,60	75,4	2457
1938	8,09	72,72	19,19	71,7	5390
1939	10,58	76,11	13,31	70,6	3634
1940	19,18	64,39	16,43	69,4	1578
1944	15,43	74,86	9,71	69,1	2826
1945	6,66	64,28	29,06	75,1	2250
1946	17,98	59,10	22,92	71,5	4250
1947	16,57	60,89	22,54	71,2	3550
1948	13,92	62,77	23,31	72,2	3900
1949	8,8	66,1	25,1	73,4	5090

DRAWING 8.

Dimensional composition of cod catches obtained near the southwestern shores of Kamchatka in 1934-1949.

<u>O. Sund's curves.</u>			<u>Length of the body of cod.</u>	
1934				
1935			1934	73,2
1936			1935	75,9
1937			1936	77,7
1938			1937	75,6
1939			1938	71,7
1940			1939	70,6
1941			1940	69,4
1944			1941	69,8
1945			1944	69,1
1946			1945	75,1
1947			1946	71,5
1948			1947	71,2
1949			1948	72,2
			1949	73,4
Small	medium	large		
40 60	80	100 cm	30 40 50 60 70 80 90 100 110 cm	

While analyzing the curves of Sund (fig. 8), we observed that there was but one fertile generation in fifteen years, i.e. the generation of 1934, the role of which was strongly felt throughout the entire period of 10 years. During the last few years (i.e. 1946-1948) the shoal was not even once substantially completed by young specimens.

Thus, we may consider it an established fact that the cod from Pacific Ocean show considerable fluctuations in the number of fishes forming different shoals, essentially depending on one fertile generation.

Considerable fluctuations in the number of fishes constitutes the Arctic-Norwegian shoal of cod are explained by various scientists as due primarily to the changes in conditions of spawning and development of cod fry. It is characteristic that the rather insignificant cod fishing near the shores of Norway and in Barents Sea does not affect the numbers of the fish population (disregarding the fact that the number of old fish specimens in the shoal decreases) and fluctuations in the number of fish do not depend on the intensiveness of fishing. Therefore, the compulsory cod fishing during the war (1939-1945) did not noticeably affect the number of fish specimens in the Arctic-Norwegian shoal. These observations confirm once more the exceptionally high regenerating ability of cod and the high biological resistance of this species.

Comparisons between mean dimensions of cod caught near the shores of Western Kamchatka show no substantial differences between samples obtained during different years by means of identical fishing implements (table 26). The clearly outlined differences can be seen only when comparing the fish obtained by trawl with those caught in a multistage fishing net. Catches obtained by means of identical fishing implements, particularly when the amount of material investigated is limited, show but very insignificant differences in the mean dimensions of fish.

TABLE 26.

Mean dimensions of cod from the western Kamchatka.

Date				Collecting points	Data provided by
June 1928	71,5 - 0,34	multist. fishing net	617	Kikhchik	
July 1929	73,9 - 0,67	" " "	204	Bolsheretsk	
June/July 1930	72,5 - 0,28	" " "	835	Vorovskaya	Maksimov
June/July 1931	63,3 - 1,12	Trawl	174	Khariuzovo	Krivobok Generozova.
June 1932	69,3 - 0,27	" "	422	Western Kamchatka	Polutov Suvorov
July 1933	65,7 - 0,45	" "	739	" " "	Shchetinina Moiseev
1938-1939	67,0 - 0,15		6347	" " "	Petrova

Summarizing the brief data on the length and weight of cod from Pacific Ocean, let us stress the following points:

The catches of cod from the Pacific Ocean contain 95.8% of fish specimens 45 to 95 cm in length and 1.5 to 7.0 kg. in weight. The maximum dimensions of cod are 115 cm in length and 18 kg. in weight. Thus, the cod from the Pacific Ocean do not grow to the maximum dimensions of the cod from Barents Sea (160 cm and 40 kg), although the dimensional groups prevailing in catches in both the Far East and Barents Sea are similar.

The mean dimensions of cod in the Sea of Japan are considerably lower than those of the cod inhabiting the Okhotsk and Bering seas, where dimensions of cod are almost identical. The lack of intensive fishing, small differences in the rate of growth and identical fishing implements used in these areas prove that the differences cannot be explained by these factors and the only plausible explanation is that along the Southern borders of their propagation the cod from the Pacific Ocean suffer a much higher mortality rate from natural causes and reach the maximum dimensions in considerably lesser numbers.

The fact - cod-fishing is little developed in the Far Eastern waters does not affect the number of specimens forming fish shoals and dimensional composition of the shoals.

AGE

There exists a vast Russian and foreign bibliography on the methods for determining the age and calculating the rate of development of Atlantic cod, but there are only

a few works on the cod from Pacific Ocean containing scant information on the methods for determining the age of these fish. V.E. Rozov, S.G. Generozova, M.N. Krivobok, E.K. Suvorov, M.A. Petrova-Tychkova and T.A. Polutov developed this important methodological problem. The aforementioned researchers established that while the annual rings for the first half of life, i.e. up to the age of 6-7, are clearly outlined on the scales, in older age groups it is very difficult to find these rings, and this, naturally, reduces the precision of determination. Analysis of otolithic material, however, proved the contrary, i.e. it is difficult to establish the limits of the early annual rings (particularly the first and the second), while the late annual rings are rather well outlined. Thus, it is most expedient to determine the age of the cod from Pacific Ocean simultaneously by the rings and otoliths mutually controlling the results of determination. When determining the age and rate of growth it is important to determine with absolute precision the first annual ring.

The lack of precision in the aforementioned determination resulted in that Suvorov could not consider the data on the age of cod from Pacific Ocean determined during his investigations, as well as provided by other scientists, fully trustworthy. Isolated data were insufficient to reach the final solution and the lack of fish specimens in the catches that were one year or less of age made it impossible to obtain the required initial data.

During recent years Polutov succeeded in obtaining a sufficient number of cod specimens one year of age and less near the eastern shores of Kamchatka and thus thoroughly studying the first annual ring. The fish specimens belonging to the generation of the current year that were caught in 1940 in Kronotski Bay (see table 32) were on an average 16.84 cm in length (from 10 to 27 cm) and had on an average 13.4 sclerites. The cod caught in May at the age of 1 year were 16.3 to 22.3 cm long (depending on the year when the fish were caught) and at the age of 2 - from 33 to 35 cm (depending on the year when they were caught).

Investigations have shown that the cod from Pacific Ocean has no "fry" ring; the first annual ring is formed between January and April in the fish reaching about 18 cm in length (on an average); 15 to 16 sclerites (usually 12-14) are formed on the scales of the cod during the first year.

Having counted the number of sclerites between the annular rings on the scale of the cod from the Bering Sea, we were able to draw the following table. (table 27).

TABLE 27.

Number of sclerites of the cod from Bering Sea.

Annular rings between which the number of sclerites was counted	Upto 1	1-2	2-3	3-4	4-5	5-6	6-7
Thresholds of fluctuations	5-14	5-19	4-15	3-12	3-12	4-10	4-9
Mean figure	10,0	9,8	8,9	7,2	6,4	5,8	5,3
Number of specimens examined	261	261	261	254	220	157	50

The study of the scale of fish specimens from the generation of the current and prededing years, as well as the data obtained from analysis of large fish specimens, provide sufficient basis for determing with precision the age of cod from the Pacific Ocean and estimating its rate of growth.

We wish to point out that the study of the structure of scales and otoliths in the Far Eastern cod does not enable us to distinguish different races of fish, determine whether the spawning occurs annually, the maximum age at which a given fish is capable of spawning etc, which Rollefsen (1933,1934), Kamernitsky (1939) and other researchers succeeded in establishing for Atlantic cod. It is probable that within the period of wintering coincidences within the spawning period of the cod from Pacific Ocean the fish have no spawning marks on the scales and otoliths.

The most recent research conducted by Polutov enabled him to observe slight differences in the structure of scales of the cod inhabiting the waters washing the eastern shores of Kamchatka and on the basis of these differences and of the differences in the rate of growth, he established two different forms of cod, "marble" and "rock cod." The former seems to be typical for the Pacific Ocean, while the latter is probably a specific form of cod essentially inhabiting the littoral waters.

In the Far Eastern waters the cod are mainly found

at less than ten years of age and only single species reach the age of 13-14 years. Analysis of the age composition of cod caught by trawl and on the hook (see table 28) enable us to assume that in the Bering sea, near the eastern and western shores of Kamchatka the catches essentially contain fish between four and eight years of age (86.5 to 99.6% of the entire catch). In the Sea of Japan the number of fish belonging to the younger age groups increases, a fact particularly noticeable in the southern and central regions. Thus, while near the shores of the southern and northern Sakhalin the fish of 7 and more years of age make up 45-53% of the catches near the shores of the Maritimes and in Peter the Great Bay their number decreases to 13-25% and near the shores of Hokkaido we found no fish specimen of seven or more years of age in an analysis of 593 fishes.

There are very few fish over 8 years of age in the catches. As a rule, fish of this age make up at most 10% of total. When comparing the cod from the waters washing Western Kamchatka with Murman cod (table 29), we may see that in Murman in 1927-1928 the main bulk of the catches was composed of older age groups (VI, VII and VIII and occasionally IX age groups) and the relative number of older age groups in Murman is higher than in the case of the cod from Western Kamchatka (Suvorov and Vadova, 1932).

Undoubtedly, the longevity of the cod from Pacific Ocean is less than that of the cod from the Barents Sea, where we often found the fish of 13-14 year in catches

and occasionally even of 24 years of age.

Let us compare the mean dimensions of different age groups of cod from different regions of Far Eastern waters (table 31), which have been obtained through direct measurements of fish belonging to different age categories. Rejecting the slight fluctuations that might be a result of the fact that the determinations of age were carried out by different people, we may observe that the cod from the Northern regions develop more rapidly, while the rate of growth of the cod from the southern regions is somewhat inhibited. Undoubtedly, as the author has already mentioned on a previous occasion, the cod from the Pacific Ocean are better adapted to a cold climate and are of northern origin. However, the severe conditions near the northwestern coast of Okhotsk sea are unfavorable for this fish and species of the cod found in this area show an exceptionally slow rate of growth reaching by the third year only 27 cm in length, i.e. the dimensions attained by the cod inhabiting the littoral zone of Kamchatka within the first year of life.

Prior to proceeding to the characterization of the rate of growth of cod on the basis of data of reverse calculations, let us dwell for a while on the data available on dimensions of fry and specimens belonging to the generation of the current year. There exist but relatively few data of this type as yet, however, these suffice to evaluate the rate of growth of cod fry during the first year of their existence.

Krivobok pointed out that 25 specimens of cod fry were caught on July 31, 1934, in Peter the Great Bay near the Scotch Peninsula (Russki Island) at the depth of 50 meters by means of an otter trawl (see table 30).

TABLE 28.

Age composition of the catches (in %) of cod in the Far Eastern Seas.

-111-

Region	1	2	3	4	5	6	7	8	9	10	11	12	M	n	Fishing means
<u>Bering Sea:</u>															
Anadyrski Bay, 1932			1,0	5,0	20,0	23,0	35,7	5,0	0,3				5,89	480	Trawl
Olyutorski Bay, 1931			0,4	21,5	41,9	25,8	8,7	1,7					5,26	1072	Multistage Fishing net
" " "		1,4	0,9	6,0	9,3	17,2	33,5	20,0	7,0	2,8	1,4		6,84	220	Trawl
Eastern Kamchatka 1934-1948:		0,8	5,9	13,8	27,7	26,7	14,2	6,6	2,9	1,4			5,65	2184	Multistage fishing net
Sea of Okhotsk:															
Western Kamchatka, 1938-1939		0,6	4,8	9,7	16,6	23,3	20,9	16,1	6,5	1,5			6,26	1437	Trawl
Sea of Japan		0,7	8,3	13,2	23,6	25,3	19,8	6,9	1,0	0,7	0,4		5,64	1362	"
Northern Sakhalin, 1933			19,3	4,3	12,5	10,7	25,8	23,2	3,2	0,7	0,3		6,47	270	"
S. Sakhalin, 1933	40,0	0,6	16,4	4,3	7,5	9,5	6,9	8,0	0,6	3,1	2,5	0,6	5,76	160	"
" " 1947		0,4	2,7	7,3	16,0	17,2	27,1	16,4	7,9	2,7	1,7	0,6	6,66	480	Multistage fishing net
Nelma, 1932			0,7	5,4	22,1	45,6	23,7	1,1	1,1	0,3			5,95	283	Trawl
Maritimes, 1932			5,2	22,0	26,0	34,2	11,1	1,6					5,29	195	"
Peter the Great Bay, 1932			2,5	17,5	30,0	33,0	14,0	3,0					5,47	133	"
Eastern shores of Hokkaido, 1937		3,0	28,7	43,8	22,8	1,7								593	Multistage fishing net

Forwarded

TABLE 29.

Age composition of the trawl catches of cod (in %) in Murman and Far Eastern Waters.

Region	Age			Years of observations
	To IV	V-VIII	IX and older	
Bering Sea	6,0-8,2	80,6-93,7	0,3-11,2	1931-1938
Western Kamchatka	15,1	76,9	8,0	1938-1939
Murman	3,6-9,2	63,8-74,1	33,4-41,0	1927-1928
Sea of Japan	22,2	75,8	2,0	1932-1933

TABLE 30.

Length of cod fry caught in Peter the Great Bay (following the data of Krivobok).

Length in cm.	4	5	6	7	8	9	n	M	
Number of specimens	1	2	9	10	3		25	6,98	

TABLE 31.

Mean dimensions (in mm) of different age groups of cod in the
Far Eastern waters.

Age	1	2	3	4	5	6	7	8	9	10	11	The data provide by:
Bering Sea:												
Navarinski Area.				54,3	61,4	73,1	77,9					
Olyutorski region		29,6	35,5	45,7	54,2	64,1	72,4	75,8	83,6	87,0	91,0	Following Generozova 1932
Eastern Kamchatka	18,1	30,7	41,3	49,9	57,3	63,4	68,4	73,9	78,2	82,6	87,0	Following Polutox, 1938-1945
Sea of Okhotsk:												
Western Kamchatka		31,8	37,7	46,1	55,8	67,0	75,2	83,3	91,8	94,9	102,0	Following Suvorov, 1929-1933
Ayanski region	16,1	34,4	48,0	53,4	61,2	69,0	75,6	80,6	87,0	96,6		Moiseev, 1938-1939
		20,0	27,5									Krivobok:1935.
Sea of Japan:												
Tatarskiy Strait			34,8	43,7	53,0	62,5	70,0	75,8	83,1	90,0	97,5	Krivobok, 1932-1933
Peter the Great Bay				43,3	50,5	57,2	66,0					
Eastern Coast of												
Hokkaido	15,5	38,2	49,0	53,3	56,6	64,0						Matsubara, 1939.
Barents Sea			29,2	35,1	43,5	52,8	61,9	70,9	81,0	90,9	98,5	Maslov, 1936.

TABLE 32

Dimensions of young specimens of cod (in cm) near the eastern shores of Kamchatka.

Length	2	4	6	8	10	12	14	16	18	20	22	24	26	28	n	M
June	1	218	282	59	5	1									568	6,48
July	-	446	1111	158	13	3	4	1			3	5	1		1736	6,74
December	-	---	--	--	1	7	34	39	9	-					99	16,84

TABLE 33

Length of cod fry near the South Eastern shores of Korea.

Number of months following the hatching

Length in mm	3-6	10-13	15-25	23-40	40-70	60-90	80-110	200-270
Month during which the measurements were made	XII-I	I-II	II-III	III-IV	IV-V	V-VI	VI-VII	XII-I

TABLE 34

Mean dimensions of different age groups of West-Kamchatka cod depending on the sex of a given specimen (in cm).

AGE	2	3	4	5	6	7	8	9	10	n
Males	34,6	44,3	51,7	58,9	67,2	71,9	76,8	83,9	-	659
Females	35,5	43,1	55,3	63,7	72,1	80,6	87,2	92,2	97,1	772

TABLE 35

Weight (in kg) and are from the cod from Pacific Ocean.

Age	1	2	3	4	5	6	7	8	9	10	11	n
Bering Sea weight Increment			0,80	1,60 0,80	2,62 1,02	3,45 0,83	5,30 1,85	6,80 1,50	8,65 1,85		11,5	440
Sea of Okhotsk weight increment	0,05	00,40 0,35	1,20 0,80	1,47 0,27	2,30 1,03	3,56 1,26	5,01 1,45	6,42 1,41	7,85 1,43			830
Sea of Japan " "			0,40	0,77 0,37	1,56 0,79	2,60 1,04	3,67 1,07	4,85 1,18	6,25 1,40	7,50 1,25		1246
Barents Sea " "			0,19	0,42 0,23	0,86 0,44	1,40 0,54	2,04 0,64	3,06 1,02	4,53 1,47	5,98 1,45		4997

TABLE 36

Mean dimensions and increment in weight of the cod from Pacific Ocean belonging to different age groups (according to reverse calculations).

AGE	1	2	3	4	5	6	7	8	9	10	11
Bering Sea, 1933 (Olyutorski bay): Mean length Increment	18,0	29,5 11,5	35,5 6,0	45,7 10,2	54,2 8,5	64,2 10,0	77,4 13,2	79,8 2,8	83,6 3,8	87,0 3,4	91,0 4,0
Eastern Kamchat- 1936 Mean length Increment	18,1	30,7 12,6	41,3 10,6	49,9 8,6	57,3 7,4	63,4 6,1	68,4 5,0	74,0 5,6	78,3 4,3	82,6 4,3	
Sea of Okhotsk, 1929-1933 Mean length Increment	22,8	34,6 11,8	44,8 10,2	53,4 8,6	60,8 7,4	67,7 6,9	75,1 7,4	84,0 8,9	84,10 0,1	85,5 1,4	87,5 2,0
Barents Sea, 1936 Mean length Increment	9,3	19,4 10,0	29,2 9,8	35,1 5,9	43,5 8,4	52,8 9,3	61,8 9,1	70,9 9,0	81,0 10,1	90,3 9,3	98,5 8,2

In view of the fact that the spawning period of cod in Peter the Great Bay is completed in the main by April and incubation period continues for 10 to 20 days, we may assume that the fry caught have hatched from roe about three months before that.

Polutov caught a great number of young specimens of cod near the shores of Eastern Kamchatka between June and December (table 32).

The mean dimensions of cod fry between June and July increased from 6.48 to 6.74 and by December reached 16.84 cm. Marukava (1918) reported that at the end of July 1915, he found in the stomach of a humpback salmon caught near the shores of Western Kamchatka a great number of young cod 1 to 60 cm in length. In January-February 1939 we caught in the same region young specimens of cod belonging to the generation of the current year which reached 16-17 cm in length and weighed about 45 gr.

Uchida (1934) observed near the southeastern coast of Korea that the rate of development of young cod specimens in this area was as shown in table 33.

The fry which hatched near the shores of Korea in december-January reached by June-July 8-11 cm in length and by the end of the year their dimensions fluctuated between 20 and 27cm.

The dimensions of cod fry hatched during the current year which we caught in August and September 1948 during the expedition on board the trawler "Toporok" in the South-Kuril shallow waters fluctuated within the limits of 7 and 13cm.

Direct measurements of cod hatched in the spring and during the early summer (April-June) of the current year showed that near the shore of Eastern Kamchatka the fish had an average body length of 20.8 cm, near the shores of southwestern Sakhalin - 16,8 cm and near the southeastern shores of Korea - 23.5 cm. Development of cod fry continues all the year round, though is somewhat inhibited during the winter.

Analyzing the data given it may be noted that during the first six months of their life the cod fry develop much more intensively in the northern waters as compared with the rate of growth of the current generation of cod in the South, in particular near the shores of Korea. Indeed, the cod fry which hatched in April-May near the shores of Kamchatka reached by December, i.e. at the end of 6-7 months, 16.5 in length while the mean length of young cod specimens after an identical period of time near the shores of Korea is 10 cm.

The rate of growth (table 34) up to the age of three years is almost identical for both males and females however, starting the fourth year of age, the females are noticeably larger in size than the males of corresponding age categories and in older age groups (8-9 years) they are 8-10 cm. longer.

Let us discuss the data on the annual increment in weight of cod inhabiting Far eastern waters (table 35) and compare these data with the data on Murman cod.

We observed that the annual increments in weight of the cod from Pacific Ocean increase with age.

Indeed, if we calculate the absolute and relative value of annual increment in weight, we shall see that while the annual increment in weight of the cod below four years of age constitutes 270-800 gr, in specimens over five years of age the increment reaches 1 kg. and more in most cases and in the cod 8-10 years old the annual increments reach 1.5 kg. Thus, the cod from the Pacific Ocean belong to the fish where the annual increments in weight progressively grows throughout their entire life.

Simultaneously we noticed that cod from the Bering sea gain weight most intensively and the cod from the sea of Japan most slowly. Undoubtedly, the cod find the most favourable conditions for their existence in the Bering Sea.

The mean weight of corresponding age groups and the annual increment in weight of cod from the Barents sea are considerably lower than those of cod from the Pacific Ocean, including the slowly developing cod from the Sea of Japan.

These differences are particularly well pronounced during the first seven years of life, when the annual increments in weight are, as a rule, half as great as those observed in the Far-eastern waters.

The table showing the annual growth of body of cod from the Pacific Ocean (table 36) enabled us to establish that cod grow during their entire life, though at a gradually decreasing rate, and it is difficult to determine the age at which the rate of development becomes inhibited, as occurs in the majority of fish species.

It is possible that fluctuations in the age at which different specimens of cod attain sexual maturity (these differences may be of several years) is responsible for the fact that in mixed material the reduction in the rate of growth connected with the sexual maturity levels off.

The lack of any intensive fishing on cod in the Far Eastern waters makes it impossible to study over a number of years the fluctuations in the age composition of a school and evaluate the number of cod specimens in different generations. Only the data collected by Polutov on the age composition and rate of development of cod obtained during fishing by means of the multistage fishing nets in Avachinski Bay between 1934 and 1949 enabled him to deduct a number of conclusions to maintain that there exist clearly-marked fertile and infertile generations. Thus, in particular, he observed that the generation hatched in 1944 was extremely powerful and prevailed in the catches of 1947 and 1948. Simultaneously, he observed considerable differences in the rate of growth of cod belonging to different generations.

Summarizing the data exposed in the chapter on age, we may arrive at the following conclusions:

Fish specimens between 5 and 8 years of age prevail in the catches obtained in the Far Eastern waters by means of trawls and on the hook. There are but few (2-11 %) older specimens. The maximum age of the cod from the Pacific Ocean is 13-15 years

The rate of growth of cod is the most intensive during the first few years of the life of these fish and gradually slows down with age. The annual linear increment regularly diminishes with age but continues into the oldest age groups.

The rate of growth of cod is similar in all the Far-eastern seas with the exception of a few regions. The cod from the Pacific Ocean develop considerably more rapidly than those from Murman waters, particularly during the first years of their life.

Changes in the age composition of a shoal and fluctuations in the rate of growth are observed in the cod from the Pacific Ocean in connections with the changes in conditions of existence, first of all, the thermic indices. We observed that near the shores of Eastern Kamchatka relatively warm years produce more fertile generations than cold years.

X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X

The sex composition of the catches of cod (obtained either by trawl or on the hook) is similar for all the Far Eastern Seas (table 37).

TABLE 37.

Sex composition of the catches of cod from different zones of the Far Eastern waters.

Region	Bering Sea		Kamchatka			Sea of Japan		
	Anastasi Gulf	Olyutorski Bay	Kara- ginski Island.	Eastern	Western	Eastern Hokkaido	Northern Maritimes	Peter the Great Bay.
Samtsov in %	46,6	57,3	46,0	51,8	46,7	50,4	50,5	52,6

The proportion of fishes of different sex is almost equal in all the zones of Far Eastern waters and shows no well pronounced prevalence of one sex over the other. Exceptions to this general rule, for example, in Olyutorski Bay) can be attributed first of all to the limited number of specimens examined. Females prevail in the majority of regions, however, this is chiefly due to the fact that the catches contained in the main large and medium size specimens of fish, and females are usually larger than males. There have been observed certain fluctuations in the sex composition of cod catches dependent on the season, however, these fluctuations were irregular in character.

The difference in sex composition over a number of years is also rather negligible (see tables 38 and 39).

TABLE 38

Sex composition of cod catches (the percentage of males) by months.

Region	January	February	March	April	May	June	July	August	September	October	November	December	Mean Figure	Author
Eastern Kamchatka						51,5	48,5	49,0	49,1				49,5	Polutov 1944-1948
Western Kamchatka	47,0	-	53,0	-	-	46,9	46,1	41,9	-	50,9	-	52,7	46,7	Moiseev 1938-1939
Northern Maritimes.				48,0	47,8	-	43,5	55,7	57,5				50,5	Krivobok 1932-1933

TABLE 39.

Sex composition of cod catches (% of males) near the shores of Kamchatka.

Region	1929	1930	1931	1933	1934	1935	1936	1937	1938	1939	
Eastern Kamchatka	--	--	--	--	51,9	51,3	55,0	51,4	53,0	53,6	
Western Kamchatka	50,5	48,0	41,4	47,4	--	--	--	--	--	47,6	
	1940	1944	1945	1946	1947	1948	Mean fig.	Author			
Eastern Kamchatka	52,6	50,2	53,0	49,9	50,5	49,3	51,8	Polutov.			
Western Kamchatka	--	--	--	--	--	--	47,8	Suvorov, Moiseev.			

At the same time, however, the relation between the sex of cod specimens and the length of the fish clearly indicate that there are definite rules governing prevalence of fish of one sex over fish of the opposite sex as the linear dimensions of cod increase (table 40).

Males somewhat exceed females among the cod under 45cm in length; the number of fish specimens of both sexes is more or less the same among the fish between 45 and 70 cm in length; the percentage of females among the fish over 70 cm rapidly increases; from 85 cm upwards this prevalence becomes multifold and we found no males among the 18 fish specimens over 100cm in length examined.

It is particularly interesting to establish the age of cod at which sexual maturity occurs, since in large cod specimens which, to judge by their dimensions had long since achieved sexual maturity were found to have very little developed sexual products, whereas other specimens of similar or even smaller dimensions had sexual products at a much higher stage of development. We later established numerous cases where the fish of a length and age fully sufficient to be considered as sexually mature contained underdeveloped sexual products. Table 41 shows the data on cod inhabiting the waters washing Western Kamchatka for the period of time between December-March when it was possible to precisely determine whether the fish are ready to spawn during the current year.

TABLE 40.

Sex composition of cod of varying dimensions from the waters washing the Western Kamchatka (in %) in 1938-1939.

Length in cm.	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Males	56,7	50,2	51,4	44,0	49,1	47,8	53,6	50,0	43,3	48,0	44,2	30,9	20,8	5,3	
Females	43,3	49,8	48,6	56,0	50,9	52,2	46,4	50,0	56,7	52,0	55,8	69,1	79,2	94,7	

	100	105	110	n
Males	-	--	--	3019
Females	100,0	100,0		3442

TABLE 41.

Dimensions of the spawning and non-spawning cod-specimens during the current year near the shores of Western Kamchatka
(December 2, 1938 - March 11, 1939).

Length in cm.	Sex	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100	100-105	n
Non-spawning	♂	2	19	39	58	88	111	129	93	26	4						571
	♀	2	20	31	52	80	97	121	129	62	14	5					633
Spawning	♂					1	8	36	58	47	38	23	18	11	1		241
	♀						4	8	25	53	41	31	36	34	16	2	250
Total	♂	4	39	70	110	169	220	294	305	188	97	59	54	45	17	2	1695
Non-spawning in %.		100	100	100	100	99,6	94,5	85,4	72,8	46,8	18,6	8,5	0	0	0	0	

The above data (obtained by examining 1965 fish specimens) enable us to conclude that variation lines for the lengths of spawning and non-spawning fish considerably overlap. Indeed, while we found specimens up to 85cm in length among the fish that will not spawn during the current year, the minimum dimensions of spawning fish sink as low as 50cm.

We observed examples where a male 50.5 cm. in length and 1600 gr. in weight reached the III stage of sexual maturity in October, i.e. was undoubtedly prepared to spawn. Moreover, though the four lines do not coincide, they are undoubtedly in direct proximity. Thus, the modulus for males that are not ready for spawning during the current year is situated in the class interval between 60 and 65 cm and that of spawning males - between 65 and 70 cm. In the case of females the coincidence is 65-70cm and 70-75cm respectively.

The cod inhabiting the coastal waters of Western Kamchatka achieve sexual maturity at the age of five years. Polutov believes that near the Eastern shores of Kamchatka certain specimens of cod begin spawning at the age of three. However, the majority of fish species become sexually mature considerably later.

TABLE 42.

Sexual maturity of cod inhabiting the littoral waters of Western Kamchatka in 1938-1939 (in %).

Readiness to spawn	AGE									
	2	3	4	5	6	7	8	9	10	
Not spawning during the current year	100	100	99,9	69,5	51,2	36,2	25,2	14,5	-	
Spawning during the current year	-	-	0,1	30,5	48,8	63,8	74,8	85,5	100	
Number of specimens	55	54	79	141	176	185	131	55	14	

Table 42 shows the composite data on the age and degree of readiness to spawn the cod caught between October 1938 and March 1939. The cod from Kamchatka waters achieve sexual maturity, at a surprisingly slow rate. In certain fish specimens it occurs at the age of 10 years. We found in the catches certain specimens 80 cm in length weighing 8,5 kg, which had reached the age of nine, but were not ready to spawn.

Similar is the picture observed near the Western coast of Sakhalin. (Kulichenko and Frolov) and Eastern shores of Kamchatka (Polutov, 1948). Polutov presented a number of data on the measurements of cod caught in Kronotsky Bay in December 1940, where he separated the measurements of fish spawning during the coming season and of the non-spawning fish. It was found that among the 390 fish specimens examined 123 (or 31.5%) were unprepared for spawning. Among the latter there were fishes up to 80 cm in length, while certain specimens 55-60 cm in length were ready for spawning.

Kulichenko and Frolov examined 177 specimens of cod caught between February and April 1947 near the shores of Southwestern Sakhalin and established that 113 fishes among them were not ready for spawning, although 30 of these fishes were at the age of 6 to 8 years. At the same time, however, this group contained specimens 57 cm in length with fully developed sexual products ready for spawning.

The earliest age at which the fish reach sexual maturity is five years and only a few specimens are sexually mature at this age; each year the fish belonging

to the older categories begin spawning in a progressively higher number and from then on all the fish spawn annually. However, undoubtedly, the fertility of the cod from Pacific Ocean is rather low as a result of the prolonged period (5 years) of sexual development in different specimens of the same school.

Let us point out that only a small percentage of Atlantic cod (Arctic-Norwegian shoal) attain sexual maturity at the age of six and the majority of fish of this species begin spawning only at the age of 10-11 years (Rollefsen, 1934).

The sexual glands of found cod in Far-eastern seas during the warm season (June-October) were in the state of rest, little developed, with a small volume and low weight of the sexual products, at the II and III stage of maturity.

We observed most thoroughly and over the course of an entire year the process of maturation of the sexual products of cod inhabiting the waters near the shores of Western Kamchatka. The following table 43 has been drawn on the basis of analysis of the sexually mature fish caught in 1938-1939.

TABLE 43.

-129-

Stages of the sexual maturity of cod found near the shores of Western Kamchatka in 1938-1939 (in %).

Date	Stages of the sexual maturity.										Number of determinations
	II	II-III	III	III-IV	IV	IV-V	V	V-VI	VI	VI-II	In %
July-August 1939	57,4	41,0	-	1,6	-	-	-	-	-	-	100,0
Oct-December 1938	-	1,0	98,8	0,2	-	-	-	-	-	-	100,0
Jan-Febr. 1939	-	-	1,7	9,2	39,2	49,8	-	-	-	-	100,0
March 1939	-	-	-	-	-	30,7	39,7	15,4	23,2	-	100,0
June 1939	84,3	-	-	-	-	-	-	-	-	15,7	100,0
											947

In June we may clearly see the effect of spawning recently completed (15.7% of VI and VI-II stages of maturity). Between July and December the sexual glands of the cod gradually increase in volume and reach the II-III and III stage of maturity. The winter season (January-February) is marked by intensive development of sexual products; the main bulk of fish achieve the IV and IV-V stages of sexual maturity, i.e. near spawning. And lastly, the last winter month, i.e. March-the effects of the early half of which we thoroughly investigated, marks the beginning of the spawning of cod from Western Kamchatka. By this time almost all the cod specimens had sexual products at the prespawning stages of maturity, i.e. IV and V-VI, and certain fishes had fluid sexual products.

The spawning of cod near the shores of Western Kamchatka begins in the early half of March and acquires a mass character during the latter half of the month.

Observations by Kulichenko enable us to analyse the process of development of the sexual products of cod near the Western shores of Sakhalin (table 44).

TABLES 44.

Stages of the sexual maturity of the cod near the shores of Western Sakhalin in 1947 (in %).

Month	Stages of the sexual maturity of cod.					
	II	III	IV	IV-V	V	VI
February	73,9	-	-	8,6	13,7	3,8
March	66,6	-	-	-	-	33,4
April	40,4	-	-	3,5	8,6	47,3
May	91,8	-	-	-	-	8,2
June	100,0	-	-	-	-	-
July	65,2	34,8	-	-	-	-
August	39,3	45,4	15,3	-	-	-
October	49,4	41,6	9,0	-	-	-

We observe that the correlation between the number of fish specimens at different stages of sexual maturity in the cod of Sakhalin waters is similar to that for Kamchatka waters, however, the preparations for spawning begin somewhat earlier. Thus, in August we observed a considerable number of cod (up to 15%) with sexual products at the IV stage of maturity. The high percentage of fish at the second stage of maturity in February-March can be attributed, as we shall see further on, to prevalence in catches of the fish that

do not spawn during the current year.

We conducted no lengthy observations on the state of the sexual products of cod in other regions and the data for May-September confirm the aforementioned assumption that the majority of cod are at that period of time at the II and III stage of sexual maturity. Thus, Krivobok found in May among the 632 specimens of cod caught near the shores of Maritimes in May-September 1933, only 6 specimens of fish at the VI stage of maturity, while the remaining fish had sexual products in the II and III stage.

In a few cases we caught single specimens of cod near the shores of Kamchatka which had no mature sexual products in June, July and even August (Marukava, 1918), however, these cases are exceptional.

The entire roe ripens simultaneously and is simultaneously (not portion-wise) released during the spawning. We observed no underdeveloped roe particles. The transition from the IV-V to the V stage occurs in females very rapidly.

The simultaneous spawning that is characteristic of the cod from Pacific Ocean shows that it is adapted to the hydrological conditions with sharply pronounced seasonal changes and a relatively long season unfavorable to the life of cod.

In this respect the cod from Pacific Ocean substantially differ from Atlantic cod, which, as is well known, are characterized by repeated seasonal spawning of roe portion, (Dryagin, 1949), which is probably conditioned by the relatively stable hydrological conditions in this zone all the year round.

The development of spermic vessels occurs portionwise and at a slower rate than maturation of ovaries. In males with soft roe only the parts of the spermic vessels situated in the proximity of annus were mature, while the remaining parts of the spermic vessels were still underdeveloped.

As we shall see below, an analogous phenomenon was observed in flounders and (as it was proved by Dryagin) other fish species. We think that simultaneous maturation and spawning of roe characteristic of the cod from Pacific Ocean, while the milt ripens and is released by portions, is one of the means of adaptation of this species ensuring successful reproduction and enabling a relatively small number of males to fecundate the roe spawned by a greater number of female fish. Moreover, the long period during which the males are ready for spawning ensures that the roe spawn by a number of females, whose roe develops within shorter periods of time, becomes fecundated.

We wish to point out that the rapid increase in volume of the spermic vessels, which fill the entire cavity of the body at the III-V stages doubtless complicated the feeding of cod since the gut of fish expands very little while receiving the food. In females, however, the volume of ovaries is relatively small and it is probable that in this respect the process of feeding during the prespawning period is not complicated. These visual observations have been confirmed by the results of the development of data on the feeding of cod (Logvinovich, 1948), which showed that in cod at the

III and IV stages of maturity the degree to which the guts of male fish are filled is half quarter that of females and only at the V stage of maturity the intensiveness of feeding of the female fish sharply drops and the feeding almost ceases.

With regard to the data on changes occurring in the stages of maturity of sexual products in the course of the year, it seems expedient to present certain figures characterizing the seasonal changes in the weight of the sexual products of cod (table 45).

Sexual products of males reach their maximum weight in December constituting 26% of the total weight of fish (with small fluctuations in specimens of varying length, but with considerable fluctuations in the absolute figures - from 850 to 2600 gr.). In January-March we did not observe in the cod inhabiting Kamchatka waters any increase in the relative weight of sexual products and their weight remained stable showing a slight tendency to decrease.

The weight of the sexual products of females reaches in December 6-11% (320-1300 gr) of the entire weight of the fish, progressively increased in January-March and reaches 11-20% (590-2550 gr) of the total weight of fish. In males, as well as in females, fluctuations in the absolute weight of the sexual products depending on the length of the fish are considerable, however, interpolated when expressed through relative figures.

By June, according to our data (and in reality immediately after the spawning, i.e. in April-May), the weight of the sexual products, or rather of the

sexual organs drops to an insignificant figure, i.e. 1.3-3.0% (60-300 gr.).

It is natural that in connection with the increase in weight of the sexual products the weight of fish specimens of identical dimensions also increases throughout the year (table 46).

The mean weight of cod 75 to 79.9 cm in length continuously grows from July to March increasing by 0.38 kg and sharply drops following the spawning decreasing by June by 0,75 kg.

TABLE 45.

Weight of the sexual products (coefficient of maturity) of the cod from Western Kamchatka (in % to total the weight).

Month	LENGTH IN CM.					
	60	70	80	90	100	110
December o	21,0	25,6-26,1	23,8	22,2-23,9	-	-
o	-	5,9	6,9	7,6-11,1	-	-
January o	-	23,5	-	-	-	-
o	-	11,0-17,1	-	-	-	-
March o	14,8	10,9-21,9	20,5	-	-	-
o	13,4	11,5-15,7	14,5-18,3	20,2	18,7	-
June o	-	1,3-1,7	-	-	-	-
o	-	1,6-3,0	2,7-3,7	1,6-3,0	-	-

Sexual products of males reach their maximum weight as early as December constituting 26% of the entire weight of the fish (with slight fluctuations in relative values for the fish specimens of varying length, but with considerable fluctuations in absolute figures - from 850 to 2600 gr). In January-March we observed no increase in weight of the sexual products in cod inhabiting the waters washing

Kamchatka and their weight remained almost stable showing a slight tendency to decrease.

The weight of the sexual products of females reaches 6-11% (320-1300 gr) of the total weight of the fish in December, continued to increase in January-March and reached 11-20% (590-2550 gr) of the weight of the fish. In males, as well as in females, fluctuations in absolute figures of the weight of the sexual products depending on the length are considerable, however interpolated when expressed through relative figures.

By June, according to our data (and in reality directly following the spawning, i.e. in April-May) the weight of the sexual products or to be more precise, of the sexual organs, dropped to insignificant values: $1.3 \pm 3.0\%$ (i.e. 60-300 gr).

It is natural that while the weight of the sexual products increases the total weight of the fish specimens of a given length also increases throughout the year (table 46).

The mean weight of cod 75-79.9 in length continuously grows from July to March, increasing by 0,38 kg, then sharply drops following the spawning decreasing by 0.75 kg. in June.

TABLE 46.

TABLE 46.

Mean weight of cod from the Western Kamchatka 75 to 79.9
cm. in length (in kg.).

Season	Mean weight	Number of specimens
July-August	5.75	64
October-December	6.11	58
January-March	6.13	36
June	5.38	56

Changes in the weight of the sexual products of cod
throughout the year near the shores of Western Sakhalin
(Kulichenko) expressed through coefficient of
maturity (table 47) confirms the above presented
scheme.

TABLE 47.

Weight of the sexual products of cod (coefficient of maturity) caught in Western Sakhalin waters in % to the total weight).

Sex	Febr.	March	April	May	June	July	Aug.	September	October
Males	14.8	-	6.9	0.64	1.05	1.73	2.16	-	5.7
Females	16.1	-	9.1	1.35	1.78	2.39	2.28	-	2.6

The high coefficients of maturity attained in February and, of course, March, are followed by rapidly dropping indices reaching the minimum figures in May. The lengthy period of rest (May-October) is characterized by the exceptionally slow increment in weight of the sexual products and only at the end of this period (October) the sexual products of the males noticeably increase in weight. It is somewhat surprising to note that the indices of the coefficient of maturity of males and females in this region differ but little, while this difference is well pronounced in Kamchatka cod.

It is interesting to observe the regularities of changes in the degree of fattening and coefficient of maturity occurring in cod in this course of a year, as well as the interrelation between the two. We might have assumed that in cod, as in the majority of other fish, the lengthy post-spawning summer period must be accompanied by intensive feeding in order to restore the substantial losses that occur in different parts of fish body during the development of sexual products, as well as to prepare the fish for the new spawning period.

TABLE 48.

Filling of guts, indices of the general fattening up, oil content in liver vitamin A and indices on the degree of maturity of cod from Western Sakhalin waters as observed in 1947-1948.

	January	February	March	April	May	June
The degree to which the guts are filled.		81.5	168.3	224.0	190.5	110.0
Index of the general fattening up.	4.0	3.1	3.5	3.7	4.9	5.3
Oil content of liver	39.5	25.0	27.0	37.7	41.2	55.4
Vitamin A content						
large cod	-	-	-	5050	2350	1480
Medium size cod	-	-	-	3390	1640	1060
Index of maturity ♂	-	14.8	-	6.9	0.64	1.05
♀	-	16.1	-	9.1	1.35	1.78

TABLE 48.

Ctd.

	July	August	Sept. ember	October ber	Novem- ber	December
The degree to which the guts are filled.	60.0	60.9	106.0	157.5	29.0(?)	
Index of the general fattening up.	5.8	5.6	5.2	5.0	4.8	5.4
Oil content of liver.	57.8	55.6	54.6	51.7	45.6	46.3
Vitamin A content						
large cod	1330	1550	240(?)			
medium size cod	930	810	200(?)			
Index of maturity.	1.73 2.39	216 228		5.7 2.6		

Average: Index of gen. etc. 5.0; oil ct liver 47,2; lrgc cd 1850-1250

Using the data of Khlupova (1950) and Kulichenko, let us draw a series of tables and schemes graphically presenting the dependence between the degree of maturity of sexual products (expressed through the index of maturity), general fattening up (in % of the weight of fish liver to the overall weight of the fish), fattening of the liver (expressed in % of the oil contents), content of vitamin A (in international units per one gram of liver oil) and index of the filling of guts (table 48).

The lowest indices of overall fattening up and oil content in the liver were recorded in February-March (fig. 9), i.e. at the period when the degree of maturity of sexual products is the highest (spawning period) and the intensiveness of feeding is low.

The end of spawning is accompanied by sharp intensification in feeding (which partly occurs in March) and gradual increase in the weight of liver and its oil content, which reach the highest steady indices in June-July. Intensiveness of feeding during this period noticeably decreases which may be due to the transition from voluminous food objects on which the cod liver during the spring (herring) to disperses objects (such as crabs, flounders etc) as well as to the fact that by this time the organism has restored reserves which have been used up during the preparation for spawning.

DRAWING 9.

Seasonal changes in the degree of filling of the guts, indices of maturity and fattening of cod inhabiting the waters near the Southwestern shores of Sakhalin (1947).

During the fall, i.e. in September-October, begins the period of more intensive development of sexual products and result in the intensification of feeding and simultaneously causes the weight of liver and its oil content to decrease, i.e. the period during which

The reserves accumulated during the summer are consumed. The content of vitamin A in the liver oil noticeable decreases while the content of oil in the liver increases which is a process analogous to the "liquifaction" of the slightly varying quantity of vitamins in a greater volume of oil. A similar increase in the weight of liver between March and June also occurs in cod inhabiting the waters washing the shores of Kamchatka (table 49).

The low weight of liver in cod below 70 cm in length caught in March as compared with the specimens caught in June attracted our attention. Logvinovich (1948) showed that small cod feed in January and February considerably less intensively than do large cod (the total index of filling is 78 and 193 respectively).

At the same time, however, starting from March, the intensiveness of feeding of the large cod drops because of the beginning of the spawning period and small cod specimen feed more intensively).

Thus, the large cod is the best-fed during the autumn and winter and the small cod-during the summer and autumn season. Similar fluctuations in the degree of fattening of cod according to different seasons have been observed in the Barents Sea (Maslov 1944).

TABLE 49.

Degree of fattening up of the West Kamchatka cod.

Length in cm,	40	50	60	70	80	90	100	110	n
March 1939									
Mean weight of cod liver in gr.	22	60	131	303	312	383	730		64
Weight of the liver in % to the overall weight of the fish	2.0	3.2	4.2	5.5	4.2	3.7	5.3		
June 1939									
Mean weight of the liver in gr.	80	93	223	284	325	380	500		77
Weight of the Liver in % to the weight of the fish	6.4	4.6	6.3	5.8	4.4	4.2	4.3		

Let us summarize all the data available on the fertility
of cod from Pacific Ocean in table 50.

TABLE 50.

Fertility of the cod from Pacific Ocean.

Region	Dimensions of the fish		No. of Fish specms	Fertility in thousands.		The data provided by:
	Length in cm	Weight in kg.		Thresholds of fluct.	Mean figure.	
Western and south-eastern Kamchatka, 1939.	68	4.4	1	-	1800	Moiseev.
	70-76	5.73	5	1425-2814	2351	
	83-88	8.88	2	2288-3822	3055	
	92	10.40	1	-	5284	
	100	13.65	1	-	5722	
Western shores of Sakhalin 1947	63-67	2,35-3.6	7	1458-2460	1986	Kulichenko and Frolov.
	73-76	4.0-5.0	3	2962-3602	3265	
	82	6.83	1	-	4745	
	93-51	8.2	1	-	6361	
Eastern shores of Hokkaido	60-90			1500-3000		Uchida Keitaro
Western Kamchatka 1916	76		1	-	1722	Marukava
	80		1	-	2578	
Japan (peninsula Noto, Isikava)				to 5000		Kamiya

On the basis of the relatively few data available on the fertility of cod from the Pacific Ocean we may conclude that individual fertility of cod fluctuates within the limits of 1425 thousands and 6361 thousands of eggs. This wide range of individual fertility depends first of all on the dimensions of fish and regions inhabited by the fish. Table 51 clearly shows that the quantity of roe produced directly depends on the dimensions of a given fish specimen.

TABLE 51.

Dependence between the fertility of cod from the Western Kamchatka and length of the fish.

Length of fish in cm.	60	70	80	90	100	110
Mean weight of fish in gr.	4400	5730	8875	10.400	13.650	
Mean weight of the ovary in gr.	590	752	1425	2.100	2.550	
Mean number of eggs per 1 gr.	3066	3007	2177	2.516	2.244	
Mean number of eggs contained in the ovary (in thousands)	1809	2351	3055	5.284	5.722	

It may be easily seen that the increase in size of the fish the dimensions of eggs also increase, and this affects the number of eggs contained in lgr of roe, however, the rapid increase in the overall weight of the sexual products ensures higher fertility of large fishes.

If we estimate the relative fertility of cod and compare the data obtained for the fish of varying dimensions, we may notice that at certain fluctuations in these figures the cod of varying dimensions produces per a unit of its weight a more or less equal number of eggs (table 52).

However, the relative fertility of cod inhabiting the littoral waters of southwestern Sakhalin is considerably higher (1.5-2 times) than that of Kamchatka cod.

TABLE 52.

Relative fertility of cod (in thousands of eggs per lkg. of weight).

Region	Length in cm.					Number of fish specimens
	60	70	80	90	100	110
Western Kamchatka.	411	410	357	508	421	10
Western Sakhalin.	662	725	700	763	-	12

It is possible that the high fertility, and, consequently, the finer roe of the cod from Sakhalin waters as compared with the cod from Kamchatka littoral waters, which confirms the general rule that (Rass, 1941) the size of eggs increases in the Northern section of the area inhabited by cod, a fact which can be explained as resulting from defence of the species against the more intensive predatory animals and fish and less favourable living conditions (more rapid currents, limited surface areas of shelf) in the Southern regions of Far Eastern seas.

By comparing the morphological characteristics of the cod from Pacific Ocean (Petrova-Tychkova, 1948) we succeeded in revealing the substantial differences in the number of vertebrae and rays in the dorsal fins of cod from different regions of the Far Eastern seas. We established beyond any doubt that the cod inhabiting the waters near the shores of Kamchatka, in Tatarski straight, near the northwestern coast of Okhotsk sea, near the Eastern shores of Hokkaido

and in Peter the Great Bay differ morphologically.

It is characteristic that in the Northwestern section of Pacific Ocean, as well as in the Northern part of Atlantic Ocean, the number of vertebrae in cod depends on thermic conditions of the region inhabited by these fish and varies according to definite rules. I. Schmidt (1930) showed on the basis of a vast data material (obtained through analysis of about 20000 specimens of cod) that in the Atlantic Ocean the regions with low temperatures are inhabited by cod with a greater number of vertebrae; when moving from the North towards the South the temperatures become progressively higher, while the number of vertebrae in cod gradually decreases. In the Far-Eastern waters the presence of cold water regions (even when such are situated in low latitudes) somewhat disturbs the regularity and the gradual decrease in the number of vertebrae of the cod populating the southern waters of this region and is not as clearly apparent and uniform as in Northern areas. However, taking into account the thermic conditions of the region, we shall see that in Far Eastern waters the coldest regions (disregarding the latitude at which they are situated) are also inhabited by the cod with a maximum number of vertebrae and the warmest areas are characterized by a minimum number of vertebrae.

Thus, in the coldest northwestern part of Okhotsk sea the cod have the highest number of vertebrae (54.9), in the Northwestern part of Bering sea, near the shores of Kamchatka and Sakhalin the number of vertebrae decreases (53.0-53.8), in Peter the Great Bay it reaches the lowest figure, i.e. 52-46.

We are unable to complete this picture by figures on the most southern school of cod in view of the lack of data on the number of vertebrae in cod inhabiting the littoral waters of Korea and Hokkaido.

The fertility of cod from Pacific Ocean is considerably higher than that of corresponding dimensional groups of Atlantic cod. However, if we take into consideration that the number of fishes over 100cm in length is much higher in Atlantic Ocean than in Pacific waters and the fertility of large specimens reaches 9300 eggs, we shall see that in view of the high fertility of large cod the Atlantic school is potentially more productive than the school of cod from the Pacific Ocean.

The presence of a great number of different local schools of cod in the Far Eastern waters accounts for the existence of respectively numerous spawning regions.

The spawning of cod, which takes place during the winter, i.e. the season unfavourable for navigation, has not been sufficiently studied as yet.

Investigations conducted by a few researchs enable us to affirm, however, that the spawning of cod from the Pacific Ocean occurs between Anadyrski Bay and Yellow Seas. Thus, the cod with inflamed sexual glands (which is a proof of the recently completed spawning) drift in May in great numbers to the Southwestern section of Anadyrski Bay (1929-1933).

Grebnitsky (1897) indicated that near Kommandor Islands the spawning occurs between January and March; however, at the end of May, 1932, Schimt (1933) still found in his area fish specimens with liquid sexual products. During the winter 1941-1942 Polutov observed spawning of cod in the central section of Kronotski Bay. Early March 1939. Moiseev (1940) found spawning cod near the southwestern extremity of Kamchatka and near its western shores. Marukava (1918) believes that the spawning of cod takes place near the western shores of Kamchatka "several months before July".

Spawning of cod also occurs near the Southern Kuril Islands in December-February. Inaba (1931) indicated that the spawning in Mutsu Bay, i.e. near the eastern coast of Hokkaido, takes place in December-January. Kamiya (1916) thinks that the cod inhabiting the waters near Hokuriku (Japan) spawn between December and February. Vada affirms that the cod near the shores of Japan multiply between January and March. Near the shores of Western Sakhalin (as observed by Kulichenko) the cod spawns mainly in February. Along the northern coast of Maritimes Krivobok observed spawning in March and April, and in Peter the Great Bay- in February and March. Along the southeastern shores of Korea (according to the data of Uchida 1936), the spawning occurs at the end of December and in January, inclusively. Near the shores of Alaska the spawning takes place in January and February (Kobb, 1927).

We wish to add that in certain cases the spawning of individual specimens is delayed. Thus Marukava (1918) caught on August 3-4, 1916, near the shores of Western Kamchatka two female cod with liquid sexual products. Fortunatov observed in the middle of September, 1932, in Kamchatka Bay several male and female specimens with liquid sexual products (he assumed, however, that these specimens belong to a special coastal form of cod). Such examples can be easily cited in a great number. The data exposed above cannot be considered complete with regard to the regions of Far Eastern waters where the spawning of cod takes place, however, this information suffices to show that the spawning regions of cod from Pacific Ocean are rather dispersed. We do not mention here the spawning regions in the south-eastern part of the Bering Sea (Kobb, 1927) and along the shores of Alaska and Canada, since these areas are inhabited by an independent school of the cod from Pacific Ocean.

The periods of spawning and the spawning regions are well coordinated with the water temperature. During the spawning the cod avoid temperatures below 0° , as well as excessively high temperatures (above 10°).

Therefore, in the northern regions with cold waters - i.e. Bering and Okhotsk seas, the spawning of cod takes place in February-April at a certain distance from the shores (up to 25-30 miles), at a depth of 100-290 meters.

Thermic conditions of spawning regions are characterized by temperatures above 0° in pre-benthic horizons.

Near the shores of Western Sakhalin, Northern Maritimes and in Peter the Great Bay the cod drift for spawning from the wintering regions (150-250 meters) to the shore, where the depths are somewhat lesser (60-120 meters).

Near the shores of Japan and south-eastern Korea, the prespawning migration towards shores, to the zone with somewhat cooler waters, occurs on a considerably larger scale.

The spawning cod drift in December to the littoral zone of Ickikawa reaching the most insignificant depths (20-30. m) where the roe is laid.

Near the southeastern coast of Korea, in the region of Chinkay Bay, the cod begin drifting to the shores in the middle of November. The spawning starts in January, however, it can be delayed if the temperature drops more slowly than usual.

It is interesting to note that near the shores of Korea the small and medium size cod specimens are the first to migrate for spawning to the shallow water regions (66-72 cm), after which, as the coastal waters grow progressively cooler, the large specimens of cod begin approaching the shores (up to 90 cm).

Thus, in the northern (north-boreal) regions, where the littoral waters drop to very low temperatures (below 0°) during the winter, the cod leave the shores and drift away to considerable depths in the wintering regions.

The spawning occurs precisely in these regions. Here the cod spawn in spring. In intermediate regions (the south-Western Sakhalin) the cod approach the shores during the spawning period. Lastly, in the regions with the warmest temperatures (south-boreal regions), i.e. the coastal waters of Japan and Korea, where the cod remain at greater depths (up to 200 and more meters) during the summer, with a drop in temperature in the coastal zone the cod proceed for spawning directly to the shore line reaching the most insignificant depths, where the drop in temperature is most considerable. Thus, these cod spawn during the winter.

TABLE 53.

Spawning period and spawning conditions of cod populating the Far Eastern waters.

Spawning regions	Spawning periods			Depths in the spawning regions.	Observations conducted by:
	Beginning	Climax	End		
Anadyrski Bay	?	?	April		
Olyutorski Bay	?	?	May		Shmit
Kommandor Islands	January	Febr/Mr.	May		Grebnitsky, Shmit
Kronotski Bay	January	Febr.	March	175-225	Polutov
Southeastern Kamchatka	March	April	March	140-290	Moiseev
Western Kamchatka	March	April	May	160-190	Moiseev
Western Sakhalin	January	Febr.	March	80-120	Kulichenko
Peter the Great Bay	Febr.	March	April	100-150	Krivobok
Southeastern coast of Korea	December	January	January		Uchida
Southeastern coast of Hokkaido	December	January	February	20-30	Kamiya.

The large area inhabited by cod, which is a fish species' essentially found in cold boreal waters and populating regions of varying thermic conditions, accounts for the differences in behaviour of this fish during the spawning period in different sections on the Far Western seas.

The spawning of cod from the Pacific Ocean occurs in the pre-benthic horizons, not on the ocean floor proper.

There are few data on the roe of cod from the Pacific Ocean, its embryonic and post-embryonic development but even these data are contradictory.

Marukava (1918) believed that the roe of cod from the Western coast of Kamchatka is transparent, pelagic, remains as a rule within the upper layers of water and is 1.6 mm in diameter.

Agreeing with him, Shmit (1933) classified the eggs which he caught in the Bering Sea and near the eastern shores of Kamchatka as cod roe, if these eggs were 1.36 to 1.66 mm in diameter and those 1.1 and 1.2 mm in diameter as the roe of Alaska pollack.

In the meantime, however, Inaba (1931) caught in the Mutstu Bay (eastern shores of Hokkaido) cod roe, the eggs reaching 0.98 and 1.08 mm in diameter; Kamiya (1916) measured the artificially fecundated roe of cod from the Japanese shore coast of the Sea of Japan, obtaining and establishing that the diameter of eggs fluctuate between 0.98 and 1.11 mm. The eggs of cod inhabiting the waters washing the eastern coast of Korea (Uchidā, 1936) are 1.25 to 1.30 mm in diameter. Numerous measurements that were carried out on the ovarial cod roe gathered during the expedition to the western shores of Kamchatka (which lasted all the year round), also gave the following figures: 0.98 and 1.23 mm.

The diameter of Alaska pollack eggs is considerably larger than that of the cod roe (1.64-2.38 mm for the Western Kamchatka) as it has been proved by Moiseev (1950), Rass and Zheltemkova (1948), who used our data. Thus, we can consider it as an established fact that certain authors (Marukava, Shmit), mistook the eggs of Alaska Pollack for cod roe and believed the former to be smaller, whereas undoubtedly the dimensions of the roe considerably exceed in size the roe of cod (1.64-2.38 mm as compared with 0.8-1.23 mm), which is almost identical in size with the roe of Far Eastern navaga.

The majority of researchers (Marukava, Shmit, Kamiya, Rass and Zheltemkova, Inaba, Polutov and others) regard the roe of cod from Pacific Ocean as a pelagian roe by analogy with the roe of Atlantic cod. However, certain factual data and theoretic speculations refute this theory. Even Kamiya (as far back as 1916) established, while artificially fecundating the roe of cod and studying its development, that the fecundated roe sinks to the bottom and continues developing at the bottom of a container even when the salt content of the water is brought to maximum. Inaba (1931) observed an identical phenomenon. Nonetheless, neither of the two dared to draw the logical conclusion stating that the roe of the cod from Pacific Ocean is of a benthic character and both discarded the phenomenon observed as an anomaly (Rass and Zheltemkova, 1948, arrived at the same conclusion).

Observations of Uchida (1936) on the artificially and naturally fecundated roe of cod from the waters washing Eastern Korea enabled him to voice a supposition that the roe of cod was of benthic character, since in both cases it sank to the bottom.

Finally, the observations carried out by N. N. Gorbunova in Peter the Great Bay (1950) enabled us to definitely establish that the roe of cod from Pacific Ocean contains no oil drop, has a higher specific weight than the water surrounding this roe and sinks to the ocean floor immediately following fecundation. We also succeeded in observing that this roe was slightly sticky, which confirms anew the benthic character of cod roe. Undoubtedly, this peculiar feature of the roe of cod from Pacific Ocean accounts for substantial differences between this roe and the roe of cod from Atlantic Ocean, which is, as is well known, pelagic. We think that the peculiar character of the Far Eastern seas where the surface areas of the continental shallow water regions are limited, the currents are intensive, the regions with varying hydrological conditions closely adjacent, though strictly isolated, the periods favourable for the development of the roe and cod fry extremely short, ice cover over the spawning regions and other factors - account for the specific nature of cod from Pacific Ocean, which contributes to the preservation and development of this fish species.

The benthic character of the roe ensures the development of roe and cod fry in the regions with the most favourable conditions and prevents their displacements to other areas that are often close by but less favourable for its development.

While in the North Atlantic Ocean the broad Gulf Stream washing North Western Europe, ensures relatively uniform hydrological conditions over vast zones and pelagian roe and fry of Atlantic cod remain throughout the entire period of their development under conditions that vary little in the North Western part of the Pacific Ocean, the conditions in which the cod roe and fry develop are different.

As we have already seen the complex scheme of currents and distribution of water volumes in Far Eastern seas accounts for the presence of large zones, which for some reason do not meet the requirements necessary for the development of the majority of benthic or pre-benthic fish species, including the cod. Great depths, constant low temperatures, limited surface areas of the continental shallow waters - such are the main factors unfavourable to benthic and pre-benthic fish.

In the given case undoubtedly the benthic and not pelagian character of roe enables the cod from Pacific Ocean to become more successfully adapted to these specific hydrological conditions and relief of the North Western Pacific. Simultaneously this specific ecology of the cod roe explains the existence of numerous local schools of cod inhabiting various zones of the Bering and Okhotsk seas, Sea of Japan and Yellow Sea, as well as isolated sections of the littoral waters of Pacific ocean.

The incubation period of cod roe from the Pacific fluctuates between 10 and 20 days depending on temperature and, probably, the region inhabited (table 54).

TABLE 54.

Incubation periods of the roe of cod from the Pacific.

Region	Temperature in °C.	Number of days prededing the hatch- ing.	The data provided by:
Chinkay Bay (Eastern Korea)	4-5.5	18-20	Uchida
" " " "	6-9	12-14	"
Mutsu Bay (Japan)	6.3-7	10	Inaba
Noto Peninsula (Japan)	8-14	9	Kamiya.

It is characteristic that the incubation period of Atlantic cod is somewhat longer, i.e. from 20 to 35 days (Apstein, 1910).

The cod fry, which is just hatched, measures 3.6-3.83 mm in length.

At the end of 10 days when it reaches 5-9 mm in length, the desintegration of the yolk is completed.

According to the data of Uchida, during the early period of its existence, the cod fry near the shores of Korea remain in the lower horizons (below 20 meters), however, when they reach 15-20 mm in length, they drift nearer the shores to the regions with temperatures up to 15°; when the temperature rise to 15-17°, the fry 70-90 mm in length migrate away from the shores to deeper layers of water.

During the first five or six months of their life the fry feed essentially on small crustaceans; after having reached the length of 70-90 mm, their diet contains young crabs shrimps and even fish.

In August the length of cod fry populating the coastal waters of Western Kamchatka fluctuates between 1 and 6 cm (reaching on an average 4.2 cm), in Peter the Great Bay - from 4 to 9 cm (7 cm on average) and by December the fry hatched during the current year are 10 to 26 cm in length (16.6 cm on an average).

Near the shores of Unalashka (Alaska) the fry of cod belonging to the generation of the current year reach 10-12 cm in length by December (Kobb, 1916).

The cod fry grow very intensively.

We wish to point out that while in conditions found off the eastern shore of Korea, the optimum temperature for cod is below $15-17^{\circ}$, near the shores of Kamchatka and in the Bering sea the development of fry occurs at the temperature of $3-5^{\circ}$ and below, since in April-May, when the fry are hatched in great numbers, the maximum temperatures in these regions do not exceed the aforementioned indices.

Let us discuss in brief the main conclusions on the problem discussed in this chapter.

The proportion of males to females among cod is approx. 1:1, however, among the fish below 45 cm in length the males are found in a prevailing number and among the fishes over 70 cm in length the females are more numerous than the males. The cod from the Pacific

reach sexual maturity at the age of five (less frequently at an earlier age); however, far from all the specimens of this age are sexually mature.

Observations have shown that only about 30% of the fishes at the age of five spawn, while the remaining cod specimens achieve the sexual maturity at a later age. We encountered single specimens of cod at the age of nine, which had not spawned as yet. In the cod from the Pacific Ocean we may distinguish three different periods of sexual maturity:

- 1) the spawning period (taking place over a period of time of about two months) is characterized by the high coefficient of maturity (at the beginning of spawning), sharp drop in the intensiveness of feeding, the lowest weight of liver and the lowest oil content in liver;
- 2) post-spawning period (which lasts for about 6-7 months) is characterized by the low coefficient of maturity (0.5-3.0), exceptionally slow rate of development of the sexual products, intensive feeding and at the end of this period high weight and oil content of the liver;
- 3) the pre-spawning period (which continues for 3-4 months) is characterized by the high rate of development of the sexual products, rapidly increasing coefficients of maturity, rather intensive feeding and drop in the weight and oil content of the liver.

The sexually mature cod specimens are fattest during the summer and autumn; during the winter the oil content in the liver drops to minimum.

Fertility of cod from the Pacific fluctuates between 1425 and 6361 thousands of eggs and depends primarily on the dimensions of fish and on regions inhabited.

The high fertility of cod (which is achieved through finer roe and therefore more numerous posterity) observed in the Far Eastern waters, particularly in the southern section of the region inhabited by cod, is probably one of the defences taken by this species against the predatory animals and fish whose activity becomes sharply intensified in the southern latitudes.

The great number of local cod schools accounts for the existence of a respectively great number of spawning regions located in the Far Eastern seas between Anadyrski Bay and Korean strait. In view of the immensity of zone inhabited by cod and the varying hydrological conditions in these areas, the spawning occurs in the southern and northern sections at various intervals of time between December and May; the most intensive spawning takes place between January and April. Within the limits of the north-boreal regions, the cod spawn during the spring, in the south-boreal areas during winter. Avoiding temperatures below zero and above 10° during spawning, the cod in the North-boreal regions spawn in the pre-benthic horizons at a certain distance from the shore (at the depths of 100 to 250 meters), where the temperatures range between 0 and $2-3^{\circ}$. In the south-boreal regions

(the coast of Korea, Hokkaido, Southern Kuril Islands) the cod drift for the spawning from the deep areas where they remain during the summer, towards the shores where in winter time the water temperature drops to $5-9^{\circ}$, sometimes even lower. In these regions, which are merely transitional, (South Western Sakhalin, Peter the Great Bay), the cod drift for spawning away from the deep regions, which they inhabit during summer, towards the shores reaching the depths of 50-100 m, i.e. to the zone of pre-benthic temperatures of $2-3^{\circ}$.

During the spawning period the cod somewhat rise above the ocean floor and the spawning occurs in the pre-benthic horizons. The cod from the Pacific Ocean is a simultaneously spawning form of cod. The roe of cod from the Pacific Ocean is benthic, in which it substantially differs from the roe of Atlantic cod having, as is well known, pelagian roe. The search for optimum conditions results in that the roe develops in the pre-benthic horizon and is not carried away by strong currents peculiar to the Far Eastern seas, to other closely situated regions, where the hydrological conditions and relief of the ocean floor are unfavourable. The incubation period continues for 10 to 20 days (as against the 20-35 days incubation period for Atlantic cod). Disintegration of the yolk sac occurs on the 10th day, after the young fish reaches 5-9 mm in length. At the end of 5-6 months

following the hatching the cod fry from the generation of the current year reach 8 to 26 cm in length and their rate of growth in the Northern regions is higher than in southern areas.

F E E D I N G.

The feeding of cod from the Pacific Ocean in certain zones of the Far Eastern seas has been studied sufficiently thoroughly to enable us to understand the importance and character of their diet, the dependence of the intensity and character of diet upon the season, sex, state of the sexual products, dimensions of the fish and environmental conditions. Considerable data on the feeding of cod (1094 guts), gathered by the author and M. A. Tychkova during the expedition to the shores of Western Kamchatka in 1938-1939 (an all-year-round expedition) and developed by Logvinovich (1948) brought to light the main regularities of feeding of cod in this region. Moreover, the numerous visual observations on the content of guts of cod, which were carried out by the members of TINRO on board the trawlers, research boats and at observation centers (the overall number of observations exceeded 12000) enabled us to clarify the contents of guts and intensiveness of feeding of the cod inhabiting the entire region described. Lastly, the development of data on the feeding of cod, which was carried out by K. Gordeeva (1951), K. Vinogradov (1935),

1. Polutov (1948) and a series of unpublished data on this subject matter provided by Kulichenko I., Frolov A., Krivobok M., Shurin A., Rozov V., Chechuro E., and Ershikova I., completed the information on the feeding of cod.

We wish to point out that the bibliography dealing with this subject matter was extremely scant and schematic prior to the publication of the results of Soviet investigations.

Brief references to the feeding of cod from the Pacific Ocean, which can be found in the works by Marukava (1918) and Kobb (1916), as well as other American and Japanese researchers, are limited, as a rule, to brief enumeration of the contents of guts.

In the guts of the cod from Pacific Ocean we found remains of over a hundred different animals, including representatives of the following zoological groups: rhizopoda, coelenterate, bryozoa, echinoderms, mollusks, crustacea, vermes, tunicata (urochorda) fish, even birds. ⁽¹⁾

The exceptional multiformity of the species composition of the diet of cod from the Pacific Ocean (a characteristic of the cod from the Barents sea, observed by Zatsepin and Petrova, 1939) enables these fishes to fully utilize the nutritive resources

(1)

Kobb (1916) found three ducks in the guts of a large cod specimen, which he caught near the shores of Alaska.

of various regions of the Far Eastern seas, pass over with a relative facility from one assortment of food to another and considerably reduce the fluctuations in intensiveness of feeding during different seasons, which are caused by changes in the quantity or accessibility of the food objects available.

On the other hand, however, the cod from Pacific Ocean, which are actively selective predatory fish, capable of considerable displacements in the horizontal, as well as vertical directions, mainly feed on 15 forms from amongst the multitude of food objects available. Even among these 15 forms it is usually easy to point out 3-4 species, which play the most important part in the diet of cod and are its constant objects of food, constituting 70% and more of the overall weight of the contents of gut.

The food assortment of cod from Pacific Ocean is similar for cod throughout the Far Eastern waters, although there exist certain, occasionally substantial regional variations.

