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SOVIET FISHERY INVESTIGATIONS CONDUCTED IN THE SOUTHERN OCEAN

Abstract

Soviet oceanological and fishery investigations in the Southern Ocean have been carried out respectively since 1946 and 1961. More than 150 expeditions have been undertaken until now. The results of investigations are outlined in brief. Species composition, the distribution of bio-resources, bio-productivity and food chains of marine organisms in Antarctica have been found to be closely connected to the latitudinal vertical and circum-Antarctic patterns of the water structure to the south of the Antarctic convergence.

Two different natural zones have been identified: the pack ice area and open water area. The ecosystem components, their status patterns of primary and overall productivity and existing food chains are discussed. Antarctic krill is the principal plankton form in the zone of the pack ice. The average annual level of krill production is 24-70 g/m^2 in this area. Some local small ecosystems along the area of the Antarctic current influence and within the shelf areas of sub-Antarctic islands have also been determined. The average estimations of fish productivity for the different parts of Antarctic waters are provided. The attention of the CCAMLR Scientific Committee has been drawn to particular scientific problems.

ETUDES SOVIETIQUES SUR LA PECHE DANS L'OCEAN AUSTRAL

Résumé

Les études océanologiques et les études sur la pêche menées par les Soviétiques dans l'océan Austral se poursuivent, respectivement, depuis 1946 et 1961. Plus de 150 expéditions ont été entreprises jusqu'à ce jour. Les résultats de ces études sont brièvement présentés. Il a été constaté que la composition des espèces, la répartition des ressources biologiques, la productivité biologique et les chaînes trophiques des organismes marins en Antarctique étaient liées de très près aux formes latitudinales, verticales et circum-antarctiques, de la structure des eaux au sud de la convergence antarctique.

Deux zones naturelles différentes ont été identifiées: la zone de la banquise et la zone de la haute mer. Les composants de l'écosystème, leurs formes de productivité primaire et générale et leurs chaînes trophiques actuelles sont discutés. Le krill antarctique est la forme majeure

de plancton dans la zone de la banquise. Dans cette zone, le niveau annuel moyen de production de krill est de 24 à 70 g/m^2. L'existence de petits écosystèmes locaux a également été établie le long de la zone d'influence du courant antarctique et sur les plateaux continentaux des îles subantarctiques. Sont fournies les estimations moyennes de la productivité de poissons pour les différentes régions des eaux antarctiques. L'attention du Comité Scientifique de la CCAMLR a été attirée sur certains problèmes scientifiques.

СОВЕТСКИЕ РЫБОХОЗЯЙСТВЕННЫЕ ИССЛЕДОВАНИЯ, ПРОВЕДЕННЫЕ В ЮЖНОМ ОКЕАНЕ

Резюме

Советские океанологические и рыбохозяйственные исследования в Южном океане проводятся с 1946 г. и с 1961 г. соответственно. За это время было проведено более 150-ти экспедиций. Кратко описываются результаты исследований. Было установлено, что видовой состав, распределение биоресурсов, биопродуктивность и трофические цепи морских организмов Антарктики тесно связаны с широтной, вертикальной и циркумполярной структурой вод к югу от Антарктической конвергенции.

Были выделены две различне природные зоны - зона дрейфующих льдов и зона открытых вод. Обсуждаются компоненты экосистемы, тенденции изменений в первичной и общей продуктивности и существующие трофические цепи. Антарктический криль является основным видом планктона зоны дрейфующих льдов. Средний годовой уровень воспроизводства криля в этом районе - 24-70 г/м^2. Кроме того, в районе воздействия Антарктического течения и в шельфовых зонах субантарктических островов было выделено несколько небольших локальных экосистем. Даны средние оценки рыбопродуктивности по различным районам антарктических вод. Вниманию Научного комитета АНТКОМ'а предлагаются конкретные научные проблемы.

INVESTIGACIONES PESQUERAS DE LA UNION SOVIETICA EFECTUADAS EN EL OCEANO AUSTRAL

Resumen

La Unión Soviética ha llevado a cabo investigaciones oceanológicas y pesqueras en el Océano Austral desde 1946 y 1961 respectivamente. Hasta el presente se han

realizado más de 150 expediciones. Se resumen los resultados de las investigaciones. Se ha descubierto que la composición de especies, la distribución de recursos biológicos, la productividad biológica y las cadenas alimentarias de los organismos marinos en la Antártida están estrechamente relacionadas con los patrones latitudinales, verticales y circumpolares de la estructura del agua al sur de la convergencia Antártica.

Se han identificado dos zonas naturales diferentes: el área del hielo a la deriva y el área del mar libre. Se debate sobre los componentes del ecosistema, sus patrones de estado de productividad primaria y total y las cadenas alimentarias existentes. El krill antártico es la principal forma de plancton en la zona del hielo a la deriva. En esta área, el nivel anual promedio de producción del krill es 24-70 g/m^2. Asimismo, se han determinado algunos pequeños ecosistemas locales a lo largo del área del influjo de la corriente antártica y dentro de las áreas de las plataformas de las islas subantárticas. Se proporcionan las estimaciones promedio de la productividad de peces con respecto a las diferentes partes de las aguas antárticas. Se llama la atención del Comité Científico de CCAMLR sobre ciertos problemas científicos.

SOVIET FISHERY INVESTIGATIONS CONDUCTED IN THE SOUTHERN OCEAN

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First data on the availability and the amount of the specific living resources in the waters near the Antarctica were got by the Russian discoverers of the Antarctica - M.P.Lazarev and F.F.Bellingshausen during the expedition on boats "Vostok" and "Mirny" in 1920. Even at that time large concentrations of brown spots were observed in the surface water layers of the Antarctic Ocean, these spots were created by large-size zooplankton, namely, by the Antarctic krill named so by the Norwegian whalers. Baleen whales feeding and growing in the Antarctic waters in warm time of the year were found in the areas of the krill concentrations.

