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MAIN RESULTS OF THE RUSSIAN MULTIDISCIPLINARY ECOSYSTEM RESEARCH, AND EXPLORATORY FISH-FINDING OF CONCENTRATIONS OF HYDROBIONTS AND THEIR FISHERIES DEVELOPMENT IN THE SOUTH PACIFIC

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RUSSIAN FEDERAL RESEARCH INSTITUTE OF FISHERIES
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This is a review of comprehensive Russian multidisciplinary research of the South Pacific ecosystems, their functional organization and spatial differentiation done between 1955 and the present time. Timing of 551 Russian cruises to South Pacific, major work at sea, its main results and discoveries are given. Special consideration is given to the history of study and fisheries development of the "jack-mackerel belt". The distribution and seasonal migrations of jack-mackerel *Trachurus murphyi* are considered in relation to oceanic mechanisms of the formation of increased bioproduction in the jack-mackerel belt waters. The paper briefly explains the present concepts of the intraspecies structure and functional organization of jack-mackerel range. Necessary measures are suggested for enhancement of population-genetic studies of the South Pacific hydrobionts in view of the preparatory work for the establishment of the South Pacific Regional Fisheries Management Organization.

A large list of references is provided including collected paper volumes on specific subjects, books, reviews, meeting materials, dissertations and the more significant publications summarizing the results of Russian research in the South Pacific Ocean (146 titles).

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CONTENTS

1. Brief history and main results of the Russian multidisciplinary ecosystem research in the South Pacific.

In the 1950-s and early 1960-s the Ministry of Fisheries and the Academy of Sciences (AS) conducted large-scale comprehensive cruises throughout the World Ocean. The objective was to implement the strategy of prospective development of Russia's fisheries sector which was to find and describe new fishing areas and objects, and to study the habitats for the assessment of their biological production. Among the most significant cruises of that period to the South Pacific we should point out the research made from the scientific and fish-finding vessel «Ob» of Glavsevmorput (1955-1960), research vessel of the Institute of Oceanology of AS (USSR) «Vitiaz III» (1957-1958, 1961) and scientific and fish-finding vessel of the Pacific Administration of Fish-finding and Research Fleet (TURNIF) «Professor Derugin» (1960) (Table 1).

Table 1. Russian cruises to the South Pacific.

Vessel	Cruise	Year	Time
Institute of oceanology, AS			
RV «Ak. Korolev»		1976	
RV «Ak. Kurchatov»		1968	August-December
		1973-74	December-April
	34	1981-82	December-April
		1987	February-March
RV «Vityaz III»		1957	
		1957-58	November-February
		1958	March-June
		1961	October-December
		1965	April-July
		1968-69	November-March
		1970	May-September
		1970-71	November-March
		1971	April-July
		1975	February-May
RV «Dmitriy Mendeleev»		1971	June-October
		1971-72	December-April
		1972	June-October
		1973	January-March
		1973-74	December-April
		1975	February-May
		1975-76	December-March
		1976	May-September
		1976-77	December-April
		1978	January-May
		1978-79	December-April
		1980	January-May
		1981	September-December

		1982-83	November-April
		1984-85	December-April
		1985-86	October-January
		1986-87	December-April
Total	4 vessels, 32 cruises		
Glavsevmorput			
RV «Ob»	1-3,5	1955-60	
Total	1 vessel, 4 cruises		
West Fisheries Facilities			
RV «Atlantida»		2002-03	August-January
RV «AtlantNIRO»	4 cruises	1989-1991	
Research and fish-detecting vessel «Bakhchisarai»		1979	March-September
		1980	
Research and fish-detecting vessel «Borodinskoe Pole»,		1989	
Research and fish-detecting vessel «Zvezda»		1978	
		1978-79	
		1981	May
		1982-83	July-April
Research and fish-detecting vessel «Kommunar»		1978	
Research and fish-detecting vessel «Kulikovo Pole»		1981-82	November-February
		1982-83	July-April
Research and fish-detecting vessel «A. Lopatin»		1978-79	
Research and fish-detecting vessel «Malta»		1989	
Research and fish-detecting vessel «Merkuri»		1980	
Research and fish-detecting vessel «Novocheboksarsk»,		1989	
		1990	
Research and fish-detecting vessel «Nogliki»		1978-79	
Research and fish-detecting vessel «Nikolai Ostrovski»		1976-77	November-April
		1977-78	December-June
		1978-79	November-May
Research and fish-detecting vessel «Plunge»		1979	
		1980	
Research and fish-detecting vessel «Poltava»		1979	
Research and fish-detecting vessel «Prometei»		1978	
		1978-79	
Research and fish-detecting vessel «K. Raud»		1978	
Research and fish-detecting vessel «Sokrat»		1990	
Research and fish-detecting vessel «Spektr»		1978-79	
Research and fish-detecting vessel «Stvor»		1980	
Research and fish-detecting vessel «Suvalkia»		1978	
		1978-79	

Research and fish-detecting vessel «Foton»		1980	
Research and fish-detecting vessel «Ekliptika»		1973	
Total	21 vessels, 201 cruises		
VNIRO			
RV «Ak. Knipovich»	11-12	1971-73	
	14	1975	
	18-20	1979-82	
Total	1 vessel, 5 cruises		
North Fisheries Facilities			
Research and fish-detecting vessel «A. Borisov»	1	1979-80	August-February
	2	1980	April-August
	3	1980-81	September-February
	5	1982	February-August
	6	1982-83	September-January
	8	1983-84	November-April
	12	1986	June-November
	13	1986-87	December-May
Research and fish-detecting vessel «M. Verbitskiy»	19	1989	May-October
Research and fish-detecting vessel «A. Generalov»	7	1983-84	October-March
Research and fish-detecting vessel «Izmailivo»	1	1986	March-August
	2	1986-87	September-January
	3	1987	March-July
	4	1987	July-November
Research and fish-detecting vessel «P. Kaykov»	9	1985	February-August
	10	1985-86	September-February
	11	1986	March-August
	12	1986-87	October-April
Research and fish-detecting vessel «Ef. Krivosheev»	8	1984	March-August
	12	1987	May-October
	16	1989	July-December
	18	1990	July-December
Research and fish-detecting vessel «N. Kuropatkin»	14	1990	February-July
	15	1990-91	August-February
Research and fish-detecting vessel «S. Makarevich»	3	1984-85	August-January
Research and fish-detecting vessel «F.Nansen»	11	1989	July-December
	12	1989-90	December-May
	13	1990	June-November
	14	1990-91	November-March
Research and fish-detecting vessel «Pavel Panin»		1984	May-August
Total	10 vessels, 31 cruises		

Far East Fisheries Facilities			
Research and fish-detecting vessel «Ak. Berg»			
Research and fish-detecting vessel «Gerakl»			
Research and fish-detecting vessel «Mys Babushkina»			
Research and fish-detecting vessel «Mys Dalniy»			
Research and fish-detecting vessel «Mys Yunony»			
Research and fish-detecting vessel «Pioner Nikolaeva»		1982	January-February
		1983	March-June
		1984	January-May
		1985	February
		1987	April-August
		1988	February
Research and fish-detecting vessel «Prof. Derugin»		1960	
Research and fish-detecting vessel «Novokotovsk»			
Research and fish-detecting vessel «Capitain Oleinichuk»			
Research and fish-detecting vessel «Ochakov»			
Research and fish-detecting vessel «Poseidon»			
Research and fish-detecting vessel «Pulkovskiy Meridian»			
Total	13 vessels, 260 cruises		
Total	**62 vessels, 551 cruises**		

The results of cruises made during the first decade allowed us to determine one of priority regions for fish searching: South Pacific. In the 1960-s and 1970-s expeditions were sent there from the Western Fish-exploratory and Research Fleet Administration (Zaprybpromrazvedka), Atlantic Research Institute of Fisheries and Oceanography (AtlantNIRO), All-Union Research Institute of Marine Fisheries and Oceanography (VNIRO), TURNIF, the Pacific Research Institute of Marine Fisheries and Oceanography (TINRO), Academy of Sciences (primarily its Institute of Oceanology), and from other regional fish scouting services (Tab. 1). This multidisciplinary ecosystem research and fishing became most intensive in the late 1970-s, and they were kept on that level till the early 1990-s.