Let us point out once more that according to the results of the racial analysis, study on the migration paths, rate of development, spawning periods and regions, the waters washing the northeastern coast of Asia are inhabited by several different schools of cod populating different, rather limited areas.

Let us describe in brief the composition of diet of the cod from different regions of the Far East.

Bering Sea. In Anadyrski Bay (to the South from Cape Navarin) the diet of fish inhabiting various areas of the bay somewhat differs from the usual. Thus, in the central part of the bay (during the cold year) the cod are rather underfed, have a little developed liver that is usually infected by nematode parasites and feed in the main on benthic animals i.e. vermes, crustacea and fish (zoarcidae, liparidae). It is interesting to note that the crab (chionoecetes), which plays the main or at least an important part in the diet of cod in other regions, is very seldom found in the guts of cod in this area.

Analysis of the contents of guts of the cod from the North-Western part of Bering Sea showed that the fish and crustacea constitute the main bulk of food consumed by the cod. Among the fish the Atherina, Alaska pollack, herring and chub are the most important species in nutrition of cod. Among the crustacea the most important species in cod feeding are the following: crab chionoecetes, spider crab (Hyas), Pandalus, Nototropis, Anonyx, Ampelisca and Mesidothea.

Young cod (less than 60 cm in length) essentially feed on small crustacea and fish. The medium size cod include larger forms in their food assortment (Chionoecetes, Alaska pollack, herring and others). Large cod (over 80 cm in length), a typical predatory fish, feed mostly on the school fish such as Alaska pollack, herring, Atherina and less frequently invertebrates such as Chionoecetes, octopus, etc.

We wish to point out that in the northwestern zone of Bering Sea (as well as near the shores of Western Kamchatka) the most dense and steady accumulations of cod are formed in the areas of their intensive feeding; moreover, as a rule, only one or two objects play an important part in the feeding of cod. In the regions where the cod feed simultaneously on a great number of different objects, we observed no accumulations of these fish.

Without further discussing the data on the feeding of cod in the region of Anadyrski Bay, which was already done by Gordeeva (1952), we shall utilize some of her conclusions.

By studying the feeding of cod in the western and eastern sections of Anadyrski Bay, as well as in the littoral and deep areas of Navarin region during the summer and fall (August-October 1950, we succeeded in clarifying the assortment of food consumed by cod, intensiveness of feeding and dependence of the behaviour of cod on the distribution of food objects.

TABLE 55.

Composition of the diet of cod from Anadyrski-Navarin region in August-September 1950 (following the data provided by Gordeeva).

Region	Depth in m.	Fish	crustacea	Mollusks	Vermes	Echino-derma	Other invertebrates	Miscellaneous	Degree of filling.
Western Anadyrski	20-50	29,6	167,8	2,7	9,6	0.1	0.6	-	210,4
Eastern Anadyrski	20-50	27,1	134.2	16.9	50.1	-	1.9	-	230.2
Littoral Navarin area	20-50	19.0	126.5	22.2	4.1	0.08	0.06	-	171.9
Deep Navarin area	140-170	118.7	54.5	7.8	3.9	-	0.6	5.5	191.1

However, the above listed food assortment consumed by cod from Anadyrski Bay substantially changes when the *Ammodytes personatus* approach the shores. These fish were observed between the middle of August and end of October all over the littoral region. Accumulations of *Ammodytes personatus* stimulate the cod to concentrate in this area in greater numbers since this fish intensively feeds on *Ammodytes personatus* during this season. The guts of cod are usually filled with this fish and during the period of feeding on *Ammodytes personatus* we obtained trawl catches of cod reaching 60 centners per an hour of trawling.

We know very little concerning the feeding of cod in the northwestern part of Bering Sea, but noticed a great number of benthic invertebrates and fish in the August-September assortment of food consumed by cod (table 56).

In the region of Kommandor Islands the cod feed essentially on the following: flounders, chubs, lump-fish, *Ammodytes*

personatus, Atherina, capelin. Among invertebrates the crustacea play the most important part, the vermes are considerably less essential while mollusks, holothurians (sea cucumbers) and echinoidea are found but very seldom.

In Olyutorski Bay we observed considerable concentrations of cod. In June-July the cod which completed spawning and remained at small depths (30-40 meters) live in the main on fish (herring, navaga, flounders, ~~Anmodytes~~ personatus, Siberian salmon, ground gudgeon, humpbacked salmon, chubs, Alaska pollack and others), with small admixtures of crabs, holothurians and star-fish. During the same season, however, the cod remaining at greater depths (130-150 meters) feed essentially on crab Chionoecetes opilio and certain other invertebrates. During the autumn (early October) the cod begin feeding on Alaska pollack and Chionoecetes opilio.

To the south from Olyutorski Bay, in the region of Korf Bay, there occur the vernal post-spawning migrations of cod to the shores following the herring which arrive in great numbers at the shore in the middle and at the end of May. During this period of time the guts of cod are filled with herring. In the fall the cod change to feeding on navaga, crabs and

Near the Karaginski Island, the cod feed in June-September on Atherina and other fish species, as well as on Arimacrus isenbecki, Paralithodes brevipes and octopus.

At the end of August-September we observed in Kamchatka Bay a mass migration of cod to the area adjacent to mouths of rivers, where they feed on salmon fry. In the guts of dissected cod specimens we found up to 35-40 salmons.

In Avachinski Bay (Polutov) the cod feed essentially on the Alaska pollack, *Chionoecetes opilio*, *Anonyx nugax*, *Synidotea nebulosa*, *Echiurus echiurus* and *Polipus gilbertianus*. K. Vinogradov (1935) quoted the following composition of food found in the guts of cod 54-84 cm in length (in % depending on the frequency at which these food objects were found in the guts of cod caught in 1934 in Avachinski Bay): the crustacea occupy the first place (68%), fish-44%, mollusks and vermes-14 and 15% respectively; echinoderms-4%, *Ascidia*-1%, algae-1%, empty space-20%. The following fish species are found most frequently in the guts of cod: herring (15%), Alaska pollack (11%), salmon, navaga and others. From crustacea the following were most frequently found: *Chionoecetes opilio* (13%), *Amphipoda*, *Eupagurus*, *Isopoda* and others; among the mollusk - the octopus *Polypus gilbertianus* (9%).

Sea of Okhotsk.

Near the shores of Western Kamchatka we found in the guts of cod about 100 forms of living organisms (Logvinovich, 1948), among which only 10-12 forms play an important part in the feeding of cod (see table 57). Fish (Alaska pollack, flounders, herring, young cod, navaga) are the main food objects and the weight of

their remains constitutes about 71% of the overall weight of the contents of guts. Next in importance are crustacea, particularly the Chionocetes and molt Kamchatka crabs. We often found octopus in the guts. The remaining food objects play a rather insignificant role in the nutrition of cod. During migrations of Salmonidae we frequently found in the guts of cod the remainders of humpbacked salmon, red salmon and Siberian salmon. During the seasonal migrations of large concentrations of herring to the shores of Kamchatka (which usually occurs in May-June), the cod intensively feed on these fish. Thus, in May 1929, G. V. Belavin dissected 500 specimens of cod caught near Kikhchik, and found 3870 herrings in the guts of 430 specimens of cod. S.I. Kostuhov observed that at the end of May beginning of June 1930, the guts of cod filled with herring. These cod specimens were cod in the region of the river Ozernaya. M. N. Krivobok conducted observations on June 23, 1939, during the migration of herring schools towards Bolshetersk and observed that the cod fed intensively on herring; in the guts of certain cod specimens he counted as many as 13-14 specimens of herring. We may quote a great number of analogous examples. As a rule, the concentrations of cod increase simultaneously with the concentration of herring. During such a season the trawler "Balkan" lifted within 40 minutes of trawling about 30 centners of cod near the river Ozernaya. The guts of these cod were filled with herring.

Small cod specimens (less than 50 mm in length) feed in the main on crustacea, small benthic fish (Blenniidae, Zoarcidae) and vermes. The smallest specimen of cod (less than 24 cm feed essentially on amphipodae.

Thus, the cod of large and medium dimensions inhabiting the waters of Western Kamchatka, feed in the main on Alaska pollack (forming up to 39% of the overall weight of the content of guts), crab Chionoecetes (12,5%), flounders (10%) and herring (7%).

Undoubtedly, the role of herring is in reality somewhat more important since the figures presented above have been obtained from the cod caught between the end of June and March, whereas the cod feed most intensively on herring during May and at the beginning of June.

TABLE 57.

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TABLE 57

Degree to which the guts of cod from Western Kamchatka
were filled when analyzed.

Food object	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Mean annual figures
Alaska pollack	58.2	78.8	60.9			47.7		25.6	28.1	2.2	11.2		39.4
Flounders	0.5	-	0.3			5.1		24.2	23.4	1.2	20.3		9.6
Herring	1.9	2.8	0.1	No data available	No data available	10.2	No data available	2.4	-	33.2	No data available	3.3	6.8
Cod fry	7.6	7.4	4.0			1.2		2.1	1.4	22.4		15.8	7.8
Other fish	3.6	1.7	1.2			4.6		22.6	3.3	8.9		9.6	6.9
Small crustacea	0.1	0.1	0.1			0.2		0.4	0.3	1.3		-	0.3
Large crustacea	12.4	6.7	30.3			28.0		12.5	35.6	7.1	35.4		20.5
Octopuses	14.4	2.0	1.1			0.2		1.4	3.1	14.5	1.4		5.0
Other benthic animals	1.3	0.2	1.9			2.8		8.4	2.8	9.2	2.9		3.7

Drawing 10 .

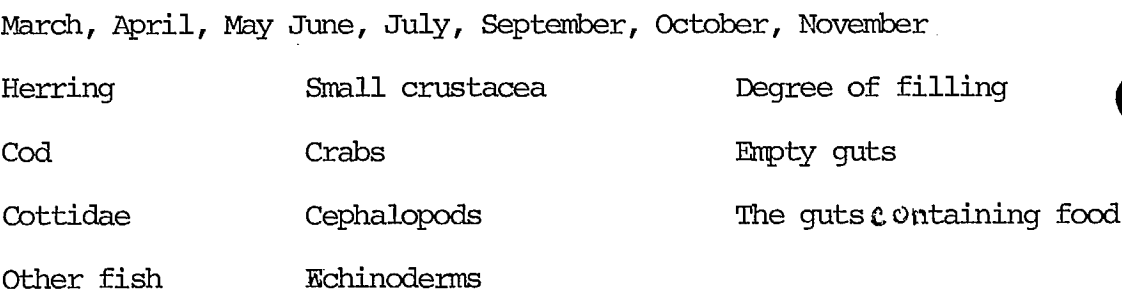


Fig. 10 Composition of the guts' content and degree of filling
of the guts of cod inhabiting the waters washing the
southwestern coast of Sakhalin (1948).

On the southern border of the region inhabited by cod from the Pacific Ocean its diet somewhat changes and the consumption of crustacea increases. Thus, the field analysis of the guts of 587 cod specimens, which were caught between the 26th and the 28th July, 1948, near the Spanberg Island (southern Kuril Islands) which was carried out by E. Manner, showed that the food components were as follows: fish-38.2; fish:33.8; mollusks-20.0; crustacea-33.8; mollusks: 5.0. Alongside with the high percentage of empty guts (37.8 %), the percentage of fish consumed decreased for large cod to 40-45% and the role of crustacea increased to 35-40%.

SEA OF JAPAN.

Near the western shores of Sakhalin the cod live essentially on fish (herring, small cod, chubs, etc.), crustacea (shrimps, crabs, etc.), Mollusks (such as octopuses etc.), echinoderms (brittle stars and Crinoidea).

Throughout the year the herring constitute 65-75% of the overall content of cod guts and during certain months (May, October) the cod feed almost exclusively on herring.

..... plays an important part in the feeding of cod during certain seasons (fig. 10).

TABLE 58.

Content of the guts of cod of varying dimensions (in % of frequency at which it is found) near the Southwestern Sakhalin (August-September 1948).

Table 58 ctd.

Food objects	Dimensional groups in cm.		
	21-40	41-80	Over 81 cm
Fish	45.5	59.7	25.3
Crustacea	33.7	17.6	6.9
Mollusks	12.8	22.2	67.5
Vermes	7.9	0.1	0.3
Other invertebrates	0.1	0.0	0.0
The overall mean index	104.3	175.3	216.4

The data provided by E. Chechuro (table 58) on the contents of guts of the cod (caught in August-September) of varying size inhabiting the waters washing the southwestern coast of Sakhalin confirm the general rule that intensiveness of feeding increases with the increase in dimensions of the fish and showed that there occur substantial changes in the general scheme of feeding. Thus, while young fish (less than 40 cm in length) essentially live on small Decapoda and Amphipoda, vermes (Polychaeta), cod fry and Pleurogrammus azonus, the diet of larger fish contains almost no vermes and Amphipoda, the percentage of Pl. azonus and cod fry sharply drops while the role of herring Chionoecetes and mollusks noticeably increases. Along the continental coast of the sea of Japan small cod (less than 50 cm) also feed during the summer mainly on crustacea (53.3%); and fish (19.0%); the cod of medium dimensions (51-70cm) live on fish (40.8%) and

crustacea (38.2%) while large cod change to a fish diet (77.2%) with considerable admixtures of crustacea (21.5%).

Mollusks, vermes and echinoderms are found in the guts in small quantities only.

During the spring, i.e. in May 1930, we observe large accumulations of cod between the gulfs of Nelm and Grossevichi (Northern Maritimes). The fish fed on the spawning herring. In Peter the Great Bay the role of fish in the food assortment of cod is considerably more important than in the more northern areas of the Sea of Japan; their percentage for cod specimens below 40 cm in length reaches in May 29.4 % and large cod (over 80 cm) feed exclusively on fish (table 59).

TABLE 59.

Contents of guts of the cod from Peter the Great Bay in May, 1933 (in%).

Length of cod	Food groups				Number of guts
	Fish	Crustacea	Mollusks	Others	
below 40 cm	44.1	37.2	0.2	18.56	28
51-61 cm	44.4	33.3	-	22.3	9
61-80 cm	60.7	25.0	-	14.3	36
Over 80 cm	100.0	-	-	-	6

It is interesting to note that cod feed intensively on sardines when the latter concentrate in great number near the shores of the Maritimes.

Small cod (below 30 cm in length) feed essentially on

Summarizing the data on the importance of different food groups in the feeding of cod from the Maritime littoral zone and Peter the Great Bay, we obtained the following table showing the constant change occurring in small cod when they go over from feeding on crustaces exclusively to fish diet, characteristic of large specimens.

TABLE 60.

Contents of guts of the cod from Peter the Great Bay and Maritimes in 1932 (in % to the weight).

Length of the cod	Food groups				Number of guts
	Fish	Crustaces	Mollusks	Others	
Up to 50 cm	19,0	53,3	5,4	6,05	105
51-70 cm	40,8	38,2			427
Over 71 cm	77,2	21,5			79

Summarizing the brief description of food assortment of the cod from Pacific Ocean in different areas of the Far Eastern waters, we may establish that despite the extraordinarily wide assortment of animals consumed, the cod live in the main on a small number of objects. While the cod fry (up to 25-30 cm) feed on small benthic crustaces and vermes, larger fishes change relatively to the feeding on fish and large benthic and nectobenthic crustaces (Kamchatka crab, Chionoecetes, Pandalidae). Moreover, apart from typically benthic inhabitants (flounders, chubs etc.), the prebenthic fish species (Navaga, Athernia, Alaska pollack, herring) and

pelagian fish play the most important part, which indicates that the medium size and large cod can easily rise from the ocean floor and drift into the intermediate and in certain cases perhaps even surface horizons.

By comparing the contents of guts of the cod from different regions of Far Eastern seas (table 61) we became convinced that they are very much alike. Everywhere the fish and crustacea (mostly large) specimens play the most important part in the diet of cod. Intensiveness of feeding is similar for all the areas (when expressed in the general mean index). The species composition of cod diet considerably depends on the season, region inhabited, dimensions and physiological state of the fish. The cod utilizes the spawning concentrations of school fish, such as in Bering Sea, Okhotsk and Japan seas forming during such seasons arather large accumulations. The importance of in the feeding of cod, particularly in the Bering and Okhotsk seas where this fish are found as a rule, together, and where is excluded from the food assortment of cod only during the periods of mass concentrations of herring or attracted our attention.

TABLE 61.

Individual indices of the filling of guts of sexually mature cod from different regions of the Far Eastern seas (in % from the overall weight of the contents of guts).

Table 61 Ctd.

Food Objects	Northwest- ern zone of Bering sea	Eastern coast of Kam- chatka	Western coast of Kamchatka.	Aniv Bay and Lape- ruza strait.	South- western the shore of Great Sakhalin Bay	Peter the Great	Southern Kuril Islands
Fish	64,8	68,0	58,2	38,8	48,0	61,8	67,1
Mollusks	1,7-7,9	10,0	3,1	17,4	27,7	10,1	13,6
Crustacea	113,7	17,0	35,9	40,7	21,8	15,0	12,2
Vermes	13,5	2,0	-	0,85	2,4	13,0	0,3
Echinoderms	0,6	-	2,8	0,0	0,0	0,1	4,1
Other in- vertebrates	7,7	3,0	-	1,6	0,1	0,0	2,7
Overall mean index	202,1	162,3	145,0	171,1	114,8	185,1	174,5
Date of collection	August 9 Oct. 13 1950	June- Oct. 1949	Sept. 1939	Sept. 1948	Aug/Sep. Nov. 1948- 1948 1949		Sept. 1948
The data provided by:	Cordeeva	Ershikova	Logvinovich	Chechuro	Chechuro	Chechuro	Chechuro

Observations conducted by Polutov and Ershikova (1951) confirmed the selective ability of cod inhabiting the waters washing the eastern shores of Kamchatka; these fish show a definite preference for certain food objects while living in shallow waters (July-October). Thus, in June/July, the guts of the cod are mainly filled with Alaska pollack. In July-August the intensiveness of feeding somewhat decreases, the consumption of Alaska pollack is also reduced and the crustacea play a progressively more important role in the diet of cod; in September the large cod feed essentially on mollusks (such as octopuses, etc.).

These changes in the food assortment consumed also effect the results of fishing on the hook, in view of which the problem of the bait used for fishing on cod in Pacific Ocean is to be considered.

Intensiveness of feeding of cod depends on the season, sex, degree of maturity of the sexual products, dimensions, hydrological conditions of the basin during the current year, abundance or scarcity of food objects.

Development of the data provide by the expedition to the shores of Kamchatka on board the research trawler "Lebed" which was conducted all the year round

(Logvinovich 1948) showed that intensiveness, as well as character or nutrition of cod changes in the course of the year.

In fishes fo different dimensional groups the course of the annual changes in the intensiveness of feeding noticeably differs for each individual group (Logvinovich failed to consider this factor and therefore arrived at an erroneous conclusion maintaining that the intensiveness of feeding increases in March, i.e. during the period of spawning).

Large fish (over 91 cm in length) feed rather intensively during winter, i.e. during the pre-spawning period (the indices of filling in January are 484, in February 203), after which in March and, of course, in April, during the spawning period, the index of filling of the guts decreases to 73. The post-spawning period (May, June, July, August) is characterized by intensified feeding (index of filling 330-311), this intensity gradually

diminishes in September (100); in October, however, the feeding becomes intensified anew (index 470) due to the rapid development of sexual products.

DRAWING II.

Feeding of cod inhabiting the waters near the Western shores of Sakhalin in the course of the year (for 1947 and 1948).

DRAWING 12.

Differences in the seasonal course of feeding of the cod obtained from the catches near the western shores of Kamchatka (1938-1939) and cod from the Barents sea (1937).

Small cod, below 50 cm in length, as well as 56 and 70 cm (as it may be seen from table 62 and fig. 12), follow somewhat different rules in feeding. During winter, i.e. in January-February, the intensiveness of feeding sharply drops (index of filling is 78-40). March provides the highest indices of the intensity of feeding (index of filling is 528), which afterwards sharply diminish and remain at a relatively low level throughout the year. The same regularity has been observed near the eastern shores of Kamchatka. The mean index of the filling of guts for small cod caught on the hook between June-October (1949) reached 40.9 only for medium size cod - 152.2 and for large cod - 172.4 (Polutov and Ershikova, 1951).

Small cod near the shores of Kamchatka feed less intensively than large specimens.

Going back to the large cod, we wish to emphasize once more the importance of Alaska pollack in their feeding, which is particularly pronounced during the winter months. As assumed on the basis of a number of facts, the large, sexually mature cod rise from the ocean floor as early as January and leave the ocean floor en masse in February-March, remaining in the intermediate horizon until the end of the spawning period. At this particular period of time Alaska pollack which is a benthic species that usually drifts into intermediate horizons, inhabit the regions where the cod prepare for spawning and intensively feed; therefore, in March, this fish constitutes up to 92% of the general index of filling of the guts of large cod (71-110 cm). During the spring, at the end of the spawning, the large cod feed on herring, then (in June) drift to shallow waters, where they feed on soft crabs from Kamchatka waters, flounders, Alaska pollack, crab *Chionoecetes* and other living organisms. In October we observed a considerable increase in the proportion of herring in the diet of cod.

TABLE 62.

Indices of filling of the guts in cod of varying dimensions inhabiting the waters near the shores of Western Kamchatka in 1938-1939 (following the data provided by Logvinovich)

pto

Table 62. Ctd.

Length in cm.	M o n t h s												Mean gene- ral index of feeding
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
31-50	78	40	528	no data available	"	100	data available	110	125	137	data available	165	146
51-70	175	230	420		"	260		80	120	180		155	206
71-90	250	100	360		"	330		200	115	255		175	230
91-110	484	225	73		"	330		311	100	470		280	286
Mean gene- ral index of feeding	193	203	397	no data	"	289	no data	161	145	240	no data	168	245
The same for Barents Sea	75	183	144	96	"	73	81	192	102	188	118	78	144

Intensiveness of feeding for males and females is similar, although it has been observed that sexually mature males start feeding less intensively earlier than females (as early as October, having reached the III stage of maturity of the sexual products, whereas we have not observed this phenomenon for females until the end of the spawning period). As we mentioned before, it depends in all probability on the volume of the spermic vessels which reach considerable dimensions at stage III of development tightly filling the body cavity and compressing the guts in view of which the latter can be filled to a lesser degree.

Annual changes in the intensiveness of feeding of the cod inhabiting the waters near western shores of Sakhalin has a similar character to those of cod from the Sea of Okhotsk (see table 63,64 and fig. 11).

The low general indices of the filling of guts (62-81) during the spawning period (February-March) rapidly rise and reach the maximum figure (in April May). The active migrations of herring to the shores of southwestern Sakhalin which occur during April and May, attract the cod to the shores in search for herring, which is almost the only food object for cod during this period of time. In June, July and August the intensiveness of feeding decreases (34-123), the importance of herring in the diet of cod drops (14-87%) and the cod begin living on cod fry, grabs, and other living organisms. In September-October we observed a certain intensification in the feeding of cod, during which herring constituted 69-93% of its diet (during this season herring form large concentrations). We wish to point out that although the general outline of the curve expressing the intensiveness of feeding of the cod from Sakhalin waters that have been caught by means of a multistage fishing net resembles that for cod from the Sea of Okhotsk caught by trawl, nonetheless the absolute figures of the indices of filling cannot be compared at all and undoubtedly, for cod from the Sakhalin these indices are somewhat below the correct figures in view of the fact that a portion of food is digested while the fish remains on the hook, as well as because only hungry fish are caught on the hook. Moreover, we wish to point out that the periods during which the spawning herring migrate

towards the shores of southwestern Sakhalin forming large concentrations there during the autumn vary from one year to another, which affects the intensiveness of the feeding of cod on herring. The aforesaid may be clearly seen from tables 63-64. The contents of guts of the cod caught in this region is a good index to the regions inhabited by and density of concentration of the cod.

Finally, the annual variations in hydrological conditions in different basins causing deflections from the mean hydrological indices (which can be easily detected on even the most superficial study of this problem) produce very considerable changes in the feeding of cod.

TABLE 63.

Composition of food assortment of the cod inhabiting the waters washing the western coast of Sakhalin (1947) in percentage from the general index of filling.

	Months.									
Food groups	II	III	IV	V	VI	VII	VIII	IX	X	
Herring	70,9	56,4	80.0	100.0	82,0	33.4	87.5	1	93.3	
Cod	7,2	-	3.6	-	13.9	16.4	5.6	1	3.9	
Other fish	9,7	18.3	2.2	-	2.8	17.5	-	1	-	
Crab	-	18.3	-	-	-	21.4	-	1	-	
Crustacea	12,2	7.0	3.6	-	1.3	2.5	1.4	1	0.8	
Cephalopods	-	-	10.6	-	-	8.3	5.5	1	0.5	
Echinoderms	-	-	-	229.0	-	0.5	-	1	1.5	
General index of filling	81.5	62.7	97.0	13.4	97.8	45.5	60.9	1	192.0	
Percentage of empty guts	17.2	32.0	23.6		37.0	18.9	37.5	1	9.2	

TABLE 64.

Food assortment of cod inhabiting the coastal waters of Western Sakhalin (1948). In % from the general index of filling.

Food groups	M O N T H S								
	III	IV	V	VI	VII	VIII	IX	X	XI
Herring	89.7	70.5	79.2	14.2	35.9	no available data	-	69.2	13.9
Cod	3.1	27.2	3.3	1.9	-		2.2	1.9	54.4
Other fish	7.2	2.3	15.8	48.6	50.8		5.0	1.7	20.3
Crab	-	-	-	-	-		10.8	3.0	-
Crustacea	-	-	-	32.0	13.3		4.3	2.6	11.4
Cephalopods	-	-	1.7	-	-		39.1	18.9	-
Echinoderms	-	-	-	3.3	-		38.6	2.8	-
General index of filling	274	351	152	123	34		106	123	29
Percentage of empty guts	2.0	8.6	37.5	26,3	25.0		36.0	35.0	39.0

Changes in the periods, regions and rate of the spawning migrations of herring immediately affect the feeding and behaviour of the cod. The disappearance or delayed formation of the cold layers during the summer may provide either free passage or an almost insurmountable barrier in the migrations of cod into the regions that are often highly productive and simultaneously alter the entire character of the feeding of cod (fig. II.).

Thus, the sexually mature cod inhabiting the North-boreal regions show the following clearly outlined periods of feeding:

- 1) the spring post-spawning period characterized through intensive feeding (end of March-April-May, as depending on the region) on herring (Sea of Japan and Okhotsk) or *Atherina* and herring (Bering Sea;
- 2) intensive summer feeding in the shallow waters (June-September) on flounders, Alaska pollack, Salmonidae and large crustacea;
- 3) autumn-winter intensive feeding (October-January) on cod and navaga fry, large crustacea, herring and *Atherina*;
- 4) the pre-spawning and spawning periods during which the intensiveness of feeding decreases (January-April) to varying degrees for different regions.

The young, sexually immature cod (as a rule less than 60-70 cm in length) near the shores of Kamchatka feed most intensively in March mainly on the , however, during the remaining part of the annual cycle the degree of intensity of feeding of these fish is rather low, and not particularly subject to change.

When analyzing the composition of food assortment of the cod from the Pacific Ocean and comparing it with the feeding of other benthic and pre-benthic fish (such as Alaska pollack, flounders, navaga, halibut and others), we arrived at the conclusion that the feeding of cod is extraordinarily specific, particularly

the feeding of medium size and large cod specimens, and the food assortment on which the cod live little resembles that of other fishes side by side with the cod. Thus, the degree of resemblance between the spectrums of feeding of Alaska pollack and cod from the Sea of Okhotsk (Mikulich, 1950) during the spring has been estimated by Mikulich (1950) as 2.2% (calculated according to the method suggested by Shorygin, 1939). During the summer, the degree of resemblance also remains low and can be estimated as 4.4%.

Feeding on the fish, first of all on Alaska pollack, herring and Atherina, as well as large crustacea - such as Kamchatka crab and crab *Shionoecetes* - i.e. objects that little used for food by other predatory fish, the cod succeed in avoiding the struggle for food affecting other species and therefore, have a high index of the filling of guts all the year round. This index for the Sea of Okhotsk is almost twice as high as the index for cod inhabiting the waters of the Barents Sea (225 and 144).

Small cod, in particular the specimens below 30 cm in length, are in a somewhat different position. Their diet consists almost exclusively of small benthic crustacea (Amphipoda) which simultaneously serve as food objects for many other benthic and pre-benthic fish species (flounders, navaga and others).

We may assume that in a number of regions these dimensional groups of cod have to face a stronger interspecies food competition, however, the high rate of growth of the cod during the early period of their life enables this fish to change relatively early (at the age of two years) to the feeding on objects that are almost exclusively used by cod (crab Chionoecetes and others). Thus, near the shores of Western Kamchatka the food assortment of cod 31 to 51 cm in length contains 36.3% of fish, 18.3% of crab Chionoecetes and 36.0% of nectobenthic shrimps, while small crustacea form only 1.3%.

We believe that the abundance of benthic fishes in the Far Eastern waters (such as flounders, cottidae, agonidae and others) which intensively feed on small benthic living organisms, results in that here, in distinction from Barents Sea, the small cod feed less intensively than the large cod, whose index of the filling of guts increases with the increase in linear dimensions. In the Barents Sea the situation is quite different. The relatively limited number of benthic school fishes reduces the food competition in the early stages of the life of cod, considerably intensifying it for older age groups of fish at the expense of the similar spectrums of feeding for fishes like haddock, pollack and ocean perch. We may assume that this circumstance is partly responsible for the fact

that large cod from the Barents Sea feed on a most varied diet which includes benthic crustacea and sea animals, undergo lengthy periods of forced starvation caused by the impoverishment of pre-benthic horizons in food organisms, and therefore, show a high percentage of empty guts (during certain months up to 82%) which on the whole sharply reduces the indices of the intensiveness of feeding of cod from the Barents Sea, while their linear dimensions increase.

However, the general character of the curve expressing the annual intensiveness of feeding of sexually mature cod from the Sea of Okhotsk and Barents Sea shows similar features.

Summarizing the aforescribed observations on the feeding of cod, we may establish that in spite of the most varied food spectrum of cod from Pacific Ocean (over 100 forms) only a small number of food objects plays an important part in the feeding of this fish. While the cod fry (up to 25-30 cm) feed on small benthic crustacea and vermes, the large cod specimens relatively early change to feeding on fish and large benthic and neo to benthic crustacea (Kamchatka crab, crab *Chionoecetes*, *Pandalidae*); moreover, among the fish consumed by cod, there are, (apart from the typically benthic inhabitants, such as flounders, *Cottidae*, etc) also pre-benthic fish (navaga, *Athernia*, Alaska pollack, herring) playing an important part in the feeding

of cod and pelagian forms (salmon, sardines), which shows that the medium size and large cod easily drift into the intermediate and in certain cases even surface horizons. The cod intensively feed on the spawning concentrations of school fishes (Athernia in Bering Sea, herring in Bering, Okhotsk and Japan seas), forming large accumulations during these seasons.

Our attention was attracted by the importance of Alaska pollack in the feeding of cod, particularly in the sea of Okhotsk and Bering Sea, where both fish species are found, as a rule, together.

The fact that cod feed in the main on fishes and large crustacea enables this fish species to intensively feed all the year round as may be seen in the high index for the filling of guts. The mean annual indices of filling are almost twice as high for the cod from the Sea of Okhotsk as for those in the Barents Sea.

The largest and permanently-settled concentrations of cod are formed in the regions of their intensive feeding

PRE-BENTHIC TEMPERATURES AND DISTRIBUTION OF THE COD.

At the present time, the problem of revealing the most complex forms of the interrelation between the numerous factors of environment and the organism of the cod is far from being solved. In view of the rather limited data available on this problem we decided to endeavour to calculate mechanically the interrelation between the distribution and behaviour of cod and one of the most important elements of environment, i.e. the temperature.

It should be taken into account that the temperature is a factor that can be most easily determined by researchers, as well as by industrial workers.

The effect of various hydrological factors on the behaviour of cod is far from being uniform. While the salt content, concentration of hydrogen ions, content of oxygen and a series of other factors within the limits of the diurnal, seasonal and annual fluctuations usual for the Far Eastern seas shows no substantial and clearly pronounced effect on the behaviour of cod, the temperature conditions considerably determine the distribution, seasonal migrations, depth and region inhabited by cod. Undoubtedly, the temperature and its fluctuations are the abiotic factor of foremost importance for the cod from Pacific Ocean over the course of its entire life cycle-starting from the roe stage up to the moment when the development of fish is completed.

It is natural, that the effect of temperature of fish, in particular on cod dwells not merely in the fact that the fish become adapted to existence within definite temperature limits, i.e. the direct correlation, but in a great number of cases this relation is indicated in other indices (distribution of food objects etc.).

The close relation between the distribution of cod and the thermic conditions of pre-benthic horizons in the Barents Sea and northern part of Atlantic Ocean, is well known (Maslov, 1944).

Moreover, we wish to point out that in the North Eastern zone of the Atlantic Ocean and in the Barents Sea, which is affected all the year round by immense warm volumes of water from the Gulf Stream, the annual fluctuations in temperature, particularly in the pre-benthic layers, are small, and as a rule, within the large region inhabited by Atlantic cod, the benthic temperatures rarely drop below 0° , be it only several tenths fractions of a degree.

However, the effect of the broad range of changeable thermic conditions in the large zone inhabited by cod of the Pacific Ocean, mainly situated within the limits of the Far Eastern Seas where hydrological conditions sharply change from one season to another, cannot be overrated.

The salt content in water, amount of dissolved oxygen, concentration of hydrogen ions and a series of other factors probably affect the distribution and behaviour of cod under Far Eastern Sea conditions relatively little, primarily because these factors show but very insignificant fluctuations, particularly in the pre-benthic layers inhabited by cod.

The thermic range, within the limits of which cod from the Pacific Ocean are found, is relatively low and can be estimated as -1.5 to 18° ; however, it must be narrowed down if we consider the reaction of cod to the temperature, age composition, sexual maturity and rate at which the cod are found.

By comparing the catches obtained by 344 trawl and at different benthic temperatures (Moiseev, 1934), we succeeded in proving that in Bering sea the adult cod are found during the summer between 1.3° below 0° and 7.3°C above 0°, however, the highest catches were obtained between 0.2° and 3.3° C above 0°.

Similar interdependence between the catches of cod on the hook and pre-benthic temperature has been observed near the eastern shores of Kamchatka.

Following the observations conducted by I. A. Polutov, experimental catches of cod on hook cordage that were carried out during the summer 1934-1935, showed the following interdependence between the results of the catch and the temperature of pre-benthic horizons (table 65).

TABLE 65.

Results of the catches of cod (per 1 hour per 2 fishermen) and temperature of the pre-benthic horizon.

	Temperature of the pre-benthic horizon					
	1-2	2-4	4-5	5-6	6-7	7-10
Catch of cod (in number of specimens) per two fishermen per 1 hour of fishing:	23.8	32.7	51.4	43.2	25.3	5.1

The figures presented above enabled us to assume that the temperature of pre-benthic horizon between 2 and 6°C is the most favourable for the existence of cod during the summer. No cod was found at temperatures below zero. Let us point out once more that in waters washing Greenland the cod are found between 0.85 and 10°, however, we observed concentrations at the temperatures of 3 to 5°C. (Beange 1931,1932; LeDanois and Beange, 1931).

In order to juxtapose the data on thermic ranges inhabited by cod, let us consider the following table:

TABLE 66.

Temperature ranges within the limits of which the cod of Pacific Ocean are found during the summer.

Region	Water temperature at which the cod are found:			Temperature range	The data provided by:
	Minimum	Optimum	Maximum		
Bering Sea	-1.3	0.2-4.5	10.0	11.3	Moiseev
Sea of Japan	-1.2	1.2-7.0	9.0	10.2	Krivobok
Sea of Japan	4.0	-	13.0	9.0	Uchida
New Foundland and Greenland	0.85	3.0-5.0	10.0	9.15	Boger?

We may see that the threshold, as well as optimum temperatures, at which the cod from Pacific Ocean are found in different regions are affinitive. The water temperature of the regions inhabited by cod from the southern areas is somewhat higher, however, the difference is rather insignificant, although regular.

Much more considerable changes in the temperature gradients occur in the same region in the course of the year. The broad scale of seasonal thermic fluctuations in the surface layers (up to 150-250 meters) of the Far Eastern Seas is one of the reasons for the regular migrations of cod, which have been already discussed in brief.

While in the northern section of the zone of propagation the post-spawning migrations of cod are towards the shore, into the shallow waters, they are towards the zone with higher (for the given area) temperatures, the cod inhabiting southern regions proceed as the temperature of coastal waters rises progressively farther away from the shores sinking to the depths at which the relatively low temperatures change but very little.

Thus in the Bering Sea, Northern half of the Sea of Okhotsk and northern part of the Sea of Japan during the winter the majority of benthic fish, the cod included, migrate to greater depths, into the zone of pre-benthic temperatures above zero. During the spring (April-May), as the littoral waters become heated, the cod migrate into the opposite direction to shallow waters, where they remain throughout the warm season.

DRAWING 13.

April May

July August

October

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Catches in number of fish specimens caught per 1 hour of trawling.

DRAWING 13-Ctd -

Temperature of pre-benthic horizon.

Fig. 13. Vertical distribution of cod depending on the pre-benthic temperature.

Fig. 13. was drawn on the basis of data obtained during the operation of trawlers in the Sea of Japan in 1932-1933 (collected by Krivobok) and clearly demonstrates the aforesaid. In April, when the prebenthic temperatures in the littoral zone are below zero, the cod are found at the depths of 55-60 to 400 meters, where the temperatures are usually above 0° .

In May, the cod drift to lesser depths, where the temperatures rise by this time above 0° , deserting greater depths (over 200 meters). In July-October the cod are found mostly at the depths of less than 100 meters within the temperature limits of 1 to 5° .

At the same time, in the southern part of the Sea of Japan, near the southeastern coast of Korea (following the data of Uchida) in connection with the intensive warming up of the coastal waters during the summer, the cod live at the depths of at least 100 meters and more (usually between 100 and 200 m), where at this time the temperature does not rise above $6-8^{\circ}$.

During the autumn, in November, as the littoral waters drop and the pre-benthic temperatures decrease in the shallow areas to $12-13^{\circ}$, the cod begin migrating toward the shores, where in December-January the temperatures drop to 5 and less degrees.

During the spring, in April-May, the rapid rise of the

temperature in the coastal zone is accompanied by the drift of large cod away from the shores. A similar scheme of seasonal migrations of cod depending on the fluctuations in temperature was observed in the region of the Southern Kuril Islands and near the shores of Japan. Near the shores of Southeastern Sakhalin the adult cod (April-May) together with herring, on which they intensively feed at this season, approach the shores, then, when the temperatures in the littoral zone rise, leave the shallow waters and are no longer found at the depths below 25-30 meters, where during the summer the temperatures in the pre-benthic horizons rise to 15° and more. The fish gradually sink deeper and deeper as the surface layers of water warm. In August-October the cod drift to the depths of 200-250 meters, from where they begin migrating back to the shores in December.

Near the shores of Western and Eastern Kamchatka, seasonal migrations of cod, which considerably depend on the changes in thermic conditions, are very similar to those in the Sea of Japan. We merely wish to add that in the former as well as in the latter regions we observed during the warmest seasons migration of adult cod away from the slight depths, at which they are found at the beginning of the summer, to somewhat greater depths. This phenomenon is caused by the increase in pre-benthic temperatures rising to $10-12^{\circ}$. In the Bering Sea (particularly in its northern section) having approached the shores, the adult cod remain in

the shallow waters throughout the entire warm season without migrating to any distance so considerable they would be worth mentioning since in the majority of regions of Bering Sea the pre-benthic temperatures during the summer do not reach indices unfavourable for the existence of cod.

Cod fry prefer somewhat higher temperatures. Thus, near the shores of Korea, when the adult cod leave the shallow waters after the temperature of the latter reaches $12-13^{\circ}$ and more, the young specimens drift to the deeper regions only after the pre-benthic temperature reaches 17° .

No adult cod has been observed in the Southern Kuril shallow region during the summer as they sink to the depths of over 150-170 meters, however, we often encountered small cod belonging to the generation hatched during the current year. Near the southwestern shores of Sakhalin the cod fry are found throughout the entire summer season at depths of 10 meters and more, while the adult cod remain at depths of at least 25-30 meters. The horizontal and vertical distribution of cod during the warm season is considerably affected by the spots of cold water with temperatures below zero, which persist throughout the summer in a number of zones of the Far Eastern waters, due to the intensive dueling of the surface layers of water during the winter.

While the cod avoid, as a rule, the regions that are constantly occupied by waters at a temperature below zero,

The sections of sea that are covered with domes of waters with negative temperatures at irregular intervals of time, are visited during the years when there are no such domes by cod and other fishes feeding here on highly nutritive biocoenoses.

Such pulsating cold spots form a peculiar, insurmountable barrier for the distribution of cod in the shallow waters and their presence and arrangement must be taken into consideration when evaluating the behaviour of cod during the summer of each year. In any case undoubtedly within the cold spots there are, nor can be formed concentrations of cod.

Such is in brief the effect of temperature on the behaviour and distribution of adult cod.

In the chapter on spawning we have already discussed certain data on the effect of temperature upon the development of roe and incubation periods. We wish to point out once more that we consider the temperature to be one of the most important factors affecting the behaviour and distribution of cod in Far Eastern Seas. We also wish to emphasize that, as we showed above, there have been observed in the Far Eastern Seas sedimentary water volumes that have been cooled down during the winter and fill vast spaces during the warm seasons. Shallow waters that are always covered with domes of cold water naturally become "regions of eternal cold" and, as a rule, are not visited by fish in industrial quantities (with the exception of Alaska pollack and *Hippoglossoides elassodon robustus*,

which form semi-industrial concentrations in certain sections of the cold regions) and therefore are without industrial importance. On the other hand, however, we know that layers within the limits of which there are water volumes at low temperatures below zero during warm seasons, but during certain years the configuration of these particular volumes substantially changes and at other times the cold layers entirely disappear. Investigations on the distribution of benthic biological volume of Western Kamchatka shelf carried out by Gordeeva (1948) enabled us to establish that the regions covered during certain years with waters at temperatures below 0° show the highest biological volume, including its nutritive portion. It is quite natural, therefore, that the cod as well as other benthic fish species (flounders, Alaska pollack, etc.) and crabs drift during the years when the cold layers vanish, to these areas rich in food, which were inaccessible to the majority of fishes until then because of the low temperatures all the year round. The distribution of cod (as well as other benthic and pre-benthic fish) during such years substantially differs from that during the years when hydrological conditions are different. We may assume that the increased abundance of food objects available in these areas at low temperatures during the winter may also be due to the fact that these regions are not visited by fish

during prolonged seasons and the benthic fauna is therefore left intact instead of being consumed during the annual migrations of cod, flounders and crabs towards shallow waters in search for food. Thus, peculiar reservation grounds of food objects are formed and are only accessible to fish during the warmest seasons of the year.

The aforesaid shows that the distribution and migrations of cod in the most important regions inhabited by these fish are closely related to the thermic conditions of the pre-benthic horizon and may substantially change during certain years.

Effective fishing of cod and forecasting of the location of cod concentrations cannot be successful without a well organized, systematic study of hydrological conditions of the industrial areas, as well as of those areas of which a thorough knowledge of conditions may explain and enable us to forecast possible changes occurring in the area in which we are directly interested. Observations on the fluctuations in the power of the Kurosivo current are particularly important, since the system of currents in the Far Eastern Seas and the hydrological conditions in this basin considerably depend on the Kurosivo current.

We may affirm that in summer in the Bering Sea the cod mainly inhabit two bathic and temperature zones: the littoral zone, within the limits of the depths of 15 to 60 meters, that are quite all heated by the

convictional currents and wind-mixing and the zone of the depths of 150-250 meters lying between the limits of lower horizons of the layer of winter cooling and upper horizons of the warm layer of water from the Pacific Ocean; it is characteristic of these zones that although neither actively sucked into the seasonal convectional mixing nor greatly affected thereby, their temperature indices remain almost constant throughout the year. Within the intermediate layer of cold, winter-cooled waters and particularly in the minus temperature zones, there are no industrial accumulations formed. This distribution of water volumes in the North Western Bering Sea is sufficient to explain the bathic distribution of cod in two horizons.

We observed a similar phenomenon near the Eastern shore of Kamchatka, where during the summer the cod inhabit the littoral warm-water zone. During the winter, due to intensive cooling of the surface layer the cod drift to greater depths that are not affected by the vertical circulation during the winter.

In the Sea of Okhotsk, or to be precise, in most of this Sea, the pattern of distribution of cod closely follows the pattern of distribution of water volumes.

As set out in the scheme of vertical zones of the sea of Okhotsk, suggested by Ushakov (1949), the most active processes and rather substantial seasonal changes in hydrological elements occur in the surface layer that is heated during the summer to depths of 40 to 50 meters.

The zone of "eternal cold", i.e. the layer of winter cooling with temperatures below 0° located at the depths of 180-220 meters above the zone of oceanic troposphere with little varying thermic, oxygen and salt indices. We also wish to point out that the suggested scheme fully corresponds to the distribution of water volumes in the North Western part of the Sea of Okhotsk, along the Eastern coast of Sakhalin and in a number of central zones of the sea. However, it can be considered as correct for the coast of Western Kamchatka, where the layer of "eternal cold" is rather changeable.

Active migrations and accumulations of cod in the Sea of Okhotsk depend primarily on the surface layer heated during the summer; this layer warms up the littoral area of shallow waters to which the large schools of fish drift from the spawning regions, where the fish remain throughout the warm season; the upper horizons of the oceanic "troposphere" remain at temperatures above zero and here the cod concentrate during the winter and remain in some numbers during the summer as well. After the winter-cooled layer reaches temperatures above 0° , the cod move into the areas freed from low temperatures where, as a rule, they find the characteristic high content of nutritive objects.

In the Sea of Japan and in part near the shores of Southern Sakhalin and Northern Hokkaido that are considerably affected by the system of currents in

the Sea of Japan, the cod are associated throughout their whole life with the water volumes of Eastern China Sea and Pacific Ocean origin, which, in the process of migration through the Sea of Japan become modified. Cod are found at depths of 200 meters and more in the Sea of Japan waters proper that vary little with the season. High summer temperatures of waters from the Eastern China Sea near the western shores of Japan, eastern shores of Korea and in part the southwestern shores of Sakhalin and northern shore of Hokkaido, account for the migration of the main bulk of cod during the warm season to the depths of 100 meters and more and their drift towards the shores during the winter. The altered and considerably cooled waters forming the Maritime current that washes the Maritime coast between Tatarski strait and Peter the Great Bay condition the behaviour of cod that drift away from the shores due to the winter drop in temperature from the depths up to the upper border of the Sea of Japan waters proper and return to the littoral zone in the spring, where the temperatures in the littoral zone rise above zero. Such is the general scheme of the interrelation between the distribution and migration of cod depending on the water volumes of different origin in the Far Eastern seas. It is quite natural that each region has its specific character and peculiar hydrological conditions which somewhat affect and modify the behaviour of fish and, in particular, of cod.

Determination of the arrangement of water volumes in the region investigated is one of the methods determining the distribution of cod accumulations on the basis of the above described regularities and interrelations.

We also wish to point out the rather considerable changes in the areas inhabited by cod, conditions of spawning and numerosity of the cod population, which occur, due to thermic fluctuations over a number of years - i.e. rise or drop in temperature.

Thorough investigations on this particular phenomenon have been conducted in the North Atlantic during the past century.

The works by numerous Soviet explorers who were the first to observe this exceptionally interesting phenomenon, are well known (see Berg, 1935, for summarized data on such observations). Maslov (1944) also presented a great number of data showing the substantial changes in the distribution and migration of cod in Barents sea.

The penetration of cod northwards under the effect of the recent warming up of the Arctic region, along the shores of Greenland, where this fish species has become an important industrial species during the last few years is well known (Taning, 1949).

Observations by Sund (1938) revealed that the regions of the most intensive spawning of the cod shifted from southwestern to northern offshores of Norway and that generations of cod hatched during the period of thaw are much more numerous than usual.

The article by Friedrichson (1949) generalizes the observations on the penetration of a series of southern animals into Arctic waters.

By analyzing numerous data available, Rollefsen (1949) arrived at the conclusion that great changes in the number of cod inhabiting the North Atlantic observed between 1870 and 1949, coincide with the periods of warming up and cooling down. Rollefsen assumed that one of the main factors determining the number of cod fry are the food conditions which, in their turn, depend on the fluctuations in hydrological conditions.

Beyond doubt, similar changes in the dwelling conditions of cod take place in the Far Eastern waters, where we revealed warm and cold periods lasting over a number of years, which depend in the degree in intensity of the Kuroshio.

The slight degree of fishing prevents us from discovering the exact effect of these multiannual fluctuations upon the number of specimens of Pacific Ocean cod, inhabiting different regions of the Far Eastern waters, however, certain data show that such fluctuations exist. Thus, in 1911-1915, in Peter the Great Bay, the cod constituted up to 20% of trawl catches and in 1930-1934 only 1-2%. In Avachinsky Bay, I.A. Polutov observed that the number of cod specimens forming a generation increase during warm years which he explains by more favourable conditions for the existence of cod fry.

The data presented in this chapter enable us to establish that the cod are found within the limits of the region inhabited by this fish in the Far East at rather similar optimum temperatures ($0-5^{\circ}$). The extensive range of seasonal thermic fluctuations in the surface layer (up to 150-250 meters) is one of the reasons for regular seasonal migrations of cod. While in the northern part of the region of their propagation (northern boreal regions) the post-spawning migrations of cod are towards the shore, i.e. to the shallow waters, into the zone of higher (for a given area) temperatures, the cod from the southern regions of propagation sink to the depths where the temperatures remain relatively low during the spring when the temperatures of littoral waters begin rapidly rising). During autumn the migration proceed in the opposite direction. The regions covered with waters at a temperature below 0° , which the cod avoid as a rule, play an important part in the distribution of cod in the shallow waters of Far Eastern seas. Changes in their configuration and complete disappearance during certain years substantially modify the distribution of cod during the summer. In the northern boreal regions the cod are distributed during the autumn, first of all in the upper warm zone (60-80 meters) and during winter - in the upper horizons (150-250 m) of the warm layer of the Pacific Ocean) (or Sea of Japan) water leaving the intermediate cold layer

of winter cooling practically vacant. It is quite natural that each region has specific hydrological conditions which slightly modify the behaviour of distribution of water volumes in a given region is one of the methods for determining the vertical distribution of cod.

FISHING INDUSTRY.

The earliest data on the distribution and frequency at which the cod is found along the North Eastern coast of Asia and western coast of America, appeared in the literature as a result of the activity of Russian seamen, travellers and explorers. Tikhmenov (1861) reported that as far back as in 1765 Russian seamen observed abundance of cod, halibut and navaga along the Pacific Ocean coast of Alaska. Krashennikov (1775) mentioned cod among the industrial fish species of Kamchatka. After that, the data on cod and fishing of this fish for local consumption purposes appeared in numerous bibliographical sources.

Veniaminov (1840) reported that cod near the shores of Alaska make seasonal migrations; drifting near the shores during the summer, where these fish are caught on the hook at the rate of several hundreds of specimens per a day per a boat, and falling to greater depths during the winter. Later Kryukov (1894), Slyunin (1900), Prozorov (1902), Shmidt (1904), Suvorov (1912) and many others indicated that the cod are abundant in the Far Eastern seas simultaneously

emphasizing that the fishing of this fish species is conducted on an insufficient scale. It was natural that the scant population of the Far East, in the late eighteenth and early nineteenth century essentially consisting of various local nationalities, should scarcely have fished cod at all, since cod-fishing must be done over the open sea; those people preferred to fish salmon in the rivers, because this required a considerably lesser effort.

Thus, the large reserves of cod in the Far Eastern Seas remained intact.

In the middle of the past century the industrial fishing of cod in Pacific Ocean began to develop. The first successful experiments in hook fishing of cod on an industrial scale were conducted in Tatarski strait by an American schooner "Timandra"; in 1857 during the transport cruise to Nikolayevsk on the Amur. After that a series of American schooners went cod-fishing in Tatarski strait and near the western shores of Kamchatka obtaining high catches. Soon, the cod-fishing off the shores of Kamchatka became an excellent excuse for a number of American poachers to illegally hunt sea-bears in Russian waters, an activity which, as is well known, is prohibited by international agreement.

Organisation of the active guard system by Russian government during the migrations of sea-bears and discovery of shallow water regions rich in cod near the shores of Alaska sharply reduced, then brought an end to the cruises of American schooners

off the north eastern shores of Asia. At the beginning of the twentieth century a Japanese cod-fishing fleet, which had reaches considerable dimensions by 1940, started operating in the Sea of Okhotsk and near the eastern coast of Kamchatka.

Between 1927 and 1929 Russian fishermen organized experimental and cod fishing from several schooners taken on a lease in the region of Kommandor and Karaginsky islands (Navozov-Lavrev, 1927-1928).

Results of this fishing can be seen from table 67 composed from observations by Navozov-Lavrov and Rozov, who participated in the fishing.

Results of the fishing were rather modest. However, if we compare these data with the mean catches obtained by large American schooners and with the average catches of 13 to 15 thousand species of cod per fisherman, we may easily see that effectiveness of cod fishing near the shores of Kamchatka that lasted for a very short period of time (51-57 working days only) from small and poorly equipped boats, was undoubtedly lower than near the shores of Alaska. The success of the first industrial schooners attracted others and the cod fishing in the Far East began developing on a large scale. Already in 1927, apart from the 219575 specimens of cod (5484 centners) caught by three schooners in Karaginski region, the littoral coastal fishing resulted in about 60 thousand specimens (about 1431 centners) of cod (the fishing stations were mainly situated on the western coast of Kamchatka), which constituted about 0.2% of the overall catch of fish in the Far East.

TABLE 67.

Results of the experimental cod fishing on board the schooners in 1927-1928.

Indices	Schooner no.1, 1927			Schooner No. 2,-1928			Schooner No.3,1928		
	Kom-man-dor	Kara-ginski	Total	Kom-man-dor	Kara-ginski	Total	Kom-man-dor	Kara-ginski	Total
Date of fishing	June 29-July 15	July 16 Sep.3	June 29 Sep.3	June 17-August 16	July 21-August 28	June 17-August 28	May 24-July 16	July 21-August 28	June 24-Aug.28
Depth of fishing	-	-	-	30-40	12-24	-	30-40	12-24	-
Number of boats	3	3	3	3	3	3	3	3	3
Number of fishermen	10	10	10	12	12	12	12	12	12
Crew	Thirty men in each schooner								
Working days	15	39	54	22	35	57	16	35	51
Catches (in number of specimens)	27673	89132	116805	30000	94920	124920	21885	67500	89385
Average per working day (in number of specimens)	1845	2285	2085	1364	2720	2191	1367	1930	1753
Average catch per 1 fisherman per day in number of specimens	184	228	208	114	227	183	114	161	146
Average weight of 1 specimen of cod in kg.	3.45	4.12	-	2.47	3.75	-	2.47	3.75	-
Observer"	Navozov-Lavrov			Rozov			Rozov		

With time cod fishing became progressively more popular. New fishing plants and companies organized the fishing of cod in the vicinal regions. Over a very short period of time it was established that almost everywhere along the coast of Kamchatka, Bering Sea and the Maritimes, cod can be successively caught on the hook throughout the entire warm season of the year.

In the spring, i.e. during April-May (less frequently at the beginning of June) the cod reach the shores along the immense coast line in abundance, i.e. from Penzhinski to Anadyrski Bay and from Peter the Great Bay to De-Kastri. Almost everywhere, where the fishing on cod has been organized, excellent industrial results have been obtained.

In 1928 the catches in the Far East reached 433363 specimens (or 117505 centners) of cod; in 1929 they constituted 1081464 specimens (38876 centners) and in 1930 the overall catches reaches 4180623 specimens (168353 centners) of cod. Practically the entire catch was obtained from the coastal zone of Kamchatka and Olyutorski Bay region and only 9000 centners were caught in Maritime region.

In 1930 the catches of cod in the Soviet waters of the Far East reached a rather considerable figure, which has been exceeded only during the post-war period. We wish to point out that the annual catches increase at a surprisingly high rate. In the course of the three years elapsed since the organization of the first experimental fishing of cod near the Soviet shores of Pacific Ocean, the catches obtained near the shores

of Alaska, where the fishing of cod was conducted for a long period. However, the catches of cod dropped sharply in 1932, due not to the state of the raw material, but to poor organization.

Fishing of cod by means of hook cordage can be successfully conducted along the entire western and eastern shores of Kamchatka, Northern and Southern Kuril Islands, in the region of Karaginski Island and Korf Bay, near Kommandor Islands, in Olyutorski Bay, Olyutorski-Navarinski region, Anadyrdki Bay, near the southwestern shores of Sakhalin, Northern and Southern Maritimes (particularly in the region of Nel'm Gulf) and in Peter the Great Bay.

The northern and north-western shores of Okhotsk Sea from Gizhiginski Gulf to Sakhalin Bay are without industrial importance due to the severe hydrological conditions. The eastern coast of Sakhalin cannot provide sufficiently high catches of cod for the same reasons as above.

The highest industrial results of cod fishing by hook cordage have been obtained near the shores of Kamchatka, in the Bering Sea and off the Kuril Islands.

Attached table 68 generalizes the data available on the average catches from a motor-boat in different zones of Far Eastern Seas.

It is interesting to note that fishing of cod on the hook proved to be highly effective. The cod from the Pacific Ocean swallows the hook prepared with any type of bait (and sometimes without any bait at all) and this simplifies fishing on hook cordage in this region as compared with similar fishing in Murman/

where, as is well known, success of the fishing on hook depends on whether capelin will or will not approach the shores and results of fishing on the latter fish serving as bait during fishing of cod. The cod from the Pacific Ocean can be taken on hook baited with any fish, mollusk, crustacea, sometimes a piece of cloth.

In spite of the aforesaid, we must admit that cod does possess a certain selective ability. Thus, the works by Polutov confirmed the fact established by fishermen from Eastern Kamchatka, who observed that during spring the cod must willingly feed on herring, during the summer on salmon and during the fall on Hexagrammos and that the cod was caught on Alaska pollack with great difficulty. The fishing where the following were used as bait proved to be the most successful: cattle-fish, octopus, herring, salmon, hexagrammos, smelt and navaga. The successful operation of motor-boats in Avachinski Bay enabled us to make catches of 1500-1800 centners per boat teams of motor-boat crews (144 working days)). The best teams of motor-boat crews (commanded by Kobylyanski, Malyakin and others) caught 4000 and more centners of cod over the season. In the Southern Kuril Islands the catches of cod per a motor-boat in 1949 reaches 1509 centners. Moreover, the same boats conducted fishing on salmon and herring and therefore, did not concentrate on cod-fishing throughout the entire industrial season. Numerous examples of analogous industrial activity of small motor boats near the shores of Kamchatka and in

Bering Sea enable us to assume that the average catch of 1500-2000 centners per a motor-boat can be reached in the majority of regions near the aforementioned coast. Even near the shores of Maritimes in the Sea of Japan during the drifts with sardine fishing nets, we obtained as a rule high catches of cod. Thus, in the region of Sovyetskaya harbour, there were cases when we caught within one operation up to 50 centners of cod per a motor boat and catches of 2-5 centners per fisherman per night were a usual phenomenon along the entire coast and particularly in its northern area between May and October. Thus in the fishing plant of Nelm in June-July 1938, alongside with the fishing of sardines, the crews of industrial boats caught 588 centners of cod, while only 58 centners were obtained by means of stationary fishing nets. The lack of serious attention to the fishing of cod deprives the fishing industry of a large amount of additional fish product.

The fishing equipment used in the Far East for cod fishing has not been thoroughly studied as yet from the point of view of its effectiveness and expediency, although there are numerous data showing that this equipment must be improved and modernized.

E.Yu. Manner obtained very interesting data by using for cod fishing special rods with 10 hooks situated one above the other along an extension of 6 meters. Having compared the catches obtained by means of this rod with the catches on a regular rod with three hooks that are fastened in the direct proximity

to each other, during the fishing at the end of June-
beginning of July, 1947, near the shores of the Northern
Kuril Islands, Manner obtained the data summarized in
table 69.

TABLE 68.

Mean catches of cod per 1 motor boat (in centners).

Fishing region	May	June	July	August	Septem-ber	Octo-ber	No- vem- ber	Aver- age	The data provided by:	
Olyutorski Bay	28.0	48.1	45.2	42.6				40.0	Polutov and Orekhova	
Karaginski region		8.5	20.0	28.4	22.0			25.7	Polutov	
Kamchatka Bay		7.6	14.3	15.9	23.6	18.3	10.7	15.1	" "	
Avachinski Bay 1944-1948	20.9	30.0	20.0	21.5	14.6	13.5	-	19.7	" "	
Western Kam- chatka (Bolshe- retsk, 1928	9.6	17.4	12.7					13.2	Krivobok	
Western Kam- chatka (Ozer- naya)	4.0	9.6	18.4	17.3	13.6			14.5	Polutov	
Northern Kuril Islands 1947		3.5	4.6	8.2				5.4	Manner	
Western Sakhalin 1946-1947 Region Chekhov- Pravda	5.9	9.3	8.1	4.2	5.6	7.4		6.7	Kulichenko	
Pravda-Gornoza- vodsk	2.2	4.2	6.8	7.8	7.0	4.9		5.4	" "	
Southern Kuril Islands 1946		4.2	13.5	10.7	3.9	0.4		9.86	Vedenski.	

TABLE 69.

Cod catches on the hook (by means of rods where the hooks are arranged in two different manners) near the Northern Kuril Islands between June 27 and July 13, 1947.

Description of the rod.	No. of fishings	Overall number of hooks	Summary catches	Catches per a fishing rod		Catches per a hook	
				No. of specimens.	In c-s of specimens.	No. of specimens.	In c-s of specimens.
Ordinary fishing rod	17	46	28	1.46	1.50	0.9	0.6
Fishing rod with 10 vertically arranged hooks	10	100	652	31.77	65.23	1.8	6.5

Effectiveness of cod-fishing by means of a rod, the upper hooks of which are situated at 8 meters from the ocean floor, is very high, as compared with the fishing rod having several hooks situated in the direct proximity of the ocean ground; the former produces a summary catch that is more than 40 times higher than the catch obtained by the latter and is 10 times higher when we calculate the catch per a hook. Once, E. Yu. Manner caught near the Northern Kuril Islands 18 centners of cod in the course of four hours of fishing. Undoubtedly, the above presented preliminary data prove the following important point: the cod from Pacific Ocean is little connected with the ocean floor during the summer, easily rises to lesser depths and usually remain in the pre-benthic horizons.

The history of trawl fishing in the Far East is considerably less striking.

Trawl fishing was initiated by two small steam trawlers "Fedya" and "Nakhodka", which were transferred in 1911 from the Black Sea to the Far East and in the course of several years (from 1911 to 1915) successfully operated in the Peter the Great Bay. The catches essentially contained flounders and Alaska pollack. The cod constituted in certain cases a considerable percentage of overall catches occupying the third place after flounders and Alaska pollack.

Bibliographical data (Tyrtov, 1911) indicate the dimensions of catches and the percentage of different species in the catches.

According to these data, the following were caught in Peter the Great Bay in the region of Askold Island between July 15 and October 15, 1911 (in pounds):

Cod	5593
Flounders	5592
	540
Sharks	220
Navaga, ruff and others	379.

Later on the researchers noted with surprise that the figures expressing the catches of cod and flounders were almost equal, which has never been observed since that time. We succeeded in utilizing the un-published observations by M.N. Pavlenko, recorded in a diary, which Pavlenko conducted during the operations of trawlers "Fedya" and "Nakhodka" in 1911-1915.

We succeeded in establishing that Tyrtov included Alaska pollack into the category of cod. The former constituted the largest portion of this group.

Generalizing the data contained in the diary by Pavlenko on the operation of the aforementioned trawlers, we obtained table 70.

TABLE 70.

Results of the operation of trawlers "Fedya" and "Nakhodka" in Peter the Great Bay between 1911 and 1915.

Year:	1911	1912	1913	1914	1915	1911-1915

Overall

catch in

centners: 1700 10000 11700 3400(?) 1500 29300

The data on 1914 and 1955 are incomplete, as we only know that catches for September and October constituted 2000c., and for February 19 - March 19, 1915, 1500 centners.

On the basis of the same data we established that in 1911 the composition of the catches was as follows: 45.5% of flounders, 39.8% of Alaska pollack, 10.0% of cod and 4.7% of other fishes. Such percentage of flounders, cod and Alaska pollack in the trawl catches approaches closely the composition determined for the trawl catches obtained in 1930-1933 (Moiseev, 1946), particularly if we take into account the fact that "Fedya" and "Nakhodka" operated mainly in October-December and February-April, when the concentrations of Alaska pollack in Peter the Great Bay are rather dense. Nevertheless, we wish to point out that on certain days in 1911 the catches of cod rather considerably exceeded the catches obtained in 1930 and 1933, which were low, as a rule.

Thus, on December 13, 1911, the cod constituted 25% of the overall catch i.e. 50 centners out of 200 centners.

Unfortunately, the trawl fishing, which started out so successfully did not develop, but came to an end.

There are documents clearly showing the hostile attitude of fish-industrialists and officials towards this effective fishing.

At the conference of fish industrialists of the Far East which took place in November 1911 in Vladivostok, there developed a discussion on the trawl fishing during which I. Solovey (1911) declared the following: "I shall not talk nonsense affirming that this is a predatory way of fishing or that they might catch all the fishes. I shall have the courage to call things by their proper names: trawlers are harmful for the entire Okhotsk-Kamchatka industry because they markedly depreciate the products brought from this region to the markets of Vladivostok". This point of view has been maintained by the majority of delegates present at the conference. Such was the attitude of the representatives of capitalist Russia towards this most effective fishing.

Soviet trawl fishing in the Far East started in 1929, when the first trawlers "Dalnevostochnik" and "Balkan" were sent to Vladivostok. In 1932 they reached the total of 20. Modern fishing boats, having a holding capacity of about 1000 tons, equipped with steam engines of 65-700 h.p., industrial equipment consisting of the 36-meters large otter-trawl, proceeded to explore the vast areas of North-West Pacific in the search for industrial accumulations of fish. From the first days.

of the existence of trawl fleet, the members of TINRO, which organized a series of expeditions in 1930-1939 in order to thoroughly study the distribution and biology of benthic and pre-benthic fishes, participated in the exploration and industrial cruises.

We wish to point out that up to 1930 we had no experience in trawling in **the** Far Eastern waters with the exception of that gathered during the operations of two small trawlers in Peter the Great Bay. We placed all our hopes in the successful outcome of the trawl fishing of cod and not of flounders, since the former can be salted directly on board the vessel and thus transformed into a high quality salted product, whereas the flounders had to be sold fresh, frozen or canned, which was very difficult in 1930-1933 in view of the fact that the fishing industry has been insufficiently developed for this kind of processing as yet.

Certain Japanese researchers (including Prof. Marukava) indicated that the West-Kamchatka cod-fishing regions are "the best in the world" and that operations conducted there by American and Japanese cod fishing schooners were highly successful. This fact and the high catches of cod obtained by fishing organizations of Kamchatka and Bering Sea region induced the members of trawling fleet to endeavour to locate large concentrations of cod within the limits of which they believed they could obtain high catches of this fish.

TABLE 71.

Catches of fish obtained by the Far Eastern trawling fleet in 1930-1933.

TABLE 71 - Ctd -

Catches of fish obtained by the Far Eastern trawling fleet
in 1930-1933.

Composition of catches	Years				
	1930	1931	1932b	1933	1930-1933
Cod in centners	12	1690	2966	927	5595
Cod in percentage	0.2	3.6	3.3	1.4	2.7
Flounders in centners	6223	44.400	78.749	60.308	189.878
Flounders in %	90.8	96.1	89.4	92.5	92.2
Other fishes in %	-	190 0.3	6434 7.3	3977 6.1	10.601 5.
Total in centners	6235	46.280	88.347	65.212	206.074

As a result of the numerous cruises of industrial, exploration and research boats across the vast reaches of the Far Eastern seas to different areas of the Sea of Japan, Okhotsk and Bering Seas, large accumulations of flounders with constantly high indices of catches have been found, while the catches of cod were modest to say the least (table 71).

During the first four years of its existence the trawling fleet caught only 5595 centners of cod, which constituted 2.7% of the overall catches, whereas the flounders came to 92.2% of the fishes caught. These low indices for the trawl fishing of cod, which were obtained by trawlers the process of operations, created an impression that trawl fishing of cod (and trawl fishing in general) is futile in the Far East this resulted in the liquidation of the Far Eastern Trawling Trust in 1934, and later, the majority of trawlers were transferred to other water basins.

However, the most superficial analysis of the operation of the trawling fleet in the Far East shows that the low effectiveness of operations of the trawling fleet was caused first of all by the shortcomings in the organization and lack of thoroughly and methodically conducted explorations.

Lengthy periods during which the trawlers did not operate, due to an unsatisfactory supply system, lack of qualified personnel, scarcity of fleet bases and distances between such and industrial regions - these and many other shortcomings in organization, which prove to be unsurmountable obstacles, prevented the development of the young trawl fleet. Vladivostok was at that time the only real base for the trawl fleet, yet it was 1200-1500 miles away from the fishing regions near the shores of Kamchatka and 2400 miles from Anadyrski Bay. The way from and to the base, repairs, unloading, and the time consumed for other purposes independent from fishing as such, occupied up to 90% of the time which trawlers had at their disposal. As a result, the effectiveness of operations was very low, the number of trawlings extremely small and periods of navigation were of short duration. It suffices to mention that in 1931 during the whole navigational period in the Bering Sea three trawlers launched only 446 trawls and in 1932 six other vessels cast 601 trawls.

