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SUMMARY AND REVIEW OF SOVIET AND UKRAINIAN SCIENTIFIC AND COMMERCIAL FISHING OPERATIONS ON THE DEEPWATER RIDGES OF THE SOUTHERN INDIAN OCEAN

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ERRATA:

Page 35. Name of fisheries research vessel given in the figure caption as '*Akademik Knipovich*' is incorrect. Correct name of vessel appeared at the picture is BMRT '*Skif*'.

SUMMARY AND REVIEW OF SOVIET AND UKRAINIAN SCIENTIFIC AND COMMERCIAL FISHING OPERATIONS ON THE DEEPWATER RIDGES OF THE SOUTHERN INDIAN OCEAN

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PREFACE

In the period from the mid-1950s to 1992, the Soviet fishing industry was centrally controlled. Fishing companies were allocated vessels and the distant water fishing world was divided among the various state-controlled fishing enterprises. There is no overstating of the tremendous achievement of the USSR in developing their fisheries during this period, which started when the USSR's first **Pushkin** class factory trawlers (modelled literally on the pioneering British factory trawlers, the **Fairsky** and **Fairtry**) moved into the North Atlantic. Between 1954 and 1956 the USSR ordered 24 ships of this class from West Germany yards. Several hundred larger **Mayakovski** class factory trawlers soon followed and this class quickly became a familiar sight in fishing ports around the world. By 1970 the Soviet Union had a fleet of 400 large (>1 000 GRT) vessels, giving them the largest distant water factory trawling fleet in the world, more than twice the size of that of Japan, its nearest rival. Bigger and better designs followed such as the **Atlantic**, **Super Atlantic**, **Tropik** and **Meridian** class vessels, often built in East German or Polish yards, were added to their fleets.

The management of the expansion of the Soviet distant water fishing had a geographical basis. In the Far East, fishing was under the control of DALRYBA with TINRO (Pacific Scientific Research Institute of Marine Fisheries and Oceanography), Vladivostok responsible for fisheries research and resource evaluation. In the North Atlantic, all three USSR Baltic States (Lithuania, Latvia and Estonia) were active and in addition Russian fishing companies were based in Murmansk (home to the largest Soviet fleet) and Kaliningrad (second largest). The Polar Research Institute of Marine Fisheries and Oceanography (PINRO) in Murmansk was responsible for research and resource evaluation for fisheries exploited by vessels from this port. Responsibility for research in the Atlantic belonged to AtlantNIRO, Kaliningrad. Responsibility for research and exploration of the Indian Ocean lay with the Southern Scientific Research Institute of Marine Fisheries and Oceanography (YugNIRO)[1] based in Kerch, Ukraine. All applied fisheries research work was generally coordinated by the All-Union Scientific Research Institute of Marine Fisheries and Oceanography (VNIRO), before December 1991 (USSR), and after December 1991 for Russia only, by the Russian Federal Research Institute of Fisheries and Oceanography, which were based in Moscow.

At the time of the beginning of Ukrainian (USSR) fishing activities in the early 1960s, little, if anything, was known about the off-shore fisheries resources of the Indian Ocean, not least the deepwater species. The pioneering activities of YugNIRO significantly changed that. And, despite the recent expansion (and contraction) of the fisheries associated with seamounts in the southern Indian Ocean, the information collected by the YugNIRO remains still the most complete source of information available. The extent and enormous value of their data was noted by both Ad Hoc Meetings on Management of Deepwater Fisheries Resources of the Southern Indian Ocean[2] and these meetings requested the FAO to seek to document, in the first instance, what information exists, and second, to explore the possibilities of arranging for the tow-by-tow data to be made available through a database. This second objective was in view of the desirability of establishing a common catch and effort database to support resource analysis and management decisions of deepwater stocks in this region. A pilot programme for encoding YugNIRO data has been undertaken so that the costs of undertaking this task may be estimated and other operational problems identified. The first step has been completed and the task of finding funds to be able to undertake this extremely important work must now be addressed. In addition, some form of access agreement remains to be negotiated that protects the interests of the Ukrainians – the source of the information – but also makes this vital source of information available for use by those attempting to provide advice on the management of the resources in this area.

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[1] Until 1989 known as the Azov-Black Seas Scientific Research Institute of Marine Fisheries and Oceanography (AzCherNIRO).

[2] FAO 2001. Report of the Ad Hoc Meeting on Management of Deepwater Fisheries Resources of the Southern Indian Ocean. Swakopmund, Namibia, 30 May – 1 June 2001. *FAO Fisheries Report*. No. 652. Rome, 61pp.

FAO 2002. Report of the Second Ad Hoc Meeting on Management of Deepwater Fisheries Resources of the Southern Indian Ocean. Fremantle, Western Australia. 22 – 24 May 2002. *FAO Fisheries Report*. No. 677. Rome, 106pp.

Dr Evgeny Romanov of the World Ocean Fishery Resources Department, Southern Scientific Research Institute of Marine Fisheries and Oceanography (*YugNIRO*), with the support and contributions of his colleagues, has achieved a commendable result in producing this report. In doing so, FAO believes that a major contribution has been made to securing the pioneering information that was collected on the unexploited fishery resources in the Southern Indian Ocean – information that is rarely available in most other heavily-exploited regions of the world. In doing this, a valuable task has been completed to the benefit not only to the regional countries of the Southern Indian Ocean, but also to the wider scientific and distant water fishing nations with an interest in exploiting the fisheries resources of this part of the world's oceans.

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Romanov, E.V. (ed.)
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ABSTRACT

This document describes the pioneering fisheries exploration undertaken of the deepwater ridges of the southern Indian Ocean. The general marine physical and geographical characteristics of the area are described including the climatic conditions. The history of the Soviet research and exploratory cruises is documented together with the results of the acoustic and trawl surveys. A list of all species encountered is provided and a tabulation of the cruises with relevant operational details.

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APPENDIXES

TABLES

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[3] The address for all authors is: Southern Scientific Research Institute of Marine Fisheries and Oceanography (YugNIRO). 2, Sverdlov St., Kerch, 98300, Crimea, Ukraine.

FIGURES

SUMMARY

A short description of the geographical and environmental characteristics of the Southern Indian Ocean area and the principal characteristics (depth, bottom topography, hydrological conditions, temperature and salinity) is given. Mention is also made of the biotic components – the plankton and benthos. The area referred to by the Circular includes the Mozambique Plateau, Madagascar Plateau (Ridge), Walters Bank (shoals), Southwest Indian Ridge, Central Indian Ridge, Ninety-east Ridge and Southeast Indian Ridge (Broken Ridge). A map of the area (in the FAO statistical area 51 20-45°S, 20-80°E; in the FAO area 57 10-45°S, 80-110°E) has been prepared showing the locations of the sea mounts referred to in the report.

An almost complete list of research and searching cruises in the area is tabulated that includes incidental operations of vessels passing through area, the period and area of operations, and their cruise objectives purposes.

The catch results of Soviet/Ukrainian fisheries is given by subareas, type of gears, type of vessels, fishing effort and catch by species. Where it is known, those vessels that participated in the fishery are listed.

For each vessel, a description of the cruise objectives and the principal results of the research expeditions, by type of fishing gears, is given in chronological order. This includes a short description of fishing gears that were used and any peculiarities of its deployment which were:

i. bottom and midwater trawling
ii. bottom longlining
iii. vertical (drop) lining and
iv. Fishing using lobster pots.

The report does not describe any tuna longline exploration or commercial fishing results for these fishes, nor lift-nets expeditions for Atlantic saury, nor fishing using vertical squid lines.

The results of trawl stock assessment surveys, including the methods of estimating biomass and the results are given for the following cruises:

i. 17th cruise of **R.V. Fiolent**
ii. 19th cruise of **R.V. Fiolent**
iii. 21st cruise of **R.V. Fiolent**
iv. 23rd cruise of **R.V. Fiolent**
v. 29th cruise of **R.V. Zvezda Kryma**
vi. 2nd cruise of **R.V. Zvezda Sevastopolya** and the
vii. 7th cruise of **R.V. Ignat Pavlyuchenkov.**

Some comment is made of the biology of principal species whose abundance was estimated and the status of stocks which includes:

i. the species composition of fish and shellfish community of the underwater ridges in the Southern Indian Ocean
ii. the biology of principal fish species that were targeted and
iii. any basic peculiarities of fish stock formations (by region) associated with the underwater ridges, taking into consideration mechanisms of higher primary productivity associated with underwater seamounts and ridges.