Throughout the entire period of investigations of the South Pacific between 1955 and 2003 Russia performed 551 expeditions using 62 vessels (Tab. 1, Fig. 1). The total cost of those cruises was $ 5 million*551=$2.275.500.000. About the same amount was spent for processing and analysis of the cruise data. Consequently, the overall expenditures of Russia for the fifty-year multidisciplinary ecosystem research in the South Pacific were $ 5.510.000.000.

R/V of VNIRO
«Akademik Knipovich»

R/V of AtlantNIRO
«Atlantida»

R/V of AtlantNIRO
«AtlantNIRO»

Research and fish-detecting vessel of TURNIF
«Pioner Nikolaeva»

Fig.1. Scientific vessels which took part in the study of living marine resources of the South Pacific.

Those comprehensive ecosystem studies in the South Pacific included such main subjects of research as described below.

1. Hydrophysical characteristics, their structure and variability in waters of various genesis, and in the intermediate contact zones. Emphasis was made on the study of hydrophysical characteristics of the frontal zones and frontal limits, and of optical properties of water. The round-the-year monitoring of ocean surface temperature variations based on fishing vessel sensoring data, concommittant oceanographic observations, satellite information.
2. Hydrochemical structure of waters, and its relationship with hydrophysical and biological fields. Determination of concentrations of oxygen, carbonic acid, organic and non organic forms of nutrients (phosphorus, silicon, nitrogen including ammonium and carbamide), manganese, vitamins, hydrogen ions, alkalinity, ambient density; micro- and macroscale regularities of distribution of suspended matter and its main components.
3. Biophysical parameters: water muddiness, spatial and temporal variability in the bioluminescent field.
4. Biological communities: their spatial differentiation pattern, spatial and temporal structure variability of various scale. Processes creating biological production at various trophic levels of communities. Composition, quantitative distribution, volume of production and destruction of bacterial plankton (by different independent techniques); phytoplankton (from picoplankton of 0.2-3 mkm); nano- and microplankton heterotrophic organisms (separately nude flagellates and infusoria); meso-, macro- and ichthyoplankton; primary and bacteria production processes and governing factors; methods of determination of phytoplankton and microorganism production; effectiveness of the use of energy and of production of plankton and benthos by various trophic and ecological groups; seasonal condition of communities in various regions of the South Pacific; regularities of qualitative macro- and mesoscale distribution of species and ecological groups of plankton and benthos; successions of different scale coenoses; pattern of distribution of energy flow along trophic web.
5. Stock assessment of hydrobionts – the main objects of Russian fisheries.

It was exactly the comprehensive ecosystem multidisciplinary approach to the study of the ocean and living resources that made it possible for Russia to make significant oceanographic and biological discoveries in the second half of the XX century.

1. Broad multiannual information on the condition of the major fishing stocks of hydrobionts in the South Pacific was collected. The main species are given below:

Pacific jack mackerel *Trachurus murphyi;*

Pacific chub mackerel *Scomber japopnicus peruanus;*

Splendid alfonsino *Beryx splendens;*

Redbait *Emmelichthys nitidus cyanescens;*

Redbait *Emmelichthys elongatus;*

Pacific pomfret *Brama japonica;*

Cardinalfish *Epigonus heracleus;*

Cardinalfish *Epigonus parini;*

Flashlightfish *Electrona carlsbergi;*

Pacific saury *Scombresox saurus;*

Wellington flying squid *Notodarus sloani;*

Angola flying squid *Todarodes angolensis;*

Striped squid *Eucleoteuthis luminosa;*

Jumbo flying squid *Dosidicus gigas*;

Neon flying squid *Ommastrephes bartrami;*

Purpleback flying squid *Sthenoteuthis oualaniensis;*

Rhomboid squid *Thyasanoteuthis rhombus;*

Deep-water lobster *Projazus bahamondei*;

and others (Fig. 2).

It may be noted that most stocks beyond 200-mile zones were discovered and described for the first time by Soviet scientists. Redbait *Emmelichthys elongates*, two species of cardinalfish, two species of headlightfish (*Diaphus parini, D. confusus*), warehou (*Seriolella tinro*), *Maomao caprodon krasyukovae* were discovered by scientists of VNIRO, AS Institute of Oceanology and TINRO.

Most valuable information on the status and structure of stocks of jack mackerel and other fishing species of the South Pacific in the pre-fishery period was obtained.

2. Despite the active fishing, no stocks were damaged or even overfished thanks to dependable scientific information on the structure and dynamics of stocks, both seasonal and interannual. As early as 20-30 years ago the Soviet Union adhered to the most strict approach to estimating the allowable catch levels which was named precautionary later. Thus, the total catch of the central fishing species – jack mackerel – by all nations in1978-1991 beyond the

coastal states' EEZs in the South Pacific was 3.1-8.4% of the fishing stock biomass, where Russian catches made up 2.8-6.2%.

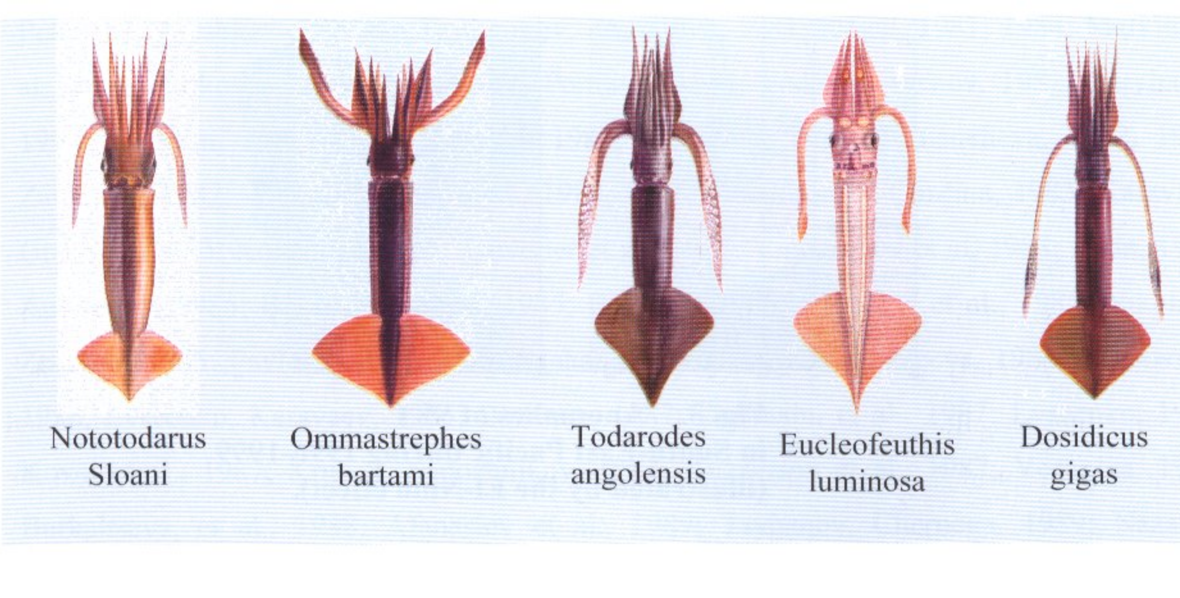
3. Over 150 seamounts were surveyed on the high seas in the Pacific, of which forty were discovered and described during that work for the first time. They compared navigation, hydrophysical and weather data for these areas, and described bottom relief, food base, and hydrological conditions of the fishing species' habitats.