The following table 72 presents complete data on the number of trawlings carried out by the Far Eastern trawling fleet with sufficient clarity.

TABLE 72.

Number of trawlings carried out by the industrial and exploration trawlers in the Far Eastern seas in 1930-1936.

Regions	Years								Number of trawlings per 1000 Sq. kilometers of shelf.
	1930	1931	1932	1933	1934	1935	1936	1930-1936	
Bering Sea	130	995	601	-	-	-	-	1 726	5.2
Sea of Okhotsk	391	366	954	618	-	-	-	2 229	26.3
Sea of Japan	1000	4000	4484	7100	3088	1924	2068	23.664	2150.0
Total	1521	5361	6039	7718	3088	1924	2068	27.619	

Indeed, the Bering Sea, which, according to all the data available, appeared to be the most favourable for effective trawl fishing and the richest in concentrations of cod, remained almost intact at the end of trawling operations, since the 1726 trawls launched over the 331 thousand square kilometers of the continental shelf of the Bering Sea cannot be considered as sufficient. Trawling was on a somewhat larger scale near the shores of Western Kamchatka and Peter the Great Bay has been covered by a grid at trawlings most thoroughly.

The scattered pattern of trawling operations which were often launched many tens of miles from each other, could not produce effective results. As we mentioned above, captains of the trawlers, which aimed at finding exceptionally heavy concentrations of cod that is concentrations of great extent and density neglected the most elementary rules of exploration and fishing within the limits of these concentrations. There was fishing along the lines perpendicular to the above line (i.e. the isobaths) followed by operations along the

isobath within the limits of which fish were discovered. In the majority of cases the boat followed general or somewhat varying courses launching the trawl at certain intervals and only in rare cases were attempts made to precisely define the limits of concentrations located. For example, we quote the data on a trawl fishing carried out by the trawler "Strelck" in 1931 in the Bering Sea. Operating in the region of C. Guenter? (Anadyrski Bay), the trawler proceeded northerly, launching one trawl after another. Trawl no. 230 caught 0.5 centners of cod. The following trawl brought 30 centners and the one after that 6.7 centners of these fish. The wise policy would seem to be to stop in the area where a concentration has been obviously located and to search it more thoroughly. However, the trawler continued its course in the direction previously taken. Following a certain period of time (trawl No. 39), the catch was 30 centners once more, but nonetheless, the trawler continued to follow its rectilinear course. After that, on its way back, when the trawler reached the area where industrial catches of cod were obtained, the trawler obtained good catches anew (trawl no. 245 - 4.9 centners; No. 246 - 20 centners), however, once more, the trawler did not stop to investigate, but pursued its course. This is characteristic of the operations of the majority of industrial boats. In the course of the entire period during which trawling operations were conducted in the Far East,

we did not observe a single case where a float (beacon) had been left to mark the concentration of cod discovered although this signal is an elementary requirement in industrial fishing, particularly indispensable in the Fareastern waters, where it is difficult to precisely establish the location due to frequent fogs, inexact maps, etc. The exploration trawlers, operated, as a rule, over short periods of time only, endeavouring to cover huge territories, and their explorations were therefore little more than superficial reconnaissance cruises. Thus, the expedition conducted by V. Shmit in 1931 on board the trawler "Plaston" in the Bering Sea operated for only 18 days and in 1932- for 29 days, during which the trawls were launched over the vast extent of the shelf - from the eastern shores of Kamchatka to St. Lawrence Island in the North and to the shores of Alaska in the East. Most other expeditions carried out in 1931-1933 also only one or two cruises. The aforesaid counted for the low indices of the mean trawl catches (table 73).

TABLE 73.

Mean catches per an hour of trawling in the Fareastern waters.

Region	YEARS						
	1930	1931	1932	1933	1934	1935	1936
Bering Sea	-	1,2	2,1	-	-	-	-
Sea of Okhotsk	4.3	7.9	9.3	14.7	-	-	-
Sea of Japan (Peter the Great Bay)	11.0	16.0	14.9	10.2	8.3	4.5	3.2

In the Bering Sea the mean catches for 1931-1932 fluctuate between 1.2 and 2.1 centners per trawling hour. In the Sea of Okhotsk (near the shores of Western Kamchatka) the average catch rose from 4.3 centners during the first year of trawling to 14.7 centners four years later (during certain months it reached 20.0 centners. Moiseev, 1946), and increased even more during the last few years. In Peter the Great Bay, where we soon discovered an area of winter concentrations of flounders, the mean catch reached its maximum figure during the second year of fishing, after which, however, the intensive fishing resulted in a rapid drop in the number of fish forming this shoal and, consequently, in a decrease of the summary and average catches (Moiseev, 1946). Thus, the figures expressing the mean catches, which are shown in table 73, are close to mean catches obtained by industrial boats in Murman waters for Peter the Great Bay only, where these catches were obtained through a great number of industrial trawlings within the limits of the so-called "Askold area" that has been thoroughly explored. The figures for mean catches in the sea of Okhotsk somewhat approach the mean industrial figures since the majority of trawlings took place in the southern zone of the West-Kamchatka shelf, where the flounders are found in the greatest abundance. The small number of trawlings in the Bering Sea and the huge territory of the continental plateau thus explored, make it impossible to regard the figures obtained as correctly expressing dimensions of the catches possible in this area.

The figures presented are mean results of extensive exploration fishing conducted by the Far Eastern trawling fleet on a large scale in the course of the first few years of its existence. Somewhat later on we shall dwell in detail on the results of the activity of different boats on different areas, which provide somewhat more accurate data on the conditions of industrial operations.

The results of the first few years of the operations of the trawling fleet showed that the composition of catches considerably varied depending on the areas of fishing.

TABLE 74.

Species composition of the cod caught during the summer in the Far Eastern Seas (in % of weight without the other fishes).

R e g i o n s o f f i s h i n g											
Species	Bering Sea:		B.S.	East-	Sea of Okhotsk				Sea of Japan		
composition	Ana-	Nava-	Korfo-	ern	South-	North-	South-	South	Ta-	Mari-	Peter
	dyr-	rins-	olyu-	Kam-	West-	West-	east-	Küril	tars-	tame	the
	ski	ki	ki	chat-	ern	ern	ern	Shal-	ki	coast	Great
				(win-	Kam-	Kam-	Sak-	low	strt.		Bay
				ter)	chat-	chat-	ha-	wat-			
					ka.	ka.	lin	ers.			
Cod	94.2	86.3	53.0	23.6	11.7	24.0	2.0	1.0	3.2	9.2	0.6
Alaska Pollack	4.2	8.5	5.0	--	3.1	12.0	6.0	4.0	4.0	8.4	2.3
Flounders	1.6	5.2	42.0	76.4	85.2	64.0	92.0	95.0	92.8	82.4	97.1

The most northern industrial region - i.e. the Anadyrski Bay - is characterized by the overwhelming percentage of cod in the trawl catches (94.2%) and by the almost complete absence of flounders. While moving towards the South, however, the number of cod in the catches decreases and that of flounders increases accordingly. Near the southwestern

shores of Kamchatka, in Tatarski strait and in particular in Peter the Great Bay, high trawl catches contained 85-95% of flounders. The specific weight of Alaska pollack in trawl catches expresses incorrectly the number of this fish available in the region, since neither the trawlers nor industrial boats fished on Alaska pollack in 1930-1933 in view of the low value of this fish and immediately drifted away from the areas where high concentrations of this fish have been revealed by accident.

Evaluating the mean trawl catches in the Far Eastern waters, particularly the trawl catches of cod, which are measured in number of cod specimens per an hour of trawling, we wish to point out once more that these mean figures cannot characterize industrial fishing as a whole and are merely results of the exploration cruises over the huge territory that has not been sufficiently explored and studied as yet; they cannot be compared with the mean catches obtained during regular fishing, such as, for example, the fishing in Murman waters.

In the chapter on distribution and migrations we already described a number of areas showing high concentrations of cod near the shores of Western Kamchatka and in the western zones of the Bering Sea, characterized by large uniform accumulations. In the same chapter we presented numerous examples of high catches obtained by individual trawls that often followed one another, in different regions of the Far Eastern seas, a fact, which confirms the existence of concentrations of cod within the

limits of which high industrial catches can be obtained.

On August 25-26, 1931, in the region of C. Guenter (Anadyrski Bay) the trawler "Balkan" obtained the following catches from seven successively launched trawls (starting from the trawl No. 14): 60.5 centners, 43 centners, 35 centners, 10 centners, 17 centners and 17 centners. Within 9 trawlings it lifted 197 centners of cod and 50 centners of Alaska pollack, i.e. 44 centners of cod per an hour of trawling. Naturally, the indices cited could have been improved by launching a beacon and methodically conducting the fishing in this area of dense concentrations of fish. It must be kept in mind that in 1931 and 1932 a number of trawlers found high concentrations of industrial character in this area. The trawler "Chayka" here obtained 13 centners of cod in the second half of August; "Plastun" in 1932 - from 5 to 25 centners; "Burevestnik" - up to 12.5 centners and so on.

Experimental trawl fishing on cod from the trawlers "Lebed", "Toporok" and "Gaga" conducted in 1951-1952 proved to be even more effective. Undoubtedly, during the summer the cod constantly form industrial concentrations here. Such examples can be quoted in great numbers, however, in the majority of cases the trawler did not stop, when it had found an industrial accumulation of fish and undertook no systematic fishing of the concentrations.

Industrial trawlers, which were stationed in Petropavlovsk - in Kamchatka - achieved rather encouraging

results during trawl fishing of cod during the last ten years. In February-March 1940 the trawler "Toporok" obtained mean catches of cod reaching 5-8 centners per trawl hour near the South Eastern coast of Kamchatka in the region of Utashud Island and Cape Sopochny. In December-February 1940-1942 high concentrations of cod where the trawl catches reached 8-10 centners, were obtained in the central zone of Kronotski Bay. Operation by means of the ordinary otter-trawls, the trawlers lost a **great** quantity of cod which escaped from the trawl while the latter was lifted on board. By using the data provided by Polutov, let us compose the following table 75.

Results of the trawl fishing of cod in February 1941 show this can be considered an industry. The mean catches of 11.4 centners of cod and the summary catch of 388 centners of cod within 34 trawlings show that a large pre-spawning concentration of cod had been **located**. During the following year 1942 the trawling operations in Kronotski Bay were repeated and in February the highest catches of cod, which formed 62.5% of the overall catches obtained by the boat, were obtained once more (1026 centners per a trawler per a cruise).

We must take into account the fact that these trawlers were fishing on flounders and not on cod. Therefore, the high percentage of cod, which was actually an accidental catch on the side and not the main catch during the winter, prove beyond any doubt that trawl fishing of this fish near the shores of Eastern Kamchatka (as well as in other regions) is possible and productive

during the per-spawning period.

We may assume that in other regions of the Far Eastern waters, in particular near the shores of Western Kamchatka, where in January 1939, the trawler "Lebed" obtained catches of cod at the rate of 10 centners per trawling hour, succesful cod fishing can be conducted during the per-spawning season.

Table 75.

Results of the trawl fishing of cod in Kronotski Bay in 1940-1941.

Date of the operations	Number of trawlings	Catches in c-s		% of cod in the catches	Mean catches in centners per 1 hour of trawling		Number of trawl that obtained more the 5 c. of cod.
		Cod	Summary		Cod	Summary	
December 1940	36	32	769	4.0	0.9	21	1
January 1941	64	130	722	18.0	2.0	12	12
February 1941	34	388	677	57.3	11.4	19	21
March 1941	49	92	445	20.7	1.9	9	4
April 1941	81	100	557	18.0	1.2	7	10
December 1940/ April 1941	262	742	3170	23.4	2.3	12	48

Summarizing the aforesaid, we may see that it has been established beyond doubt that cod can be successfully caught on trawl in a number of zones during the summer and autumn (Anadyrski-Navarinski region), summer and winter (eastern and western shores of Kamchatka) etc. Of course, the productiveness of trawl fishing of cod all year round will be lower in the Far East than in Barents Sea due to certain biological peculiarities of cod,

The configuration of the ocean-floor and specific characteristics of hydrological conditions of these regions, however, it is equally clear that the cod should form a considerable part of the catches obtained by the trawling fleet.

Trawl explorations of the shallow water plateau in the Far Eastern Seas were in a number of regions a reconnaissance operation, only carried out during the warm season by a small number of boats commanded by inexperienced crews, who operated in a number of cases without either applying elementary rules of exploration of fishing of the accumulations discovered on an industrial scale.

It seems probable that the cod from the Pacific Ocean do not remain on the Ocean-floor, but inhabit intermediate horizons, and we therefore feel it desirable to set up experimental fishing on a large scale by means of trawls somewhat elevated above the ocean-floor with a high vertical clearance (opening?). Up to the present time, the majority of exploration and industrial operations have been carried out by means of the usual 34-meters otter trawls, which are not very suitable for cod fishing. We think that the problem of cod fishing in the Far East can be solved consequent upon thoroughly conducted and thoughtfully set up cruises of exploration-industrial trawlers in the regions, where we have found or expect to find concentrations of cod.

Evaluating the pros and cons of various methods of cod-fishing, we reached the conclusion that cod-fishing in the Far East must be of varied character. On the one hand it is expedient to ensure development of cod fishing from small cod fishing boats and motor-boats which would operate by means of the hook cordage in the direct proximity of their bases. Near the shores of the Maritimes, Sakhalin, Kuril Islands, Kamchatka and along the western shores of the Bering Sea numerous local populations of cod will ensure successful fishing almost all the year round and along the entire extent of the shore line of the above-named regions. High yields, lengthy fishing periods and simplicity of operation, low cost of the fishing implements, and the chance to operate close to bases-such are the main advantages of this method of fishing.

On the other hand, it is absolutely essential to develop the medium size and heavy trawling fleet to be used all the year round. Cod would then play an important part in the assortment of catches obtained by such a fleet, particularly in the case of the boats operating near the shores of Kamchatka and in the Bering Sea. The opportunity to manoeuvre rapidly over wide areas at great distances from the bases, operations at great depths, annual navigation, high mechanization of fishing and high catches obtained per fisherman - such are the advantages of the trawl

fishing of cod.

The wisdom of special fishing of cod from large schooners is very doubtful.

It must be kept in mind that the effectiveness of a schooner as a fishing vessel is relatively low, since it requires a great number of workers for fishing on the hook conducted from this type of vessel and for processing the fish which is also done directly on board the schooner.

The great distances between the fishing grounds and the shore bases (Western Kamchatka, Kommandor Islands, etc.) account for the long cruises to the fishing place and back, while the climatic factors, making winter navigation impossible, narrow down the period of industrial activity of the schooner even more.

If we take into account that 1500-2000 (up to 4000 centners of cod can be caught from a motor-boat having a tonnage of 12-15 tons and serviced by a crew of 5 - 6 men on board usually reaches on an average 3-4 thousand centners, it becomes clear that the effectiveness of fishing from small boats which daily deliver the fish to the bases on the shore, is much higher.

We believe that considering the specific biological properties of the cod from Pacific Ocean and peculiar conditions under which these fish live, it is wise to use small motor-boats for fishing cod.

These motor boats should be provided with hook cordage. Trawlers with large modern trawls should also be used. Under conditions of the Far East, the cod-fishing cannot be conducted according to one single method.

Provided there is regular and uniform development of the industrial fishing of cod along a considerable part of the Pacific Coast of the Soviet Far East, its catches can be greatly increased.

Let us dwell briefly on cod-fishing near the Pacific shores of America, in Japanese and Korean waters.

As Kobb correctly indicated (1916), "The history of the Pacific-Ocean cod-fishing denotes the energetic struggle of a few individuals and companies against the gigantic cod fishing industry along the Atlantic coast". This statement remains correct for our epoch as well. The rate at which the cod are caught near the shores of Canada and Alaska, is first of all determined by the conjuncture of the market and results of the competition between different fishing companies and not by the raw material available. In view of the aforesaid, the fishing cod in this region was never conducted on a large scale and was limited in the main to several areas which were known to contain large concentrations of cod, while a great number of similar zones near the Pacific shores of America were left intact. The fishing is mainly conducted from schooners and from shore bases by means of small fishing boats.

The American fishing of cod which started in 1863 (after 7100 specimens of cod were caught in the Okhotsk sea), resulted 6 years later (in 1869) in an overall catch of more than a million specimens of cod, but was not further developed and is still on a level similar to that at the beginning. The establishment of shore bases from where cod-fishing has been conducting as well as from boats increased the summary catch, however, the latter is still rather low judging by the official data presented in Fishery Resources of United States for 1945 on the fishing of cod near the Pacific Ocean shores of North America during the last 35 years (the mean annual catch is shown in thousands of centners):

1914-1918: 136.0, 1921-1922: 40.8; 1926 - 108.9;
1927-1935: 72.6; 1938-1942: 45.4.

The above quoted source indicated that "the transportation over long distances and low market price of the fish account for the decreased catches of the last few years".

The fishing of cod in Japan and Korea was considerably more developed. The overall catches of cod in Japan proper and in the so-called "far waters" (i.e. Kuril Islands, Southern Sakhalin and near the shores of Kamchatka) as well as in Korean waters reached 2346 thousands of centners in 1935 (see table 76).

TABLE 76.

Catches of cod in the northern zone of the Pacific Ocean
in 1929-1938 (in thousands of centners).

Fishing regions	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	Mean catch for 10 years
Catches obtained by the USSR	39	168	161	94	40	48	65	67	72	137	89
Japan proper											
(mainly Hokkaido)	863	830	792	845	938	996	1039	1087	959	980	933
Japanese catches in far waters mainly Kuril Islands, Sakhalin and Kamchatka waters)	283	378	348	514	693	762	1100	1088	962	828	696
Korea	260	303	357	363	344	236	207	149	142	197	256
Total catch in the northwestern part of Pacific Ocean	1445	1679	1658	1816	2015	2042	2411	2391	2135	2142	1973
Pacific Ocean shore of Northern America (approximate figures)	70	68	66	64	61	60	58	55	50	47	60
Total catch in the Northern part of the Pacific Ocean	1515	1747	1724	1880	2076	2102	2469	2446	2185	2189	2033

TABLE 77.

Cod fishing near the shores of Southern Sakhalin and Kuril Islands.

Years:	Northern Kuril Islands			Southern Kuril Islands			
	Overall catches in thousands of centners	Number of boats	Average catch per a boat (in centners)	Overall catch in thousands of centners.	Number of boats	Average catch per a boat in centners	Southern Sakhalin catches in thousands of centners
1934	37.8	62	608				148
1935	57.1	65	578				152
1936	30.6	68	449				159
1937	15.1	60	248				134
1938	39.9	58	636	133.0	90	1470	110
1939	145.0	102	1422	188.0	155	1213	105
1940	159.0	92	1740	133.0	80	1660	139
1941	175.0	95	1840	224.0	164	1360	291
1942				116.0	45	2580	169
1943				137.0	53	2600	166
1944				?	10	2200	115
1945							200

Fishing of cod was conducted by means of casting nets and trawls from small boats, by means of trawls from medium size trawlers, as well as by many other fishing implements. In northern waters and primarily near the shores of Kamchatka and Kuril Islands, the fishing was conducted by means of multistage fishing nets mostly from schooners with several small boats at their disposal and from ships with motors of 100-200 h.p. capacity.

Intensifying the fishing of cod near the shore of Southern Sakhalin and along the Kuril Islands, without regard to the need to protect certain reserves of this fish during some years, the Japanese fishermen caught up to 600 thousands of centners of cod in the regions which, since that time have been reunited with the Soviet Union.

The cod fishing in southern Sakhalin waters was particularly intensive. As is well known in this region the fishing activity drops sharply after the vigorous drift of herring and the fishing of cod somewhat compensates the drop in the overall catches. In 1912-1913, the catches of cod reached their record figure - 538 thousands of centners, after which it began rapidly sinking remaining from 1934 to 1945 within the limits of 100 and 300 thousands of centners. Catches of cod in the waters washing the Kuril Islands, were relatively high; moreover, the region around the northern group of these islands is considerably more effective than the southern zone (see table 77).

Fishing of cod near the shores of Japan proper was conducted in the main around Hokkaido Island, where the annual catches reaches 700-800 thousands of centners of cod. The catches of cod in Korean waters were also considerable (up to 360 thousands of centners in 1932).

Thus, the summary catch of cod in the northern zone of the Pacific Ocean (up to 2470 thousands of centners) considering the low intensiveness of fishing and almost intact reserves of this fish in the northern sector of the region inhabited by cod is only 5-6 times lower than intensive fishing of cod in the northern part of the Atlantic Ocean (up to 13-15 thousands of centners).

The data presented in this chapter show that the history of the fishing of cod in the Far Eastern waters is a rather short one. Only since 1927 has the fishing of cod by Soviet organizations become an independent branch of industry and the catches have since totalled 170-220 thousands of centners of cod. Despite the rather effective fishing of the hook in the Bering Sea, near the shores of Kamchatka and Sakhalin (up to 2.5 - 2.7 thousands of centners of cod per a motor boat) modern fishing is not yet conducted on a scale corresponding to the amount of raw material available.

The attempt to organize trawl fishing in Far Eastern waters in 1930-1933 proved unsuccessful as a result of a great number of shortcomings from the point of view of the organization and insufficient scale on which the exploration work was conducted. Analysis of the operations carried out and results of the exploration cruises enable us to affirm that the trawl surveying conducted in 1930-1933 was of purely reconnaissance nature, was carried out during the warm season of the year and in the majority of cases did not obey the elementary rules of industrial fishing of the concentrations discovered.

Certain high trawl catches of cod near the shores of Kamchatka and in the Bering Sea obtained between 1930 and 1933, the results of the expedition of the TINRO in 1937-1939, the constantly high winter trawl catches of cod from industrial boats off the shores of Kamchatka

in 1940-1942 the discovery of large industrial accumulations of cod in Anadyrski-Navariniski region by the expedition TINRO in 1950-1952 - all this leads us to believe that the trawl fishing of cod in the shallow regions near the shores of Kamchatka and, particularly, near the northwestern shores of the Bering Sea can be sufficiently effective.

FLOUNDERS

BRIEF ZOO-GEOGRAPHICAL DESCRIPTION.

The large order of Pleuronectiformes is divided by the classification of Berg (1941) into five families (Psettoidae, Bothidae, Pleuronectidae, Soleidae and Cynoglossidae). The overwhelming majority of species inhabit equatorial waters and only two sub-families (Scophthalmi and Pleuronectini) are found in boreal seas; moreover, the species belonging to the sub-family Scophthalmi are essentially found in the Atlantic Ocean, while the majority of species of the Pleuronectini sub-family populate the northern part of the Pacific Ocean. The flounders belonging to the sub-family Pleuronectini are the most numerous form large concentrations and are most important from the industrial point of view. Among the 33 species of flounders (sub-family Pleuronectini) inhabiting the waters washing the Pacific shores of Asia, 28 are found near the shores of the Soviet Far East (table 78) while three species (*Pleuronichtys cornutus*, *Dexistes rikuzenius* and *Tanakius kitaharae*) may be encountered in the South Kuril shallow waters or near the southern shores of Sakhalin.

Thus, the majority (90.9%) of the representatives of the sub-family Pleuronectini from the Asian part of Pacific Ocean inhabit the Far Eastern waters of the USSR and only a few representatives of the Indian-Australian fauna, encountered near the southern shores of Japan, do not reach our waters. Representatives of other families of the order Pleuronectiformes (Heterosomata) are not found in the Soviet Far Eastern waters with the exception of *Paralichtys olivaceus* (Bothidae). Along the northwest Pacific coast the representatives of sub-family Pleuronectini are found between Taiwan and the Bering strait, penetration into the Chukotski sea, i.e. are distributed between 20° - 22° and 70° of northern latitude. However, the majority of species are adapted to the region situated between 32° and 56° - 58° of northern latitude, i.e. from the southern shores of Japan and the northern shores of Kamchatka, within the limits of the moderate zone of the North Pacific Ocean, which confirms the boreal character of this family. Thus, for example, to the North from 64° of northern latitude there are found 3 species; between 54° and 64° of northern latitude (excluding the western coast of Kamchatka to the North of cape Yuzhny) - 12 species; between 48° and 56° of northern latitude (including the entire West-Kamchatka shelf, but excluding the Bay of Terpeniya) - 28 species;

between 40° and 48° of northern latitude - 24 species;
in the region between 32° and 40° of northern latitude -
25 species and between 24° and 32° of northern latitude -
5 species. It is here, in the moderate zone of the
North Pacific Ocean that the overwhelming majority
of species live; moreover, the most important
industrial flounders belonging to the genera *Limanda*,
Pleuronectes, *Pseudopleuronectes*, *Cleisthenes*,
Hippoglossoides, *Hippoglossus*, *Atherestes* and others
are adapted to the north-boreal areas of this region.
The great generic variety of flounders inhabiting
these regions attracted our attention. 33 species
of flounders found near the Pacific coast of Asia
(to the North of Taiwan) belong to 25 different
genera, 19 of which comprise one species only,
4 genera include 2 species and only two genera
consist of three species each.

The sub-family *Pleuronectini*, which amalgamates
all the industrial flounders of the Far Eastern
waters and representatives of which live in the
main near the Soviet shores of the Far East and in
adjacent waters is of great practical interest to
us. In order to facilitate further zoo-geographic
analysis, let us discuss in brief the species com-
position of each genus of the aforementioned sub-
family and its geographic propagation.

Genus ATHERESTHES is a local Pacific genus and can be
divided into two species inhabiting the waters near
the northwestern shores of the Ocean: *A. evermanni*

Jordan et Starks - from the shores of the Japan to the Northern Bering shallow waters. *A. stomias* (Jordan and Gilbert) inhabits the waters washing the northwestern shores of the Pacific Ocean from the Bering Sea to San Francisco.

Genus REINHARDTIUS - comprises one species only (*R. hippoglossoides* Walbaum) divided into the two sub-genera having amphi-boreal propagation. *R. hip. hippoglossoides* (Walbaum) inhabit great depths of the northern part of Atlantic Ocean to the North from the line C. Newfoundland-British Islands. *R. hip. matsuurae* Jordan et Snyder are found in the upper horizons of the depths of the northwestern Pacific Ocean.

Genus HIPPOGLOSSUS shows an amphi-boreal propagation. In the northern part of the Pacific Ocean (near the Asian as well as American shores) it is represented by the Pacific Ocean boreal *H. hyp. stenolepis* Schmidt and in the northern part of Atlantic Ocean, from Spitzbergen to Biskayski Bay and from Greenland to Cape Cod it is replaced by *H. hip. hippoglossus* (Linné).

Genus HIPPOGLOSSOIDES, having an amphi-boreal propagation consists of five sub-species, among which the *Hip. el. elassodon* Jordan et Gilbert, *Hip. el. dubius* Schmidt and *Hip. el. robustus* Gill et Townsend are inhabitants of the Pacific Ocean; moreover, all the three are found near its northwestern shores and *Hip. el. robustus* penetrates as far as the Pacific coast of North America.

Hip. platessoides (Fabricius) is the only species found in the Northern Atlantic Ocean. Hip. plat. platessoides inhabit the waters near the shores of Greenland and along the northwestern shores of North America to the South from Cape Cod, while the Hip. plat. lomanoides (Bloch) occupies the opposite side of the ocean inhabiting the region between Barents Sea (including Spitsbergen) and Medverh'i Islands) up to the shores of England.

Genus ACANTHOPSETTA is a genus to the northwestern part of Pacific Ocean represented by one moderately boreal species (ac, Nadeshnyi Schmidt) populating the waters of the Sea of Japan, Okhotsk Sea and southwestern part of Bering Sea.

Genus CLEISTHENES, represented by a single south-boreal species (Cl. Herzensteini (Schmidt) is endemic to the sea of Japan and waters washing the Japanese Islands.

Genus LYOPSETTA represented by species L exilis (Jordan et Gilbert) is endemic to the American Pacific and found near the shores of Alaska and California.

Genus EOPSETTA - is endemic to the Pacific Ocean, and has an amphi-Pacific distribution. Of the two species belonging to this genus, the E. Jordani (Lockington) is found near the North American shores of Pacific Ocean between Puget-Sound and Monterey, while the sub-tropic boreal species

E. Grigorievi (Herzenstein) is propagated between Tayvan and the northern shores of Japan.

Genus PSETTICHTHYS represented by the species *P. melanostictus* Girard is found along the Pacific coast of North America between Sitka and Monterey.

Genus VERASPER is represented by two endemic Asian species found in the Pacific Ocean: South-boreal *V. moseri* (Jordan et Gilbert) and subtropic-boreal from *V. variegatus* (Temminck et Schlegel) inhabiting the waters between Tayvan and shores of Sakhalin.

Genus CLIDODERMA is an endemic Pacific genus represented by a single south-boreal species *Cl. asperrimum* (Temminck & Schlegel) found near the shores of Japan.

Genus HYP SOPSETTA with the only species *H. guttulata* (Girard) is known to populate the waters washing the shores of California.

Genus PLEURONICHTHYS comprises seven Pacific endemic species encountered only in the northern part of the Pacific Ocean, namely: near the shores of Japan, China, Formosa, *Pl. cornutus* (Temminck et Schlegel), near the shores of California (*Pl. verticalis* Jordan et Gilbert, *Pl. nephelus* Starks et Thompson, *Pl. coenosus* Girard, *Pl. ritteri* Starks et Morris, *Pl. tocellatus* Starks et Thompson) and along the Western shores of North America from California to Alaska (*Pl. decurrens* Jordan et Gilbert). This amphipacific genus is the only representative of the subfamily Pleuronectini, comprising a greater number

of species near the Pacific coast of America than in the waters washing Asia. So far this fish has not been found in our waters.

Genus ISOPSETTA is a Pacific endemic with the only representative *I. Isolepsis* (Lockington) inhabiting the waters washing the shores of Northern America between Puget Sound and Southern California. Very affinitive to the genus *Lepidopsetta* and might be identified in the future as a synonym of the latter.

Genus PAROPHRYS comprising one species only (*P. vetula* Girard) is also an American Pacific endemic found between Sitka and Santa Barbara (Southern California).

Genus Lepidopsetta consists of two sub-genera: *Lep. bil. bilineata* (Ayres) and *Lep. bil. mochigarei* Snyder. The former form is widely propagated in the northern part of Pacific Ocean from the shores of Kamchatka to the northern shallow-water plateau of the Bering Sea and descend southwards to Monterey along the Pacific coast of North America. The second form is localized in the sea of Japan, near the shores of Japan and in adjacent regions. The genus *Lepidopsetta* is an endemic of the Pacific Ocean.

Genus LIMANDA comprising 5 species of the most important industrial flounders. The panboreal *L. aspera* ascend from the shores of Korea to the North reaching Chukotski sea and descend along the Pacific coast of North America to Vancouver. In the north-western part of Pacific ocean there exist two affinitive

species, one of which - North-boreal form (*L. punct. proboscidea* Gilbert) inhabits the northern zone of the region of propagation of *L. Aspera* penetrating southwards to the Cape Terpeniya (eastern coast of Sakhalin) and is replaced farther to the South (near Korean Bay) by the moderately boreal *Lim. punct. punctatissima* (Steindachner). The Atlantic Ocean near the coast of North America (from Labrador to New York) is populated by *L. ferruginea* (Storer) and near the shores of Europe (from the Murman coast to Biskayski Bay) - by *L. limanda* (Linneé).

From the systematic point of view the Atlantic *Lim. limanda* and the Pacific *L. aspera*, as well as the *Lim. ferruginea* and *Lim. punctatissima* are the forms most affinitive to each other. The amphiboreal character of these two groups of species further emphasizes the exchange of faunae which occurred recently between the northern zones of the Atlantic and Pacific Oceans.

Analysis of the regions of propagation of *L. punct. proboscidea* and *L. Punct. punctatissima* leads to assume that the formerly separated regions are gradually approaching each other anew. The centre of the region inhabited at present by *L. Punct. proboscidea* is located near the shores of Kamchatka, while that of *L. punct. punctatissima* - in the northern zone of the sea of Japan.

Genus PSEUDOPLEURONECTES unites three species, two of which (/Ps. herzensteini (Jordan et Snyder) and Ps. yokohamae Guenter)/ exist in the sea of Japan and near the shores of Japan, while Ps. americanus (Walbaum) inhabits the waters washing the Atlantic coast of North America - from Labrador to Chesapeake. It is interesting to note that the fish of this genus, which populate the waters washing the Pacific coast of Asia, belong to the south-boreal species. The ps. americanus is adapted to cooler water and is a purely boreal form.

Genus Dexistes has one single representative - the species D. rikuzenius Jordan et Starks, which can be found only near the shores of Japan.

Genus PLEURONECTES includes a series of species amalgamated under four subgenera: Pleuronectes, Platichthys, Liopsetta and Platessa (Shmidt, 1950). The two affinitive species are Pl. stellatus Pallas and Pl. flesus Linne ; moreover, the latter includes a number of subspecies (Berg, 1949) and inhabits the northern part of Atlantic Ocean (from the Black to the Bering Sea). The essential boreal Pl. stellatus are wide-spread in Pacific Ocean and ecologically related to the littoral zone with a low salt content; this form can exist at temperatures below 0° and

frequently penetrates into rivers and Chukotski Sea. This flounder is marked by an amphiboreal propagation. Among the four species classified under the subgenus *Liopsetta*, two - *Pl. obscurus* (Herzenstein) and *Pl. pinnifasciatus* (Steindachner) are endemic to the basin of the Sea of Japan and adjacent waters, *Pl. Putnami* (Gill) are found near the Atlantic coast of North America, while *Pl. glacialis* (Pallas) is wide-spread in Arctic waters. All the above-named forms are essentially adapted to coastal waters and frequently penetrate into the rivers.

The existing, partly circumpolar, partly amphiboreal propagation of the representatives of subgenus *Liopsetta*, while the basin of Pacific Ocean is inhabited by two and that of Atlantic Ocean by one endemic, is probably a result of the penetration along the shores of Asia or America of the representatives of this subgenus, a part of which (*Pl. glacialis*) became adapted to low-temperature waters with a low salt content, and became widely spread over the Arctic zones.

We observed in the basin of the Sea of Japan the formation of two morphologically and ecologically affinitive forms - *Pl. obscurus* and *Pl. pinnifasciatus* having a rather limited area of propagation the borders of which do not go beyond the limits of the Sea of Japan; these species, adapted to the littoral waters with a low salt content, spawn at temperatures below 0°.

Subgenus PLATESSA, consists of two species - *Pl. platessa* (Linne) and *Pl. quadrituberculatus* (Pallas) - and is spread amphiboreally.

Pl. platessa inhabit the waters washing the shores of Europe from the White Sea and Barents Sea to Southern France.

while the *Pl. quadrituberculatus* are propagated between Peter the Great Bay and the northern part of Bering Sea. It is interesting to note that while the fry of the Atlantic form regularly visit fresh waters, the Pacific *Pl. quadrituberculatus* inhabit relatively great depths (over 50 m) and as a rule, do not penetrate into the mouth of rivers (although once a specimen was caught near the mouth of river Lyutoga in the Bay of Aniv/Schmidt, (1904/)).

Genus MICROSTOMUS has three species - *M. kitt* (Walbaum), *M. achne* (Jordan et Starks) and *M. pacificus* (Lockington), and shows a wide amphiboreal propagation. The affinitive flounders *M. achne* and *M. pacificus* inhabit the following waters: the former populates the littoral zone of Japan and China, the latter - waters washing the Pacific coast of North America from Alaska to Southern California. *M. kitt* are widespread near the northwestern shores of Europe from the western part of the Barents Sea to the Bay of Biskay.

Genus EMBASSICHTHYS with a deep water species *E. bathylius* (Gilbert) has been discovered near the shores of California at depths of 800 to 1200 meters.

Genus TANAKIUS including one single species - *T. kitaharae* (Jordan et Starks) is a Pacific-Asian endemic encountered near the shores of Japan.

Genus GLYPTOCEPHALUS has an amphiboreal propagation and comprises three species: *G. stelleri* (Schmidt), *G. zachirus* Lockington and *G. cynoglossus* (L.). The

former two have an amphi-pacific propagation inhabiting the sea of Japan and waters washing the shores of Japan (*G. stelleri*), as well as the waters extending between Alaska and California (*G. zachirus*). *G. cynoglossus* are wide-spread in the northern Atlantic region descending towards the South along the American coast to Cape Cod and down to the Bay of Biscay near the shores of Europe. Sinks to great depths (up to 1600 meters).

Genus KAREIUS with one representative - the species *K. bicoloratus* (Basilevsky) is a Pacific-Asian endemic inhabiting the coastal waters of China, Korea and Japan. Let us summarize the data on the distribution of the genera and species of the subfamily Pleuronectini in the oceans of the world (table 79), including in the table the genera which do not exist in the waters washing the shores of our country.

The analysis of the data in table 79 enables us to assume as probable that the subfamily Pleuronectini is of Pacific origin. Among the presently known 25 genera and 57 species and subspecies of this group, all 25 genera and 57 species (82.3%) are encountered in the northern zone of the Pacific Ocean and only 10 endemic species (17.7%) inhabit the northern zone of the Atlantic Ocean, where we found no endemic genus at all. The *Pl. glacialis* alone populates the Arctic zone. A more detailed analysis of the distribution of representatives of Pleuronectini enables us to reveal the prevailing multitude of forms near the Asian shores of the Pacific Ocean: among the 25 genera and

and 47 species populating the Pacific Ocean, 9 genera (76.0%) and 29 species (61.7%) were found near the shores of Asia.

9 Genera (36.0%) and 24 species (51.1%) that are known to populate the northwestern zone of the ocean, are not found near the Pacific coast of America at all, and the endemic fauna Pleuronectini of the northwestern part of Pacific Ocean consists of 6 genera (24.0%) and 16 species (34.2%), while 7 species (14.7%) are common for both.

As we already mentioned before, the Pleuronectidae are widespread in the northern part of Pacific Ocean inhabiting the entire littoral zone of the eastern coast of Asia from the Arctic shores of Chukotka to the Indian Ocean. Within the limits of the sea washing the shores of Soviet Far East, the Pleuronectidae are found everywhere. However, this rather wide propagation narrows down when we investigate the regions populated by different species and study their ecological characteristics.

Owing to the works by Ortmann (1896), Schmidt (1905, 1935), Lindberg (1928, 1947), Eckman (1935) Vinogradov (1947), Guryanova (1935, 1939), Shchapova (1948), Makarov (1941) and many others, in particular the brilliant work by Andriyashev (1939), which was developed more thoroughly by Vinogradov (1948), the modern conception of the division of the Far eastern waters into different zoogeographic zones is rather distinct and clear. We believe it impossible to re-examine according to the data of the geographic distribution of Pleuronectidae the above

presented scheme of the zoo-geographic division into different zones, which has been drawn on the basis of analysis of a lengthy list of fish (Andriyashev), crustacea (Guryanova, Makarov, Vinogradov), echinoderms (Dyakonov), laiminariaceae (Shchapova) and others, and therefore, we shall accept the scheme of the zoo-geographic division of the fareastern waters into different zones suggested by Andriyashev and developed in detail by Vinogradov and, having exposed the factual data, we shall discuss this scheme from the point of view of its applicability for determination of the distribution of Pleuronectidae. First of all, let us expose the data on the geographic distribution of Pleuronectidae inhabiting the northwestern zone of Pacific Ocean and their ecological characteristics.

The numerous data on the places inhabited by flounders in the fareastern seas have not been summarized as yet. Characteristics of the geographic distribution are presented in brief by Jordan and Everman (1898), Schmidt (1904, 1933, 1950), Soldatov and Lindberg (1930), Norman (1934), Taranets (1937), Okada and Matsubar (1938), Andriyashev (1939), Lindberg (1947) and others, however, in the majority of cases these data are rather laconic, of general character and based on limited material.

We believed it appropriate to present the description of the distribution of flounders in the Fareastern waters, make an attempt at ecological characterization of these fish and expose certain considerations with regard to the region and living conditions of each individual species.

In order to complete this task we used both - the bibliographical sources, as well as field diaries and observations of the following expeditions:

the expedition on board the trawler "Dalnevostochnik" in 1932, in the Bering and Chukotski seas; ichthyologist A. P. Andriyashev; the expedition on board the trawler "Chayka" in 1932, in the Bering sea; ichthyologist A. N. Starostin;

the expedition on board the trawler "Finval" in 1932 in the Sea of Japan; ichthyologist D. I. Okhryamkin;

the expedition on board the trawler "plastun" in 1932 in the Sea of Okhotsk; ichthyologists I. A. Polutov and M. L. Alperovich;

the expedition on board the trawler "Krasnoarmeets" in 1933, in the Bering Sea and Chudotski Sea; ichthyologist K.I. Panin;

the expedition on board the trawler "Plastun" in 1933, in the Okhotsk Sea; ichthyologists E. K. Suvorov and I. A. Polutov;

the expedition on board the trawler "Plastun" in 1932 in the Yellow Sea and East-China Sea; ichthyologist M. N. Krivobok;

the expedition on board the trawler "Lebed" in 1934 in the Sea of Okhotsk; ichthyologist P.A. Moiseev;

the expedition on board the trawler "Lebed" in 1935 in the Sea of Okhotsk; ichthyologist D. I. Okhryamkin;

the expedition on board the trawler "Lebed" in 1937 in the Sea of Okhotsk; ichthyologist I. A. Polutov;

the expedition on board the trawler "Toporod" in 1937 in the Sea of Japan; ichthyologist P. A. Moiseev;

the expedition on board the trawler "Lebed" in 1938-1939 in the Sea of Okhotsk; ichthyologists P.A. Moiseev and M.A. Tychkova;

the expedition on board the trawler "Toporok" in 1947 in the southern Sakhalin waters; ichthyologists G.U. Lindberg, E.P. Rubenberg;

the expedition on board the trawler "Toporok" in 1948 in the Kuril-Sakhalin region; ichthyologists G.U. Lindberg, P.A. Moiseev;

the expedition on board the "Toporok" in 1949 in the Kuril-Sakhalin region; ichthyologists G.U. Lindberg and M.A. Tychkova;

TABLE 78.

List of the flounders found in the Fareastern waters.

No.	Scientific name	American Name
1.	<i>Paralychthys olivaceus</i> (Schlegel)	
2.	<i>Eopsetta grigorievi</i> (Herzenstein)	
3.	<i>Verasper moseri</i> Jordan et Gilbert	
4.	<i>Verasper variegatus</i> (Schlegel)	
5.	<i>Acanthopsetta nadeshnyo</i> Schmidt	
6.	<i>Hippoglossoides hippoglossoides elassodon</i> Jordan et Gilbert	Flat-Head Sole
7.	<i>Hippoglossoides hip. dubius</i> Schmidt	
8.	<i>Hippoglossoides hip. robustus</i> Gill et Townsend	
9.	<i>Gleisthenew herzensteini</i> (Schmidt)	
10.	<i>Hippoglossus hippoglossus stenolepis</i> Schmidt	Pacific Halibut
11.	<i>Reinhardtius hippoglossoides matsuurae</i> Jordan et Starks	
12.	<i>Atheresthes evermanni</i> Jordan et Starks	
13.	<i>Lepidopsetta bilineata bilineata</i> (Ayres)	Rock sole
14.	<i>Lepidopsetta bil. mochigarei</i> Snyder	
15.	<i>Limanda aspera</i> (Pallas)	Yellow-Fin sole
16.	<i>Limanda punctatissima punctatissima</i> (Steindachner)	
17.	<i>Limanda punctatissima proboscidea</i> Gilbert	
18.	<i>Pseudopleuronectes yokohamae</i> (Guenther)	
19.	<i>Pseudopleuronectes herzensteini</i> Jordan et Snyder	
20.	<i>Pleuronectes quadrituberculatus</i> (Pallas)	
21.	<i>Pleuronectes obscurus</i> (Herzenstein)	
22.	<i>Pleuronectes stellatus</i> (Pallas)	
23.	<i>Pleuronectes glacialis</i> (Pallas)	Arctic Flounder
24.	<i>Pleuronectes pinnifasciatus</i> (Kner)	
25.	<i>Kareius bicoloratus</i> (Basilevsky)	
26.	<i>Clidoderma asperimum</i> (Schlegel)	
27.	<i>Clyptocephalus stelleri</i> (Schmidt)	
28.	<i>Microstomus achne</i> (Jordan et Starks)	

TABLE 79.

*** The species *Pl. stellatus* penetrates into the southern part of Chukotski Sea.

-258-

DISTRIBUTION OF GENERA AND SPECIES OF THE SUBFAMILY PLEURONECTINI IN THE OCEANS OF THE WORLD.

		Pacific Ocean				Arctic Region				Atlantic Ocean			
		Asian Coast		North Am. Coast		Asian Coast		North Am. Coast		Asian Coast		North Am. Coast	
		Number of species and subspecies	%	Number of species	%	Number of species	%	Number of species	%	Number of species	%	Number of species	%
1.	<i>Atheresthes</i>	2	1	50.0	1	50.0	-	-	-	-	-	-	-
2.	<i>Reinhardtius</i>	2	1	50.0	-	-	-	-	-	1	50.0	1	50.0
3.	<i>Hippoglossus</i>	2	1	50.0	1	50.0	-	-	-	1	50.0	1	50.0
4.	<i>Hippoglossoides</i>	4	2	50.0	1	25.0	***	-	-	1	25.0	1	25.0
5.	<i>Acanthopsetta</i>	1	1	100.0	-	-	-	-	-	-	-	-	-
6.	<i>Cleisthenes</i>	1	1	100.0	-	-	-	-	-	-	-	-	-
7.	<i>Lyopsetta</i>	1	-	-	1	100.0	-	-	-	-	-	-	-
8.	<i>Eopsetta</i>	2	1	50.0	1	50.0	-	-	-	-	-	-	-
9.	<i>Psettichthys</i>	1	-	-	1	100.0	-	-	-	-	-	-	-
10.	<i>Verasper</i>	2	2	100.0	-	-	-	-	-	-	-	-	-
11.	<i>Clidoderma</i>	1	1	100.0	-	-	-	-	-	-	-	-	-
12.	<i>Hipsopsetta</i>	1	-	-	1	100.0	-	-	-	-	-	-	-
13.	<i>Pleuronichthys</i>	7	1	14.3	6	85.7	-	-	-	-	-	-	-
14.	<i>Isopsetta</i>	1	-	-	1	100.0	-	-	-	-	-	-	-
15.	<i>Parophrys</i>	1	-	-	1	100.0	-	-	-	-	-	-	-
16.	<i>Lepidopsetta</i>	2	2	100.0	1	50.0	-	-	-	-	-	-	-
17.	<i>Limanda</i>	5	3	60.0	1	20.0	-	-	**	1	20.0	1	20.0
18.	<i>Pseudopleuronectes</i>	3	2	66.7	-	-	-	-	-	1	33.3	-	-
19.	<i>Dexistes</i>	1	1	100.0	-	-	-	-	-	-	-	-	-
20.	<i>Microstomus</i>	3	1	33.3	1	33.3	-	-	-	-	-	1	33.3
21.	<i>Embassichthys</i>	1	-	-	1	100.0	-	-	-	-	-	-	-
22.	<i>Tanakius</i>	1	1	100.0	-	-	-	-	-	-	-	-	-
23.	<i>Clyptocephalus</i>	3	1	33.3	1	33.3	-	-	-	1	33.3	1	33.3
24.	<i>Pleuronectes</i>	8	5	62.5	2	25.0	1***	12.5	1	12.5	1	3	37.5
25.	<i>Kareius</i>	1	1	100.0	-	-	-	-	-	-	-	-	-
		57	29	50.9	22	38.6	1	1.8	1	1.8	7	9	15.8

* The Pacific for 4. cl. *robustus* penetrates to the southern zone of Chukotski Sea.

** The species *Lim. aspera* penetrates into the southern part of Chukotski Sea.

*** The species *stellatus* penetrates into the southern part of Chukotski Sea.

LIMANDA ASPERA (PALLAS).

Being the most numerous group of flounders in the Far-eastern waters, *Limanda Aspera* (Pallas) form in several regions large and dense concentrations exceeding all the other known accumulations of flounders in the oceans of the world. *Limanda aspera* (Pallas) are widespread in the northern zone of the Pacific Ocean. Along its western coast, the southern border of propagation passes near the southeastern shores of Korea (the region of Pusan) and shores of Hokkaido. Farther to the North, the *Limanda aspera* (Pallas) are found everywhere (with the exception of Shantar(?) Islands) up to the southern zone of the Anadyrski Bay. Along the shores of America, this fish penetrates with warm waters farther to the North and its single specimens are found in Chukotski Sea (Kotsubu Bay). To the south from St. Lawrence Island, along the shores of Alaska, the *Limanda aspera* (Pallas) descend to Vancouver, in view of which its propagation in the northern zone of Pacific Ocean is not marked by intermittent amphipacific character peculiar of certain other species of flounders. It is interesting to note that in Sakhalin Bay (more precisely in its eastern zone) *Limanda aspera* (Pallas) are found considerably more often than in the vicinal areas. However, within the limits of this large region of propagation the *Limanda Aspera* (Pallas) are distributed rather non-uniformly. While near the shores of western Kamchatka, in Tatarski strait, near the southeastern shores of Sakhalin and in Peter the Great Bay the *Limanda aspera* (Pallas) form large industrial

accumulations (particularly in Kamchatka water), in other zones these fish are found as a rule in the form of a by-catch.

DRAWING 14.

Pleuronectes stellatus

Pleuronectes quadrituberculatus

Limanda punctatissima proboscidea

Limanda aspera

Hippoglossoides el. elassodon

Lepidopsetta bil. bilineata

_____ Mean catch per 1 trawling hour;

-----Frequency at which a given form is found (in %);

Fig. 14. Distribution of flounders in dependence with the water temperature near the western shores of Kamchatka (at the left - during the winter; at the right - during the summer).

DRAWING 14.

Pl. quadrituberculatus

Lep. bil. mochigarei.

Limanda aspera

Pl. pinnifasciatus.

Lim. punct. punct. atissima.

Cl. Herzensteini.

Ps. herzensteini.

Glypt. stelleri.

Ac. nadeshnyi

Hip. el dubius.

Ps. yokohamae.

_____ Mean catch per 1 trawling hour in number of specimens;

-----Frequency at which the fish are encountered (in %);

Fig. 15. Distribution of flounders in dependence with the water temperature in the Sea of Japan.

Being a typical inhabitant of the continental plateau, the *Limanda aspera* (Pallas) are found in their zones of propagation essentially at the depths of 5-10 to 180-250 meters, which, however, depends in the main on the season.

Accomplishing regular migrations of seasonal character, the *Limanda aspera* (Pallas) populate the shallow waters of the northern zone of its region of propagation (10-60 meters during the summer) and sink in the winter to 150-250m, deserting the shallow areas, where the benthic temperatures sharply drop often below zero as a result of the winter cooling.

The thermopathy graphically presented in fig. 14 and 15, clearly shows the optimum temperatures for the existence and development of flounders thus explaining the reasons for bathimetric distribution of this fish.

During the warm season of the year the *Limanda aspera* (Pallas) are found within the limits of a wide temperature range - from 1 to 16⁰, however, concentrate mainly between 8 and 12⁰. During the cold season the benthic temperatures in the coastal zone drop below 0⁰, which compels *Limanda aspera* (Pallas) and many other fish species to drift gradually farther from the shores sinking to the depths that are not affected by the winter vertical circulation. The tendency to avoid the regions with temperatures below 0⁰ is clearly pronounced in the *Limanda aspera* (Pallas), occasionally single specimens are found in cool areas, however, this phenomenon is purely accidental.

On the other hand, however, not only the waters at temperatures below 0° , but the northern zones of the propagation of *Limanda aspera* (Pallas) with low (though above zero) summer temperatures do not seem to be favourable for the existence of this fish species. Thus, to the North, from Olyutorski Bay the number of specimens of this form progressively decreases and the frequency at which it is caught by trawls dropped to single specimens. It is quite obvious that the temperature conditions under which the *Limanda aspera* (Pallas) exist to the North from Olyutorski Bay are not very favourable. An analogous phenomenon, though caused by rise in the temperature occurs in the southern zones of the region of propagation of *Limanda aspera* (Pallas). While in Tatarski strait, near the southeastern shores of the Sakhalin and in Peter the Great Bay, i.e. in the north-boreal regions, the *Limanda aspera* (Pallas) are encountered in large industrial concentrations, near the shores of Korea and Hokkaido and in the South Kuril shallow waters the *Limanda aspera* (Pallas) are very rarely found in catches. Simultaneously this flounder migrates to greater depths with lower temperatures. Thus, in particular, in the South Kuril shallow waters the fry of *Limanda aspera* (Pallas) were found during the summer between 50 and 60 meters at temperatures of $10-13^{\circ}$ and single large specimens were caught at depths of 70-75 meters.

Let us point out once more that the fry of this flounder species in the north-boreal regions remain at most insignificant depths (5-15 meters), while adult specimens prevail at depths not exceeding 30-40 meters.

Near the eastern and southern shores of Hokkaido the *Limanda aspera* (Pallas) populate during the summer depths of 100-200 meters.

Limanda aspera (Pallas) is a Pacific-boreal form widespread in the moderate zone of the North Pacific Ocean, however avoids the "glacial" region of the Okhotsk sea and low Arctic regions. The theory of Vinogradov (1946) concerning the hibernation of *Limanda aspera* (Pallas) at temperatures below 0° is based on very limited data material. The wintering of *Limanda aspera* (Pallas) near the southwestern shores of Kamchatka at depths of 120-150 meters is a proven fact, however, this hibernation also occurs in the sections of the shelf, where the benthic temperatures are above 0° , since the waters with temperatures below zero do not penetrate in this region which is under the influence of the streams of warm water of Pacific origin, below the depths of 100-130 meters. In all the regions of the Far Eastern waters large winter concentrations of *Limanda aspera* (Pallas) are found in the lower horizons of the shelf, outside the sections covered with water at temperatures below 0° .

LIMANDA PUNCT. PUNCTATISSIMA (STEINDACHNER).

This form is propagated in the northern zone of the Sea of Japan between Vonsan on the continental shore to the northern part of Tatarski strait, then descends to Sangarski strait, perhaps even farther to the south, along the western shores of Sakhalin and Hokkaido. In the southern zones of the Okhotski Sea it reaches Terpeniya Bay in the north, is found in the Aniv Bay and near the shores of northern Hokkaido. From the Southern Kuril Islands the border of propagation extends along the eastern shores of Japan to Tokay Bay. The most compact concentrations of industrial character are formed in Peter the Great Bay, Tatarski strait, near the shores of Southern Sakhalin and in the South-Kuril shallow waters, although this form of flounders is not relatively numerous as compared with other species.

In Peter the Great Bay and in the north-boreal regions the *Limanda punct. punctatissima* (Steindachner) populate the continental plateau, hibernate at depths of 170-250 meters and remain during the summer in the littoral zone at depths of 5-10 to 25-30 meters. In the south-boreal regions this flounder sink during the summer to considerably greater depths. Thus, in the South-Kuril shallow water region the depths of 60-70 meters are marked by the highest frequency at which this fish is encountered at the beginning of September. Near the eastern shores of Hokkaido this flounder remains at depths of 70 to 200, or even 300 meters.

LIMANDA PUNCT. PROBOSCIDEA GILBERT.

The area of propagation of this species is adjacent to that of a more southern endemic - the *Limanda punct. punctatissima* (Steindachner). Between the southeastern shores of Sakhalin, where the regions of propagation of both forms overlap along the eastern coast of Sakhalin, the Sakhalin Bay, near Shantarski Islands and along the entire northwestern and northern shores of the Okhotsk Sea (including the Shelikhov Bay), the *Limanda punct. proboscidea* Gilbert are found but in small quantities. Near the western and eastern shores of Kamchatka and Northern Kuril Islands these flounders form dense concentrations often constituting a considerable percentage of trawl catches. Near the western shores of the Bering Sea it is found everywhere (with the exception of the Kommandor Islands), penetrates to the North from the Anadyrski Bay, reaching in the northeastern zone of the sea the mouth of the river Yukon and in the southeastern direction the Pribylovye Islands. The data available on bathi- and thermopathy of the *Limanda punct. proboscidea* Gilbert show that this fish is an inhabitant of the continental plateau and accomplishes seasonal migrations from the wintering areas in the lower horizons of the sublittoral to shallow waters (10-40 m) within the borders of the north-boreal regions, which are the main areas inhabited by this fish. However, within the limits of the cold water regions, where this species is also found (although in relatively small numbers) there occur no extensive migrations and the

Limanda punct. proboscidea Gilbert hibernate at low temperatures (below 0°) and during the summer remain in the coastal zone, where the temperature rises to $10-15^{\circ}$.

PLEURONECTES QUADRITUBERCULATUS (PALLUS).

The great industrial importance of this flounder in the far-eastern seas is determined by its great number, as well as by the large dimensions of this fish, considerably exceeding in size all the other industrial fishes.

The geographic distribution of *Pleuronectes quadrituberculatus* (Pallus) strongly resembles that of the *Limanda aspera* (Pallas), although the region of propagation of the former is considerably less extensive in the South. This is a wide-spread form in the northern zone of the Pacific Ocean inhabiting in the main the north-boreal regions and penetrating but seldom into the south-boreal areas. In the Sea of Japan the industrial concentrations are found in the northern part of Tatarski strait, while in Peter the Great Bay, which is the southern border of the region of propagation of this fish, we found but single specimens. Near the southern shores of Sakhalin the *Pleuronectes quadrituberculatus* (Pallus) are found but in small numbers, although the frequency at which these flounders are encountered near the southeastern shores is greater. Single specimens along the shores of Northern Hokkaido reach the Kuril Islands and even penetrate in the northeastern shores of Hokkaido (in the South up to 43° of northern latitude), where these

fish are found during the summer at depths of 100 to 160 meters. Farther to the North it is found in Shantarski region (Lindberg and Dulkate (?) (1939) and, following a certain gap (which we think exists only because of the insufficient explorations of the northwestern zone of the Sea of Okhotsk), appear in the region of Tuyski Gulf and are found along the shores of Kamchatka and western coast of the Bering Sea (with the exception of the region of the Kommandor Islands) up to the southern zone of the Anadyrski Bay.

Within the limits of the North-Bering shallow waters-plateau these fish are found almost everywhere and in its eastern zone ascend almost as far as the Bering strait. Along the Pacific coast of America these fish descend to Southern Alaska. The largest concentrations of *Pleuronectes quadrituberculatus* (Pallas) are formed near the western shores of Kamchatka (particularly in the region of the river Moroshechnaya and Sopochneya), in the northern section of Tatarski strait and near the eastern shores of Kamchatka. Within the limits of the Okhotski glacial region (Vinogradov, 1948) these fish are found rather seldom. To the north from the Olyutorski Bay and up to the Anadyrski Bay, as well as within the limits of the North-Bering shallow water regions the frequency at which this species is found drops so sharply that the percentage of *Pleuronectes quadrituberculatus* (Pallas) in trawl catches is practically zero.

Pleuronectes quadrituberculatus (Pallas) is an inhabitant of the lower zone of the sublittoral and rarely rises to its upper horizons. During the winter the maximum density of concentrations is observed at depths of about 200 meters and during the summer warming up this flounder leaves in great number the region of hibernation and drift to the depths of 40 to 130-150 meters; moreover, as is the case with the majority of flounders, the small fishes remain at lesser depths. However, even during the summer a small number of *Pleuronectes quadrituberculatus* (Pallas) are found at the depth of 400 meters. Thermopathy of the *Pleuronectes quadrituberculatus* (Pallas), which determines to a considerable extent its adaption to great depths, is characterized through a somewhat narrow thermic range, particularly during the summer. The optimum for adult fishes lies between -0.8 to 10° , for the fry between -0.3 and 14° . During the winter the *Pleuronectes quadrituberculatus* (Pallas) remain essentially in the waters at temperatures close to 0° (from -1 to 1° above zero). Undoubtedly, the *Pleuronectes quadrituberculatus* (Pallas) is one of the migrating flounders, inhabitants of the shelf, most adapted to low temperatures. Its existence in the cold water regions its absence from the south-boreal regions (with the exception of single specimens found in Peter the Great Bay and near the southwestern shores of Sakhalin), penetration far to the North in the

Bering Sea (almost as far as the Bering strait) and relatively frequent penetration into the patches of cold waters with temperatures below zero - all this compels us to agree with the theory of Andriyashev, maintaining that the *Pleuronectes quadrituberculatus* (Pallas) should be classified with the subarctic boreal forms.

In view of the aforesaid, the *Pleuronectes quadrituberculatus* (Pallas) find most favourable conditions for their development near the shores of Kamchatka (particularly in the northern sections of the West and East Kamchatka shelf) and in the Tatarski strait. The somewhat narrow temperature range, within the limits of which the *Pleuronectes quadrituberculatus* (Pallas) are propagated, results in that during the intensive feeding of the summer these fish remain in somewhat deeper horizons than the most numerous *Limanda aspera* (Pallas).

CLEISTHENES HERZENSTEINI (SCHMIDT).

This species is characterized by its relatively limited region of propagation. Being mainly concentrated in Peter the Great Bay, where the accumulations of these fish reach considerable density, the *Cleisthenes herzensteini* (Schmidt) are spread over the littoral zone of the Maritimes up to the northern section of Tatarski strait, along the western and eastern shores of the Sea of Japan, near the southern extremity of the Sakhalin, the South-Kuril shallow waters and along the eastern Coast of Hokkaido descending southwards along the Pacific coast of Japan to the 38° parallel of northern latitude.

In the Yellow Sea the *Cleisthenes herzensteini* (Schmidt) are known to populate the waters near the shores of Korea and Shandun. Within the limits of this rather narrow region of propagation this flounder is usually found in Tatarski strait and in the South-Kuril shallow waters excepting in Peter the Great Bay. In the remaining zones of its propagation the *Cleisthenes herzensteini* (Schmidt) are found in small numbers only.

In Tatarski strait and in Peter the Great Bay the *Cleisthenes herzensteini* (Schmidt) populate the shallow water plateau and make seasonal migrations: during the spring - to the shallow waters for spawning and feeding, where these fish remain at the depths of 5-8 and 40-60 meters, during the winters to the depths of 180-230 meters, to the border sections of the continental shallow waters plateau.

In the areas occupied by warmer waters (near the shores of the Hokkaido and Nippon Islands) the *Cleisthenes herzensteini* (Schmidt) intensively avoid warm littoral areas and usually drift to the depths of at least 50-60 meters sinking occasionally as deep as 300-350 meters. The same has been observed in the South-Kuril shallow waters plateau, where, during the summer, no large specimens were found at the depths of less than 70 meters, and the fry was located as a rule at the depths of at least 40 meters. In Peter the Great Bay, however, these depths are usually not the upper, but the lower border of the vertical propagation of the *Cleisthenes herzensteini* (Schmidt).

The graphics presented in drawing 15, which were drawn for Peter the Great Bay and Tatarski strait demonstrate that the optimum conditions for development of *Cleisthenes Herzensteini* (Schmidt)

and *Limanda aspera* (Pallas) are very much alike. The former species is the next most numerous flounder in Peter the Great Bay after the *Limanda aspera* (Pallas). It is interesting to note that in spite of the similar requirements with regard to the environment from the point of view of the temperature and bathimetric conditions (which also accounts for the fact that their regions of wintering coincide) the *Cleisthenes herzensteini* (Schmidt) and *Limanda aspera* (Pallas) are not competing with each other for food as they have totally different feeding spectra.

PSEUDOPLEURONECTES YOKOHAMAE (GUENTER).

The propagation of the *Pseudopleuronectes yokohamae* (Gunter) is limited by the Sea of Japan, the shores of the Japan and adjacent regions. *Pleuronectes yokohamae* (Günter) inhabit the waters between Tatarski strait, along the western and eastern shores of the Sea of Japan up to the Korean strait along the entire Pacific coast of the islands Kyushu, Nippon, Hokkaido, the South Kuril shallow waters plateau and Aniv Bay. It is interesting to note that these flounders are found in the Sakhalin Bay, into which they probably penetrated through Nevelski strait.

These fish form no particularly large concentrations; however, they constitute a considerable percentage of the catches obtained by industrial boats in Peter the Great Bay occasionally forming the largest portion of the catches obtained by individual boats.

The *Pseudopleuronectes yokohamae* (Guenter) populates the continental plateau and is one of the first species to drift to the shallow waters from the regions of hibernation (at the depths of 180-240 meters) in Peter the Great Bay, after which these fish drift to the minimum (for migrating forms) depths (5-20 meters) and remain there throughout the entire warm season of the year.

Pseudopleuronectes yokohamae (Guenter) inhabit in the main the south-boreal regions and only partially penetrate into the north-boreal regions. The fishes of this species hibernate at temperatures above zero and remain during the summer in the warmest sections of the littoral zone.

PLEURONECTES STELLATUS (PALLAS).

This species is widely propagated in the northern section of the Pacific Ocean. Between the Pusan and Vakas Bay in the Sea of Japan and in the Tokiy Bay in the South the *Pleuronectes stellatus* (Pallas) populate the waters along both coasts of the Sea of Japan up to Nevelski strait in the north along the Pacific shores of the Japan up to the South Kuril shallow water region and northern shores of Hokkaido. In the Sea of Okhotsk these fish inhabit the littoral zone along the entire shore-line. From the eastern shores of Kamchatka schools penetrate North along the Asian shores of the Bering Sea (including the Kommandor Islands) up to Bering Strait, and are found in the littoral zone

of Chukotski Sea, as well as in the American sector of the Arctic region, along the Pacific coast of America, descending from Bering Strait to California. Near our shores the largest concentrations of the *Pleuronectes stellatus* (Pallas) are encountered near the western and near a part of the eastern shore of Kamchatka; here during the summer these fish enter casting nets in great numbers. Remaining as a rule at shallow depths (below 50 meters) all the year round the *Pleuronectes stellatus* (Pallas) occasionally approach close to the shores and (usually during the summer) penetrate into the estuaries of rivers and areas lying just to the fore of the estuaries of rivers reaching fresh waters. Populating in the main the north-boreal "glacial" sub-Arctic, low-Arctic and upper-Arctic regions where the winter pre-benthic temperatures during the summer drop to $1.5 - 1.8^{\circ}$ below zero, the *Pleuronectes stellatus* (Pallas) hibernate at the aforementioned low temperatures and remain during the summer at high temperatures (from 6-8 to $15-20^{\circ}$, see drawing 14).

PLEURONECTES OBSCURUS (HERZENSTEIN).

There exist relatively few data on the distribution of *Pleuronectes obscurus* (Herzenstein) and we believe that these data are incomplete with regard to the actual region of propagation of this species. The *pleuronectes obscurus* (Herzenstein) are found between Inchon in the Yellow Sea along the western, southern and eastern

shores of Korea up to the northern section of the Tatarski strait. Moreover, these fish are found in Aniv Bay, along the northern shores of Hokkaido and in the South-Kuril shallow waters region. We may be certain that this species will be discovered in the future near the southwestern shores of the Sakhalin and along the eastern and western shores of Hokkaido.

This littoral form which is an inhabitant of the upper horizons of the sublittoral (up to 30 meters) throughout the entire year, frequently penetrates in to the pre-mouth regions of rivers. It hibernates within the limits of the northern zone of the sea of Japan at temperatures below zero and during the summer remain in the waters heated up to 20°. In the southern zone of the region of their propagation these fish hibernate at temperatures above zero. *Pleuronectes obscurus* (Herzenstein) form no large concentrations.

PLEURONECTES PINNIFASCIATUS (KNER).

This is a littoral form inhabiting the upper horizons of the sublittoral, which does not sink through the entire year below 25-30 meters (with very rare exceptions). It has a very limited region of propagation and is known to populate the waters along the northwestern coast of the sea of Japan from Peter the Great Bay to the northern zone of Tatarski strait. Moreover, it has been discovered in Aniv Bay, Sakhalin Bay and the estuary of the Amur river while it penetrates easily, as well as into the estuaries of many other rivers, being highly enzyhaline.

It is very doubtful whether the *Pleuronectes pinnfasciatus* (Kner) inhabit the Avachinski Bay (Popov, 1933). Thus, this form is found only within the limits of the north-

boreal regions, as it extends southwards the region of propagation of the *Pleuronectes glacialis*, which is a very affinitive form to the one discussed.

PLEURONECTES GLACIALIS (PALLAS).

This is a wide-spread form found along the Arctic shores of the Europe, Asia and America. In the Pacific Ocean these fish descend to the south along the shores of Alaska and the Asian shores of the Bering Sea to the eastern shores of Kamchatka. In the majority of cases this form remains in the most littoral zone often penetrating far into lagoons with low salt content and mouths of rivers.

The co-existence of affinitive forms (*Pl. obscura* and *Pl. pinnifasciatus*) in the Sea of Japan (which has not been observed in the Arctic region) leads us to assume that the *Pleuronectes glacialis* (Pallas) is not an endemic Arctic species, but is closely related to the Arctic boreal forms, which originated in the northwestern zones of the Pacific Ocean rather than in the Arctic basin (Andriyashev, 1939).

GLYPTOCEPHALUS STELLERI (SCHMIDT).

These flounders are found in the main in the northern half of the sea of Japan, along the continental shores of Vonsan up to the northern zone of Tatarski strait, from where they descend to the South along the western shores of the Sakhalin and Hokkaido up to the Sangarski strait. This fish penetrate into the southern zone of the sea of Okhotsk (Aniv Bay, northern coast of Hokkaido)

and ascend along the Sakhalin Coast of the Okhotsk Sea northwards reaching the northern extremity.