Some comments are provided about the history of Soviet/Ukrainian fisheries in the Southern Indian Ocean and the strategies required to ensure sustainable utilization of fish stocks associated with the seamounts, and some considerations on the need for international cooperation in fisheries regulation and stock managements in the area.

1. INTRODUCTION

The area which is covered by this review comprises the Southern Part of the Indian Ocean (the southern part of FAO Statistical Areas 51 and 57) located beyond the equatorial zone (southward from 20 °S in the Area 51 and southward from 10 °S in the Area 57) (see Figure 1). Numerous long-term studies of YugNIRO were undertaken in the equatorial zone of the Indian Ocean (Mascarene Plateau, Saya-de-Malha bank, Chagos Archipelago, etc.), in the Antarctic part of the Indian Ocean (the CCAMLR Convention area), FAO Statistical Area 58, and in the adjacent areas of the Atlantic Ocean (Agulhas Plateau), but this work is not considered in this review. All the vessels operated under the flag of the USSR (until 1991) and since 1992, under the flag of the Ukraine.

The operations described here were undertaken by organizations located in the territory of the Ukrainian Soviet Socialist Republic during the USSR era. These organizations operated under the aegis of the Ministry of Fisheries of the USSR (*Minrybkhoz SSSR*[1]) until 1991 and from 1992, under the control of the Ministry of Fisheries of Ukraine[2]. During the Soviet era the research, scouting and exploratory fishing expeditions undertook research programs that were approved and financed by the Ministry of Fisheries of the USSR. From 1992 on, the operations of all the vessels mentioned in the report in the Southern Indian Ocean have been commercial or exploratory cruises and were financed by ship owners and operators. Fisheries statistics presented here for operations subsequent to 1992 consist of the catches of Ukrainian flag vessels which prior to this date were recorded in the catches of vessel operators located in the territory of the Ukrainian Soviet Socialist Republic.

This review includes results from fishing and scouting operations that were aimed exclusively at exploration and fisheries research of marine living resources of deep-water species, i.e. those whose life cycles and distribution is connected completely or partially with seamounts, deeper banks and the continental slope, etc. Research activities and fishing operations of the pelagic species inhabiting the area under review (including species forming temporary associations near seamounts), research with tuna long-lines for tuna and associated species, use of lift nets for Atlantic saury (*Scomberesox saurus*), longlining for pelagic squids and pelagic midwater trawling outside of seamount areas are not considered in this report. Neither Soviet era expeditions organized by Academy of Sciences of the USSR nor expeditions with submersibles for the study of fish behaviour of the seamounts of the Southern Indian Ocean are considered in this review.

To give an indication of commercial fishing operations in the southern Indian Ocean, information relating to the catches of distant water fishing countries that has been taken from the FAO Reported Landings data base is given in Appendix III together with the names of Soviet (Ukraine) fishing vessels that had operated in that area.

2. GENERAL PHYSICAL AND GEOGRAPHICAL CHARACTERISTICS OF THE UNDERWATER RIDGES OF THE SOUTHERN INDIAN OCEAN

The median ridges of the Indian Ocean form three branches diverging from the area of the Rodriguez Island north-westwards (the Northwest Indian Ocean Ridge), south-westwards (the Southwest Indian Ridge) and south-eastwards (South-Eastern Ridge). The first two branches are typical mid-oceanic ridges and the last is a lower, wide mid-oceanic ridge, resembling a huge swell. The whole system of the ridges is generally described as the Mid-Indian Ocean Ridge. Figure 1 provides a bathymetric illustration of the study area.

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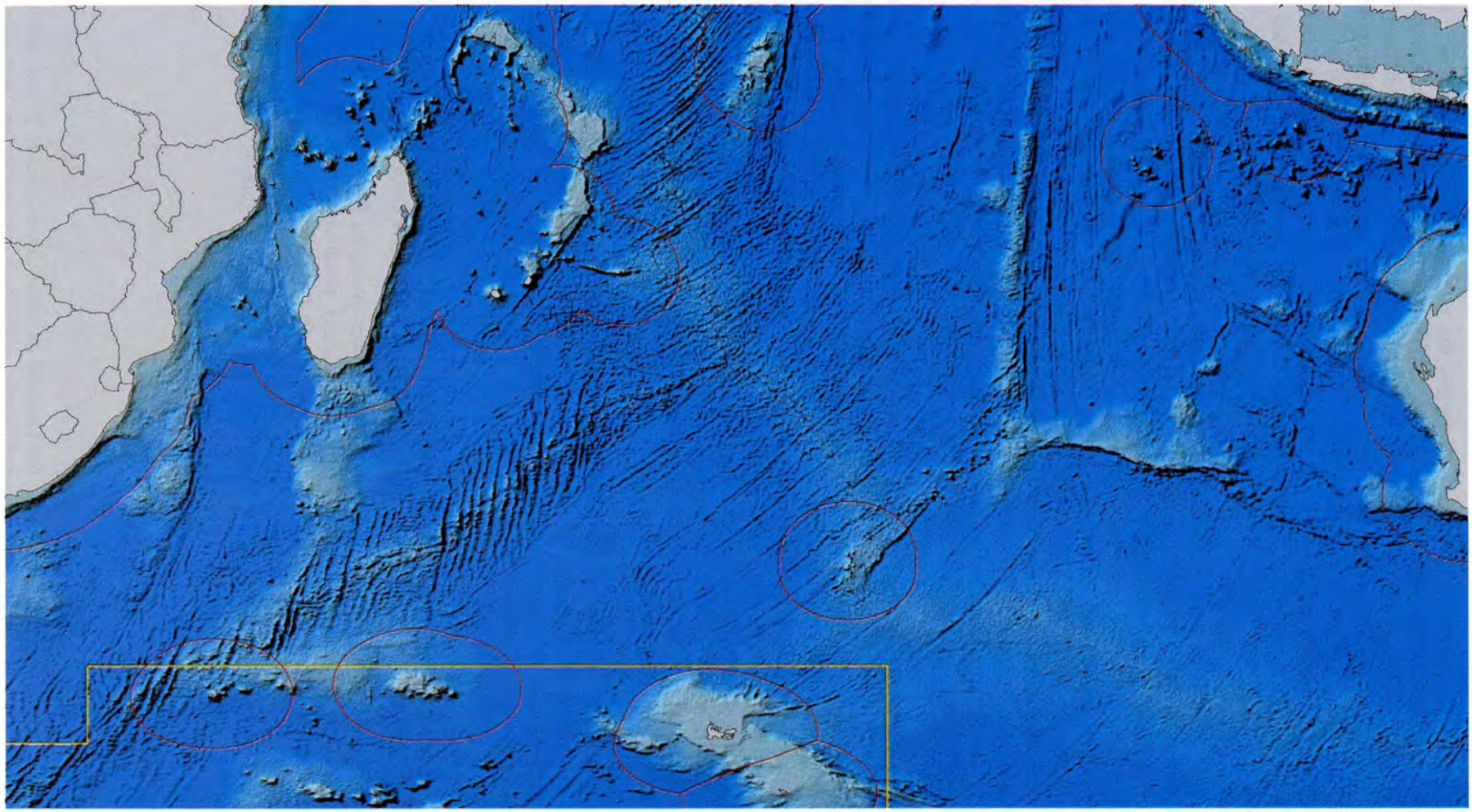
[1] In full; Ministerstvo rybnogo khozyajstva SSSR.

[2] Note: the Ministry of Fisheries of Ukraine has changed its status several times. It was called the State Committee for Fisheries of Ukraine then revereted to being a Ministry and recently has been called the State Department for Fisheries (in the Ministry of Agrarian Policy of Ukraine).

Figure 1

Bathymetric map of the Southern Indian Ocean

Credit: D. Barratt, Fisheries and Marine Sciences Program, Bureau of Rural Sciences, Department of Agriculture, Fisheries and Forestry – Australia



Red lines indicate boundaries of exclusive economic zones. The yellow line indicates the boundary of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) convention area.

Each branch of the Middle Indian Ocean Ridge divides into two parts: the northwestern ridge into the Middle Aden Gulf Ridge and the Arabian-Indian Ridge; the south-western ridge into the Southwest Indian and the African – Antarctic Ridges. The south-eastern ridge divides into the Mid-Indian Ridge and the Australian – Antarctic Elevation. The border between two parts of each branch is the Owen Fracture Zone, Prince Edward Island and Amsterdam and Saint-Paul Islands (Kanaev, Neyman and Parin 1975). The principal scheme of the underwater ridges in the southern Indian Ocean is shown in Figures 2 and 3.