In 1946, the first expedition was undertaken to the Antarctic Ocean, and a scientific group of VNIRO and GOIN was taken on board a whaling fleet "Slava". Since that time, the Soviet oceanological investigations were systematically conducted in the South Ocean. The fundamental investigations of the Soviet Antarctic Expedition (SAE) were annually performed either according to the program of the International Geophysical Year (1957/58), or to other international programs.

Since 1961, complex fishery investigation in the Antarctic Ocean were completed by efforts of VNIRO, AzcherNIRO, AtlantNIRO and TINRO, the results obtained can be considered as a valuable contribution into the studies of the oceanographical and biological structure of the South Ocean and waters adjacent

to the Antarctica. Annually, from 4 to 12 research vessels performed scientific trips in the waters of the Atlantic, Indian and the Pacific Sectors of the Antarctic Ocean, and, up to 1976, 87 complex scientific and scouting expeditions were undertaken. More than 150 Antarctic expeditions were made on the whole up to the present time.

During the period from 1961 up to nowadays, complex fishery investigations were completed throughout a large area of the South Ocean (about 15 mln km^2) by Marine Institutes of the USSR Ministry of the Fisheries, they gave valuable data of scientific and practical character. The most productive zones were found both in the area of action of the Antarctic circumpolar current and in the area of high latitudes lying to the south of 60°S, and general regularities of the bioproduction formation were determined in these waters already early in the seventies (Figs.1 and 2).

Presently, basic grounds of the rational exploitation of the Antarctic bioresources from the ecosystem positions are elaborated in essence as a result of the fishery and oceanological investigations conducted by Arctic and Antarctic Institutes, Institute of Oceanology of the USSR Academy of Sciences and Zoological Institute of the USSR Academy of Sciences.

It was determined by us that the species composition and the distribution of the bioresources, the formation of the bioproductivity, the character of food chains among marine organisms in the Antarctic are closely connected to the latitudinal, vertical and, circumantarctic zonation of the oceanographical water structure of this Area. Two different natural zones are

distinguished within the area lying to the south of the Antarctic convergence in accordance to the latitudinal and vertical zonation of the oceanographic structure. They are distinguished by climatic and ice conditions, the regularities of the distribution of the main physical and chemical characteristics, the biogenic elements, water masses, the specificity of water dynamics, the character and the rhythm of the bioproductional processes at the initial levels of the organic matter transformation (that of the phytoplankton, zooplankton).

On the whole, the bioresources of the Antarctic area of the South Ocean (to the south of the Antarctic convergence) are represented by the most mass groups and species of marine organisms both inhabiting always the Antarctic waters and the seasonal migrants. Those include mass euphausid species, namely the Antarctic krill, a group of the near bottom fish and the near bottom-pelagic Notothenia and Chaenichthidae, a group of mezopelagic fish, namely, Myctphidae, as well as mezo-and-bathy-pelagic squids and marine mammals, i.e. whales and pinnipeds.

The studies of the species composition of the bioresources and the distribution of some groups and species in the Antarctic waters according to new paleoclimatical and paleogeographical data, also the studies of the character of their modern spatial and quantitative distribution testify to enough clear dissociation of the areas, where mass groups and species dominate. In other words, the whole complex of the differences in the physical environmental conditions within the Antarctic area determines specific peculiarities of the biological struc-

ture, the essence of which lies in the latitudinal, vertical and the circumantarctic zonation.

The zonation of the space and quantitative distribution of the bioresources and, first of all, dominated species and groups of marine organisms, the peculiarities of their ecology and the character of food chains testify to a large scale differentiation of the communities and the existence of several ecosystems within the Antarctic Area.

First of all, there are two largest ecosystems different by the specific regularities in the formation of their bioproductivity, they are the Antarctic circumpolar current and closed quasistationary cyclonic gyres adjacent to the outlined seas of the Antarctic Continent. The first of the above mentioned large ecosystems corresponds to a natural area of the open Antarctic waters, the second one - to a natural area of drifting ice (Fig.3).

Natural area of the open Antarctic waters occupying an area about 27 mln.km^2 is free of ice all year round. This is the area of the constant action of the Antarctic circumpolar current, the most powerful circular system of the World Ocean. The processes of water lowering dominate there, and the Antarcti warm deep water masses prevail in the vertical structure of water column. The processes of the first production formation are continuing there during 8-9 months per year, and two maxima of the phytoplankton vegetation have place in the spring and autumn time. Copepoda plankton serves as base to the secondary production, their biomass is kept at a high level in the water

column from the surface up to 600-700 m depth during the most part of a year that is connected to water lowering.

Natural zone of drifting ice occupies an area of 19 mln.km^2 this area is free of ice only in summer for the exception of stationary ice massifs and shore ice occupying the territory about 3 mln.km^2. This area is that one of the action of large scale cyclonic closed circulations timed to the Antarctic outlying seas. The processes of warm water upwelling prevail here and cold water masses, namely, surface and near bottom Antarctic water masses are mainly upwelling in the vertical water structure. Warm Antarctic deep water is practically absent throughout the most part of this nature area. The processes of the primary production formation are bearing here a sharply expressed seasonnal character and continue for 3-4 months per year, and, there is only one maximum of the phytoplankton vegetation in spring time. Euphausiacea macroplankton, mainly, the Antarctic Krill makes the basis of the secondary production, its biomass is high only in warm period of the year and it is limited by the upper 100-meter layer.

