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Studies of and Fishery for Pandalid Shrimps (Crustace, Decapoda, Pandalidae) In Boreal Area: Review on the Eve of the XXI Century, with Special reference to Russia

by

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Abstract

All commercial pandalid species were described in 1814-1935. J.Hjort and C.Petersen discovered commercial densities of *Pandalus borealis* in Norwegian fjords in the late 19th century. A.Berkeley (1929, 1939) discovered proterandry in pandalids.

In 1936-1941 *P.borealis* life history had been studied mainly in southern areas. It resulted in that the species was thought to have similar life cycle everywhere. B.Rasmussen (1953) broke this assumption and demonstrated great variability in growth and maturation depending on environment. Horsted and Smidt (1956) and Allen (1959) studied life history in the most severe and mild areas of *P. borealis*.

In Europe and North America fishery for pandalids began in the late 19th century. History of the fishery in European, American and Japanese waters was described in Proc. Internat. Pandalid Shrimp Symp., February 13-15, Kodiak, Alaska, 1981, while that in Russia was poorly documented.

In the North Atlantic USSR/Russia began to fish for *P. borealis* off West Greenland in 1974. Introduction of 200-mile zone in 1977 resulted in leaving this area by the Soviet boats which moved to the Barents Sea. Shrimps in this sea began to be exploited actively only from 1977, and in 1978 their catch reached 18,000 t already.

In the Pacific Russia started industrial shrimping (*P. hypsinotus*, later *P. borealis* also) in the Tartar Strait in 1979, off north-eastern Sakhalin in 1995, off south-west Kanchatka in 1996. After 20 year interval shrimping recommenced in the western Bering Sea. Historical fishery for shrimp was conducted in the Gulf of Alaska (*P. borealis*), in the Anadyr Bay.

History of research and changes in scientific notion (ideas?) about shrimps are described.

Key words: Pandalidae; shrimp fishery; history of research, shrimping in Russia.

Introduction

Pandalid shrimps are of a very great commercial importance. As a fishing object they mainly attracted attention at the very end of the X1X century. That is why all the history of their fishing and studies practically falls within the XX century. At present it would be timely to turn back and make a historical reviewof the most important events in studies of commercial and biological characteristics, as well as development of harvesting of pandalid shrimps in the passing XX century (including the systematics from the XIX century). Therewith it should be borne in mind that in the present paper I primarily refer to the fishery biological aspects in pandalid studies in the Northern hemisphere. Besides, a comprehensive review in pandalids fishing until the late 70s has been already made by Balsiger (1981) in the Proc. Internat. Pandalid Shrimp Symp., 1981. In his review and in other authors' papers published in the Proceedings of the same Symposium, the characteristics are given in biology, fishing and its management in various countries and areas of the Northern hemisphere. That is why I try to draw attention not only to the sequence of chronological events, but also to the development of ideas (notion?) of pandalids, the influence of research studies upon fisheries and vice versa. Besides, I try to pay more attention to the history of Russian investigations as they are poorly described in literature. The given review doesn't pretend to make the picture complete, but it is rather a personal retrospective glance at the shrimp situation.

The following abbreviations of Russian Fishery Instritutes are used in the text:

KamchatNIRO, Kamchatka Research Institute of Fisheries and Oceanography, Petropavlovsk-on-Kamchanka;
MoTINRO, Magadan Branch of TINRO, Magadan;
PINRO, N.M.Knipovich Polar Research Institute of Fisheries and Oceanography, Murmansk;
SakhNIRO, Sakhalin Research Institute of Fisheries and Oceanography, Yuzhno-Sakhalinsk;
TINRO, Pacific Research Institute of Fisheries and Oceanography, Vladivostok;
VNIRO, Russian Research Institute of Fisheries and Oceanography, Moscow.

Systematic studies, commercial species

It is natural that before studying biological characteristics of a species it is necessary to establish its identity. *Pandalus montagui* Leach, 1814, *Pandalus borealis* KrØyer, 1838, *Pandalus platyceros* Brandt, 1851; *Pandalus hypsinotus* Brandt, 1851; *Pandalus danae* Stimpson, 1857; *Pandalus goniurus* Stimpson, 1860; *Pandalus latirostris* Rathbun, 1902 (= *P. kessleri* Czerniavsky, 1878); *Pandalus jordani* Rathbun, 1902; *Pandalopsis dispar* Rathbun, 1902; *Pandalus nipponensis* Yokoya, 1933; *Pandalus borealis eous* Makarov, 1935 were described, they are abundant pandalid species in the North Atlantic and Pacific. These studies represent a zoological systematic stage in the pandalid researches. Up to the present, this stage cannot be presumed to be completed. It is enough to say that the interrelationships between such important commercial species as northern shrimp (*P. borealis*) in the Atlantic and North Pacific remain to be not fully clear. Some authors consider Pacific and Atlantic forms as conspecific. At least the name *P. borealis* KrØyer is used practically in all the fishery biological studies conducted in the North Pacific. Other zoologists consider Pacificm form as a subspecies (*P. borealis borealis* Kr. in the Atlantic and *P. borealis eous* Makarov, 1935, in the Paicific) (see Sokolov, 1997). Besides, they are also believed to be two separate valid species (*P. borealis* Kr. in the Atlantic and P.*eous* Makarov in the Pacific; Squires, 1992). In the present paper I use the name *P. borealis* for the Pacific form as it has been assumed so far in the majority of nontaxonomic publications. I share opinion (Sokolov, 1997) that both the Atlantic and Pacific forms are no more than subspecies.

Much new in the systematics has been found quite recently in such an important commercial genus as *Pandalopsis* (Komai, 1994).

Unlike the Atlantic, where among pandalids the most abundant is the only species, *P.borealis* (the fishery for *Pandalus montagui* is negligible off the British and Canadian coasts), in the North Pacific many species are commercially important. While moving from the Bering Sea southward, in the Pacific a more important role is played by other pandalid species. Thus, if in the Bering Sea the most important species are *P. borealis* and *P. goniurus* (Ivanov, 1979), in the Sea of Japan more numerous are *P.borealis, P.hypsinotus, P.nipponense* and others

(Kurata, 1981), as well as off the British Columbia coast and southward *P. hypsinotus, P.platyceros, P.jordani, Pandalopsis dispar* (Butler, 1964, 1970, 1980; Dahlstrom, 1970).

Nevertheless, in the Pacific also, at least in its northern areas, fisheries developed mainly due to *P.borealis*. Only during some periods another species, *Pandalus goniurus*, was more numerous. But in the North Pacific *P. borealis* was not considered by fishermen as deep-sea prawn as its fishing was often conducted at depths less than 100 m.

First fishery biological studies and fundamental biological discoveries

At the end of the X1X century, J. Hjort, C. Petersen discovered potentials of commercial fishery for *P. borealis* in the southern Scandinavian fjords. It attracted much attention to this species as a commercial object and it gave impetus to its study (Hjort and Ruud, 1938). Norwegian fishery and results of studies of *P.borealis* in Norway for a long time will define our notion (ideas?) about this species and its "image".

Wollebaek A. (1903, 1908) made first attempts to describe biological peculiarities of *P. borealis* before proterandrias had been discovered. But the real understanding of pandalid biology became possible only after A.Berkeley's discovery.

Alfreda Berkeley (1929, 1930) discovered proterandric hermaphroditism in the pandalids. It was the most important achievement in the biological studies of pandalid shrimps. Only after this most interesting peculiarity in pandalids had been established, their research obtained a sound scientific base. She also described larval stages in a number of Pacific species.