The Southwest Indian Ocean Ridge extends from the Central Massive south-westwards conjugating with the Mid-Atlantic Ridge. In the area of the Prince Edward Islands this branch is divided into two ridges: the Southwest-Indian and African-Antarctic Ridges. The latter ends in the Atlantic Ocean in close proximity to Bouvet Island. Madagascar Ridge is located southwards from the Madagascar. Breaks and seamounts are characteristic of the Southwest Indian and Madagascar Ridges and are found even at the bottom of the basins.

The Southeastern Mid-Ocean Ridge is represented by the Mid-Indian Ridge and Australian-Antarctic Elevation. The greater part of the ridge belongs to the Australian-Antarctic Elevation. The border between them is the south-eastern foot of the mountain system Amsterdam.

The Southwest Indian Ridge is a large underwater mountain system with highly cut terrain extending 1 200 miles from the area of the Rodriguez Island to the Prince Edward Islands. It varies in from 200 to 300 miles in width (Shcherbachev, Kotlyar and Abramov 1989). The relative height of the base of the northwestern part of the Ridge is 2 500–3 000 m and in the south-western part, 4 000–3 000 m over the bottom of the Agulhas and Mozambique Basins. Over the entire region, the relative elevation varies between 500 and 2 000 m over the bottom of the narrow gully extending between the middle ridge and the foot of the Prince Edward and Crozet Islands. The ridge depth varies from 1 000 to 4 000 m reaching a maximum height of 5 300 m on the 37 °S parallel (Kanaev, Neyman and Parin 1975). The minimum depths over the peaks of seamounts, found between 32 and 42 °S, are 102, 150, 250, 422, 690 and 710 m, etc. The slopes of the mounts are steep and rocky and the bottom sediments on the ridges are patchy in distribution. The principal sediments are foraminiferous ooze. The thickness of the sediments increases along the ridge from the northeast to the south-west in connection with the increased deposition of sediments due to the higher biological productivity of the Antarctic waters. However, in the axis part of the ridge, including the bottom of the rift canyons, sediments are generally absent.

The structure of the active layer of waters over the ridge is represented by the transitional zone of the interaction of two surface waters, the southern tropical and subtropical water masses. The southern tropical water mass lies northwards of region of the 30–32 °S parallels from the surface down to 500–600 m. Its distinctive temperature fluctuation are in the range 16–27 °C and salinity fluctuations are in the range of 34.8–35.3‰. The surface southern subtropical water mass is located between the 30 °S parallel and the Subantarctic front (located around 45–50 °S). It is characterized by a temperature range of 17–24 °C and salinity range of 35.4–35.8‰. This water mass also has a subsurface structure with 12–17 °C temperature zones, a salinity of 35.0–35.5‰ and is separated from the surface water with layers of increasing vertical gradients of the oceanographic parameters. These three water structures have, in different seasons, from three to eight modifications when mixing with each other and intermediary Antarctic water mass. A particularly great variety of mixes of surface, subsurface and intermediary mater masses are distinguished at seamounts of the Western Indian Ridge (Seamounts 150, 251, 415 and 102) due to the specific oceanographic conditions (upwelling, oceanographic gyres, etc.) generated in the regions of these seamounts. The intermediary Subantarctic water mass in the area of the ridge is positioned in the layer deeper than 800 m. Its distinctive temperature range is 3–5 °C and salinity range of 34.3–34.6‰. In the area of seamounts this water mass may be found in depth range of 500–600 m (Burlenko 2001) due to local upwelling recorded at the seamounts.

The Madagascar Ridge consists of a massive elevation of the bottom, extending between the micro-continent of Madagascar Island and the Western Indian Ridge for a distance of almost 700 miles. The

Figure 2

Principal underwater features and seamounts at the Madagascar Ridge, Southwest Indian Ridge and Mid-Indian Ridge (northwest part)
FAO Area 51

Proposed sub-areas for fisheries statistics purposes are also presented.

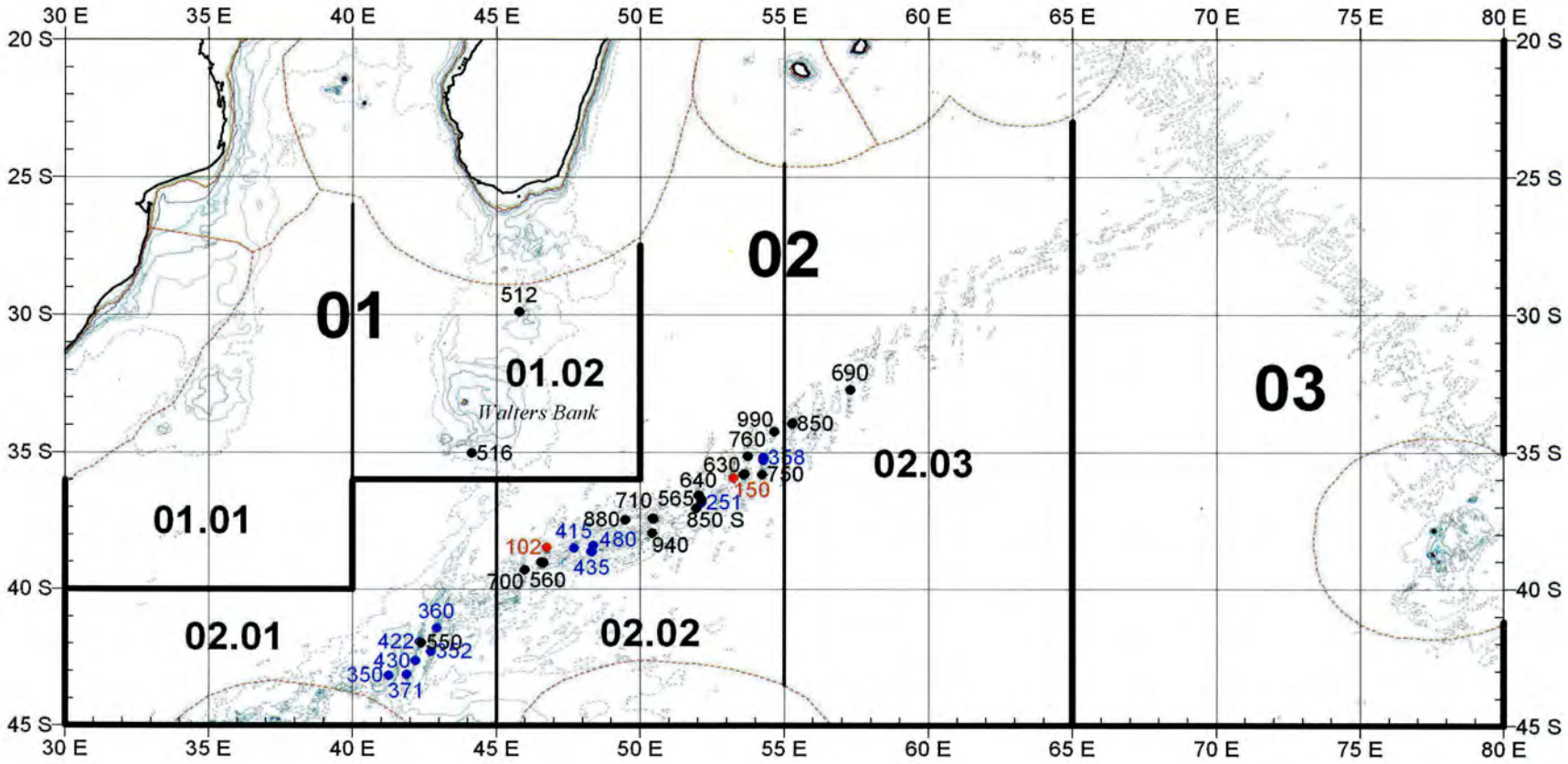
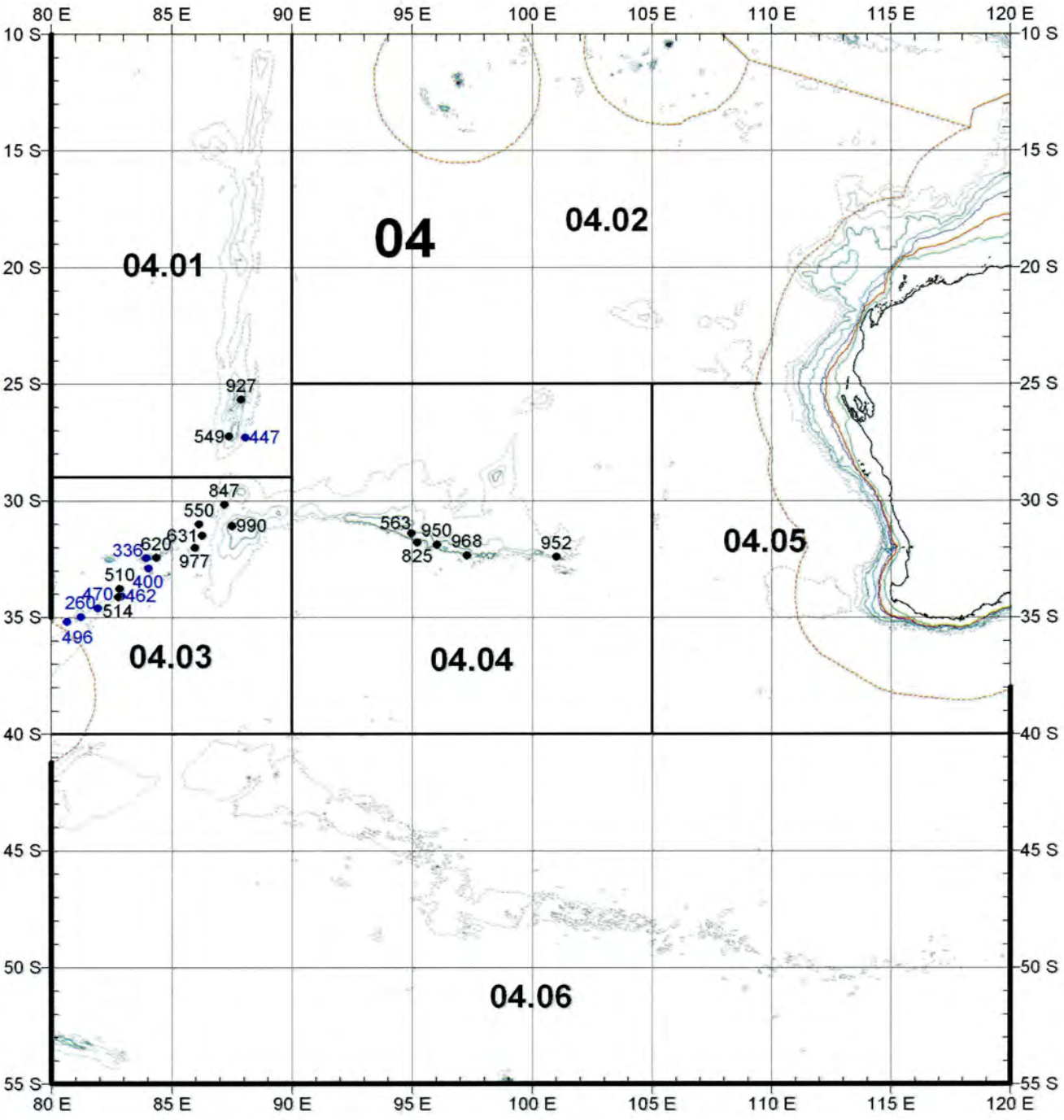