A high productivity of the Copepoda zooplankton makes a base for the existence and the functioning of the pelagic community to the first of large ecosystems determined. According to IOAN of the USSR Academy of Sciences, an area of the Antarctic circumpolar current, and, especially the Polar Antarctic front water is an area, where copepod plankton dominate in number, that corresponds to the Antarctic convergence and to waters of its southern adge. The calculations completed on the base of

the modelling of the copepods annual life cycles, their populations structure, and functioning, daily and annual P/B coefficients with taking into account the ecological efficiency of the second trophycal level gave the possibility to determine the summary production of the mesoplankton as high as 1.3 billion tons per year in the area of their densest concentration. A high level of the mesoplankton production in the natural zone of the open Antarctic waters and a constant process of copepods accumulation up to 600-700 m depth due to water lowering ensure a rich food base to small sized fish -plankton-eaters.

Investigations conducted in the field of the fisheries allowed to determine that the majority of mass species of Myctophidae inhabit and perform their reproduction in the waters of the Antarctic circumpolar current and they form dence feeding and growing concentrations within 200-600 m water column from the surface up to the bottom. And, the main areas of the mesopelagic Myctophidae correspond to the areas of the quasistionary zones of waters lowering located in the Polar Antarctic front (Fig.4).

An average biomass of the whole group of mesopelagic fish is as high as 212-396 mln.tons within the area lying southwards from 40°S, this up-to-date assessment of their stock condition was performed on the base of the mathymatical modelling by IOAN specialists. When Myctophidae inhabiting to the south of the Antarctic convergence were excluded from the composition of this group, it was determined as a result of the comparison of this assessment to the results got presently to the actual data

of the density concentrations in the areas of their domination that the summary biomass of these fish is within the range from 70 up to 200 mln.tons.

Up to ten species of the notal and Artarctic squids inhabit a meso-and-bathypelagic natural area of the open Antarctic waters. It was found that the meso-pelagic fish, namely, the plankton-eaters, of them, first of all the Myctophidae make the base of these squids feeding. These squids serve in their turn as a feeding base to the sperm whale migrating in the Antarctic waters in summer period. In spite of the fact that the quantitative data on the production of the meso-and-bathy-pelagic squids in the Antarctic area are absent yet, one can suppose that their number is very high in this natural area. It is known, first of all, that the greatest number of the sperm whales are distributed in the Antarctic between 40° and 60°S, i.e. in the circumpolar current of the Antarctic. It is determined, secondly, that the sperm whales catch their food in the areas of the mollusks concentrations.

Thus, the main ecosystem of the natural area of the open Antarctic waters is characterized by the predominance of the mesopelagic ecological complex of marine organisms existing and functioning on the base of a high productivity of the cope-pod zooplankton.

The pelagic community of the natural area of drifting ice is functioning due to the formation of the high production of

the Antarctic krill, which inhabit mainly an area of the outlying seas of the Antarctic Continent. Long-term fishery investigations allowed to find out that the north limit of the distribution of the mass concentrations of this numerous euphausid is lying according to the limit, where the waters of the outlying seas of high latitudinal modification and those of the southern outlying district of the Antarctic circumpolar current are separated or interactioning. This limit is going along 58°-69°S i n the Atlantic and the western parts of the Indian Antarctic sectors and along 62°-65°S - in the Pacific and the eastern part of the Indian Antarctic sectors.

The areas of Euphausiacea drifting with the current of the Weddell Sea in the relatively low latitudes are considered as an exception (Fig.5).

The Soviet specialists suppose that a part of the natural area of drifting ice, where the Antarctic krill dominate among the plankton and fprm the mass concentrations takes from 13 to 17 mln.km^2. It is natural that the Antarctic krill concentrations are distributed unevenly within the area of their domination, the density of their concentrations varies also within enough large range depending, mainly, on
the changeable character of water masses dynamics. The lowest values of the biomass compose up to 1-2 g/m^3 , and the highest ones up to 15-16 kg/m^3. Basing on data got as a result of the counting surveys performed in time of the expeditions of Soviet research vessels during a number of years, it was calculated that the number of crustaceans of the eldest year-classes at separate areas in the areas of the Antarctic krill domination

composed from 47 up to 60 mln.tons on the average. These values appeared to be somewhat lower compared to those calculated some later during FIBEX in different areas of the Atlantic, Indian and Pacific sectors of the Antarctic Ocean. But, as an area of the counting made only a little part of an area, where mass krill concentration are formed, these values can testify to the fact that this species stock level is very high.

Basing on the comparison of the estimation parameters on the production of the copepods and the Antarctic krill and by modelling the life period of the population, there were got the results showing an average annual production of the last one to be as high as 24-47 g/m^2 at the coefficient P/B equal to 1.9 (according to data by IOAN, USSR Academy of Sciences), and, the modern estimations gave the value up to 67 g/m^2 per year. Thus, an average annual level of the Antarctic krill production is within the range from 24 to 70 g/m^2 in the area, where this species dominates, and, the population production on the whole throughout the area of their abundance is within the range from 360-600 mln.tons to 1 billion tons on the area up to 15 mln.km^2. If one considers to be the most real a value of the primary production equal to 100 g/C m^2 (Rither, 1963), the level of the secondary production determined by us is not too high. Thus, EL - SAWED (1978) estimated that the quantity of the carbon synthesized by the phytoplankton composes $3,80.10^9$ tons of dry matter, and the overall production of the second trophical level in the Antarctic Ocean reaches 3.8 billion tons.