J✶gersten G. (1936) was the first to distinguish primary and secondary females, i.e. those females which hadn't functioned before as males and hence hadn't changed their sex.

In late 30s - early 40s, the ecology and life cycle of *P.borealis* were described (Hjort and Ruud, 1938; J✶gersten, 1936; Poulsen, 1946). These works were performed not far from the southern boundaries of *P. borealis* area. As a consequence of similarity in biological parameters in the areas under study, an impression was formed about a slight variability in the processes of growth and maturation in this shrimp. Being adopted not in so many words (silently?), this paradigma was completely destroyed after B.Rasmussen's investigations.

The Second World War hampered considerably the development of fishery for and studies of pandalids in the Northeast Atlantic. Military operations were conducted in the sea from the Barents Sea to Iceland. Besides, in hard war years when the USSR and West Europe experienced difficulties with food, the fishermen paid more attention to abundant fish species rather than to delicacy crustaceans. Fishermen of many countries, including Russian ones in the Barents Sea, at the risk of their life, continued fishing to provide their peoples with fish, paying much less attention to harvesting for shrimps.

In the USSR/Russia shrimps generally hadn't been popular among the people and gradually with Russia's later passing out of the long isolation, and after the development of economic relations with western countries where shrimps had been popular since very long ago, their commercial value became recognized. Nevertheless, their harvesting was delayed until the middle of the 60s because of shortage of freezing units both on board and on land. It is a paradox but lack of cold in Russia became an obstacle in the development of fishery for shrimps.

But Birger Rasmussen (1942, 1945, 1947, 1953) continued working even during the War and after it was over, he described biological peculiarities of the life cycle of *P. borealis* over a huge area from the southern Norway to Spitsbergen. He was the first who demonstrated great variability in growth rate and maturation of *P. borealis* along its extended area.

Now the conception of variability of the main biological parameters of *P. borealis* as a function of geographical position/temperature conditions in that area seems completely natural. That is why the importance of B. Rasmussen's contribution to science may be underestimated. But it is enough to become familiar with scientific papers of the "pre Rasmussen period" in which the authors who worked in the northern parts of the area tried to explain their observations on the basis of a widely accepted "old paradigm" (similarity of biological cycle and most important biological parameters of the species over the whole species area) (see for example, Palenichko, 1941), and the importance of Rasmussen's merits in breaking old ideas becomes clear.

After Rasmussen's researches the studies of biological characteristics of various populations began to advance successfully and their biology in the North Atlantic were described soon.

In 1967 in frame work of FAO World Scientific Conference on the biology and culture of shrimps and prawns, Mexico-City, Mexico, 12-21 June 1967, where specialists on penaeids greatly predominated in number, Dr. B. Rasmussen held "mini-symposium" of pandalid biologists at his room in hotel "Reforma" in Mexico-City. I was among participants together Mr. Apollonio, Dr. Butler, Dr. Gotshall and others. Probably, it was the first international meeting of pandalid scientists and Dr. Rasmussem, as an organizer, helped to make personal acquiatance for the participants and to arrange a scientific exchange which existed (was lasting?) for dozens years.

Investigations and fisheries in the Atlantic

After Dr. Rasmussen publications, number of good papers appeared with description of results on life history local populations. Horsted and Smidt (1956, 1965), Allen (1959) described the life history of *P. borealis* off Greenland, the most severe part of its area, and off Northumberland, the "warmest" part, respectively.

In the western Greenland the lethal effect of long term influence of negative water temperatures upon the eggs of females and even adult shrimps was observed for the first time. After these studies in the Atlantic the biology of the species was investigated within the whole temperature range of the species area.

It is interesting that *P. borealis* in each area was confined to a rather narrow temperature range and could be considered and even considered as a stenothermal species. Norwegian fishermen used off-bottom water temperature as a very useful tool for shrimp commercial concentrations searching. Nevertheless, if we compare the general temperature range within the whole area where commercial concentrations of the species are encountered, we see that *P. borealis* is far from being a stenothermal species. Its fishery is usually conducted at temperatures from 1^0 to 8^0C (Ivanov, 1972).

Similar alterations (change?) in our knowledge also occurred with regard to bathymetric distribution of the species. While studying ecological conditions of the species in Scandinavia an idea appeared that *P. borealis* is a bathyal species predominantly inhabiting deepwater fjords and bays located comparatively close to the shores (for example, in Skaggerack, in the Gulf of Maine). Only much later, in the second half of the 60s, commercial concentrations of this shrimp were encountered in the Barents Sea, far from the shores.

Dow (1963, 1964) showed a relationship between the abundance of year-classes and catches of *P. borealis* in the Gulf of Maine, on the one hand, and climate conditions, on the other. His studies are likely to be the first to analyze the dynamics of abundance of one population of the species depending on environmental factors (temperature) over a long-term period.

In the USSR, in the middle of 60s - early 70s drastic changes happened in our knowledge concerning abundance and biology of shrimps in the North Atlantic. Over prolonged periods fishermen and scientists hold to the idea that *P. borealis* forms concentrations only in the fjords. Such an opinion was due to the shrimp fishery pattern in Norway, the nearest Russian neighbouring country, where shrimps had been harvested since very long ago. The "oldest" domestic trawl fishery, which marked its centenary in 1999, dates back to the 20s in the Barents Sea. It would seem to confirm this opinion because commercial shrimp concentrations were not recorded in spite of long term fishery in the high seas. Targeting for only fish harvest suggested that shrimps in the high seas were only a food item for fishes rather than an object for the directed fishery.

In 1967, Norwegian fishermen registered commercial concentrations of *P. borealis* in open parts of the Barernts Sea. This event made it possible to change our belief that *P. borealis* was a dweller of coastal bays and fjords. The early 70s is considered to be the beginning of Norwegian fisheries for *P. borealis* in the open waters of the Barents Sea and off Spitsbergen. Russian fishermen have started their fishing operations there only since 1974. Now this area became very important for shrimping in the World.

At the very beginning of 70s the Faroes fishermen also recorded commercial concentrations of *P. borealis* off the West Greenland out of the coastal fjord zone (Store Hellefiske Bank). Some time later, in 1973, Soviet reconnaissance vessel BMRT-422 "N.Kononov" also recorded these concentrations. Shortly after this, area became one of the main fishing grounds for many European and American fishing vessels. Now the total catch in this area reached well more 50,000 t. Rapid growth of shrimp fisheries in Davis Strait and adjacent areas is may be the most impressive event in last 25 years.

Taking into consideration all the importance of these fisheries, the North West Atlantic shrimp stocks monitoring is carried out by specialists from many countries, and results of their studies are regularly discussed at the NAFO meetings. Canadian scientists play the leading role in these explorations. Publications from this area became so numerous that it was difficult already to assimilate them.

Russian fishermen started commercial harvesting for shrimps in NW Atlantic in the autumn of 1974 and continued increasing it until 1976. Annual catches of shrimps (in tonnes) were as follows: 1974 - 3,517; 1975 - 6,033; 1976 - 6,468. In 1977, Greenland declared its 200 miles Exclusive Economic Zone and as a consequence the Soviet fleet deprived of possibilities for fishing. Nevertheless, Russian fishermen had already aquired experience for this fishery, admitted high value of shrimps and turned their attention to the concentrations which had been ignored before. If in 1974-1976 in the Barents Sea, shrimp fishing was carried out only by one or two vessels and during very short time, since 1977 shrimps have been harvested by 10 to 15 vessels, and in 1978 their catch in the Barents Sea reached 18,000 tonnes. The highest annual catch was taken by the Russian fleet in the middle of 80s when it amounted to 43,000 tonnes.