Figure 3

Principal underwater features and seamounts at Mid-Indian Ridge (southeast part), Ninety East Ridge and Broken Ridge
FAO Area 57

Proposed sub-areas for fisheries statistics purposes are presented also.



ridge crest is wide and has depths from 1 000 to 2 500 m (at the positions of seamounts up to 567 m). The minimum depth falls on the Walters shoals (15 m). The shoals are cone-shaped with flat tops, its base is defines by the 800 m isobath. The flat top is covered by coral reefs with a broken and jagged relief, especially along the outer edges. The slopes of the shoal are steep; the angle of the incline ranges from 6–12 °. The sediments consist of foraminiferous ooze enriched with sand along the crests (Kanaev, Neyman and Parin 1975). The tops of other mounts rising over the ridge are located in depths from 84 m down to 567 m and deeper. In the southern part of the ridge between 31 and 35 °S parallels, depths of 900–1 100 m predominant. The ridge down to a depth of 1 500 m has mainly a flattened relief with the predominance of sloping-wave and stepped valleys. On the surface of these valleys hollows occur with amplitudes of 20 m as well as hills and furrows. At the eastern slope of the ridge there are several troughs and crests with sharp peaked mounts up to 250 m in height and more. The surface of the ridge down to depth 1 400–1 900 m is covered with sand, silty sand and in the deeper regions, with foraminiferous silt (Kanaev, Neyman and Parin 1975; Shcherbachev, Kotlyar and Abramov 1989).

The water masses over the ridge consist of surface southern subtropical water mass and its mixtures down to depths of 300–350 m and the intermediary Subantarctic water mass down to a depth m, a layer of 1 200–1 300 m.

The Mid-Indian Ridge differs from the other middle ridges of the Indian Ocean in being lower, slightly more dissected and it has no deep rift valley. The ridge is 1 200 miles in length and 400–500 miles in width. The highest rises are Amsterdam and Saint-Paul mounts, which are near the southeastern extremity of the ridge where they form the volcanic islands with the same names. The tops of the highest underwater mounts in the ridge are located in depths of 2 000–2 500 m. Sediments consist of foraminiferous mud (Kanaev, Neyman and Parin. 1975; Shcherbachev, Kotlyar and Abramov 1989). The structure of water masses in the Mid-Indian Ridge is similar to that of the Southwest Indian Ridge as its ridges are located in the same climate zone.

The climate in the regions of the Southwest Indian, Madagascar and Mid-Indian Ridges depends upon their location as they occupy two climate zones: tropical and subtropical. In the tropical zone during the austral winter, air masses of the temperate latitudes predominant, i.e. tropical in summer and precipitation slightly exceeds evaporation. The distinctive features of the weather and climate reveal themselves in the interaction of the Southern Indian Ocean subtropical zone of high pressure, which is situated between 25 and 35 °S, intra-tropical zone of convergence, located northwards from 10 °S, and the southern polar front, which is located between 44 and 46 °S. In the austral winter the Southern Indian Ocean subtropical zone of high pressure extends along the parallel 30 °S with maximum pressure 1024gPa at the eastern border of the area. In summer it shifts to between 35–36 °S with a simultaneous reduction in pressure down to 1016hPa. The air temperature decreases from north to south. The minimum temperatures of 18–26 °C are recorded in July–August in the region of the northern border of the area and of 4–18 °C along the southern border.

The greatest warming of the air takes place in February when temperature reach up to 30 °C in north and up to 22 °C in the south. The daily temperature variability is slight – in the range 0.5–1.0 °C. Short-term air temperature decreases are recorded during pressure cyclone troughs moving over the area. From July till September, anticyclone air movements predominant over the greater part of the area. From October until June slightly cloudy weather is observed northwards to the parallel 35 °S and to the south, cloudy conditions with a cloudiness of 6-8 points. Annual precipitation is about 1 135 mm with a minimum of 10–20 mm in July and a maximum of 140 mm during February – March. Fogs are common in winter. The area of ridges can be provisionally divided into three parts: northern by the nature of the wind regime (20–30 °S), central (30–38 °S) and southern (38–42 °S).

In the northern part of the area winds of the eastern direction predominant throughout the year with speeds of 6–10 ms^{-1} and a recurrence of 46–52% in winter and 32% in summer. In the central part the wind direction is not stable and from November until March winds of all directions occur with equal frequency. From June till October the northern, northwestern, southern and southwestern winds are

mostly observed with a recurrence of 18–20%. In the southern part westerly winds (20–30%) predominate year round; northern winds occur with a frequency of 25%.

Mean wave height is about 1.5 m. During June–August southwards of 30° wave height can reach 15 m (recurrence 1%) and for the rest of the year sea roughness does not exceed 10 m (Anon., 1986).