Thus, a mass species, namely, the Antarctic krill dominates in the bioresources composition of the second large ecosystem -

the outlying seas of the Antarctic Ocean. Due to a high production of this species in the summer period, a high bioproduction is proper to an area lying to the south of the limit of the water divergence of a high latitudinal modification of the cyclonic circulations of the outlying seas and the southern outlying areas of the Atlantic circumpolar current, mainly, the epipelagical. It is known that the Antarctic krill serves as the main feeding base to baleen whales, ice seals and to some extent to the near bottom-pelagical Notothenia and Chaenichthidae. It is also supposed that some species of the mesopelagic squids (2-3 species) are able to mount to a lower epipelagical and can feed on the krill. Besides that, the krill is used as a food them by some marine birds. The modern actual data given by the Soviet and the foreign authors in the scientific literature testify to the fact that a little more than 200 mln.tons of the krill are taken by its main consumers.

There are local independent smaller ecosystems of the Antarctic shelf waters on the background of large scale ecosystems of the natural zone of open Antarctic waters (the pelagial of the area of action of the Antarctic circumpolar current) and a natural area of drifting ice (the pelagical of the closed cyclonic gyres of the outlying seas of the Antarctica).

First of all, these are the ecosystems of the shelfs adjacent to the islands within the area of action of the main stream of the Antarctic Current (Kerguelen, Crozet, South Georgia Islands, underwater hills Ob, Lena of the Kerguelen Ridge and so on), as well as the ecosystems of the shelfs adjacent to the high latitudinal areas of the West Antarctic (South Shetland, South Orkneys

Islands and so on). Every of these microscale ecosystems is distinguished by its specific character of the physical and biotic environmental conditions, its specific character of the composition both of the bioresources and the dominant species, as well as by the character of the interrelation among them and the peculiarities in the formation of the bioproductivity. Long-term Soviet fishery investigations showed at the same time that all these ecosystems are characterized by an extremely high level of the bioproduction at all the levels of the production cycle and by the complexity of the structure of marine organisms communities due to the circumantarctic zonality.

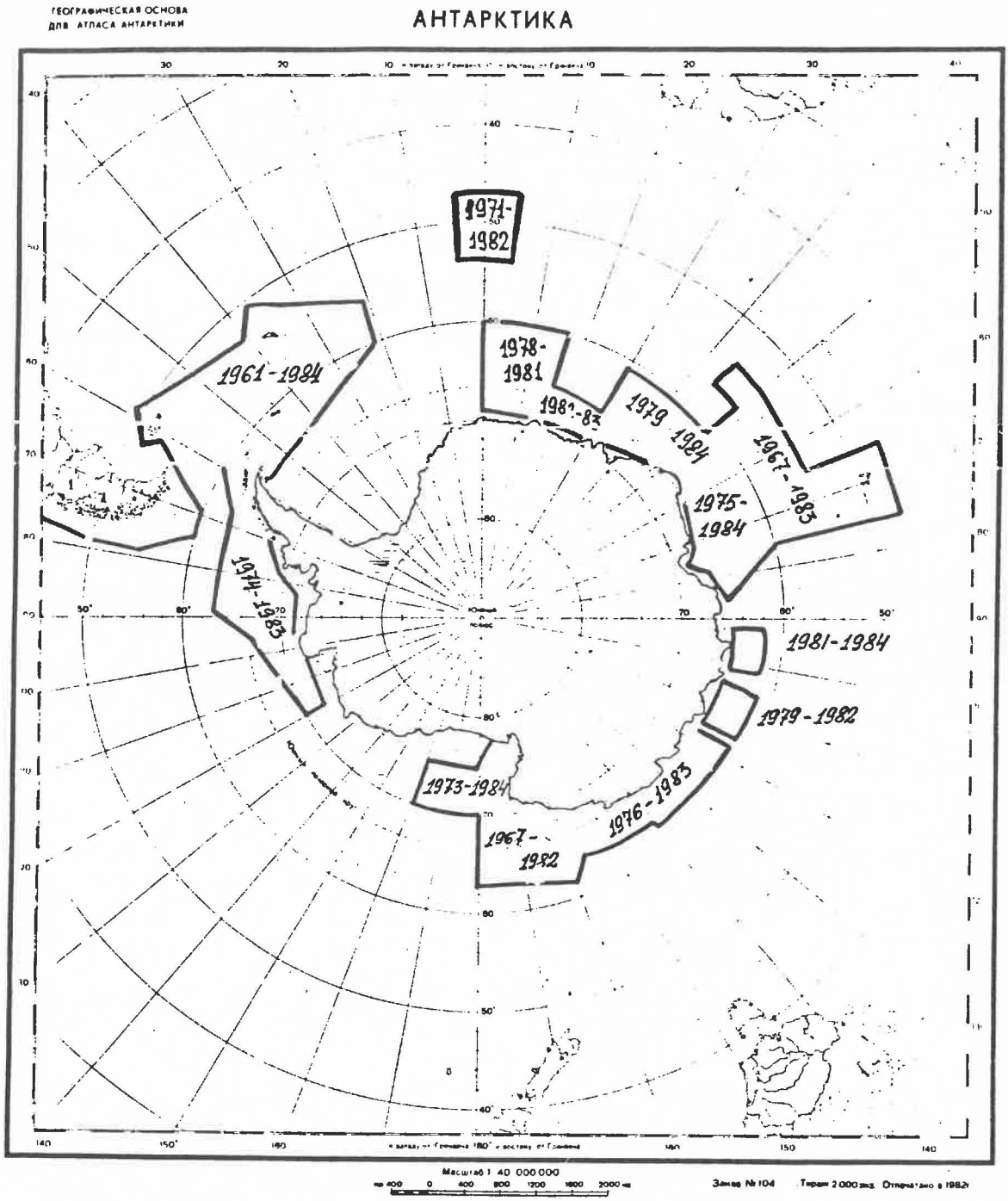
Thus, if large scale ecosystems of the Antarctic pelagial are distinguished by more or less simple trophical chains, the interrelations among the components of the structure of the micro scale local ecosystems of the shelf zones are complecated due to the development and the functioning of numerous bottom biocenoses. A high productivity of the mesoplankton and the macroplankton as well as of the food benthos and the nectobenthic invertebrates ensure an enough high level of the fish productivity in the shelf waters of the area of the Atlantic circumpolar current action and, also, in the outlying seas of the Antarctica compared to many areas of the Northern Hemisphere shelf waters (Fig.4). Shelf waters of the subantarctic islands lying in the area of action of the main stream of the Antarctic circumpolar current are characterized by the highest fish productivity. Our estimations based on the determination of the actual values of the biomass of the dominating near-bottom and bottom-pelagic fish showed that the productivity level of the shelf waters of