So far the Barents Sea and waters off West Spitsbergen are shown to be the most important shrimp fishing area for Russia. Areas of Russian harvesting of shrimp are represented in fig.1. Norwegian fishermen also operate here and their catches are approximately twice as big as Russian ones. Russian fishermen underexploite shrimp stocks because of unsufficient fishing efforts. Other species, as for example cod, are often more profitable and prevent the fishers from shrimping. In 1998 Russian shrimp catch in this area was only 4,900 t.

Beginning with 1982, Russian scientists from PINRO annually perform trawl stock surveys in the Barents Sea and adjacent areas. Since 1984, these studies have been coordinated with the Norwegian colleagues and are conducted with commom survey methods (Berenboim, 1998).

In spring of 1993, concentrations of *P. borealis* were recorded on the Flemish Cap Bank out of the 200-mile Economic Zone. Soon shrimp fishery was carried out by 15 countries, including Russia. Maximum annual catch (48.600 tonnes) was reached in 1996. Russia began its fishery in this area in 1994 and the highest catch was taken in 1996 (4,444 tonnes) (Parsons, 1998).

At present, the studies of pandalid shrimps in the Atlantic have become regular and well coordinated due to international scientific fishery organizations ICES (Shellfish Committee) in the Northeast Atlantic and NAFO in the Northwest Atlantic. These organizations are characterized by the use of modelling approach when studying dynamics of populations and stocks of fishing objects, including shrimps.

Investigations in the North Pacific

After A.Berkeley's excellent studies in the Pacific pandalids biology, there was a prolonged recession. Shrimp researches seems to be mainly exploratory, no important papers on fishery biology of shrimps were published up to 60s. T.H. Butler (1964) in British Columbia was one of few who studied local populations of pandalids and published his results. Nevertheless, pandalids fisheries were developing both along the Pacific coasts of US (California, Oregon and Washington) and in British Columbia and Alaska.

As in the Atlantic, in the middle of 60s - beginning of 70s, serious changes occurred in the knowledge (notion?) of Russian biologists concerning the distribution of abundace of Far Eastern shrimps.

In previous years Russian marine biologists hold to the idea (notion?) that the richest area as to the species diversity and abundance in the Far Eastern seas is the Peter the Great Bay (Sea of Japan). But this opinion has drastically changed in late 60s.

First evidences of high abundance of shrimps in the north which could be not less than in the Peter the Great Bay were obtained off Sakhalin in 1958-1959. Commercial concentrations of humpy shrimp enough for trawl fishery were recorded in the Aniva Bay (Kundius and Skalkin, 1962; Skalkin, 1970). But in those years the Soviet fish industry was not ready to exploit shrimp resources as there were no vessels equipped with deep freezing units and the on-shore infrastructure was not adequately developed. That is why this discovery had a slight influence upon the scientific thinking (ideas?) about shrimp potential in the Russian Far Eastern Seas. However in the early 60s even more dense concentrations of *P. borealis* were recorded in the Gulf of Alaska and Bering Sea. These concentrations were discovered as a result of studies conducted during the Bering Sea reconnaissance and fish trawling expedition held by TINRO-VNIRO in 1957-1965 in the Bering Sea and the Gulf of Alaska. During this expedition and some time later there were found concentrations of northern shrimp (*P. borealis*) near the Pribilof Islands (in 1960) and in the Gulf of Alaska (in 1961-1962); humpy shrimp (*P. goniurus*) in the Gulf of Anadyr (1967), the Anastasya and Dezhnev Bays (1972), the south of the Navarin Cape (1974) (Ivanov and Stolyarenko, 1992a; Ivanov, 1979). As a result of this expedition, the geography of Soviet fishery has heavily (greatly?) changed. Among other things, this expedition became a real "scholarship of marine biologists". I also consider myself as a scholar of this long-term expedition.

In 1954-1965, large-scale explorations for shrimp stocks were carried out in the Gulf of Alaska by American scientists (see Roncholt, 1963, for a summary). American and Russian investigations (the latter have been conducted since 1961) completed each others well as the American ones were mainly performed within the US fishing zone (in those years it was 12 miles wide), while the Russian explorations were carried out of 12 miles zone. This work resulted in a discovery of important fishing grounds of northern shrimp both by American and Russians, i.e. within the US fishing zone and out of its boundaries: to the east of the Shumagin Islands, in the Stepovak Bay, the Pavlof Bay and near the Kodiak Island (Roncholt, 1963; Ivanov, 1963, 1970).

In 1960, Russian research vessel "Bronnitsa" recorded a commercial concentration of northern shrimp near the Pribilof Islands, in the eastern Bering Sea (Anufriev, 1961). In the same year, a large-scale Japanese fishery for *P. borealis* started in that area. The peak of Japanese catches took place in 1963 (31,600 tonnes). Later there occurred a precipitous decline in catches and the concentration disappeared. After 1967, the fishery practically ceased near the Pribilof Islands (Ivanov, 1964, 1974).

It would be interesting to mention that the discovery of the unique Pribilof concentration at a distance of hundreds of miles from the continent, over flat even bottom, at relatively low depths (Ivanov, 1970) didn't lead to a change in the ideas of European biologists concerning (considering?) the northern shrimp as a primarily "fjord" bathyal species inhabiting deep waters on the slopes and in the depressions of closed bays, or at least not far from large land masses. In general, the results of explorations in the Pacific seem to be little known to the European scientists and/or didn't produce much effect on their ideas.

In 1967 at the expedition by TINRO on board SRT "*Kalmar*" during searching shoals of Arctic cod (*Boreogadus saika*) huge concentrations of humpy shrimp (*Pandalus goniurus*) were incidentally found. Their trawl catches reached up to 10 t/15 min. Probably the shrimp concentrations were the densest in the world. Even though the shrimp is small-size species, such powerful concentrations attracted fishers and the shrimp supported Russian shrimp fishery after Pribilof concentration disappearing. Japanese fishers also exploited the stock.

In the North Pacific (Gulf of Alaska and Bering Sea) the shrimp stocks are known to greatly fluctuate (Anderson, 1988; Orensanz et al., 1998). The abundance of *P. borealis* to the south of the Alaska Peninsula sharply decreased after 1978 and its stocks haven't recovered so far. While in 1976 the catch of pandalids in the Alaska waters amounted to 58,500 t, in 1993 their catch was only a few thousands of tonnes (U.S.Dep. Commerce, 1993). A huge concentration of *P. goniurus* in the Gulf of Anadyr, the biomass of which in 1975 was estimated at a level of 350,000 tonnes, by 1983 had lost its commercial importance (Ivanov, 1981; Ivanov and Stolyarenko, 1992). Among other areas of the World Ocean similar drastic fluctuations in the shrimps abundance were recorded only in the Gulf of Maine (Dow, 1963, 1964).

Large catches of shrimps taken by Japanese vessels in the Bering Sea in the 60s and an active development of shrimp harvesting in the Gulf of Alaska seemed to give the first place to the North Pacific in global pandalid fisheries pushing aside the North Atlantic, but a sharp "serial" depletion in their abundance in the Bering Sea and in the Gulf of Alaska kept for the North Atlantic its leading position in the World pandalid shrimping.