Water circulation over ridges consists of an extensive eastwards and southwards gyre from Madagascar Island, with transport of warm waters from north by the southern branch of the South Equatorial Current, Mozambique Current and its continuation as the Cape Agulhas Current. The greater part of the Cape Agulhas current then turns to the south and east, forming the Agulhas Retroflection. One part of this current comes back to the system of the Cape Agulhas current, the other moves to the east. This chain of the southern subtropical gyre is called the Southern Indian Ocean Current and moves water to the east with a speed of 0.61.0 knots. In moving eastwards streams diverge from the South-Indian current, which forms meanders for the greater part of the area. In the southern part of the area, the Agulhas Retroflection and South Indian Ocean Current are confluent with the Antarctic Circumpolar Current, moving with a speed of 0.4–0.8 knots during November–March and up to 0.5–1.3 knots during May–September. As a result of the confluence of the three currents with the Subantarctic zone, there is an extension from the surface down to depths of 80–1 200 m. Under the impact of the seasonal and synoptic variability of currents the frontal zone is subject to great latitudinal and longitudinal fluctuations. In general this scheme of circulation extends to 200 m depth (Kanaev, Neyman and Parin 1975; Shcherbachev, Kotlyar and Abramov 1989). Over the seamounts of the ridges local rings are formed that are subject to changes under the affect of synoptic changes in water movement. The area of intense upwelling is greater in May – September than in November – March. As a result of this process the enrichment of the active layer with nutrients and oxygen takes place, which explains increased biological productivity of the seamounts.

The Ninety East Indian Ocean Ridge is the largest elevation of volcanic origin of the Indian Ocean seafloor and extends for more than 4 700 km along of the 90 °E meridian from the Bay of Bengal almost to the western extremity of the Australian – Antarctic Elevation. The ridge is narrow, approximately only 120 miles wide and consisting of a large amount of elevations as seamounts above its base. The least depths over seamounts discovered by YugNIRO expeditions in the southern part of the ridge were about 400, 540 and 620 m. Foraminiferous ooze predominates along the crests of the ridge (Kanaev, Neyman and Parin 1975).

Water masses over the ridge northwards from the equator are represented by the surface Northern Tropical Water Mass (0–400 m), the Bengal Intermediary Water Mass (400–1 500 m) and the North-Indian Deep Water Mass (1 800–3 500 m). The transitional zone of the interaction of the southern tropical and equatorial surface waters, intermediary waters of the Banda sea and Subantarctic waters (down to the depth 1 600 m) extends southwards to the equator, up to 12 °S. The Ninety East Ridge from the 14 °S parallel to its southern tip is covered by surface tropical and subtropical waters (the interaction zone is about 23–25 °S) down to depths of 350–400 m. Tropical surface waters have higher temperatures (22–26 °C in summer and 20–22 °C in winter) and lower salinities (35.0–35.4‰) than the subtropical surface waters. The latter occupy the area from 25 to 38–39 °S and characteristically have temperatures of 20–22 °C in summer and 15–10 °C in winter with salinities of 35.2–35.9‰. They are distinguished by the presence of an intermediary salinity maximum of 35.9‰ and an oxygen minimum in the 25–200 m depth range. The intermediary structure is separated by a thermocline from the surface to depths of 300–700 m. The core of the intermediary Subantarctic waters (down to 1 700 m) is distinguished by a salinity minimum of 34.4‰ and a temperature range of 3–8 °C and is located at depths of 200–1 000 m in the southern part and 700–800 m in the northern part. The increased salinity and decreased depth of the location of the core of the Subantarctic intermediary waters are caused by under flowing of the Banda Sea waters, which have the same temperature and a higher salinity (35.6‰). The deep structure consists of central Indian Deep Water from 2 000 down to 4 000 m (Anon., 1982a, 1982b, 1982c).

The Broken Ridge is located approximately 600 miles from the underwater extremity of the Western Australia and is morphologically related to the Australian continent. The Broken Ridge borders the Eastern Indian Ridge at 30 °S. This latitudinal massive mountain system is about 800 miles long and up to 300 miles wide, rising from the ocean floor to heights of 4 000 m and is sharply asymmetrically from south to north. The shallowest depth recorded over seamounts are in the range of 600–800 m. There is a possibility of finding unknown shallower seamounts with dense fish aggregations, which exist as a result of orgographic effect, like those at the Southwest Indian Ridge (Anon. 1979, 1982a). Sediments along the crest and the northern slope consist of foraminiferous ooze with vertical extents of up to 800 m. On the southern slopes sediments occur on the gentle slopes and on the steeper bedrock stairs (Kanaev, Neyman and Parin 1975; Shcherbachev, Kotlyar and Abramov 1989).

The water structure on the ridge consists of southern subtropical water (0–300 m), intermediary Subantarctic (500–1 700 m), Banda Sea Water (1 000–2 000 m) and Deep Central Indian Water (2 000–4 000 m). The water characteristics are described above.

The weather conditions in the southeastern Indian Ocean are determined by the nature general atmospheric circulation, which depends on the season, location and intensity of the South Indian atmospheric pressures maximum. The geographical location of its centre occurs between coordinates of 25–30 °S, 70–80 °E. Moving southwards from the 35 °S parallel, a high gradient baric field occurs with the pressure trough in the area of 50–60 °E, often transforming into local cyclones with pressures in the centre down to 1 000 mb. The shift of the centre of the South-Indian maximum breaks through the low pressure region beyond 30 °S and forms local cyclones that result in unstable weather and changeable wind. Easterly winds predominate.

In the area of the ridges a meridional-type atmospheric circulation reigns during the winter (June – August). The stratocumulus cloudiness of about 6–8 points predominates with low precipitation. Air temperature decreases by 5–6 °C during the passage of atmosphere fronts. The air temperature varies from 22 °C in north to 10 °C in south. The instability of the barometric field during this season results in a swell direction that does not always correspond to wind direction. Waves of southern directions predominate.

Gale force winds in the Southern Indian Ocean, home of the "roaring forties" can make fishing hazardous, if not impossible. Here the *RTMS Zvezda* Sevastopolya, a Super-Atlantic class trawler, dodges in heavy weather.

The wind regime in the area of ridges differs in summer (December–February). Easterly winds predominate in the region of the sea-mounts of the Ninety East Ridge located along the periphery of the centre with high pressures (occurrence 34%) and in the region of the seamounts of the Broken Ridge where weather conditions in this season form under the impact of the central part of the Southern Indian Maximum when there are southerly winds (occurrence 22%). The air temperature range varies greatly from the north to the south: from 27 °C at 20 °S to 12 °C at 40 °S. The mean extent of the sky coverage with clouds reduces from 6–7 points southwards from 33 °S to 3–4 points in the region of 18–24 °S. The occurrence of days with precipitation is less than 5%. Visibility is in the range of 8–9 points (Anon. 1979, 1982a, 1982b, 1982c).

The water circulation in the area is determined by the South Indian Ocean Current, which occurs along the southern periphery of the pertinent anticyclonic subtropical water gyre. When it reaches the western coast of the Australia southwards of 19 °S it turns northwards forming the beginning for the Western Australian current and transport cold Subantarctic waters into the area of the southern tropics and in north into the anti-cyclonic gyre (Sukhovej and Baskaran 1995).

The oceanographic conditions of the southeastern parts of the Ninety East and Broken Ridges are characterized by the active meandering and rings formation and the availability of the quasi-stationary frontal zones in the area of seabed elevations. The zones of upwelling and downwelling are peculiar for the area between 25 and 31 °S. The general deepening of the subtropical waters on the way northwards is interrupted by upwelling in the zone between 27 and 29 °S (Anon. 1982a).

3. THE HISTORY OF RESEARCH AND EXPLORATORY CRUISES IN THE AREA

Systematic investigations of biological resources of the Indian Ocean deep seas by YugNIRO started in the mid-1970s prompted by the introduction of the 200 mile exclusive economic zones by many Indian Ocean countries. Such studies started of the deepwater slopes and ridges of the Arabian Sea. Research cruises then moved south toward the Southern Indian Ocean and Antarctic while YugNIRO fisheries research in the Antarctic were started in the 1967. The first fisheries research trawling was undertaken by vessels moving through that area to and from the Antarctic. Directed research of the Southern Indian Ocean was started by YugNIRO and PPP Yugrybpoisk[3] in 1978[4] and in the following years these cruises became a regular research activity. The main objective was to determine the potential of the fishery resources.

From 1972 to 2000, a period of about 30 years YugNIRO and Yugrybpoisk undertook more than 80 research expeditions. In the course of these expeditions more than 8 000 trawl stations were undertaken hauls ranging from the surface to the depths of around 2 000 m, mainly by midwater trawls in near-bottom layers. In some expeditions bottom trawls, mechanical lines and pelagic and bottom long-lines were also used. A comprehensive list of research and scouting vessels that fished in that area, including incidental fishing operations by vessels passing through the area) and details of the fishing operations are presented in Table 3.1 (Appendix II).