the subantarctic islands reaches 2.0-4.8 t/km^2. It appeared that the fish productivity was somewhat lower and made 1.3-2.5 t/km^2 in the shelf waters of the natural area of drifting ice including the areas of the shelfs adjacent to the Antarctic islands and the archipelagos of the West Antarctic. It was determined that the Antarctic krill is the main item in the formation of the fish productivity both in the natural area of the drifting ice and in the natural area of the open Antarctic waters.
The formation of a high fish productivity in the shelf waters adjacent to the subantarctic islands in the East Antarctic is based on a high level of the production of the copepod plankton and the predatory macroplankton. A high productivity of the benthos and the benthonekton invertebrates is of a great significance to the trophical chain in the shelf waters of the outlying seas of the East Antarctic, their biomass reaches 200-250 g/m^2 that prevails an average value of the benthos biomass in the productive shelfs of the Northern Hemisphere.

Thus, long-term native oceanological and fishery investigations conducted in the Antarctic Ocean resulted in the determination of the trends in the differencial studies of the structure and the functioning of the discrete communities to a series of the independent ecological systems. The ecological principles determined nowadays allow to consider the using of the Antarctic bioresources basing not only on an actual estimation of the biomass and the number of the mass species populations, but also with taking into account the ecological importance of any dominating species and dominating complexes of marine organisms of

separate ecosystems. Such an approach to the using of the Antarctic living resources will not involve any detriment to the reproduction of any populations and will allow to keep a structural base of the Antarctic ecosystems.

The Convention on the concervation of marine living resources in the Antarctic Ocean is a base to put into action a comprehensive international-legal and natural-protection regime in the south-polar area of the World Ocean, it signifies a qualitatively new stage of the investigations in the Antarctic Ocean. On the threshold of the most complex new stage of the investigations, namely, that one of the qualitative energy transfer in the Antarctic ecosystems determination, the results got already in the bioresources studies taking into account the ecosystems acquire a specially important and principal significance. Basing on the results got of the oceanographical studies of the Antarctic Ocean structure, it becomes possible to pass to the systematic analysis within separate communities and the ecosystems. The determination of such system variables such as the energy quantity at the trophical levels of the producers and the consumers in their turn will allow to determine a balanced cycle of the removal and the restoration of the Antarctic living resources, that is the main task of the Scientific Committee and the Commission.



Советских

Рис.I. Районы проведения комплексных рыбохозяйственных исследований в водах Антарктики