Important fluctuations in stocks were observed in the populations of *P. borealis* and *P. goniurus* inhabiting mainly relatively shallow waters on the shelf (less than 100-120 m). Bathyal populations even of the same species, *P. borealis*, inhabiting the continental slope and/or deepwater troughs at depths over 200 m seem to be more stable. The dynamics of abundance of relatively shallow water and bathyal populations may depend on different factors.

The causes of changes in pandalid abundance are poorly studied but it is definitely to say that the dynamics of shrimp populations is affected by the environmental factors - abiotic and/or biotic ones (particularly, pressure of fish predators). Overfishing has always been under suspicion but it was not conclusively proved as a main cause in the shrimp stock declines. Mass fishes feeding on shrimp such as cod (*Gadus morhua*, *G. macrocephalus*), polloch (*Theragra chalcogramma*) etc. seem to be a factor which can greatly reduce a shrimp abundance (*P. borealis*, *P. goniurus*) both in the Atlantic (Ponomarenko and Yaragina, 1984; Berenboim et al., 1993; Lilly and Parsons, 1991) and Pacific (Zgurovsky et al., 1989). The study of interrelationships between shrimp and fish predators (like, for instance, Nilssen and Hopkins, 1992) seem to be very promising for understanding regularities of shrimp stock dynamics.

Fluctuations in shrimp stocks greatly affect the scale of their investigations: at a high level of their stock abundance the fishery biological studies usually become regular, while declines in stocks lead to reductions and even to complete halting of shrimp surveys.

Harvesting for pandalids in the Russian Far East

Until the late 50s the harvesting for pandalids in the Russian Far East was insignificant and was practically based upon only one species - grass shrimp *Pandalus latirostris* (=*P. kessleri*). This species inhabits meadows of sea grass *Zostera marina* at depths not more than 10 m. It was harvested from motor boats by means of small trawls or traps. Fishery is conducted within the coastal zones in numerous bays of the Peter the Great Bay, in the sheltered bays along the whole Primorie (Maritime Territory) to the north of the Tartar Strait, off the western coast of Sakhalin, in the Aniva Bay, in the Bussey lagoon, off the southern Kuril and near the Malaya Kurilskaya Gryada.

Before the 90s the harvesting was mainly for subsistense. In late 20s in the Peter the Great Bay, the total catch of shrimps amounted to 4.2 to 10.6 tonnes. In 1931-1937, it fluctuated from 24.2 to 76.2 tonnes (on average, 45.0 t). At that time potential catch of grass shrimp was estimated at 500 tonnes.

In 1931 concentrations of commercial sculptured "bear shrimp", *Sclerocrangon salebrosa*, were recorded in the nortern Tartar Strait (A.Ivanov, 1931). This discovery was disregarded for many years. Up to now the shrimp attract little attention of fishers even though the commercial stock (biomass) is estimated as high as 18,000 tons.

The fishery for the shrimp has a good promise but its development is restrained by low demand for this shrimp species.

In 1938-1942 in the Southern Sakhalin and Southern Kuril waters, i.e. when these areas were under the Japanese governing, the total catch amounted to 75-842 tonnes (on average, 435 t). After the Second World War the catch of shrimps didn't reach that level. Statistical data are scanty. In 1948 and 1949, the catch reached only 17.6 and 1.8 t, respectively. In 1954-1958, it varied between 2.8 and 4.9 t. Possible catch in these waters was assessed at 600 tonnes. Nevertheless, the actual catch was likely to exceed the registered one, as the fishing was mainly performed for personal consumption, statistical data were not reliable.

Thus, over a long period of time when the USSR/Russia followed a planned economy model and state monopoly in business activity, the catch of grass shrimp was much lower than potential one. A "bashful" poaching fishery developed violating numerous restrictions imposed on private trade.

In the 90s, after the transition to market economy, weakening of state control over foreign trade and fishing, the harvesting for grass shrimp, especially off the Southern Kuril Islands, i.e. in proximity of the Japanese ports, became more intensive and the fishermen land their catches of shrimps (and crabs) in Hokkaido. Poaching traditions obtained a new impulse and gained great scales. "Bashful" poaching has transformed into an insolent and provocative activity. Therefore the real fishing statistics is practically unavailable. Now Russian annual landings of grass shrimp taken off the Southern Kuril Islands, Sakhalin and Primorye are likely to reach a few hundreds of tonnes.

In winter of 1959-1960, the scientists from TINRO found commercial concentrations of deepwater large humpback shrimp (*P. hypsinotus*) in the Peter the Great Bay. They were recorded at depths of 150 to 450 m between 131^{o}10' and 131^{o} 45' E and between 132^{o}10' and 132^{o}45' E. Maximum catches (100-150 kg/h) were taken from depths 200 to 315 m. Nevertheless, this discovery didn't result in stable harvesting for shrimps in that area. It was conducted from time to time as freezing vessels were unavailable yet.

In 1959, commercial concentrations of sculptured shrimps *Sclerocrangon salebrosa* were recorded at depths of 50 to 80 m to the south and southwest of the Askold Island. This discovery supported in that time the conclusion that the Peter the Great Bay is the richest area in respect to both their species diversity and stock abundance.

In 1958, operative reconnaissance vessels from the "Sakhalinrybprom" (State Fishery Company) recorded comparatively large concentrations of shrimps off the Southern Sakhalin coasts in the Aniva Bay. They were observed in the open part of the Aniva Bay at depths of 45 to 105 m. The species fished was *Pandalus goniurus*. Trawl catches reached 0.1 to 1.5 t/h. In 1960, two vessels took here 40 tonnes of shrimps. In May of 1961, their catches amounted to 1-1.5 t per 1.5 h trawlings at depths from 80 to 100 m. One of these vessels during 17 working days made 61 trawlings and its catches reached 10.4 t (Kundius and Skalkin, 1962; Skalkin, 1970).

Promising results were also obtained near the Kuril Islands. To the north of the Shikotan Island and near the Malaya Kurilskaya Grayda at depths of 100-115 m catches of large humpback shrimp (*P. hypsinotus*) (50-400 kg per 1.5 h trawling) were taken (Kundius and Skalkin, 1962). But then it was too early to exploite these stocks.

Although Soviet/Russian fishery biologists were the first to discover a commercial shrimp concentration near the Pribilof Islands, or at least found it at the same time with their Japanese colleagues, USSR/Russia didn't harvest for shrimps in the Bering Sea because of lack of freezing trawlers in early 60s. Besides, the Soviet planned economics was targeted to mass species rather than to valuable fish and invertebrate species, and the plans for fish landings were drawn up only by weight rather than by value. That is why fishermen were not interested in harvesting for valuable but not abundant fishing species. Perhaps, only king crab was one of few exceptions. The importance of its fishery was recognized before and this crab (in former times famous canned crab "Chatka") became one of most important hard currency sources in the USSR.

Thus, shrimp fishery in Russian Far East up to mid-60s was mainly subsistence, artisanal or semi-industrial and harvesting was conducted near consumption centers mainly. Industrial shrimping began from appearence of freezing trawlers. In 1964-1966 in the Gulf of Alaska there were up to 15 freezing boats and 1 transport vessel were engaged in exploiting *P. borealis* stocks on the banks discovered in previous years (mainly east of Shumagin Islands and off Kodiak). In 1966 catch of Russian fleet here was about 10,750 t. One boat caught more than 3-5 t per day.