4. Ocean surface temperature information was accumulated for the period from January 1986 till the present time, including weekly maps, ST anomalies (Fig. 3), ST trend, and monthly, seasonal and interannual differences.

5. Comprehensive knowledge was obtained of the abiotic and biotic structures of the South Pacific ecosystems, their functional set-up and spatial differentiation; quite a number of features of biological communities unknown before was found out. Besides, the mechanisms determining spatial, seasonal and long-range variability of South Pacific ecosystem characteristics were studied and described for the first time. Integral structural characteristics of all the components of the system, and intensity of processes within the ecosystems keeping those components together were assessed and quantified. Matter and energy flows were computed.

6. Biogeographic zones, position of their boundaries, composition and structure of the communities inhabiting them were described in detail.

7. The special characteristics of adaptation of the communities and populations of the most abundant species to the conditions of intermittent upwelling where the periods of exceedingly great primary production alternate irregularly with periods of its acute decline were tracked down.



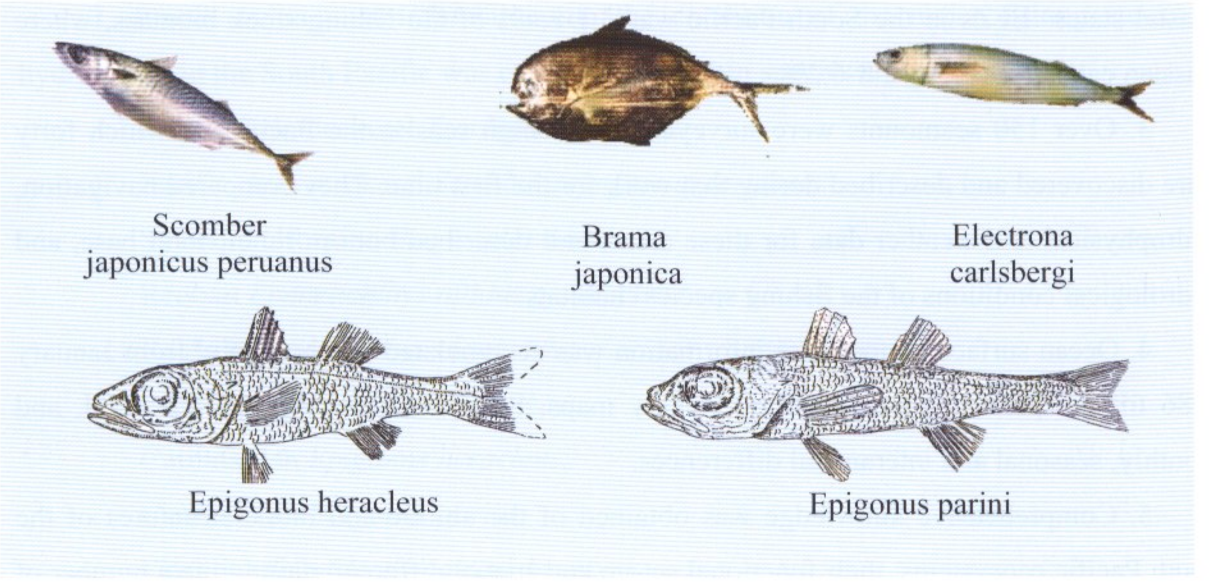


Fig. 2. Main fishery species discovered and described in the course of the Russian Multidisciplinary Ecosystem Research (squids drawings by D.Alexeev /VNIRO/).

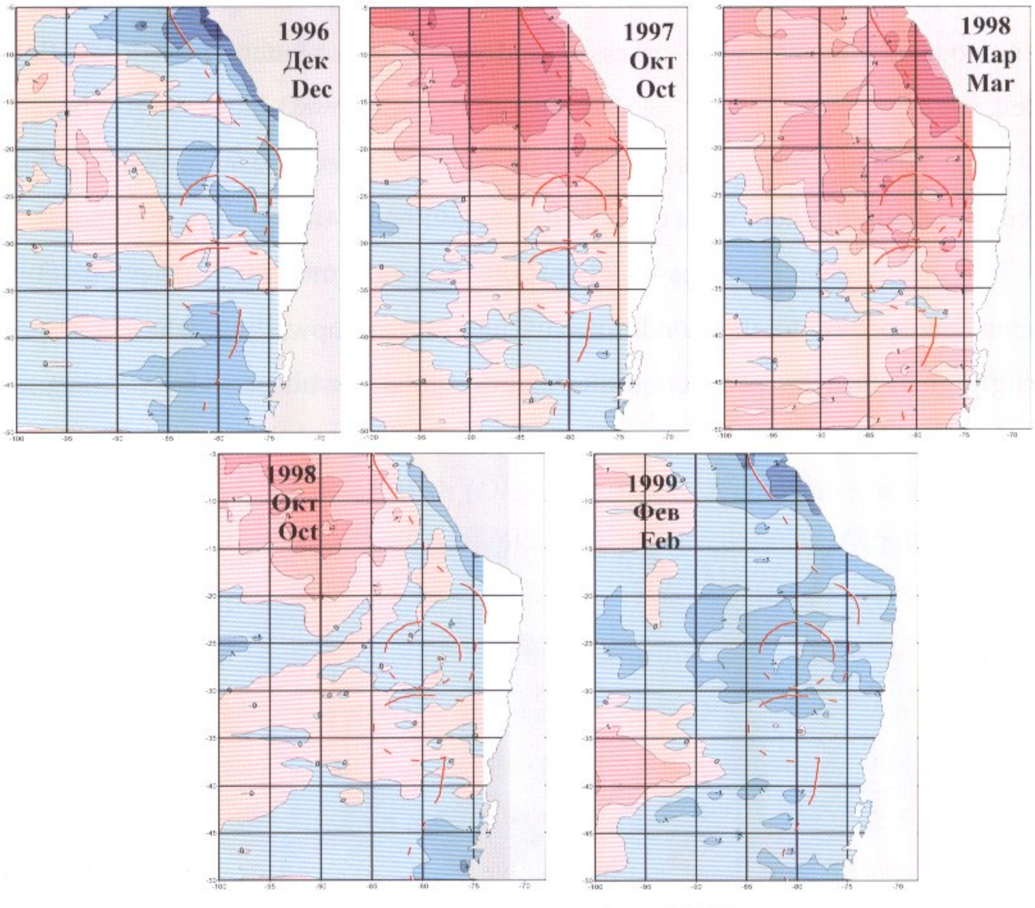


Fig. 3. Anomalies of SST in South-East Pacific during 1996-1999 (illustrated by the El-Nino effect).