ГЕОГРАФИЧЕСКАЯ ОСНОВА
ДЛЯ АТЛАСА АНТАРКТИКИ

АНТАРКТИКА

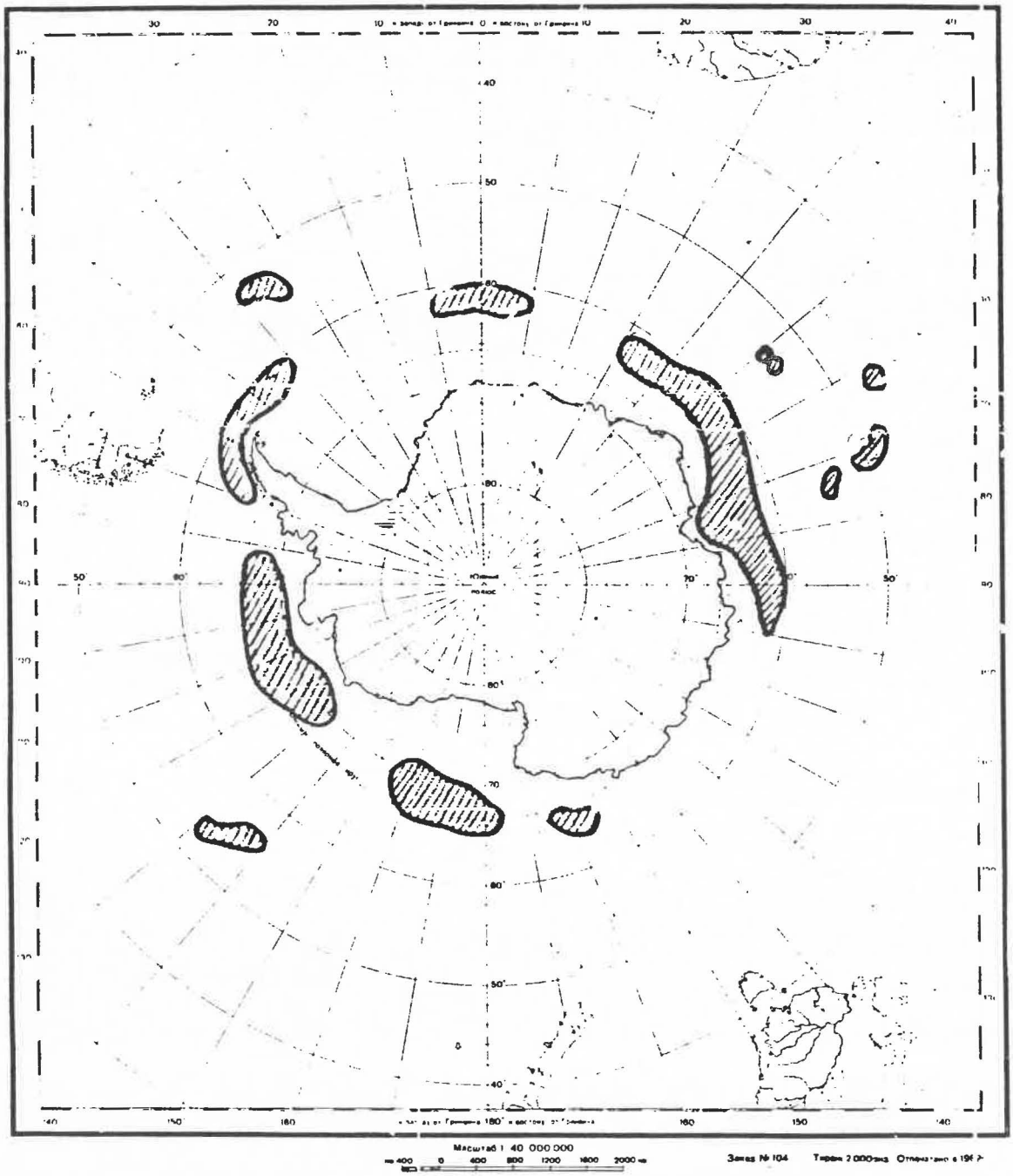


Рис.2. Наиболее продуктивные районы Южного океана

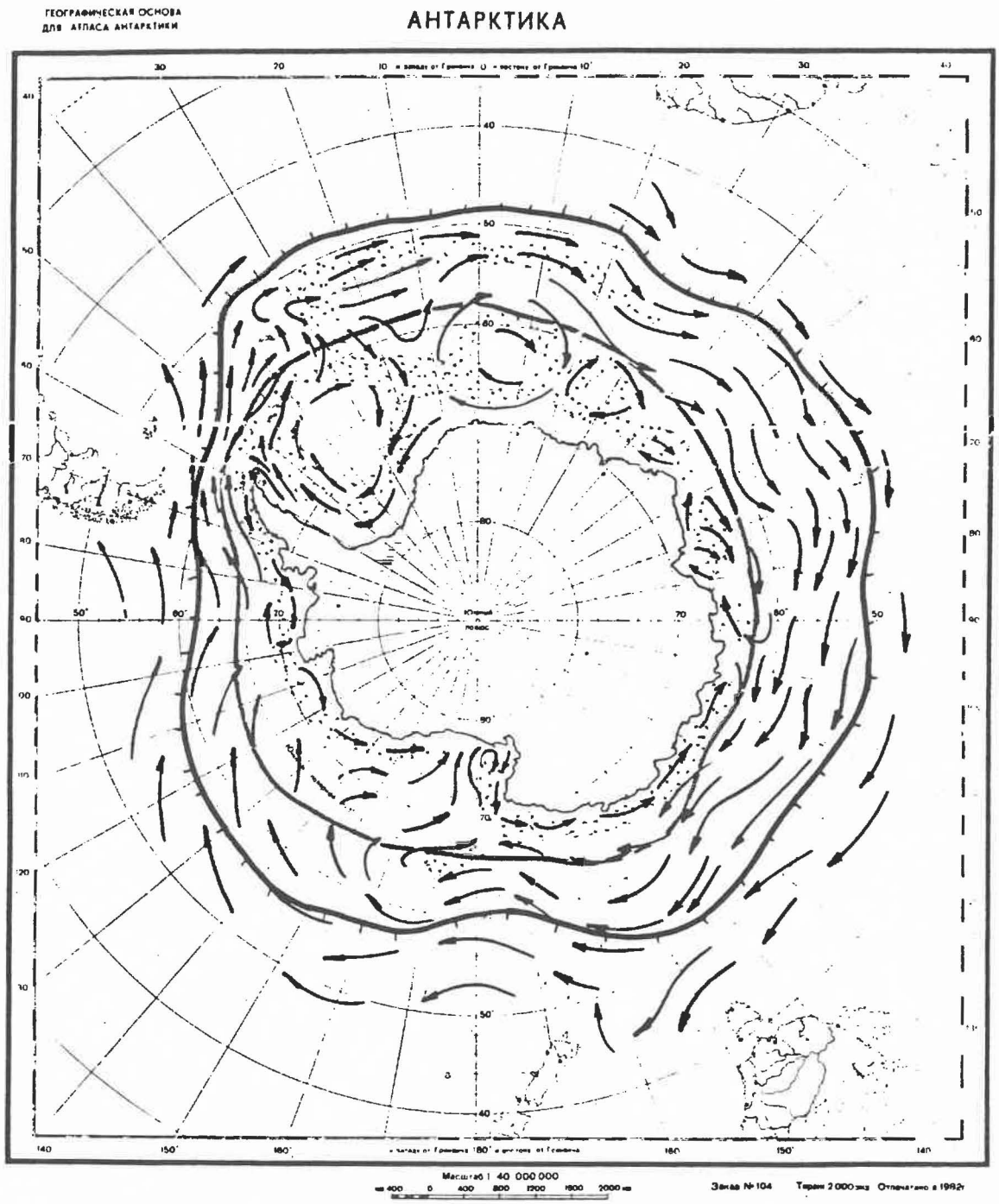


Рис.3. Схема горизонтальной циркуляции вод Южного океана и наиболее вероятное распределение областей повышенного обилия антарктического криля (Масленников,1980)

— — — – Антарктическая конвергенция;
—— – северная граница природной зоны дрейфующих льдов;
:::: – распространение вод высокоширотной модификации