Clyptocephalus Stelleri (Schmidt) was found in the Sakhalin Bay. These fish are propagated from the South Kuril shallow waters along the Pacific Coast of the Japan up to Takay Bay and are found in small quantities near the western shores of Kamchatka. The densest concentrations are formed in Peter the Great Bay, where these fish populate the continental plateau accomplishing seasonal migrations from the region of hibernation (150-250 meters) to the shores reaching the depths of 20-50 meters. In the southern regions (eastern shores of the Isle of Nippon) this species remains at great depths rarely rising to the depths of less than 50 m, and frequently sinking as deep as 750 meters.

LEPIDOPSETTA BILINEATA (AYRES).

Lepidopsetta bilineata from the northern part of the Pacific Ocean comprises several sub-species, among which the *Lep. bilineata mochigarei* populates the Sea of Japan and adjacent regions, while the *Lep.*

bilineata umbrosa inhabit the waters washing American shores to the south from Puget Sound.

The *Lep. bilineata bilineata* proper has a rather large area of propagation. Near the Asian shores of the Pacific Ocean these flounders are found in the littoral waters of Western Kamchatka and near the northern Kuril Islands up to Anadyrski Bay (including the Commander Islands). In the North-Bering plateau the *Lepidopsetta bilineata* penetrate with the warm

waters eastwards from St. Lawrence Island to the North almost as far as Bering Strait and in the south descend to Bristolki Bay, spread beyond Bering Sea, reach Puget Sound and are replaced farther to the south and down to California by the afore-named sub-species. In the Sea of Japan and in the southern zone of the Sea of Okhotsk the *Lep. bil. mochigarei* are found along the continental shores of Wonsan up to the northern section of Tatarski strait and along the eastern shore - along the western coast of the Sakhalin, Hokkaido and Northern half of Nippon up to Tsuruga. From Aniv Bay along the northern shore of Hokkaido these flounders reach the South-Kuril shallow waters, then descend along the eastern shores of Japan to the south of Tokiy Bay. Moreover, this form (*L. bil. mochigarei*) was found in the Sakhalin Bay.

Industrial concentrations were found in the Peter the Great Bay and are particularly large during winter to the south-east from Cape Lopatka (Kamchatka).

Both forms in question are inhabitants of the shelf accomplishing seasonal migrations from the region of wintering to lesser depths. Such migrations are particularly well pronounced in Peter the Great Bay, Tatarski strait and near the shores of Kamchatka, where we observed the drift of flounders to greater depths beyond the region of the temperatures below zero.

During winter the *Lepidopsetta bilineata* remain in these regions at small depths between 25 and 90 meters.

In more southern (south-boreal) regions this flounder remains during the summer at somewhat greater depths (60 to 90 meters in the South Kuril shallow area). The *Lepidopsetta bilineata* sinks occasionally as deep as 400 (perhaps even more) meters.

PSEUDOPLEURONECTES HERZENSTEINI JORDAN ET SNYDER.

These flounders are spread in the Sea of Japan and the waters washing the Pacific Coast of Japan. It is found along the eastern and western shores of the Sea of Japan from the Korean Strait up to the northern section of Tatarski Strait, forms densest concentrations in Peter the Great Bay and inhabits the waters washing the northern shores of Hokkaido and South Kuril Islands penetrating in small numbers to the north along the southeastern shores of Sakhalin only as far as 45-46° of the northern latitude.

Near the shores of the Pacific Ocean, these flounders descend from the South Kuril shallow waters to the south along the eastern shores of the Hokkaido, Nippon up to the southern part of the Island Kyushu. From the point of view of the vertical distribution this form of flounders is a typical inhabitant of the continental plateau accomplishing seasonal migrations from the wintering regions to shallow areas at depths of 10-15 to 40-50 meters. This pattern is particularly well pronounced in the north-boreal regions of Peter the Great Bay. In the south-boreal regions this flounder remains during

the summer at somewhat greater depths (in the South-Kuril shallow waters the fry inhabit the depths of 40-75 meters and the adult specimens are found at depths of 70-150 meters) and occasionally reaches the 300 meter horizons near the eastern shores of Japan).

Avoiding the temperatures below zero, the *Pseudopleuronectes herzensteini* Jordan et Snyder are found within a rather large temperature range (from 0 to 20-22⁰).

HIPPOGLOSSOIDES ELASODON JORDAN ET GILBERT

In the Far-eastern waters there exist several affinitive forms of this flounder differing in their propagation and ecologic characteristics, however, their systematic position is not sufficiently clarified as yet in view of which we shall tentatively classify them as sub-species. *Hippoglossoides el elassodon* is the most wide-spread form in the North Pacific waters and inhabits the littoral zone of Kamchatka ascending northwards along the Asian shore of the Bering Sea up to the Olyutorski-Navarinski region (including the Kommandor Islands); its representatives are found in the North-Bering shallow waters and farther on along the Pacific coast of America up to the State of Washington. It is doubtful whether these fish exist in Tatarski Strait and near the eastern shores of Sakhalin (P. Schmidt).

The given form inhabits the shelf, accomplishes seasonal migrations from the wintering regions (where the

temperatures remain above zero) to the shallow waters, where it rarely sinks to depths of less than 40-60 meters.

Another form - *Hippoglossoides el robustus* Gill et Townsend - is distributed spotwise. Being mainly centered in the Bering Sea (particularly in its northern section) where these flounders are found in the Bristolski Bay and cold Anadyrski Bay and penetrate into the Chukotski Sea (the fry), the *Hip. el. robustus* were also found in the littoral zone of Eastern Kamchatka and are relatively wide-spread in the Sea of Okhotsk. It is interesting to note that the distribution of the given form is closely related to the cold water volumes. Thus, in the northern part of the Okhotsk Sea the *Hip. el. robustus* were known to exist in the Giszhiiginski Gulf up to the region of the Okhotsk and near the shores of Sakhalin from Sakhalin Bay and along the eastern shores of Aniv Bay. We noticed that the density of concentrations of these fish within the borders of the regions with temperatures below zero is higher than in the area where benthic temperatures are above zero. No seasonal migrations of this form have been observed.

Hippoglossoides el dubius Schmidt occupy the southern section of the overall region of propagation of the genus *Hippoglossoides*.

This form is spread from the southeastern shores of Korea to the northern zone of Tatarski Strait and along the eastern coast of the sea to the South

extending as far as Vakas Bay; from the northern shores of the Hokkaido along the Southern Kuril Islands, eastern shores of the Hokkaido and Isle of Nippon down to Tokiy Bay - such is the region of propagation of the *Hip. el. dubius*. Accomplishing seasonal migrations from the region of wintering (which takes place in the shallow water regions with temperatures above zero and temperatures close to 0° to the depths of 20-40 up to 60-70 meters, these flounders as a rule, do not approach the shoreline as closely as the species of the genera *Limanda*, *Pseudopleuronectes* and others. Being a relatively stenothermal form, the *Hip. el. elassodon* and *Hip. el. dubius* sink to the depths of 300-400 meters.

ACANTHOPSETTA NADESHNYI SCHMIDT.

These flounders are relatively wide-spread in the North-Pacific moderate zone - the Sea of Japan, Okhotski and Bering Seas. From Pusan (the southeastern shore of Korea) they are found along the continental shore of the Sea of Japan up to the northern section of the Tatarski Strait, although they seem to populate Peter the Great Bay and Tatarski Strait in small numbers only.

Then the border of the region of their propagation descends along the western shore of the Sakhalin and Hokkaido to Sangarski Strait, edges the Hokkaido and South-Kuril shallow water region, where these flounders are found in relatively small quantities. Farther on from the northern shores of Hokkaido, the *Acanthopsetta nadeshnyi* Schmidt are found along the eastern shores of

Sakhalin (particularly often near the southern section of the coast), in the Sakhalin Bay, single specimens were caught along the northwestern and northern shores of the Okhotsk Sea including the region of the Shantarski Islands and Shelikhov Bay. They are usually found near the western coast of Kamchatka and western shores of the Bering Sea up to Olyutorski Bay, although the frequency at which they are encountered gradually decreases. Thus being propagated mainly within the limits of the north-boreal regions, the *Acanthopsetta nadeshnyi* Schmidt includes in its region of propagation the south-boreal and glacial Okhotsk areas. The relatively large area of propagation of these flounders within the limits of the North-Pacific moderate zone can be explained by its ability to exist at temperatures below zero and adaption to relatively great depths. Moreover, during the summer these form migrates to the shores (within the limits of the north-boreal and glacial regions) drifting to the depths of 40-100 m, while a considerable number of flounders (particularly in the south-boreal regions) remains within the limits of great depths. Thus, in Peter the Great Bay these fish were found at depths reaching 550 meters and near the eastern shores of Hokkaido even at 900 meters.

CLIDODERMA ASPERRIMUM (SCHLEGEL).

These flounders spread from the southern shores of the Japan to the Kommandor Islands. In the sea of Japan they are found along the western shores from Pusan to Peter the Great Bay and they penetrate into the Yellow Sea.

Being found everywhere near the shores of the Japan in the Sea of Japan and Pacific Ocean, the *Clidoderma asperrimum* (Schlegel) form small industrial concentrations in the South-Kuril shallow waters and penetrate to the North along the eastern and western coasts of Sakhalin up to approximately 50° of northern latitude. The few representatives of this species are known to populate the waters washing the Northern Kuril Islands, as well as the waters around the southern extremity of the Kamchatka and Kommandor Islands.

Being an inhabitant of the lower half of the shelf, the *Clidoderma asperrimum* (Schlegel) remain during the summer near the shores of Kamchatka, Kommandor Islands and southern Kuril Islands at the depth of 250 meters. Near the eastern shores of Japan it is found even deeper (from 150 to 500 meters).

VERASPER MOSERI JORDAN ET GILBERT.

This is a large and not a numerous species of flounders found in the northern littoral waters of the Isle of Nippon along the shores of the Hokkaido, in the South-Kuril shallow waters, near the shores of Southern Sakhalin, where it penetrates along the eastern shores almost as far as its northern extremity, and along the western shore - up to 50° of the northern latitude reaching at this latitude the continental shore.

Near the southwestern shores of the sea of Japan these fish are found from Peter the Great Bay (in the North) down to the Korean Strait, and in the Yellow Sea -

near the western shores of Korea. This form inhabits the littoral zone and rarely sinks below 100-150 m. With regard to the character of its propagation the *Verasper moseri* should be classified as between the south-boreal group of the Pacific boreal species and subtropic boreal species. Farther to the South (Southern Japan and China) we found an affinitive species - *Verasper variegatus* (Schlegel), single specimens of which were occasionally caught in our waters as well (Peter the Great Bay).

PARALICHTHYS OLIVACEUS (SCHLEGEL)
KAREIUS BICOLORATUS (BASILEWSKY)
MICROSTOMUS ACHNE (JORDAN ET STARKS).

This group of subtropic-boreal species is found in our waters as well, however, is mainly propagated near the shores of Korea, in the Yellow Sea, near the shores of Northern China and Southern Japan. The northern border of its region of propagation reaches as far as Peter the Great Bay, southern shores of the Sakhalin, northern shores of the Hokkaido and the South-Kuril shallow waters. In the overwhelming majority of cases we found during the summer single large representatives of these forms penetrating to the northern borders of the south-boreal regions.

HIPPOGLOSSUS HIP. STENOBEIBIS SCHMIDT.

This form is rather wide-spread in the northern zone of the Pacific Ocean. It is found along the shore-

line of the Hokkaido to the North Bering shallow waters and in the South as far as San Francisco. Discussing in detail the regions inhabited by these fish, we wish to point out that being spread in the south of the northwestern zone of the Pacific Ocean up to the waters washing the southern shores of Hokkaido, this form populates the littoral waters along the eastern and northern shores of this island, near the South-Kuril Islands and penetrates (through the Laperuza strait) the northern section of the Sea of Japan, where it is found as a rule near the Moneron Island, southwestern shores of Sakhalin and even as far as the region of De-castri; in the South it penetrates almost to Sangarski Strait. Along the eastern shores of Sakhalin these fish are found almost as far as at the northern extremity of this island. Near the northern and northwestern shores of Okhotsk Sea, we found no representatives of this form and there are no reasons to assume that it can be found at depths of less than 180-200 meters; however, we have grounds to assume that it exists in the lower horizons of the sublittoral and in the upper horizons of the bathyal, i.e. at depths of 180-200 meters to 300 meters (which, we wish to point out, have not been explored as yet). It is found everywhere within the limits of the West-Kamchatka shelf from Cape Yuzhny to Cape Kambalny and Northern Kuril Islands. It is usually found along the eastern shores of the Kamchatka, near the Kommandor Islands and along the western shores of the Bering Sea

reaching as far as the southwestern zone of the Anadyrski Bay. Being encountered in the North Bering shallow waters, these fish do not penetrate farther to the North than Matheus Island, descend to the South along the Pacific coast of America as far as San Francisco. Populating in the main the lower horizons of the sublittoral and the upper zone of the bathyal, these fish are, however, adapted to considerably more shallow waters than the remaining Fareastern flounders and are usually found within the borders of the continental plateau, frequently drift to the most insignificant depths (20-30 meters) and penetrate into semi-enclosed bays (such as the Avachinski Gulf). The *Hippoglossus hip. stenolepis* Schmidt are found within a wide range of temperature conditions (from 0° to 15-18°) although they do avoid sub-zero temperatures. We observed no clearly pronounced migrations in the Fareastern waters.

REINHARDTIUS HIPPOGLOSSOIDES MATSUURAE JORDAN ET STARKS.

In distinction from the afore-described *Hippoglossus hip. stenolepis* Schmidt, which are widespread in the boreal regions of the Asian and American shores of the Pacific Ocean, the *Reinhardtius hippoglossoides matsuurae* Jordan et Starks populate waters along the Asian shores only. Found near the eastern coast of Sakhalin and farther to the North along the edge of the continental area up to the mouth of Shelikhov Bay.

This species is usually caught near the western shores of Kamchatka and Northern Kuril Islands as well.

In Bering Sea these fish are found between Cape Navarin along the North Bering shallow water region to the East from Matheus Island. It is an inhabitant of the upper horizons of the bathyal, rarely penetrates into the sublittoral to depths of less than 100 meters. In the majority of cases it is found at depths of 180-200 to 400 meters (sinking not deeper than 600 meters). Its existence at the depths situated below the surface layer of water, within the borders of which there occur seasonal thermic fluctuation, accounts for the stenothermal character of this fish species, which is adapted to low temperatures above zero - i.e. from 1 to 3-4°.

ATHERESTHES EVERMANNI JORDAN ET STARKS.

This fish-species is somewhat ^omore wide-spread geographically than the Reinhardtius hippoglossoides matsuurae Jordan et Starks.

These flounders inhabit the waters between 38° of Northern latitude in the North along the eastern shores of the Isles of Nippon and Hokkaido, the South Kurils near the eastern shores of Sakhalin up to 50° of northern latitude. Moreover, these fish penetrate through the Laperuso strait into the region of Moneron Island (the southwestern shore of Sakhalin). Following a certain break along the northern section of the Okhotsk shelf, the *Atherestes evermanni* Jordan et Starks appear near the shores of Western Kamchatka and can be found along the entire shoreline. Along the Pacific coast of the Kamchatka and Asian shores of the Bering Sea (including the Commander Islands) these flounders reach Cape Navarin and Matheus

Island in the East.

In the eastern zone of the sea and near the American shores of the Pacific Ocean (to the south from San-Francisco) it is replaced by a species of the same genus (*Ath. stomias*). The *Atheresthes evermanni* Jordan et Starks are adapted in the main to the upper bathyal and lower sublittoral and are found most frequently (the adult specimens) at the depths of 100 to 250-300 m (although these fish also sink as deep as 650-700 m and perhaps more). The fry remain at lesser depths (between 60 and 90-100 meters in the South Kuril shallow waters). This is an inhabitant of the lower horizons of the North (partially south-) boreal regions.

Having characterized in brief the distribution of each species, we wish to mention the rather interesting observations carried out by Kiesewetter (1951) on the ability of different flounders to accumulate vitamin A in internal organs.

On the basis of the analysis of the samples of liver and intestines in the guts of flounders collected in August-September, 1948, off the shores of Sakhalin and of the Southern Kuril Islands, we were able to establish a number of interesting peculiarities.

It has been established that the vitamin A content in the liver and tissues of digestive organs of this species shows a clearly pronounced tendency to rise as the depth at which the given fish exist, increase; this tendency is undoubtedly associated with the drop in the water temperature. It has been observed that

the content of vitamin increased between August and September with the increase in the weight of the fish. Lastly, the results of analysis showed that the species adapted to cold temperature and relatively great depths accumulate considerably more vitamin A in their organism than do the fishes adapted to warm waters and lesser depth (Table 80).

TABLE 80.

Vitamin A content (expressed in international units) per lgr of the flounder liver oil.

Species	Content of vitamin A	Zoo-geographic characteristics.
Hip. el. robustus	4170	Glacial
Pleuronectes stellatus (Pallas)	4000	Essentially boreal.
Pleuronectes quadri-tuberculatus (Pallas)	2910	Subarctic-boreal.
Limanda aspera (Pallas)	2960	Pacific-boreal.
Clyptocephalus stelleri (Schmidt)	4270	
Lepidopsette bil. bilineata (Ayres)	2710	
Pseudopleuronectes herzensteini Jordan et Snyder	2480	Moderately boreal.
Limanda punct. punctatissima (Steindachner)	2320	
Cleisthenes herzensteini (Schmidt)	1870	
Verasper moseri Jordan et Gilbert	2070	
Gidoderma asperrimum (Schlegel)	1230	South-boreal
Pseudopleuronectes yokohamae (Guenter)	730	

If we assume that the increase in the amount of the vitamin A accumulated in the organism of flounders is a means of adaptation of the organism to existence under more severe temperature conditions, then it is expedient to include with the indices characterizing a species, the data on the content of vitamin A in the organism, which determines its zoo-geographic profile.

Results of the analysis of the *Hip. hip stenolepis* and *Ath. evermanni* confirmed the aforesaid. It has been established that the content of vitamin A per kg. of the overall weight of the fish is about one-third (13220 and 31280 IU respectively) in the former fish, which, as is well known, inhabits lesser depths than the latter species.

Let us discuss the results of the examination of the geographic distribution of the Far-eastern flounders and the data on ecology of each individual species which will enable us to divide them into zoo-geographic groups in accordance with the system of Andriashev (1939) and Vinogradov (1948);

Pleuronectes glacialis.

Subarctic boreal species that are wide-spread in the waters of the Pacific Ocean, however, overcome the Anadyrski fauna barrier and penetrate into the region of the Bering Sea:

Pleuronectes quadrituberculatus.

Essentially boreal species that are wide-spread in the waters of the Pacific Ocean, but also penetrate into the low Arctic areas of the Arctic region:

Pleuronectes stellatus.

Pacific boreal species that do not overcome the Anadyrski fauna barrier, are not found in the Anadyrski region of the North-Bering zone and are either absent or very rare in the Nortonski zone of this region:

Limanda aspera

Atheresthes evermanni

Hippoglossus hip. stenolepis

Reinhardtius hippoglossoides matsuurae.

The large group of species belonging to this zoo-geographic class may be further divided as follows:

a) North-boreal Okhotsk-Bering species that are wide-spread in the Okhotsk and Bering seas, however do not descend to the South farther than Cape Terpeniya (the eastern shores of the Sakhalin) and do not penetrate into the Sea of Japan:

Limanda punct. proboscidea

Lepidopsetta bil. bilineata

Hippoglossoides el. elassodon.

b) moderate boreal species from the Sea of Japan that are distributed over a rather limited area mainly in the seas of Japan and adjacent regions:

Pseudopleuronectes herzensteini

Acanthopsetta nadeshnyi

Limanda punct. punctatissima

Lepidopsetta bil. mochigarei

Pleuronectes pinnifasciatus

Cleisthenes herzensteini

Glyptocephalus stelleri

Hippoglossoides el dubius.

c) South-boreal Japanese species populating mainly the coastal waters of the Japan and the Sea of Japan within the limits of boreal zones, however, penetrating rather far to the North (into the North boreal zones) and South (into the subtropic zones):

Pseudopleuronectes yokohamae

Cidoderma asperrimum

Verasper moseri

Pleuronectes obscurus.

d) Subtropic boreal Japanese-Chinese species that are usually found near South Japan, along the shores of North China and Taiwan, and penetrate into the boreal waters in the North:

Paralichthys olivaceus

Kareius bicoloratus

Microstomus achne

Verasper variegatus

Eopsetta grigorievi.

Lastly, we wish to mention the Hip. el. robustus, which is a species adapted in the main to cold water regions and has been classified by A. Vinogradov (1948) with the "glacial" group.

Let us summarize the data available on the geographic distribution of flounders in the Far Eastern waters in table 81 and characterize in brief all the regions of the Far Eastern seas from the point of view of the distribution of flounders.

Farther to the North, in the Chukotski sea, we found mainly the Arctic *Pleuronectes glacialis* and the widespread boreal form *Pleuronectes stellatus*. Both these forms are found here in rather limited numbers.

In the southern zone of Chukotski Sea we found only the fry of the glacial *Hip. el. robustus* (Andriashev, 1939) (although judging by the ecological characteristics, these waters should also be inhabited by the adult specimens of *Hip. el. robustus*), which leads us to assume that the populations of this species in the given region are rather limited. Furthermore, the Pacific-boreal form *Limanda aspera* is known to inhabit the Bay of Kotsebu.

The northern part of the Bering Sea (to the North from St. Lawrence Island), and particularly its warm eastern section, from the northern border of the regions of propagation of the most important industrial flounders of the Far Eastern waters - the subarctic-boreal *Pl. quadrituberculatus* and the Pacific-boreal *Limanda aspera*, which penetrate into this region in single specimens.

Within the limits of the Anadyrski Bay we encountered, apart from the aforementioned flounders, the *Lep. bil. bilineata* and therefore conclude that the overall number of the flounders in the Chukotski province

and the North Bering region (Anadyrski and Nortonski areas zones) is six.

In the aforementioned regions the flounders neither are, nor will be in the future, industrially important. The flounders form considerable concentrations only from the Koryatsky North-boreal region and somewhat farther southwards.

The number of flounder species found in the southwestern zone of Anadyrski Bay rises to 11 on the account of the north-boreal *Hip. el elassodon* and *L. punct. proboscidea* and Pacific-boreal forms (*Hip. stenolepis*, *Ath. evermanni*, *Reinh. hip. matsuurae*).

Migrations of these forms in the northerly direction cease at the ledge of the Anadyrski fauna barrier (Andriyashev, 1930) due to the temperature conditions and bathimetric factors.

In spacious North-Bering shallow waters region certain areas (for example, near the St. Lawrence island) of an exclusively high benthic biological volume, which acquire a hydrological character suited to the existence of flounders during the warm season, are not visited by flounders because these fish have relatively inert migration habits. In order to travel to regions rich in food objects from the areas of possible hibernation, the fish must travel at least 300 miles in one direction.

The concentrations of flounders within the limits of the shelf extending from the southwestern part of Anadyrski Bay to Cape Olyutorski are rather negligible . It

suffices to mention that in 1931 the flounders constituted 0.65% of the overall trawl catches in the Anadyrski Bay and 5.2% in the Olyutorski-Navarinski region. However, the flounders may be of industrial importance in this region as a by-catch and even as the main catch if the fishing is conducted from small boats based at nearby fishing plants. Undoubtedly, planning the organization of fishing industry in this region must concentrate on halibuts.

Olyutorski Bay and the waters washing Karaginski Island (including Korf Bay and Litke strait), which Andriyashev partly included in the Koryatsky province and which are partially transitional regions to the more southern moderately-boreal Avachinski region, scarcely differ with regard to number of and type of species of flounders from the more northern areas of Karyatsky fauna district, excepting for *Ac. nadeshnyi* present in this zone. However, the density of the flounder population increases in this area and they constitute 42% of the overall trawl catches. We believe that effective flounder fishing could be successfully organized in this region. The Kommandor Islands (the Kommandor moderately boreal region) are characterized by a rather poor flounder fauna (since *Pl. glacialis*, *Pl. quadrituberculatus*, *Acanthopsetta nadeshnyi*, *Limanda aspera*, *L. punct. proboscidea*, in other words the main industrial flounders) are not found in this area, a finding which may be due to insufficient investigations in this area, but which is to a considerable extent due to unfavorable

conditions for the development of these flounders in this region. We found here the south-boreal *Cl. asperrimum*, but this species is also known to inhabit the waters washing the eastern shores of Kamchatka. Near the shores of eastern Kamchatka, which is situated within the limits of the Avachinski North-boreal region, the fauna of flounders remains almost identical within that of the Asian littoral zone of the Bering Sea (may we point out the absence of endemics in the western part of Bering Sea and near the eastern shores of Kamchatka), however, their number sharply increases. Here, in the Avachinski, Kamchatka and particularly Kronotsky Bays, we discovered (especially during the winter) large concentrations of *L. aspera*, *Pl. quadrituberculatus*, *Lip. bil bilneata* and others, on which trawl fishing on a large scale is conducted. The number of *Pl. stellatus* is high in the coastal zone and these fish often fill up the casting nets launched from the shore. To the south-east from Cape Lopatka, we discovered large winter concentrations of *Lepidopsetta bi.bilineata*. The off-shore waters of East-Kamchatka are the region of all Bering waters and adjacent Pacific areas which promises best results in organized flounder-fishing. In the west-Kamchatka north-boreal region the species of flounders are the same as on the eastern shores and south-western shores of the Bering Sea. *Pl. glacialis* and, of course, *Hip. el. robustus* are the only species that

are not found here. Among the south-boreal forms the *Cl. asperrimum* and *Cl. stelleri* are found in this area.

The specific hydrological conditions of this region considerably affect the distribution of flounders over the West Kamchatka shelf.

We find in the southern section all the species enumerated in table 81; moreover, the *Limanda aspera* constitutes up to 80% of the overall catches in this area.

In the largest northern and central sections of the shelf we find no *Cl. asperrimum* or *Lep. bil. bilineata* and the *Pl. quadrituberculatus* prevail in catches (up to 60%).

The West Kamchatka shallow waters cover a spacious area, have high indices of food biological volume, hydrological conditions and a number of other factors (primarily weak currents) which are favourable to the existence of the North-Pacific and south-boreal flounders. Although there is no great variety of species of the latter fish in this area, those present do form immense industrial concentrations (consisting of *Limanda aspera*, *Pl. quadrituberculatus*, *Lep. bil. bilineata* and *Lim. punct. proboscidea*). *Pl. stellatus* are found here in small numbers only and mainly concentrate in the littoral zone.

Shelikhov Bay and its western section in particular, the northern and northwestern shores of the Okhotsk sea

and to an even greater degree the Shantarski region, have a poor fauna of flounders. All the halibuts which are so common on the West Kamchatka shelf, disappear (excepting in the depression near the eastern approaches to Aion Island); in the region of Shantarski Island the following are not found either: *Lim. aspera*, *Lim. punct. proboscidea* and *Hip. el. robustus*. The *Lim. aspera* and *Pl. quadrituberculatus* that are found near the northwestern shores of the Okhotsk Sea, move close to shore during the summer. These flounders are obviously in an inhibited state, as may be seen from the slow rate of development and their relatively rare occurrence. The *H. el. robustus* alone is widespread (with the exception of Shantarski Island). There are no possibilities of organizing worth-while industrial fishing on a large scale in this area at all. Sakhalin Bay, and particularly, its eastern part, affected by the waters of the Amur, has a richer fauna than the north-western part of the Okhotsk Sea (than Shantarski region especially). This richness of fauna occurs on the one hand at the expense of the restoration of those species which have disappeared from the northern and western region, namely *Lim. punct. proboscidea*, *Hip. el. robustus*, *Lim. aspera*, and, on the other hand, at the expense of the apparition of new forms, mainly from the Sea of Japan and moderately boreal region, of flounders, such as *Pl. pinnifasciatus*, *Ps. yokohamae*, *Lep. bil. mochigarei*, *Cl. stelleri*, which have penetrated this region through the estuary of the Amur (the two former forms) and via the eastern shores of the Sakhalin (the latter two species).

Insufficient investigations made of the ichthyofauna of the Sakhalin Bay lead us to assume that we shall eventually find a few more forms of flounders (perhaps the *pleuronectes obscurus* and other species) within the limits of this bay.

In any event, as we shall state further on, Sakhalin Bay cannot be classified with the cold-water regions.

GEOGRAPHIC DISTRIBUTION OF THE FLOUNDERS OF THE FAR
EASTERN WATERS.

Species.	Chukotski Sea	Bering Sea						
		Northern zone (to the North from St. Lawrence Island)	Anadyrski Bay (central and North- ern zone)	From the mouth of Anadyr to cape Olyutorski	Olvutorski Bay	Korf Bay and Litka Strait	Kommandor Islands.	
1. Pleuronectes glacialis	+	+	+	+	+	+	+	
2. Pleuronectes Pinnifasciatus	-	-	-	-	-	-	-	
3. Pleuronectes obscurus	-	-	-	-	-	-	-	
4. Pleuronectes stellatus	+	+	+	+	+	+	+	
5. Pleuronectes quadrituberculatus	-	+	+	+	+	+	+	
6. Hippoglossoides el elassodon	-	+	+	+	+	+	+	
7. Hip. el robustus	+	+	+	+	+	+	+	
8. Hip. el dubius	-	-	-	-	-	-	-	
9. Hippoglossus hip. stenolepis	-	-	-	+	+	+	+	
10. Reinhardtius hippoglossoides matsuurae	-	-	-	-	-	-	-	
11. Atheresthes evermanni	-	-	-	+	-	-	+	
12. Lepidopsetta bil. bilineata	-	-	-	+	+	+	+	
13. Lep. bil. mochigarei	-	-	+	+	+	+	+	
14. Acanthopsetta nadeshnyi	-	-	-	-	-	-	-	
15. Limanda aspera	-	-	-	-	+	+	+	
16. Limanda punct. proboscides	+	+	+	+	+	+	+	
17. Limanda punct. punctatissima	-	-	-	+	+	+	+	
18. Pseudopleuronectes yokohamae	-	-	-	-	-	-	-	
19. Pseudopleuronectes herzensteini	-	-	-	-	-	-	-	
20. Glyptocephallus stelleri	-	-	-	-	-	-	-	
21. Microstomus achne	-	-	-	-	-	-	-	
22. Cleisthenes herzensteini	-	-	-	-	-	-	-	
23. Clidoderma asperimum	-	-	-	-	-	-	+	
34. Verasper variegatus	-	-	-	-	-	-	-	
25. Verasper moseri	-	-	-	-	-	-	-	
2. Kareius bicoloratus	-	-	-	-	-	-	-	
27. Paralichthys olivaceus (Schlegel)	-	-	-	-	-	-	-	
28. Eopsetta grigorievi (Herzenstein)	-	-	-	-	-	-	-	
(10)	4	5	6	11	10	(+8)	10	
Near the Aion Island							(+17)	
(16)								
(16)								
Only near the shores of Alaska								

TABLE 81
(see original text of book on pages 147, 148, 149)

Sea of Okhotsk	Eastern shore of the Kamchatka and Northern Kuril Islands	
	Western shores of Kamchaska	
	Shelikhov Bay	
	Northwestern shores	
	The region of Shantarski Islands	
	Sakhalin Bay	
	Northwestern shores of Sakhalin from Cape Elisabeth to Cape Terpenya.	
	Southeastern shores of Sakhalin	
	Aniv Bay	
	Northern shores of Hokkaido	
Sea of Japan	Northern zone of Tatarski Strait	
	Maritime Coast	
	Peter the Great Bay	
	Korean Bay	
	Eastern shores of Korea	
	Southwestern shores of Sakhalin	
	Western shores of Hokkaido	
	Northwestern shores of the Nippon Island	
	Southwestern shores of the Nippon Island	
Pacific Coast	South-Kuril Islands	
	Eastern shores of Hokkaido	
	Northeastern shores of the Nippon Island	
	Southeastern shores of the Nippon Island	
	Kyushu Island	
	Yellow Sea	
	Shores of the China and Taiwan	
	Pacific Coast of America	
	Atlantic Coast of Europe and Barents Sea	
	Atlantic Coast of North America	
	REMARKS	

The northeastern shores of Sakhalin (to the North from Cape Terpeniya) are marked by the South-Okhotsk fauna, known to be abundant. Despite the severe hydrological conditions, the south-boreal *Veraspermoseri*, *Clidoderma asperrimum* and the moderately-boreal *Cl. Stelleri* penetrate into this region, (mainly into the southern zone adjacent to Cape Terpeniya).

The remaining species composition of the flounders is almost identical with that of the West-Kamchatka littoral zone, with the exception of *Lep. bil. bilineata*, which is not found here, and *Hip. el robustus* which replaces in this area the *Hip. el elassodon*. During the warm season the majority of species concentrate in groups in the littoral zone; a few remain at greater depths (*Hip. el robustus*) and such as *Hip. Hip. stenolepis*, *Reinh. hip. matsuurae*, *Ath. evermanni* populate the depths situated beneath the horizons with temperatures below zero. The unfavourable distribution of water-volumes, i.e. the isolation by cold waters (the residual layer of winter cooling) of the coastal zone from the deep section of the shelf as well as relatively intensive currents results in that flounders of these regions form small concentrations only, and therefore there can only be a very limited development of coastal fishing from small boats.

Near the south-eastern shores of Sakhalin, where the "Glacial", north-boreal and south-boreal regions meet, there exist 16 species of flounders.

Apart from the great number of endemics of the north-boreal regions (such as *L. aspera*, *Pl. quadrituberculatus*), we find here the south-boreal *Cl. asperrimum*

and *Ver. moseri*, the usually moderately-boreal *Cl. stelleri*, *Ac. nadeshnyi* and the wide-spread "glacial" *Hip. el robustus*.

It is interesting to note that the southern border of propagation of *Lim. punct proboscidea* overlaps, in this area, the northern border of the propagation of *Lim. punct. punctatissima*. In view of the relatively great numbers of the aforementioned species (primarily of *Limanda aspera*) and limited region of propagation, the summer concentration of flounders in the Bay of Terpeniya and near the southeastern shores of the Sakhalin are marked by high concentrations and may ensure a large-scale fishing industry from small boats.

Aniv Bay is to a great extent a transitional region between the south-boreal and north-boreal zones. The number of flounder-species found in this area total 21. The border of the bay is located in the migration paths of flounders from the sea of Japan into the sea of Okhotsk, of the descent southwards of the northern forms along the cool littoral zone of Sakhalin and of the migration of species adapted to warm waters along the northern shores of Hokkaido (which is warmed up by the branch of the current of the Sea of Japan) - so that a great number of both warm-and cold-water flounders are found in Aniv Bay.

The fauna of flounders comprises a great number of northern representatives (*Pl. quadrituberculatus*, *L. aspera*, *Hip. hip. stenolepis*), which are found side-by-side with the south- and even subtropic-boreal forms (such as *Cl. asperrimum*, *Microstomus achne*, *Par. olivaceus*, *Ver. moseri*, *Kar. bicoloratus*). At the same time, the Japanese flounders (such as *Cl. herzensteini*, *Lep. bil. mochigarei*, *Lim. punct. punctatissima*, *Ps. herzensteini*, *Pl. obscurus*, *Pl. pinnifasciatus*) and the glacial *Hip. el robustus* are usual in Aniv Bay. The concentrations of flounders, found in the main in the littoral zone, are sufficiently large and dense for the organization of a relatively inextensive fishing industry in this region from small boats.

The large shallow-water plateau which is adjacent to the northern shores of Hokkaido, is populated with a varied fauna of warm water flounders (21 species). Apart from the species inhabiting Aniv Bay (with the exception of *Hip. el robustus* and *Liop. pinnifasciata*), the subtropic-boreal *Eopsetta grigorievi* and *Reinh. hip. matsuurae* live in the Hokkaido zone. There are no large concentrations of flounders which would ensure successful operation of a large trawling fleet in this region and effective fishing can be conducted only from small boats.

The region of the Southern Kuril Islands (including the South-Kuril shallow waters) is populated with the flounders absolutely identical with the species from the northern shores of the Hokkaido. Moreover, we find here the *L. aspera* and *Pl. quadrituberculatus* and other forms of more northern origin, but they are not numerous (even rare). A number of forms of the South-boreal character, however, (for example the *Cl. asperrimum*), which are found farther to the North in single specimens only, here form semi-industrial concentrations. The behaviour of many species, the main region of propagation of which is situated somewhat farther to the North, substantially changes in the region of the South-Kuril shallow waters. The high summer temperature of water in the shallow areas compel certain flounders to migrate during the summer to greater depths returning during the winter to the shallow areas (*Ath. evermanni*) or else, to remain during the summer at a depth of 60 or more meters at a certain distance from the shore (*Lep. bil. mochigarei*), *L. aspera*, *Cl. herzensteini*).

We wish to point out that this region is abundant in flounder species from the Sea of Japan (with the exception of *Pl. pinnifasciatus*), such as *Lep. bil. mochigarei*, *Pl. obscurus*, *Cl. herzensteini*, *Ac. nadeshnyi*.

The region of the South-Kuril Islands has no great industrial importance, however, fishing from small boats may be successfully conducted in this area.

Near the eastern shores of the Hokkaido and farther to the South along the Pacific Coast of the Japan, near the northeastern shores of the Nippon Island, a process of gradual unification of the fauna of flounders belonging to the sub-family Pleuronectini occurs at the expense of the disappearance of northern forms. In this region there are no subarctic-boreal *Pl. quadrituberculatus* and the following reach only as far as the Tokiy bay: the essentially boreal *Pl. stellatus*, the Pacific-boreal *L. aspera*, *Ath. evermanni*, *Reinh. hip. matsuurae*, *Hip. hip. stenolepis*, moderately boreal *Ac. nadeshnyi*, *Lim. punct. punctatissima*, *Lep. bil. mochigarei*, *Gl. stelleri* and the south-boreal *V. mozeri*. Thus, Tokiy Bay is a well pronounced fauna barrier between the North-Pacific moderate and Indian West-Pacific subtropic region, where the large groups of the flounders inhabiting the northern regions, disappears. Simultaneously with the disappearance of the aforementioned flounders, there occurs a certain increase in the number of the south-boreal and particularly, subtropic-boreal forms, to which the *Ver. variegatus*, *Pleuronichthys cornutus*, *Dexistes rikuzenius*, *Tanakius kitaharae* (the latter three have not been found in our waters) belong. The industrial importance of the regions in question is relatively small, since the majority of flounders

of southern origin form no large concentrations and fishing is successfully conducted from small boats only.

Near the southeastern shores of the Isle of Nippon and near the shores of Kyushu Island, there exist only 7 representatives of the sub-family Pleuronectini (plus the *Paralichthys olivaceus*), also found in the waters of the Soviet Far East.

Even if we add here the three species of this sub-family which appeared for the first time near the northeastern shores of the Isle of Nippon, and three species of other sub-families of the family Pleuronectidae *Poecilopsetta plinthus* (Jordan et Starks), *Lepidoblepharon ophthalmolepis* Weber, *Samariscus inornatus* (Lloyd) penetrating to the North along the eastern shores of the Japan up to the 34° of northern latitude, we still have to admit that the fauna of flounders (the family Pleuronectidae) of Southern Japan is rather poor.

Within the limits of the Sea of Japan and particularly, in its northern zone, there exist a number of species, which have definitely originated in the Sea of Japan.

In the northern part of Tatarski Strait, which, as is well known, is characterized by relatively severe hydrological conditions favourable to the forms of more northern origin (such as *L. aspera*, *Pl. quadrituberculatus*, *Pl. stellatus*), forming considerable concentrations in this area (with the exception of *Pl.*

stellatus, which are less numerous), the fauna of flounders consists in the main of the species of the Sea of Japan (or adjacent regions) of moderately boreal origin. The *Pl. pinnifasciatus*, *Pl. obscurus*, *Ac. nadeshnyi*, *Ps. yokohamae*, *Ps. herzensteini*, *Cl. stelleri*, *Cl. herzensteini* are found here as are a number of forms affinitive to the species populating the waters somewhat farther to the North but substantially differing from the latter (such as the *Hip. el dubius*, *Lep. bil. mochigarei*, *Lim. punct. punctatissima*). There are almost no southern elements here. The large shallow water plateau a large section of which is characterized by abundant benthic biological volume and hydrological conditions peculiar to the regions of the north boreal character, ensure favourable conditions for the existence of numerous species forming large industrial concentrations. Near the Maritime (northwestern shores of the Sea of Japan, we find the same 14 species of flounders as in the northern zone of Tatarski Strait. The narrow continental stage and the strong currents prevent the flounders forming large concentrations and the fishing in this region may be conducted only in the region of the Nelm, Rynda, Olga, Preobrazheniya bays etc. and on a rather limited scale. We observed that in Peter the Great Bay the assortment of species of flounders is considerable more varied (and reaches 20 species) owing to the existence in

these waters of a great number of the south-boreal and even subtropic-boreal forms (*Eopsetta grigorievi*, *Par. Olivaceus*, *Kareius bicoloratus*, *Ver. variegatus*) penetrating in single large specimens into the bays during the warm seasons of the year, a penetration which occasionally occurs once every few years only. At the same time no subarctic-boreal *Pl. quadrituberculatus* was found here.

The relatively extensive shallow water plateau, the abundance of food objects and the moderate north-boreal hydrological conditions favour the existence of numerous *L. aspera*, *Ps. herzensteini*, *Cl. herzensteini* and other species, forming large concentrations and ensuring fishing on a medium scale from small and large boats.

Farther to the South, in the Korean Bay and near the southeastern shores of Korea, the northern species become less and less numerous, while the flounders of southern origin gradually increase in number. *Pl. quadrituberculatus*, *Pl. obscurus*, *Lep. bil. mochi-garei* are no longer found here whereas *Microstomus achne* and other southern species become more numerous. Near the southwestern shores of Sakhalin, the species of flounders are rather numerous (18 species plus 3 possible species) and varied. Together with the northern forms (such as *Pl. quadrituberculatus*, *L. aspera* and others) we found, particularly in the

southern zone, in the region of Moneron Island, numerous southern elements (*Micorstomus achne*, *Par. olivaceus*, *Ver. moseri*, *Cl. asperrimum*), as well as flounders originating in the Sea of Japan. Although the flounders population is varied in this region, the number of representatives of different forms is relatively limited but nonetheless may ensure successful fishing from small boats.

The character and number of flounders - species in the littoral waters of Western Hollaido is almost exactly the same as on the coastal zone of South-western Sakhalin; the *Pl. quadrituberculatus* are not found here at all, but the *Kareius bicoloratus* and *Eopsetta grigorievi* are found in their stead.

The flounder fauna along the shores of the Sea of Japan and of the Isle of Nippon is practically the same (14 species) and the fauna barrier in the region of Vakas Bay is not as clearly pronounced in the case of these fish, as in the case of the crustacea (Vinogradov, 1946) and other animals (Eckman/1935, Lindberg/1947/ and others).

The penetration of representatives of the sub-family Pleuronectini into the Yellow Sea, Eastern and Southern Sea of China, is very rare.

We know that 7 representatives of this sub-family exist in the Yellow Sea (plus *Par. olivaceus*) and populate the northern zone in the main. These are essentially southern forms (*Cl. asperrimum*, *Ver.*

variegatus, Ver. moseri, Kar. bicoloratus, Micr. achne and species from the sea of Japan, i.e. Pl. obscurus, C. herzensteini).

The 5 following southern species are found near the northern shores of China and penetrate to the South, as far as Taiwan Island: Ver. variegatus, Kar. bicoloratus, Par. olivaceus, Eopsetta grigorievi and Mich. achne. No other representatives of the northern fauna are found.

The relatively well outlined regions of propagation, zoo-geographic classification and biology of flounders enable us to disregard the relatively limited species composition of this group and discuss in brief the existing division of the Far Eastern seas into zoo-geographic zones.

We wish to point out that being relatively inactive, the flounders do not make prolonged migrations so the presence of these fish clearly indicates the zoo-geographic character of different zones.

Due to this peculiarity, all marine geographers point out that flounders are the most important indicator to the division of zoo-geographic zones.

The data provided by the expedition into the Bering Sea undertaken for the purpose of classifying the fish population, have been thoroughly developed by Andriyashev (1939).

No explorations and collections have been conducted in the Bering Sea since that date. We do not have any supplementary data material, therefore, which would enable us to define more precisely or change the excellent scheme provided by Andriyashev on the zoogeographic division of the Bering Sea.

In the Sea of Okhotsk, however, we believe it possible to define the scheme of the zoogeographic division (which has been suggested by Andriyashev/1939/, Vinogradov /1946, 1948/ and other explorers) with greater exactitude.

The penetration of the north-boreal fauna (including the north-boreal flounders, such as *Lim. punct. proboscidea*, *Lep. bil. bilineata*, the moderately boreal *Ac. nadeshnyi* and others into the eastern zone of Shelikhov Bay enables us to classify this region (that is adjacent to the Kamchatka shores) as north-boreal.

Its western zone, where the fish fauna is rather poor, must be classified with the Okhotsk-glacial region (following the terminology used by Vinogradov).

The region of Sakhalin Bay and, particularly, the eastern zone, must be excluded from the glacial region, with which Vinogradov included it (1948); Schmidt (1904) classified it with the region of Shantarski Islands. It must be kept in mind that the immense water volumes of the Amur, which are carried into Sakhalin Bay and subsequently deflect

towards the eastern zone, substantially affect the hydrological conditions in Sakhalin Bay (particularly during winter), creating sharp differentiations between the thermic conditions in its eastern and western zones.

This sharp characteristic difference in hydrological conditions is one of the most important factors, and accounts for the penetration of the warm water fauna into Sakhalin Bay, although this Bay is surrounded by the glacial Okhotsk region and a corresponding fauna. This warm water fauna includes a number of moderately boreal (*Lep. bil. mochigarei*, *Acanth. nadeshnyi*, *G. stelleri*) and south-boreal forms (*Pseudopl. yokohamae*), which increase the number of flounder forms inhabiting Sakhalin Bay, to 10, while the glacial Okhotsk region is populated by 6 species only. Thus the fauna of flounders inhabiting Sakhalin Bay, or to be more precise, its eastern zone, must be classified as north-boreal. The northern shores of Hokkaido are characterized by an exceptionally rich fauna of flounders comprising 21 species. Its composition is identical with the fauna of flounders populating the South Kuril shallow waters, which were correctly classified by Vinogradov (1948) with the south-boreal zone. Thus, the south-boreal character of the fauna of flounders populating the region adjacent to the northern shores of Hokkaido

and comprising a great number of South-boreal and subtropic-boreal forms (see table 81), as well as the hydrological conditions of this region provide grounds for classification of this shelf with the south-boreal region.

The correctness of the classification of Peter the Great Bay (Vinogradov, 1948) with the south-boreal regions on the basis of the analysis of the fauna of crustaceous decapoda seems questionable. We wish to point out that the zoo-geographic character of Peter the Great Bay has not been thoroughly clarified as yet.

P. Schmidt (1905-1950) drew the border between the southern and northern zones of the Sea of Japan along the line Wonsan-Hokkaido and, as a result, the Peter the Great Bay has been classified with the subarctic region of the northern zone of the Sea of Japan, Lindberg (1925), while working on the division of the Sea of Japan into the southern and northern zones drew the border line somewhat farther to the North, from Olga Bay to La Perouse Strait. Somewhat later (1946) during a tentative division of the Sea of Japan into zones (which was done while registering the fish species inhabiting these waters), the same author characterized Peter the Great Bay as a separate zone. Balls (1924) suggested that a great number of subtropic forms are admixed with the fauna of the northwestern

littoral waters of the Sea of Japan in Peter the Great Bay.

We believe that the fauna of fish and particularly, of flounders inhabiting Peter the Great Bay, has a number of features characteristic of both the north- and south-boreal regions and must be defined as a transitional, though essentially boreal fauna.

In Peter the Great Bay the hydrological conditions during winter are severe as in most north-boreal glacial or Arctic regions; during the summer the hydrological conditions in this area are characterized by high temperature in the surface layer of water and temperatures of water at depths of 70-100 meters that are usual for the north-boreal regions. This circumstance naturally affects the composition of fauna in Peter The Great Bay and must be taken into account in the classification of this region into a zoo-geographic category.

The abundant southern elements in the fauna of Peter the Great Bay (Lindberg, 1928, Taranets, 1938; Rumyantsev, 1947, and others) comprise first of all the pelagian and, to a considerably lesser extent, benthic forms. The overwhelming majority of these fish are caught during the summer. Undoubtedly, during the intensive warming up of the water in the bay there appear both regularly and sporadically great numbers of southern fishes sharply increasing

the number of southern elements in this region and affecting its general zoo-geographic characteristic, which, therefore, should be classified as essentially southern. Moreover, Peter the Great Bay is the region of the Far Eastern waters whose ichthyofauna has been the most thoroughly studied and a great number of southern (occasionally very rare) elements are known to exist within the limits of this region.

However, the analysis of the number and variety of species and biology of flounders either populating or found in the Bay leads us to assume that this bay is a region much more affinitive to the Maritime coastal waters or the Northern zone of Tatarski Strait, i.e. the north-boreal region, than to the Korean Bay or eastern shores of the Korea, i.e. the south-boreal regions.

Indeed, among the 20 species of flounders encountered in Peter the Great Bay, 13 are found near the shores of the Maritime and in the northern zone of Tatarski Strait, making up 100% of the fauna of flounders of these areas. The subarctic boreal *Pl. quadrituberculatus* and *L. aspera* descend to Peter the Great Bay and remain there. The former do not reach the Korean Bay, while the latter form large concentrations that have not been found farther to the South or in the south-boreal regions.

Moderately foreal forms, such as *Limanda punct. punctatissima*, *Lep. bil. mochigarei*, *G. stelleri*, *Ae. nadeshnyi*, live here and form large industrial concentrations.

All these species make seasonal migrations from the region of wintering in the lower horizons of the sublittoral (150-220 meters) to the shores.

These migrations are induced by the drop of benthic temperatures in the littoral zone during winter, and therefore, the flounders drift away from the shores towards greater depths.

What are the remaining 6 species of flounders found in Peter the Great Bay? These are the southern *Verasper moseri*, *Clidoderma asperrimum*, the subtropic-boreal *Paralichthys olivaceus*, *Kareius bicoloratus*, *Verasper variegatus* and *Eopsetta grigorievi*. It may seem that such considerable percentage (30%) of the southern elements in the fauna of flounders in Peter the Great Bay should be an index to the character of the entire region. However, none of the aforementioned species of southern origin in Peter the Great Bay inhabit it permanently, but merely penetrate into these waters in single specimens during the summer. Although the fishing is conducted in the Bay all the year round, no fry of the aforementioned species have been found in these waters and the overall number of fish caught belonging to these forms reaches a few dozens of specimens. Thus, beyond doubt, we here deal with

immigrants from the vicinal regions. The aforesaid compels us to classify the fauna of flounders inhabiting Peter the Great Bay as north-boreal fauna with admixtures of the elements of the south-boreal fauna from the northern shores of Korea, which join the former during the summer.

It is equally difficult to agree with Vinogradov, who believes that the Aniv Bay is an intermediate region between the glacial and north-boreal zones. The numerous fauna of flounders (21 species) of this bay, the composition of which is fully identical with the south-boreas fauna inhabiting the littoral waters of northern Hokkaido and almost coinciding with the fauna of flounders of the South Kuril Islands, leads us to consider Aniv Bay to some extent as a transitional region between the north-boreal region on one side and the south-boreal zone on the other side. The fact that one glacial species of flounder (*Hip. el robustus*) lives in these waters cannot be considered as sufficient reason to classify this region and fauna of fish populating it as a glacial north-boreal region, since the numerous representatives of the southern flounders living here indicate that the fauna of flounders in Aniv Bay, is much more closely related to the south-boreal than to the north-boreal category.

Lastly, we wish to add a few remarks with regard to the stabilization of the terminology of the glacial fauna, glacial regions, and, first of all, of the Okhotsk glacial region extending between Shelikhov Bay along the northwestern shores of the Sea of Okhotsk and eastern shores of Sakhalin Island (Schmidt, 1935; Andriyashev, 1939; Vinogradov, 1946, 1948).

Beyond any doubt such areas as these must be individually classified. However, it must be kept in mind that similar areas (though lesser in dimensions) are also found in Tatarski Strait, in Aniv Bay, near the western shores of Kamchatka, where, as already indicated, there exists a peculiar fauna within the limits of cold patches (Ivanov, 1931; Gordeeva, 1948).

While doing so, we must take into consideration the multi-annual hydrological fluctuations observed in the zone of the Kuroshio, which produce considerable changes in the temperature and other hydrological elements in all the Far Eastern marginal seas. For example, it is well known that periods of several years have been observed during which the character of water covering the West-Kamchatka shelf is undoubtedly glacial, while temperatures during summer never drop below zero. Furthermore, the "glacial" periods leave clearly marked traces in the form of regions containing high biological volume, which have been classified by Gordeeva (1948) as a separate zone

of residual below-zero temperatures. The benthic and pre-benthic fishes, crustaceous decapoda (Vinogradov) and, of course, many other animals react to the temperatures below zero with equal sensitivity, as may be seen from the character of their propagation. Similar fluctuations in the lines of threshold of the cold water regions (and occasionally their complete disappearance) are known for a number of regions in the Far-Eastern seas. We believe that in the given case the aforementioned phenomena must be taken into account and the possibility of the disappearance of temperatures below zero during certain years must be reckoned with when characterizing certain regions, as, by doing so, we may prevent the erroneous classification of fauna.

Such are the general considerations pertaining to the existing scheme of the zoo-geographic division of the Far Eastern waters into different zones (Andriyashev, 1939, Vinogradov, 1948). Otherwise, the distribution under discussion is perfectly compatible with the general scheme.

While analyzing the fauna of flounders of the north-western zone of the Pacific Ocean, we observed the following peculiarity that has been previously emphasized by certain researchers: namely, a great number of flounder species are propagated in the

Sea of Japan and vicinal regions (see table 81).

Indeed, out of the 22 flounder species inhabiting the Sea of Japan, 6 forms (*Lim. aspera*, *Pl. quadrifasciatus*, *Ac. nadeshnyi*, *Hip. hip. stenolepis*, *Ath. evermanni*) are wide-spread in the Far-Eastern waters, essentially north from the Sea of Japan, while all the remaining forms are to a greater or lesser degree adapted to the Sea of Japan or regions adjacent thereto. Thus, *Pl. pinnifasciatus* is an endemic from the Sea of Japan. A great number of species (*Lep. bil. mochigarei*, *Cl. herzensteini*, *Hip. el dubius*, *Gl. stelleri*, *Ps. herzensteini*, *Ps. yokohamae*, *Lim. punct. punctatissima*, *Pl. obscura*) are wide-spread in the Sea of Japan and most numerous within its limits, however, penetrate mainly into the southern zone of the Okhotsk and Yellow Sea. This distribution of flounders argues that the formerly abundant fauna of flounders penetrated at one time into the Sea of Japan and became isolated from the other basins. The flounders existing within the limits of this basin underwent a series of morphological and biological modifications and formed endemic sub-species (*Lep. bil. mochigarei*, *Hip. el dubius*, *Lim. punct. punctatissima*), species (*Pl. obscura*, *G. stelleri*, *Ps. herzensteini*, *Ps. yokohamae*, *Cl. herzensteini*) and genera (*Cleisthenes*).

After communication with the vicinal regions was re-established, the fauna of flounders from the sea of Japan began penetrating into the regions affinitive in hydrological and other conditions with the conditions of the Sea of Japan. Thus, a great number of flounders from the Sea of Japan reached Aniv Bay, the southeastern shores of Sakhalin, populated the northern and northeastern littoral waters of Hokkaido and certain forms penetrated as far as the Yellow Sea. Such an assumption must naturally be based on an extensive data material (and not merely on the distribution of flounders), first of all, on geological and paleontological data.

Unfortunately, the geological history of the Far East and of the seas washing the Far Eastern shores, has not been sufficiently developed as yet. The available data material is insufficient to justify pure hypotheses. According to modern theories of geologists and geomorphologists/Ikoyama (1911), Krishtofovich (1932), Yabe (1929), Lindberg (1937a, 1937b, 1946, 1947a, 1947b, 1948), Klenov (1948) and others/, as the study of ichthyofauna of the Far Eastern Fishes (Taranets, /1936/, Lindberg /1946, 1947/, Schmidt/1950/) the area occupied at present by the Sea of Japan was, during the quaternary period, either firm land or an enclosed basin holding either fresh or slightly salted water. Later on, as a result of several upheavals and transmigrations - the deep

depressions near the shores of Asia were filled and the presently existing outlines of the continent formed. The investigation of underwater valleys and the presence of coastal benches at the level of 500 meters in Japan, leads us to assume that the upheavals and transmutations of the mainland were extremely strong. All these scant data enable us merely to affirm that the Sea of Japan is of recent origin and that its communication with the Pacific Ocean was disturbed during the quaternary period.

Therefore, we believe that the data on the geographic distribution of flounders enable us to complete the available factual materials on the geological history of the Sea of Japan and consider that during the quaternary period it was at least twice re-united with the vicinal seas. During the first re-unification, the flounders penetrated therein, found themselves isolated in the basin; during the second transmigration these fish drifted away from the basin of the sea of Japan and penetrated into the vicinal regions. The present brief outline of the distribution of representatives of the sub-family Pleuronectini, inhabiting the northwestern part of the Pacific Ocean, enables us to establish beyond any doubt that this group originated in the Pacific Ocean and is of boreal character.

The division of all the flounders inhabiting the Far Eastern waters into the zoo-geographic groups (see page 142) provides grounds for a more precise

division of the Far Eastern waters into zoo-geographic zones than that provided by Andriyahev (1938) and Vinogradov (1948). In particular, we wish to underline the importance of the biological analysis of the identical objects populating different zoo-geographic zones, since the change in their behaviour depending on the conditions of existence may substantially complete the data substantiating the zoo-geographic division.

The character of distribution and the species composition of the flounders from the Sea of Japan and adjacent regions confirms the afore-discussed assumption that during the quaternary period there occurred at least a twofold reunification of this sea with the ocean and that during the last dismemberment this sea preserved its high content of salt.

The existing zoo-geographic division of the Far Eastern seas into zones is clearly confirmed by the distribution of flounders and facilitates our understanding of the existing differences in their behaviour within the limits of their region of propagation.

DISTRIBUTION AND MIGRATION.

Twenty eight species and sub-species of flounders populate the waters washing the shores of the Soviet Far East, i.e. the seas of the Chukotsk, Okhotsk, Japan and Bering Sea. The majority of these forms may have an industrial importance. After a more thorough study of the regions adjacent to the Kuril Islands and Southern Sakhalin, a few more forms will be added to

the list of flounders known to populate the Soviet Far Eastern waters.

Among the aforementioned 28 forms of flounders, five species (*Microstomus* Achne, *Paralichthys olivaceus*, *Verasper Variegatus*, *Verasper moseri*, *Kareius bicoloratus* and *Eopsetta grigorievi*) have no industrial importance in our waters, are rarely found in catches and obviously belong to the southern fauna; the most southern sections of the Soviet Far East - i.e.

Peter the Great Bay and Southern Kuril shelf coincide with the northern border of their propagation.

The remaining 22 forms have or may have industrial importance, although not to an equal degree. While several (6-7) species (*Limanda aspera*, *Pleuronectes quadrituberculatus*, *Lepidopsetta bilineata bilineata*, *Cleisthenes herzensteini*, *Limanda punctatissima punctatissima*, *Pleuronectes stellatus* and *Hippoglossoides hi.*) prevail in the catches of all the regions of the Far Eastern waters, the remaining species constitute a considerably lesser portion of catches.

Moreover, the majority of large concentrations of flounders consist in the main of two species - *Limanda aspera* and *Pleuronectes quadrituberculatus*; the former are found in the greatest numbers near the shores of Kamchatka and in Tatarski Strait, the latter - near the southeastern shores of Sakhalin.

Pleuronectes quadrituberculatus and *Cleisthenes herzensteini* are the most numerous flounders in Peter the Great Bay. However, we must not underrate the importance of the "secondary" species existing side by side with the main industrial forms. As we shall show further on, their importance as a reserve school is great, particularly since the number of fish belonging to the main species has decreased as a result of intensive fishing. In view of the numerous affinitive features in the behaviour of the majority of flounders species or of some individual group of species, as well as insufficient data available on the industrial and semi-industrial flounders, we believe it expedient to discuss the distribution, migration and other biological peculiarities of flounders according to different groups of flounders instead of individual species, which would have considerably complicated our task. While doing so, the biological characteristics peculiar to each individual form will be outlined.

The distribution of flounders in Peter the Great Bay has been described in a rather detailed manner by Moiseev (1935, 1946a, 1946b), Okhryamkin, Moiseev and Taranets (1936), Moiseev and Gavrilenko (1939) whereas the distribution of flounders in the Tatarski Strait and near the shores of Kamchatka has been discussed in a condensed form only, (Moiseev, ~~Andriyashev~~ (1940, 1946) and there exists but extremely limited data material (published by Andriyashev (1937, 1939) on the distribution of flounders in the Bering Sea.

The distribution of flounders throughout the annual cycle in Peter the Great Bay and near the shores of Western Kamchatka has been most thoroughly studied. All the remaining regions of the Far Eastern seas have been visited by expeditions during the warm period of the year and data gathered on these occasions is of purely seasonal character.

Passing over to the discussion of the distribution the flounders of the Far Eastern waters may be divided into the following three groups:

1. The sublittoral species, which are found all the year round in the upper horizons of the sublittoral, within the limits of the depths from 15 to 25 meters and do not make extensive seasonal migrations. To these species belong almost all representatives of the genus *Pleuronectes* (*glacialis*, *pinnifasciatus*, *stellatus*, *obscurus*), which usually remain in the continental shelf in single specimens only.

2. Littoral species, remaining throughout the year within the limits of the continental plateau, however, accomplishing seasonal migrations from the regions of hibernation to the shallow coastal zone, where their spawning and feeding take place.

This group comprises all the species of the genera *Limanda* (*aspera*, *punct. punctatissima*, *punc. proboscidea*), *Hippoglossoides*, *Lepidopsetta*, *Cleisthenes*, *Glyptocephalus*, *Pseudopleuronectes*, as well as the

Pleuronectes quadrituberculatus and certain others.

3. Bathyal species, remaining during most of the year at depths of 100 and more meters and found particularly often between 100 and 400 meters of depth, where the spawning and feeding occurs. Only single specimens, occasionally drift to lesser depths, mostly in the regions alongside an abrupt and steep edge of the continental shelf. All the Far-eastern halibuts (*Hippoglossus*, *Atheresthes*, *Reinhardtius*) may be classified within this group.

The distribution and migrations of industrial flounders in the Far-eastern waters are rather alike, which enables us to dwell on the seasonal distribution and scheme of migrations of flounders in the most important industrial regions and discuss very briefly the regions of secondary industrial importance.

Flounders are found everywhere over the extensive continental shelf of the Northeastern shore of Asia, but do not always form concentrations of industrial dimensions.

The largest concentrations were found in the Bering Sea (Olyutorski Bay), near the eastern shores of Kamchatka (Kronotski Bay) and to the south-east of Cape Lopatka, along the western shores of the Kamchatka (particularly in the region of the Cape Kambalny-Ozernaya river), in the northern part of Tatarski Strait, near the southeastern shores of Sakhalin and in Peter

the Great Bay. In the remaining sections of the coastal zone, from the Korean to Anadyrski Bay, the flounders are usually found in concentrations sufficient for the organization of a low tonnage fleet (with the exception of the northwestern shore of the Okhotsk Sea from Shelikhov Bay to Shantarski Islands and along the northeastern shore of Sakhalin), but insufficient for successful operation of a low tonnage trawling fleet.

We have already discussed in detail the data on the distribution and migrations of flounders in Peter the Great Bay (Moiseev, 1946) and shall dwell on this subject very briefly. At the end of the winter, owing to the intensive vertical circulation, the drift of the majority of flounders populating the bay around the edge of the continental shelf and its eastern zone to the south from the line Askold Island-Cape Zeleny, to the depths up to 250 meters, is completed. It is there, over a relatively limited area (about 200 square miles), at the depths of 180 to 250 - 270 meters that the main industrial species of flounders concentrate, namely: *Limanda aspera*, *Cleisthenes herzensteini*, *Limanda punctatissima punctatissima*, *Pseudopleuronectes yokohamae*, *Pseudopleuronectes herzensteini*, *Hippoglossoides hip.* *Lepidopsetta bilineata bilineata* and others. These forms occupy separate, though somewhat overlapping sections within the concentrations. The littoral forms such as the *Pleuronectes obscurus*, *Pleuronectes pinnifasciatus* and *Pleuronectes stellatus*, remain near the shores, at the depths of less than 30 meters. The intensiveness of feeding sharply drops

and by February-March the flounders entirely (or almost) discontinue feeding.

In the latter half of March the sexual products of flounders reach the stage of maturity that is close to the spawning stage. Simultaneously the temperature conditions in the bay particularly in its coastal zone, change: i.e. the water temperature begins gradually rising and the vernal spawning-feeding migration of flounders to shallow waters begins. The March concentrations of flounders begin dispersing in the direction of lesser depths (fig. 16-17).

It is interesting to note that despite the displacement of the centre of maximum catches in April to the depths of 130-170 meters, the southern border of high catches discontinues as before, i.e. at the edge of the continental shelf, at depths of 220-270 m., which indicates beyond any doubt that a considerable number of flounders exists at great depths than those within the limits of which the fishing is conducted. Increase in the area populated by flounders sharply reduces the mean trawl catches, which drop in April to 2.5 - 9.9. centners per trawling hour (whereas in March they reach 15.0 - 20.0 centners).

DRAWING 16.

Distribution of trawl catches of flounders in Peter the Great Bay (April - September).

DRAWING 17.

Distribution of the trawl catches of flounders in Peter the Great Bay (October-March).

The flounders drift towards the shores in the following order: *Pseudopleuronectes yokohamae*, *Limanda punctatissima punctatissima*, *Pseudopleuronectes herzensteini*, *Cleisthenes herzensteini*, *Limanda aspera*, *Hippoglossoides hippoglossoides*, *Glyptocephalus stelleri*, *Lepidopsetta bilineata bilineata*, *Acanthopsetta nadeshnyi* Schmidt. Starting from the end of March, the littoral forms i.e. the *Pleuronectes obscurus*, *Pleuronectes pinnifasciatus* and *Pleuronectes stellatus* accomplish seasonal migrations, though on a considerably lesser scale, drifting from the central sections of gulfs and bays (where they remain throughout the winter) into the estuaries and shallow gulfs, to the depths of 3-8 meters. In May the migrations continue. A great number of flounders leave the edge of the continental shelf and drift to depths of 40-80 meters. The area occupied by the concentrations of flounders increases in comparison with the preceding month, the density of concentrations decreases, the mean catches drop and do not exceed 10 centners. The main industrial forms i.e. the *Limanda punctatissima punctatissima*, *Pseudopleuronectes herzensteini*, *Cleisthenes herzensteini* and *Limanda aspera* appear one after another at the depths of 35-50 meters in the estuary of Ussuriyski Bay. Still earlier, (at the beginning of April) the *Pseudopleuronectes yokohamae* arrive in this region. In other regions (America Bay, Vostok Bay, region of Askold

Island, Posiet Bay) the flounders drift to shallow waters (below 50 meters) at the beginning or in the middle of April.

By the end of June the vernal migration of flounders to the shallow regions from the regions of wintering is almost completed. By this time no large concentrations are found at depths of more than 80 meters. The largest concentrations of flounders are observed in June in Ussuriyski Bay and near the shores of Russki Island. With the increase in depth the catches rapidly drop. The horizons of 80-100 and more meters are almost completely vacant and only in rare cases one may find here deep water flounders such as the *Acanthopsetta nadeshnyi*, *Hippoglossoides hippoglossoides*, *Lepidopsetta bil.* and *Glyptocephalus stelleri* (fig. 16).

The spawning, which certain flounders begin in March and the majority of species starting in April-July, occurs in the shallow waters. The appearance of flounders at slight depths marks the beginning of intensive feeding, which discontinues almost entirely during winter and early spring. By the middle and on to the end of June the majority of flounders concentrate in the shallow waters, in the regions of spawning, feeding and development of roe and fry. The energetic migrations of fish, which for spawning and feeding are discontinued and the summer period, marked by immobility of flounders in Peter the Great Bay begins; these fish remain within the limits of the region of their summer propagation until September. Although

there occur certain migrations of flounders during summer, they are insignificant in both vertical, as well as horizontal directions and in the majority of cases do not proceed beyond 60-70 meters isobath and 20-30 miles horizontal.

During the summer we observed a certain tendency for the centre of the maximum catches to be displaced to the region of great depths. This gradual displacement occurs as a result of the insignificant drift of the specimens which have completed spawning, to greater depths and migration of deep water forms to shallow waters.

In October the autumn migration of flounders from Peter the Great Bay to the wintering regions begins.

The factors responsible for the autumn migrations of flounders have not been clarified as yet. We believe, however, that one of the important indices of the readiness of flounders to undertake pre-winter migration is their degree of fattening up.

In October, shoals of flounders are still dispersed over the immense territory of the shallow water region. Mean trawl catches in the greatest part of this zone do not exceed 5 centners and only a few sections provide somewhat higher catches (6-8 centners). The mean depth at which the flounders remain increases by this time and the industrial fishing is conducted at the depths of up to 100 meters; deeper horizons remain as little populated by flounders as before (fig. 17).

In November the migration of flounders to the regions of wintering, which becomes further intensified and developed, started in October; the areas inhabited by

flounders decrease, the density of concentration increases and the catches rise. The map showing the distribution of catches in November rather clearly outlines the distribution of fish in the bay and indicates the displacement of the shoal of flounders to greater depth. The centre of maximum concentration of fish in November is situated to the south from Askold Island at the depths of 70-90 meters and the mean catches exceed 10 centners (over an area of approximately 130-180 square meters).