The results of those studies were used for the publication of subject collected papers, books, reviews, meeting materials, dissertations (Melnik et al., 1974; Pelagic ecosystems.., 1975; Mikheev, 1978; Nekton and ichthyoplankton, 1979; Ichthyofauna of the southeast Pacific Ocean, 1980; Fisheries potential.., 1980; Pelagic ecosystems.., 1980; Fish resources of the southeast Pacific Ocean, 1981; Flint, 1981; Gretchina, Kuznetsov, 1981; Fauna and hydrobiology.., 1982; Fisheries research in the southeast Pacific, 1982; Oceanological conditions.., 1982; Alekseev, Mesherjakov, 1983; Bekker, 1983; Bioproduction of upwelling ecosystems, 1983; Fisheries – oceanographic research.., 1984; Fisheries research of the high seas.., 1984; Frontal zones.., 1984; Intraspecific differentiation.., 1984; Voronina, 1984; Nesis, 1985; Resources and prospects of utilization of squids.., 1985; Tormosov, 1985; Zuev et al., 1985, 1988; Life cycles.., 1986; Living resources of the Pacific Ocean, 1986; Oceanological variability.., 1986; Present status of mesopelagic fish research.., 1986; Study of the living resources and status of fisheries.., 1986, 1987; Living resources of the high seas, 1987; Nekrasov, Karatateva, 1987; Voronina, 1987; Ecological fisheries research.., 1988; Ecosystems of the subantarctic zone in the Pacific, 1988; Parin, 1988; Development of fisheries.., 1989; Description of seamounts.., 1989; Moiseev, 1989; Ecosystems of the eastern boundary currents.., 1990; Reserve food living resources.., 1990; Condition of living resources.., 1991; Ecological fisheries research in the south Pacific, 1991; Kotenev, 1992; Fisheries research of fishing items.., 1993; Pelagic ecosystems.., 1993; Fisheries-biological investigations.., 1994; and others), and individual articles in scientific publications (Berman, 1976; Kotliar, 1976; Semenov, Berman, 1977; Arseniev et al., 1978; Chekunova, Naumov, 1978; Grossman, 1978; Ponomareva, Drobisheva, 1978; Shushkina et al., 1978; Sorokin, 1978, 1983; Vedernikov, Sapozhnikov, 1978; Vedernikov et al., 1978; Darnitskij, 1979; Markina, 1979; Menshutkin, 1979, Shuntov, 1979; Abramov, Kotliar, 1980; Konchina, 1980; Pelimskij, Arashkevich, 1980; Kolesnikov, Zhigalova, 1981; Koval, 1981, 1984; Markina et al., 1981; Ratkova, 1981; Tarverdieva, Permitin, 1981; Fedorov, Ivanov, 1981; Barkhatov, 1992; Kashirin, 1982; Flint, Timonin, 1982; Semenov, 1982; Tumancheva, 1982, 1985; Zakharov, 1982; Aleksandronets et al., 1983, 1986; Galaktionov, Gardina, 1983; Karavaev, Grechina, 1983; Konchina, 1983; Truveller et al., 1983; Vinogradov et al, 1983; Parin, 1984; Andrianov, 1985; Bordovskij et al., 1985; Fedorov, 1985; Morozov et al., 1985; Nikolaev, Zhiltsov, 1985; Pavlova et al., 1985; Suchanova et al., 1985; Alekseeva, 1986; Bordovskij, 1986; Evseenko, Karavaev, 1986; Bazanov, 1987; Dobrusin, et al., 1987; Evseenko, 1987; Koval et al., 1987; Krukov, Sapozhnikov, 1987; Kuznetsov et al., 1987; Voronina, 1987; Burkaltseva, et al., 1988; Afanasiev et al., 1989; Tsyganov, Chernega, 1989; Nazarov, Nesterov, 1990; Parin et al., 1990; Pavlov, 1990, 1991; Kalchugin, 1991; Zaripov et al., 1991; Elizarov et al., 1992; Nesterov, 1996; Naletova et al., 1997; Konchina, Pavlov, 1999 and others).

Altogether over 50 books on specific subjects on the South Pacific were published in Russia; each one is a large volume.

2. History of discovery and fisheries exploration of the jack mackerel belt in the South Pacific.

One of the main results of the integrated comprehensive ecosystem research in the South Pacific was the discovery and detailed description of the jack mackerel belt.

The species of Pacific jack mackerel *Trachurus murphyi Nichols* was described in 1920. For nearly forty years the genus of jack mackerels was believed to have a bipolar range. It was thought that in South Pacific the Pacific jack mackerel inhabits exclusively the temperate waters off Chile south of 50°S (Berg, 1920; Aleev, 1957). The coastal subtropical and tropical parts of jack mackerel's range between Ecuador and Peru were found and described later (Berry, Cohen, 1972). Until the 1970-s it was believed that the Pacific jack mackerel inhabits the shelf and slope waters only. The high seas part of its range remained to be unexplored.

This largely resulted from the fact that prior to the early or middle 1980-s most fishing nations conducted research in their own coastal zones trying to make full use of the aquatic living resources of the exclusive economic zones (EEZ) introduced in the middle of 1970-s.

The implementation of the strategy of Russia aimed at prospective sustainable development of high seas fisheries led to finding jack mackerel beyond the limits of the South American continent's shelf zone. In 1973-1975 the pelagic layer around the underwater ridge Nasca was examined during the national research cruises. Concentrations of jack mackerel of virtually all the size-age groups were fished there. In 1978 the West Fishery Association «Zapryba» organized jointly with the West Fish-finding Service a fishery and exploratory expedition to the Southeast Pacific which made it possible for the first time to detect beyond the EEZ of Peru considerable concentrations of pelagic species – jack mackerel, mackerel and sardine within the oceanic upwelling over the subsurface Peru-Chile countercurrent.

Consequently the basic result of the first stage of comprehensive Soviet research in the South Pacific which went on for 24 years (1955-1978) was the discovery and description of the area of habitation of jack mackerel beyond the EEZs of Peru and Chile between 5°S and 55°S, up to 105°W (Tab. 2, Fig. 4).

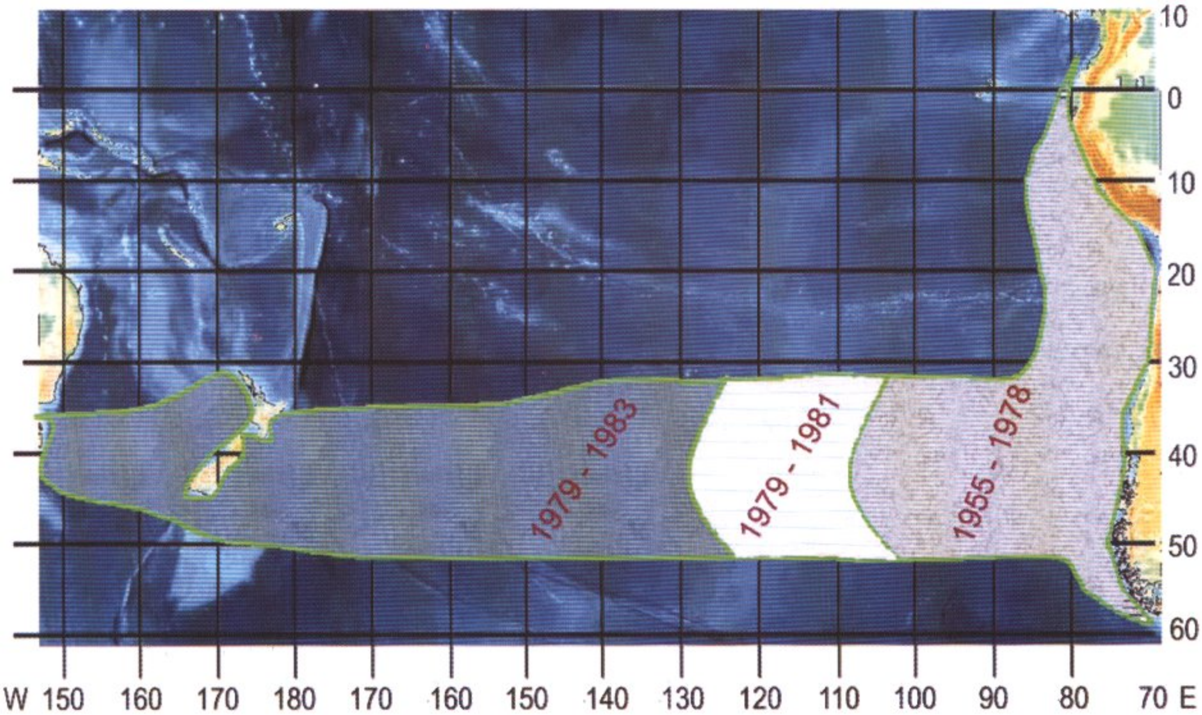


Fig. 4. Time history of Russian discoveries of jack mackerel in the South Pacific.