Before 1967, Russian shrimp fishery was conducted mainly in the Gulf of Alaska. Later, after the discovery of large humy shrimp stock in the Anadyr Bay and after protective measures, importance of *P. goniurus* in the Russian catches became higher. In 1975 catch of this small shrimp reached 14,300 t. This success proved to be fatal. It was impossible to sold such volume of shrimp in demestic markets. The people showed no interest to buy the shrimp due to their small size. Because of prolonged storage and violation of temperature regime a good deal of shrimp production deteriorated. Even farms for rearing of fur animals rejected such production. So several thousand tons of spoiled shrimps were thrown out into the waters of Peter the Great Bay. This action provoked protests of conservationists concerned on the water pollution. Ministry of Fisheries of the USSR was to organize a special consideration of this case and punished the guilties. The fishing organizations responded radically, they stopped to fish for humpy shrimp. The allergy to humpy shrimp fishing was retained for very long time.

Now some evidence to fishery for humpy shrimp appeared but catch of the species is negligible due to low abundance of the species. Low level of *P. goniurus* stocks is observed for more than 20 years already. So harvesting of more valuable shrimp species is more profitable for fishers.

Fishing for deep water shrimps in the Okhotsk and Japan Seas was developing without such dramatic events (cases?).

In the Sea of Japan, Tartar Strait is the most important area of shrimp fishery. The fishery is supported by two species, humpback shrimp (*Pandalus hypsinotus*) and northern shrinp (*Pandalus borealis*) with little admixture of *Pandalopsis japonica*. Russia began to fish for these shrimps in Tartar Strait from 1979. Japanese fishers caught shrimps here till 1984 and they worked only outside of 12-mile fishing zone between $47^0$00' and $48^0$30' N (Galimzyanov, 1994). Before 1984 Japanese catch was higher than that of Russia (Table 1). From 1984 shrimp fishery is conducted by Russian boats only excluding 1994 and 1995 when Japanese fleet was permitted again to fish for shrimp in the Tartar Strait covered completely by the Russian 200-mile exclusive zone. The shrimping in this area began to develop very intensively from early 90s after a refuse from the state monopoly on the foreign trade. Number of shrimp vessels from 1990 to 1994 increased from 14 to 35 units and in 1995 there was 62 vessels already harvesting shrimps here. Catch data for shrimp fishery in the Tartar Strait are represented in Table 2.

Shrimp pot fishery season in Tartar Strait lasted from April to December till 1991 but in 1992 fishing commenced from February already. In beginning of the season shrimp pots are set usually at the depth of 100-200 m where the most dense concentrations of humpback shrimp are observed in that time. In summer and autumn when the shrimps get more scattered and moved at the greater depths, fishers harvested them up to 500-600 m deep.

The humpback shrimp is much more attractive for fishers in terms of value compared to the northern shrimp. That is why the fishers try to realize common quotas for two species (even they received the quotas separately for each species), only at expense of *P. hypsinotus* while *P. borealis* quota remains under-harvested. Accordingly to SakhNIRO biologists, it resulted in decline humpback shrimp abundance in 1990-1993 due to overfishing. To protect this species stock in Tartar Strait SakhNIRO recommends to introduce (employ ?) strict limitations (decrease of number of shrimp boats, decrease of quota, a ban on trawling at the depths less of 400 m etc.).

Experimental trawl fishing in Tartar Strait was conducted in 1993. Due to low level of humpback shrimp major species fished was *P. borealis*. The catches of this shrimp were very good at the depths of 400-600 m and commercial trawl fishery for shrimp here began from 1994. The northern shrimp in Tartar Strait is characterized by very large sizes. Females reach 40 mm in size (carapace length). SakhNIRO recommends to limit trawl fishing between $46^0$00' and $49^0$30' N and depth from 400 to 600 m only to protect depressed humpback stock.

In 1997 catch of P. borealis in Tartar Strait was 651.8 t. The catch was taken by 19 boats.

In 1995 trawl fishing for the northern shrimp began along eastern coast of Sakhalin Island, Okhotsk Sea. The catch in 1995 was only 40 t. In 1996 the catch was already 442 t and in 1997 the harvest was approximately as high as that in 1996. Twelve shrimp boats were engaged in this fishery in 1996. The harvesting of the shrimp was conducted from Cape Terpeniya ($48^0$30' N) northward to latitude ca. 54^0 N. The dense concentrations of the shrimp confined to the depths of 250-300 m north 49^0 N. A shrimp trawler harvested about 25 t per a month or 200 t per a fishing season. Trawl fishing proved to be much more effective than pot fishery. For comparison, a boat with shrimp pots harvested only 10 t per a month or 60 t per a season. Shrimps off eastern Sakhalin can be fished from June to December. Shrimp biomass here was estimated as high as 14-15x10^3 tons by SakhNIRO.

In 1997 trawl fishing of humpback shrimp was undertaken for the first time in south-western Aniva Bay. The fishing was at the depth of about 100 m. The fishing was successful. The biggest ovigerous female weighed 117 g. The fishery here is expected to be regular.

In 1993 shrimp concentration (*P. borealis*) were rediscovered off south-west Kamchatka Peninsula, the Okhotsk Sea. In past (1970-1976) the concentration were actively exploited by Japanese fleet. The fishing was carried out at the depth of 200-300 m at latitudes from 52^0 to 54^0 N from May to December. Peak of catches were in July. Annual catch of Japan in this area reached 5,000 t 91973). The stock was estimated to be 10-15 x 10^3 t in 1970 but later it declined to 5,000 tons. The observed decrease in available stock size was attributed mainly to fishing activity. The allowable biological catch from this stock was estimated at a level of about 3,500 mt/year with a total 18,000 hours of trawling efforts (Kurata, 1981).

In 1997 Russian fishers took off sout-western Kamchatka Peninsula between $51^0$30' and 53^0 N 26 t of northern shrimp, but in 1998 the catch was already 591 t. Average catch here in 1998 was 1,438 kg per day for a boat. Shrimp counts ranged from 51 to 105 specimens/kg (mean 66 spec/kg). Undoubtly, the fishery for shrimp in this area will grow fast.

In 1998 harvesting of northern shrimp began in the western Bering Sea off Cape Navarin along continental slope. Maximum catches were recorded at the depth of 240-365 m. In August-October 1998 the catches were usually 470-600 kg/hr haul (maximum catch was 1635 kg/hour). Besides *P. borealis*, large-sized side-striped shrimp *Pandalopsis dispar* occured in trawl catches as a by-catch. The area became one of the most attractive for shrimping.

Areas of Russian shrimping in the North Pacific are represented in fig.2.

Studies of some biological aspects

In this part of my paper I refer only to some fishery biological aspects of investigations, particularly those in which Russian scientists participated and which are likely to be little known to foreign colleagues.

<u>Growth studies</u>

It is well known that growth studies in crustaceans in general, and particularly in shrimps, involve considerable difficulties as they have no growth registering structures. As a rule, growth of shrimps under natural conditions is studied by analyzing population size structure (usually by samples from trawl catches). In this case the fundamental assumption follows the principle "one size group corresponds to one age group". This assumption is quite reasonable as in boreal waters pandalids have one generation per year. But B.Rasmussen, one of the most competent investigators of shrimps, challenged this generally accepted fundamental assumption (Rasmussen, 1953, 1967). Based on observations over the changes in the size composition of shrimp population in one fjord he drew a conclusion that within even a small population, shrimps of one generation and hence one size (modal) group may be divided into two separate size/modal groups consisting of fast and slow-growing inviduals. Thus, according to Rasmussen, one age group may correspond to two size/modal groups.