4. FISHERIES

Fisheries exploration and research studies of the seamounts of the Southern Indian Ocean were carried using seven classes of vessels: PPR, RTMS, BMRT, RTMA, STM, SRTM and SRTMK[5]. The principal specifications of these vessels are listed in Table 4.1.

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[3] Former Department of Searching and Scientific Research Fleet of the Southern Basin (Yugrybpromrazvedka) (till 1989). Starting from 1993 operated as fishing company.

[4] Research cruise operated at Walters shoals during 1973 mentioned by Collette and Parin (1991) was not identified during preparation of this review.

[5] Translating Russian vessel class terms into English is not easy, and generally only the abbrevations were used in Russian. The authors give the following:
PPR – Promyslovo Proizvodstvennyj Refrizhrator (~Fishing (or Fisheries) Processing Refrigeratory Vessel)
RTMS – Rybolovnyj Trauler Morozil'nyj Super (~Fishing-Freezing Super Trawler)
BMRT – Bol'shoj Morozil'nyj Rybolovnyj Trauler (~Big Fishing-Freezing Trawler)
RTMA – Rybolovnyj Trauler Morozil'nyj Atlantik (Fishing-Freezing Trawler type Atlantic)
SRTM – Srednij Rymolovnyj Morozil'nyj Trauler
SRTMK– Srednij Rymolovnyj Morozil'nyj Trauler Kormovoj (Medium Fishing-Freezing Stern Trawler) – (Ed)

Table 4.1
Principal characteristics of Ukrainian research and fishing vessels operated in the Southern Indian Ocean

Vessel class	Type of vessel	LOA (m)		GRT		Engine power (kW)	
		Min	Max	Min	Max	Min	Max
PPR	Stern trawler	102.70	103.59	4734	5019	2205	2280
RTMS	Stern trawler	101.46	102.00	3090	3149	2484	2852
BMRT	Stern trawler	83.57	84.70	2323	3170	1470	1470
RTMA	Stern trawler	82.00	82.20	2164	2177	1705	1710
STM	Stern trawler	62.20	62.20	2062	2062	1764	1764
SRTMK	Stern trawler	54.80	54.80	635	722	735	853
SRTM	Side trawler	52.90	54.80	558	632	588	588

The research vessels had the same fishing abilities as commercial fishing vessels, except they had less hold capacity as some internal space was used for scientific laboratories. Vessels of the SRTM and SRTMK class were generally used for line, longline and pot fishing. For this purpose they were specially converted to be able to deploy vertical lines, lobster pots, bottom and pelagic long-lines and lift nets. However they retained the ability to fish using trawls.

This review uses the following common names of fishes:

Butterfishes, meaning a mixture of:
- rudderfish (*Centrolophus niger*)
- bluenose warehou (*Hyperoglyphe antarctica*)
- New Zealand ruffe (*Schedophilus huttoni*)
- black ruffe (*Schedophilus maculatus*)
- and violet warehou (*Schedophilus velaini*).

Rubyfishes means a mixture of:
- Cape bonnetmouth (*Emmelichthys nitidus*)
- and rubyfish (*Plagiogeneion rubiginosum*).

A complete list of fish recorded at the Southern Indian Ocean seamounts and their common English names is presented in Appendix I.

Statistics of fishing effort and annual catch of the Soviet (Ukrainian) fleet by vessel class and type of fishing gear are listed in Tables 4.2 and 4.3. Target species for the Soviet (Ukrainian) fleet were alfonsino (*Beryx spelendens*), rubyfishes (two species) and butterfishes (generally two species *C. niger* and *H. antarctica*). The Soviet (Ukrainian) fishing fleet never targeted orange roughy (*Hoplostethus atlanticus*) and dories in this area though these species were recorded in research vessel catches[6].

5. RESEARCH, SCOUTING AND EXPLORATORY FISHERIES SURVEYS

The description of the cruises presented in this Chapter is based on cruise reports, which contain preliminary results. During all research and scouting cruises series of oceanographic and meteorological observations were carried out. It consists of oceanographic surveys, near trawl/longline oceanographic/MBT stations. Correct data on number of observation is unavailable at the time of preparation of this review.

[6] This species has no commercial interest for Soviet/Ukrainian fishing vessels, which operated generally for internal food supply of the country. Under hygienic regulations this species was not allowed for human consumption due to its chemical composition (high content of nonsaponifying fats).

Table 4.2
Catch statistics of Soviet/Ukrainian vessels on Southwestern Indian Ridge Seamounts (FAO Statistical Areas 51.01 and 51.02)

Year	Vessel type	Gear	No of vessel	Fishing days	No of trawl hauls	Hours of trawling	Total catch	Catch by species (t)															
								Beryx splendens	*Emmelichthys* spp.	Centrolophidae	*Trachurus picturatus*	*Polyprion* spp.	*Epigonus* spp.	*Pseudopentaceros richardsoni*	*Lepidopus caudatus*	*Promethichthys prometheus*	*Allocyttus verrucosus*	*Thunnus* spp.	*Electrona subaspera*	*Seriola lalandi*	Selachimorpha	*Jasus lalandi*	Marine fishes nei.
1980	PPR	OTM-2	1	26	91	158	847	...	538	255	7	...	...	...	...	24	...	...	...	...	...	...	23
	RTMS		4	89	599	791	2386	7	1230	586	66	...	...	...	...	23	...	...	...	...	...	...	474
	RTMA		7	137	791	1265	2796	13	1484	990	60	...	...	...	...	64	...	...	...	...	...	...	185
	Total						**6029**	**20**	**3252**	**1831**	**133**	...	...	...	...	**111**	...	...	...	...	...	...	**682**
1981	RTMS	OTM-2	3	277	983	1432	2141	764	209	328	223	35	38	...	8	9	...	...	2	...	...	...	525
	RTMA		6	237	790	1522	3099	1760	166	719	32	36	25					16	15	...	...	...	330
	SRTM[1]	LHM+FPO	4	-	-	-	232	-	-	-	-	107	-	-	-	-	-	73	-	-	17	3	32
	Total						**5472**	**2524**	**375**	**1047**	**255**	**178**	**63**	**...**	**8**	**9**	**...**	**89**	**17**	**...**	**17**	**3**	**887**
1982	RTMS	OTM-2	2	273	796	1302	1866	910	226	70	49		77	414	13	11			38				58
	RTMA		1	32	74	103	79	11	42	10	1		3		2	1							9
	SRTM	LHM+FPO	2	196	-	-	167					142									2	16	7
	Total						**2112**	**921**	**268**	**80**	**50**	**142**	**80**	**414**	**15**	**12**	**...**	**...**	**38**	**...**	**2**	**16**	**74**
1983	RTMS	OTM-2	1	176	340	493	731	184	299	141	45	...	21	4	...	...	...	...	20	...	...	...	17
	RTMA		3	100	246	271	873	668	57	114	...	...	6	...	...	...	13	...	...	...	...	...	15
	SRTM[2]	LHM+FPO	5	253	-	-	116	-	-	-	-	78	-	-	-	-	-	4	-	-	28	6	-
	Total						**1720**	**852**	**356**	**255**	**45**	**78**	**27**	**4**	**...**	**...**	**13**	**4**	**20**	**...**	**28**	**6**	**32**
1984	RTMA	OTM-2	1	38	98	104	126	57	40	7	22	...	...	...	...	...	...	...	...	...	...	...	...
	SRTM	LHM+FPO+ LLSB	1	73	-	-	26	-	-	-	-	20	-	-	-	-	-	-	-	-	3	3	-
	Total						**152**	**57**	**40**	**7**	**22**	**20**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**3**	**3**	**...**

[1] For vessels of SRTM-type, data on fishing effort are unavailable (fishing effort consisted of hand lines, mechanized lines, pot fisheries, bottom longlines and sometimes trawl fisheries).
[2] Since exploratory fishing by bottom longline were carried out by chartered vessel from Russian home ports, their catches are not included in the catch statistic of the Ukraine.