According to the program of fisheries research of the World Ocean cruises were made during the ensuing 5 years to the central-southern and west-southern parts of the Pacific Ocean. The specialized coordinated effort of all the institutes and fish-finding services of the Ministry of Fisheries, Academy of Sciences of USSR allowed us to discover stable fishing concentrations in 1979-1983 west of the range of jack mackerel found in previous cruises. It was found out in the cruise on «Kulikovo Pole» (West Fish-finding Service) (October 1981 – February 1982) that fishing concentrations of the Pacific jack mackerel occur between 35°S and 52°S and 105°W – 130°W (Fig. 4).

In 1979 two fish-scouting ships «Poltava» and «Plunge» (West Fish-finding Service) found for the first time small concentrations of the Pacific jack mackerel in the waters adjacent to the EEZ of New Zealand. During the fish-finding and fishing expedition organized by the Ministry of Fisheries of Russia in 1982-1983 involving 13 vessels the data on the range of jack mackerel extending to the EEZ of New Zealand and Australia were confirmed (Fig. 4).

In 1980-s, the estimated fishing biomass of jack mackerel in the eastern region was, according to the Russian survey data, between 8 and 10 million tons (Nesterov, Nazarov, 1991; Nesterov et al., 2004); it was 9-14 million tons between 105°W and 160°W; the entire jack mackerel belt estimates for the South Pacific were about 18-25 million tons (Elizarov et al., 1992; Kotenev, 1992).

The eastern region began to be explored by the fishery in 1978. The Soviet catch of jack mackerel in the first year of fishing reached 50700 tons. The catch increased tenfold as early as next year: 532000 tons. In 1981 active Russian harvesting of jack mackerel began in the central region; after a year it began in the west region.

Table 2. History chart of the discovery and description of the «jack mackerel belt» in the course of Russian research.

Area	Position	Prior to start of commercial fisheries researches were conducted by	Year when commercial exploitation of region began
East	5^0 S - 55^0 S West of Chile and Peru EEZs to 105^0 W	West Fish-finding Service, AtlantNIRO, VNIRO, TINRO, TURNIF, USSR Academy of Sciences; 1955-1978	1978
Center	25^0 S - 55^0 S 105^0 W - 130^0 W	All institutes and fish-finding services of the USSR Ministry of Fisheries, USSR Academy of Sciences; 1979-1981	1981
West	30^0 S - 55^0 S 130^0 W – EZZs of New Zealand and Australia	All institutes and fish-finding services of the USSR Ministry of Fisheries, USSR Academy of Sciences, 85 cruises of RVs and fish search boats used for research, up to 13 vessels at one time; 1979-1983	1982-1983

The Soviet catch of jack mackerel in FAO area 87 in 1984 exceeded one million tons (Fig. 5). In area 81 the peak of Soviet catches of jack mackerel was reached in 1986: 152500 tons (Fig. 6). The total maximum Soviet catch of jack mackerel in the South Pacific was recorded in 1984: 1123900 tons (Fig. 7).

Throughout the most intensive period of the Soviet fishing fleet's operations (1978-1991) the overall catch of jack mackerel in area 87 was 10125900 tons, or 79.8% of the total world catch of jack mackerel in this area beyond 200-miles zones; in area 81 it was 651950 tons or 63.4% of the world catch. In total over 13 million tons of fish was taken by the USSR in the South Pacific during those thirteen years including 10.78 million tons of jack mackerel, or 78.6% of the world catch.

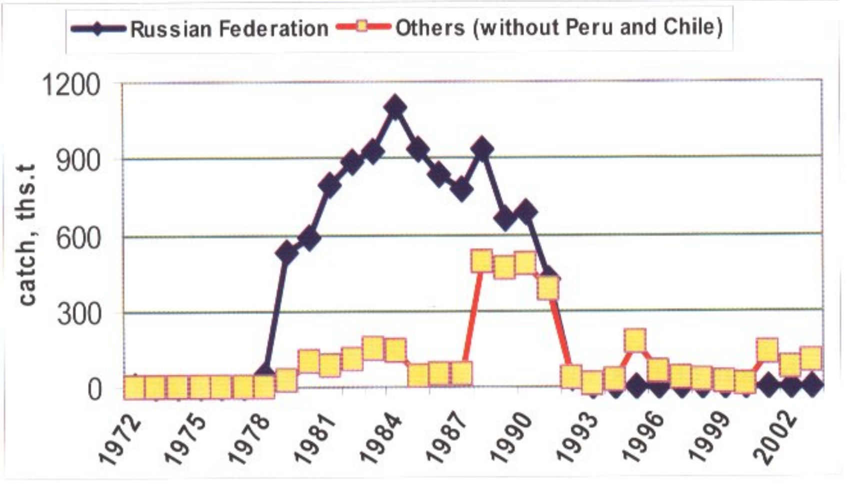


Fig. 5. Catch of jack mackerel by Russia and other countries in the South Pacific beyond EEZs of Peru and Chile (FAO area 87).

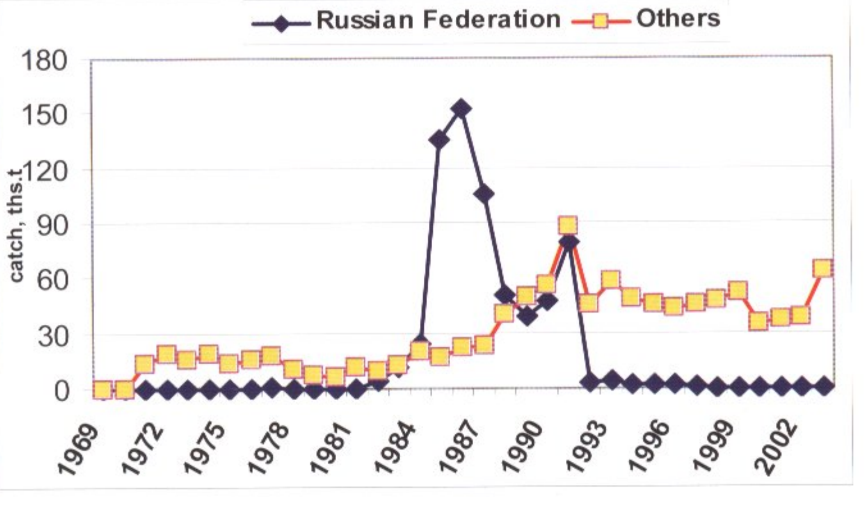


Fig. 6. Catch of jack mackerel by Russia and other countries in the South Pacific (FAO area 81).