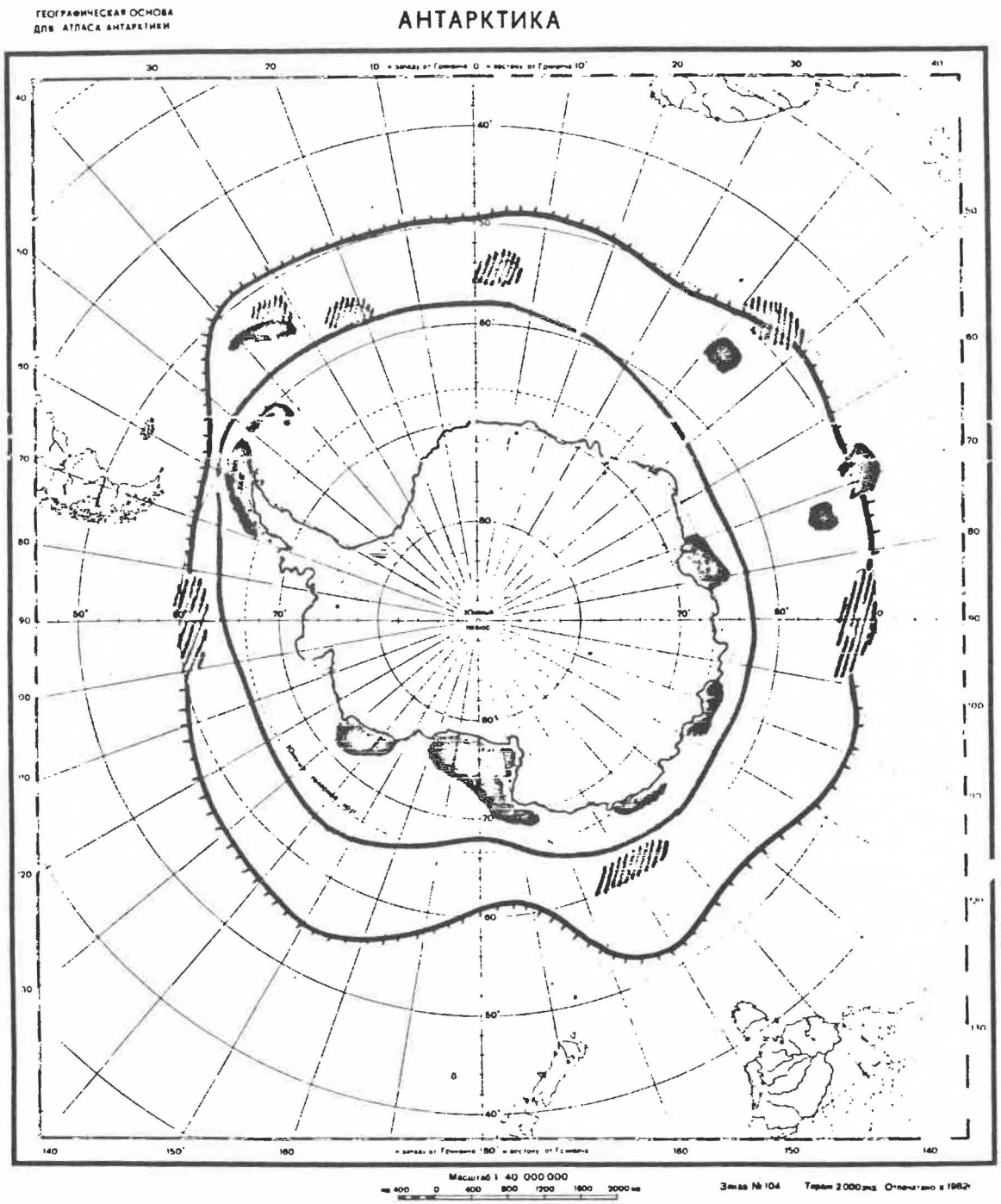


Рис.4. Распределение областей повышенных концентраций антарктических рыб

- рыбы придонного комплекса
- мезопелагические рыбы открытой части океана
- Антарктическая конвергенция
- северная граница природной зоны дрейфующих льдов