This study, being very important by its conclusions and consequences, was not practically discussed in scientific literature. I suppose that all specialists who studied shrimp growth came to a "silent" agreement to ignore and disregard this work as the recognition of Rasmussen's conclusion rightness would have resulted in severe problems and even impossibility in interpretation of length frequency distributions for ageing of shrimps. For these specialists Rasmussen's work was approximately the same as "Jenkins' nightmare" for Ch. Darwin.

When Dr. D.A.Stolyarenko and me began studying *P.goniurus* growth in the Bering Sea, I had to revise carefully Rasmussen's original data which his conclusion had been based upon. It appeared that his data can be interpreted otherwise and it eliminates difficulties created by Rasmussen: the second group considered by him as an evidence of division of one generation, actually was a result of variations in size composition in shrimp samples. This second group was not previously presented in samples and its appearance doesn't mean that one generation is divided into two size groups (Ivanov, 1978). Appearance and disappearance of a size/modal groups in shrimp samples can't be regarded unusual.

It is very difficult to age the first modal group when analyzing length frequency distributions. Yearlings (0+) and early juvenile shrimps (1+) are often absent or occur so rarely in samples that they don't form a well-defined modal class. That is why when ageing the first modal group in samples, it is often erroneously underestimated, which results in erroneous ageing the following groups. A similar error is seen, for example, in Dow's studies (1963, 1964). In this respect, I find very important the work by Simard et al. (1990) who distinguished three cohorts of *P. borealis* pre-recruits in the Gulf of St.Lawrence: cohorts 0, I and II with carapace of 2.5-4.5, 4.5-9.5 and 9.5-14.5 mm long, respectively.

Shrimp growth investigations are of great importance and the studies are conducted by many specialists. Several simposia on the pandalids growth were held (Frechette and Parsons, 1983; Parsons, 1989) which elaborated a number of very useful recommendations. Various approaches to the analysis of length frequency distributions of shrimps when studying their growth were examined by Ivanov and Stolyarenko (1995). They propose a new model for shrimp annual increment determination (using an example of *P. goniurus*) as the first stage in growth studies and ageing in shrimps (as well as crabs and other species with strongly overlapping by sizes of year classes). I believe that the application of this model (author D.A. Stolyarenko) may be highly promising when analyzing time series of length frequency distributions of shrimps of one population.

<u>Survey methodology, stock assessment</u>.

At present, monitoring of shrimp stocks is mainly carried out by trawl surveys which are regularly conducted in principal Atlantic fishing areas. In the North Pacific (off the U.S. coasts), Bering Sea and Gulf of Alaska, shrimp stocks are depleted and now stock surveys are likely to be conducted occasionally. In the vicinity of Russian coasts the surveys are performed by research vessels but also only occasionally. In the northern Sea of Japan, *Pandalus hypsinotus* stocks are studied by means of pot and trawl surveys. In the Northeast and Northwest Atlantic, when conducting such surveys a stratified random design is used. In the Bering Sea, the U.S. scientists conduct multispecies stock surveys using a regular grid of stations. In Russia, a software system has been developed for carrying out surveys based on spline approximation method with adaptive design which uses a more advanced model of shrimp distribution and is characterized by a number of advantages compared both with the survey by a regular grid of stations and the random stratified survey (Stolyarenko, 1986, 1987; Stolyarenko and Ivanov, 1987; Stolyarenko and Ivanov, 1988; Ivanov et al., 1988). This approach may be used for marine fishery GIS (Stolyarenko, 1995). Such software systems are widely used in Russia (at PINRO, SakhNIRO, KamchatNIRO, MoTINRO, TINRO and VNIRO).

<u>Shrimp behavior, migrations</u>

Pandalid shrimps are known to migrate both in horizontal and vertical directions. The horizontal movements of shrimps are more pronounced (or can be recorded better) in shallow water (=shelf) populations than in deep water (slope) ones. Horizontal migrations can be performed as a drift by currents during night ascent of shrimp into water column. The seasonal migrations of the northern shrimp, *Pandalus borealis*, were recorded off Pribilof Islands in the eastern Bering Sea in 60s when the species formed dense concentrations here. With winter cooling the shrimp concentrations migrated from depth of 85-100 m where they were observed in summer south-westwardly into deeper layer, 95-120 m, to inhabit mainly waters at the temperature of >1.8°C. The distance of the migration was about 30-40 n. miles (Ivanov, 1970). In the Anadyr Bay, the western Bering Sea, horizontal migrations were studied in humpy shrimp, *Pandalus goniurus*, by comparison of spatial shrimp concentrations during two trawl surveys with an interval about 20-25 days. During this interval "spots" of shrimp concentrations moved up to 67 km north-easterwardly in June-early July 1975. Hence average speed of movement of shrimp concentration along straight line was estimated as up to 3.2 km/day (Ivanov and Stolyarenko, 1992b). Horizontal migrations of *P. borealis* were described also in Greenland and Norwegian fjords (e.g. Bergstrom, 1991; ICES, 1994) but of lesser scale (distance?).

Vertical migrations of pandalids are known to affect the commercial catches by season and by time of day (both seasonal and diurnal aspects?). In general, the catches decline in fall and winter seasons when dark period become longer and at night because of ascend of shrimps upwards and escapement from bottom trawls. Due to the migrations, shrimp harvesting is more effective in daytime and day research hauls during a stock assessment survey are more representative than those made at night.

The vertical migrations of pandalids can be a serious obstacle for their stock assessment by means of underwater photography (Kanneworff, 1979). Migratory activity of shrimp in shallow water populations seem to be less pronounced than that in deep water ones (probably due to higher illumination of shallow bottom in day time which get lower swimming activity of shrimp). Perhaps, deeper shrimp habitat, higher proportion of shrimp stock is in the water column, even during daytime. If so, stock assessment by means of underwater photography could be more successful for shallow water population than for deepwater ones. At least, maximum densities of shrimp on the bottom pictures (dozens specimens per m^2) were recorded for *P. goniurus* inhabiting depths <100 m in the western Bering Sea (Ivanov, 1981), indirect evidence of absence active vertical migration in this species in daytime (at night *P. goniurus* was described to ascend well above bottom; Barsukov and Ivanov, 1979).

Some large-sized pandalids show no active migratory behavior. Bukin and Zgurovsky (1988) did not recorded vertical migrations in *P. hypsinotus* in the Sea of Japan and explained it by large size of the species, feeding on bottom organisms and vulnerability of shrimp for pelagic fish predators. The prawn, *P. platyceros*, was showed such slightly motile that they died due to hypoxia after influx the water with deficiency of oxygen into the fjord while even little movement upward along steep slope would provide to reach layer enough oxygenated (Jamieson and Pikitch, 1988).

Shrimps on the bottom are highly oriented in one direction often. The orientation habit was recorded in *P. borealis* (Blacker, 1971; Berenboim and Popkov, 1980), *P. goniurus* (Ivanov, 1981), *P. jordani* (Pearcy, 1972). In *P. hypsinotus* the orientation was observed only if shelters (depression on the bottom, large Crinoidea, Actinia etc.) were absent nearby (Bukin and Zgurovsky, 1988). Coclusions about the direction of the shrimp orientation relative to a current were rather contradictory. Berenboim and Popkov (1980), Ivanov (1981) and Pearcy (1972) considered that shrimps oriented by their heads against currents while Bukin and Zgurovsky (1988) concluded that the shrmps were turned to currents with their tails. If one take into account experiments with juvenile *P. borealis* described by Shumway et al.(1985, p.22), the latter conclusion that the shrimps usually face away from currents seems more likely.