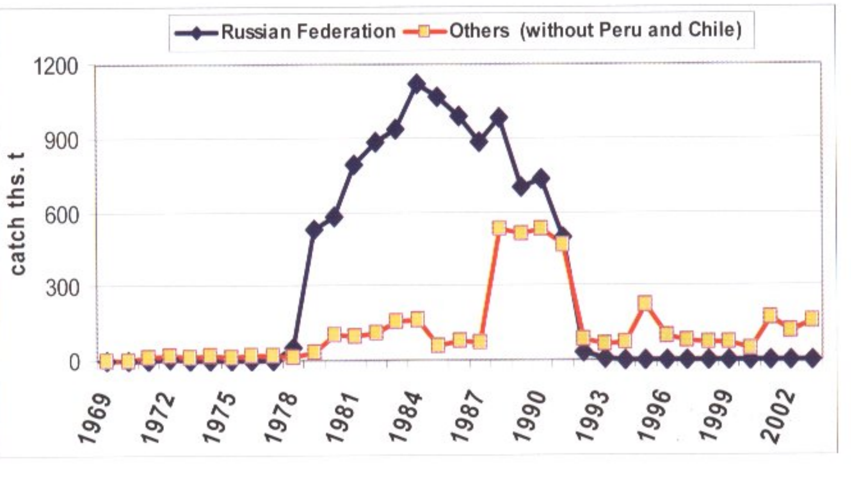


Fig. 7. Total catch of jack mackerel by Russia and other countries in the South Pacific (FAO area 81and 87).

High and stable catches were achieved by Russia by way of conducting comprehensive ecosystem research during the whole period of intensive fishing, and by summarizing the data from the cruises made earlier.

3. The increased bioproduction in the jack mackerel belt: mechanisms of formation.

In the course of investigations made by Russia they collected and analyzed multiannual data on the distribution of jack mackerel and its seasonal migrations guided by the ocean mechanisms of formation of increased bioproduction in the jack mackerel belt.

As early as in 1967, V.G. Bogorov identified the transoceanic natal region encompassing subantarctic waters between South America and New Zealand as one of the highly productive regions in the Pacific (Ecosystems of the Pacific subantarctic zone, 1988). Location of this region in the most «oceanic» sector of the South Pacific ensured maximum vastness of oceanological zones, rather low atmospheric pressure gradients, relatively low rate of transport of the Antarctic circumpolar and South Pacific currents in the temperate latitudes. At the same time the jack mackerel belt is contiguous to the regions where in the south the processes of formation of deep and intermediate Antarctic waters are unusually intensive; in the north this is true of subtropical waters. Such intensity of formation of specific water types caused an increased longitudinal exchange of the subsurface and intermediate waters. Longitudinal exchange is also facilitated by the bottom relief. The sublongitudinal chains of seamounts, the East Pacific and Chilean elevations fortify the flows having a longitudinal element. (Vasilieva et al., 1982; Zyrianov, 1982; Kotenev, 1992). The meandering of flows resulting from the interplay of latitudinal and longitudinal water transport brings about the formation of oceanic zones with stable conditions which attract hydrobionts of various trophic levels (Krukov, 1982; Vasilieva et al., 1982; Kashirin, Melnik, 1984; Ecosystems of the Pacific Subantarctic zone, 1988; Bendik, 1991; Kotenev, 1992; Sushin, 2003).

The increased biological production of such zones, and concentration of various plankton components there is ensured by the factors as given below.

- Local water dynamics, and formation of semienclosed units having a high rate of vertical transport velocity (Poyarkov, 1984; Sukhanova et al., 1984).
- Permanent emergence of cyclonic eddies around the frontal sections (Zatsepin et al., 1984) where the nutrient-rich subsurface waters are brought to the surface (Sukhanova, Vedernikov, 1985).

- Interaction among the pelagic communities differing in structure, level of production and succession maturity within the frontal zone and frontal section which might lead to the consumption of the surplus food resources of the other, and to the respective increase in biomass of the latter (Vinogradov et al., 1980, 1983, 1984; Flint, 1981; Timonin, Flint, 1985).

The specific coastal circulation brings about hydrological isolation of the regions of upwelling over the shelf which is proved by numerous biological characteristics (Burkov, 1980; Kashirin, Melnik, 1984).

This is followed in future by the formation of biocenoses in the zones with stable hydrological conditions. The presence of such zones can be illustrated by the dynamic topography of the ocean surface, surface temperature, and distribution of salinity (Fig. 8).

Plankton concentrations move together with water mass; hydrobionts of higher trophic levels follow them. Hence, schools of jack mackerel made nearly a full circle between 87°W – 95°W and 36°S – 40°S during 16 days of January 1986 (Fig. 9).

4. Outline of the studies of jack mackerel population structure in the South Pacific by Russia.

Russian researchers detected several geographically isolated groupings of jack mackerel within the species belt; these groupings were attached to zones having stable hydrological conditions (Vasilieva et al., 1982; Chur et al., 1984; Kashirin, Melnik, 1984; Rudometkina et al., 1988; Elizarov et al., 1992; Kotenev, 1992). Each one had its own isolated spawning ground, makes circular seasonal migrations, and they differed in the time of spawning (Vasilieva et at., 1982; Storozhuk et al., 1984; Kotenev, 1992), characteristics of maturation rate, gametogenesis and spawning (Storozhuk et al., 1984; Ermakov, 1986; Kotenev, 1992), morphophisiological indices, physiological and biochemical indicators (Storozhuk et al., 1984), size-age composition (Nazarov, Shevchuk, 1984; Elizarov et al., 1992; Kotenev, 1992), parasitofauna (Kashirin, Melnik, 1984) and other aspects. The high abundance of eggs and larvae of jack mackerel in the oceanic part of the region is commensurate with that in the EEZs of the coastal states (Rudometkina et al., 1988).

The eastern spawning ground of jack mackerel in 1978-1991 was between 78°W – 90°W and 37°S – 42°S (Fig. 10). Spawning in this area occurred in November-March. The southern boundary of the region having the greatest density of eggs agreed with the 16°C isotherm. The core of the ground was between 37°S and 38°S. Its western limit in some years shifted up to 100°W –105°W.