The November distribution of flounders shows that by this time the majority of flounders have not penetrated below 100-140 meters in depth and are found at depths of 40 to 50 meters.

December, January, February and the early half of March are characterized by a further decrease in the area populated by flounders, increase in the density of flounder concentration in the region situated to the south from the line Askold Island-Cape Zeleny, and drift of the entire concentration to greater depths. In December, the southern border of the concentration reaches the edge of the continental shelf, i.e. the depths of the order of 220-250 meters; a certain number of flounders leave the continental plateau and sink to the edge of the continental shelf. The southern border of the distribution and catches of flounders

during winter passes along the isobath 220-250 meters, i.e. coincides with the line of the edge of the continental shelf, while the regions with maximum catches are located in the most southern extremity of the concentration, i.e. are pressed against the edge of the continental shelf. At the same time the catches in the North decrease. We believe that the southern border of the propagation is situated at greater depths than the border which may be drawn on the basis of data provided by trawl catches. While in October, and particularly in November, there occurs a rapid displacement of large shoals of flounders from shallow waters to the regions of wintering in December and the following months (January, February and March), migration of the main industrial species of flounders is almost complete and the fish concentrate in the Askold shoal. During winter there occur only insignificant drifts of different shoals within the region of wintering; these migrations appear in the form of small drifts of fish within a concentration. During December and January, the main concentration is supplemented by the shoals lagging behind the main bulk of fish, in view of which the density of concentration increases and the catches in the region of the wintering shoal waters rise, while the area is occupied by the concentration decreases. In January the region marked by catches with mean indices exceeding 10 centners, extends; in February, this area decreases, which is probably a result of the discontinuation of the migration of flounders from shallow waters and drift of a certain number of fish to the edge

of the continental shelf.

The above described scheme of the migrations of the flounders within the limits of Peter the Great Bay pertains to the seasonal migrations of the main shoal in the bay (fig. 18).

DRAWING 18.

Scheme of the migrations of flounders in Peter the Great Bay.

XXXXXX - Winter concentrations
///// - Summer concentrations

The overwhelming majority of flounders inhabiting Peter the Great Bay (i.e. the *Pseudopleuronectes herzensteini*, *Limanda punct. punctatissima*, *Limanda aspera*, *Pseudopleuronectes yokohamae*, *Cleisthenes herzensteini*, *Lepidopsetta bilineata bilineata*, *Acanthopsetta nadeshnyi*) make two seasonal migrations yearly:

- 1) the vernal spawning-feeding migration from great depths to shallow waters;
- 2) the autumn migration to the regions of wintering, i.e. from shallow waters to greater depths.

The scheme of migration of flounder shoals to the regions of spawning and feeding of the return drift to the wintering regions is identical for all the nine most important industrial species and deviations from the norm were observed only on the dates when the migrations begin and are completed and in the course of migration paths.

These differences may be explained to a great extent by different spawning periods and regions of individual species. Migration paths followed by flounders within the region of spawning and wintering vary but little during different years.

Several species, constituting a small percentage of the variety of species and of the overall number of flounders (the *Pleuronectes obscurus* and *Pleuronectes pinnifasciatus*), make smaller-scale migrations. Remaining during this period of time at most insignificant depths (less than 10-15 meters) these forms partly leave their summer regions and migrate in October-November to the depths of 20-40 meters. During the spring the *Pleuronectes obscurus* and *Pleuronectes pinnifasciatus* proceed towards the littoral zone and reach depths of 6-10 meters. Thus, even these two forms make the spring and autumn migrations, although the extent of their migration paths is considerably shorter than that of the aforelisted industrial species.

The spacious shallow water plateau extending along the western shores of Kamchatka from Paramushir Island to Cape Yuzhny is inhabited by 13 species, the majority of which are industrially important and form large concentrations of high density. The favourable temperature conditions over the large area of the West-Kamchatka shallow water region, as well as its high content of biological volume, account for the great number of flounders, for the dimensions and character

of their concentrations, which are unique and are not found in other seas of the Northwestern Pacific Ocean or oceans of the world.

The peculiar hydrological conditions and the extent of the continental plateau are responsible for the differences in the distribution and migration of flounders in different sections of the West-Kamchatka shelf and other regions of the Far Eastern seas.

During winter, under the effect of intensive cooling the water temperature rapidly drops. At this moment all the species of flounders inhabiting this region (with the exception of the *Pleuronectes stellatus*), drift away from the shores and sink to greater depths. Investigations conducted by the expedition on board the trawler "Lebed", which took place in 1938-1939, as well as the industrial trawl fishing in 1940-1952 enabled us to precisely determine the wintering regions of flounders near the southwestern shores of Kamchatka.

The flounders populating the waters washing the shores of Western Kamchatka along a course of 450 miles drift for hibernation to nearest deep-water sections, forming a series of winter concentrations along the lower edge of the continental plateau. At present we know two regions of large concentrations of flounders near the shores of Western Kamchatka: the first is situated near the southwestern shore in the region of Cape Sivuchy-river Yavina at the depth of 100 to 170 meters,

the second in the regions of the river Kikhchik - river Kimichey at the depth of 180 to 250 meters. It is obvious that the wintering of flounders which during the summer populate the regions of the river Vorovskaya - river Krutogora and river Moroshechnaya-Cape Khariuzov takes place in the adjacent deep water sections, as may be seen from the map (fig. 19).

DRAWING 19.

Scheme of migrations of flounders near the shores of Kamchatka.

At the beginning of April, the warming-up of the littoral waters and the approach of the spawning period mark the beginning of the migration of flounders from the regions of wintering to shallow waters.

The first to drift are the schools essentially consisting of *Limanda punct. proboscidea*, these are followed by *Limanda aspera*, which is the most numerous species of flounders inhabiting the West-Kamchatka shelf, and lastly, the *Hippoglossoides hip.* and *Pleuronectes quadrituberculatus*.

In May, the migration of flounders to shallow waters continues and becomes intensified and in June the flounders populate the depths of less than 100 meters. *Pleuronectes stellatus*, which constitutes the greatest portion of the catches of flounders obtained by means of casting nets during the summer, remain in the direct proximity of the shore (at the depths of less than 10-15 m).

Somewhat greater yet insignificant depths (from 10-15 to 55-60 meters) are inhabited during the summer by *Limanda punct. proboscidea*. The maximum concentration of these fish is usually observed at the depth of 15-30 m. *Limanda aspera* occupies almost identical horizons (from 15 to 60-70 meters and in the majority of cases its maximum catches are obtained from the depths of 40-50 meters and less. *Pleuronectes quadrituberculatus*, which is one of the largest (with the exception of halibuts) flounders of the Far East, remain at considerably greater depths and drift to shallow waters following the *Limanda punct. proboscidea* and *Limanda aspera*, however, while drifting towards the shores, these fish fill the horizons of 30 to 150 meters forming the densest concentrations between 45 and 120 meters of depth. *Hippoglossoides hip.* remain throughout the summer at greater distances from the shores populating the depths of 40 - 150 meters. Its maximum catches are obtained from the depths of 80 to 120 meters.

After the spawning has been completed, the *Lepidopsetta bil. bilineata* and *Glyptocephalus stelleri* intensively feed, occasionally making rather extensive horizontal migrations depending on the temperature conditions of a given year, however, the general scheme of the vertical distribution of different species remains unchanged. In October-November-December the autumn migration of flounders to the regions of wintering continues to develop and becomes further intensified.

By January the process of the drift of flounders away from the shores to greater depths is completed, in January-March we observe only small migrations of flounders within the limits of winter concentrations that are caused first of all by the increase in their density as a result of the decrease in the area occupied, and corresponding increase in the density of the concentrations of flounders.

In February-March, the spacious areas of the West-Kamchatka shelf up to the depth of 150-200 meters become unsuitable for the existence of the majority of flounders. The *Pleuronectes stellatus* is the only form which remains in the shallow waters. Such is the general scheme of seasonal migrations and distribution of flounders in the shallow waters of the West-Kamchatka shelf.

As may be easily seen the above presented outline is most reminiscent of that of the distribution and migration of flounders in other regions of the Far Eastern waters; however, we wish to point out a number of details and peculiarities which we shall discuss against the background of a more detailed description of the distribution and migrations of flounders near the western shores of Kamchatka.

Expeditions to the shores of Kamchatka on board the exploration trawler "Lebed", which took place in 1934 and 1938-1939, as well as the data collected by a great number of expeditions on board the exploration, research and fishing boats, which operated in the West Kamchatka continental plateau enabled us to obtain a relatively

vast data material on the distribution of flounders. Among the species of flounders, which are found in this region, the *Pl. stellatus* alone is, as a typically littoral form, caught in single specimens, whereas these fish enter the casting nets launched from the shore in great numbers. For all the remaining species the analysis of trawl catches provides sufficient data for the evaluation of their vertical, as well as horizontal distribution and the percentage of different forms in catches enables us to reveal the relative importance of each individual species in the given region.

Summarization of the results of trawl fishing carried out by the expedition on board the trawler "Lebed" in 1938-1939 enables us to draw tables 82-87.

These tables comprise the data on the trawls launched within the limits of the entire West-Kamchatka continental plateau (from Cape Kambalny to Cape Yuzhny); however, the majority of them pertain to the southern and central regions (in view of the fact that between December and March all the trawls were launched in southern and central zones).

The summer vertical distribution of flounders (June-September) is typical for the north-boreal regions (table 82, fig. 22).

TABLE 82.

Distribution of flounders according to different depths in number of specimens per trawling hour in the West-Kamchatka shelf in June-September 1938-1939.

table 82, ctd.

Species	Depths in meters								
	20	25	50	75	100	150	200	250	300
Aresthes evermanni	-	-	1	1	1	1	8	19	
Hip. el elassodon	-	1	36	260	222	175	100	80	
Hippoglossus hip. stenolepis	-	1	1	-	1	-	-	-	
Reinhardtius hippoglossoides matsuurae	-	-	-	-	-	1	1	1	
p. bil. bilineata	-	1	3	42	48	12	1	1	
Limanda aspera	2700	360	262	4700	144	265	-	-	
Limanda punct. proboscidea	-	1	1	-	-	-	-	-	
Pleuronectes quadrituberculatus	4	8	38	52	32	1	-	-	
Pleuronectes stellatus	6	6	1	-	-	-	-	-	
Glyptocephallus stelleri	-	-	1	1	1	1	-	-	
Number of trawls	1	52	19	20	23	4	1	1	

The subarctic-boreal Pl. quadrituberculatus and the Pacific boreal Lim. aspera are spread in the main over depths of less than 100 meters; moreover, the latter drift to small (less than 25 m) depths in greater numbers than the former species form. The north-boreal Lep. bil. bilineata are found within a wide range of depths (25 to 300 meters) and the maximum density of their concentration is situated between 75 and 150 meters of depth. The H. el elassodon are found at approx. the same depths as above; in divergence from the majority of species whose fry remain at the minimum depths inhabited by a given form, the fry of this species are found at shallow depths, as well as down to the

lowest bathymetric border of its propagation where the number of young specimens prevails over that of adult fish.

With the increase in depth the frequency at which the *Atheresthes evermanni* are found noticeably increases and the *Reinh. hip. matsuurae* are found only at the depths exceeding 150 meters, while the *Hip. hin. stenolepis* drift to depths of 30-35 meters.

The south-boreal *Cl. stelleri* remain at the depths of 50 to 150 meters, but are found in single specimens, which indicates that the conditions in the littoral zone of Kamchatka are unfavourable for this southern species.

The depth of the penetration of *Pl. stellatus* does not exceed 60-70 meters. The frequency at which the *Lim. punct. proboscidea* are found is insignificantly low, which may be partly explained by the fact that the number of trawls launched at the depth of 20-30 meters where these flounders concentrate in great numbers during the summer, was insufficient.

We may see from the vertical distribution of flounders in October-November (table 83) that the character of distribution at the depths of more than 25 meters changes but little.

The operation of the boat during this period of time outside the industrial concentrations of flounders substantially reduced the absolute figures presented in the table, however, their relative value closely corresponding to the true state of affairs.

Undoubtedly, October and November mark the beginning of the autumn-winter migration, during this season, however, the migration mainly affects the most littorally propagated fish species which find themselves during this season in the zone with rapidly dropping temperatures, and but little affects the distribution of flounders at the depths of more than 30-40 meters that have not been influenced by the vertical circulation as yet.

TABLE 83.

Distribution of flounders according to different depths (in number of specimens per trawling hour in the West Kamchatka shelf during October-November 1938-1939.

Depth in meters	25	50	75	100	150	200
Athenes evermanni	-	-	1	1	-	
Hip. el elassodon	1	1	7	7	3	
Hippoglossus hip. stenolepis	-	1	-	-	-	
Reinhardtius hippoglossoides matsuurae	-	-	-	-	1	
Lepidopsetta bil. bilineata	50	22	68	3	2	
Limanda aspera	108	38	60	6	9	
Limanda punct. proboscidea	11	1	1	-	3	
Pleuronectes quadrituberculatus	9	10	6	20	1	
Pleuronectes stellatus	1	1	1	-	-	
Glyptocephallus stelleri	1	1	-	-	-	
Number of trawls	6	10	11	8	15	

Lastly, table 84 presents the data on the distribution of flounders between December and March after the autumn-winter migration has been completed.

We may clearly see that the flounders practically vacated

the depths of less than 50 meters and only mildly populate the horizons between the depths of 50 and 75 meters (mainly in December). The most densely populated depths are situated between 75 and 100 meters (in December-January) and 100-150 meters (in February-March). It is interesting to note that even *Pl. stellatus* drifted away from the shores and were found in considerable quantities (124 specimens per a trawl) at the depth of 50 to 75 meters.

Limanda aspera prevail in overall catches (90-95%) all the year round. The next most numerous species are *Hip. el elassodon* and *Pl. quadrituberculatus*, which, however, jointly constitute only 15-20% of catches. While *Limanda aspera* prevail in trawl catches, in the catches obtained by casting nets the *Pl. stellatus* are often the most numerous fish species.

TABLE 84.

Distribution of flounders according to different depths
(in number of specimens per an hour of trawling) in the
West Kamchatka shelf during December-March 1938-1939.

Depth in meters	25	50	75	100	150	200	250	300
<i>Athenes evermanni</i>	-	-	-	1	1	1	-	
<i>Hip. el elassodon</i>	-	1	7	30	5	36	54	
<i>Reinhardtius hippoglossoides</i> <i>matsuurae</i>	-	-	1	1	1	1	1	
<i>Lep. bil. bilineata</i>	-	6	1	1	5	62	1	
<i>Limanda aspera</i>	3	580	1180	420	8	1	6	
<i>Limanda punct. proboscidea</i>	-	1	1	2	-	-	-	
<i>Pleuronectes quadrituberculatus</i>	-	52	195	118	42	11	11	
<i>Pleuronectes stellatus</i>	-	124	6	2	6	1	-	
<i>Hippoglossus hip. stenolepis</i>	-	-	1	1	1	1	-	
Number of trawls	1	3	23	39	45	31	4	

However, following a detailed analysis of the distribution of the varieties of species in catches according to different regions, we are compelled to somewhat modify our statement concerning the universal prevalence of *Limanda aspera* over all the remaining flower species.

In the southern (Ozernovsky) region of the West-Kamchatka shelf during the summer and autumn, at the depth of less than 100 meters, the *Limanda aspera* occupies the most important place.

It is followed by the Hip. el elassodon, then Pl. quadrituberculatus. In the littoral zone (of less than 30 meters) the importance of Lim. punct. proboscidea increases and directly near the shores the Pl. stellatus are the most numerous fish (see table 85).

Table 85 .

Distribution of flounders accoridng to different depths (in number of specimens per an hour of trawling) in the southern zone of the West-Kamchatka shelf (the region of river Ozernaya) between September 23 and October 1, 1934.

Species	Depth in meters							
	50	60	70	80	90	100	150	200
Acanthopsetta nadeshnyi	-	n	-	1	3	N	-	
Hip el elassodon	675	o	462	264	170	o	125	
Reinhardtius hippoglossoides matsuurae	-	d				d		
	10	a	6	2	3	a		
Lep. bil. bilineata	-		-	1	3		50	
Limanda aspera	1125		1312	414	475		-	
Pleuronectes quadrituberculatus	200		250	116	110		-	
Glyptocephallus stellari	-		-	1	4		-	
Number of trawls	1		2	7	3		1	
Mean catch in centners	9,0		9,5	3,9	3,7		1,0	

In the central zone of the West Kamchatka shelf the *Limanda aspera* overwhelmingly prevail over other species (fig. 86.). In August-September, within the limits of the depths of 20 to 150 meters representatives of this species constitute 80-97% of the flounders found at these depths and its specific weight drops to 70% only in the most littoral zone (less than 30 meters), where it is gradually replaced by *Lim. punct. proboscidea*.

TABLE 86.

Distribution of flounders according to different depths (in number of specimens per and hour of trawling) in the central zone (river Kekhta-river Krutogorova) of the West-Kamchatka shelf between August 16 and September 22, 1954.

Species	Depth in meters										
	20	30	40	50	60	70	80	90	100	150	200
<i>Acanthopsetta nadeshnyi</i>	-	-	-	-	-	2	-	-	1	-	-
<i>Hip el. elas-sodon</i>	-	-	-	2	2	5	3	3	2	1	-
<i>Uppoglossus hip. stenolepis</i>	-	-	-	-	-	-	-	1	-	1	-
<i>Lep. bil. bilineata</i>	48	31	42	-	-	-	-	-	-	-	-
<i>Limanda aspera</i>	820	420	520	1348	2264	500	51	27	134	1	-
<i>Limanda punct. proboscidea</i>	310	70	19	114	1	-	-	-	-	-	-
<i>Pleuronectes quadrituberculatus</i>	-	1	7	102	77	168	43	88	32	-	-
<i>Glyptocephalus stelleri</i>	-	-	1	1	-	1	-	-	-	-	-
Number of trawls	5	29	9	14	16	3	3	4	14	1	-
Mean catch in centners	5.0	2.2	2.5	8.3	10.1	3.7	0.6	0.7	0.6	0.0	-

In the northern section of the West Kamchatka shelf (in the region of the Cape Khariuzov-river Moroshechnaya) the quantity of *Limanda aspera* in the catches noticeably drops, while the absolute as well as relative of the frequency at which the *Pl. quadrituberculatus* are found (table 87) simultaneously increase reaching 50% and more of the catches.

TABLE 87.

Distribution of flounders according to different depths (in number of specimens per trawling hour) in the northern zone of the West Kamchatka shelf (the region of the river Moroshechnaya, 1934).

Species	Depth in meters							
	50	60	70	80	90	100	150	200
Hip. el elassodon	8	30	-	-	-	4	-	-
Limanda aspera	4400	1250	60	125	105	0	-	-
Pleuronectes quadri- tuberculatus	1540	500	36	150	87	20	-	-
Lep. bil. bilineata	1	5	-	-	-	-	-	-
Hippoglossus hip. stenolepis	-	1	-	-	-	-	-	-
Number of trawls	1	1	1	1	1	1	1	1
Mean catch in centners	18,0	10,0	0,6	2,0	1,3	0,2	0,0	0,0

However, the limited data on the basis of which table 87 has been drawn do not fully demonstrate the correlation between different species in the northern zone, where, in distinction from all the other zones of Western Kamchatka, large concentrations of flounders essentially

consisting of the *Pl. quadrituberculatus* are formed. As far back as 1932, I.A. Polutov and M.L. Alperovich indicated (on the basis of data provided by the cruises on board the exploration boats) that *Pl. quadrituberculatus* are the predominant species in the Khariuzovski region. During the last ten days of July, E.K. Suvorov on board the trawler "Plastun" discovered at the depth of 75-96 meters a rather large (about 25-30 square miles) concentration of flounders, consisting of 80-99% *Pl. quadrituberculatus* constituted. The mean catches obtained per trawling hour reached 12 centners. In 1934, while working on board the trawler "Lebed" in the same region, within the borders of the concentration found by E.K. Suvorov, we failed to reveal an equally well outlined accumulation of *Pl. quadrituberculatus* and the catches were of mixed character with prevalence of *Limanda aspera*. We observed identical phenomenon in 1938-1939 during the operation of the expedition on board the trawler "Lebed". Of course, the northern zone of the West Kamchatka shelf is populated in the main by two species of flounders, i.e. *Lim. aspera* and *Pl. quadrituberculatus* and the specific weight of the latter (particularly during the summer at the depth of 70 and more meters) is considerably higher than that in more southern zones. As a rule, *Limanda aspera* prevail (85%) in this littoral zone (at a depth of less than 50 meters) and the main catches per trawling hour reach 18 centners.

Thus, the northern zone of the West Kamchatka shelf acquires a particular importance in view of the fact that it is populated en masse by large specimens (up to 3.2 kg.) of *Pleuronectes quadrituberculatus*. As we previously mentioned (Moiseev 1938; Moiseev and Gavrilenko, 1939; Moiseev, 1946), the fry of the majority of Far Eastern as well as Atlantic species of flounders remain during the summer at minimum depths inhabited by a given species.

This regularity is well pronounced near the shores of Kamchatka, particularly for the *Pleuronectes quadrituberculatus*, the fry of which usually remain at depths of 20-30 meters, while adult specimens populate the depths of 50-60 and 100-120 meters. Let us discuss the data provided by I.A. Polutov and E.K. Suvorov showing changes in the mean dimensions of flounder specimens depending on the depth (table 88), which have been observed in August, 1932, and July 1933, and supplemented by our data obtained in September 1934.

TABLE 88.

Changes in the mean dimension (in cm) of flounders near the shores of Western Kamchatka in dependence with the depth (in meters) in July-September.

Table 88 Ctd.

Pl. quadri- tuberculatus		Limanda aspera		Limanad punct. proboscidea	
Depth	Mean dimensions	Depth	Mean dimensions	Depth	Mean dimensions
31-33	32.10	22-40	33.35	17-40	28.00
42-46	37.50	45	33.62	36-47	30.50
58-62	39.51	36-46	35.15	-	-
52-80	40.59	-	-	54-58	29.95
60-67	43.35	58-62	35.19	-	-
81-95	44.85	60-97	36.84	-	-
134-235	43.45	95-134	35.50	-	-

This regularity is highly important and must be kept in mind when choosing the depth for fishing from an industrial boat.

The above presented tables and the brief explanatory text enabled us to illustrate the scheme of the distribution of flounders according to different zones of the West-Kamchatka continental plateau. The character of distribution outlined in this scheme is well pronounced during the summer. Along the entire extensive shoreline of Western Kamchatka, at a depth of less than 15 meters, the littoral and essentially boreal Pl. stellatus prevail (this fish sinks during the summer

to the depths of 75 and more meters). The said species constitute the greatest portion of catches of flounders obtained by means of casting-nets and freely penetrate into waters with low salt content and into fresh water regions.

Somewhat deeper (occasionally starting from 10 meters) we find the north-boreal *Lim. punct. proboscidea*, which rarely form the greatest portion of catches and is usually caught in the form of a 1-5% admixture with the main industrial species of the West Kamchatka shelf- i.e. the Pacific boreal *Limanda aspera*, the fry of which penetrate to the depth of 8-12 meters and the adult specimens of which occupy a relatively large bathimetric range (from 10-20 to 200 meters), but only form dense concentrations between 20-25 and 60-70 meters, where these fish constitute 80-85 and, occasionally 100% of catches.

The fry of the subarctic-boreal *Pl. quadrituberculatus* also penetrate to slight depths (15-20 meters), but adult fish are systematically found starting from the depth of 25-30 meters and constitute as a rule, only 5-10% of catches. Only in exceptional cases these fish form 50% of the overall catch.

The remaining species are represented by single specimens. In particular, the *Hp. hip. stenolepis* were found during the summer near the shores of Western Kamchatka at minimum depths (even in casting nets launched from the shores), but are encountered within the borders of the continental plateau only accidentally.

Below 50 meters of depth (up to 75 m) the *Limanda aspera* continue prevalent (80% and more), however, the north-boreal *Hip. el. elassodon* begins to appear as a significantly independent group. In a number of cases the specific weight of *Pl. quadrituberculatus* reached 20-30% and more.

Within the range of depths between 75 and 100 m the number of *Hip. el. elassodon* and *Pl. quadrituberculatus* continues increasing and occasionally the latter prevail in catches (particularly in the northern zones).

In individual cases the number of *Hip. el. elassodon* may increase to 40-50% (when the overall catches reach 15 centners). At the depths of 100 to 150 meters the number of *Limanda aspera* sharply drops, while the importance of *Pl. quadrituberculatus* rises (particularly in the northern zones), and the *Hip. el. elassodon* usually form the main bulk of catches at these depths. The frequency at which the north-boreal *Lep. bil. bilineata* are found, noticeably rises and representatives of this species often form a considerable (up to 10%) portion of catches in the southern sections of the continental plateau. Below 150 meters in depth we may find forms with numerous representatives during the summer, a certain number of *Limanda aspera*, *Pl. quadrituberculatus*, *Hip. el. elassodon*. Their number is, however, negligible. These depths are almost completely vacated by the majority of flounders,

but are inhabited during the summer by various halibuts (*Hip. hip. stenolepis*, *Ath. evermanni*, *Reinh. hip. matsuurae*), which are found everywhere along the lower edge of the West-Kamchatka shelf. Taking into account their great industrial importance, we wish to point out that the organization of thorough explorations with the purpose of determining the region of their concentration, is most desirable.

The distribution and migration of flounders in the Bering Sea and particularly, in its northern zone, are substantially affected by the cold temperature conditions existing in this water basin, which are especially severe in the waters washing the shores of Asia. The relatively small difference in the temperatures of the pre-benthic horizons within the limits of the sublittoral during the summer accounts for the whole bathymetric range of distribution of the majority of flounders populating these waters, whereas in more southern regions the same forms occupy considerably smaller ranges of depths.

We shall not dwell on the geographic distribution of flounders, which has been thoroughly discussed in the covering chapter. We merely wish to add that while gradually moving to the North along the western shores of the Bering Sea, the number of flounder species and of flounders specimens populating the waters washing these shores decreases. While in the Olyutorski Bay the flounders constitute a noticeable by-catch obtained by trawl (up to 5-6% and more), the frequency

at which these fish are caught by trawls in the Olyutorski Navarinski and Anadyrski regions is measured in single specimens.

Table 89 shows the vertical distribution of flounders in Olyutorski Bay during the last decade of July and was drawn on the basis of data provided by the expedition on board the trawler "Pältus".

Table 89.

Distribution of flounders at different depths (per trawling hour) in Olyutorski Bay between July 22 and 31, 1932.

Species	Depth in meters											
	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-150	150-200	200-250	250-300
Limanda punct. p proboscidea	-	1	-	-	-	-	-	-	-	-	-	-
Limanda aspera	113	90	10	22	-	16	4	14	2	-	-	-
Pleuronectes quadrituberculatus	-	2	-	-	-	4	-	16	8	7	-	-
Hip. el elassodon	-	1	-	-	-	2	2	6	6	1	12juv	2
Lep. bil. bilineata	12	18	6	13	-	5	-	-	1	-	-	-
Hippoglossus hip. Stenolepis	-	-	1	-	-	3	-	1	2	4	-	-
Atheresthes evermanni	-	-	-	-	-	-	-	-	1	3	-	14
Number of trawls	1	2	3	2	1	2	1	2	11	8	1	1

We only caught two specimens of *Limanda punct. proboscidea*, but frequently found *Limanda aspera*, *Lep. bil. bilineata*, *Pl. quadrituberculatus*, *Hip. hip. stenolepis* and *Atheresthes evermanni* specimens in our trawls. The two former species undoubtedly remain in the zone closest to the shore indeed, a littoral water environment is most characteristic of

Limanda aspera. On the other hand, some flounders of both types do remain at greater depths (down to the 150 meter level) in late July, during the period of maximum warming up.

We found *Limanda aspera* and *Hip. el. elassodon* fry on the 75 m level. We observed no increase in the density of concentration of the *Lep. bil. bilineata*, but this flounder undoubtedly does drift down to greater depths than do the aforementioned species and is regularly to be found in catches taken between 70 and 330 metres, the latter being the maximum depth at which trawling is conducted in this area.

Both halibuts found in this region - i.e. the *Hip. hip. stenolepis* and *Ath. evermanni* - are found in single specimens in the catches from the 40 meter level. (*H. hip. stenolepis*) and at a constantly increasing frequency from the 90-100 meter level. This is particularly true in the case of *Ath. evermanni*).

Within the limits of Olyutorski Bay and in adjacent waters the maximum concentrations of the Pacific boreal *Lim. aspera* are found during the summer in the coastal, most heated zone, down to the 30-40 meter level. The north-boreal *Lep. bil. bilineata* are found in the littoral area and somewhat deeper down to 60-90 metres, the subarctic boreal *Pl. quadrituberculatus* and the north-boreal *Hip. el. elassodon* at 75-125 metres. Both Pacific-boreal halibuts are inhabitants of the upper horizons of the bathyal, adapt their propagation to subarctic water volumes (Vino-gradov, 1948) and are common at 100-150 metre depths and

deeper.

The flounders populating the southwestern section of the Anadyrski Bay and sections of the adjacent shelf, one of the most northern zones of propagation of the boreal flounders, are found in single specimens and the regularities of their vertical distribution are very difficult to establish. The following table 90 has been drawn on the basis of data provided by the expedition on board the trawler "Plastun" and enables us to establish that *Pl. quadrituberculatus* and *Lep. bil. bilineata* have been found at depths of 30 down to 125 metres, while *Hip. el. elassodon* was found below the 90 metre-level. The two halibuts encountered in this area remain at maximum depths. The *Hip. hip. elassodon* were spread (as usual) up to 60 metres of depth and *Reinh. hip matsuurae* were not encountered at any depth less than 90 metres. We wish to point out that to the South-East from Cape Navarin, on the edge of the continental shelf (150-300 metres), the frequency at which halibuts (including the *Ath. evermanni*) are encountered, sharply increases and catches containing several dozens of specimens of this fish per a trawl are common.

TABLE 90.

Distribution of flounders at different depths (in number of specimens per trawling hour in the south-eastern zone of Anadyrski Bay between September 26-30, 1931.

Species	30	40	50	60	70	80	90	100
<i>Pleuronectes quadrituberculatus</i>	1	1	1	-	-		1	-
<i>Hip. el. elassodon</i>	-	-	-	-	-		8	4
<i>Lep. bil bilineata</i>	1	1	-	6	3		1	-
<i>Hippoglossus hip. stenolepis</i>	-	-	-	1	1		-	1
<i>Reinhardtius hippoglossoides matsuurae</i>	-	-	-	-	-		2	6
Number of trawls	13	2	1	2	1		8	11

Insufficient observations on the distribution of flounders in the Bering Sea during different seasons resulted in that we have no factual data on either their winter distribution or their paths of seasonal migrations, however, our knowledge of hydrological conditions in the Western zone of this sea and of the behaviour of flounders in other Far-eastern waters enables us to voice a few hypotheses on the subject. Undoubtedly, during the autumn all flounder-species (with the exception of *Pl. glacialis* and *Pl. stellatus*) drift away from the shores, i.e. from the zone of rapid and intensive cooling and sink to depths of about 200 metres. It is possible that a certain number of flounders and primarily the *Hip. el robustus* inhabiting the large shallow water regions remain there throughout the winter at low sub-zero temperatures. However, in the areas of narrow shelf the majority of species migrate in the autumn to greater depths. Large and very cold patches of residual waters of winter cooling play an important part in the distribution of flounders and selection of their migration paths, particularly during the summer. These patches are, as a rule avoided by all the benthic and pre-benthic industrial fishes including the flounders. The lines of their boundaries change yearly, generally speaking and must be taken into account in analyzing the distribution of flounders and their migration paths.

Numerous peculiarities about the hydrological conditions in the waters washing the southeastern shores of Sakhalin southwards from Cape Terpeniya, determine which species of flounders inhabit the shelf in this region, their distribution and migrations. During the summer a narrow strip of the littoral shelf offers favourable conditions for the existence of flounders. All the flounders with the exception of the Pacific glacial hip. el robustus concentrate in this area (see table 91).

TABLE 91.

Distribution of flounders at different depths (number of specimens taken per trawling hour off the southeastern shores of Sakhalin between September 11-12, 1948.

Species	Depth in metres								
	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-150	150-200
Acanthopsetta nadeshyni	lojuv.		41	-	-	-	4+9juv.	-	8+2juv.
Hip. el robustus	1	2	6+33juv.	-	-	-	3+1juv.	-	1
Gleisthenes herzensteini	1	-	-	-	-	-	-	-	-
Atheresthes evermanni	-	-	6juv.	-	-	-	-	-	1
Limanda punct proboscidea	10	-	-	-	-	-	-	-	-
Pleuronectes quadrituberculatus tuberculatus	104	25	2	-	-	-	1	-	-
Limanda aspera	965	291	20	-	-	-	3+2juv.-	-	1 juv.
Pleuronectes stellatus	7	-	-	-	-	-	-	-	-
Glyptocephalus	53	17	1juv.	-	-	-	3	-	2+1juv.
Number of trawls	1	1	1				1		2

Moreover, inhabitants of the lower horizons of the sublittoral and upper part of the bathyal (such as *Ath. evermanni* and *Hip. hip. stenolepis*) may enter these waters from greater depths.

The north-boreal character of the region and that of the narrow area populated during the summer lead to high density of concentration of the *Limanda aspera* and *Pl. quadrituberculatus* found here in very much the overwhelming majority as compared to flounders of other species, not excepting flounders of southern origin, which often penetrate the most southern extremities of this region.

As may be seen from table 91, the flounders concentrate most densely at depths below 40 metres (perhaps even less), a fact primarily due to the rapid drop in benthic temperature consequent upon increase in depth. This distribution pattern of flounders was observed during the summer off the southeastern shores of Sakhalin between Terpeniya Bay and Cape Senyavin and suggests that benthic casting nets and trawls launched from small boats might successfully be applied to making catches of these fish. This also accounts for flounders being an important by-catch in fishing casting nets launched from shore.

During the winter, the majority of flounders drift away from the rapidly cooling down littoral zone and sink to 200 metre level around the edge of the continental shelf. However, the migration paths of the flounders into the wintering region and back to

the shallow waters are unknown and thusfar it has been difficult to establish their exact location.

We believe it advisable to study the distribution of flounders in the northern zone of Tatarski Strait during the first half of May. According to the observations made by M. N. Krivobok considerable concentrations of flounders, mainly *Limanda aspera* (forming 80-90% of catches within the limits of the concentrations), appear at this period of time off the shores of Sakhalin in the region located northward from Aleksandrovsk, as far north as 51° 25' latitude) at the depth of 15 to 30-35 metres, i.e. in the relatively narrow littoral zone between the shoreline and the depths of 20-40 and more metres. Here, as we mentioned before, the *Limanda aspera* are the prevalent species. Just off-shore at depths of less than 25 metres, the littoral *Pl. stellatus* are found in schools admixed with the former species, whereas the remaining forms constitute but a negligible percentage of the concentrations. With the increase in depth, the density of flounder population decreases. Closer to the continental shore the fish are smaller and do not form large concentrations. The northern part of the concentration has been cut in two by trawlings conducted between De-castri and Cape Uandi (see table 92). It must be borne in mind that data on minimum depths in the left column of this table

were obtained during the operations in littoral waters off Sakhalin and data on minimum depths in the right column were obtained during operations off continental shores.

TABLE 92.

Distribution of flounders (in number of specimens per trawling hour at different depths in Tatarski Strait in May (May 10, 1933) in the section De-Castri-Uandi (along 51°25' northern latitude).

Species	Depth in metres			
	20	30	40	50
Hip. el dubius	-	2	4	
Cleisthenes herzensteini	-	-	-	
Lep. bil. mochigarei	-	1	-	
Limanda aspera	3000	15	93	
Limanda punctatissima	-	-	4	
Pseudopleuronectes herzensteini	-	2	1	
Pseudopleuronectes yokohamae	-	5	21	
Pleuronectes quadrituberculatus	59	5	22	
Pleuronectes stellatus	470	41	9	
Mean catch in centners.	10,0	1.0	0.6	

The respectively high (up to 15 centners per trawling-hour catches were obtained on May 10-12, 1933, from the considerable extent of some 15 miles along the western coast of Sakhalin at depths of 16-53 metres.

The trawling operations in this zone showed that there are no concentrations of industrial character southerly from the Aleksandrovsk traverse. We found single specimens or groups of tens of specimens of the following fish: *Pl. quadrituberculatus*, *Hip. el. dubius*, *Pl. stellatus*, *Lep. bil. mochigarei*, *Ps. yokohamae* and *Ps. herzensteini*. We wish to emphasize once more that these fish were found in quantities insufficient to justify supposing the existence of large-scale concentrations or migrations en masse. During the winter we observed that the majority of flounder species drift towards the South, into the regions where depths are about 100-150 metres. The return drift of flounders to shallow waters for spawning and feeding primarily in a northern direction where the water is abundant in food objects, occurs relatively early (probably at the beginning of April) and by the beginning of May the majority of flounders inhabiting these waters reach the latitude at which Aleksandrovsk is situated and penetrate farther north, travelling mainly along the shoreline.

The data on the summer (first half of July) and autumn (latter half of September and October) distribution of flounders over the relatively large area of Northern Tatarski Strait (starting from 50°30' of northern latitude), collected by the expedition on board the

ttawler "Finval" under the leadership of D. I. Okhryamkin in 1933, enabled us to draw the following table 93.

TABLE 93.

Distribution of flounders at different depths (in number of specimens per trawling hour in Tatarski Strait (northerly from 50° of northern latitude) between June 30 and July 14, 1933.

SPECIES	Depth in meters								
	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Acanthopsetta nadeshnyi	-	-	40	20	39	16	-	-	20
Hip. el dubius	-	5	46	155	544	159	600	N O	116
Cleisthenes herzensteini	-	4	17	-	-	-	-	d a t a	-
Lep. bil. mochi-garei	-	-	-	42	-	4	-	-	-
Limanda aspera	400juv.	865	960	327	414	294	300		28
Limanda punct. punctatissima	50	48	53	-	-	-	-		-
Pseudopleuronectes yokohamae	25	8	20	-	-	-	-		-
Pseudopleuronectes herzensteini	-	75	60	-	-	-	-		-
Pleuronectes adrituberculatus	100juv.	54juv.	240	155	840	106	600		2
Pleuronectes stellatus	10	1	-	-	4	-	-		-
Pleuronectes pinnifasciatus	10	3	7	2	-	-	-		-
Glyptocephalus stelleri	-	3	7	3	6	8	-		-
Number of trawls	1	4	3	4	5	4	-		1
mean catch in centners	3.0	3.9	4.7	2.9	6.4	2.0	5.0		0.5

Most species are adapted to the depth-level of 40 metres at least but the highest catches are determined by the dimensions of the shoals of the species prevalent in this region (*Pl. quadrituberculatus*, *Limanda aspera* and *Hip. el dubius*) and were obtained at the depth of 50 to 60 metres. All the moderately boreal and south-boreal species (*Lim. punct. punctatissima*, *Ps. yokohamae*, *Ps. herzensteini*, *Pl. pinnifasciatus*) and the littoral *Pl. stellatus* are found at insignificantly shallow above 40 metres depths, where the water is thoroughly heated. The fry of subarctic-boreal and Pacific -boreal *Limanda aspera* and *Pl. quadrituberculatus* also populate these depths.

With the increase in depth, the number of sexually mature and large specimens noticeably increases. The moderately boreal *Lep. bil. mochigarei*, *Hip. el dubius* and *Ac. nadeshnyi* are found at relatively great depths (mainly between the 40 and 80 metre levels).

We observed that a number of substantial changes affected the distribution of flounders after May (fig. 31). All the species of flounders approached the shore. *Pl. stellatus* drifted to insignificantly shallow depths in July and were therefore not caught in the trawls, although in May, 13.3% of the overall trawl catches from the depths of 20 - 30 m consisted of these fish.

The number of *Hip. el dubius*, *Lim. aspera* and *Pl. quadrituberculatus* considerably increased at the depths of 50 metres. The *Gl. stelleri* and *Ac. nadeshnyi* not

previously found in trawl catches reappeared in the catches. By July the heavy migration of flounders from the deep waters of hibernation has, in the main been completed and the data on their vertical distribution (table 93) are characteristic for the summer distribution of flounder species by different zones. We wish to point out that in North Tatarski Strait the vertical distribution of flounders is marked by all the features which characterize the summer distribution of these fish in the north-boreal regions. The arrival of a great number of new species and increase in the number of specimens of the forms found in May in the littoral zone changed the proportion of species in catches. The *Limanda aspera* still form the overwhelming portion of catches (85%), while *Pl. quadrituberculatus* and *Hip. el dubius* are the two other leading species. Their proportion somewhat changes depending on the depth at which fishing is conducted, however, their total number constitutes 90-95% and more of the overall catches obtained by trawlers. Throughout July and August the flounders remain at the depths which they inhabited during the summer, occasionally travelling short distances within the borders of these regions.

During the autumn when the temperature in the surface layers of water drops and vertical circulation becomes more marked and this primarily affects the temperature in the benthic horizons of the most littoral zone),

the autumn-winter migration of flounders from small depths to the deeper zones in the ⁹region of their wintering, takes place (table 94).

TABLE 94.

Distribution of flounders at different depths (in number of specimens per trawling hour in Tatarski Strait, north from 50° of northern latitude) between September 17 and October 28, 1933.

Species	Depth in meters								
	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Acanthopsetta nadeshnyi	2 juv.	-	10	69	186	198	114	94	13
-p. el dubius	5	1	38	145	152	249	172	105	47
Cleisthenes herzensteini	-	-	9	1	1	2	1	-	1
Lep. bil. mochigarei	1	1	-	2	1	-	1	-	-
Limanda aspera	78	271	852	1217	655	556	535	55	462
Limanda punct. punctatissima	11	12	1	3	-	-	-	-	-
Pseudopleuronectes yokohamae	5	10	25	4	3	2	4	-	2
Pseudopleuronectes herzensteini	17	49	29	8	1	5	5	-	4
Pleuronectes quadrituberculatus	56 juv.	105	166	120	184	267	95	20	92
Pleuronectes stellatus	15	157	9	2	-	1	-	-	-
Pleuronectes pinnifasciatus	4	33	7	1	1	-	-	-	-
Glyptocephalus stelleri	-	-	-	10	7	16	1	-	4
Number of trawls	12	2	4	10	11	9	9	1	2
Mean catch in centners	5.5	2.0	2.9	5.5	3.9	4.2	3.1	1.0	3.0

This drop in temperature marks the beginning of the gradual migration of all the species of flounders away from the shores to greater depths with a consequent drop in the density of their concentration at the depths shallower than 40 meters.

We wish to point out the simultaneous drift of a number of those species which populate the central zone of the sublittoral waters (*Ac. nadeshnyi*, *Hip. el. dubius*, *Lep. bil. mochigarei*) during the summer drift closer inshore and are found in single specimens at depths shallower than 20 metres.

The second half of September marks the beginning of the autumn migration of flounders which by October is most pronounced and heavily packed. As they migrate away from the shores, the flounders travel towards the south.

The foregoing bathymetric distribution of flounders and listing of species have been drawn upon the basis of results of trawl-fishing from large boats, conducted, as a rule, at the depth of at least 40 metres. The data thus obtained are naturally correct for trawl fishing but cannot be compared with the results obtained by using other fishing implements from different types of boats.

Fishing with benthic casting nets from small boats, conducted in Tatarski Strait at depths lesser than

40-50 metres (as a rule less than 30 metres), in particular yields date differing from the above discussed figures (see table 95).

TABLE 95.

The species composition of catches obtained by using benthic fishing nets in Tatarski Strait (Shitokaya Pad-Tangi) in 1944-1945 (in %).

	Months							
	May		June		July		August	
	Year							
	1944	1945	1944	1945	1944	1945	1944	1945
Hip. el dubius	7.9	0.8	3.8	25.9	7.3	16.3	9.6	9.7
Cleisthenes herzensteini	-	-	-	-	-	0.9	-	-
Limanda aspera	85.4	94.4	92.4	71.5	88.3	71.4	83.6	69.9
Limanda punctatissi- ma punctati- ssima	-	-	0.9	0.5	-	0.08	-	-
Pseudopleuro- nectes yokoha- mae	0.4	-	0.5	-	0.5	-	-	-
Pleuronectes quadrituber- culatus	6.0	3.6	1.7	1.3	3.7	10.3	6.2	16.7
Pleuronectes obscurus	0.15	0.4	0.4	0.3	-	-	-	-
Pleuronectes pinnifascia- tus	-	-	0.08	0.5	-	0.08	-	-
Glyptocephalus stelleri	0.15	-	0.08	-	-	0.8	0.6	2.8
Other species	-	0.8	0.14	-	0.2	0.14	-	0.9

In trawl fishing the three species which are found in approximately equal proportions (20-30% each) taken at the depths of 40 to 80 metres) prevail one to another in the catches...

Among the 12 forms found in this region, whereas the overwhelming proportion of catches taken in benthic casting nets (71-94%) consists of *Limanda aspera*, while the remaining forms (including *Hip. el dubius* and *Pl. quadrituberculatus*) are found in small numbers only. The number of *Hip. el dubius* and *Pl. quadrituberculatus* increases only in catches taken in July and August (16-20% of catches), when these fish approach the shores after spawning. Finding the *Pl. obscura*, a fish never caught in a trawl before, since it remains at depths lesser than 15 metres during the summer, may indicate the highly "littoral" character of operations conducted by the low tonnage fleet.

The above data on the distribution of flounders in the northern zone of Tatarski Strait during the period of time between May and October enable us to draw an approximate plan of the migrations occurring in this region (see fig. 20).

DRAWING 20.

The plan of migrations of flounders in Tatarski Strait.

Winter concentrations.

Summer concentrations.

The section of Tatarski Strait lying north from the line Cape Syurkum-Cape Pilevo, is a spacious shallow plateau (covering about 50000 square miles) with rather slowly changing shallow depths (in the majority of cases the depths are below 100 metres).

Up to the present, the wintering region of the majority of flounders, which populate the northern section of Tatarski Strait during the summer, has not been located as yet. Taking observations during the winter is highly complex and none have been conducted thus far. By analyzing the behaviour of flounders in other regions of the Far Eastern waters, we have reached the definitive conclusion that the flounders drift to greater depths in the region of Cape Pilevo during the spring, and we believe, the hibernation takes place in this region at the depths of 100-150 metres.

With the advent of spring the vernal spawning-feeding migration of flounders begins. In Tatarski Strait, the main stream of flounders proceeds towards shallow waters from greater depths, i.e. mainly in the northerly direction, with simultaneous drifts closer to the shores of the continent and Sakhalin. The greatest number of flounders travel into the regions of the so-called Aleksandrovsk Flounders bank (from Cape Rogaty in the South to Viakhtu Bay in the north) spreading as far as the continental shore.

The drift of flounders from great depths into shallow waters begins in April and by May large schools of these fish are found down to 40-50 m depths.

Limanda aspera usually heads the vernal migration and is the main industrial species in Tatarski Strait. As in Peter the Great Bay, the first to appear in the shallow waters are the young specimens of this species. These are followed by schools of fish of gradually increasing dimensions. By mid-May the *Limanda aspera* penetrate North as far as the traverse of Viakhtu Bay, however, they do not approach the shore-line too closely and the highest catches of these fish have been registered at depths of 30 to 50 metres, i.e. at a distance of at least 10-15 miles from the shores of Sakhalin. (see fig. 31.) Following *Limanda aspera*, the *Pleuronectes quadrituberculatus* and *Hippoglossoides hip.* drift towards the shallow waters which they reach after some delay. This circumstance may be due to the fact that the spawning of *Pleuronectes quadrituberculatus* occurs in March-April at a depth of about 100 metres.

In Tatarski Strait almost the entire catch of industrial boats consists of the three above-named species of flounders.

In June, the migration of flounders towards the shore continues. Moreover, at this time numerous schools of large flounders, such as the *Pleuronectes quadrituberculatus* and *Hippoglossoides hip.* drift to the depths accessible to fishing from small boats.

The flounders concentrate close to the shore of Sakhalin and the centre of maximum catches also

becomes displaced to depths of 15 to 40 metres. By the end of June the horizontal migration of flounders decreases to a minimum; the spawning period begins (or continues) and intensive feeding takes place. In divergence from *Limanda aspera* and other forms, the fry of *Hippoglossoides hippoglossus* approach the shores after the large specimens remaining at the depths of about 100 metres, while the fry of the remaining species fill the depths of 40 and less metres.

In July the flounders continue accumulating in the shallow waters. At the point of their maximum concentration, the flounders fill the maximum volume of water and successful fishing may be conducted in the region of Aleksandrovs Bank, as well as along the entire continental shore from Cape Syurkum to De-Castré Bay (fig. 31). Simultaneously with the decreases in the density of flounders schools at great depths, we observed a certain drop in catches made in the direct proximity of the shores. The densest concentrations are found at the depth of 40-60 metres and this naturally reduces the effectiveness of fishing with large fishing nets.

August marks no changes in the above-described. The flounders at the depths of 60 and less, higher catches mainly consisting of *Pleuronectes quadrituberculatus* have been obtained only and in the southern section of the Aleksandrovs concentration,

at the depths of 60 to 80 metres. We wish to point out that during the summer large specimens of *Limanda aspera* do not sink below 70-80 metres and its fry populate the shallow water depths down to 20-30 metres; *Pleuronectes quadrituberculatus*, however, remain at somewhat greater depths. Its large specimens populate the depths of 50-70 metres, while the fry fill the shallow waters (fig. 21, I, II). This vertical distribution of flounders depending on their dimensions strongly resembles that in the North Sea (Herstang, 1909). The vertical distribution of groups of different dimensions of the *Hippoglossoides hip.* is quite different, however, (fig. 31/III), the largest fish specimens move towards the shore, whereas the number of young specimens increases with depth increase and the number of medium-size fish gradually decreases.

TABLE 96.

Distribution of flounders (in number of specimens per trawling hour at different depths off the south-western shores of Sakhalin (48°00'-48°24' from September 24 to October 2, 1948.

Species	Depth in metres.						
	10-20	20-30	30-40	40-50	50-60	60-70	100-125
<i>Verasper moseri</i>	2	-	1	-	-	-	-
<i>Acanthopsetta nadeshnyi</i>	-	-	-	35 juv.	46 juv.	1 juv.	-
<i>Hip. el dubius</i>	-	-	-	-	-	36 juv.	14
<i>Cleisthenes herzensteini</i>	-	2	20-11 juv.	1-7 juv.	17	-	-
<i>Lep. bil mochigarei</i>	-	37-10 juv.	27	102	115	37	-
<i>Limanda asper</i>	10 juv.	1-40 juv.	80-65 juv.	21	28	-	-
<i>Limanda punct. punctatissima</i>	730	108-146 juv.	288	-	-	-	-
<i>Pseudopleuronectes herzensteini</i>	90-70 juv.	30-35 juv.	122	-	-	-	-
<i>Pseudopleuronectes Kokshamae</i>	4-1 juv.	9	5	-	-	-	-
<i>Pleuromectes quadrituberculatus</i>	3	2	2	-	2	1	-
<i>Pleuromectes stellatus</i>	196	15	4	-	-	-	-
<i>Clidoderma asperrimum</i>	-	-	-	-	-	1	-
<i>Glyprocephalus stelleri</i>	3	1	5	-	55	8	4
Number of trawls:	1	2	2	1	3	3	1

In September the flounders drift slowly to greater depths. The maximum catches are now made in the central zone of the strait and down south as the school shift southerly. The zone immediately adjacent to the Sakhalin shore-line is poorer because the flounders remain at the depths down from 20-30 to 70 metres. At the same time, somewhat higher catches were made in September off the continental shore in the region of Cape Khoy-Cape Opasnosti. In October, migration into deep water regions in the southern direction becomes intensified.

DRAWING 21.

Limanda aspera May-October 1933,

-- Mean Length of flounders in cm.

_____ % of fry (less than 22.5 cm)

Pleuronectes quadrituberculatus. May-October, 1933.

-- Mean length of flounders in cm.

Hip. el dubius.

-- Mean length of flounders in cm.

_____ % of fry (less than 24 cm).

FIG. 21. Distribution of certian species of flounders in the northern zone of Tatarski Strait according to age (dimensions) of the schools fished.

In November- January the flounders travel farther to great depths and concentrate in this area.

It may seem that large winter concentrations of flounders

in Tatarski Strait should be located closer to the shores and highly dense.

Distribution of flounders near the south-eastern shores of Sakhalin (southerly from the 49° of northern latitude) is non-uniform.

Within a framework of hydrological conditions characteristic along the greater part of the coast of the Pacific Ocean, the summer distribution of flounders inhabiting these waters is in many respects the same as in West-Kamchatka waters and Peter the Great Bay (table 96).

The moderately-boreal *Lim. punct. punctatissima*, *Ps. yokohamae* and *Ps. herzensteini* approach the shores reaching the minimum depths (less than 40 metres) and forming industrial and semi-industrial concentrations in a number of coastal zones, for example, in the region of Ilyinsk. *Pl. stellatus* run close against the shores of Sakhalin. Moderately-boreal forms, such as *Lep. bil. mochigarei*, *Cl. herzensteini*, *Cl. stelleri* and *Ac. nadeshnyi*, remain at somewhat greater depths (40-60 metres), behaving, therefore, exactly as this species behave in Peter the Great Bay and in the northern zone of Tatarski Strait.

It is characteristic that in the given zone of the south-western shore of Sakhalin, there are no industrial accumulations of the main industrial species of the north-boreal regions, i.e. *Limanda aspera* and *Pl. quadrituberculatus*, which are so common farther to the North.

In this region, the aforementioned fish are found only in single, usually small (*Li. aspera*) specimens. A number of forms of southern origin (*Ver. moseri*, *Cl. asperrimum* and others) penetrate here in single specimens (usually of large dimensions). The species composition of flounders suggests the advisability of searching for industrial concentrations in the coastal zone during the summer, at the depths of 40 and less metres, where concentrations of *Li. punct. punctatissima*, *Pl. herzensteini* and *Pl. stellatus* may be found. However, it is doubtful whether large-scale concentrations of these fish can be found in this area. During the winter, the flounders leave the immediate off-shore zone, drifting to the closely situated regions where the depths are 100-150 metres; however, the drop in water temperature in the littoral zone is insufficient to produce increased concentrations of flounders;

TABEE 97.

Distribution of flounders (in number of specimens per trawling hour at different depths off the southwestern shores of Sakhalin (47° 53' - 48° 00') between May 19-20, 1933.

Species	Depth in metres.							
	50	60	70	80	90	100	150	200
Acanthopsetta hadeshnyi	-		-	-	+	+	+	
Ip. el. dubius	-		+	+	+	+	+	
Cleisthenes herzensteini	+	No data	-	+	+	+	+	
Lep. bil. mochigarei	-		+	+	+	-	-	
Leuronectes quadri- tuberculatus	+		+	-	-	+	+	
Glyptocephalus stelleri	+		+	3	+	+	+	
Number of trawls	1		1	1	1	1	1	

We have very limited data at our disposal on the vertical distribution of flounders in this region during the first half of May. The data were collected by M.N. Krivobok from an exploration trawler. During this season almost all the species (see table 97), i.e. the moderately-boreal (*Cl. stelleri*, *Cl. herzensteini* and others) and subarctic-boreal (*Pl. quadrituberculatus*) forms are found between 50 and 200 m., forming no large concentrations at any definite horizon. *Ac. nadeshnyi* alone have been found at the depths of 90 and more metres. As a rule, however, this fish feed at somewhat greater depths. The catches were very low (3 centners and less) and all the trawls (excepting the trawls launched in the littoral zone) contained *Hip. el dubius* for the most part. It is interesting to note that the south-boreal *Cl. asperrimum* and *Ver. moseri* were not found at all and probably penetrate into this region only during the summer.

Somewhat farther south in the shallow region between Moneron isle and the coast of Sakhalin, the number of flounders observed considerably decreased. The peculiar hydrological conditions of this zone account for a somewhat unusual distribution of benthic fish, the south-boreal representatives of which were found in greatest numbers at maximum depths, while the species adapted to cold water drifted towards the small littoral depths (fig. 23).

Hip. hip. stenolepis and Ath. evermanni penetrate via La Perousse Strait into the Sea of Japan and primarily to the region of Moneron Isle.

The distribution of flounders near the Souther Kuril Islands strongly affects the south-boreal character of this region. Research by the Kuril-Sakhalin expedition of the Zoological Institute of the Academy of Sciences of the USSR and TINRO in 1948-1949 provided the most ample data which served as a basis for classifying the species and determining the behaviour of flounders during the summer in the South Kuril shallow waters and off the Pacific Coast of the Iturup Isle, i.e. in the regions little explored as yet.

TABLE 98.

Distribution of the flounders at different depths off the South Kuril Islands between September 2 and 10, 1948.

	Depth in metres									
	20-30	40-50	50-60	60-70	70-80	80-90	90-100	100-125	125 150	175 200
<i>Verasper moseri</i>	5	1	-	-	-	-	-	-	-	-
<i>Acanthopsetta nadeshnyi</i>	-	-	-	-	7 juv.	-	-	1 juv.	1 juv.	-
<i>Cleisthenes herzensteini</i>	-	218 juv.	292 j.	304 j.	23-104	29	5	1	-	-
<i>Hippoglossus hip. stenolepis</i>	-	-	-	-	2	1	1	1	1	-
<i>Atheresthes evermanni</i>	-	-	-	8 juv	51 juv	84	9-15 juv	16	31	-
<i>Lep. bil. mochi-garei</i>	-	30	95 j	55	180	216	76	20	50	-
<i>L. anda aspera</i>	-	-	4 juv	5 juv	1	-	-	-	-	-

Depth in metres.

SPECIES	20-30	40-50	50-60	60-70	70-80	80-90	90-100	100-125	125-150	150-175	175-200
<i>Limanda punctatissima punct.</i>	6	7	94	-	-	-	-	-	-	-	-
<i>Pseudopleuronectes herzensteini</i>	84	73	108	21	28	-	-	-	-	-	-
<i>Pseudopleuronectes yokohamae</i>	142	6	4	-	-	-	-	-	-	-	-
<i>Kareius bicoloratus</i>	1	-	-	-	-	-	-	-	-	-	-
<i>Clidoderma asperum</i>	6	8	95	53	76	32+4	37	18	26	4	
<i>Glyptocephalus</i> <i>gillii</i>	-	-	-	-	10+4j.	50+5	36	2	1	-	
<i>Microstomus</i> <i>achne</i>	-	-	-	-	-	2	2	2	2	2	
Number of trawls	1	1	1	3	4	2	2	2	2	2	

The flounder-population in the region of the Southern Kuril Islands is exceptionally varied, consisting of 21 species, probably because a number of forms from the northern zone (*L. aspera*, *Pl. quadrituberculatus* and others) penetrate into these waters from the Sea of Okhotsk (this region being the southern border of their area of propagation), joining the rich south-boreal fauna of flounders - *Cl. asperum*, *Ver. moseri*, *Microstomus achne* and others - and a considerable number of the moderately boreal forms (*Pl. obscurus*, *Lim. punct. punctatissima*, *Lep. bil. mochigarei* and others), which inhabit these waters.

During the summer the flounders are distributed within the limits of the South-Kuril shallow waters at different depths, in conformity with the pattern common to all the regions.

However, in the given case, the distribution of flounders is shifted towards greater depths of the bathymetric range (see table 86)

At the depths down to 20 metres, we found the south-boreal *Ver. moseri*, *Cl. asperrimum*, *Kareius bicoloratus* as well as a number of moderately-boreal forms, i.e. *Pl. obscurus*, *Ps. herzensteini*, *Ps. yokohamae*, *Lim. punct. punctatissima*. With the increase in depth we found increasingly greater numbers of moderately-boreal and Pacific-boreal forms, generally speaking, in the regions with lower pre-benthic temperatures.

At the depths of 70-90 and lower, there appeared *Hip. hip. stenolepis* (small specimens), *Ath. evermanni*, the fry from 60-90 m.- adult specimens - somewhat deeper -, *Gl. stelleri*, *Ac. nadeshnyi*. Here we also found single specimens of *Lim. aspera*. From the depth of 40 metres down to 150 metres we found the most numerous flounder to be the *Lep. bil. mochigarei* species.

The maximum catches of flounders were obtained from 70-80 m depths and only amounted to 1.5 to 2.0 centners per trawl hour.

Thus, the bank of flounders observed near the South Kuril Islands seems to have shifted towards the great depths (fig. 23). In the north-boreal regions, i.e. in the regions where there are industrially exploitable banks of flounders, most species, particularly the industrial forms remain in these waters during the summer, approaching

the shores and filling the levels from 50 m up, whereas in the South Kuril shallow waters the levels from 50 down to 100 metres are those most densely populated, due to the high degree of warming up of the immediate off-shore shallow zone. Undoubtedly, the winter distribution of flounders in the South Kuril shallow zone differs from the distribution in the north-boreal region to an even greater extent.

Specific hydrological conditions account for the peculiar character of the distribution and migration of the majority of flounders and other benthic and pre-benthic fish (Alaska pollack, cod) as compared with the migrations into the regions of north-boreal character.

During the autumn, we observed in the South-Kuril shallow waters a migration in the direction contrary to that of the customary autumn migration - i.e. from the shores to greater depth. Numerous species of flounders of northern origin, Alaska pollack and cod, drift away from the summering regions towards the shores, where at this time the temperatures drop to indices suitable for the existence of these fish.

During most of the winter the flounders remain at relatively shallow depths, partially returning in the spring and early summer to deeper regions.

Such is the general pattern of migrations and distribution

of flounders off the shores of the Southern Kuril Islands. This pattern is particularly well pronounced in the South-Kuril shallow waters, but has been also observed in a somewhat modified form off the Pacific and Okhotsk shores of the Iturup Isle. In view of the fact that the concentrations in the South Kuril shallow waters most probably comprise not the south-boreal forms (which, as we know, are not numerous), but the Pacific moderately boreal species, we believe that the summer concentrations comprise most probably industrial schools of *Ps. herzensteini* and *Ps. yokohamae* at the depth of less than 50 metres, *Lep. bil. mochigarei* between 50 and 100 metres and halibuts (*hip. hip. stenolepis*, *Ath. evermaini*) at the depths lower than 100 metres. During winter, the Bathymetric zone where industrial catches may be obtained, narrows down and the overwhelming majority of species are found at the depths of 20 to 60 metres with the exception of halibuts, which remain at greater depths. These are the depths where we may expect to find industrial concentration of considerably greater density than those located during the summer.

There are but a few data on the vertical distribution of flounders in more southern regions. The short article by Kuronuma (1940) enabled us to draw table 9i showing the bathymetric distribution of flounders off the eastern shores of Japan (from 46 to 32° northern latitude) during the summer.

TABLE 99.

Frequency at which the flounders are found at different depths off the Pacific shores of Japan.

[illegible]

It is characteristic that *Aca nadeshnyi* sink to great depths (as deep as 950 metres) penetrating in Peter the Great Bay to the depth of 700 m.; *Cl. stelleri* are found as deep as 750 m. and were caught in Peter the Great Bay at the depth of 450 m. (Moiseev, 1946). Let us point out once more that in the Atlantic Ocean *Cl. cynoglossus*, which is a form affinitive to the aforementioned species, sinks to the depth of 1600 metres (Good and Bean, 1895). It is interesting to note that *Cl. asperrimum* also sink as deep as 500 m. and this enables us to understand and explain why this fish - an undoubtedly southern species - succeed in penetrating as far as the shores of Kamchatka and Kommandor Islands.

The remaining species sinks to the levels between which they may be also found in the northern regions. However, the fish reach these depths in the North, because low temperatures compel the flounders to migrate to greater depths, whereas in this case this phenomenon is induced by the rise (instead of drop) in temperature in the littoral zone during the summer, a rise exceeding the upper threshold indices of optimum temperature. Having thus completed the brief description on the distribution and migrations of flounders in different regions of the Fareastern waters, we wish to draw a few conclusions from the aforesaid.

The overwhelming majority of the industrial species of flounders adapt their entire vital cycle to the range of depths of the continental plateau, with the exception of a small group of forms (the species of the genera *Hippoglossus*, *Atheresthes*, *Reinhardtius* and partly the *Acanthopsetta*) remaining during the greater part of the year at the depths of 100 and more metres and sinking as deep as 500 metres and more. Populating almost exclusively the regions of boreal character, or, to be more precise, the north-boreal regions, the majority of flounders very sensitively react to seasonal fluctuations in temperature occurring in the surface layer of water (down to 200 metres) and, particularly, to the drop in temperature indices below zero. Only some littoral forms (*Pl. glacialis*, *Pl. pinnifasciatus*, *Pl. obscurus* and *Pl. stellatus*) remain in the narrow littoral zone down to 30-40 metres during the summer, and, when the pre-benthic temperatures drop to -1.5 and lower.

Compare the graphic presentations of the vertical distribution of flounders in different regions during the summer (fig. 22 and 23.) In all the regions the depths most densely populated during the summer are situated below 100 metres. Even within the limits of these depths the densest concentrations of flounders are found in shallow waters of less than 60 metres in depth. The depths of 100 and more metres are very sparsely populated during the warm season and

halibuts are the only fish found in such areas in industrial quantities.

During the winter the greatest variety of species and the largest concentrations of flounders are found in the lower horizons of the continental plateau.

A survey of the geographic distribution of flounders, description of the migrations and distribution of flounders in the north-western part of Pacific Ocean enable us to establish that a large group of boreal species of flounders is rather wide-spread within the borders of the North Pacific moderate zone (the sub-family Pleuronectini). These fish also penetrate into the Arctic and Indian West-Pacific region.

Great numbers of industrial flounders have been observed almost exclusively within the limits of the north-boreal regions and it is quite possible, therefore, that large schools will be found here. In the cold water (glacial) and south-boreal regions no large concentrations of flounders can be expected to exist, although, of course, there may be some zones where the flounders will accumulate in numbers, sufficient to justify the organization of semi-industrial fishing. It is most probable, however, that halibuts form large concentrations within the borders of the lower zone of sub-littoral and upper horizons of the bathyal.

The aforesaid enables us to assess to what extent the

regions which have not been explored as yet, hold industrially exploitable stocks of flounders.

We may assume that large winter concentrations of flounders (mainly *Limanda aspera* and *Pl. quadrituberculatus*) might be found in the lower section of the West-Kamchatka shelf, to the North from the traverse of the river Bolshoy and as far as the traverse of Cape Khriuzov at the depths of 150 to 220 metres. During the summer, a search should be made for concentrations of flounders within the borders of the glacial regions in the warm littoral zone at the depths of 10 to 40-60 m., whereas in the south-boreal regions dense concentrations may most probably be found at the depths of 40-50 to 80-120 metres, where the most important north-boreal flounders remain during this season.

There are grounds to believe that the winter concentrations of *Limanda aspera* and (somewhat deeper) *Lep. bil. bilineata* may be found during the winter at the depths of 100 to 230 metres eastwards and westwards from the Northern Kuril Islands (primarily from Paramushir Islands).

DRAWING 22.

DRAWING 22.

Southwestern shores of Kamchatka (June-September 1938).

D
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Northern zone of Tatarski Strait (June-September, 1939).

D
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Peter the Great Bay (June, 1932).

D
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Pleuronectes quadrituberculatus	Pleuronectes stellatus	Limanda aspera	Limanda punct. punctatissima	Lepidopsetta bil. bilineata	Hippoglossoides hip.	Pseudopleuronectes herzensteini	Acanthopsetta nadeshnyi	Cleisthenes herzensteini	Glyptocephalus stelleri.

Fig. 22.

Vertical distribution of certain species of flounders in the north-boreal regions.

Number of specimens per trawling hour.

DRAWING 23.

Southeastern shores of Sakhalin Island (the Glacial region)

D
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Southwestern shores of Sakhalin.

D
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h

i
n

m.

Southern Kuril Islands (south-boreal region).

D
e
p
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h

i
n

m.

Pleuronectes quadrituberculatus
Pleuronectes stellatus
Atheresthes evermanni
Limanda aspera
Limanda punct. punctatissima
Lepidopsetta bil. bilineata
Hippoglossoides hip.
Pseudopleuronectes herzensteini
Acanthopsetta nadeshnyi
Cleisthenes herzensteini
Glyptocephalus stelleri
Pseudopleuronectes yokohamae.

Fig. 23. Vertical distribution of certain species of flounders off the shores of the Southern Sakhalin and Kuril Islands.
(The legends indicating catches are the same as in drawing 22).

Within Kamchatka Bay as well as farther to the North, up to Cape Olyutorski, we shall undoubtedly find industrial concentrations of flounders of medium density during the summer as well as during the winter. Large concentrations probably drift into the northern zone of Tatarski Strait, where the maximum depths of 100-150 metres occur towards the North from the entire zone of shallow waters of the northern belt of this strait, as do flounders from the continental coastal waters of Sakhalin.

At the levels of 100-150 down to 250-400 metres and deeper, along the entire area extending between Cape Navarin in the North and the Southern Kuril Islands, including the whole Sea of Okhotsk and the region of Moneron Isle in the Sea of Japan, industrial concentrations of halibuts from Pacific Ocean may be found.

We believe it probable that the most substantial concentrations of halibut are formed within the limits of the 500-metre area extending from the central section of the Okhotsk depression in the direction of the estuary of Shelikhov Bay as well as off the southwestern shores of Kamchatka, off the Southern Kuril Islands and in the region of Olyutorski Bay and Cape Navarin.