Ivanov and Stolyarenko (1988) hypothesised that the shrimp orientation can affect fishing efficiency. The mathematical analysis of trawling results showed that a relationship between supposed direction of shrimp orientation and direction of haul does exist. Hauls made with the water current caught more shrimp than hauls made against the current. Trawl catchability is thought to depend upon the direction of tow in relation to the mean vector of shrimp orientation and the degree of dispersal about the mean. Taking into account that the currents are determined by the lunar cycle time of tow and also direction of tow should be taken into consideration in improving the efficiency of the trawl fishery and accuracy of stock assessement by means of trawl surveys.

Conclusions

Zoologists of many countries contributed into identity studies of boreal pandalids. Among them systematic zoologists of USA achieved major success (Stimpson, M. Rathbun). The fishery for shrimp in the North Atlantic is based on exploitation of stocks of one species, *Pandalus borealis*, while importance of other species is negligible. In the North Pacific diversity of commercial species is much more and about 10 species (*Pandalus borealis, P.*

goniurus, P.hypsinotus, P. platyceros, P. jordani, P. latirostris, P. nipponense, Pandalopsis dispar, P. japonica) are commercially important.

Fisheries for shrimp seems to begin in the north Pacific, in Puget Sound, earlier than in the North Atlantic, but only after explorations by Norwegians (C. Petersen, J. Ruud, J.Hjort) shrimp fishery became to acquire industrial character.

In fishery biology a daughter of Canada Alfreda Berkeley made the most important and spectacular fundamental discovery in late of 30s. She discovered a proterandry in pandalids. Norwegian Birger Rasmussen in 40s-50s demonstrated great variability of the most important biological parameter of pandalid population depending upon environmental conditions. In 50s life histories of almost all important shrimp populations in the North Atlantic were described in series of good papers.

Fishery for shrimps and shrimp studies developed in a close relationship between each other. Many discoveries of new commercial stocks by fishers resulted in increased scientific activities, and, vice versa, fishery explorations resulted in discovery of commercially important shrimp concentrations. In the North East Atlantic shrimp fishery extended to high seas from coastal waters in 60s. The Barents Sea and waters off Spitsbergen became important area of shrimping. The same occurred in the Northwest Atlantic in 70s after discovery offshore shrimp grounds off West Greenland and in the Davis Strait. Here the scale of shrimp harvesting proved even much more than that in NE Atlantic. Extension of shrimp fishery to offshore areas far away from large land masses, out of 200-mile zone border, seem to be very impressive event evaluating retrospectively.

In the northern North Pacific large scale explorations were conducted by USA, Japan and Russia in late 50s-60s for searching of shrimp stocks. The fishery biologists of all the counries were lucky. As a result, several important stocks of shrimps were discovered. The most important *P. borealis* stocks were situated off Pribilof Islands in the Bering Sea (Japan and Russia), east of Shumagin Islands (Russia), Pavlof and Stepovak Bays (USA), off Kodiak Islands (USA and Russia). Besides *P. borealis*, huge humpy shrimp stocks (*P. goniurus*) were discovered in the western Bering Sea. The stocks were in Anadyr Bay (Russia and Japan), south-west Cape Navarin (Russia), off Anastasiya and Dezhnev Bays (Russia).

In 60s-early70s shrimp fisheries in the Gulf of Alaska, in the Bering Sea and in the northern Sea of Japan were multinational ones but after establishment of 200-mile exclusive zone Russian and Japanese fleets confined their efforts to their national waters. In contrast to the North Atlantic, no international shrimp fisheries exist now in the North Pacific. Development of fishery for shrimp in the northern North Pacific suffered very much from serial depletions of *P. borealis* and *P. goniurus* stocks in the Gulf of Alaska and in the Bering Sea in 70s and 80s. Factors responsible for these declines are unknown yet.

It is a paradox but Russian shrimp fishery in the Atlantic began off West Greenland in 70s. After introduction 200-mile zone in Greenland in 1977, an experience accumulated by Russian fishers off Greenland provided them to develop quickly Barents Sea shrimp stocks. Industrial shrimp harvesting in the North Pacific drastically fluctuated due to discovery and exploitation of new shrimp grounds in the Gulf of Alaska and in the Bering Sea, losses of fishery opportunities off coasts of other countries, declines of stocks and rediscovery of stocks. Shrimping received new powerful impulse in 90s after transition Russia to market economics. But the transition created new problems also, particularly in unprecedented poaching, disorganization of fishery statistics (especially in Far East).

In Russia the shrimp studies are carried out by PINRO, Murmansk (with occasional contribution of VNIRO), and by all fishery research institutions in Far East from Vladivostok to Anadyr-City (also with irregular participation of VNIRO). By my estimate, the pandalid investigations in PINRO are organized much better than that in Far Eastern institutions.

In predictable future, in early 20^{th} century, one can expect essential improvement in methodology of stock assessment, in growth study, in interspecies relationships between fish and shrimp, in computerization of field and laboratory analyses of biological data.

In the North Atlantic two international institutions, ICES and NAFO, involved in organization of fishery research and management, particularly, of pandalid shrimps. In ICES Shellfish Committee exists which deals with pandalids as one of the most important groups. In the North Pacific one of PICES Working Groups (No.12- Crabs and Shrimps) also deals with this crustaceans but its status has not been defined yet. Hopefully, PICES structure will provide some type of Shellfish Committee to improve scientific exchange between the North Pacific countries.

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Table 1. Shrimp fishery in Tartar Strait, the northern Japan Sea, in 1980-1985 by Soviet and Japanese boats (after Galimzyanov, 1994) (R, USSR/Russia; J, Japan).

	1980		1981		1982		1983		1984		1985	
	R	J	R	J	R	J	R	J	R	J	R	J
Shrimp boats	2	8	2	7	3	7	3	7	4	2	4	0
Boat/ Days	302	856	135	835	161	861	222	675	645	303	693	0
Number of pots	755	2988	405	2546	452	3306	601	2286	1772	747	2018	0
Catch, t	111	501	153	469	132	600	131	380	549	138	576	0

Table 2. Catches (total for USSR/Russia and Japan), proportions of species landed from Tartar Strait in 1979-1996. (P.h., *Pandalus hysinotus*; P.b., *P. borealis*; P.l./P.j., *Pandalopsis lamelligera/P. japonica*)

Years	Catch (t)	Proportion in catches (%)		
		P.h.	P.b.	P.l./P.j.
1979	240			
1980	612			
1981	622	11.0	88.9	0.1
1982	732	12.3	87.7	
1983	511	27.9	71.2	0.9
1984	688	72.1	29.9	
1985	576	93.5	6.5	
1986	352	77.8	22.1	0.1
1987	504	83.3	16.4	0.3
1988	604	94.9	4.9	0.2
1989	844	96.7	3.3	
1990	1501	96.5	3.5	
1991	2335	99.4	0.6	
1992	2604	96.5	3.5	
1993	1380	70.0	30.0	
1994	1130	87.0	12.7	0.3
1995	1756	65.7	34.3	
1996	1109	19.9	80.4	
1997*	790	-	100	
1998*	1451	-	100	

* Data from President of the Union of Fishermen, Sakhalin, Mr. V.I.Barmouta (pers. communication).