Year	Vessel type	Gear	No of vessel	Fishing days	No of trawl hauls	Hours of trawling	Total catch	Catch by species (t)														
								Beryx splendens	*Emmelichthys* spp.	Centrolophidae	*Trachurus picturatus*	*Polyprion* spp.	*Epigonus* spp.	*Pseudopentaceros richardsoni*	*Lepidopus caudatus*	*Promethichthys prometheus*	*Allocyttus verrucosus*	*Thunnus* spp.	*Electrona subaspera*	*Seriola lalandi*	Selachimorpha	*Jasus lalandi*	Marine fishes nei.
1985	RTMS	OTM-2	1	9	20	38	96	3	91	2	...	...	...	...	...	...	...	...	...	...	...	...
	SRTM	LHM+FPO+ LLSB	3	131	-	-	57			2	-	46	-	-	-		-	1	-	-	6	2	-
	Total						**153**	**3**	**91**	**4**	**...46**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**1**	**...**	**...**	**6**	**2**	**...**
1986	SRTM	LHM+FPO+ OTM-2	2	84	-	-	34		9	1	-	5	-	-	-	-	-	-	-	-	2	16	-	1
	Total						**34**		**9**	**1**	**-**	**5**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**16**	**-**	**1**
1987	BMRT	OTM-2	1	49	87	181	96	1	32	8	...	...	...	...	...	...	...	...	...	46	...	...	...	...
	RTMA		4	113	316	369	1376	1	775	600	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Total						**1472**	**2**	**807**	**608**	**...**	**...**	**...**	**9**	**...**	**...**	**...**	**...**	**...**	**46**	**...**	**...**	**...**	**...**
1988	BMRT	OTM-2	1	43	62	159	337	...	9	...	312	...	...	...	...	...	...	...	...	...	...	...	...	16
	RTMA		1	58	118	101	246	...	57	128		45	...	...	...	...	...	...	...	...	...	...	...	16
	Total						**583**	**...**	**66**	**128**	**312**	**45**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**32**
1989	BMRT	OTM-2	1	11	27	31	36	10	...	...	26	...	...	...	...	...	...	...	...	...	...	...	...	...
	Total						**36**	**10**	**...**	**...**	**26**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**
1990	STM	OTM-2	1	19	19	-	15	0	10	4	0	0	...	1	...	...	...	...	0	0	...	...	...	...
	Total						**15**	**0**	**10**	**4**	**0**	**0**	**...**	**1**	**...**	**...**	**...**	**...**	**0**	**0**	**...**	**...**	**...**	**...**
1991	SRTM	LHM+FPO	1	21	-	-	10	-	-	-	-	6	-	-	-	-	-	-	-	-	-	4	-	
	Total						**10**	**-**	**-**	**-**	**-**	**6**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**4**	**-**	
1992	RTMA	OTM-2	1	102	-	-	1676	314	468	828	...	...	20	45	...	...	...	...	...	...	...	...	1	
	Total						**1676**	**314**	**468**	**828**	**...**	**...**	**20**	**45**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**1**	
1993	RTMS	OTM-2	1	23	-	-	283	...	226	5	52	...	...	...	...	...	...	...	...	...	...	...	...	...
	RTMA		1	102	-	-	1208	462	325	296	75	...	18	...	...	...	8	...	...	...	...	...	...	24
	SRTM	LHM+FPO+ LLSB	1	73	-	-	9	-	-	-	-	1	-	-	-	-	-	-	-	-	-	8	-	
	Total						**1500**	**462**	**551**	**301**	**127**	**1**	**18**	**...**	**...**	**...**	**8**	**...**	**...**	**...**	**...**	**8**	**24**	

Year	Vessel type	Gear	No of vessel	Fishing days	No of trawl hauls	Hours of trawling	Total catch	Catch by species (t)															
								Beryx splendens	*Emmelichthys* spp.	Centrolophidae	*Trachurus picturatus*	*Polyprion* spp.	*Epigonus* spp.	*Pseudopentaceros richardsoni*	*Lepidopus caudatus*	*Promethichthys prometheus*	*Allocyttus verrucosus*	*Thunnus* spp.	*Electrona subaspera*	*Seriola lalandi*	Selachimorpha	*Jasus lalandi*	Marine fishes nei.
1994	BMRT	OTM-2	1	15	-	-	217	60	25	124	...	...	...	...	...	...	...	...	...	...	...	...	8
	RTMA		1	159	-	-	2416	1474	202	608	...	...	...	40	...	...	...	...	...	...	...	...	92
	Total						**2633**	**1534**	**227**	**732**	**...**	**...**	**...**	**40**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**100**
1995	BMRT	OTM-2	1	59	-	-	256	224	5	21	3	...	2	...	...	...	...	...	1	...	...	...	...
	RTMS		1	40	-	-	708	276	116	274	...	...	21	21	...	...	...	...	...	...	...	...	...
	RTMA		1	147	-	-	2006	1749	23	190	...	...	10	33	...	...	...	...	1	...	...	...	...
	Total						**2970**	**2249**	**144**	**485**	**3**	**...**	**33**	**54**	**...**	**...**	**...**	**...**	**2**	**...**	**...**	**...**	**...**
1996	RTMS	OTM-2	1	42	-	-	520	452	16	25	...	...	5	17									5
	RTMA		1	151	-	-	2960	2627	12	229	...	...	48										44
	Total						**3480**	**3079**	**28**	**254**	**...**	**...**	**53**	**17**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**49**
1997	RTMA	OTM-2	1	159	-	-	1570	1031	7	440	...	...	17	33	...	...	...	...	...	...	...	...	42
	Total						**1570**	**1031**	**7**	**440**	**...**	**...**	**17**	**33**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**42**
1998	RTMA	OTM-2	1	130	-	-	1623	859	275	395	15	...	...	78	...	...	...	...	...	...	...	...	1
	Total						**1623**	**859**	**275**	**395**	**15**	**...**	**...**	**78**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**1**
1999	RTMA	OTM-2	1	182	-	-	3303	1964	181	753	11	...	...	108	...	...	...	...	...	...	...	...	286
	Total						**3303**	**1964**	**181**	**753**	**11**	**...**	**...**	**108**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**286**
2000	RTMA	OTM-2	1	232	-	-	2015	1578	...	360	...	...	...	77	...	...	...	...	...	...	...	...	...
	Total						**2015**	**1578**	**...**	**360**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**
2001	RTMA	OTM-2	1	136	-	-	810	371	121	299	7	...	...	12	...	...	...	...	...	...	...	...	...
	Total						**810**	**371**	**121**	**299**	**7**	**...**	**...**	**12**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**

Table 4.3
Catch statistics of Soviet/Ukrainian vessels from the Mid-Indian Ridge and Broken Ridge Seamounts (FAO Statistical Area 51.04)

Year	Vessel type	Gear	No of vessel	Fishing days	No of trawl hauls	Hours of trawling	Total catch	Catch by species (t)															
								Beryx splendens	*Emmelichthys* spp.	Centrolophidae	*Trachurus picturatus*	*Polyprion* spp.	*Epigonus* spp.	*Pseudopentaceros richardsoni*	*Lepidopus caudatus*	*Promethichthys prometheus*	*Allocyttus verrucosus*	*Thunnus* spp.	*Electrona subaspera*	*Seriola lalandi*	*Selachimorpha*	*Jasus lalandi*	Marine fishes nei.
Mid-Indian Ridge (51.04.03)																							
1981	RTMS	OTM-2	1	18	31	93	442	...	439	...	...	...	...	...	...	...	...	...	...	...	...	-	3
	Total						**442**	**...**	**439**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	-	**3**
Broken Ridge (51.04.04)																							
1981	RTMS	OTM-2	4	288	558	773	553	120	3	109	3	...	...	14	...	...	...	...	...	...	...	...	304
	Total						**553**	**120**	**3**	**109**	**3**	**...**	**...**	**14**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**-**	**304**
1982	RTMS	OTM-2	1	5	52	53	22	2	...	...	...	...	...	2	...	...	...	...	...	...	...	-	18
	SRTM	LHM	1	91	-	-	6	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	-
	Total						**28**	**2**	**...**	**...**	**...**	**6**	**...**	**2**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**-**	**18**
1983	SRTM	LHM+LLD	1	14	-	-	10	-	-	-	-	-	-	-	-	-	-	2	-	-	8	-	-
	Total						**10**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**	**-**	**8**	**-**	**-**
1984	RTMS	OTM-2	1	33	94	183	40	6	3	...	...	...	...	...	...	...	...	...	31	...	...	-	...
	Total						**40**	**6**	**3**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**...**	**31**	**...**	**...**	**-**	**...**

5.1 Trawl surveys

5.1.1 Gear

Trawl fishing operations at the seamounts of the Southern Indian Ocean were undertaken using large trawlers of the classes BMRT, RTMA, and RTMS type (Table 4.1). Trawling, unless otherwise stated, was done using a 1625-design bottom trawl that had a horizontal opening of 36.6 m. Figures 4a and 4b illustrate the dimensions configuration of this net. Midwater trawling was undertaken using a 110-600 trawl (see Figures 4c and 4d). These trawls have a head rope length of 110 m and a stretched-mesh circumference at the opening into the trawl of 600 m.