In concluding the chapter on distribution and migrations, let us dwell in brief on the effect of

sub-zero temperatures upon the distribution of flounders in the Fareastern waters. As already mentioned above, the importance of this factor must not be underestimated. The effect of climatic fluctuations on the behaviour of fish is universally known. Berg reported in his work (1935) numerous cases of several species of fish penetrating the North Atlantic and Pacific Oceans due to the warming up observed in the Arctic and subarctic regions during the last few years. This reaction is particularly noticeable in the case of pelagian fish, which frequently expand or reduce their region of propagation. The examples quoted by Rumyantsev in this article published in 1947 clearly show that a great number of warm-water forms have penetrated the Sea of Japan during the last few years. The effect of multiannual thermic fluctuations on the relatively immobile fish species travelling but short distances during migration periods has been studied to a considerable lesser degree. The peculiar multiannual "pulsation", i.e. changes in the surface areas and regions of the territories filled with water at sub-zero temperature which takes place in several zones of the Fareastern seas, considerably affects the the distribution of industrial concentrations of flounders.

As may be seen from numerous bibliographic sources (Makarov, 1894; Moiseev, 1938; Ushakov, 1940, in the

Okhotsk and Bering seas (occasionally in the sea of Japan as well), there have been observed spacious areas where a layer of water at sub-zero temperature at the depths of 25 to 200-250 metres remained intact throughout the entire summer and considerable areas of shallow water were covered with a layer of water at sub-zero temperature (as low as -1.7°). Furthermore, in a number of regions of the Far Eastern seas there occur considerable multi-annual changes in the dimensions of the surface areas of ocean-floor covered with water at sub-zero temperature, and during certain years the complete disappearance of sub-zero temperatures has been noted in three regions.

Flounders react very sensitively to the disappearance of the temperature barriers. Large and dense concentrations of flounders appear in other regions. The latter is caused by the rise in benthic temperature and by the abundant biological volume of benthos usually observed in these regions (Gordeeva, 1948). The relatively abundant biological volume of benthos and particularly the nutritive part of benthos is noticeably higher than in zones densely populated by fish and is probably at least partly due to fish and other sea animals not visiting these areas during the seasons when the temperatures drop, below zero, so the benthos is left intact.

The importance of thermic fluctuations on the distribution of flounders and a series of other benthic and pre-benthic animals is extremely high. Since the rise in the benthic temperatures above

zero or drop to sub-zero may induce considerable displacements of industrial concentrations and change in their density.

As we already mentioned before (Moiveev, 1946), the extent of migrations and seasonal vertical drifts of flounders in the Far Eastern waters is considerably greater than the negligible linear and vertical seasonal migrations in the Northeastern Atlantic Ocean, due to the insignificance of the annual thermic fluctuations and constantly high (above zero) benthic temperatures. Even in the Barents Sea the migrations of sea flounders are not extensive (Somov; 1927; Averintsev, 1937; Milinsky, 1933).

Off the Pacific shores of America the distances covered by flounders during migrations are also small, however, we observed single marked specimens of flounders (for example, *Parophrys vetulus* travelling from Florence Bay (Vancouver Island), as far southwards as the State of Oregon, i.e. approximately 200 miles (Manzer, 1946). But in most cases the flounders populating the coastal waters along the Pacific shores of America are adapted to definite banks and do not travel great distances.

The flounders in the Atlantic Ocean, particularly in its northern zone (Iceland, Northern England and other regions), also follow the general rules for the vernal spawning-feeding migrations towards shallow waters and autumn-winter migrations to greater depths, which have

been described in detail by a great number of explorers (Bowman, 1933; Taning, 1934; Fulton, 1905; Johansen, 1915, and many others).

The vertical distribution of flounders (adult specimens as well as fry), which occupy clearly outlined zones off the European shores of Atlantic Ocean, is characterized by much the same features as characterize distribution in the above discussed regions.

Off the shores of the Far Eastern waters, as well as in the North Sea, the following genera of flounders are adapted to the most shallow waters: *Pleuronectes* (*Pl. stellatus* and *Pl. flesus* respectively) and *Limanda* (*Limanda punct. punctatissima* and others in the Pacific Ocean and *Lim. limanda* in the Atlantic Ocean), whereas the genus *Glyptocephalus* (*Gl. stelleri* and *Gl. cynoglossus* respectively) inhabit the greatest depths.

It is, however, equally clear that the substantial differences in the environment of flounders inhabiting the northeastern zone of the Atlantic Ocean and northwestern part of the Pacific Ocean result in formation of a series of original biological characteristics modifying to a certain degree the regularities common to the flounders in both oceans.

x.x.x.x.x.x.x.x.x.x.x.x.x.x.x.x.

Let us summarize the above discussed.

The distribution and migrations of flounders in all the Far-eastern waters are similar in character, differences in character being primarily due to the differences in hydrological conditions in different regions.

From the point of view of the bathymetric distribution all flounders may be divided into the following groups:

- a) sublittoral species which, as a rule, do not sink below 30-40 metres;
- b) alittoral species remaining within the depths of 5-10 to 150-250 metres;
- c) bathyal species remaining throughout the year at the depths of 100 to 400 and more metres.

The distribution and migration of flounders belonging to the aforelisted different groups substantially vary from one case to another.

The process of migration of alittoral species, which includes the overwhelming majority of industrial flounders to the depths of 150-250 metres, i.e. into the above-zero temperature regions, is completed in the north-boreal regions by the end of the winter in connection with the winter circulation reducing the temperature of surface layers of water to sub-zero.

The sublittoral species (*Pleuronectes obscurus*, *Pleuronectes pinnifasciatus*, *Pleuronectes stellatus* and *Pleuronectes glacialis*) remain throughout the winter at great (over 100 metres depths and drift in relatively small numbers to the depths of less than 50-100 metres only during the summer.

During the spring (in April), with the gradual warming up of the littoral waters and with the beginning of the intensive maturation of the sexual products, the vernal feeding and simultaneously, the spawning migration of flounders towards the shores into the shallow waters, where they intensively feed, takes place.

The overwhelming majority of flounders (with the exception of halibuts) occupy the levels of 100 (even 50) metres and their return migration begins only in September-October following the drop in temperature of the littoral waters.

In the south-boreal regions the aforesaid scheme of migrations and distribution of flounders somewhat changes. Here, during the summer, the subarctic-boreal Pacific-boreal and north-boreal species remain at considerably greater depths, whereas the well-heated shallow waters are populated in the main by the south-and moderately-boreal forms. In view of the limited numbers of the south-boreal species of flounders, the maximum catches of flounders are obtained at from 50 down to 100 metres, i.e. within the horizons inhabited by north-boreal and moderately boreal forms. During the winter the majority of flounders in the south-boreal regions do not drift away from the shores, but approach the shore-line more closely, as the temperature conditions in the immediately coastal zone are most suitable for their existence.

The extent of the course of the seasonal migrations of the Fareastern flounders is not great: it does not exceed 80-100 miles (with the exception of halibuts). The study of migrations paths and age composition showed that in the Fareastern waters the concentrations of all the species of flounders have been strongly localized and even the flounders inhabiting adjacent regions (for ezample, the region of Peter the Great Bay) do not, as a rule, drift from one region to another. Our knowledge of the ecological characteristics of the Fareastern flounders enables us to clarify the pattern of their vertical distribution. This distribution depends primarily on the distribution of water volumes of different origin.

x.x.x.x.x.x.x.x.x.x.x.x.x.x.x.x.x.x.x.x.x.

LENGTH AND WEIGHT

The dimensions of most flounders inhabiting the Fareastern waters vary little. Thus, the species of the genera Hippoglossoides, Cleisthenes, Lepidopsetta, Limanda, Pseudopleuronectes, Pleuronectes and Glyptocephalus, i.e. almost all the main industrial flounders, rarely exceed 45-50 cm in length and 800-1000g in weight.

Pl. quadrituberculatus is the largest flounder among the species forming industrial concentrations and reaches 60cm in length and 3.2 kg. in weight off the shores of Kamchatka.

Among the flounders of exceptionally small dimensions we wish to mention *Ac. nadeshnyi*, the length of which reaches in certain cases 45cm and weight - 440 gr. We wish to add, however, that normally this fish is 35 to 30 cm in length and 200-230 gr. in weight.

The majority of south-boreal and subtropic flounders penetrating our waters (*Par. olivaceus*, *Eopsetta griorievi*, *Ver. moseri*, *Ver. variegatus*, *Micr. achne*) are large fish reaching 60-65 cm in length and 4.5-5.0 kg. in weight (Moiseev. 1938), however, as we mentioned before, they are not numerous and therefore, have little industrial importance.

Halibuts form a separate group (*Reinh. hip. matsuurae*, *Hip. hip. stenolepis* and *Ath. evermanni*) of large flounders exceptionally important to the fishing industry. *Hippoglossus hip. stenolepis*, found in our waters, reaches 215 cm in length and 80 kg weight; *Atheresthes evermanni* - 80 cm and 6 kg respectively, and *Reinhartius hippoglossoides matsuurae* - 95 cm and 10 kg.

It is characteristic that all the predatory flounders (the halibuts and aforelisted southern flounders) are the largest and least numerous forms, whereas flounders feeding on benthos are relatively small in size. The number of species fished is great, in view of which we are compelled to somewhat

reduce the data material at our disposal and discuss the length and weight of the main species inhabiting the most important industrial regions.

As previously mentioned, the most wide-spread and numerous forms in Peter the Great Bay (before the reserves were exhausted) were *Lim. aspera*, *Cl.*

herzensteini and *Ps. herzensteini* (Moiseev, 1946).

In the following table 100, we present the data on linear dimensions of the flounders caught in Peter the Great Bay during the early period of development of trawl fishing, i.e. before intensive fishing affected the state of the schools of flounders and dimensions of fish specimens. Thus, these figures correctly express the correlation between dimensional groups in an industrial school, which has been left almost intact in its natural state.

It is easy to observe that the overwhelming greater part of catches of industrial flounders by the trawl fleet (78.3% in the case of *Limanda Aspera*, 80.8% - *Cl. herzensteini*, 77.3% - *Ps. herzensteini*) consist of fish specimens over 28 cm in length. *Ac. nadeshnyi* was the only species whose specimens measuring less than 30 cm made up 88.8% of the catches.

In the case of *Limanda aspera* the prevalent number of fish in the catches ranged from 26 to 36 cm. (76.1%), in the case of *Cl. herzensteini* - from 28 to 40 cm (72.7%) and 80.0% of *Ps. herzensteini* were 26 to 36 cm in length.

TABLE 100.

Correlation between groups of flounders of different dimensions found in trawl catches in Peter the Great Bay in 1931-1933.

Species	Units of mea- sure- ment	10- 12	12- 14	14- 16	16- 18	18- 20	20- 22	22- 24	24- 26	26- 28	28- 30	30- 32
Acanthopsetta nadeshnyi	Speci- mens %	2 1.6	8 6.4	4 3.2	22 17.6	10 8.0	15 12.0	12 9.6	20 16.0	13 10.4	5 4.0	6 4.8
Hip. el dubius	Speci- mens %								2 1.4	9 6.4	15 10.7	30 21.4
Cleisthenes herzensteini	Speci- mens %				26 2.2	51 4.3	48 4.0	29 2.5	29 2.5	44 3.7	94 7.9	166 14.0
Lep. bil. mochi- g ei	Speci- mens %								2 2.2	4 4.4	10 11.1	17 18.9
Limanda aspera	Speci- mens %				1 0.2	4 0.2	31 1.3	72 3.0	152 6.3	263 10.9	439 16.2	494 20.5
Pseudopleuron- ectes herzenst- eini	Speci- mens %						1 0.2	14 2.6	36 6.6	73 13.3	93 16.9	104 18.9
Glyptocephalus stelleri	Speci- mens %									2 0.9	5 2.2	2 0.9
		32- 34	34- 36	36- 38	38- 40	40- 42	42- 44	44- 46	46- 48	48- 50	M	n
Acanthopsetta	Speci- mens %	2 1.6	2 1.6	1 0.8	1 0.8	- -	1 0.8	1 0.8			22.60	125
H. el dubius	Speci- mens %	33 27.2	23 16.4	10 7.1	4 2.9	4 2.9	5 3.6				33.00	140
Cleisthenes herzensteini	Speci- mens %	192 16.3	173 14.7	134 11.4	99 8.4	62 5.2	27 2.3	7 0.6			33.26	1181
Lep. bil. mochi garei	Speci- mens %	17 18.9	15 16.6	14 15.6	4 4.5	4 4.5	3 3.3				33.63	90
Limanda aspera	Speci- mens %	398 16.6	288 11.9	149 6.1	75 3.1	38 1.6	8 0.3				31.16	2412
Pseudopleuron- ectes herzen- steini	Speci- mens %	99 18.0	71 12.9	39 7.1	15 2.8	4 0.7					30.9	549
Glyptocephalus stelleri	Speci- mens %	13 5.7	26 11.4	34 14.4	44 19.2	24 10.5	21 9.1	31 13.5	25 10.9	2 0.9	39.86	229

In Peter the Great Bay *Limanda Aspera* reached 43.5 cm, *Cl. herzensteini* - 48cm and *Bs herzensteini*-42 cm in length.

In order to study the dimensional composition of flounders in Peter the Great Bay more thoroughly, let us present the data on dimensions of flounders caught by the low tonnage fleet at the depths of less than 50 metres by means of benthic casting nets (table 101).

It is easy to see that the finely meshed benthic casting nets, by means of which the fishing of flounders is conducted from small industrial boats in the regions populated by these fish during the summer, i.e. at the depths down to 50-60 metres, bring in considerably smaller fish than do the large-meshed nets. Although we found a certain number of flounders of maximum dimensions in this fishing, since in both cases-at great depths during the winter and at shallow depths during the summer - the fishing is conducted over the same school of flounders, though the region inhabited changes according with the regions, nonetheless the number of fish over 28 cm in length noticeably decreased (*Lim. aspera* of this size were 58.9% the catches of *Cl. herzensteini* 54%, of *Pa. herzensteini* 48.7%) with a corresponding increase in the number of small specimens. Undoubtedly, this phenomenon is partly due to the fact that by 1935-1936 (i.e. the years when the data presented in table 101 were collected) the schools of flounders considerably changed as a result of intensive fishing, so that the flounders given no longer characterize

a school unaffected by fishing. However, we have no recent data, and as we shall see later, when discussing the changes that occurred in the pattern of dimensions of flounders in Peter the Great Bay, the data in table 101 may reflect the state of schools of flounders relatively little affected by intensive fishing as compared with the effect of fishing in recent years. These data seem important to us since at present the fishing of flounders in the Sea of Japan is conducted mainly with benthic casting nets.

Let us now discuss the dimensions of flounders in trawl catches obtained in the coastal waters of Western Kamchatka (table 102).

This is the most important industrial region and all the species of flounders are represented by large specimens. Indeed, we found in catches only 6.8% of *Limanda aspera* specimens below 30 cm in length, 22.0% of *Hippoglossus elassodon*, 1.6% of *Platichthys stellatus* and 6.8% of *Pl. quadrituberculatus*. Even in the case of the relatively small *Lim. punct. proboscidea*, 49.3% of specimens were over 30 cm.

At the same time we observed that the same species reach larger linear dimensions off the Far Eastern waters. *Hippoglossus el. elassodon* reaches 47.5 cm in length; *Lep. bil. bilineata* - 52 cm; *Limanda aspera* - 48 cm; *Pl. quadrituberculatus* - 60 cm; *Pl. stellatus* 56 cm. Undoubtedly,

the flounders of north-boreal character find more suitable conditions for existence within the borders of the West-Kamchatka shelf. The most numerous species of the Far-eastern flounders, i.e. the *Limanda aspera* and *Pleuronectes quadrituberculatus* - reach in this region their maximum linear dimensions. The largest and densest concentrations of these fish have been also observed in this zone.

It is interesting to note that the mean dimensions and proportion between the number of representatives of different sex of *Limanda aspera* and *Pleuronectes quadrituberculatus* in the northern and southern regions of the West Kamchatka shelf are different (table 103).

The mean dimensions of *Limanda aspera*, inhabiting the northern regions (Khariuzovo) are much higher as compared with the fish from more southern regions (Ozernaya-Krutogorovo), whereas flounders from the central sections of the shelf (Kekhta-Vorovskaya) have intermediate mean dimensions. This may be due to the prevalence of males (77%) in the southern and an equally high percentage of females in the northern (76%) zone.

TABLE 101.

Proportion of flounders of different size in catches obtained by means of benthic casting nets in Peter the Great Bay in 1935-1936.

SPECIES	Units of measurement	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-26	26-28	28-30
Hip. el. dubius	Sp. %									1 0.9	2 1.9
Cleisthenes herzensteini	Sp. %		4 0.1	9 0.3	73 2.4	371 12.0	404 13.0	223 7.9	141 4.6	175 5.7	271 8.8
Lep. bill. mochegarei	Sp. %	2	2	55 1.5	78 2.1	68 1.8	200 5.3	314 8.3	358 9.5	477 12.6	560 14.8
Limanda aspera	Sp. %	1	65 4.0	209 12.9	336 20.9	253 15.6	219 13.5	165 10.2	172 10.6	115 7.1	51 3.2
Limanda punct. notatissima	Sp. %		3 0.3	18 1.8	72 7.1	128 12.6	127 12.5	225 22.2	202 19.9	94 9.2	41 4.0
Pseudopleuronectes yokohamae	Sp. %			5 0.2	47 1.8	229 8.9	299 11.7	396 15.4	342 13.3	380 14.8	306 11.9
Pseudopleuronectes herzensteini	Sp. %										
Glyptocephalus stelleri	Sp. %				2 0.4	24 4.8	86 17.3	171 34.3	113 22.7	46 9.3	20 4.0
		30-32	32-34	34-36	36-38	38-40	40-42	42-44	44-46	46-48	48-50
Hip. el. dubius	Sp. %	15 14.0	10 9.4	9 8.4	15 14.0	14 13	17 15.9	13 12.2	8 7.5	3 2.8	
Cleisth. herzenst.	Sp. %	472 15.3	135 4.3	254 8.3	126 4.0	83 2.7	27 0.9	13 0.4	1 0.1	2	
Lep. bil. mochi-garei	Sp. %	557 14.8	513 13.6	284 7.5	184 4.9	99 2.6	23 0.6	6			
Limanda asper	Sp. %	27 1.7	5 0.3								
Limanda punct. punctatissima	Sp. %	39 3.8	33 3.2	20 2.0	7 0.7	7 0.7					
Pseudopleuronectes yokohanae	Sp. %	229 8.9	165 6.4	94 3.7	57 2.2	16 0.6	4 0.2				
Pseudopleuronectes herzensteini	Sp. %	2 1.6	1 1.8	14 10.9	24 18.8	25 19.5	10 7.8	15 11.7	20 15.6	16 12.5	1 0.8
Glyptocephalus estelleri	Sp. %	17 3.4	9 1.8	6 1.2	2 0.4	2 0.4					
M resp. n	37.86, 107	27.82, 3084	29, 14, 3780	20, 86, 16180	23, 76, 1016	26.88, 2569	42.00, 128	24.22; 498			

TABLE 102.

Proportion of flounders of different dimensions in the trawl catches obtained in the littoral zone of Western Kamchatka in 1931-1938.

Species	Units of mea- sure- ment	10- 12	12- 14	14- 16	16- 18	18- 20	20- 22	22- 24	24- 26	26- 28	28- 30	30- 32	32- 34	34- 36	36- 38	38- 40	40- 42	42- 44	44- 46	46- 48	48- 50	52- 54	54- 56	58- 60	M	
Hip. el. el- assoson	Sp. %	1 0.4	1 0.4	2 0.8	7 2.8	7 2.8	2 0.8	2 0.8	8 3.2	9 3.7	17 6.9	17 6.9	27 11.0	35 14.2	33 13.4	27 11	27 11.0	20 8.1	2 0.8	2 0.8					34.14	
Lep. bil. bilineata	Sp. %											1 1.3	4 7.3	2 3.8	3 5.7	6 11.3	7 13.2	9 17.0	16 30.2	4 7.5	- -	1 1.9			41.70	
Limanda aspera	Sp. %						13 0.39	20 1.4	7 0.5	20 1.4	36 2.6	110 7.9	213 15.4	318 22.9	307 22.1	177 12.8	105 7.6	43 3.1	12 0.9	7 0.5					35.54	
Limanda punct. probos- cidea	Sp. %						1 0.9	3 2.8	11 10.0	20 18.4	20 21.1	23 19.3	21 7.3	8 0.9	1 0.9	1									29.80	
Pleuronectes quadritubercu- latus	Sp. %						1 0.2	2 0.3	3 0.4	13 2.0	26 3.9	54 8	59 8.9	43 6.5	81 12.2	88 13.2	90 13.5	59 8.9	53 8.0	40 6.0	22 3.3	16 2.4	9 1.4	4 0.6	1 0.2	38.46
Pleuronectes stellatus	Sp. %											1 1.6	1 1.6	3 4.8	6 9.7	10 16.1	11 17.7	8 12.9	5 8.1	8 12.9	4 6.5	3 4.8	1 1.6	- 1.6	1 1.6	41.0
n= resp.		246				(Ftnt 1)		(2)		(3)			(4)		(5)		(6)									

TABLE 103.

Mean dimensions and proportion of specimens of different sex among *Limanda aspera* found in trawl catches obtained off the shores of Western Kamchatka in 1934.

Regions	Khariu- zovsky	Kekhta- Vorov- skaya	Kruto- gorovsky	Ozer- novsky	The entire Western Kamchatka.
Mean length in cm.	36.90	35.19	33.62	34.10	34.65
Percentage of males	24.0	62.0	69.3	77.0	
Depth at which the fishing was conducted in metres.	58	60	45	66	

TABLE 104.

Percentage of flounders of different dimensions in the catches obtained in Tatarski strait with benthic casting nets in May-August, 1944, and by trawls in 1933.

Species	Length in cm.															
	12- 14	14- 16	16- 18	18- 20	20- 22	22- 24	24- 26	26- 28	28- 30	30- 32	32- 34	34- 36	36- 38	38- 40	40- 42	42- 44
Catches obtained with benthic fishing nets																
<i>Limanda aspera</i>	0.3	0.5	0.7	2.7	4.0	3.8	6.0	16.2	25.5	21.1	11.1	5.2	1.9	0.5	0.3	
<i>Hip. el dubius</i>		0.1	0.3	0.5	2.7	3.0	6.0	12.3	14.3	13.3	14.5	13.3	9.8	7.4	3.7	
<i>Pleuronectes quadrituberculatus</i>					3.1	5.6	7.7	10.1	12.7	11.5	11.5	10.0	7.1	4.7	3.0	
Catches obtained by trawls																
<i>Limanda aspera</i>	1.5	0.7	0.7	1.9	2.4	5.5	7.6	11.6	14.8	17.8	18.7	10.7	4.4	1.1	0.4	0.1
<i>Hip. el dubius</i>	0.3	0.3	0.8	0.4	0.8	3.1	8.7	9.2	11.3	8.7	10.6	13.4	12.4	12.0	5.3	0.9
<i>Pleuronectes quadrituberculatus</i>	0.1	0.1	0.7	2.5	5.3	5.0	7.4	8.2	7.6	6.6	6.4	7.7	8.0	7.2	5.2	5.3

Table 104 Ctd.

Length in cm.										
Species.	44-46	46-48	48-50	50-52	52-54	54-56	56-58	58-60	M	n
Catches obtained by benthic fishing nets.										
Limanda aspera									30.84	
Hip. el dubius	0.5	0.2	0.1						33.74	
Pleuronectes quadrituberculatus	3.1	2.6	1.9	1.2	1.3	1.1		0.8	34.86	
Catches obtained by trawls										
Limanda aspera	0.1								30.10	10207
Hip. el dubius	0.5	0.3							33.10	3069
Pleuronectes quadrituberculatus	4.6	4.2	3.1	1.9	1.3	0.7	0.2	0.1	34.84	3596

TABLE 105.

Percentage of different dimensional groups of Pl. quadrituberculatus in the trawl catches obtained during the summer in different zones of Far-eastern waters.

Length in cm	10	15	20	25	30	35	40	45	50	
Eastern coast of Kamchatka	-	-	-	-	-	-	7.2	43.5	30.5	
Western coast of Kamchatka	-	-	2.6	5.8	15.6	26.9	24.9	19.1		
Tatarski Strait	0.1	3.3	14.0	19.0	16.8	19.1	12.8	9.6		
	50	55	60	M	n	Collected by:				
Eastern coast of Kamchatka	18.8	-	44.69	69		A.P. Andriyashev, 1932				
Western coast of Kamchatka	4.7	0.4	39.65	1013		E.K. Suvorov, P.A. Moiseev, 1933 1934				
Tatarski Strait	3.6	0.6	32.30	3596		D.I. Okhryamkin, 1933.				

By comparing the mean dimensions of *Pl. quadrituberculatus* from the Khariuzovsky and Ozernovsky regions, we shall observe once more that large specimens prevail in catches obtained in the North. Thus, in 1933, E.K. Suvorov established that the mean dimensions of *Pleuronectes quadrituberculatus* from Czernovsky region (41,40 cm) are 4 cm below the mean index for these flounders from Khariuzovsky region (45.40 cm). However, this difference, as well as an analogous difference in the case of *Limanda aspera*, may be due to the different proportion of male and female specimens in the two regions, since the mean dimensions registered for males and females separately are very similar in both regions. Thus, according to the data of I.A. Polutov, 21.5% of male *Pl. quadrituberculatus* were found in trawl catches obtained in the Khariuzovsky region in June, 1932, and 43.4% in August, 1932. The reason for this prevalence of one sex over the other is, in our opinion, due to the fact that trawling operations were conducted in the two regions at different depth-levels. As a rule, in the northern region the trawls were launched by somewhat greater depths than in the South. As we mentioned before, the dependence of mean dimensions upon the depth inhabited by fish is clearly pronounced. S.M. Kaganovskaya provided data on dimensions of the main industrial flounders in Tatarski Strait fished with benthic nets in the region of Aleksandrovsk. D.I. Okryamkin described the dimensions of flounders found in trawl catches (table 104).

Table 104 clearly shows that Tatarski Strait is populated by considerably larger flounders than Peter the Great Bay. If we take into account that the large *Pl. quadrituberculatus*, forming during certain months up to 17% of the overall catches obtained in Tatarski Strait and reaching here 60 cm in length and 3100 gr. in weight, are not found in Peter the Great Bay at all, it becomes further apparent that the former waters are populated by much larger flounders than are those in Peter the Great Bay.

However, we wish to point out that the dimensions of *Ac. nadeshnyi* inhabiting these waters are usually very small. The 36 specimens of this species that were measured by D.I. Okhryamkin in June, 1933, were 16 to 28 cm in length and averaged 21 cm. In most cases these fish are equally small in Peter the Great Bay. By comparing the dimensions of *Limanda aspera* found in different regions, we shall see that the coastal waters of Western Kamchatka offer the most favourable conditions for the existence of this flounder.

Limanda aspera are most numerous, as well as largest in this region.

The same applies to *Pleuronectes quadrituberculatus* (table 105), although the data on dimensions of these fish in different regions of the Far-eastern-Eastern waters are scarce. We wish to emphasize once more the exceptionally large size of these flounders. Almost half (49.1%) of all the fish caught off the shores of Western Kamchatka

are over 40 cm in length and reach even higher indices off the eastern shores of this peninsula.

It would be too lengthy to present a considerable body of data and figures on the length and weight of various species of flounders, data all very similar in most cases. We shall therefore merely examine two industrial species - *Limanda aspera* and *Cl. herzensteini*, the former with a broad, the latter somewhat elongated shape of body (tables 106 and 107).

The correlation between the length and weight of the body of *Limanda aspera* resembles that of all the species of the genera *Limanda*, *Pleuronectes*, *Pseudopleuronectes* and *Lepidopsetta* and the correlation between these two indices in *Cl. herzensteini* is reminiscent of the species of genera *Hippoglossoides* and *Acanthopsetta*.

To facilitate our task, we shall draw table 108, showing increment in weight of certain industrial flounders, occurring as a result of the increase in their length.

TABLE 106.

Correlation between the length (in cm) and weight (in gr)
of Limanda aspera from Peter the Great Bay (March 11, 1933).

Length	Weight															M	n
	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400-450	450-500	500-550	550-600	600-650	650-700	700-750	750-800		
16	1															75.0	1
18	2	1														91.5	3
20		4	2													141.5	6
22		1	7	2												180.0	10
24																	
26			9	14	4	1										220.0	28
28				12	29	4	1									269.0	46
30				3	14	20	5	1	1							314.0	44
32						6	22	8	2	1						386.5	39
34							2	15	14	4	1					457.0	36
36									1	4	2					531.0	7
38										1	2	2	2			610.5	7
40														1	1	750.0	2
Total	3	6	18	31	47	31	30	24	18	10	5	2	2	1	1	359.5	229

TABLE 107. Cleisthenes herzensteini

Length	0-50	50-100	100-150	150-200	200-250	250-300	300-350	350-400	400-450	450-500	500-550	550-600	600-650	650-700	700-750	800-850	M	n
16	2	3	1														67.0	6
18	1	22	1														75.0	24
20		15	7														90.5	22
22		2	1														91.5	3
24			7	3													140.0	10
26				10	13	1	1										211.0	25
28				3	20	13	5										249.0	41
30					16	25	16	4	2								286.5	63
32						8	35	10	9								341.0	62
34						2	12	7	10	5							380.3	36
36							2	2	7		8	1					457.3	20
38											3		2	1			583.0	6
40													2	3	2		675.0	7
42																1	775.0	1
44																		
Total	3	42	17	16	49	49	71	23	28	5	11	1	4	4	2	1	283.5	326

TABLE 108.

Correlation between the length (in cm) and weight (in gr)
of flounders inhabiting Peter the Great Bay.

Length in cm.	16	18	20	22	24	26	28	30	32	34	36	38	40
Cleisthenes herzensteini	67	75	91	102	138	210	246	292	334	382	485		
Limanda aspera	75	93	142	180	220	258	314	386	458	532	611	750	
resp: M -	30.74	-	32.16			n - 2422	-	4019.					

In *Limanda aspera* the weight increases with the increase in length at a considerable higher rate than in *Cleisthenes herzensteini*. While in *Limanda aspera* the increase in length from 19 to 21 cm signifies an increase in weight of 49 gr., in the *Cl. herzensteini* the increase is only 16 gr. We observed that increments in weight of large specimens are very high and reach 50 to 80 gr. per each centimetre of the length of the fish.

We observed a well pronounced dimensional and gravimetric sexual dimorphism.

The mean length of females is always greater than that of males probably due to the marked longevity of females with the result the females prevail over males in older age groups of fish and, consequently, among the large fish. As an example, we shall quote the data on the correlation between the number of flounders of different sex and varying dimensions, inhabiting Peter the Great Bay (table 109).

In the majority of species of flounders between 28 and 30 cm in length the males greatly outnumber the females. Later on, both are found in more or less equal numbers, but in large fish the females are represented by a considerably greater number than males and the specimens of 36-40 cm in length are always females. In smaller flounders - such as *Lim. punct. punctatissima* and *Ac. nadeshnyi* - this regularity is somewhat shifted towards smaller dimensional groups. It is hard to assume that the prevalence of males among small flounders is as considerable, as shown in table 109, however, females undoubtedly prevail among large specimens. This phenomenon may be easily explained from the biological point of view because, during the mass spawning of flounders a small number of males is able to fecundate the roe laid by a considerable greater number of females.

TABLE 109.

Proportion between the number of fish of different sex (in %) in different demensional groups of industrial flounders inhabiting Peter the Great Bay.

Species	14- 16	16- 18	18- 20	20- 22	22- 24	24- 26	26- 28	28- 30	30- 32
<i>Cleisthenes herzensteini</i> ♂+				96.7	97.2	86.8	82.0	62.5	42.6
				3.3	2.8	13.2	18.0	37.5	57.4
<i>Limanda aspera</i> ♂+				77.3	69.9	65.9	73.5	60.5	44.0
				22.7	30.1	34.1	26.5	39.5	56.0
<i>Limanda punct. punctatissima</i> ♂+	76.7	51.1	42.2	47.2	58.9	38.1	29.9	11.6	5.9
	23.4	48.9	57.8	52.8	41.1	61.9	70.1	88.4	94.1
<i>Pseudopleuronectes herzensteini</i> ♂+				100	78.6	94.4	71.2	47.3	48.1
					21.4	55.6	20.8	52.7	51.9
<i>Pleuronectes pinnifasciatus</i> ♂+				76.7	66.7	47.8	52.2	20.0	23.6
				23.3	33.3	52.2	47.8	80.0	76.4

Table 109 Ctd.

Species	Length in cm.								n
	23-34	34-36	36-38	38-40	40-42	42-44	44-46	46-48	
Cleisthenes Herzensteini	42.6 57.4	23.6 71.4	6.6 93.4	1.1 98.9	- 100	- 100	- 100	- 100	2475
Limanda aspera	40.5 59.9	24.7 75.3	6.4 93.6	- 100	- 100	- 100	-		2610
Limanda punct. punctatissima	- 100								
Pseudopleuronectes herzensteini	24.2 75.8	11.3 88.7	7.7 92.3	6.7 93.3	- 100				549
Pleuronectes pinnifasciatus	11.1 88.9	- 100	- 100	- 100	-				498

An even greater difference between the maximum dimensions of males and females of different species of flounders is observed in Tatarski Strait.

We established that the fish below 33 cm in length are mostly male on the basis of measurements taken from 10207 specimens of *Limanda aspera*; this prevalence was particularly pronounced (being twofold) in the fish between 24 and 32 cm. After that the correlations abruptly changes and among the fish over 33 cm in length the females outnumber the males. Among the specimens over 41 cm in length we found no males at all, whereas the females occasionally reached 46 cm in length.

We observed an almost identical phenomenon in the case of *Hip. el. dubius* (having measured 3069 specimens). Here, too, the males prevail among the fish below 32 cm in length, whereas among larger fish the percentage of females

increases very rapidly. The maximum length of male fish proved to be 38 cm, whereas females often measured 47 cm. Among *Pleuronectes quadrituberculatus* (3596 measurements) the prevalence of females over males has been registered for specimens over 42 cm in length. The males reached a maximum length of 51 cm, the females 60 cm. An analogous phenomenon has been observed off the shores of Kanchatka. We also wish to point out that females weigh more than males of the same length (see table 110).

TABLE 110.

Mean weight (in gr) of males and females of *Cl. herzensteini* depending on the length of the body (in cm).

Sex	Length							M	n
	26	28	30	32	34	36	38		
Males	215	237	286	330	370	414		32.78	1852
Females	215	265	278	364	417	593		33.14	2132

We observed that all female flounders weigh more than male fish of identical dimensions. This phenomenon is particularly well pronounced in the fish over 32 cm in length and is due to the fact that the sexual products of females (reaching during the pre-spawning period 20-25% of the overall weight of fish) are heavier than the sexual products of males (forming 10-12% of the total weight of a fish).

In conclusion, we wish to present the mean indices (length and weight) of industrial flounders inhabiting the Far Eastern waters (table 111-112). These tables include the mean dimensions of fish populating the regions where active fishing is conducted, as well as areas that have not been industrially explored thusfar.

TABLE 111.

Mean length (in cm) of industrial flounders inhabiting the Far Eastern waters.

Species	Eastern Shores of Kam- chatka	Western shores of Kam- chatka.	Tatarski Strait (northern zone)		Southwestern coast of Sak- halin	Peter the Great Bay		Southeastern coast of Sakhalin	Southern Kuril Islands.
			Trawls	Benthic fishing nets		trawls	Benthic fishing nets		
<i>Limanda aspera</i>	2	34.6	30.1	30.7	30.1	31.2	26.0	25.5	-
<i>Pleuronectes quadrituberculatus</i>	44.7	42.0	34.8	34.7	-	-	-	30.8	-
<i>Cl. herzensteini</i>	-	-	-	-	-	32.3	29.0	-	-
<i>Hip. elassodon</i>	35.8	33.7	33.1	34.8	-	33.0	33.0	-	-
<i>Lep. bil bilineata</i>	43.0	35.6	-	-	30.9	33.6	-	-	31.5
<i>Pseudopl. herzenstni</i>	-	-	-	-	24.9	30.9	28.0	-	-
<i>Pseudopl. yokohamae</i>	-	-	-	-	-	-	23.7	-	31.8
<i>Pluxron. stellatus</i>	30.4 ²	37.2	-	-	-	-	-	-	-
<i>Glyptoceph. stelleri</i>	-	-	40.1	-	35.3	39.9	-	-	35.4
<i>Acanthops. nadeshnyi</i>	-	-	-	-	23.4	22.6	-	28.3	-
<i>Limanda punct. pta</i>	-	-	-	-	22.3	-	24.0	19.6 ⁴	-
<i>Clidoderma asperrimum</i>	-	-	-	-	-	-	-	-	26.4
Mean length of floun- ders in the region:	38.0	-	-	33.0	-	-	27.0	-	-

TABLE 122.

Mean weight (in gr) of industrial flounders populating the Far Eastern waters.

	Western coast of Kamchatka.	Southeastern Aniv Bay coast of Sakhalin.	Southern Kuril Islands	Tatarski Strait Trawls	Benthic fishing nets	Southwestern Coast of the Sakhalin.	Peter the Great Bay Benthic fishing nets.	
Limanda aspera	480 ¹	291	470	-	333	305	412	250
Pleuron.quadrituber- culatus	1000	401	-		1170	590		-
Hip. elassodon	-	-	239 ²		335	333	354	330
El. herzensteini	-	-	-		-	-	-	280
Lep. bilineata	900	-	-	800	-	-	535	-
Pseudopleuron.hsteini	-	-	-	476	-	-	250	290
Pleuronectes stellatus	900	480	-	642	-	-	642	-
Glyptocephalus stelleri	-	381	-	642	-	-	476	650
Acanthopsetta nadeshn.	-	323	-		68	-	214	188
Limanda punct.pcta	-	140	-		-	-	106	240
Pseudopleuron.yokohamae	-	360	-	400				
Mean weight of the flounders inhabiting the region in which the fishing was conducted	560	-	-	-	-	-	-	252

The flounders currently caught in Peter the Great Bay are exceptionally small, a particularly striking fact in view of the high mean indices for the length and weight of flounders found in other regions. This phenomenon is a result of the excessive fishing that has been irrationally conducted in this region. We shall dwell on this problem in detail under the proper chapter of this work.

Thus we have established that the dimensions of flounders inhabiting the Far-eastern waters vary little. Almost all the industrial species (with the exception of the *Pl. quadrituberculatus*, reaching 60 cm in length and 3.2 kg. in weight) rarely exceed 45-50 cm in length and 800-1000 gr in weight. The largest dimensions are attained by halibuts, *Hippoglossus hip. stenolepis* in particular (up to 215 cm and 80 kg).

AGE.

The scales and otoliths of flounders have been studied by M. Demidova, S. Generozova and M. Tychkova to determine the age of the fish and these scientists showed that in the majority of cases age may be successfully established by the scales. Only in the case of certain large and finely-scaled species (*Pl. quadrituberculatus*) and, naturally, in the case of fish devoid of scales (such as *Pl. stellatus*, *Cl. asperrium* and others) the determination of age by otoliths produces better results.

In view of the abundance of different forms of flounders inhabiting the Far-eastern waters and the profusion of data collected on the age of flounders found in catches and rate of development observed in the course of several years, we are unable to discuss this problem in detail.

Moreover, a few years ago, Moiseev (1946) presented the data characterizing the age of certain species of flounders found in Peter the Great Bay.

Let us first of all deal with the age groups covering the flounders found in the catches obtained with the benthic fishing nets in Peter the Great Bay (that are now also used for fishing on flounders off the shores of the Maritimes).

We wish to point out that fishing from small boats, conducted in shallow waters (less than 50-60 cm) during the summer provided catches of flounders, the composition of which (with regard to both - age and species) is hardly comparable with the composition of the catches of flounders obtained by large trawlers operating as a rule with other trawls at considerable depths. As already mentioned in the chapter on length and weight, the catches obtained with different fishing implements must be discussed on an individual basis. Taking into account the fact that the rate of development of the flounders of different sex is varied, we shall present the data on the age and mean dimensions of different age groups of flounders discussing the fish of each sex separately (table 113).

By analyzing table 113, we conclude that the majority of flounders inhabiting Peter the Great Bay resemble each other in age composition and rate of development. Indeed, the fish between the age of four and seven years prevailed in the catches.

In certain species (*Lim. punct. punctatissima*, *Ps. yokohamae*) the prevailing age groups ranged from three to seven, in others (*Gl. stelleri*) - from three to eight - ten years, probably due primarily to *Cl. stelleri* (including its fry) remaining at the depths not readily accessible to benthic fishing (50-80 metres) and the catches usually contain the large specimens which penetrate into shallow waters.

On the other hand, the two former species of flounders approach the shores during the summer and occupy the narrow immediately coastal zone, so that the fishermen cannot possibly manoeuvre in search for the concentrations of large fish and the catches therefore mainly contain young specimens. Thus, the fishing in 1935-1936 was based on the 3-5 age groups of each species forming 88 to 92% of catches.

The longevity of all the flounders populating Peter the Great Bay does not exceed 13-14 years. We failed to find among the numerous forms any specimen aged 14 years although 12-13 year-old specimens of *L. aspera*, *Lep. bil. mochigarei* and other species have been occasionally found in very limited numbers. Thus, we found only 2 fish (0.02%) 12 years of age among 7066 specimens of *Limanda aspera* caught in 1936-1937) whose age was determined.

The percentage of old fish (9 and more years of age) in the school was insignificant and in the majority of cases

did not exceed 2-3%.

The results of analysis of the rate of growth of flounders from Peter the Great Bay have been summarized in table 114. However, the data showing the annual increments in the weight of flounders are even more convincing (table 115).

We observed exceptionally high increments in weight in the fish over 5-6 years of age (as high as 45% of the overall weight of a given fish).

The general rule is the same for all species as in this case. Having attained the maximum linear increment during the first year (6.5-8.8 cm), the rate of growth noticeably declines, whereas the gravimetric increment continuously rises. After having attained sexual maturity, which occurs in the majority of species at the age of 4-5 years, the rate of growth drops most noticeably, although all the flounders continue developing throughout their whole life.

The rate of growth is different for males and females. In all age groups the males are smaller than females, a contrast further accentuated with age; while during the first year of the life of the fish it reaches several fractions of a centimetre, by the age of 4-5 years this divergence is 1.5 - 3.5 cm and in the oldest groups reaches 4-6 and more centimeters.

TABLE 113.

Length (in cm) and age of flounders found in the catches obtained by means of benthic fishing nets in Ussuriysky Bay in 1935-1936.

Species	Sex	Age					
		2+	3+	4+	5+	6+	7+
Hippoglossoides el dubius	♂			27.0	30.3	32.0	35.9
	♀			-	-	36.9	40.7
	% ♂ ♀			1.9	9.2	42.6	31.0
Cl. herzensteini	♂	16.6	19.7	22.0	27.8	31.6	33.5
	♀	-	20.3	25.0	29.1	32.7	36.2
	% ♂ ♀	3.2	16.9	26.9	12.3	25.5	10.5
Limanda aspera	♂		21.0	22.3	25.5	28.6	30.9
	♀		20.3	24.8	26.2	30.0	34.0
	% ♂ ♀		0.5	7.9	20.9	20.0	35.5
Lim. punct. puncta	♂	16.1	18.0	21.3	24.6	27.9	-
	♀	17.7	19.8	23.4	27.0	29.5	31.0
	% ♂ ♀	5.6	34.2	28.1	19.2	10.6	1.5
Pseudopleuron. herbst.	♂	17.0	19.6	20.1	24.7	27.8	32.3
	♀	17.0	20.4	24.4	28.4	30.7	34.9
	% ♂ ♀	0.5	11.7	27.7	26.5	23.6	8.3
Pseudopl. yokohamae	♂	15.6	18.2	23.5	27.0	31.3	33.5
	♀	15.0	19.2	24.8	29.6	32.7	34.3
	% ♂ ♀	1.6	18.2	21.2	15.9	22.2	12.9
Glyptocephalus stel.	♂	20.2	21.2	26.5	29.8	34.5	36.4
	♀	-	-	30.0	-	-	40.1
	% ♂ ♀	1.2	3.4	6.8	7.2	8.3	18.4

Species	Sex	8+	9+	10+	11+	n	Date of collections
Hippogl. el dubius	as above	40.0	-				
		42.6	45.0				
		14.4	0.9			216	V.1935-1936
Cl. herzensteini	" "	39.0	-	-			
		38.9	41.8	43.0			
		3.8	0.7	0.2		2574	V-VI. 1936 r.
Limanda aspera	" "	31.8	33.7	37.2			
		35.7	37.0	41.4			
		11.6	3.0	0.7		2610	V. 1935 r.
Lim.punct.puncta	" "	31.0	-				
		-	33.0				
		0.5	0.3			395	V-VI. 1935-19
Pseudopleur. herzen.	"	33.0	33.0	-			
		37.0	39.0	41.0			
		0.7	0.8	0.2		1968	V-VI.1936 r.

TABLE 113. (continued)

Species	Sex	8+	9+	10+	11+	n	Date of collec.
Pseudopl. yokohamae	%	34.2 36.0 6.4	- 39.7 1.6			559	IV-V.1935-3 rr.
Glyptocephalus stel	%	38.2 43.4 30.0	39.5 45.3 17.8	40.3 44.6 6.3	- 47.0 0.6	188	V.1935-193 rr.

TABLE 114. Mean lengths and increments (in cm) of flounders (males and females) in Peter the Great Bay (following the reverse calculations

Species: Collected in:	Cleisthenes herzensteini	Limanda aspera	Limanda punct. puncta.	Pseudopl. herzen- steini	Pseudopl. yokohamae	Glyptoce- phalus stelleri
length & increment:	1936-1937 l t	1933-1937 l t	1935 l t	1933-1937 l t	1936 l t	1938-1939 l t
1	8.8 8.8	6.5 6.5	7.9 7.9	7.7 7.7	8.6 8.6	8.1 8.1
2	15.0 6.2	12.7 6.2	14.0 6.1	14.2 6.5	15.0 6.4	15.8 7.7
3	20.5 5.5	18.3 5.6	19.1 5.1	18.6 4.4	21.1 6.1	21.8 6.0
4	24.8 4.3	22.7 4.4	23.1 4.0	23.3 4.7	26.3 5.2	27.0 5.2
5	28.6 3.8	26.6 3.9	26.2 3.1	26.7 3.4	29.4 3.1	
6	31.9 3.3	29.3 2.7	28.0 1.8	29.2 2.5	32.6 3.2	
7	35.3 3.4	31.6 2.3		31.4 2.2	35.0 2.4	
				34.0 2.6		

TABLE 115.

Mean weight of flounders of different age groups from Peter the Great Bay

Species	Age							
	1	2	3	4	5	6	7	8
Limanda aspera				210.8	264.5	375.9	594.0	916.6
Cleisthenes herze- nst.	65.0	127.9	188.7	281.8	349.9	410.0	595.5	795.0

We wish to mention anew there has been considerable fishing on the school of flounders and the school has reacted accordingly (See the chapter on the effect of fishing upon the state of the school of flounders). Therefore, the data presented may characterize the age of flounders caught by means of benthic fishing nets, only for the given period of time. To characterize this period more clearly, we believe it wiser to present the correlation between different age groups of fish found in trawl catches in 1931-1934(i.e.

at the earliest stage of industrial exploitation of the concentration of flounders in the bay, see table 116).

TABLE 116.

Correlation (in %) between different age groups of flounders found in trawl catches obtained in Peter the Great Bay in 1931-1934

Age:	2+	3+	4+	5+	6+	7+	8+	9+	10+	11+	12+
<i>Limanda aspera</i>		0.5	4.6	16.7	32.2	28.6	11.8	3.1	1.5	0.8	0.
<i>Cleisthenes herzensteini</i>	1.4	3.9	10.6	22.7	42.5	15.0	3.9				
<i>Pseudopleuron. herzensteini</i>			3.9	23.4	36.8	19.2	12.2	4.3	1.2		
<i>Glyptocephalus stelleri</i>	12.5	37.5	22.0	10.4	4.1	4.1	5.2	2.1	2.1		

The trawl fishing conducted during the summer within the borders of Askold Bank resulted, as a rule, in catches of fish among which the older age groups were as compared to those obtained by small boats during fishing in the littoral zone.

In the regions situated farther to the North - i.e. Tatarski Strait, off the southeastern shores of Sakhalin and off the shores of Kamchatka - the age, as well as the rate of growth of identical species of flounders noticeably differs from those of the flounders inhabiting Peter the Great Bay. We here observed a more inhibited rate of development and an older range of ages with the prevalence of older fishes (table 117).

TABLE 117.

Species	Units of measurement:	1-	2-	3-	4-	5-	6-	7-	8-
Limanda aspera	length	5.0	9.0	13.8	18.0	22.6	25.3	29.7	32.4
	%	0.9	0.4	8.8	16.8	8.4	2.5	4.6	13.0
Limanda punct. punctatissima	length				24.5	27.5	31.0	32.3	34.1
	%				2.5	18.5	37.0	28.4	13.6
Pleuronectes quadrituberculatus						28.0	28.0	32.3	33.5
						5.2	16.9	13.0	14.3
Species:	Units of measurement:	9-	10-	11-	12-	13-	14-	Collected by:	
Limanda aspera	length	35.2	37.6	39.8	40.4	43.6		Krivobok, 1931.	
	%								
Limanda punct. punctatissima	length							Klyaritskaya, 1933	
	%								
Pleuronectes quadrituberculatus	length	39.0	41.7	44.3	45.2	45.0	47.0	Moroz, 1933.	
	%	7.8	15.5	11.7	10.4	3.9	1.3		

Thus, analyzing the data on the age of *Limanda aspera* found in catches taken in different zones of the Far-eastern waters, we may easily see that while in Peter the Great Bay the fishing netted, in the main, (89.3%), four age groups (between five and seven years of age), in Tatarski Strait the prevalent number of fish in catches (72.7%) ranged between seven and 10 years of age, off the south-eastern shores of Sakhalin 45.9% of trawl catches consisted of five and seven-year-old fish and off the shores of Kamchatka eight-, nine-, ten-, and eleven-year-old fish (49.1%), although fish of a different age also played an important part in the catches (over 4 years of age).

Thus, the age of fish found in the catches and mean dimensions of different age groups of flounders from different regions of the Far Eastern waters confirmed the theory already expressed that the northwestern zone of the Pacific Ocean is populated by a series of different shoals of flounders that do not intermix. This conclusion is particularly interesting since the biometric comparison of meristic characteristics of a series of flounders from different regions revealed no significant differences, whereas the data on the age undoubtedly establish the presence of substantial divergences. Moreover, the study on the rate of growth of flounders even from such closely adjacent regions as the bays of Vostok, Ussuriysky and Posyetsky (which are all located in Peter the Great Bay) that are separated by several dozens of miles of shallow water plateau only showed that the adaptation of flounders to a definite region is extremely marked and the fish do not intermix while inhabiting adjacent areas.

TABLE 118.

Mean dimensions (in cm) and correlation (in %) between different age groups of *Limanda aspera* (both sexes), in trawl catches obtained from different zones of the Far Eastern waters.

Region	Units of measurement	Age						
		1+	2+	3+	4+	5+	6+	7+
Western Kamchatka	length	5.0	9.0	13.8	18.0	22.6	25.3	29.7
	%	0.9	0.4	8.8	16.8	8.4	2.5	4.6
South-Eastern Sakhalin	length			12.8	17.0	21.5	23.0	24.2
	%			3.4	15.9	22.3	11.2	23.6
Tatarski Strait	length		13.0	15.0	17.0	22.0	22.2	23.4
	%		1.5	3.0	7.4	2.0	3.4	19.7
Peter the Great Bay	length			22.1	23.0	26.9	27.4	31.8
	%			0.5	4.6	16.7	32.2	28.6

Table 118 Ctd.

Region	Units of measurement	Age						n	Collected in
		8-	9-	10-	11-	12-	13-		
Western Kamchatka	Length	32.4	35.2	37.6	39.8	40.4	43.6	238	1931
	%	13.0	14.3	11.7	10.1	7.2	1.3		
Southeastern Sakhalin	Length	25.5	28.7	31.1	36.5			233	1949
	%	6.9	5.6	9.4	1.7				
Tatarski Strait	Length	25.5	29.1	31.5	35.1	38.3		203	1932
	%	17.2	25.0	10.8	2.5	1.5			
	Length	35.0	37.3	38.3	40.6	41.0		1127	1930-1932
	%	11.8	3.1	1.5	0.8	0.2			

Each species of flounders forms within its region of propagation a series of isolated shoals, the rate of growth and age of which are specific for each zone.

Limanda aspera inhabiting Peter the Great Bay develop during the first three-four years at an exceptionally high rate reaching 21-33 cm at the age of three, whereas in Tatarski Strait and off the shores of Western Kamchatka these flounders attain this size only at the age of 5-6 years. On the other hand, the rate of development of sexually mature or older fish off the shores of Western Kamchatka noticeably exceeds that of *Limanda aspera* from Peter the Great Bay, as a result of which there is no substantial difference in dimensions of fish belonging to the same age groups (reaching 5-8 cm in the fish of 3 and 4 years of age) constituting only 1-2 cm in the 9-12 years old fish. These facts prove once more that the environment and elements in Peter the Great Bay under which the adult fish and fry exist, substantially differ from those in the regions situated farther to the North. We believe that the above exposed changes in the rate of growth are adaptive character and depend primarily on

the exceptionally aggressive activity of ichthyophagous fish and animals affecting most strongly the fry of flounders. Indeed, this region is inhabited by a great number of various gobies. (*Myoxocephalus*, *Gymnocanthus*, *Ceratocottus*, *Alcichthys*, *Icelus*, *Hemitripterus* and others). The frequency at which these fish are encountered is illustrated by the fact that the annual by-catch of these forms with benthic fishing nets during flounder-fishing in the shallow waters of Peter the Great Bay reaches 10 to 20 thousand centners (i.e. about 20% of the overall catch of flounders). 1500 Centners of gobies alone were caught in the Ussuriysky Bay over a 40 day-period in 1936. Such an abundance of gobies has not been observed either in Tatarski Strait or off the shores of Kamchatka.

Dissection of the guts of gobies showed that they are usually filled with small flounders. We may assume that the high rate of development of *Limanda aspera* in Peter the Great Bay during the first few years of its life contributes to the preservation of great numbers of this species. The abundance of food resources on the West-Kamchatka shelf where benthic biological volume is considerably higher and occupies larger areas of the shelf than in Tatarski Strait and Peter the Great Bay, ensures intensive feeding and higher rate of development of the sexually

mature flounders as compared with that in the aforementioned two regions. The composition of catches, where older age groups prevail to a considerable extent, as well as the relatively low rate of growth of flounders, convincingly show that the shoals of flounders forming concentrations off the shores of Kamchatka, in Tatarski Strait and in the southeastern littoral zone of Sakhalin, have not been greatly affected by fishing as yet.

Attention should again be drawn to the fact that in the chapter on age we do not deal with the changes (in both the rate of growth and age groups) which occur and partly have already taken place in the shoal of flounders inhabiting Peter the Great Bay, since a special chapter is dedicated to this problem.

However, we wish to mention that the saturation of the shoal from Peter the Great Bay with older specimens of flounders (already observed prior to the organization of the intensive fishing on this concentration), as well as the intensified rate of development that has been registered since the beginning of industrial fishing and which intensified the processes of reproduction ensured high mean level of catches despite the intensive fishing over a prolonged period of time. (13-14 years). In the light of the aforesaid the great potential

possibilities of industrial fishing over these concentrations of flounders and the specific importance of the study of age and rate development of flounders under the conditions conducted in Fareastern waters in industrial fishing became obvious. The latter will enable us to evaluate the effect of such operations upon the reserves of fish. We believe that systematic analysis of the age of a shoal and examination of the changes occurring in the age composition and rate of development provide possibilities for a most objective determination of the changes and degree of change in a shoal of flounders occurring due to fishing and the reaction of individual species to fishing and proportion between their representatives in a shoal.

The age groups found in catches, the longevity and rate of development of halibuts substantially differ from all the other flounders. The largest halibut, i.e. *Hip. hip. stenolepis* reaches 215 cm in length and 80 kg of weight in Fareastern waters. It is obvious that the longevity of *Hip. hip. stenolepis* exceeds 30 years. *Atheresthes evermanni* lives a shorter time (18-20 years) reaching 80 cm in length and 3-4 kg in weight. *Reinh. hip. matsuurae* reaches 95 cm in length (6-7 kg) at the age of 24-25.

Let us compare the mean dimensions of different age groups of the Fareastern halibuts (table 119) using the data presented in the works by Vernidub and Panin (1934, 1935, 1936).

TAB

TABLE 119.

Rate of growth (in cm) of halibuts in the Sea of Okhotsk (Western Kamchatka).

AGE	1	2	3	4	5	6	7	8	9	10	11	12
Hippoglossus hip.stenolepis	12.4	23.1	32.4	40.2	46.8	52.5	58.1	63.0	69.1	75.1	79.6	84.
Atheresthes evermanni					33.5	40.0	43.2	48.2	53.0	-	55.5	62.
Reinhardtius hippoglosso- ides matsuurae	11.8	20.7	27.7	23.5	38.9	43.8	48.2	52.7	56.7	60.4	63.9	67.

AGE	13	14	15	16	17	18	19	20	21	22	23
Hippoglossus hip.steno- lepis	89.6	93.9	98.1	102.2	106.4	110.4	114.3	118.4	122.1	125.6	128.
Atheresthes	67.0	67.0	7.15								
Reinhardtius hippoglosso- ides matsu- rae	69.8	72.7	76.2	79.1	81.2	83.9	86.2	86.3	89.1	91.0	94

This shows that Hippoglossus hip. stenolepis develop at the highest rate, whereas Atheresthes evermanni and Reinhardtius hippoglossoides matsuurae grow much more slowly.

Compare the data presented in table 120 on the age of Fareastern flounders as compared with the age and rate of growth of affinitive forms inhabiting the northern zone Atlantic Ocean.

The flounders of Barents Sea develop more slowly than affinitive species in other regions of the Fareastern waters. Flounders of older group found in the catches obtained in the Far East

were also much larger than those in Murman, although the latter region has been little affected by industrial fishing on flounders. The rate of growth of *Pl. platessa*, found off the shores of Northern Iceland (Taning, 1929) is an exception. The prevailing age groups among these flounders are younger than among Kamchatka, *Pl. quadrituberculatus* (the fifth, sixth, seventh and fourth groups), however, the mean dimensions of specimens belonging 5-7 year groups are 4-6 cm larger than the length of the said Kamchatka flounders.

Paulsen (1933), Johansen (1931), Blegwad (1927), Tirsbi Pelam (1930) and many other researchers indicated that as a result of intensive fishing in the North Sea and vicinal regions there were found but few flounders over five years of age.

We may easily see from the aforesaid that the longevity of the majority of flounders does not exceed 13-15 years. Halibuts alone live considerably longer (30 and more years). The catches of *Limanda aspera* in Peter the Great Bay mainly comprise specimens of 5-8 years of age, off the shores of Kamchatka - 8 to 11 years of age and in Tatarski Strait 7 to 10 years of age. The abundance of older age groups off the shores off Kamchatka and in Tatarski Strait shows that the vast concentrations of flounders in these regions have not been particularly affected by the fishing industry thus far.

The rate of growth during the first three-four years of the majority of species of flounders inhabiting Peter the Great Bay is exceptionally high, whereas the flounders found farther to the North develop much more slowly.

Mean dimensions of different age groups of industrial flounders in the northern zones of Atlantic Ocean.

Species	1-	2-	3-	4-	5-	6-	7-
Limanda							
Limanda				23.6		24.2	
Platessa platessa					30.4	32.2	34.4
Hippoglossoides ♂♂	9.0	14.6	18.8	20.0	23.2	25.2	28.2
platessoides							
limanoides ♀♀	13.0	14.7	17.6	20.4	23.4	26.0	28.8
	8-	9-	10-	11-	12-	13-	
Limanda limanda	27.4		29.9	35.4		38.6	Porchnikha Esipov, 1928.
Platessa platessa	36.5	38.6	39.8	42.6	46.1		Barents sea, Esipov 1935/36
Hippoglossoides ♂♂	32.0	31.8					Murman waters, Milinsky, 1944
platessoides							
limanoides ♀♀	32.6	36.4	40.0	42.0	43.6	43.0	

R E P R O D U C T I O N.

The biology of development of roe and fry of the Fareastern flounders has not been studied very much so far. Among the works published on this subject may we mention the articles by Mishchenko (1938), Rass and Zheltenkova (1948), lecture by Dekhnik (1950) and a small publication by Yamamoto (1939). Results of the research conducted by the aforementioned scientists, as well as the unpublished data provided by P.V. Ilyina enable us to draw certain conclusions. Without dwelling on the details of embryonal and postembryonal development of the fareastern flounders, we shall summarize in table 121 the data on the duration of the incubation of roe of the most widespread species.

TABLE 121.

Incubation periods of roe of certain Far-eastern species of flounders.

Name of the species	Diameter of an egg in mm.	Incubation temperature in °C.	Duration of incub- ation in degree- days		Dimensions of the hat- ched specimen in mm.	Dimensions of the specimen on the 2nd day after the hat- ching	Number of Days at the end of which the yolk sac be- comes resolved.	The data provided by:
			Prior to the first hatching	Prior to the general hatching.				
<i>Limanda aspera</i>	0.80-0.95	10.02	50.0	55.0	2.0-2.5		5-7	Mishchenko
<i>Limanda punctatissima</i> <i>punctatissima</i>	0.78-0.86	17.03	58.0	68.1	2.38-2.48	2.15-2.81		Ilyina
<i>Pseudopleuronectes</i> <i>herzensteini</i>	0.81-0.93	10.02	42.0	50.0	2.0-2.3		10	Mishchenko
<i>Cleisthenes herzen-</i> <i>steini</i>	0.92-1.08	17.4	56.0	69.6	2.11-2.20	2.81		Ilyina
<i>Glyptocephalus</i> <i>stelleri</i>	1.40-1.57	15.7	70.0	78.5	5.08-5.35			Ilyina
<i>Kareius bicoloratus</i>	1.10	13.5	64.8	-	3.0			Kuragami

The roe and fry of the majority of flounders are of pelagian character and remain within the upper horizons; the roe of *Hippoglossus hip. stenolepis* is bathypelagian, that of *Pseudopleuronectes yokohamae*, *Pleuronectes obscurus* and *Pleuronectes pinnifasciatus* - benthic. In the majority of species the hatching of fry begins on the third day of incubation and changes to mass phenomenon on the fifth day. Judging by the reaction of the fecundated roe of *Ps. yokohamae* to the fluctuations in temperature and salt content of water, we may assume that these fluctuations usual in the regions inhabited by flounders, have little effect on the development of roe and fry and may merely shift to a slight degree different periods of development. Thus, the series of experiments set up by Yamamoto showed that the optimum temperature for the normal development of fry of *Ps. yokohamae* lies within the limits of 7.7 and 19.7°C. The most favourable indices of salt content proved to be 14.34 to 33.74% and deformation of fry has been observed only when it dropped below 7.83% (The tests were carried out at the parallel observations under temperature of 4 to 22°C and salt contents of 6.0 to 46.7%). We noted a characteristically high sensitivity of fry to the increase in the salt content above the normal (which does not occur under natural conditions) and their rather weak reaction to a considerable drop in salt content, a common phenomenon in the littoral zone, where the roe of the majority of flounders develops.

The widely eurythermic character of the ripening roe and developing fry, which experience considerable changes in the temperature of the surface horizons in the spawning regions, is equally characteristic and easy to explain. The duration of the pelagian period of fry has not been precisely determined as yet, however, it is well known that in *Ps. herzensteini* the yolk sac is fully dissolved on the 10th day following hatching- in *Limanda aspera* - on the 5-7th day. Thus, the general duration of the pelagian period of roe and fry of numerous Far-eastern species of flounders shall be estimated at 15 days at the minimum.

We believe that so prolonged a period of passive existence in the surface layer of water plays an important role and must be taken into account when studying the general pattern of distribution of flounders in the Far-eastern waters.

Indeed, to ensure the normal existence of a shoal of flounders, particularly if this shoal comprises a great number of fish and to maintain this number at a sufficiently high level not only must the relief of the ocean-floor be suitable soil, but hydrological conditions must be favourable and food content in a given water basin high since all these conditions contribute and are essential to a successful reproduction and development of roe and fry.

Taking into account the low mobility of flounders that are unable to make extensive migrations, we believe that spawning is most effective when carried out in the regions where water volumes are rather immobile leaving the growing roe and fry intact instead of carrying it away into regions unsuitable for the existence of both the fry and adult fish. The importance of relatively immobile water can be appreciated from the fact that constant currents of as low as 0.8 mph in spawning regions can carry roe and fry to a distance of at least 200-250 miles from the spawning place before they sink to the ocean floor. Knowing the bathymetric and hydrological peculiarities of Far-eastern waters, it is easy to understand that so considerable a displacement of roe and fry will result in the death of the young fish or its compulsory existence in a region unsuitable for the development of flounders. No such extensive migrations of the fry of flounders takes place in the Far East. This indicates the importance of immobile water volumes in the spawning regions.

There are very few data on the biology of young flounders. It is known that following the transition to the benthic existence the fry of the majority of species of flounders (with the exception of halibuts, *Ac. nadeshnyi* and *Hip. elassodon*) remain in shallow gulfs and bays, where they populate the most immediate coastal zone. Weedy, sandy or oozy shallow waters are the favourite regions of summer habitation of the young flounders. Here, among the thick weeds or tightly pressing against the ground, the fry find sufficient food and protection against enemies. We wish to emphasize that young, sexually immature

flounders remain at a distance from adult fish intermixing with them only for short periods of time.

It is characteristic that during the vernal migration towards the shores in Peter the Great Bay, as well as in more northerly regions, the shoals of young fish precede adult flounders. The fry of the majority of species of flounders leave the wintering regions relatively early, drift to the depths of less than 25-40 m, approach the shore line very closely or fill shallow depth regions, frequently forming dense and lasting concentrations.

As already mentioned, the fry of *Ac. nadeshnyi* remain throughout the entire summer at somewhat greater depths and may be found at 150-200 and more metres level; the fry of *Hip. elassodon* and occasionally, of *Lep. bilineata* were also found at such depths.

During the autumn with the drop in temperature, the young flounders begin drifting away from the shores (with the exception of *Pl. obscurus* and *Pl. pinnifasciatus*).

Thus, the general pattern of migrations and behaviour of young flounders is highly reminiscent of that of adult fish.

During the first few years of their life the flounders grow rapidly, particularly if their development is not inhibited by unfavourable factors in environment and food supply.

Sexual maturity occurs in the majority of the species of flounders after linear dimensions of 20-25 cm have been reached, i.e. at the fourth-sixth year of life.

It is interesting to note that similarly to a series of other fish (herring and others), the flounders become sexually mature not at a definite age, but after having reached certain linear dimensions. In different regions of the Far-eastern waters the rate of growth of the same species of flounders differs considerably, so that sexual maturity is reached at a different age, after the fish has grown to a certain length. Let us consider the following data on the dimensions and age, at which the Far-eastern flounders attain sexual maturity (table 122).

TABLE 122.

Dimensions of flounders (in cm) which have reached sexual maturity.

Region	Ac. nadeshnyi	Hippoglossoides hip.	Cleisthenes herzensteini	Lepidopsetta bil. bilineata	Limanda aspera	Pimanda punctatissima Pseudopleuronectes yokohamae	Pseudopleuronectes herzensteini	Pl. quadrituberculatus	Glyptocephalus stelleri
Tatarski Strait	16	22-25		21-22	20-23	21	22-23	20-21	23
Peter the Great Bay			22-25		20-23	19 20	22		24

It may thus be seen that while the linear dimensions of flounders proceeding to the first spawning are identical, their age differs considerably.

Observations on the shoal of flounders from Peter the Great Bay, intensively fished for several years, showed that where a school was heavily thinned by fishing, the rate of growth of the remaining fish in the shoal rose with consequent earlier sexual maturation. Thus, in 1930-1933 the *Limanda aspera* attained sexual maturity at the age of 4-5 having reached the length of 20-23 cm in length, whereas in 1940 the majority of fishes reached these dimensions at the age of 3-4, which naturally precipitated their sexual maturation. This example shows that the process of reproduction in flounders follows a definite pattern as may be confirmed particularly well in the retardation or precipitation of the development and age at which the sexual maturity occurs depending on environment.

A high density of concentrations of flounders has an inhibiting effect on the rate of growth and reproduction, whereas reduction in the number of fish (particularly of the fry) is compensated by more intensive reproduction by means of early spawning of young fish.

The spawning of the overwhelming majority of the Far-eastern flounders occurs during the summer (June-August). The littoral forms alone (*Pl. pinnifasciatus*, *Pl. obscurus*, *Pl. glacialis* and *Pl. stellatus*) spawn between the latter half of February and middle of April, whereas halibuts begin spawning during the late autumn or in the winter (August-December). Let us now summarize the data available on the spawning periods of the Far-eastern flounders (table 123 and drawing 24).

We wish to point out that the flounders populating more northerly waters, where hydrological conditions are severe and the winter lasts longer, have a different spawning period to that observed for identical species of flounders farther to the South. The severe environment undoubtedly affects (as proved by Dryagin, 1949) the maturation of sexual products, and therefore, the spawning periods are shifted accordingly. The spawning of *Pl. pinnifasciatus*, *Pl. glacialis*, *Pl. obscurus* and *Pl. stellatus* takes place in the littoral zone, at the depths below 25-30 cm., at sub-zero, temperature.