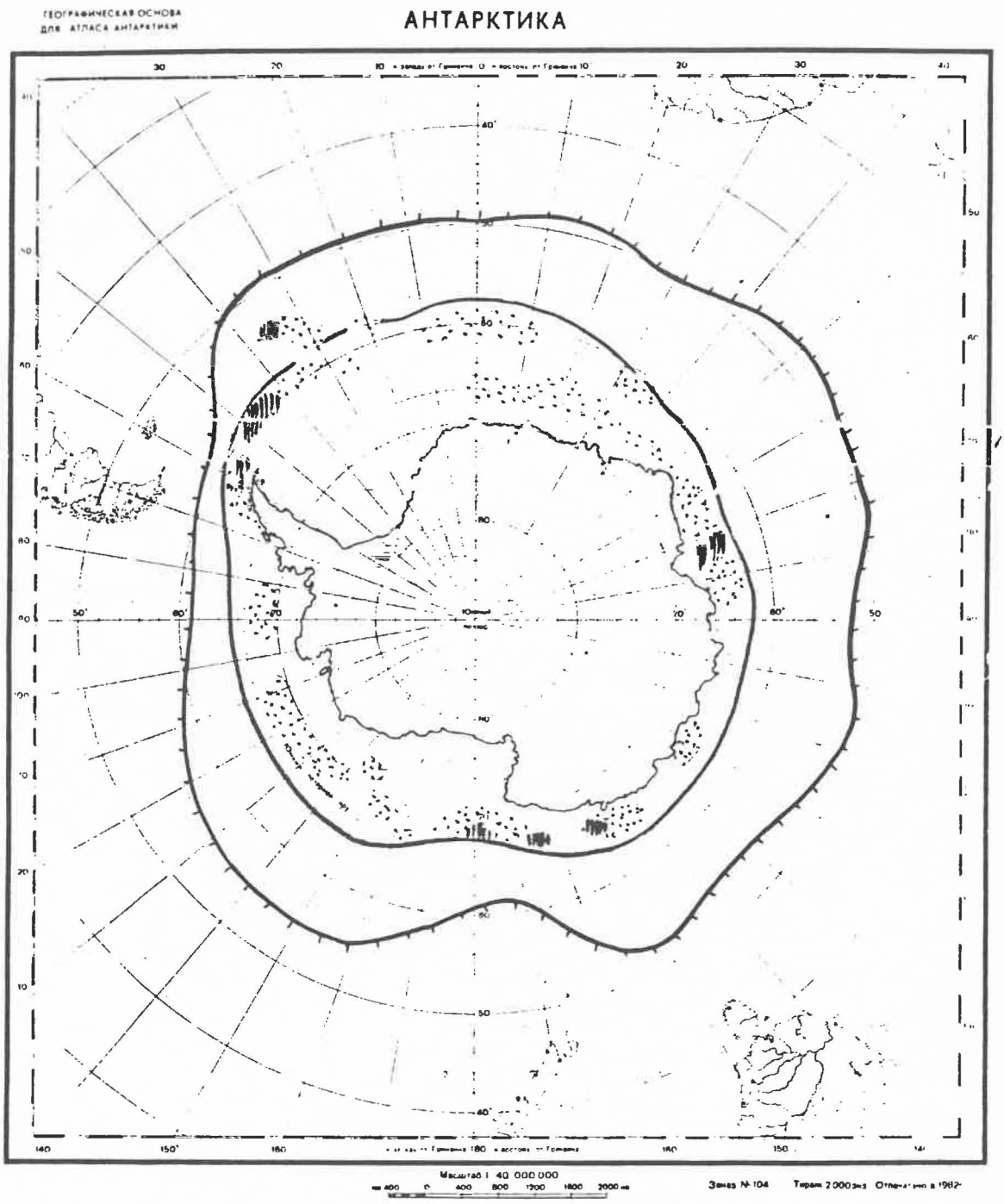


Рис.5. Распределение скоплений антарктического криля

— — — – Антарктическая конвергенция;
———— – северная граница природной зоны дрейфующих льдов;
⁘⁘⁘ – распределение скоплений криля

Fig. 1. Areas of Soviet integrated fisheries research in Antarctic waters.

Fig. 2. Most productive areas of the Southern Ocean.

Fig. 3. Diagram of the horizontal circulation of Southern Ocean waters and the most likely regional distribution of high Antarctic krill abundance (Maslennikov, 1980)
- Antarctic Convergence;
- northern boundary of pack-ice zone;
- extent of high-latitude modification.

Fig. 4. Regional distribution of high concentrations of Antarctic fish
- benthic fish;
- mesopelagic fish of the open waters;
- Antarctic Convergence;
- northern boundary of pack-ice zone.

Fig. 5. Distribution of Antarctic krill swarms
- Antarctic Convergence;
- northern boundary of pack-ice zone;
- distribution of krill swarms.

Fig. 1 Régions couvertes par les recherches d'ensemble sur la pêche conduites par les Soviétiques dans les eaux de l'Antarctique.

Fig. 2 Régions les plus productives de l'océan Austral.

Fig. 3 Diagramme de la circulation horizontale des eaux de l'océan Austral et de la répartition régionale la plus probable d'abondance élevée de krill antarctique (Maslennikov, 1980)
- convergence antarctique;
- limite septentrionale de la zone de banquise;
- étendue de la modification de haute latitude.

Fig. 4 Répartition régionale des grandes concentrations de poissons en Antarctique
- poissons benthiques;
- poissons mésopélagiques de haute mer;
- convergence antarctique.
- limite septentrionale de la zone de banquise.

Fig. 5 Répartition des bancs de krill antarctique
- convergence antarctique;
- limite septentrionale de la zone de banquise;
- répartition des bancs de krill.

Рис.1. Районы проведения советских комплексных рыбохозяйственных исследований в водах Антарктики.

Рис.2. Наиболее продуктивные районы Южного океана.

Рис.3. Схема горизонтальной циркуляции вод Южного океана и наиболее вероятное распределение областей повышенного обилия антарктического криля (Масленников, 1980)
- Антарктическая конвергенция;
- северная граница природной зоны дрейфующих льдов;
- распространение вод высокоширотной модификации

Рис.4. Распределение областей повышенных концентраций антарктических рыб
- рыбы придонного комплекса;
- мезопелагические рыбы открытой части океана;
- Антарктическая конвергенция;
- северная граница природной зоны дрейфующих льдов.

Рис.5. Распределение скоплений антарктического криля
- Антарктическая конвергенция;
- северная граница природной зоны дрейфующих льдов;
- распределение скоплений криля.

Ilust. 1 Areas de investigación pesquera integral soviética en aguas antárticas.

Ilust. 2 Areas más productivas del Océano Austral.

Ilust. 3 Diagrama de la circulación horizontal de las aguas del Océano Austral y la más posible distribución regional de la abundancia del krill de zonas antárticas altas (Maslennikov, 1980)
- convergencia antártica;
- límite norte de la zona de hielo a la deriva;
- extensión de la modificación de latitud alta.

Ilust. 4 Distribución regional de grandes concentraciones de peces antárticos
- peces bentónicos;
- peces mesopelágicos de mar abierto;
- Convergencia Antártica;
- límite norte de la zona de hielo a la deriva.

Ilust. 5 Distribución de cardúmenes de krill antártico
- Convergencia Antártica;
- límite norte de la zona de hielo a la deriva;
- Distribución de los cardúmenes de krill.