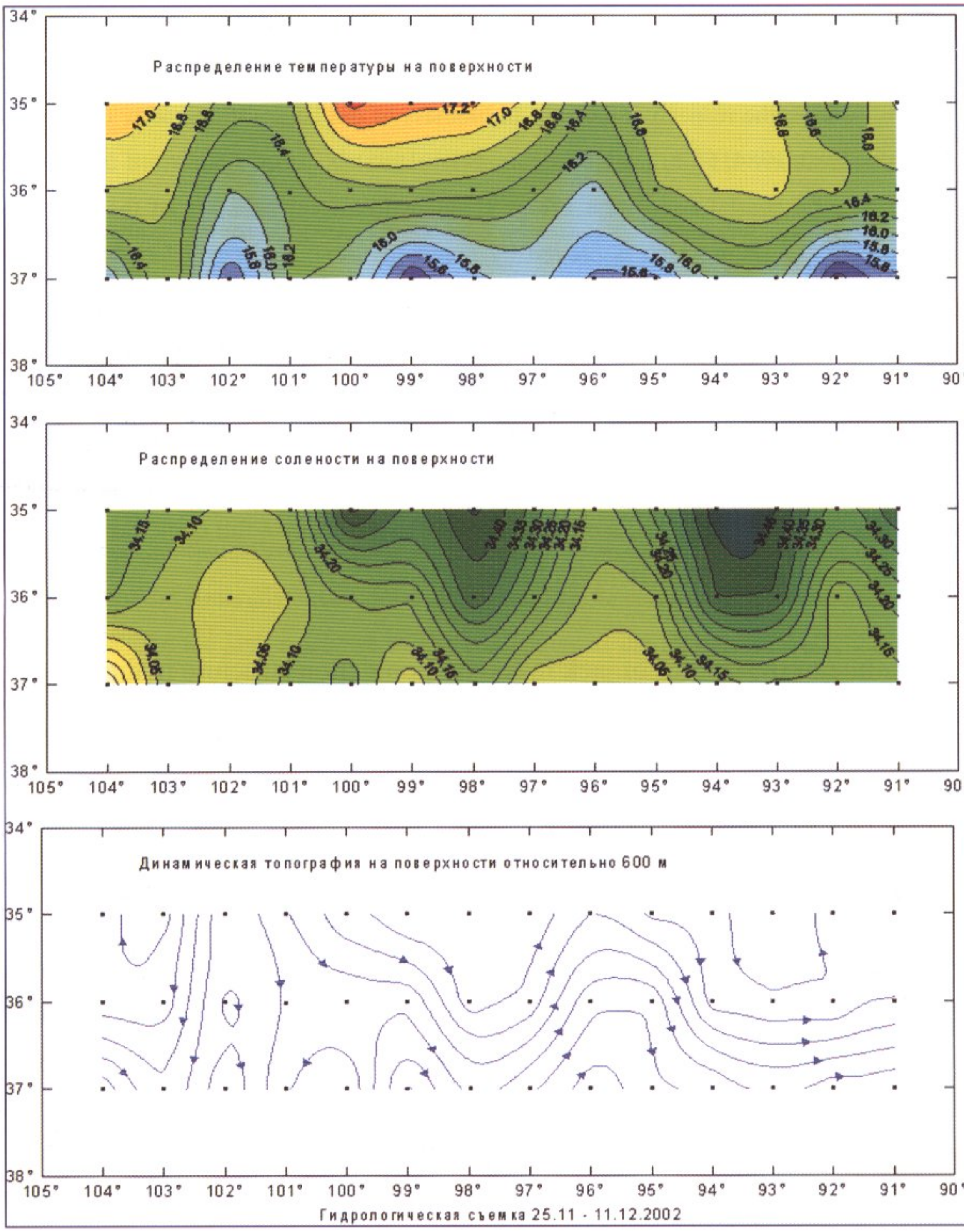


Fig. 8. Temperature, salinity and dynamic altitudes on surface (Chukhlebov et al., 2004).

Individuals of the central grouping of jack mackerel spawned in 105°W – 125°W and 5°S – 38°S. Spawning concentrations were recorded up to the 42-nd parallel of the Southern Hemisphere (Fig. 10). Depending on the ocean and weather conditions the core of spawning was around 110°W (1985-1986) or 114°W – 117°W (1988). Upon completion of spawning the jack mackerel of this group migrated southwards in January-February, then it moved west, returning to the spawning sites afterwards, thus making a circle of migration during a year.

The west grouping spawned near 130°W – 155°W and 35°S – 40°S. In the west of the South Pacific the jack mackerel spawned from August-September to January, i.e. it was three months earlier than in the central and eastern regions. The post-spawning migrations of large jack mackerel from the west grouping started already in December: the fish moved southwards, down to the subantarctic front effect zone, and to the periphery of subantarctic divergence (between 43°S – 48°S) where the food zooplankton bred most abundantly. In January the post-spawning migrations terminated. In February the fish of the west grouping migrated eastwards and north-eastwards; in May-June migrations were to the north, up to about 43°S. In June concentrations moved westwards along the mid-subantarctic front, and north of it along 39°S and 42°S. In August spawning concentrations of the largest fish began to be formed west of 130°W. The yearly round migration cycle of the west group fish thus closed.

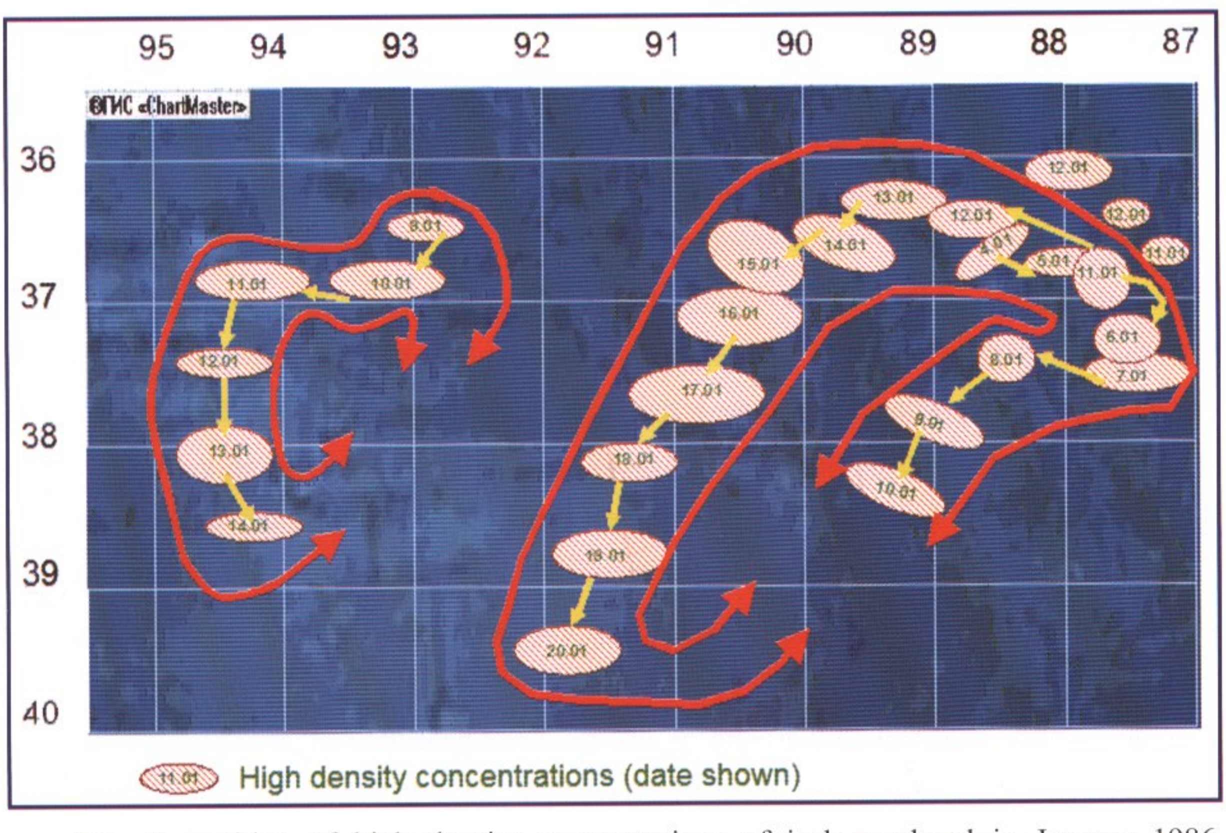


Fig. 9. Position of high density concentrations of jack mackerel in January 1986 (Sushin, 2003).