Prior to the beginning of spawning the flounders belonging to the genera *Cleisthenes*, *Limanda* and *Pseudopleuronectes* approach the shores, drifting into the shallow waters of less than 304 metres in depth. Here, in the well heated shallow zone, at the benthic temperatures of 5 to 15° (8 to 20° in the surface layers), their spawning takes place. A series of other species belonging to the genera *Glyptocephalus*, *Acanthopsetta*, *Hippoglossoides*, *Lepidopsetta*, *Pleuronectes pleuronectes* (*Pl. quadrituberculatus*), also drift towards the shores during the pre-spawning period, leaving the great depths at which they remained during the winter, however, their spawning occurs as a rule within the limits of the depth level 40-50 to 100 metres, at benthic temperatures of 1-2° and 6-8°. Lastly, the spawning of the inhabitants of the lower horizons of the sublittoral and edge of the continental shelf - i.e. of halibuts - occurs during a rather prolonged period of time at the temperatures of 0° to 3-4°.

The development of sexual products of flounders during the post-spawning period takes place during different seasons and at a varying rate. In the course of a relatively prolonged period of time (two-three months) immediately following the spawning new sexual products are formed in the ovaries and seminal sacs of flounders attaining the II-III stage of maturity by October-November. The sexual products gradually develop quantitatively, as well as qualitatively and during the winter the overwhelming majority of flounders have sexual products at the third stage of maturity and of a considerable weight (coefficient of maturity 10-12). During the winter there occur no visible processes of further development of the sexual products in the majority of flounders and their development remains at the same stage (usually at the III stage) throughout January and March (i.e. usually the third stage). Representatives of the genus *Pleuronectes* (*obscurus*, *pinnifasciatus*, *glacialis* *stellatus*) are the only fish species characterized by intensive development of the sexual products during the winter. March, and particularly April and May, are marked by rapid maturation of sexual products and are followed by their transition into the fourth and fifth stage of maturity (fig. 25).

We repeat that this pattern applies to the overwhelming majority of flounders with the exception of the forms of flounders and halibuts inhabiting the coastal zone all the year round.

During the period of their most intensive development the sexual products form up to 20-25% of the overall weight of fish (in females).

The overall duration of spawning of a species is usually 30-60 days. (see drawing 24). The spawning is simultaneous, also the maturation and depositing of roe in individual specimens occurs portion-wise over a relatively longer period of time in males as compared with females. Analogously to many other species at first there appear in the regions of spawning shoals of fish where the male specimens prevail and the sexes become equalized in number only at the end of the spawning period.

The spawning of flounders takes place in the regions permanently inhabited by these fish and mainly in those sections of the sea marked where water volumes are immobile. No extensive spawning migrations and none over 100 miles long were observed either in the coastal zone of Northeastern Asia, nor in any other region.

DRAWING 24.

Ac. nadeshnyi	Ps. yokohamae
Hipl el dubius	Ps. herzensteini
Cl. herzensteini	Pl. obscurus
Lep. bil. mochiga=	
rei	Pl. stellatus
Lim. aspera	Pl pinnifasciatus
Lim. punctatissima	Gl. stelleri

Fig. 24. Spawning periods of flounders in Peter the Great Bay.

//////// Overall spawning period
//////// Intensive spawning.

DRAWING 25.

Stage of maturity of the sexual products
Fig. 25. Stage of maturity of the sexual products (in %) of flounders in Peter the Great Bay.

TABLE 123.

Spawning-periods of the Far-eastern Flounders.

Species	Shores of Kamchatka		Region of the Southern Kuril Islands	Tatarski Strait	Peter the Great Bay
	Eastern	Western			
Ac. nadeshnyi	-	-	-	20.VI-20.VII	10.VI-1.VII
Hip. el elasso-don	-	-	-	-	-
Hip. el dubius	-	-	-	1.VII-20.VIII	10.V-5.VII
Cleisthenes herzensteini	-	-	VI-VII	-	1.VI-20.VII
Hippoglossus Hip.stenolepis	-	VIII	VII-VIII	-	-
Reinhardtius hippoglossoides matsuurae	-	VIII-X	-	-	-
Atheresthes evermanni	VIII	X-XII	-	-	-
Lep.bil.bili-neata	5.VI-10.VII	VI-VIII	-	-	-
Lep. bil. mochi-garei	-	-	-	-	1-20.VI
Limanda aspera	5.VI-10.VII	1.VII-25.VIII	-	VI-VIII	10.VI-25.VII
Limanda punct. proboscidea	-	1.VII-5.VIII	-	-	25.V-15.VII
Limanda punct. punct.	-	-	-	-	25.V-15.VII
Pseudopleuronectes yokohamae	-	-	-	15V-25.VI	1.IV-10.VI
Pseudopleuronectes herzensteini	-	-	-	-	25.V-15.VII
Pleuronectes quadrituberculatus	15.VI-20.VII	-	-	III-IV	-
Pleuronectes obscurus	-	-	-	-	10.III-15.IV
Pleuronectes stellatus	III-V	II-III	II-III	-	1 - 25.III
Pleuronectes pinnifasciatus	-	-	-	-	10.II-25.III
Glyptocephalus stelleri	-	-	-	-	15.V -15.VIII

Sexual products of male flounders mature earlier than the sexual products of females. Observations have shown that certain schools of sexually mature fish comprise a great number of males with liquid milt, but where females are as yet without liquid roe. The same phenomenon takes place at the end of spawning - i.e. males with liquid milt disappear from the catches at a much later date than do females with liquid roe. Taking into account the protracted period of maturation of the sexual products in males, which simultaneously lengthens the duration of spawning, and much shorter periods of maturation and spawning in females, can appreciate the importance of the early "readiness" of males to spawn ensuring the fecundation of the roe deposited even by the early maturing females. The spawning of the Far-eastern flounders is simultaneous.

The proportion of flounders of the opposite sex is usually close to 1:1, however, sharp changes occur during the pre-spawning migration, when certain shoals of identical species comprises, as a rule, different proportions of fish of the opposite sex. Usually the males outnumber the females during the early spawning drift, after which the increasing number of females balance the proportion of the sexes.

The correlation between the number of fish of the opposite sex obeys a regular pattern within groups of different dimensions for all the species of flounders.

The number of males is greater than that of females in all the species of flounders measuring less than 28-32 cm in length. Among large specimens, the females are more numerous than males. The maximum dimensions of females considerably exceed those of the males. Thus, among 2610 specimens of *Limanda aspera*, which were measured in 1936 in Ussuriysky Bay, we found no male longer than 39 cm, whereas 105 specimens of females exceeded the aforementioned dimensions. Some of these females were 44 cm in length. Among 2475 specimens of *Cleisthenes herzensteini* caught in the same region we found no males over 40 cm in size, whereas 41 specimens of females measured up to 47 cm. Similar examples may be given for all the species of flounders. Undoubtedly, the longevity of females is greater than that of males, and this fact, together with the prevalence of males during the early period of the life of fish (including the first two or three spawning periods) and continuously growing fertility of females, ensures maximum reproduction of a species.

The data available on the fertility of industrial flounders inhabiting Peter the Great Bay enable us to draw quite a number of important conclusions.

Table 124 shows the great range of fluctuations in the number of eggs deposited by different specimens of the same species, as well as by flounders of different species.

The data on the fertility of different species of flounders depending on their linear dimensions are presented in table 125.

TABLE 124.

Fertility of flounders in Peter the Great Bay (according to the data collected in Ussuriysky Bay in 1937).

	<i>Limanda aspera</i>	<i>Pseudopleuronectes herzensteini</i>	<i>Pseudopleuronectes yokohamae</i>	<i>Limanda punct. punctatissima</i>	<i>Cleisthenes herzensteini</i>	<i>Hippoglossus dubius</i>	<i>Glyptocephalus stelleri</i>
Minimum	625.950	352.860	205.716	161.823	492.660	211.228	145.336
Maximum	1.132.656	1.170.800	1.088.762	528.000	941.843	241.359	369.936
Mean	1.088.829	685.919	473.475	371.528	699.658	228.451	227.806
Number of specimens	5	5	13	3	4	4	5
Date of sampling	10-17 June	10-17 July	14-20 May	15-20 June	17-19 June	19-24 May	20-24 May

TABLE 125.

The relationship between the fertility of flounders and their linear dimensions.

Species	Length in cm					
	20	25	30	35	40	45
<i>Limanda aspera</i>				879.303	1.228.523	
<i>Pseudopleuronectes herzensteini</i>		416-577	865.481			
<i>Pseudopleuronectes yokohamae</i>		334.128	407.320	985.706		
<i>Limanda puncta punctatissima</i>	161 823	476.380				
<i>Cleisthenes herzensteini</i>			289.166	714.027	896.000	

That the dimensions of flounders determines the quantity of roe produced by a given specimen characterizes all the fish and is clearly pronounced in the case of the flounders inhabiting Peter the Great Bay. In *Pseudopleuronectes herzensteini* the fertility increases twice with each 5 cm increase in length, in *Limanda aspera* it increases almost twice, in *Pseudopleuronectes yokohamae* it also almost doubles and in *Limanda punctatissima* it trebles.

Franz (1908) provided the following data on the relationship between the fertility of *Pleuronectes flesus* in the Baltic Sea and the dimensions of the fish (table 126).

Ketchen (1947) presented increasing figures on the interrelation between the age and quantity of roe produced by the flounders *Parophrys vetulus* populating the coastal zone off the shores of British Columbia (table 127).

TABLE 126.

Interdependence between the fertility and dimensions of *Pleuronectes flesus* inhabiting the Baltic Sea.

Length in cm,	Fertility.
21-25	55 400
26-30	87 600
31-35	187 000
60-40	339 346

TABLE 127.

Mean quantity of roe produced by *Parophrys vetulus* at different ages.

Age	3	4	5	6	7	8	9	10
Length in cm,	30.0	33.0	35.5	38.2	40.2	41.6	43.1	43.7
Number of eggs (in thousands)	150	500	850	1200	1500	1700	1850	1950

With a 13.7 cm increase in the length of the fish(i.e. 45.7% of its length) the quantity of roe produced rises 13 times.

The increase in the quantity of roe in large flounders takes place almost exclusively at the expense of the increase in weight of the sexual products, since the dimensions of the eggs remain more or less the same. (See table 128).

TABLE 128.

Weight (in gr) of the sexual products of flounders populating Peter the Great Bay depending on the length of fish (length in cm).

Species	20	25	30	35	40	50	Fertility (in thousand of eggs)
<i>Limanda aspera</i>			76.5	107.0			1089
<i>Limanda punct. punctatissima</i>	12.7	32.6					372
<i>Pseudopleuronectes herzensteini</i>		36.1	63.7				686
<i>Pseudopleuronectes yokohamae</i>		76.8	105.1	242.8			476
<i>Cleisthenes herzensteini</i>			44.9	109.9			700
<i>Hip. el dubius</i>				83.4	99.2		228
<i>Glyptocephalus stelleri</i>					89.1	105.4	228

On the other hand, we observed that the weight of roe in fish from groups of identical dimensions of different species of flounders varies greatly. Thus, the weight of the sexual products of *Pseudopleuronectes yokohamae* is three times that of the products of *Cleisthenes Herzensteini* which are of identical linear dimensions.

We obtained different results, however, when comparing the fish of different dimensions and the dimensions of their eggs (table 129). We observed no considerable fluctuations in the size of eggs of flounders.

Analyzing the figures showing the mean fertility of flounders inhabiting Peter the Great Bay, we note a certain interdependence between the fertility of these fish and their specific weight in the shoal. It appears that fertility is directly proportionate to the percentage formed by representatives of a given species as compared with other flounders.

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TABLE 129.

Number of eggs in 1gr of roe of flounders of different species.

Species	Length of fish in cm.						
	20	25	30	35	40	45	50
<i>Limanda aspera</i>			11.242	11.506			
<i>Pimanda punct. punctatissima</i>	12.742	14.633					
<i>Pseudopleuronectes herzensteini</i>	11.686	11.346	12.763				
<i>Pseudopleuronectes yokohamae</i>		4.430	3.720	4.180			
<i>Cleisthenes herzensteini</i>	8.910	-	11.475	8.570			
<i>Hip. el dubius</i>				2.253	2350		
<i>Glyptocephalus stelleri</i>				2.010		1475	

The absolute number of eggs produced by each species denotes the proportion of the given form in catches. Indeed, *Limanda aspera* prevailed over all the other flounders during the first few years of fishing, and has the highest fertility as compared with other species.

The second most numerous form -*Cleisthenes herzensteini*- is also the most fertile species after *Limanda aspera*. This is precisely the form of flounders that dominated in the catches after the number of *Limanda aspera* decreased as a result of intensive fishing. The fertility of *Pseudopleuronectes herzensteini*, which at first occupied the third place in the catches, then (in 1934-1936) moved to the first - and later to the second place is only slightly below that of *Cleisthenes herzensteini*. The catches obtained in 1938-1939 from small tonnage boats contained in the main the *Pleuronectes yokohamae* and *Limanda punctatissima* punct., i.e. the species of lower fertility than the *Pseudopleuronectes herzensteini*, but higher fertility than the remaining species. *Hippoglossoides hip.* and *Glyptocephalus stelleri* are the least fertile species of flounders (the fertility of these two species are almost identical). Although their percentage in catches has increased during the last few years, nonetheless, they do not prevail over other forms of flounders. The absolute number of these fish is rather small.

The above quoted examples show that in Peter the Great Bay, fertility plays an important role in the number of representatives of different species populating these waters. Having mostly pelagian roe, the fry of flounders depend on a number of factors similarly affecting the roe and fry of different species of flounders. In view of the aforesaid the absolute

fertility figure is very important. Moreover, we observed a directly proportionate correlation between the fertility and specific weight of a species in the composition of the different shoals of flounders. The fishing industry usually first thins out the most numerous species so decreasing the density of the population of flounders and stimulating the reproduction of other forms. When the natural reserves of the prevailing form have been considerably exhausted, that form disappears from the catches and the species whose fertility ranks second and which ranks next in numbers now becomes the predominant catch. Later on, as this second form is depleted, its place in the catch is taken by the species whose fertility ranks third and so on.

To conclude the chapter on fertility, may we compare Far-eastern flounders and flounders from the Atlantic Ocean. According to the figures, provided by Fulton, 1905, the fertility of *Lim. limanda* from the North Sea fluctuates between 79000 and 128000, that of *Glyptocephalus cynoglossus* - between 473000 and 883254. We observed that the fertility of Atlantic *Limanda* is considerably lower than that of *Limanda* from Pacific Ocean, whereas that of *Gl. cynoglossus* is higher than the fertility of *Gl. stelleri*.

The data on fertility of *Hippoglossoides platessoides limanoides* from the Barents Sea were obtained by Milinsky (1944) on the basis of analysis of very large fish specimens (47-49 cm in length, 1.18-1.36 kg. in weight,

weight of the sexual products - 182-245 gr) and therefore, cannot be compared with our data on the fertility of *Hip. elassodon*, which pertain to fish 37-42 cm in length. We believe, however, that comparison of specimens of identical dimensions of these two species would show that the fertility of *Hip. pl. limanoides* (241-236 thousands) is either equal or somewhat lower than that of *Hip. elassodon* (211-241 thousands).

We think it incorrect to attribute this difference mainly to the activity of predatory fish and animals, which Nikolsky (1950) believes to exercise a considerably stronger effect on the coastal forms of flounders from the littoral zone off the Pacific shores, stimulating their ability to reproduce, than on inhabitants of the shallow zone of the Atlantic Ocean with the result that the population at greater depth levels finds itself under much more favourable conditions. We believe that the high fertility of Pacific Ocean fish and flounders is not only due to the attacks on the species by predatory fish and animals but is a means of adaptation to the exceptionally unfavorable relief and hydrological conditions of the Far Eastern regions which cause the death of great numbers of eggs and fry that are carried away by the currents beyond the borders of the continental plateau or to regions unsuitable for their development. Let us conclude this chapter with a brief summary of the aforesaid.

The eggs and fry of the Fareastern flounders are pelagian and benthic. The incubation period of the majority of species continues for 2-3 (rarely 5) days. The eggs and fry develop as a rule within the wide range of temperatures and salt content usually observed under natural conditions. The overall duration of pelagian stage of roe and fry is 15 to 20 days.

This lengthy passive existence of roe and fry in a thick volume of water is highly significant and must be taken into account when analysing the general distribution of flounders in the Fareastern seas.

If the spawning of flounders takes place in a region where the velocity of currents is 0.2-0.3 miles an hour, the young specimens are as a rule, carried away from the spawning region into the areas, where conditions are unsuitable for their development, and they die. Observations have shown that the largest concentrations of flounders are adapted to shallow water regions, where there are no intensive currents and conditions are generally favorable to the existence of flounders.

The majority of flounders attain sexual maturity once they reach certain linear dimensions. Changes in the rate of growth directly affect the age at which maturity occurs and this reflects the ability of flounders to regulate the rate of reproduction depending on the conditions of their environment.

The spawning of the majority of species occurs during the summer (June-August) at the temperature of 5 to 15° (benthic). The littoral forms alone deposit

the roe between the latter half of February and middle of April at subzero temperatures while the halibuts shift their spawning periods to the late autumn and winter months (August-December). The spawning of identical species in more northerly regions, where the winter is more prolonged, somewhat lags behind the spawning in the southern zones due to the late maturation of the sexual products of flounders inhabiting the former waters. The overall duration of the spawning is estimated at 30-60 days (with the exception of halibuts, which spawn over a more protracted period of time). The spawning is simultaneous, however, the males are prepared to spawn somewhat earlier than females. The males deposit the sperm portionwise over the course of several days, whereas the roe of females ripens simultaneously.

This ensures maximum degree of fecundation of roe even under conditions when the females greatly outnumber the males.

The fertility of Far-eastern flounders is undoubtedly one of the most important factors determining their number. The fertility of flounders inhabiting the same regions and having similar spectra of feeding determines to a great extent the numerousness of a given species.

x.x.x.x.x.x.x.x.x.x.x.x.x.x.x.x.x.x

FEEDING.

The multitude of the species of flounders populating the Far-eastern seas may be divided into three groups of similar feeding habits. The number of forms greatly varies within each of these groups and the groups are as follows: halibuts, small-mouthed and large-mouthed flounders. Each specification has its own characteristic feeding habits and although the difference in feeding habits between forms are rather insignificant, the divergences between different groups are considerable. We shall, first of all, consider the feeding habits of small- and large-mouthed flounders whose regions of propagation often overlap.

DIET.

The small-mouthed flounders (*Limanda*, *Lepidopsetta*, *Clydoderma*, *Glyptocephalus*, *Pleuronectes*, *Pseudopleuronectes*) feed on small benthic animals (or fry of larger forms), swallowing through the small mouth characteristic of these flounders.

The large-mouthed flounders (*hippoglossoides*, *Cleisthenes*, *Acanthopsetta*, *Verasper*) have, as the name of the group leads us to assume, large mouths, which in *Cleisthenes* may be opened twice as wide as in representatives of the genus *Limanda* and three times as wide as in *Glyptocephalus*. This circumstance enables the large-mouthed flounders to feed on large mobile objects.

Lastly, halibuts (*Atheresthes*, *Hippoglossus*, *Reinhardtius*) are large, mobile fish, actively predatory, feeding in the main on other fish.

As previously mentioned, the range of foods eaten by the small-mouthed flounders consists mainly of small benthic animals propagated in the continental shallow waters, in the upper section of the edge of the continental shelf. Small mollusks (*Yoldia*, *Tellina*, *Nucula*, *Philine*, *Venus*, *Bela*, *Rissoia* and others), small crustacea (*Caprellidae*, *Gammaridae*, *Anonyx*, *Ampelisca*) and echinoderms (mainly *Ophiura sarsi*) are the most important of their foods. Fish remainders are occasionally found in the guts of flounders feeding on the wastes from fish plants.

Apart from benthic animals included in the diet of small-mouthed flounders, the large-mouthed flounders feed on a number of nectobenthic and nectic invertebrates and fish. Plankton crustacea (*Thysanoessa inermis*), fish and Decapoda (*Pandalidae*) play an important role in the feeding of *Cleisthenes herzensteini*. The specific structure of jaws enabling the fish to seize the food with the upper jaw, the location of an eye in the hollow in front of the dorsal fin, the strong flexible body and a number of other characteristics of this species undoubtedly show that *Cleisthenes herzensteini* are adapted to exist off the ocean-floor for considerable periods of time and to travel vertically at great distances. A series of observations based on catches of this flounder taken with drifting fishing nets casts at great depths confirm this conclusion. Other representatives of the large-mouthed flounders (*Hippoglossoides*,

Acanthopsetta) are hardly able to drift off the ocean-floor with the same facility as the afore-discussed species, however, they are also provided with relatively large jaws and strong teeth, enabling them to include a number of large forms in their diet. This, together with their great mobility enables them to feed on the nectobenthic and planktonic forms (Mysidae).

Pacific halibuts (*Hippoglossus hip.stenolepis*, *Atheresthes evermanni*, *Reinhardtius hippoglossoides matsuurae*, as well as *Verasper variegatus*, *Verasper moseri*, *Kareius bicoloratus* and *Eopsetta Grigorievi*) are actively predatory forms and feed in the main on fish (Alaska pollack, less frequently herring, Salmonidae and others), large crustacea (*Chionoecetes opilio*, *Hyas coarctata*) and occasionally cephalopods mollusks. Food spectra of halibuts resemble those of cod more than that of large-and small-mouthed flounders.

Despite the relatively short migration paths of flounders in the Fareastern waters, the annual cycle of feeding is markedly seasonal in character due to the displacements of flounders because of the conditions of their environment and physiological state of their organism.

This seasonal character of their feeding is particularly well-pronounced in small- mouthed flounders, somewhat less so in large-mouthed flounders and scarcely noted in halibuts.

Let us examine first of all, the seasonal changes occurring in the feeding of small-and large-mouthed flounders living under similar conditions and closely related biologically.

Due to the autumn-winter vertical circulation of water-masses, the water volumes at low temperature penetrate into the pre-benthic horizons of the littoral zone compelling the flounders to gradually drift to greater depth levels until the fish reach the region left intact by the winter drop in temperature in the upper layers of water, which usually occurs at the upper edge of the continental shelf (Ushakov, 1949) and at the depth levels of 150 to 220-250 metres. Here the flounders, or more precisely speaking the majority of flounders excepting several species of the genus *Pleuronectes*, which remain throughout the winter in the shallow waters) hibernate, returning during the spring to shallow waters for spawning and feeding.

It is interesting to note that during the entire period of hibernating, which lasts for 2.5 - 3.5 months (December-March) the food-intake of flounders in the wintering grounds either drops to nothing or tapers off to virtual discontinuance.

Krivobok (1931) pointed out that the majority of flounders drifting to Askold bank in Peter the Great Bay by mid-December, completely discontinue feeding. These visual observations have been confirmed by the analysis of the contents of guts of flounders caught

in Peter the Great Bay and off the shores of Kamchatka and the Maritimes. The data obtained by dissection of more than 3000 guts of flounders showed that the seasonal changes in the intensiveness of feeding of all the small-mouthed flounders inhabiting Peter the Great Bay are similar. During the entire winter the fish cease to feed and the duration of this starvation period is almost identical for all species. May we mention that in this case the discontinuation of feeding does not depend on the onset of the pre-spawning period, since the spawning of the majority of flounders, abstaining from feeding during the winter, takes place in June-July, i.e. 6-7 months following the drop in the intensiveness of feeding and 3-4 months following the end of the "starvation" period. March (in Peter the Great Bay - middle and end of March) marks the beginning of the vernal migration of flounders towards the shore, to shallow waters, for spawning and feeding. Fewer and fewer flounders are found with empty guts in these waters. The fish begin feeding intensively from the beginning of the drift off the edge of the continental shelf towards the shores, changing their feeding habits depending on the biocoenotic factors encountered on their way. Having reached the shallow waters, the flounders begin feeding intensively somewhat reducing the intensiveness of feeding only during

the spawning period which is rather lengthy in each individual case, as well as in the group of migrating species.

Between May and September the flounders actively feed. The intensiveness of feeding somewhat drops in October/ November, when the autumn-winter migration of flounders into the wintering regions begins. The gradual drop in the intensiveness of feeding leads to the complete discontinuation of feeding in November/ December. Such is the pattern for the seasonal fluctuations in the intensiveness of feeding of small-mouthed flounders. This pattern is found repeated in the case of large-mouthed flounders which differ from the former groups of fish only in that during the winter these flounders do not completely cease feeding but continue to consume food in very limited quantities.

May we detail the seasonal changes in the diet of flounders.

In Peter the Great Bay the migrations of flounders from the region of wintering into the spawning regions are not more than 70 miles long. Following this course, the flounders gradually pass from one biocenotic group to another, so that a knowledge of the composition of these groups is indispensable to an understanding of the changes, frequently substantial that occur in the diet of flounders in different regions.

Zaks (1927), then Deryugin (1939) provided a tentative characterization of the biocoenoses of Peter the Great Bay and Deryugin in co-operation with Somova (1941) subsequently supplied quantitative indices of the distribution of benthos within the limits of this region. Referring to the aforelisted sources for a more detailed description of the distribution of biocoenoses by zones, may we merely point out that the flounders of the eastern zone of the winter concentration in Askold Bank occupy the biocoenosis of water lilies and in the central and western zones the biocoenosis of *Solariella*. We also wish to emphasize that in the eastern zone of concentration we find *Cleisthenes herzensteini* in the main, in its lower horizons - the *Hippoglossoides hip.*, in the central and western zones - the species of the genus *Limanda* and *Lepidopsetta bilineata bilineata* (Moiseev, 1946).

While the small-mouthed flounders hardly feed at all during the winter, the large-mouthed flounders (*Cleisthenes herzensteini*, *Hippoglossoides hip.* and *Ac. nadeshnyi*) continue feeding, although the intensiveness of their feeding drops sharply. The percentage of empty guts reached 44.4% (table 130). Between December and March we found in the guts of *Cleisthenes herzensteini* the components of *Ophiura sarsi*, *Ophiocantha bidentata* and different species of *Polychaeta*. Moreover, the *Cleisthenes herzensteini* consumes planktonic and nectobenthic crustacea, such as *Mysidae*, *Euphausiacea* (*Thysanoessa inermis*) and *Amphipoda* (*Hyperiidæ*), during this period of time.

TABLE 130.

Degree of filling of guts with food in *Cleisthenes Herzensteini* during the winter of 1933-1934 in Peter the Great Bay (in %).

	Empty	Filled		Stretched guts	Total number of guts
		Partly	Full		
November	36.0	21.0	33.0	-	30
January	44.4	44.4	11.2	-	9
March	4.6	38.2	45.2	12.0	153

Starting the migration towards shallow waters in the latter half of March, the large-, as well as small-mouthed flounders begin drifting in April-May towards the shores along the continental shelf.

The intensive migration towards the shores is paralleled by active feeding of all the species of flounders.

The percentage of empty and partially filled guts decreases and the assortment of foods consumed varies more markedly. The small-mouthed flounders (*Limanda aspera*, *Pleuronectes quadrituberculatus*, *Glyptocephalus stelleri*, *Lepidopsetta bilineata* and others) absorb in their diet various Polychaeta (*Maldanidae*, *Phyllodocidae*, *Polychaeta*), small crustacea (*Gammaridae*, *Gumacea*, *Caprellidae*), mollusks (*Bela*, *Rissoia*, *Yoldia* and others) and echinoderms. (*Ophiura sarsi*, *Stegophiura* and others).

During this period of time, the large-mouthed flounders (*Cleisthenes Herzensteini*, *Hippoglossoides hip.* and *Ac. nadeshnyi* mainly feed on *Ophiura sarsis* (we turned up as many as 10 discs of the latter per 1 gut) as well as *Polychaeta*, *Mysidae* *Amphipoda*.

The majority of species of flounders drift rather rapidly towards the shores and reach the depth level of 70-80 metres in April-May, and their travelling-speed then somewhat decreases. The flounders enter a rather highly productive biocenetic zone. In this zone all the species of flounders considerably intensify their rate of food intake except for the fish that begin to spawn. A great number of animals in the given biocoenosis live on fish, primarily on flounders. The guts of flounders are here found filled with small mollusks (*Venus fluctuosa*), *Bela* *Yokdia* and others), different species of amphipoda (*Ampelisca macrocephala*, *Byblis* and others), Polychaeta and brittle stars. The small-mouthed flounders feed in the main on mollusks to a lesser extent on Polychaeta and small crustacea. The role of primary importance played by brittle stars in the diet ceases. It is interesting to compare (table 131), the percentage of different groups of animals in the biocenosis and in the contents of guts of *Limanda aspera* caught in May within the limits of the given biocenosis.

TABLE 131.

Percentage of different food groups in the composition of biocenosis and in the contents of guts of *Limanda aspera*.

Food groups:	In percentage			
	Mollusca	Polychaeta	Small crustacea	Echinodermata
Biocenosis				
Venus				
-Yoldiella-				
Ampelisca	40.8	35.7	17.8	5.7
Guts of Li-				
manda aspe-	73.5	13.6	6.6	5.9
ra				

During the first few years of industrial fishing the flounders caught were partly salted and partly sold in fresh or frozen state. Later, a considerable portion of catches was processed into canned or technological products. We have already indicated that during the four years of the operation of the Far-eastern trawling fleet the flounders formed 92.2% of the overall catches. Only in the Bering Sea were the cod caught in greater amount (gravimetrically) than flounders. The large concentrations of flounders, vast in scope and high in density, enabled the trawlers to obtain high catches. Thus, the trawlers in Peter the Great Bay, provided with ordinary otter-trawls, lifted up to 70 centners of flounders (Krivobok, 1934 within 5 minutes, obtaining as much as 1500 centners of fish over a period of 4-5 days.

Similar facts were observed during the summer operation of trawlers off the shores of Kamchatka. The density of winter concentrations on these regions is so high that the mean duration of a trawling operation (1950-1952) ^{from duration} is now 16.4 minutes with the mean catch for this period of time of 51 centners. Recalculating these figures in trawling-hours we obtain the surprisingly high index of 187 centners. The duration of trawling operations over the course of an entire cruise is often 2 - 3 (even 1.5) days, when the trawler obtains its full load of fish (200-250 tons).

Without analyzing in detail the operation of trawlers in different regions and during different seasons (Moiseev, 1938) may we summarize the data on the mean

monthly catches (per trawling-hour) obtained in the main regions of industrial flounder-fishing (table 147).

TABLE 147.

Mean monthly trawl catches (per a trawling-hour) of flounders in the Far East. (In centners).

Regions	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
West-Kamchatka shelf	60.0	60.0	65.3	11.5	16.2	15.0	15.0	15.0	15.0	20.0	17.9	29.5	1932-33 (VI-X) 1941-44 (XI-V)*
Tatarski Strait					2.0	3.6	7.6	9.2	14.8				1933
Center the Great Bay	19.5	19.5	10.4	9.9	5.6	3.6	5.5	5.2	6.2	4.0	17.3	11.0	1931-32

The mean indices of catches obtained by the trawling fleet in the Fareastern waters are extremely high. In the bibliographic data there are no examples of catches abundant as those obtained off the shores of Kamchatka. Indeed, are there in any other oceans of the world as large concentrations of flounders, occupying hundreds and thousands of square miles, yielding mean catches per trawling hour of 60 centners and sometimes of 187 centners?

By comparing these data with the mean catches of flounders in other water basins, particularly in the northern zone of the Atlantic Ocean, the immense difference between the two figures is obvious. Thus, in the Barents Sea, the mean datches obtained by the Soviet trawling fleet per trawling hour, (including the cod, sea perch, flounders and other fish) during the period of time between 1919 and 1933 did not exceed 11.9 centners (1937) and in most cases reached 6-9 centners (Maslov, 1944).

Milinski (1938) reported that the mean catches of flounders in the Barents Sea dropped from 25.6 centners (in 1909) to 2.1 centners (in 1932) per cruising day. Off the shores of Iceland, in 1922-1926, a trawler caught during the course of 100 hours of operations between 42 and 56 centners of flounders and in the Bering Sea from 94 to 870 centners (Taning, 1929). In the North Sea the catches of all fish per trawler fluctuate between 40 (in 1938) and 60-70 centners (1946-1947) during the same period of time (Margarets and Holt, 1947).

This proves that the mean catches of flounders in the Far Eastern waters exceed by tens and, during certain months, hundreds of times the catches obtained by trawlers operating in the Atlantic Ocean. The development of trawl fishing in the Far East has undoubtedly a great future. The shelf of the Western Kamchatka is the most important industrial region. Here, between the western shores of Paramushir Island and Cape Khariuzov, we found large and dense concentrations of flounders, the largest of which occupy a territory of 4 - 5 thousand square miles during the summer.

The Ozernovski concentration of flounders extends between Cape Kambalny, in the South, to the mouth of river Koshegochek, in the North, over a surface area of approximately 800 square miles. The trawlers, which operated within the limits of this concentration during the summer of 1933, obtained 14.7 centners of flounders on an average per each trawling hour.

The Ozernovsky concentration consists in the main (up to 80%) of *Limanda aspera* with a negligible admixture of *Pleurocetes quadrituberculatus*, *Hippoglossoides hip.* and *Limanda punctatissima proboscidea*. During the summer late May-early June) a great number of flounders (mainly *Limanda aspera* and *Limanda punct. proboscidea*) drift towards the shores population small depths levels (10-30 metres) whilst a few species remain at somewhat greater depth levels (*Pleuronectes quadrituberculatus*, *Lepidopsetta bilineata bil.*, and others), but the catches sharply decrease below 60-65 m. The following table 148 (drawn by K.I. Papanin) sufficiently evidences that the density of concentration of flounders increases within the limits of the aforementioned depth levels.

TABLE 148.

Varying mean catches of flounders off the shores of South-western Kamchatka at the indicated depth levels, obtained in June, 1932.

Depth in m.	10	20	30	40	50	60	70	80
Mean catch per trawling- hour in centners	21.1	15.0	10.1	15.2	18.1	5.3	5.0	
Number of trawlings	10	41	26	27	5	2	1	

The central concentration situated in the central zone of Western Kamchatka between the estuaries of the rivers Opala and Kimichey, is 100 miles long and 10 to 30 miles wide occupying the depth levels of 10-15 to 60 metres.

The overall surface area of the concentration covers 2000 square miles. Mean catches of trawlers do not drop below 10 centers per a trawling hour in this region and in certain cases reached 45 centners. *Limanda aspera* is the prevalent species taken in the catches (fig. 28).

The Northern concentration, situated between the estuary of the river Moroshechnaya and Cape Khariuzov, has been explored to a lesser degree. The data available show, however, that a large summer concentration of flounders consisting in the main of *Limanda aspera* and *Pleuronectes quadrituberculatus* and occupying a territory of 1000 square miles or more, is situated off the northern section of the Okhotsk shores of Kamchatka. The mean catches in this region reached 12-15 centners per trawling-hour when the fishing was conducted by otter-trawls. The concentration of flounders is adapted to the depth level below 60-65 metres.

We wish to point out that during certain years the regions containing dense concentrations of flounders become considerably displaced so that an effective industrial exploration must be organized in order to ensure successful fishing.

During the summer the flounders drift to greater depths, the density of their concentration considerably rises, the areas occupied by the concentrations become reduced and the catches made sharply increase in volume (fig. 29). Trawl fishing of flounders off the shores of Kamchatka may be conducted all the year round.

Off the Eastern shores of Kamchatka, starting from the eastern shores of Paramushir Island and including Kronotsky Bay, trawl fishing of flounders is probably best conducted during winter at depths of 150-180 to 200-250 metres (fig. 30).

DRAWING 28.

River:	River:	Rivers:	River:
Icha	Icha	Icha	Icha
Krutogorova	Krutogorova	Krutogorova	Krutogorova
Vorovskaya	Vorovskaya	Vorovskaya	Vorovskaya
Bolshaya	Bolshaya	Bolshaya	Bolshaya
June	July	August	September
985 trawls	359 trawls	113 trawls	98 trawls
Catches per 1 trawling hour: 2 to 5 centners; 5 to 10 centners; over 10 centners.			

Fig. 28. Distribution of trawl catches of flounders off the western shores of Kamchatka (1930-1933).

Farther to the North the mean trawl catches decrease and northerly from Olyutorski Bay the organization of trawl fishing of flounders (excepting the halibuts) is not advisable in view of the limited number of these fish in the given region.

Tatarski Strait is the second most important region for trawl fishing of flounders. Its northern zone, where during the summer the so-called "Aleksandrovski" bank is located, is particularly abundant in these fish. Here, at the depth levels of 50-70 metres, somewhat

closer to the shores of Sakhalin, in the region of Cape Rogaty and Cape Khoy, a relatively large concentration of flounders is situated during the summer (May-October). This concentration covers an area of approx. 600 square miles and consists in the main of *Limanda aspera*, *Hippoglossoides hip.* and *Pleuronectes quadrituberculatus* (fig. 31). During the winter the concentration shifts towards the South to the depths of 100-150 metres, but, its exact borders have not been determined as yet. We believe that a trawling fleet would successfully operate in Tatarski Strait almost all the year round moving during the winter towards the South and working during the winter months which are the most difficult for navigation, off the shores of the Southwestern Sakhalin. The mean catches shown in table 147 are the minimum indices, as they have been obtained on the basis of analysis of the industrial operations conducted from two trawlers only.

Within the limits of Peter the Great Bay, trawl fishing may be conducted in the region, where the majority of flounders inhabiting the Askold Bank (that is situated to the South from the line Askold Island-Cape Zeleny), concentrate during the winter, at the depth levels of 170-200 and deeper. The main industrial flounders drift to this area from almost the entire bay. The Askold bank of flounders is characterized by a very limited area of concentration of fish, a concentration reduced by March to 90-110 square miles, and by a simultaneous

high density of concentrations. These factors demand skill on the part of navigators if they are to remain within the limits of the concentration.

Almost the entire Far Eastern trawl fleet operated within the limits of the Askold Bank during the winter 1930-1934. The maximum catches during this period of time reached 100 and more thousand centners. However, at the present time the trawl fishing in the Askold Bank cannot provide high catches until the heavily reduced flounder reserves in Peter the Great Bay are restored.

As already established, up until 1930 fishing of flounders in the Far East was conducted on a very negligible scale. It was conducted by a few small fishing boats using hook cordage and supplying the needs of local markets, and occasionally was conducted by casting nets launched from the shore. The first attempts to initiate the fishing of flounders from large boats - from trawlers, using either otter-trawls or benthic fishing nets and small trawls for the shallow depths were made in 1930. Considerable reserves of flounders, the high density of their concentrations in the regions where they form schools, their short migration paths and the ease of the operations involved in their search, made it possible to master the new system of fishing from trawlers and small tonnage boats.

The first successful catches of flounders obtained by small tonnage boats within the limits of Peter the Great Bay in 1930 stimulated the introduction of a new branch of industry in the fish plants situated on the shores of this bay. The fishing of flounders became particularly popular because the migration en masse of these fish towards the shores occurred before the arrival in the coastal waters of sardines, which were the main goal of industrial fishing at that time. The industrial season was thus considerably lengthened by the operations conducted during a previous idle season and this, in turn, stimulated the rapid development of fishing of flounders from low-tonnage boats. In 1935, about 35000 centners of these fish were caught within the limits of Peter the Great Bay alone.

At first a great number of all types of small tonnage boats concentrated in Ussuriysky Bay, where the greatest quantities of flounders were caught. However, some time later, successful fishing was organized in the adjacent regions by the southern as well as northern fish plants in the Maritimes.

We highly recommend the exploitation of the concentrations of flounders available in the vicinity of the fish plants. The fleet should be transferred only from the regions where the reserves of fish have been exhausted or where there are no concentrations.

Gradual enlargement of the fishing fleet and decrease in the number of sailing boats resulted in gradual introduction of large boats for flounders -fishing.

In 1936 the first large boats of Seiner type were experimentally used for the fishing of flounders and the results obtained were highly satisfactory: a small seiner (60 NR) caught in one month 920 centners of fish, whereas the boats previously used obtained 120 centners at the maximum as a rule.

Acquiring experience in the fishing of flounders from low-tonnage boats, the fishermen from the Maritimes extended this type of fishing as far north as Peter the Great Bay, into the Valentine Gulf and the bays of Peobrazheniya, Ryndu, Nelmu, Sovgavan. At present, the fishing with benthic fishing nets is the main industrial method used by fishermen in the Maritimes.

The experience gathered during the fishing of flounders by low-tonnage fleet enabled us to organize a series of expeditions into Tatarski strait and initiate the fishing of these fish from the proximate fish plants. The duration of the industrial season for the operations of the low-tonnage fleet in the northern zone of Tatarski strait is from May to October, i.e. approx. 170-180 days. The high mean catches, the gradualness of changes in the depth level, the large areas occupied by the concentration, the large dimensions of the fish, the intact reserves of flounders and the possibility of transferring the small tonnage boats from the regions of the Southern Maritimes into the desired areas easily distinguish the Aleksandrovski concentration of flounders as industrially important.

However, the peculiar hydrological conditions in Tatarski Strait require the close attention of industrial workers in reconnaissance operations and fishing of flounders. Therefore, the activity the activity of the industrial fleet, particularly within the borders of Tatarski Strait must go hand in hand with a well organized reconnaissance service and measurements of the temperature or pre-benthic layers of water.

There was no actual fishing of flounders in Tatarski strait until 1943 and the reserves of flounders in this region were left practically intact. In the catches we observed the prevalence of older groups of fish(8,9 and 10 years old). It is only in recent years that a fleet has been directed into the waters of Tatarski Strait. The fleet consisted of various types of boats, as well as floating fish plants and freezing plants which achieved high indices in their industrial activity. As early as 1943, despite a number of shortcomings owing to faulty organization, insufficient knowledge of the region explored and distances from the bases, the fishing of flounders in Tatarski Bay provided considerably higher catches than did the same fishing operations in Peter the Great Bay (table 149). The mean catches per boat per benthic casting net was 18.6 centners in 1943 in Tatarski strait and 32.5 centners in 1944.

The mean monthly catches obtained by seiners in Tatarski Strait are higher than the catches obtained by boats of this type in Peter the Great Bay. Moreover, when comparing the annual catches, the difference is 5-7 fold. When we take into account that the seiners that operated in the southern Maritimes worked 25 days a month, while in Tatarski Strait they worked only 10-15 days monthly, the advantages offered by this new industrial region as compared with the exhausted reserves of flounders in Peter the Great Bay are readily apparent.

TABLE 149.

Mean monthly catches of flounders obtained by seiners in Peter the Great Bay and Tatarski Strait (in centners per boat.

Region	Year	June	July	August	Total
Peter the Great Bay	1942	523	385	294	1202
Idem idem	1943	210	115	49	374
Tatarski Strait	1943	1043	534	576	2158
Idem idem	1944	1216	1439	903	3558
Idem idem	1945	878	595	454	1927

In 1944-1945 and during the following years the fishing of flounders in Tatarski Strait was highly successful. Catches of 50 centners per casting of a benthic fishing net and as much as 170-200 centners daily were usual. In certain cases 1500 and more centners of flounders were caught monthly by the crews of leading seiners.

Correct organization of the explorations, liquidation of the break between the fishing and processing, acceleration of the processes for unloading fish, operation during both day and night should further improve the effectiveness of operations by the boats of the low-tonnage fleet in

Tatarski Strait. Fishing of flounders from low-tonnage boats by benthic nets and trawls may be organized with equal or even greater effectiveness.

TABLE 150.

Mean catches (in centners) per casting of the benthic fishing net in Tatarski Strait (following the data of S.M. Kaganovskaya).

Year	May	June	July	August
1943	-	15.4	18.4	-
1944	10.7	17.8	16.5	11.6
1945	24.1	9.3	5.9	6.0

The shallow waters extending along the shores of Eastern and Western Kamchatka offer immense possibilities for the development of such a fishing industry.

The experience of successful fishing of flounders by benthic fishing nets off the shores of the Northern Kuril Islands and near the southwestern extremity of Kamchatka is rather significant. Based on Paramushir Island, the industrial boats fish flounders all the year round off the Pacific, as well as Okhotsk shores of the islands and in the region of Cape Kambalny.

The results of the first attempts of fishing with benthic fishing nets off the south-eastern shores of Kamchatka (in the region of Gulf Zhirovaya) carried out in 1950, were favorable: 58 centners of flounders were after a few tentative casts.

There are great possibilities for the development of fishing by benthic fishing nets off the shores of Sakhalin. High concentrations of flounders pressed closely to the shore-line off the southeastern shores and remaining at a certain distances from the south-western shore during the entire year, ensure

high catches for the low tonnage boats even if the latter operate at a certain distance from the shore.

Some data on the working conditions of several small boats fishing off the southeastern shores of Sakhalin (the region of Starodubsky) are available.

TABLE 151.-

Results of fishing with benthic fishing nets off the south-eastern shores of Sakhalin in 1946.

No. of boats	Duty of engine.	Number of expeditions	Number of working days.	Number of casts.	C a t c h in centners.		
					per a cast.	per 24 working hours.	Summary catch.
86	40	24	48	158	6.4	21.3	1020,7
87	25	37	74	230	6.4	21.2	1273.3
88	25	43	86	268	4.35	13.3	1153.4.

Results of the operations were most effective.

In the opinion of the workers in the industry, the total number of castings may be increased to 800 and this would raise the overall catch per boat with a 25-40 HP. morot, to 5000 centners.

May we point out that, in 1943-45, the mean catch per similar boat off the southwestern shores of Sakhalin fluctuated between 4950 and 8233 centners and the catches contained almost equal amounts of cod and flounders.

Many more regions can be listed where successful fishing of flounders from low-tonnage boats can be organized, but the data already given suffice to show the advisability of developing this type of fishing industry, as the methods discussed enable us to utilize the reserve of flounders dispersed over a vast territory of shallow waters in the Far-East.

May we dwell briefly on the possibilities of organizing fishing of halibuts in the Far Eastern waters. It is well-known that the by-fishing of halibuts (particularly *Hippoglossus hippoglossus stenolepis*) off the shores of Karaginski and Kommandor Islands during codfishing (Navozov-Lavrov) is most effective, however, no special fishing of halibuts has been set up in the Soviet waters thus far.

No industrial concentrations of *Hippoglossus hippoglossus stenolepis* are known in the Far Eastern waters, and no specific investigations on the biology and distribution of these fish or experimental industrial fishing have been carried out so far. Even by-catches of halibuts obtained in the form of admixtures with other fish have not yet been estimated, although the halibuts are regularly found in the seines and casting nets in a number of regions.

For example, when in 1931 we estimated the catches of *Hippoglossus stenolepis* from Olyutorski-Navarin region (Bering Sea), the results were as follows: obtained by casting nets 551 specimens, i.e. 96.2 centners (mean weight 17.4 kg, length 115-125 cm); caught by multi-stage fishing nets 3488 specimens i.e. 428.8 centners (mean weight 12.3 kg., length 100-105 cm). Total catch - 4082 halibuts weighing 525 centners.

Dimensions of the halibuts caught in this region fluctuated between 46 and 98 cm and 1.4 to 10.5 kg.

In 1952, in the region of Cape Navarin, as much as 4 centners of halibuts were often found in the trawl during the exploratory trawling for cod.

There are no statistics on the catches of halibuts obtained by fishing nets off the shores of Western Kamchatka.

They were found in single specimens in the otter-trawls (seldom more than 3-5 specimens). Analysis of the frequency at which these fish are found in the otter-trawls leads us to assume that a successful fishing may be organized on *Hip. hip. stenolepis* in the region of Cape Khariuzov and off the southwestern shores of Kamchatka. The exceptionally high quality of the fish and their large dimensions are the main factors arguing for *Hip. hip. stenolepis* fishing in the Soviet waters of the Far East.

Atheresthes evermanni propagated off the shores of Kamchatka and in the Bering Sea (i.e. in the northern zone of its propagation) may also prove a valuable goal to fishing fleets (as are all the other halibuts) whether taken by hook cordage or by trawls, since the regions and depths populated by all the three species of halibuts almost coincide. In the southern region of its propagation (the region of the Southern Kuril Islands) halibuts fishing (particularly of *Atheresthes evermanni*) was conducted by hook cordage, and this can be resumed anew. During certain years several dozens of centners of *Atheresthes evermanni* are caught in the region of Kunashir and Iturup Islands as a by-catch to cod. Despite the limited number of trawlings at great depths, the effective results of the fishing on *Reinhardtius hippoglossoides matsuurae* conducted in August-September off the western shores of Kamchatka over the pre-spawning concentrations, yielding up to 5 centners of large fish (4-5 kg), known to be very tasty, led us to

assume that providing supplementary explorations for the fish be set up, trawl fishing for *Reinhardtius hippoglossoides matsuurae* can be successfully organized.

During the spring and summer these fish should be taken in multi-stage fishing nets cast at great depths, as well as in the shallow waters known to be inhabited by this species.

There is no doubt that provided special explorations in the Far Eastern waters be conducted, halibut fishing will be carried out mainly by hook cordage, and during certain years by trawls. The most promising regions for this type of fishing are the coastal zone of the Bering Sea, from the southwestern part of Anadyrski Bay to Karaginski Island and the northeastern zone of the Okhotsk Sea.

While recommending omnifarious development of fishing of flounders, we nonetheless wish to point out that reserves of these fish must be carefully safeguarded, since the flounders sensitively react to disturbances in the rules of fishing.

We have already discussed in detail the effect of fishing on the state of the school of flounders (see the chapter in this book) and have described the reasons and degree of a series of substantial changes occurring in the shoal of flounders (including the sharp drop in the number of fish in the shoal populating Peter the Great Bay, observed during the last few years / Moiseev 1946a, 1946b). Therefore, we shall make no further reference to this problem. However, we wish to emphasize anew

that the shoal of flounders in Peter the Great Bay has been brought into a state of a deep depression through excessive intensive fishing on fry and sharp intensification of the general fishing. We must not forget the clearly defined localities of the shoals of flounders, adapted to definite regions, and, consequently, the development of the fishing industry must be planned conform to the raw material resources of a given development of the region. The fishing cannot follow a general plan for the entire Far East or for one of its seas.

The raw material resources of flounders in the regions adjacent to Kamchatka and off the shores of Sakhalin are exceptionally high. Immense territories covered with shallow waters, where hydrological conditions and food resources favour the development of flounders, adjoin the western shores of Kamchatka occupying the northern zone of Tatarski Strait. This is precisely the region where the largest concentrations of flounders little affected by fishing accumulate; the reserves of flounders of the Southern Maritimes have already been subject to severe disturbance by men. Therefore, the closest attention must be given to the development of fishing of flounders in the waters washing Sakhalin and Kamchatka, while simultaneously reducing the extent of fishing in the Maritimes.

This is the first, most effective step towards the rational exploitation of the reserves of flounders.

The second, equally important step, towards the preservation of the reserves of flounders and the maintenance of these reserves at the desired level resides in the systematic introduction of measures limiting the fishing of young,

sexually immature fish. The regions where the young specimens prevail must be located and industrial fishing within the borders of such regions must be prohibited. In particular, in Peter the Great Bay the fishing from industrial boats around the Vampaushi Gulf, Kangauz Gulf and in a series of other regions must be restricted until the reserves are restored anew. Furthermore, the minimum linear dimensions of flounders accepted by the fish processing plants from the fishermen of the industrial fleet must be established. In view of the varying dimensions of flounders in the different regions of the Far East, the minimum dimensions of flounders acceptable for fishing must somewhat differ for each region. Thus, the dimensions of acceptable flounders (from the tip of the snout to the end of the tail fin) will be 23cm for Tatarski strait, 26cm for Peter the Great Bay and 28cm for Kamchatka waters.

In order to calculate the size of the mesh to be used to prevent small fish being caught, we present in table 152 the relevant data on the length and circumference of the body of industrial flounders.

TABLE 152.

Length and circumference of the body of flounders
(*Limanda aspera*).

Length in cm...	18	20	22	24	26	28	30	32	34
Circumference in cm.	17.0	18.8	20.2	22.1	24.8	26.5	28.8	30.0	

By using these data we may easily obtain the minimum dimensions of the mesh required in benthic fishing nets and trawls used to fish flounders; the dimensions thus will be (in mm. from one knot to another) as follows:

	<u>central part of the net</u>	<u>wing.</u>
Peter the Great Bay	55	70
Tatarski strait	45	60
Kamchatka	55	75

Determination of the mean dimensions of the mesh is one of the most effective means for reducing the catches of fry. Increase in the size of mesh simultaneously increase the absolute number of large fish in the catches. Numerous examples of similar regulation of the dimensions of mesh in the fishing implements in the West as well as in our waters, are highly significant and convincing. Moreover, the wear and tear on the fishing implements considerably decreases, the expenditure of materials for production of fishing nets is reduced, the task of fishermen is facilitated and the amount of unnecessary by-catches decreases.

If properly carried out, the afore-discussed counter-measures will undoubtedly help us to preserve the reserves of fish. The possibility of developing industrial fishing of flounders in the Far-eastern waters is great and it is certain that in the near future the flounders will be the third most important fish taken (ranking only after Salmonidae and herring) from the viewpoint of quantity.

May we briefly describe the degree of development of fishing of flounders off the Pacific Coast of North America, off the shore of Japan and Korea.

In American coastal waters the fishing of flounders is conducted from Bristol Bay at the Southern extremity of California peninsula. However, this fishing is conducted on an insignificant scale and we observed a certain rise in the catches only during World War II (table 153).

TABLE 153.

Catches of flounders off the Pacific Coast of North America.

	Year		
	1933	1938	1943
Overall catches in thousands of centners	53.5	68.0	170.1
Number of industrial boats	32	93	294

The summary catch of flounders (without the halibuts in the Pacific waters of North America is insignificant and only slightly exceeds the maximum catches of flounders in Peter the Great Bay. Such low indices depend first of all on economic factors and not on the raw material resources available since only 60 thousand square miles out of the overall territory of shalooow waters of 600 thousand square miles known to exist near the Pacific shores of North America and populated by flounders are fished at the present time. Even there the fishing is not intensive.

The high catches of halibuts produced, as we know, a certain reduction in the school and over a number of years there certain restrictions on fishing these species were enforced. The annual catches of halibuts fluctuated

few years between 200-250 thousand during the last centners.

The fishing of flounders off the shores of Japan and Korea and in the waters adjacent to these regions, is considerably more intensive.

As may be seen from table 154, the mean annual catches of flounders during the 10 years preceding World War II (1920-1938) off the shores of Japan proper reached 163 thousand centners. In the waters washing Southern Sakhalin, the Kuril Islands, in the Eastern and Southern China seas and in other regions the catches came to 466 thousands centners. Off the shores of Korea, 163 thousands centners of flounders were caught yearly. The catches of halibuts included in the overall catches were insignificant. Thus, the overall catches of flounders in the north-eastern zone of the Pacific Ocean (including the Soviet catches) during the pre-war years were over 1200 thousand centners, i.e. only slightly below the results of the most intensive activity (i.e. fishing on flounders) of the immense fishing fleet operating in the northern zone of the Atlantic Ocean (1600-1800 thousand centners). In conclusion, may we wish to point out that despite the great possibilities, the fishing of flounders has been insufficiently developed in the Far Eastern waters thus far.

TABLE 154.

Catches of flounders (including halibuts) obtained in the northern northern zone of the Pacific and Atlantic Oceans in 1929-1938.

	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	Mean fig- ure for 10 yrs
Catches obtained by the USSR	10	14	80	127	104	64	40	67	57	32	59
Japan proper	189	157	130	132	139	155	152	178	180	220	163
Japanese catches obtained in distant waters (mainly Sakhalin, Kuril Isles, Eastern Chinese Sea)	529	444	423	504	500	476	525	402	426	437	466
Korea	155	162	165	180	142	187	175	163	126	178	163
Total catches in the northwestern zone of Pacific Ocean	865	777	798	943	885	882	892	810	789	867	851
Pacific coast of North America	325	289	252	254	261	272	271	294	298	292	281
Total catches in the northern zone of the Pacific Ocean	1190	1066	1050	1197	1147	1154	1173	1104	1087	1159	1200
Northwestern zone of Atlantic Ocean	250	266	237	207	213	210	217	240	251	265	236
Northeastern zone of Atlantic Ocean	1529	1555	1460	1430	1437	1482	1388	1398	1400	1342	1442
Total catches in the northern zone of Atlantic Ocean	1779	1821	1697	1637	1650	1692	1605	1638	1651	1607	1678

The concentrations of flounders, which are known to populate various regions of the Fareastern waters, and primarily, the coastal waters of Kamchatka, may permit operation of a large industrial fleet all the year round and continuous operation of a low-tonnage fleet in the vicinity of the majority of fish plants in the Maritimes, Sakhalin, Kuril Islands and Kamchatka.

The exceptionally high trawl catches of flounders off the shore of Kamchatka, enabling the trawler to obtain the full load of fish within 1.5-2 working days, are unknown in any other region of the oceans of the worlds. The formation of an appropriate fishing fleet and processing bases will enable us to somewhat increase the existing catches of flounders in the Far East and considerably reduce the dependence of fishing industry of the Far East upon the different seasons.

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C O N C L U S I O N .

The shore-line of the Soviet Far East extends over ten thousand kilometers and is washed by the waters of the Sea of Japan, the Sea of Okhotsk and Bering Sea. The surface areas of these seas totals approximately 5 million square km., a figure which considerably exceeds the surface area of the seas off the shores of the European Soviet Union. The ichthyofauna of the Fareastern seas is exceptionally varied. Benthic and pre-benthic fish are particularly numerous. The number of forms of these fish is greater in the Pacific than in the Atlantic Ocean, although affinitive forms of the overwhelming majority of industrial benthic and pre-benthic fish populate both oceans. There are substantial similarities between the multitude of species and genera forming the faune of the main industrial families of benthic and pre-benthic fish, i.e. cod and flounders of the Pacific and Atlantic Oceans, probably due to the fact that the Atlantic (or more precisely, the North-Atlantic) origin of cod led to the amalgamation of the fauna of cadidae of the Pacific Ocean, Only certain representatives of this family succeeded in penetrating into the Pacific Ocean basin. The Pacific Ocean origin of flounders (subfamily Pleuronectini) accounts for the relatively small variety of species of flounders in the Atlantic Ocean.

Representatives of the genera *Cadus* and *Eleginus* (the industrial species of *cadidae*) are found in both oceans. Among the flounders - the representatives of genera *Limanda*, *Hippoglossus*, *Hippoglossoides*, *Pleuronectes* and *Platessa* are also found in both Oceans. It is interesting to note that the most important industrial flounders have affinitive forms in both oceans.

We might expect the behaviour of these fish to be similar in both oceans, particularly when we take into account the systematic differences of affinitive forms persist in most cases at the level of species or even of sub-species.

This seemingly apparent resemblance between the biology of benthic and pre-benthic fish inhabiting the North Atlantic and North Pacific Oceans led to methods of search for benthic fish, successfully used in the Barents sea and other basins (Prof. Suvorov, Prof. Mesyatsev) having been often automatically applied to fishing in the Far-eastern waters. These methods proved inadvisable in a series of cases, since the specific biology of the Far-eastern inhabitants had not been taken into account and erroneous conclusions on the character of concentrations and number of benthic and pre-benthic fish in the Northern Pacific Ocean were reached.

It is undeniable that a series of related forms in both cases are biologically affinitive.

Certain similar traits in particular are readily noted in the behaviour of the Atlantic and Pacific cod, navaga, *Pollachius virus* and Alaska pollack, *Limanda* and *Pleuronectes quadrituberculatus*, as well as a series of other species.

However, the investigations on the biology of benthic and pre-benthic fish populating the northwestern zone of the Pacific Ocean carried out during the last few years by the TINRO enabled us to find substantial differences in the biology of inhabitants of the Pacific and Atlantic oceans. These differences are conditioned, in marked degree, by the peculiar conditions and environment in each basin.

We shall endeavour to clearly summarize the reasons and character of the existing differences in the biology of a series of benthic and pre-benthic fish inhabiting the northern zones of the Pacific and Atlantic oceans, respectively.

We shall open with a most superficial characterization of the hydrological conditions of the Far Eastern seas emphasizing the specific peculiarities of these conditions, which, in our opinion, account for the biological characteristics of cod, flounders, Alaska pollack and a series of other fish populating these waters.

Deep (4-6 thousand metres) depressions forming the Sea of Japan, Okhotsk and Bering Sea and occupying large territories within these seas, the relatively limited dimensions of the continental plateau which throughout its largest extent is a narrow strip along the North-eastern shores of Asia, the rapid drop in the depths (to 3000 and more metres) along the edge of the plateau are features distinguishing the Far-eastern waters from the north-eastern regions of the Atlantic Ocean, characterized as we know by large shallow water areas occupying a surface area of approx. 3 million square kilometres whereas in the north-western zone of Pacific Ocean the shallow waters only cover a territory of about 1200 thousand square kilometres.

The severe hydrological conditions of the adjacent continental regions and the isolation of the Far-eastern border-seas from the open Pacific Ocean by a chain of Islands, are the most important causes of the intensive winter-cooling of the surface layers of waters over the areas of these seas. At this period, temperatures drop to sub-zero. Some water-bodies, notably the Northwestern Okhotsk Sea, the waters along the eastern shores of Sakhalin, Anadyrski Bay and other water-bodies never become thoroughly warmed up during the year and as they cover an extensive shallow-water basin, they are an unsuitable habitat for benthic and pre-benthic fish.

When the great distances from the potential wintering regions and the inaccessibility to industrial fish of considerable ~~shallow-water regions~~ (northern zone of the Bering Sea and southern zone of the sea of Chukotsk) during the summer are taken into account, it follows that the overall surface area of the shallow waters in the Fareastern region where conditions for existence of benthic fish are favorable will be reduced to approximately 800-850 thousand square kilometers. Intensive cooling (to the sub-zero temperature) during the winter and the wide range of seasonal thermic fluctuations in the surface layer of water (particularly in the southern zone of the Okhotsk Sea and Sea of Japan) establish a considerable contrast between hydrological conditions in Fareastern waters and in the waters washing the northwestern shores of Europe. Very insignificant annual thermic fluctuations and an almost complete absence of sub-zero temperature characterize the waters washing the northeastern shores of Europe.

Lastly, the velocity of permanent and low and high tide currents in the Fareastern waters usually somewhat exceeds the velocities of currents in the northeastern Atlantic Ocean, which, as we know, is affected by the slowly moving water volumes of the Gulf Stream whereas the majority of permanent currents in the Bering, Okhotsk and Japan seas proceed at higher speed.

The relatively rapid currents displacing water volumes from the shallow regions to the regions of great depths or into the areas at sub-zero temperature, create unfavorable conditions for the animals having pelagian roe and fry (i.e. for the majority of benthic fish). May we point out, once more, that for several months, ice-flows, either floating or stationary, cover vast areas of the Far-eastern waters, particularly the shallow water regions, whereas the greatest part of the surface area of the Northeastern Atlantic ocean is free of ice all the year round.

The above enumerated peculiarities of the hydrological conditions of the Atlantic and Pacific Oceans suffice to show that benthic and pre-benthic fish in the two oceans live under markedly differing conditions, and this naturally affects their biological properties.

There are, furthermore, some other factors considerably affecting the development of benthic and pre-benthic fish in the Atlantic and Pacific Oceans - i.e. the food factor and the activity of predatory fish and animals.

By comparing the biological volumes of benthos and zooplankton in the Atlantic and Pacific Oceans, it becomes readily apparent that the indices of biological volume and zoological plankton are, as a rule, somewhat higher in a number of regions of the Far-eastern waters than in the seas washing North- and Northwest Europe.

It suffices to mention that while in most shallow-water regions in the Far-eastern seas the mean biological

volume of benthos fluctuate between 100 and 500 gr/m²; in the North European seas these indices fluctuate between 20 and 50 gr/m² (see table 155). The biological volume of plankton shows similar indices (160-300 mg/m³ and 50-140 mg/m³ respectively). These divergences in the favour of the Far-eastern waters may be further increased if we consider the large zoo-planktons (mainly Euphausiidae) found in profusion in the Sea of Japan and particularly, in the Okhotsk Sea.

The high biological volume of benthos and zoo-plankton of the Far-eastern waters ensures the formation in a number of regions of large and very dense concentrations of benthic and pre-benthic fish. However, it must be born in mind that the mere fact of the abundance of benthic population does not, necessarily indicate the presence of industrial concentrations of benthic fish. Thus, for example, Anadyrski Bay is very rich in nutritive biological volume but has no industrial concentrations of fish; in the northern zone of the Bering Sea and over the entire territory of Chukotski Sea no industrial concentrations of flounders, cod or Alaska pollack are formed, although food objects are found in these areas in exceptionally great quantities and hydrological conditions during the summer are very favourable (for cod and Alaska pollack). No fish penetrate these areas because of the great distances between these waters and the regions of hibernation. It is obvious that in numbers of regions of the Far-eastern waters the abundant food base is exploited in an insufficient degree.

TABLE 155.

Mean biological volume of benthos and zoo-planktons
of the Atlantic and Pacific Oceans (to the depth
of 200 metres).

Seas	Benthos (in gr/m ²)	Zoo- plankton ₃ (in mg/m ³)	The data provided by:
Chukotski	213	160	Makarov, 1937 Bogorov, 1939.
Bering	227		Makarov, 1937.
Okhotsk	483*	300	Gordeeva, 1948. Kusmorskaya, 1940.
Japan	302**	240	Deryugin and Somova, 1941. Kusmorskaya, 1938.
Kara	50	48	Zenkevich, 1947. Bogorov, 1939.
Barents	100	140	Zenkevich, 1947.
White	20	100	Zenkevich, 1947.
North	244		Zernov, 1934.
Baltic			Zenkevich, 1947.

* - Western Kamchatka

** - Peter the Great Bay

High biological volumes of plankton and benthos are intensively consumed by fish and the comparison between the degree of filling of guts of a number of the most numerous industrial fish species sufficiently evidences that the intensiveness of feeding of the majority of inhabitants of the Far-Eastern waters is considerably greater than that of the inhabitants of the Atlantic Ocean.

Thus, the mean annual index for the degree of filling of the guts of cod from the Okhotsk Sea is 225 (Logvinovich, 1948) whereas this index for cod from the Barents Sea is only 144 (Zatsepin, 1939). In view of this particular circumstance, i.e. the abundance of food objects - the majority of Fareastern benthic and pre-benthic fish feed on a limited number of objects (though their spectrum of feeding is wide). Thus, the Pacific cod consuming over 100 various animals, feed on 4-5 forms only (Logvinovich, 1948, Gordeeva, 1951). Different species of flounders and halibuts, the food spectrum of which consists of 200 and more species live on only a few forms (Mikulich, 1952).

As already observed, the rate of growth and the annual increments in weight (and size), the degree of fattening up and content of fat of the majority of Fareastern fish considerably exceed those of the inhabitants of the northeastern zone of Atlantic Ocean. Thus, the Pacific cod in particular, shows annual increments in weight that are 1.5- 3 times higher than the increments of cod from the Barents Sea (see table 156).

As a result, the mean weight of Pacific cod is 2-3 times that of the cod from Atlantic Ocean of identical age.

The inter-species relations with numerous benthic and pre-benthic fish are also an important though little studied factor in the development of industrial fish of benthic and pre-benthic nature. The multitude of species (as many as 166 as compared with 48 in the Northern Atlantic Ocean) and great number of representatives of other benthic fish (see table 157), having feeding habits similar to those of the industrial forms in a number of cases and occasionally living on their fry and roe (sometimes even adult specimens) undoubtedly affect the biology of benthic and pre-benthic industrial fish stimulating the development of counter-measures to the activity of predatory forms and reduction of food reserves caused by activity of "polluting species".

The by-catches of undesirable fish are particularly high in the Sea of Japan and southern zone of the Okhotsk Sea, where, as a rule, each trawl brings centners, occasionally tons of these fish. It suffices to mention that in Peter the Great Bay 25% of the catches obtained by benthic casting nets consists of the unintended by-catch.

TABLE 156.

Annual increments in weight of the Pacific and Atlantic cod in kg.

	Age						Degree of fattening up (following the data of Clark).
	4	5	6	7	8	9	
Bering Sea							
weight increment	1.60	2.62	3.45	5.30	6.80	8.65	
increments	0.80	1.02	0.83	1.85	1.50	1.85	1.12
Barents Sea							
weight increment	0.42	0.86	1.40	2.04	3.06	4.53	
increments	0.23	0.44	0.54	0.64	1.02	1.47	0.85

TABLE 157.

Number of species of the benthic and pre-benthic non-industrial fish in the Pacific and Atlantic Ocean.

Families	Pacific Ocean				Atlantic Ocean.
	Bering Sea	Sea of Okhotsk	Sea of Japan	Pacific coast of America.	Barents Sea
Cottoidae	73	50	36	38	14
Agonidae	16	15	15	15	4
Hexagrammidae	6	5	4	5	-
Cyclopterini	9	23	10	13	3
Liparini	22	-	-	-	4
Blenniidae	40	55	37	29	23
Total	166	148	100	100	48
The data provided Andriyashiev Schmidt Lidberg Schulz Knipovich,					
	1939	1950	1947	& de Laei 1935	1926

These are the main differences in the environment of benthic and pre-benthic fish in the northeastern zone of Atlantic and Northwestern zones of Pacific Ocean, and, in our opinion, they are most substantial. Further investigations will undoubtedly reveal a number of new peculiarities specific of one or another basin and conditioning the existence of benthic and pre-benthic fish, however, the data presented above suffice to show the clearly evident characteristic features of the relief, hydrological conditions and population of the Far-eastern waters. These specific characteristics of environment conditioned to a considerable degree the peculiarities of biology of benthic and pre-benthic fish population the north-western zone of the Pacific Ocean

It is here that the Pacific endemic - the Alaska Pollack - originated and became wide-spread. This form is necto-benthic rather than benthic, easily migrates into the intermediate horizons, feeds in the main on planktonic and necto-benthic crustacea and only in exceptional cases consumes benthos. Alaska pollack in the northern zone of Atlantic Ocean is ecologically affinitive to pollack of the Atlantic Ocean, intensively feeds on the abundant biological volume of plankton, occasionally of benthos as well. These fish are scarce in the relatively narrow strips of the continental plateau, easily withstand sub-zero temperature. Being one of the main food objects of cod, having a similar area of propagation and seasonal distribution, Alaska pollack are consumed by cod all the year round and this accounts for the high index of the filling of the guts of the latter in most regions. Cod, flounders, navaga, Alaska pollack, Scorpaenidae and other fish populating the Fareastern waters, due to the localization of the numerous regions suitable for the existence of benthic and pre-benthic fish, formed a series of isolated shoals between which there is no inter-communication and dispersed over different regions of the Fareastern waters having become adapted to development under somewhat differing conditions.