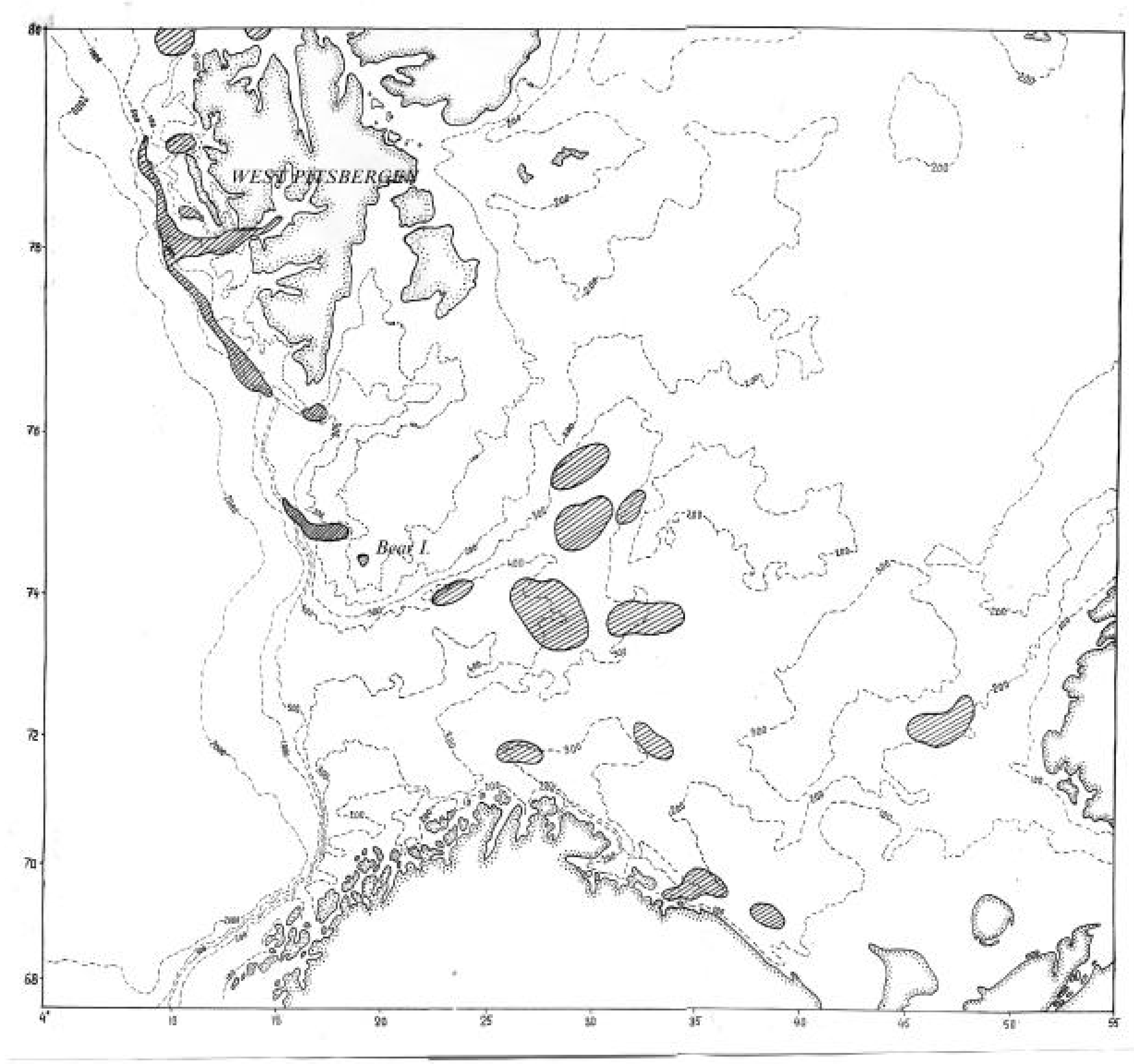

Fig.1. Shrimp grounds of *(Pandalus borealis*) fished by Russian fleet in the Barents Sea and adjacent area.

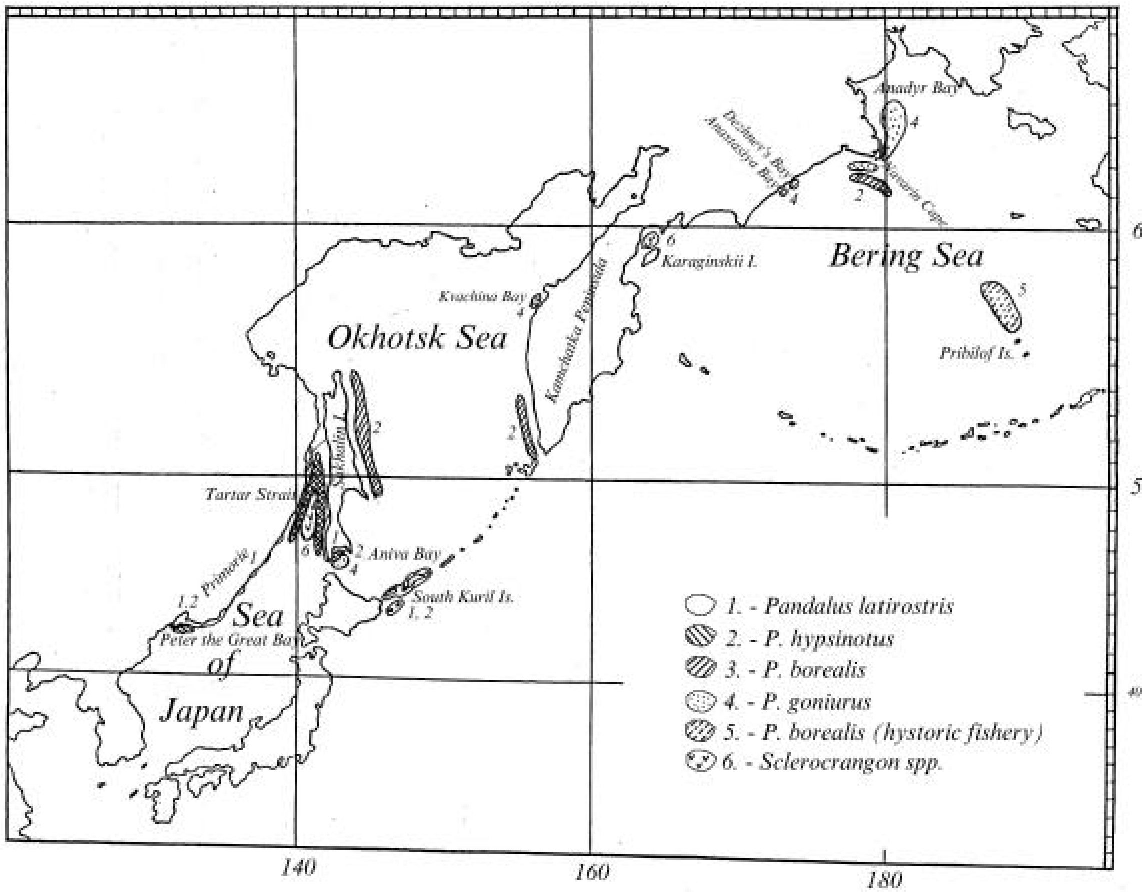

Fig. 2. Areas of Russian fishery for shrimps in the Far Eastern Seas.