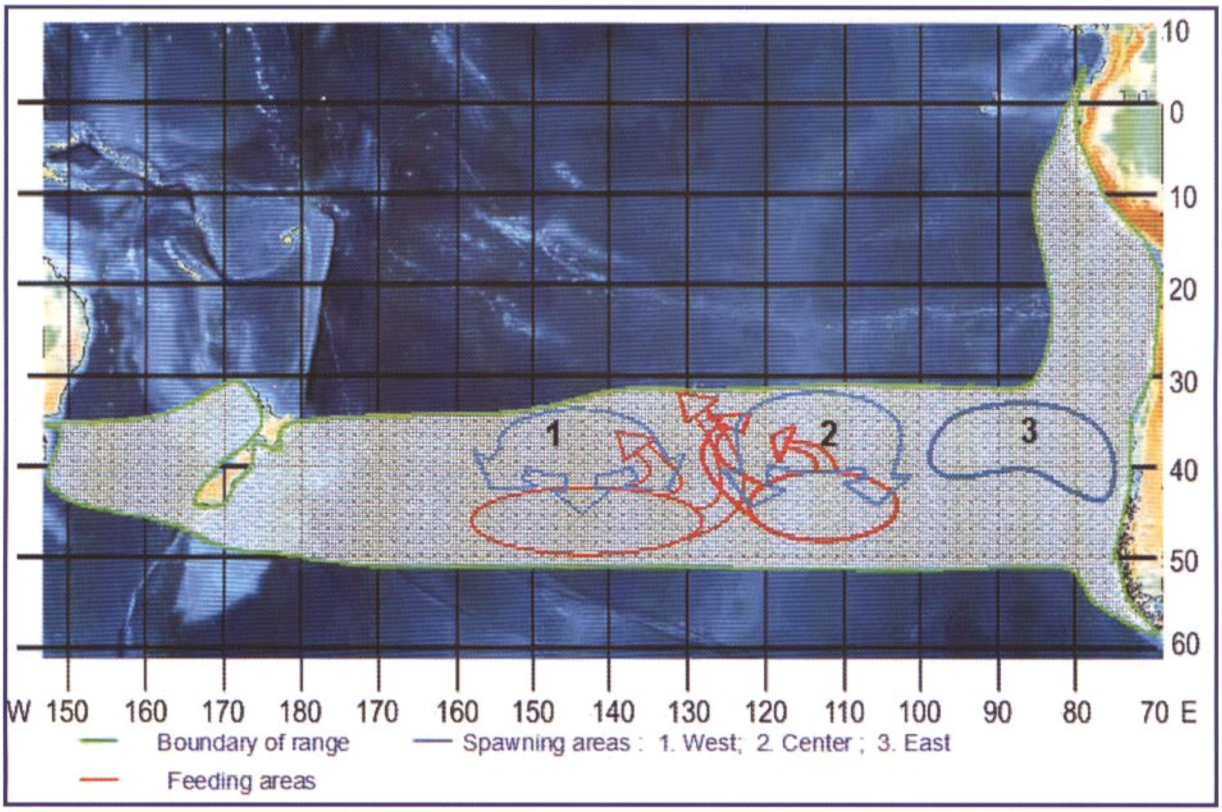


Fig. 10. Functional structure of oceanic and neretic jack mackerel in the South Pacific.

The west grouping spawned near 130°W – 155°W and 35°S – 40°S. In the west of the South Pacific the jack mackerel spawned from August-September to January, i.e. it was three months earlier than in the central and eastern regions. The post-spawning migrations of large jack mackerel from the west grouping started already in December: the fish moved southwards, down to the subantarctic front effect zone, and to the periphery of subantarctic divergence (between 43°S – 48°S) where the food zooplankton bred most abundantly. In January the post-spawning migrations terminated. In February the fish of the west grouping migrated eastwards and north-eastwards; in May-June migrations were to the north, up to about 43°S. In June concentrations moved westwards along the mid-subantarctic front, and north of it along 39°S and 42°S. In August spawning concentrations of the largest fish began to be formed west of 130°W. The yearly round migration cycle of the west group fish thus closed.

It is known the spawning ground of jack mackerel near the Galapagos islands attached to the vergent area in the equatorial front zone (Gorbunova, Evseenko, 1984).

In-between the major spawning areas described above there was only sparse occurrence of jack mackerel with melting sex products. This fact indicated a relatively small overlapping, hence, mixing of individuals from various groups during spawning.

The separate nature of spawning grounds, circular closed seasonal migrations, the established maturation rate, growth features and parasitofauna of individuals from various grouping, as well as food sufficiency in oceanic regions at all stages of ontogeneses, from larvae to adult fish suggest possible existence of at least three independent populations of jack mackerel in the South Pacific. The morphophysiological and metabolic adaptations to concrete statios may give rise to reproductive isolation, making the genetic divergence of jack mackerel populations stronger.

The life cycle of the eastern one is closely tied up with the EEZs of Chile and Peru while the ontogenesis is of the fish from the central and west grouping is fully within the oceanic waters of the South Pacific.

At the same time, during the most intensive research of jack mackerel of the South Pacific high seas waters (1978-1991) conditions were favourable for abundance growth pratically simultaneously near the shores and on the high seas. This obstructed much the study of the intraspecific and intrapopulational structure because of overlapping of the suggested population ranges. That is why the attempts to identify the population structure of the South Pacific jack mackerel using phenetic and genetic markers produced quite contradictory results, from the existence of several (2-4 and more) populations (Shaboneev et al., 1979; Koval, 1981, 1984; Kashirin, Melnik, 1984; Storozhuk et. al., 1984; Alekseev, 1986; Koval, Gordeev, 1987; Nekrasov, Karataev, 1987; Nekrasov, Timokhina, 1987; Kalchugin, 1991) to a single population within the entire jack mackerel belt (Parin, 1984; Evseenko, 1987; Parin, 1988; Nazarov, Nesterov, 1990).

Unfortunately until now there have not been population-genetic research of the oceanic groupings of jack mackerel using modern techniques of genome DNA polymorphism evaluation, including microsatellite sequences, jointly with the biological and ecological data. Such a study would facilitate unambiguous identification of the population structure in the South Pacific jack mackerel.

5. Conclusion.

Between the 1960-s and early 1990-s Russia discovered and made a detailed description of the pelagic and seamount ecosystems of the South Pacific, including the pattern of formation of the raised bioproduction zones, spatial-temporal and functional structure of both the entire biocenoses and their component species; the initial idea of the population structure of fishing species was obtained.

The major fishing species were the basic object of research, the jack mackerel ranking first.

Unfortunately, in the 1990-s the Russian research in the high seas of the South Pacific was stopped, while the studies made by other nations did not reach the magnitude of the Soviet investigations of the previous decades.

In August 2001-January 2003 Russia made a study of the status of aquatic living resources in the Southeast Pacific. The study was made after a ten year interval by AtlantNIRO, with participation of VNIRO scientists. Between the EEZ of Chile and 105°W (362100 miles ^{2}) the biomass of jack mackerel was 7.635 million tons, the average density of concentrations was 23.2 tons/mile^2 (Nesterov et al., 2004). The trawl-acoustic surveys made in 1985 and 1987 in the same water area showed that the estimated biomass was 5.39 and 4.50 million tons respectively. The density was 16.5 and 10.9 tons/mile^2. Consequently, the size of jack mackerel biomass in 2002-2003 exceeds the 1980-s values, and is close to the retrospective ones obtained by cohort modeling, using CPUE data (VPA).

Thus, at present the jack mackerel stocks in the South Pacific are on a stable and high multiannual level. At the same time, throughout the last 15 years data are lacking on the status of individual stocks of this species, primarily the central and western ones.

In order to develop conservation and management measures for the South Pacific hydrobionts that would be adequate to the population structure it appears reasonable to:

1. Establish an ecology-genetics working group for the study of fishing species of hydrobionts in the South Pacific.
2. The working group would have to formulate the main principles of collecting genetic and biological samples, adopt standard data processing procedures and set research priority species to which Russia suggests to refer jack mackerel and mackerel.
3. The working group would have to prepare during 2006 and present at the upcoming meetings a draft international program of research of the oceanic stocks of hydrobionts.

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