Localization of the different regions inhabited at present by the cod, Alaska pollack, navaga and flounders in the region of propagation of these fish in the Fareastern waters and the presence of biological

and morphological differences in the majority of forms now populating different regions show that the situation is one of varying benthic and pre-benthic fish found localized in a number of isolated regions.

In the past this fauna populated the waters washing the northeastern shores of Asia.

The geological history of the countries of the Far East and particularly, the thorough investigations carried out during the last few years by G.U. Lindberg on the distribution and history of the fresh water fauna of Northeastern Asia that a series of transgressions and regressions occurred off the shores of Eastern Asia in the Quaternary period, in the process of which immense depressions in the territories occupied at present by the Far Eastern border-seas were formed.

The data on the distribution and biology of benthic and pre-benthic fish further develop this hypothesis showing that not only the fresh water fauna, but the sea fauna as well (primarily the fauna of benthic and pre-benthic fish of the Far Eastern waters), which was in the past a relatively integral fauna, split up.

We may assume that as a result of transgressions and particularly as a result of the formation of depressions, the continental plateau narrowed down and there were formed large regions of great depths; there appeared regions with strongly varying hydrological conditions and, possibly, the velocity of currents became accelerated.

All this produced the dismemberment of the formerly united area of propagation of benthic and pre-benthic fish, localization of separate shoals of fish in a series of regions on the Far East with varying natural environment and accounted for the formation of a great number of localized schools of cod, flounders, Alaska pollack, navaga and other fish and development of a series of individual, biological and morphological features in these fish.

Instead of lengthy and extensive horizontal migrations of cod, pollack and other benthic and pre-benthic fish in the Atlantic Ocean, the fish in these regions make short seasonal migrations from great depths to shallow waters and back. These drifts are caused by sharp seasonal changes in hydrological conditions, as well as by the distribution of food objects and other factors. This sharp change in the hydrological conditions caused the transition of all the benthic industrial fish to simultaneous spawning, increased duration of the incubation period, formation of lengthy periods of winter starvation in a number of species of flounders which are accompanied by a sharp drop in the vital activity of the organism.

The existing zoo-geographic division of the Far Eastern waters (Andriyashev 1939; Vinogradov, 1948) is in the main quite compatible with the biological classification of the species inhabiting different zoo-geographic regions.

However, the study of the biology of the benthic and pre-benthic fish enabled us to establish that the spawning periods, character of migrations and vertical distribution, rate of growth and a series of other features of the biology of Pacific benthic and pre-benthic fish substantially change depending on the region of propagation. Basing our opinion on the biology of fish investigated, we succeeded in a number of cases in more precisely defining the formerly existing borders of the zoo-geographic regions.

Careful study of the biology of the objects (particularly of the widespread industrial animals), their ecological characterization and determination of the biological divergences present in different regions will undoubtedly enable us to improve the zoo-geographic division of the Far-eastern waters which so far has been based mainly on the data of the analysis of fauna.

As already mentioned earlier, one of the most important peculiarities of the Far-eastern waters, affecting the type of species, as well as the biology of animals populating these regions is the system of currents of characteristic permanency and great velocity.

Taking into account the low degree of development of the continental plateau, the large surface areas covered by great depths and the sharply varying hydrological conditions (even in closely adjacent regions), the great velocity of currents in the Far-eastern waters are an unfavorable factor to a number of animals inhabiting these regions and having pelagian roe.

It may be easily seen that the roe, fry and young specimens are in danger of being carried away by currents to great distances from the places of spawning into places where conditions would prove unsuitable for the satisfactory development of most of the fish.

The simplest estimation has shown that at the velocity of current of 0.5 mile an hour over the 15-20 days during which the roe and fry remain in pelagia, the fry of flounders will be carried 180-240 miles away from the spawning place, i.e. as a rule, beyond the region favorable for their development.

The fish with attached roe (Cottidae, Blenniidae, Zoarcidae, Cyclopteridae, Liparidae, etc.) find favorable conditions for their existence in the Far-eastern waters, whereas the fish with pelagian roe developed a series of characteristics ensuring the reproduction of the species and maintenance

of the number of its representatives at a high level, which enables these fish to counteract the lethal effect of intensive currents. Thus the flounders in the regions with high velocities of currents, approach the shores for spawning, enter bays and gulfs and spawn there, in immobile waters. Moreover, investigations by Ostroumova showed that *Pseudopleuronectes yokohamae* have a benthic adhesive roe. The sections with intensive currents and undistorted shore-line are devoid of large concentrations of

flounders, whereas all the large accumulations of these fish are adapted to the regions with immobile waters. Atlantic cod have pelagian roe, whereas the cod populating the Far-eastern waters are characterized by benthic roe, and this prevents the roe being carried away by currents and ensure its development in the horizons where the temperatures are the most suitable. Moreover, the benthic character of roe protects it from the action of floating ice floes covering the largest part of the spawning regions during the spawning seasons of cod.

Alaska pollack, depositing pelagian roe, approach the shores to spawn, drift into the regions where currents are slow (Vedensky, 1949). Its most important spawning regions in Korean Bay, Peter the Great Bay and off south-western Kamchatka are situated in relatively well sheltered areas. The effect of currents upon the behaviour of fish in the Far-eastern waters extends to the pelagian fish as well. Indeed, the inhabitants of pelagia, such as sardine, Scombridae, *Seriola quinqueradiata* and other fish, drift towards the shores for spawning, enter the bays and gulfs, where the spawning takes place. Pacific herring roe is attached and deposited in the direct proximity of shores (in distinction from the Atlantic herring) so that its population remains numerous even in the regions marked by intensive currents. Similar examples may be given in great numbers, however, the above presented data suffice to show the effect of specific hydrological conditions of the Far-eastern waters, currents in particular, upon the great regularities of the biology of fish populating these waters.

In the light of these theories the reason for the coastal character of spawning of the majority of fish having pelagian roe, the focus-wise location on the spawning regions of fish with benthic roe and the great number of fish with attached roe in the Fareastern waters become clear.

The abundance of predatory fish and animals was one of the stimuli that accelerated the rate of growth of cod and flounders during the first few years of their life, stimulated the development of formation of protective pins (annal pin in flounders) and increased the fertility of certain species (flounders, navaga).

The relative abundance of food objects, variety and comparative stability of the biocenetic groups resulted in clear differentiation of food spectra of the most numerous species (small-and large-mouthed flounders, cod, Alaska pollack and others).

We believe that the increased fertility of the majority of benthic and pre-benthic fish populating the Pacific Ocean (as compared with the affinitive Atlantic species) developed primarily as a defence against specific hydrological conditions (mainly currents) and to the intensive activity of predatory fish and animals characteristic of the Fareastern waters.

By comparing the fertility of the majority of related species of benthic and pre-benthic fish populating the Atlantic and Pacific Oceans (table 158), we may easily see that Pacific inhabitants have, as a rule, considerably higher fertility than their Atlantic relatives.

The data on fertility of pelagian fish (table 158) are equally significant and confirm the aforesaid. It is difficult to agree with Nikolsky (1950, who, while drawing a comparison between the fertility of fish producing eggs of varying dimensions, was compelled to isolate them into a separate group of fish spawning away from the shores" with which he included the fish spawning in the Pacific Ocean in the direct proximity of shore-line (for example, Scombridae, Hippoglossoides). It is quite obvious that the fertility of the majority of fish inhabiting Pacific Ocean and having pelagian roe is the higher despite the rapid currents in the Pacific Ocean and the intensive activity of predatory fish and animals.

TABLE 158.

Fertility (in thousands of eggs) of certain species of fish in Pacific and Atlantic Oceans.

Species	Pacific Ocean	Atlantic Ocean
Cod	411-763 ¹	170-250 ¹
Navaga	250-210.0	6.2-63.0
Limanda	626.0-1133.0 ²	80.0-140.0 ⁴
Hippoglossoides	162.0-528.03	241.0-336.0 ⁶
Capelia	211.0-241.05	
Scombridae	15.3-39.9	6.2-13.4
	400-800 ⁷	350-450 ⁸
Anchovy	35 ¹⁰	30 ⁹
Herring	39.9-93.4	14.8-23.3

We may establish that the development of means of adaptation to the specific conditions of environment of the Pacific benthic and pre-benthic species resulted in: increased fertility (flounders, navaga); transition to simultaneous spawning (cod, flounders, navaga, Alaska pollack); pre-benthic character of roe (cod, certain flounders); reduction of the incubation period (cod, flounders, navaga); accelerated rate of growth during the first few years of the life of fish (flounders, cod); clear differentiation of food spectra of the most numerous species (small-and large-mouthed flounders, cod and Alaska pollack); localization of the regions inhabited by different schools (all forms); well-pronounced seasonal migration from great depths to the shallow waters and back (all fish); small extents of horizontal migrations (all fish); lengthy compulsory starvation periods which are accompanied by sharp drop in the vital activity of the organism in certain species of fish (flounders).

The development of the aforescussed specific features of biology of benthic and pre-benthic fish due to the peculiar conditions of the Fareastern waters enabled the fish populating the northwestern zone of Pacific Ocean, to remain in great numbers despite the small surface areas of the shallow waters (including a number of areas with unfavorable hydrological conditions).

These fish feed on the abundant benthos and plankton available in the Fareastern waters. We believe that

conditional on the organization of a rational fishing industry, the benthic and pre-benthic fish of the Far-eastern waters may ensure catches corresponding to the catches presently obtained in the northeastern zone of Atlantic Ocean, which, as we know, covers a vast shallow waters plateau with more favorable hydrological conditions. The theory that the northern zone of Atlantic Ocean and particularly, its northeastern region which is a large shallow waters plateau washed by warm waters of the Gulf Stream is exceptionally rich on benthic and pre-benthic industrial fish, has been universally accepted. On the other hand, it has been maintained that industrial benthic and pre-benthic fish are little numerous in the northern zone of Pacific Ocean (including its northwestern regions), the shallow-water regions are limited and hydrological conditions are unfavorable, so the formation of those large concentrations peculiar to the Atlantic Ocean is hardly possible. Derzhavin (1930) wrote: "If we could assume that the productivity of our (i.e. Far-Eastern P.M.) waters is equal to the North-European productivity, which reaches 44 centners per 1 square mile of industrial surface area, then their possibilities would reach 12.7 million centners. However, as we already observed, the severity of elements of the Far-eastern shores excludes the possibility of such comparison. Large sections of our waters of particularly unsuitable and unfavorable hydrological conditions and not in favorable

geographic locations (such as, for example, the northwestern and northern zone of the Okhotsk Sea) are in all probability considerably less productive in sea fish".

Suvorov and Shchetinina (1935) also voiced the belief that the reserves of Pacific cod in the Far Eastern waters are limited. Many other authors, including P. Schmidt (1948) are inclined to believe that perspectives of fishing benthic and pre-benthic fish in the Far Eastern waters are poor.. Simultaneously, these authors point out the large-scale fishing industry based on these fish in the northeastern Atlantic Ocean,

We think these theories arise primarily from lack of knowledge of the biology and distribution of benthic and pre-benthic fish populating the northern zone of Pacific Ocean. Indeed, when comparing the catches of benthic and pre-benthic fish obtained in the two oceans (table 159) we see that 22 million centners of fish (cod, *Melanogrammus aeglofinus*, pollack, flounders and halibuts, sea perch and other fish) are yearly caught in the northern zone of the Atlantic Ocean whereas in the northern zone of the Pacific Ocean the annual catches at the low intensiveness of fishing reached almost 9 million centners (including the cod, Alaska pollack, flounders, halibuts and other fish).

TABLE.

Catches of benthic and pre-benthic fish obtained in the Northern zones of Pacific and Atlantic Oceans in 1936-1940 (in million of centners).

Cod	Haddock	Pollack	Other Cadidae	All Cadidae	Flounders	Other benthic	All benthic and pre-benthic	Cod	Alaska pollack	All Cadidae	Flounders	Other benthic	All benthic and pre-benthic
13.1	3.6	1.7	1.8	20.2	1.5	0.5	22.2	2.5	4.2	6.7	1.2	0.8	8.7

However, it must be taken into account that the intensiveness of fishing on benthic and pre-benthic fish in the northern zone of Pacific Ocean is negligible (with the exception of the regions adjacent to Japan and Korea proper and fishing on halibuts off the Pacific shores of North America) and could be considerably increased to raise the overall catches of all fish species.

Lastly, we must keep in mind that apart from the numerous seals, the Pacific Ocean is inhabited by a multi-million herds of fur-seals feeding mainly on Alaska pollack. Tentative estimates enable us to affirm that the fur-seals consume yearly at least 15 million centners of fish, mainly Alaska Pollack.

All these data lead us to assume that the number of benthic and pre-benthic fish populating the northern zone of Pacific Ocean does not differ to a great extent from that in Atlantic Ocean. However, the mere juxtaposition of figures of the catches obtained by the existing and possible fishing industry must not overshadow the great divergences in the type of fish species forming the catches and character of fishing on benthic

and pre-benthic fish in the two oceans.

On the basis of the data on biology of benthic and pre-benthic industrial fish of the Fareastern waters, the theory maintaining that the northern zone of Pacific Ocean is little abundant in benthic and pre-benthic fish must be re-evaluated and rapid development of industrial fishing on these fish must be encouraged.

At the same time, the established localization of the main industrial species must be taken into account during the development of fishing on benthic and pre-benthic fish in the Fareastern waters (offering great possibilities), since the said development must be conducted in strict conformity with the raw material resources of the given region. The said example of excessive fishing on navaga and flounders in Peter the Great Bay are highly significant. In view of the existence of a number of biological peculiarities and particularly, of the easy transition of Pacific cod into the sub-benthic horizons (especially during the pre-spawning and spawning periods) the fishing implements (trawls in particular) successfully used in Atlantic ocean, cannot be mechanically transferred for the use in the Fareastern waters.

The data obtained thusfar convincingly indicate the expediency of organizing trawling industry in the Far East, which would be conducted alongside with the fishing from small-, medium-and large-tonnage fleet.

Rapid and effective development of fishing industry in the Far East may be assured only by intensive development of the fishing of benthic and pre-benthic fish, as well as development and organization of fishing on herring, Scombridae, tunnics and a series of other pelagian fish.

x.x.x.x.x.x.x.x.x.x

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Undoubtedly, the feeding of *Limanda aspera*, the main industrial species depends on the food groups found in a given biocenosis, however, the selective ability of this flounders is equally apparent, as it prefers small mollusks to other animals of the biocenosis.

Having reached the depth level below 60-70 metres, the large-mouthed flounders feed on Polychaeta, small mollusks and crustacea as well on the brittle stars, which continue to play an important role in their diet. Simultaneously, we find Mysidae in the guts of *Cleisthenes herzensteini* and *Acanthopsetta nadeshnyi*.

The highly productive zone Venus - Yoldiella - Ampelisca is one of the "pastures" for flounders in Peter the Great Bay and a number of species remain within its limits for a lengthy period of time on their way towards shallow waters (*Glyptocephalus stelleri*, *Lepidopsetta bilineata bilineata*, *Acanthopserra nadeshnyi* and *Hippoglossoides hip.* in particular).

The arrival of flounders in the shallow water marks the beginning of extensive feeding, as well as maturation of the sexual products and onset of spawning. The majority of flounders have, as a rule, a rather protracted spawning period continuing in certain cases for 2-2,5 months. During the spawning period the fish stop feeding but resume feeding anew immediately after the spawning has terminated.

The sharp drop or complete discontinuation of feeding of flounders during the spawning period has been observed in all the regions of the Far-Eastern waters. Thus, according to the data provided by L. Mikulich, empty guts were observed in 73% of the spawning specimens of *Acanthopsetta nadeshnyi* in Tatarski Strait in 1949, whereas the index of filling of the remaining specimens was extremely low - .45. In the specimens that completed the spawning this index reaches 246.1. We observed an analogous phenomenon in *Hip. el. dubius*: the spawning specimens of this species showed a 19.3 index of filling of the guts whereas the specimens, which had already completed spawning or did not spawn at all intensively fed (the index of filling was 101.9).

At the end of May and in early June, almost all the small-mouthed flounders (with the exception of the majority of *Glyptocephalus stelleri*, remaining at the depths above 30-40 metres) enter the bays of America, Vostok, Strelak, Ussuriyski, Amurski and Posyetski and spread over these areas while some of the fish (particularly *Pseudopleuronectes yokohamae*, *Pleuronectes stellatus*, *Limanda punct. punctatissima*, *Pleuronectes obscurus* and *Pleuronectes pinnifasciatus*) hug the shore-line. The most numerous species of the small-mouthed flounders (*Limanda aspera*, *Pseudopleuronectes herzensteini*) and large-mouthed (*Cleisthenes herzensteini*) flounders avoid the areas

overgrown with waterweeds and plants, usually populating the waters clear of vegetation. In their chosen waters, most flounders from Peter the Great Bay feed on the numerous and varied biocenetic groups, which, as a rule are high in nutritive value and they continue feeding a relatively prolonged period of time (June-September). May we summarize the character of feeding of certain species of flounders in the shallow waters of Peter the Great Bay.

Limanda punct. punctatissima travel in March-May from the Askold Bank to the shallow waters and in June and July spread over the shallow gulfs and bays at the depth levels of less than 30-40 metres where the spawning and the pre-and post-spawning feeding takes place.

Table 132 shows the composition diet of *Limanda punct. punctatissima* during the summer and fall.

TABLE 132.

Contents of the guts of *Limanda punctatissima punctatissima* in Peter the Great Bay in 1931-1934 (in % of the frequency at which it is encountered).

Date and place of fishing	Mollusca	Polychaeta	Small crustacea.	Echinodermata, Ophiu-ridae	Water weeds	Others	No. of specimens
July	20.0	60.0	20.0	-	-	-	9
August	30.6	38.7	4.0	1.0	8.4	17.3	18
September	5.8	90.4	0.3	-	3.0	0.5	44
October: Ussuriysky Bay, off the shore; Basyeta Bay	1.9	96.3	0.9	0.1	0.8	-	68
November Off the shore Askold Bank	1.6 The guts are empty	94.8	2.2	-	1.2	0.1	46 4

Polychaeta constitute the main food of these flounders during their entire stay in the shallow waters. Small molluska (Nucula, Tellina, Philine, Yoldia, Bela, particularly in July and August) play an important part in this diet. We observed a considerable percentage in small crustacea (up to 30.5%) in Posyetski Bay alone. Echinoderms have been very rarely found in the guts. The feeding habits of Limanda aspera, Pseudopleuronectes yokohamae and Pleuronectes stellatus are similar to the above described.

Pleuronectes obscurus feed in July on the Polychaeta and in August on mollusks. Throughout the feeding-period the crustacea play an important part in the diet of flounders (Gammaridae, Caprellidae, Mysidae, Gummacea, Izopeda).

TABLE 133.

Contents of guts of Pseudopleuronectes herzensteini in Peter the Great Bay. (September-October, 1932).

	Mollusca	Polychaeta	Small	Large	Echinodermata	Others
In % of weight	3.5	41.6	6.4	0.3	47.9	0.
In % of frequency at which it is encountered	28.9	28.9	15.8	2.6	21.1	2.

Pleuronectes herzensteini feed between June and October mainly on brittle stars and Polychaeta. Mollusks and crustacea are an insignificant portion of their diet. (Demidova, 1939). Lepidopsetta bilineata bilineata and Glyptocephalus stelleri drift to shallow waters considerably later than Limanda punctatissima punctatissima and remain at the depths over 40 metres for a prolonged period of time.

TABLE 134.

Contents of guts of *Lepidopsetta bilineata bilineata* from Peter the Great Bay in 1933 (in % of the frequency at which it is encountered).

Months	Food groups							No. of specimens
	Mollusca	Poly-chaeta	Small crustacea	Echino-dermata Ophiuro-idea	Water weeds	Fish	Others	
March	-	28.6	42.8	-	-	28.6	-	) 77
July	0.5	21.8	55.4	0.1	-	21.8	0.4	
October	1.7	54.5	43.6	-	0.2	-	-	

Throughout the entire feeding period (between March and November) the *Lepidopsetta bil. bilineata* consume 42-55% of small crustacea (Gammaridae, Cumacea), 21-54% of Polychaeta and 21-28% small fish. Although for the longest fraction of the year these flounders remain within the limits of biocenosis rich in mollusks, we found a very low content of Mollusca (*Yoldia*, *Venus*) in the guts of these flounders. *Glyptocephalus stelleri* show a well outlined Polychaeta diet (63-92%) at the expense of the numerous representatives of Maldanidae, Phyllodocidae and other groups of worms.

TABLE 135.

Contents of guts of *Glyptocephalus stelleri* in Peter the Great Bay (in % of the frequency at which it is encountered).

Month	Food groups						Number of specimens
	Mollusca	Poly-chaeta	Small crustacea	Echinodermata Ophiuroidea	Water weeds	Others	
January	The guts are empty.						9
March	0.37	71.8	25.9	1.9	0.04	-	54
June	5.9	63.5	28.8	0.6	-	1.2	39
October	0.6	92.0	5.2	-	1.4	1.1	11
November	The guts are empty.						

Small crustacea (Gammaridae, Gumacea, Caprellidae) play an important part in the feeding. The remaining animals (Ophiura, small mollusks) are seldom eaten by the *Glyptocephalus stelleri*.

The fry of all the species of flounders (small- and large-mouthed) mainly feed on Polychaeta.

The end of September, and particularly October mark the intensive drift of flounders from shallow waters to greater depths in the region of hibernation. The flounders alone follow the same course as in their vernal migration, though travelling in the opposite direction. Intensiveness of feeding noticeably drops and the majority of species discontinue feeding during the winter. The assortment of foods also somewhat changes due to the drift of flounders from one group of biocenosis to another.

Small-mouthed flounders discontinue feeding as a rule, at the end of November - beginning of December. It is interesting to note that the fish, which by that time have sunk to greater depths, cease feeding whereas the flounders that are still in the littoral zone continue consuming food (see table 135). The drop in the intensiveness of feeding, then complete discontinuation of feeding during the winter is accompanied in small-mouthed flounders by contraction of intestinal muscles, formation of numerous folds on the exterior surface of the guts and filling of the contracted guts with mucus.

In large-mouthed flounders we observed a similar, though less strongly pronounced process of the decrease of intensiveness of feeding during the fall and very slight

degree of feeding during the winter. In Peter the Great Bay the *Cleisthenes herzensteini* continue feeding on pelagian forms (*Thysanoessa inermis*) and animals (*Ophiura*, *Polychaeta*, *Amphipode*) characteristic of the biocenetic groups among which the *Cleisthenes herzensteini* hibernate (*Heliometra glacialis* - *Ophiura sarsi*).

Hippoglossoides hip. also live during the winter on *Ophiura sarsi*, *Gammaridae* and *Polychaeta*, however, do not consume planktonic animals.

It can be established that, beyond doubt, the sharp drop in the intensiveness of feeding of the large-mouthed flounders and the clearly-noticeable lengthy winter starvation of small-mouthed flounders in Peter the Great Bay, as well as in most other regions of the Far Eastern waters (as we shall see further on) is not caused by the lack of foods in the flounders' wintering regions, since the latter are located in the benthic zones holding a wide assortment of the foods usually consumed by flounders, but is primarily due to the severity of hydrological elements in the wintering regions. It is these conditions which sharply reduce the vital activity of the majority of flounders found here during the winter.

The food assortment of the above-named species of flounders in other regions of the Far Eastern waters and primarily in the regions of industrial concentrations (Western shore of Kamchatka, Tatarski Strait, South-eastern shores of Sakhalin and others) strongly resembles that in Peter the Great Bay. Thus, *Glyptocephalus stelleri* in Tatarski Strait feed in July and August on *Polychaeta* (77-79%) and

small crustacea (21-23%). Moreover, the proportion of these food groups is almost identical to that found in guts of *Glyptocephalus stelleri* from Peter the Great Bay (see table 136).

TABLE 136.

Contents of guts of *Pleuronectes quadrituberculatus* in Tatarski Strait in 1932 (in % of the frequency at which it is encountered).

Months	Food groups					Number of specimens
	Mollusks	Polychaeta	Small crustacea	Echino-dermata, Ophi-roidea	Others	
April	-	45.2	-	54.8	-	41
May	60.42	38.82	0.02	0.74	-	19
June	40.0	50.0	5.0	-	5.0	13
July	33.5	65.4	0.9	0.13	0.07	73

In addition to the aforescussed, we present data on the feeding of *Pleuronectes quadrituberculatus* in Tatarski Strait. This flounder is an important industrial fish in both straits, as well as off the shores of Kamchatka.

Pleuronectes quadrituberculatus together with the overwhelming majority of small-mouthed flounders, feed in the main on Polychaeta and mollusks. Brittle stars are introduced into their diet only in April (and March, of course).

The very extensive data on the feeding of flounders inhabiting the coastal waters off the southern shores of Sakhalin and Southern Kuril Islands, collected in 1947-1949 by the Kuril-

Sakhalin expedition of TINRO and ZIN of the Academy of Sciences of the USSR and developed by L.V. Mikulich (1935) fully confirm the previous conclusions on the feeding habits of the main industrial flounders. These data, moreover, prove the high intensiveness of feeding of the Far-Eastern flounders. The general index of filling for all the species of flounders in all the regions examined by the expedition, was, as a rule, above 100 (excepting for *Clidoderma asperrimum*, whose index was 281.9).

We shall not dwell in detail on the data summarized in table 137 and merely wish to point out that these figures clearly show the divergences in the assortment of foods consumed by small- and large-mouthed flounders and the marked effect of the biocenetic groups found in the regions inhabited by different flounders upon the feeding habits of the latter, and furthermore, show how each species adapts itself to a definite assortment of food objects. May we also mention that in the Bay of Terpeniya, where we found the mollusk *Leda* in abundant quantities, the guts of *Hip. el robustus* were filled with the aforementioned mollusks.

The feeding of halibuts populating the Far-eastern waters has not been sufficiently studied as yet. All the three species of halibuts inhabiting our waters, are actively predatory fish.

Reinhardtius hippoglossoides matsuurae feed mainly on Alaska pollack, less frequently on crustacea (*Crangonidae*, *Pandalidae*, *Hippolytidae*). In May the *Reinhardtius hippoglossoides matsuurae* approach the shores (drifting to the depth level of 100-200 metres) in search for food,

then (in July-September) travel away to considerable depths (500 and more metres) to spawn and the intensiveness of feeding at these levels decreases.

Hippoglossus hip. stenolepis also live mainly on fish (Alaska pollack, flounders, Salmonidae and others) and to a lesser degree on crustacea (*Chionoecetes opilio*, *Nectocrangon*, *Hyas* and others).

Atheresthes evermanni feed almost exclusively on Alaska pollack, occasionally on herring and other fish, and in the regions of Southern Sakhalin and Southern Kuril Islands - on fish and *Ommastrephes sloanei-pacificus*. Thus, the feeding of all the halibuts strongly resembles that of Pacific cod (Alaska pollack, herring, flounders, *Chionoecetes opilio*, *Hyas*, Salmonidae and others) but has nothing in common with the feeding of flounders, not excluding the large-mouthed species (*Cleisthenes Hippoglossoides*, *Acanthopsetta*). Only young halibuts and flounders have similar feeding habits.

By comparing the diet of different species of flounders we can see that almost all the small-mouthed flounders feed mainly on three groups: small mollusks, Polychaeta and small crustacea. Thus, the affect of feeding of ten species of small-mouthed flounders found in considerable numbers in Peter the Great Bay, upon the benthic animals is undoubtedly very marked.

It is clear that there is (or was) a certain competition for food among the flounders populating Peter the Great Bay. This assumption may be confirmed by the common spectra of feeding of the majority of species, as well

as by the noticeable rise in the rate of growth of flounders as a result of intensive fishing, which we described above (Moiseev, 1946).

It is equally clear that the large resources and relative stability of basic foods were a factor responsible for the development of substantial divergence in diet and food spectra of different species and this somewhat reduces the intensity of the competition for food.

Lepidopsetta bilineata bil. and *Glyptocéphalus stelleri* are found during the summer in similar regions, for instance obviously feed mainly on the same groups of animals (Polychaeta and small crustacea), however, while Crustacea prevail in the assortment of foods of the former species, the latter prefer Polychaeta.

Limanda aspera and *Pseudopleuronectes yokohamae* have similar feeding habits (both feed on Mollusks and Polychaeta), the former occupies, however, the open sections of bays and gulfs during the summer, whereas the latter species populates the weedy sections closely adjacent to the shore-line. The regions of propagation of the three most numerous species of the genus *Limanda* (i.e. *Limanda aspera*, *Pseudopleuronectes herzensteini* and *Limanda punctatissima*) coincide during the summer but feeding habits of each of the three species markedly differ.

Limanda aspera mainly feed on mollusks whereas Polychaeta play a secondary role in their nutrition and *Limanda punctatissima* live mainly on Polychaeta with certain admixtures of mollusks. *Pseudopleuronectes herzensteini* (the second most numerous form among the small-mouthed flounders) feed in the main on brittle

stars (during the spring these fish consume even Tunicata) and to a lesser degree on Polychaeta. May we point out that the intensive fishing considerably shifted the regions of propagation of different species and modified the range and numbers of species inhabiting certain regions.

TABLE 137.

Diet of flounders populating the region of Southern Sakhalin and Southern Kuril Islands (August-September, 1947-1949). A- the southwestern coast of Sakhalin ; B- the southeastern coast of Sakhalin (including Aniv-Bay) C-Southern Kuril Islands, Pacific zone.

Species of flounders	Food components in % of the general index																		General index in ?		
	Vermes			Mollusca			Crustacea			Echinodermata			Varia			Pisces			A	B	C
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C			
<i>Limanda aspera</i>	10.4	37.2	-	23.4	22.0	-	16.3	31.4	-	43.0	0.9	-	2.1	2.7	-	3.7	3.2	-	98.1	110.3	-
<i>Limanda punct. punctatissima</i>	68.4	52.1	59.1	10.1	47.2	19.8	12.8	0.7	1.9	8.6	-	19.2	0.1	-	-	-	-	-	118.8	95.2	63.8
<i>Pseudopleuronectes herzensteini</i>	11.5	-	14.0	47.4	-	6.6	24.8	-	13.9	9.0	-	63.4	7.3	-	1.8	-	-	0.3	119.0	-	124.8
<i>Clidoderma asperrimum</i>	-	-	0.2	-	-	0.1	-	-	54.5	-	-	45.1	-	-	0.1	-	-	-	-	-	281.9
<i>Kareius bicoloratus</i>	-	-	-	-	-	1.7	-	-	76.4	-	-	-	-	-	-	-	-	21.9	-	-	140.2
<i>Acanthopsetta nadeshnyi</i>	1.1	-	-	-	-	-	96.6	-	-	2.2	-	-	-	-	-	-	-	-	101.7	-	-
<i>Hip. el dubius</i>	5.0	-	33.9	5.0	-	2.2	20	-	-	65	-	63.9	-	-	-	5.0	-	-	-	-	120.9
<i>Hip. el robustus</i>	-	25.68	-	-	1.45	-	-	5.18	-	-	0.01	-	-	32.4	-	-	35.28	-	-	83.2	-
<i>Verasper moseri</i>	-	-	-	-	-	-	27.4	-	-	-	-	-	-	-	-	71.6	-	100	108.1	-	-
<i>Atheresthes evermanni</i>	-	-	0.3	83.0	-	16.1	-	10.1	6.7	-	-	3.2	-	-	-	17.0	87.5	73.7	86.1	94.6	121.5

The above data on the assortment of foods of large groups of flounders show that the spectra of feeding of the small-mouthed flounders overlap.

The variety and numbers of animals consumed by the large-mouthed flounders is larger and more varied. However, the prevalence in the diet of all the three species of flounders (*Ac. nadeshnyi*, *Cleisthenes herzensteini* and *Hippoglossoides hi.*) of Ophiuroidea and the abundance of *Cleisthenes herzensteini* also result in serious overlapping of food spectra. Certain divergencies in the regions of propagation of these fish during the summer somewhat reduce the importance of this factor, however.

We wish to point out that the divergences in the structure of jaws, gills and a series of other morphological characteristics in the large- and small-mouthed flounders are so considerable that numerous authors classified representatives of these groups with different sub-families, occasionally even with different families. Indeed, a number of features, particularly the structural parts needed in feeding and digestion (dimensions of the jaws and mouth aperture, shape of teeth, number, size and character of gills, form of the guts, length of intestines etc.) of the small-mouthed and large-mouthed flounders differ fundamentally and partially reflect the equally considerable divergencies in the character of feeding. Consider the data provided by Yamamoto (1949) and analyze certain figures characterizing the differences between the large-mouthed and small-mouthed flounders.

The data in table 138 show that the size of the mouth aperture in the small-mouthed flounders is half as great as in the large-mouthed fish now compared.

We observed similar proportions in the number and dimensions of the gills, which are short and few in small-mouthed flounders and elongated and numerous in the fish of the large-mouthed group.

The shape of guts and intestines fully conforms to the character of the oral cavity and accordingly differs, depending on the group to which the specimen examined belongs. Large-mouthed flounders are characterized by clearly-marked guts and short intestines, whereas in small-mouthed fish the guts gradually overlap the long intestines.

TABLE 138.

Morphological characteristics of the oral cavity of certain species of flounders.

Species	Length of the head		Number of gills on the 1st bow.		Length of the longest gills.
	Length of the mouth aperture on the right.	Length of the mouth aperture on the left.	Fluctuations	Mean index	
Large-mouthed flounders:					
Eopsetta grigorievi	3.31	3.21	17-23	20	12.37
Cleisthenes herzensteini	3.18	3.11	20-27	25	8.63
Hippoglossus eldubius	2.95	2.61	13-18	16	10.11
Small-mouthed flounders:					
Dexistes rikusenius	5.01	3.78	10-13	11	26.95
Tanakius kitaharae	5.00	4.87	10-13	12	27.68
Glyptocephalus stelleri	6.09	4.30	9-14	12	25.74

These considerable differences in the structure of the oral cavity and digestive tract permit the large- and small-mouthed flounders to develop and keep to spectra of feeding that do not coincide.

The large mouth and numerous gills enable the large-mouthed flounders to successfully feed on both non-benthic crustacea and fish, and on certain benthic forms, whereas the small-mouthed forms of flounders are reduced to almost exclusively feeding of small mollusks and Polychaeta. It would be wise to compare the annual pattern of feeding and range of foods consumed by the Pacific and Atlantic flounders. The most extensive data were provided by Komarova (1939). These data detail the feeding habits of *Hippoglossoides platessoides* inhabiting the Barents Sea. We may see that the food spectrum of these flounders markedly resembles that of *Hip. elassodon* populating the Far-eastern waters. In both cases the echinoderms (*Ophiura*), small mollusks, *Pandalidae* and fish play the most important role in the diet of fish. Intensiveness of feeding also drops considerably during March-May (indices 10-20), however, this decrease is caused not by temperature conditions (as in the case of Pacific forms), but is due to the onset of spawning. The effect of the benthic group within the limits of which the fish are found, on the character of feeding of flounders is equally apparent.

May we list some of the numerous works on the food problem of flounders from the North-eastern zone of the Atlantic Ocean.

Investigations by Peterson, Boysen and Iensen (1911), Petersen (1918), Blegwad (1928) and others enabled us to establish that among the abundant and varied foods consumed by flounders only a few are important. It has been found that the ability of flounders to select food is reflected

not only in their selection of definite food objects from the multitude of different animals available as food, but also in the dimensions of the objects.

Thus, small mollusks are intensively fed upon, whereas large specimens of the same species are left intact.

These observations compel us to carefully differentiate between the nutritive portion of a given biocenosis and the non-nutritive portion.

In the Barents Sea, for instance, in the waters of the North Sea and off the shores of Norway, Denmark, Germany and England the flounders do not undergo any periods of compulsory starvation during the winter and the considerable fluctuations in the intensiveness of feeding are a result of the discontinuation of feeding during the spawning period. We shall not dwell here on the publications devoted to the diurnal food rations of flounders, since we have no material on the Far-eastern flounders with respect to this problem.

The above data indicate that the food-intake pattern of flounders may be divided into the following three groups"

- a) benthophagous flounders, feeding on small benthic animals. This group comprises almost all the small-mouthed forms (*Limanda*, *Pseudopleuronectes*, *Lepidopsetta*, *Pleuronectes*, *Glyptocephalus* and others);
- b) fish of mixed feeding habits living in the main on benthic animals but whose diet includes non-benthic animals and fish. Small large-mouthed flounders, such as *Cleisthenes*, *Hippoglossoides*, *Acanthopsetta* are in this group.

- c) Predatory flounders feeding on fish in the main and large benthic animals. This group comprises halibuts and a number of southern flounders (*Verasper*, *Kareius* and others).

There are great changes in intensiveness of feeding of the flounders belonging to the two former groups over the course of the year, and this affects their behaviour. The diet of the majority of small-mouthed flounders consists mostly of Polychaeta, small crustacea and small mollusks. Echinoderms play an important role in the feeding of several species only during the period of their migrations from the wintering regions to the shallow waters and back. The majority of flounders (not halibuts, however) feed in the main on echinoderms, small crustacea (including nectobenthic crustacea) and on fish in part. The importance of mollusks and Polychaeta is insignificant. Large halibuts feed almost exclusively on large fish. There are four cycles in the food-intake patterns of small and large-mouthed flounders during the course of the annual vital cycle:

- a) the period of winter starvation (December-March) when the small-mouthed forms completely discontinue feed, whereas the large-mouthed flounders reduce the intensiveness of their feeding;
- b) Vernal (March-May) intensification of feeding;
- c) intensive summer feeding (May-September);

d) autumn drop in the intensiveness of feeding

(October-December).

All the flounders either cease to feed or reduce the intensiveness of feeding during the spawning period. Their assortment of food changes depending on the biocoenetic group, within the limits of which the flounders are found but depends to an even greater extent on the spectra of food of the majority of small-mouthed and some large-mouthed flounders which often overlap during the summer period.

THE EFFECT OF FISHING ON THE CONDITION OF A SHOAL OF FLOUNDERS.

The large concentrations of flounders known to populate different regions of the Far Eastern waters are either entirely unaffected by fishing as yet or exploited to an insufficient degree. Intensive fishing is conducted only in the waters washing the southern shores of the Maritimes, Southwestern Kamchatka and in Peter the Great Bay. The effect of fishing on the condition of the shoal of flounders may be estimated in these regions relatively easily. (Moiseev, 1946).

The problem of the effect of fishing on the state of the shoal of fish in a water basin has been frequently discussed in ichthyological literature. All the ichthyological investigations conducted at present reveal, as a rule, substantial changes occurring within the school as a result of the interference of men. However, in the overwhelming majority of cases the investigations are set up a considerable time following the organization of fishing. Thus, the researchers can only state what changes have already taken place without being able to evaluate the degree of these changes. Thus, Rossel (1942) said in one of his lectures that "we only get hold on a few data on the population of

sea fish which survive fishing. There must be certain data on the state, condition and composition of fish population in the regions left intact by fishing but these data are not as thorough and abundant as we should like.

The study of the effect of intensive fishing on the school of flounders in Peter the Great Bay began simultaneously with the organization of fishing, so we were able to register numerous changes in the state of the school almost from the first months when such changes occurred. As mentioned earlier, Peter the Great Bay covers a territory of over 12000 square kilometres but there is a depth level of less than 200 metres under about 4/5 of this surface. The school of flounders inhabiting the bay comprises the following 12 industrial forms:

- 1) *Hippoglossoides elassodon dubius* Schmidt;
- 2) *Acanthopsetta nadeshnyi* Schmidt;
- 3) *Cleisthenes Herzensteini* Schmidt;
- 4) *Lepidopsetta bilineata mochigarei* Snyder;
- 5) *Limanda aspera* Pallas;
- 6) *Limanda punctatissima punctatissima* Steindachner;
- 7) *Pseudopleuronectes Herzensteini* Jordan et Snyder;
- 8) *Pseudopleuronectes yokohamae* Guenther;
- 9) *Glyptocephalus stelleri* Schmidt;
- 10) *Pleuronectes obscurus* Herzenstein;
- 11) *Pleuronectes pinnifasciatus* Kner;
- 12) *Pleuronectes stellatus* Pallas.

All aforesaid species are not equally important from an industrial viewpoint, a point which will subsequently be developed.

Apart from the above species single specimens of the following seven forms are found in these waters;

Paralichthys olivaceus Schlegel, *Verasper moseri* Jordan et Gilbert, *Clidoderma asperrimum* Schlegel, *Pleuronectes quadrituberculatus* Pallas, *Kareius bicoloratus* Basilevsky, *Eopsetta grigorievi* Herzenstein.

The large continental plateau, suitable conditions for development, the absence of industrial fishing - all these factors favoured the existence of a large shoal of flounders in Peter the Great Bay in 1932.

No intensive fishing on flounders was conducted in Peter the Great Bay until 1929-1930 when the first trawlers appeared in the Far East. Up to that date the fishing was of essentially amateurish character and the annual catch did not exceed 5000 centners. Consequently, the relatively large school of flounders was not subject to extermination by fishing until 1929-1930. The arrival of large steam trawlers stimulated the organization and rapid development of flounders fishing in the Far East, particularly within the borders of Peter the Great Bay. The trawl fishing was conducted in winter as a rule, within the limits of the so-called "Askold Bank", at the depth levels of 150-250 metres, where a large part of the school of flounders sank for hibernation. A few years later, i.e. starting in 1934, flounder-fishing from low tonnage boats with benthic fishing nets was initiated, developed and soon reached considerable dimensions, displacing the

trawl fishing. Taking into account the fishing conducted by Japan (exact dimensions of which cannot be estimated) the annual catches obtained in these waters over a twenty-year period (i.e. between 1930 and 1949) totalled 50 thousand centners, but occasionally rose as high as 102 thousand centners.

During the first five years the overwhelming portions of catches were taken by the trawl fleet operating at great depths during the winter, whereas during the last 15-17 years, fishing from small tonnage boats played the leading role in the fishing industry. In view of the relatively small area where the depths are of industrial importance, the effectiveness of the fishing was relatively high. Thus, in the North Sea, from 6 to 7 centners of benthic and pre-benthic fish have been taken per square kilometer, whereas in Peter the Great Bay the mean catches of flounders were 40 centners per square kilometer during the four winter months alone. Undoubtedly, since industrial fishing of flounders was first organized, the intensiveness of fishing has been high.

How did the school of flounders react to this intensive industrial fishing? Regular observations conducted since 1930 (though not sufficiently thorough) established beyond doubt that numerous changes had taken place in the shoal, behaviour and biology of flounders populating Peter the Great Bay.

May we point out that by marking the flounders, studying the

rate of growth of the flounders from the vicinal regions, analyzing the migration paths and examining the configuration of the ocean-floor in adjacent regions, we established that the shoal of flounders populating Peter the Great Bay was almost completely local in character, a fact which greatly facilitates observations on the state of this school.

Catches obtained by the trawlers employed in flounder fishing proved high during the first few years of industrial fishing. In 1930-1932 we often observed catches of 50-80 or more centners obtained within 5-10 minutes of trawling.

Certain boats obtained 1200-1500 centners of fish during 4-5 days' fishing without particular effort.

During the winter of 1931-1932 the mean catches reached maximum dimensions of 17.3 to 19.5 centners of fish per trawling hour during December-February. However, beginning the winter of 1932-1933 we observed a rather rapid drop in the mean catches (up to 3.2 centners in 1935-1936) accompanied by the simultaneous decrease of the overall catch to 13 thousand centners.

The catches continued to decrease until the end of the trawl fishing, which shows that the shoal of flounders was reduced by intensive fishing.

A similar drop in the mean catches was observed in the regions industrially fished from low-tonnage boats. Thus, in Ussuriyski Bay the mean diurnal catch per motor-boat decreased from 5.35 to 4.20 centners between 1935 and 1937. The reduction of the school of flounders in Peter the Great Bay was also reflected in the territory occupied by the

winter concentration constituting about 1500-2000 square kilometers in 1930-1933. During subsequent years it was difficult to find an accumulation of flounders occupying a territory of more than 100-150 kilometers.

Simultaneously with the increase in industrial indices there occur substantial changes of a different character in the school of flounders. First of all, the catches contain different species, as may be seen from table 139.

TABLE 139.

Changes in the species of flounders found in the trawl catches (in %) obtained in Peter the Great Bay (region of winter concentration).

Species	1930-1931	1933-1934	1935-1936
<i>Limanda aspera</i>	60-70	14	In single specimens
<i>Cleisthenes herzensteini</i>	10-15	26	35
<i>Pseudopleuronectes herzensteini</i>	3-4	27	25
Other species	10-15	43	40

Intensive fishing on flounders was also reflected in the dimensions of catches and in the species composing the catches. The correlation between different species gradually changed and by 1936 became completely transformed. The species dominating in catches i.e. the *Limanda aspera* and *Cleisthenes herzensteini*, which formed up to 85% (occasionally even more) of the catches, were forced out by other forms, which had previously been found in insignificant quantities. The fishing industry therefore concentrated on the secondary forms, which, during the winter of 1935-1936, formed up to 65% of the overall catch. The process of rotation of species occurs continuously. The secondary industrial forms become gradually

more important in the fishing industry. Thus, *Clyptocephalus stelleri*, which was found by lone specimens in trawls during the first few years when fishing was organized, became a fish of some importance by 1939 in both - the trawl catches and in fishing from low-tonnage boats.

In certain cases the catches consisted mainly of these fish. Furthermore, *Acanthopsetta nadeshnyi*, which is a relatively rare fish, usually remaining at great depths, has been frequently taken during the last few years (1944-1948) in the catches made from low-tonnage boats. May we point out that in Peter the Great Bay the species forming a shoal depended to some degree upon the individual fertility of the given flounders when industrial exploitation of the shoal first began. The subsequent appearance in catches of these species considered hitherto as secondary also occurred as a result of the drop in individual fertility of the hitherto leading species.

Thus, the rapidly developing flounder-fishing undoubtedly affected the type of species forming the shoal within a very short period of time.

The leading forms constituting the greatest part of the shoal, gradually drop out, decrease in number and give place to other species, which had hitherto been of secondary importance. May we, however, mention that the food situation is the most important factor determining the qualitative correlations of different species in the shoal of flounders populating Peter the Great Bay. As we already mentioned in the chapter on feeding, the analysis of the feeding habits of flounders

inhabiting the given bay showed that within its limits there exist at least two biological groups feeding on different objects. Overlapping of spectra occurs first of all within the species belonging to the same group. All the species of flounders from Peter the Great Bay may be divided into two groups depending on the food available: the large-mouthed flounders (*Cleisthenes*, *Hippoglossoides*, *Acanthopsetta*) and small-mouthed flounders (*Limanda*, *Lepidopsetta*, *Pleuronectes*). While the representatives of the former group feed in the main on various crustacea and Ophiuroidea, the latter group mainly consume small mollusks and Polychaeta. The correlation of species and the sequence in which their importance varies as a result of the gradual extermination of the leading industrial species by fishing, follow the drop in individual fertility. Thus, with data on fertility and character of feeding of flounders available, we can predict the order in which the main industrial species will be replaced by other forms, as well as assess the catches a priori.

Simultaneously with the drop in catches and changes occurring in the species composing a shoal, we observed the disappearance of older age groups and a sharp increase in the rate of growth of all the species of flounders. As mentioned earlier, the figures expressing the mean dimensions of flounders and correlations between different age groups of fish found in catches serve merely as auxiliary material in the estimation of the reserves of fish, such as flounders, when the measurements are taken from a relatively small number of samples

obtained by trawls of benthic fishing nets, since the differentiated distribution of flounder species, and of flounders of particular dimensions, depends on region and depths, so that a sample taken from one or another boat is of purely individual importance. This statement is particularly true in the case of trawlers operating within a wide range of depth levels.

May we analyze the data on changes occurring in the age composition of the catches of flounders taken in Peter the Great Bay during the period of intensive fishing conducted between 1930 and 1941. We shall examine particularly closely the main industrial forms, such as *Limanda aspera*, *Pseudopleuronectes herzensteini* and *Cleisthenes herzensteini* - the overwhelming portion of all catches.

The age composition of *Limanda aspera* found in the catches of trawlers over the course of the first five years of industrial fishing underwent insignificant changes. The six and seven year old fish always prevailed in the catches (49.6 - 69.6%) forming together with the five- and eight-year-olds up to 86.4 and 90.7% of catches. Analyzing the age composition of trawl catches obtained during these few years, we see that the generation of 1926 was undoubtedly "fertile" and for a number of years (1931-1936) was much more abundantly represented in the catches than were the corresponding groups of other generations. The "infertile" generation of 1928, the development of which was also followed by researchers up to 1936, provides a totally different picture.

Analyzing the age composition of *Limanda aspera*, *Cleisthenes Herzensteini* and *Pseudopleuronectes Herzensteini* in the catches obtained by low-tonnage boats in Ussuriyski Bay between 1935 and 1941, it is very difficult to find clearly-marked prevalence of one generation over another (tables 140-142).

This is because the industrial concentrations of *Limanda aspera* and reserves of *Cl. Herzensteini* and *Ps. Herzensteini* were already considerably exhausted in 1935-1938 so that it is difficult to find fluctuations in the number of different generations, since the exhaustion of a shoal as a result of the intensive fishing results in that fishing operations drag up on young, non-industrial categories. This development is clearly illustrated in the tables presented below.

On the basis of an analysis of the correlation between different age groups of *Limanda aspera*, *Cl. Herzensteini* and *Ps. Herzensteini* in the Ussuriyski Bay (Peter the Great Bay) between 1935 and 1941, we state as certain that the number of older flounders continuously and rapidly dropped while the younger age groups became more numerous (fig.26).

Thus, by 1941, the eight, nine-and ten-year-old fish had already disappeared from catches, whereas in 1935 these fish formed 14.6% of the catches. The specific importance of the five, six-and seven-year-old specimens decreased accordingly from 86.5% to 13.0%, whereas the young and mostly sexually immature fish came to form 87.0% of the catches instead of 8.9%. By 1950 this process became further intensified.

TABLE 140.

Age composition (in %) of the catches of *Limanda aspera* in Peter the Great Bay in 1931-1941.

Year	Age										
	2	3	4	5	6	7	8	9	10	11	12
Askold Bank (Trawls)											
1931	-	0.8	4.7	27.7	37.5	14.8	8.4	4.5	1.6	-	-
1932	-	-	0.9	12.7	38.0	31.6	8.4	3.9	1.8	2.1	0.6
1933	-	1.0	8.5	7.9	24.2	37.1	17.2	1.8	1.8	0.5	-
1934	-	-	6.6	9.9	15.2	34.4	27.6	2.9	3.4	-	-
1936	-	-	1.0	19.1	44.9	17.6	8.7	8.7	-	-	-
Ussuriyski Bay (Benthic fishing nets)											
1935	-	0.6	8.3	20.7	20.6	35.2	11.1	2.9	0.6	-	-
1936	4.5	12.8	12.1	17.0	25.7	18.4	8.8	0.7	-	-	-
1937	1.5	19.7	21.2	12.0	27.4	12.2	3.2	2.1	0.7	-	-
1938	3.8	39.7	48.3	5.3	2.1	0.8	-	-	-	-	-
1940	-	19.3	23.0	18.0	21.4	10.0	7.0	1.3	-	-	-
1941	-	50.0	37.0	12.0	1.0	-	-	-	-	-	-

Table 141.

Age competition (in%) of the catches of *Cleisthenes Herzensteini* in Ussuriyski Bay in 1935-1941.

Year	Age									
	2	3	4	5	6	7	8	9	10	n
1935	0.5	1.6	4.8	21.2	35.0	23.8	11.1	1.5	0.5	816
1936	3.0	15.9	26.0	12.2	25.4	11.3	5.0	1.0	0.2	2768
1937	0.4	5.7	26.9	23.5	39.1	4.0	0.3	0.1	-	1696
1938	1.9	23.2	35.5	22.8	13.2	1.9	1.5	-	-	211
1939	2.6	17.9	40.4	30.6	7.5	1.0	-	-	-	400
1940	0.3	6.4	20.8	25.5	30.0	9.4	6.4	1.3	-	298
1941	-	24.0	29.0	20.0	16.0	4.0	6.0	1.0	-	-

TABLE 142.

Age composition (in %) of catches of *Pseudopleuronectes herzensteini* in Ussuriyski Bay in 1935-1940.

Year	Age.									
	2	3	4	5	6	7	8	9	10	n
1935	-	3.8	22.9	24.6	24.6	14.9	6.5	2.6	-	751
1936	0.5	12.1	27.5	26.0	24.0	8.3	7.0	0.8	0.1	2239
1937	-	23.5	28.6	25.3	18.5	3.3	0.7	0.1	-	660
1938	3.8	31.4	38.6	20.6	5.2	0.4	-	-	-	267
1940	-	17.9	36.4	30.1	14.0	1.3	0.3	-	-	301

DRAWING 26.

Changes in the age composition of certain species of flounders in the catches obtained in the Ussuriyski Bay (Peter the Great Bay) in 1935-1945.

TABLE 143.

Mean dimensions (in cm) and number (in %) to the overall number of fish of small flounders found in catches obtained by means of benthic fishing nets in the Ussuriyski in 1935-1949.

Year	<u><i>Cleisthenes herzensteini</i></u>				
	Percentage of small (below 26 cm) fish in the catches	Mean dimensions of fish in the catches.	Percentage of small (below 24 cm) fish found in the catches	Mean dimensions of fish caught.	Number of small flounders of all the different species in the catches.
1935	8.1	30.2	10.5	29.6	33.1
1936	20.6	33.0	23.1	28.7	29.2
1937	28.4	28.8	43.5	26.7	44.0
1938	43.6	27.9	62.4	23.1	-
1939	34.3	27.6	-	-	68.3
1941	64.6	25.9	63.3	23.0	-
1943	44.0	22.6	92.4	19.4	-
1944	95.6	18.7	92.4	20.7	-
1946	72.5	24.0	68.9	22.2	-
1947	47.4	26.6	43.5	25.3	-
1949	80.1	21.4	-	-	-

It is superfluous to quote facts in similar vein, since the data presented prove beyond doubt that the number of fish belonging to older groups rapidly decreased in the shoal and the fishing progressively concentrated.

A similar phenomenon has been observed in the proportion of different age groups of *Cleisthenes herzensteini* found in the catches from Ussuriyski Bay. The developing fishing industry gradually concentrated on progressively younger age groups. Thus, in 1935, the five, six- and seven-year old fish formed 80% of catches, whereas in 1941 these flounders constituted 40% of catches only.

The age composition of other industrial species underwent similar changes. In 1935, the catches of *Pseudopleuronectes herzensteini* in Ussuriyski Bay contained only 3.8% of fish under four years of age and 23.9% of flounders over six, whereas in 1938 these figures changed to 30.0 and 0.4 respectively.

It is superfluous to quote more facts in similar vein, since the data presented prove beyond doubt that the number of fish belonging to older sexually immature age groups.

Analysis of the statistical data on catches, particularly where the latter were obtained from low-tonnage boats operating in the regions of where there are concentrations of both large fish and of fry, provided supplementary data on the decrease in the mean length of the fish caught (fig. 27). The percentage of fry found in the catches changed yearly. Seven or nine years following the beginning of industrial fishing this percentage reached a considerable figure and the mean length of the main industrial flounders dropped from 29-30 cm (in 1935) to 22-25 cm (in 1946-1949).

In 1939 the number of fry in catches was twice that of large specimens (table 143). It is obviously inexpedient from the point of view of industrial effectiveness to exterminate such great quantities of small, sexually immature fish (less than 24-25 cm in length). Moreover, this type of fishing unfavorably affects the reserves of the fish.

Returning to the analysis of data on the age of fish, may we discuss more thoroughly the changes occurring in the rate of growth. In order to prevent the effect of the Rosa Li phenomenon or, to be more precise, to counter-act this effect in making estimations, we shall present the data on the samples of *Limanda aspera* and *Pseudopleuronectes herzensteini* aged five from Peter the Great Bay following reverse calculations. (Table 144). The mean dimensions of flounders of all ages progressively increase and the most intensive acceleration in the rate of growth began in 1929-1930, i.e. at the beginning of industrial fishing. The study of annual linear increments in each age group showed that the growth underwent the most drastic changes during the first few years of the life of flounders. Thus, the length of one year old males of *Limanda aspera* increased between 1926 and 1937 by 76.7% whereas the annual increments of two-year-old specimens was 34.4%. Meanwhile, the rate of growth of older fish remained almost the same. The length of one-year-old males of *Pseudopleuronectes herzensteini* also increased by 61% between 1927 and 1936.

DRAWING 27.

Length in cm.

Fig. 27. Changes in the dimensions of certain species of flounders found in the catches from Peter the Great Bay, due to the effect of intensive industrial fishing.

TABLE 144.

Mean dimensions of males of *Limanda aspera* and *Ps. herzensteini* belonging to different age groups. (in cm.).

Age	Generation					
	1928	1929	1930	1931	1932	1933
<i>Limanda aspera</i>						
1	5.15	5.25	7.60	6.58	7.12	8.34
2	10.25	11.85	13.60	11.70	13.80	14.10
3	16.40	18.05	19.40	17.42	18.82	19.44
4	20.45	23.45	24.00	21.22	22.02	24.32
5	25.05	28.65	26.80	25.42	26.38	27.66
<i>Pseudopleuronectes herzensteini.</i>						
1	6.2	-	6.2	7.24	9.14	8.42
2	12.4	-	12.1	13.36	15.00	14.34
3	17.5	-	17.0	18.16	19.70	19.50
4	22.0	-	21.2	22.26	23.14	23.84
5	25.2	-	24.3	24.96	26.16	27.16

It is now obvious that the age composition and dimensions and the rate of development of the most important industrial flounders in Peter the Great Bay changed considerably. These changes undoubtedly occurred as a result of the reduction of the shoal of flounders due to intensive fishing. The 5 light fluctuations in the rate of growth caused by the varying fertility of different generations have been overshadowed by the considerable changes in the rate of growth due to

the effect of fishing and therefore, have not been registered.

The degree of intensification of the rate of growth of flounders shows that by fishing out a considerable number of fish the industrial fishing created more suitable conditions for the existence of the remaining specimens. The changes occurring in the shoal populating Peter the Great Bay, due to effective fishing resulted in the decrease of mean and overall catches; changes in the type of species forming the shoal, so that fishing concentrated to a progressive greater degree on secondary forms decrease in the number of fish belonging to older age groups in the shoal; sharp increase in the relative number of sexually immature fry in the catches and intensification in the rate of growth of flounders (particularly of younger specimens). The aforescribed changes were studied starting from the first few months of industrial fishing, a rare phenomenon in the history of industrial research.

The other regions of the Far Eastern waters have been insufficiently explored by industrial flounder fishing thus far so that changes in dimensions, age composition of the shoal and species forming the latter are too insignificant to be observed as yet. The measurements of *Limanda aspera* - the most important industrial species - taken over a number of years off the shores of the Western Kamchatka (table 145) show that the trawl fishing conducted in this area did not affect the dimensions of fish forming a school. However, the intensive flounder

trawl fishing within the limited territory of Ozernovsky Bank off the southwestern shores of Kamchatka somewhat reduced the mean dimensions of the flounders caught there during recent years.

TABLE 145.

Correlation between different groups of *Limanda aspera* (in %) found in the trawl catches obtained during the summer off the Western shores of Kamchatka.

Year	Length in cm.						n	'The data provided by:'
	20	25	30	35	40	45	50	
1931	11.2	11.2	18.4	38.4	13.7	1.1	179	Krivobok
1932	0.2	8.0	56.0	32.9	2.8	0.1	2145	Polutov
1933	3.4	13.1	50.9	26.8	5.8	-	429	Suvorov
1934	2.1	5.2	45.4	41.8	5.1	0.4	1081	Moiseev
1938	-	0.3	19.8	53.5	24.2	0.2	315	Moiseev
1931-1938	1.9	7.3	46.5	37.1	6.7	0.5		
Number of specimens:	62	237	1502	1201	216	16	4149	

It is essential that the exploitation of a school of fish be conducted in the future in a manner ensuring that a definite number of fish be eliminated from the school and that the correlation between different age groups ensuring normal reproduction be preserved. This would enable the natural factors to increase the live weight most effectively. Excessive fishing should be avoided, as it may result in the disappearance of older fish and consequently, fishing operations would result in catches where younger specimens predominate so the favorable effect of fishing upon the school would be nullified. Western fishing exterminated flounders in excessive numbers as is well known.

we shall mention only a few works in the vast literature devoted to this problem.

Thus, Strodtmann and Kandler (1935) indicated that the number of flounders belonging to older age groups rapidly decreased in the catches obtained in the Central zone of the Baltic Sea between 1922 and 1930. For example, in 1922, the six-, seven- and eight-year-old fish prevailed in catches, whereas in 1930 the fishing was mainly based on the two-three-and five-year-old specimens. Blegvad (1927) showed that in waters washing the shores of Denmark only 2.2% of flounders caught in 1926 were over five years of age. This process is quite natural and easy to understand; with the development of unrestricted fishing the specimens belonging to older age groups decrease in number, then completely disappear from catches and the fishing brings in concentrations of younger fish. Similar data have been presented by Milinski (1944), Kandler (1931), Kotthaus (1936), Strodtmann (1935) and many other authors. Simultaneously with this phenomenon, we observed changes in the rate of growth. Andersen (1938), Iensen (1931), Molander (1926, 1931), Paulsen (1938), Petersen (1926), Strodtmann and Langammer (1925) and many other authors showed that intensification of fishing reduces the reserves, but simultaneously intensified the rate of development of flounders. Thus, in the Baltic Sea, in the region situated eastwards of Falster, the length of three-yearold flounders increased from 15.2 cm in 1909 to 26.7 cm in 1924; that of the five-year-old fish from 19.3 to 27.3 respectively. Iensen (ibid.) stated that in 1930 the length of two-year old flounders in Baltic Sea was greater than that of four-year old flounders caught in 1905-1907.

It is interesting to note that in Peter the Great Bay, as well as in many other seas washing the shores of Western Europe, the acceleration in the rate of growth of flounders is caused by the reduction in the number of consuming flounders with the result that the remaining flounders have richer basic food at their disposal. With the increase in reserves of fish the rate of growth of flounders becomes inhibited. Thus, Johansen and Smith Kirstin (1919) observed a considerable decrease in the rate of growth of flounders in the North Sea in 1915-1919 as compared with 1905-1907 due to the increase in reserves of flounders due to fishing having been neglected during the world war.

A similar development took place in the North Sea during World war II (1939-1945) due to the sharp drop in the intensiveness of fishing. Results of a series of investigations into this problem have been written up in a number of articles published during the last few years. Thus, Margarets and Holt (1947) gave numerous data indicating that the age composition and dimensions of flounders in the North Sea considerably increased when the intensiveness of fishing dropped.

Mulicki (1947) gave similar data on the flounders of Gdanski Bay. Iensen (1947) - on the North Sea and adjacent regions.

A brief survey of the few works (among the numerous bibliographic data) on the effect of fishing upon the correlation between different age groups in catches and changes in the rate of growth in the West-European seas shows that

intensive fishing similarly affects the flounders of both the Atlantic and Pacific Ocean.

However, the Soviet ichthyologists were the only scientists to discover the rules governing dynamics active within a shoal of fish as one of the "means of adaptation of a species" (Nikolski, 1950); knowledge of these rules enables us to accurately assess the problem of ensuring high productivity of a water basin.

x x x x x

The brief data on the effect of fishing upon the condition of a school of flounders in Peter the Great Bay enabled us to establish that the fishing which annually resulted in catches totalling 100 and more thousand centners of fish over a period of 20 years (including a considerable percentage of fry) substantially affected the condition of the school of flounders populating this bay, which had not been fished up until that date. The changes occurring in the shoal of flounders in Peter the Great Bay as a result of intensive fishing were as follows:

- a) the mean and overall catches decreased;
- b) the species caught have changed, i.e. the secondary forms gradually gained in importance while the percentage of main industrial flounders sharply decreased in catches;
- c) the number of flounders belonging to older age groups decreased in the school;
- d) the relative number of sexually immature fish sharply increased in catches;
- e) the rate of growth of flounders (particularly of young specimens) sharply increased,

Increase in the rate of growth of flounders, due to thinning of the shoal through fishing in the first stage of fishing ensured that the fish belonging to all age groups attained high gravimetric indices. Rationally conducted fishing may increase the effectiveness of consumption of the available food resources by flounders.

FISHING.

Despite the large concentrations of flounders populating the Soviet waters off the northeastern shores of Asia, there was no large-scale fishing in these regions until 1930. The fishing was by hook cordage, fishing nets cast from the shore, benthic nets and other implements used on a very limited scale and was conducted from a few large consumer-cities (such as Vladivostok). Fishing operations were conducted by individual fishermen and small fishing teams and the fish obtained were sold fresh at the market and consequently not recorded in statistical data.

In view of the aforesaid, it is impossible to obtain any trustworthy figures on the catches of flounders at present. Moreover, most statistical data list the catches of flounders under "other fish". Some occasional data record that catches of flounders in Peter the Great Bay in the region where these catches reached the highest indices, did not exceed 5000 centners until 1929-1930.

Kryukov (1894) believes that in 1891 there about 940 centners of flounders were caught in the region of Vladivostok.

Pavlenko (1920) mentioned that in 1910-1915 small-scale flounders fishing on flounders met the needs of the local Vladivostok market. In other regions of the Far East no fishing on flounders proper was conducted and these fish were caught only accidentally. The arrival in 1911 of two

small steam trawlers - "Fedya" and "Nakhodka" - provided with otter-trawls, considerably intensified the fishing activity. As mentioned before, these trawlers discovered in the very first days of their activity large winter concentrations of flounders in Peter the Great Bay and conducted successful fishing of both - the flounders (which formed 45.5% of catches in 1911) and other fish (Alaska Pollack, cod, etc.). The overall catches obtained by these trawlers in the course of 5 years reached at least 30-50 thousand centners. Moreover, flounders formed the main bulk of catches. However, this fishing of benthic fish so successfully initiated in direct proximity to Vladivostok has been discontinued due to the energetic intervention of fish industrialists, who believed that trawlers, providing fresh fish at low prices, presented serious competition for the expansive products supplied by Kamchatka fishing industry.

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Flounder-fishing was developed to some extent in the waters washing the Southern Sakhalin and Kuril Islands when these waters were in Japanese hands, the latter rapaciously exploited the raw material resources available in these regions.

The data available on the fishing of flounders in these Japanese waters are presented in table 146.

TABLE 146.

Catches of flounders (in thousands of centners) off the shores of Southern Sakhalin in 1936-1945.

Year	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945
Southern Sakhalin	139	157	176	53	104	86	145	200	270	200

Their boats operated hauled in a summary catch of at least 20 thousand centners.

The amount of flounders caught in the Japanese waters off the shores of Sakhalin rapidly reached high indices (210 thousand centners in 1913), then began to fluctuate within a wide range of indices. Intensive fishing seems, to us, to have been subject to no rules, to have rapidly exterminated excessive quantities of fish thus causing drop in the overall catches. It is interesting to note that the Japanese fishermen most obviously tried to exploit most thoroughly fishing territories adjacent to the waters of other states. Japanese fishing boats conducted industrial fishing as far north as Peter the Great Bay and the shores of the Northern Maritimes (Moiseev, 1946), where in 1933-1937 several dozens of their boats operated hauled in a summary catch of at least 20 thousand centners.

Thus, as mentioned earlier, the arrival of trawlers in 1929-1930 and the organization of the Soviet trawling fleet in the Far East were the factors responsible for the relatively high catches of flounders obtained in the Okhotsk Sea and the Sea of Japan, and particularly in Peter the Great Bay. The experience gathered during the operation of these trawlers became a valuable asset when a regular flounder-fishing-industry was organized from low tonnage boats in the Maritimes and from trawlers off the shores of Kamchatka.

The rapid increase in catches obtained by the trawling fleet during the winter in Peter the Great Bay and during the summer off the shores of Kamchatka and later by the low-tonnage fleet whose operations were considerably stepped up in 1935, and use heavy catches

Of flounders taken by casting nets in Kamchatka meant that from 1930 forwards flounders became one of the most important of the quarries for the Soviet fishing industry in the Far East. Shortly afterwards, a series of exploratory cruises on board trawlers and exploration boats were organized and consequently, large concentrations of flounders were discovered in Peter the Bay, Tatarski Strait and off the Western shores of Kamchatka - the main fishing regions developed for industrial fishing. Liquidation of the trawling fleet in 1934 led to a sharp drop in the overall index for catches of flounders in the Far East, but the continuously growing low tonnage fleet transferred to the Maritimes to fish on flounders after the disappearance of sardines in 1941, made high catches throughout the Great Patriotic war during the entire fishing season. Organizing the expedition to fish on flounders in Tatarski Strait, in 1943-1945, the effective winter flounders fishing off the shores of Kamchatka and organizing the processing of flounders caught by casting nets off the shores of Kamchatka considerably increased the overall catches of flounders in the Far East. May we mention, however, that fishing is conducted at present on a scale insufficient to satisfactorily exploit the raw materials available (excepting in Peter the Great Bay, where reserves of flounders are unsatisfactory).

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