5.1.2 Cruises

1972

The First Cruise of the RTMA *R.V. Fiolent*, February – August 1972

This vessel generally operated in the Antarctic waters of the Indian Ocean south from 45 °S. During this cruise records show that one seamount, 770 at the southern boundary of the Southwest Indian Ridge was located. No trawling operations at this seamount were reported.

1973

The Sixth Cruise of the BMRT *R.V. Skif*, July 1973 – January 1974

A hydrographic and hydrological research cruise was undertaken in the area 40°00'–47°30'S, 38°00'–45°00'E. Four geo-hydrological zones were described along the Southwest Indian Ridge. The third zone included the crest of the Southwest Indian Ridge, which consists of five large parallel ridges with a relative height in the range 2 000–2 800 m. Seamounts that were earlier unknown were found; these were at relatively shallow depths and several had elevations suitable for deepwater bottom trawling. No trawling operations in the area of the underwater ridges of the Southern Indian Ocean were carried out during this cruise.

1974

The Fifth Cruise of the RTMA *R.V. Fiolent*, August 1974 – January 1975

Survey operations along the Southwest Indian Ridge were carried out from 20 November until 6 December 1975. Two areas were studied during the cruise by acoustic means: 44–47 °S, 35–39 °E and 30–40 °S, 44–48 °E. Several large seamounts were found that had rough surfaces; they located in the axial part of the ridge. Some of the seamount peaks were suitable for the trawling, however, the complex seabed and rocky ground of the mounts of the ridge did not allow bottom trawling with ordinary fishing gears. Three sites were found with favourable bottom topography for fishing with a bottom trawl. Attempts to fish off bottom were undertaken by means of a 1625-design bottom trawl that had a horizontal opening of 36.6 m. Five trawl sets were undertaken for 4.05 hours of trawling, three of these sets malfunctioned, including one that resulted in a complete loss of the trawl. The principal species caught were *Macrourus carinatus*, *Notothenia squamifrons*, *Alepocephalus* sp., *Antimora rostrata* and *Dissostichus eleginoides*.

1976

The Sixth Cruise of the RTMA *R.V. Zvezda Kryma*, May – October 1976

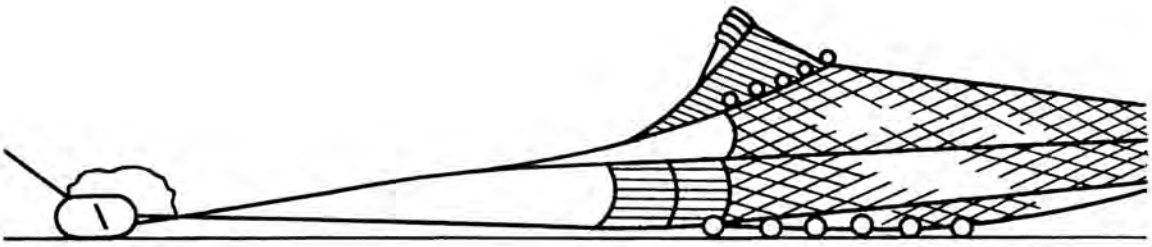
This cruise was the first expedition, whose principal goal was the search for and study of fish resources at great depths. The main research areas were as follows: Madagascar Ridge, Southwest Indian Ridge and Ninety East Ridge. The search operations were made at the Mozambique, Mascarene and Broken Ridges, there were examined areas north-eastwards the Broken Ridge and Equator Seamount. In all the areas except Southwest Indian Ridge (due to the absence of spots suitable for bottom trawling and stormy weather), exploratory trawl hauls were made.

In the search for fish aggregations, suitable stations for trawling were identified using a KhAG–432 echo sounder. A Furuno netsounder was used to control the trawl. The main gear was 31 m 326 design bottom trawl equipped with a rigid foot rope and 500 mm diameter bobbins. Its minimum

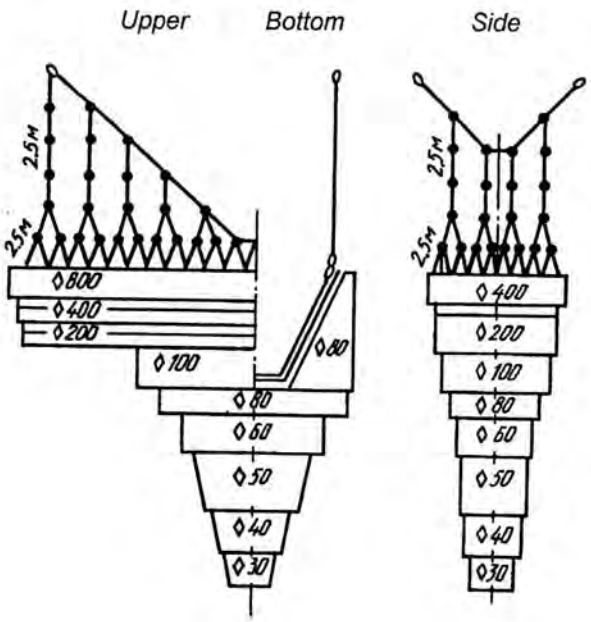
Figure 4

Design diagrams of trawls used by Soviet vessels in the Southern Indian Ocean
Bottom trawl design

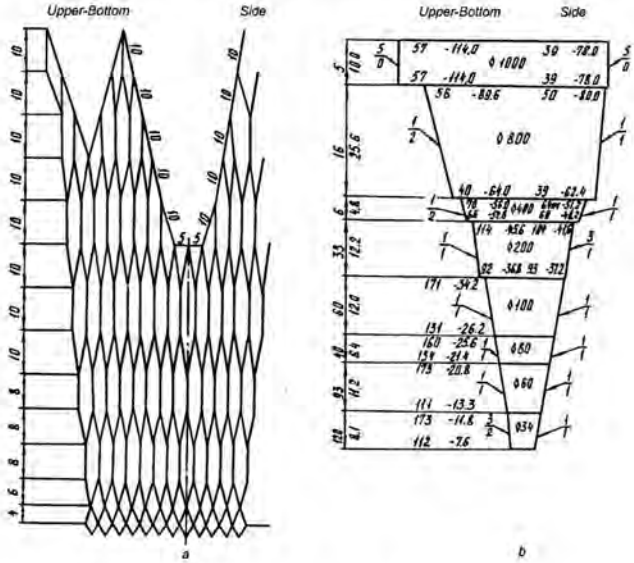
4a Side view of trawl opening



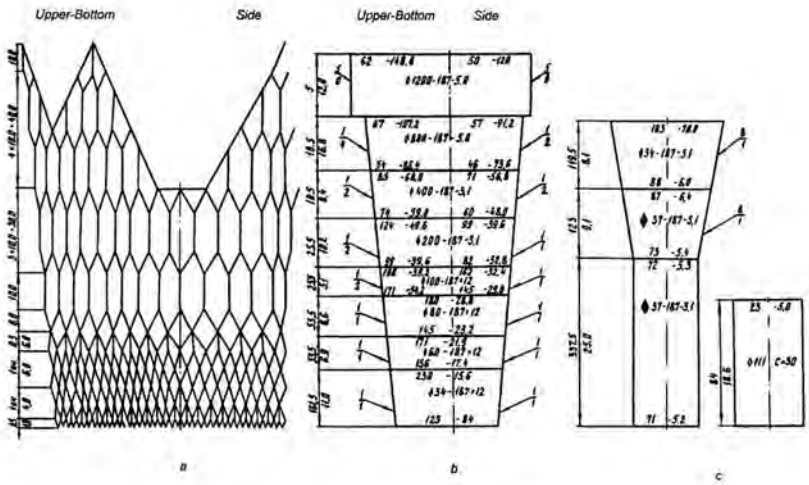
4b Plan diagrams of trawl



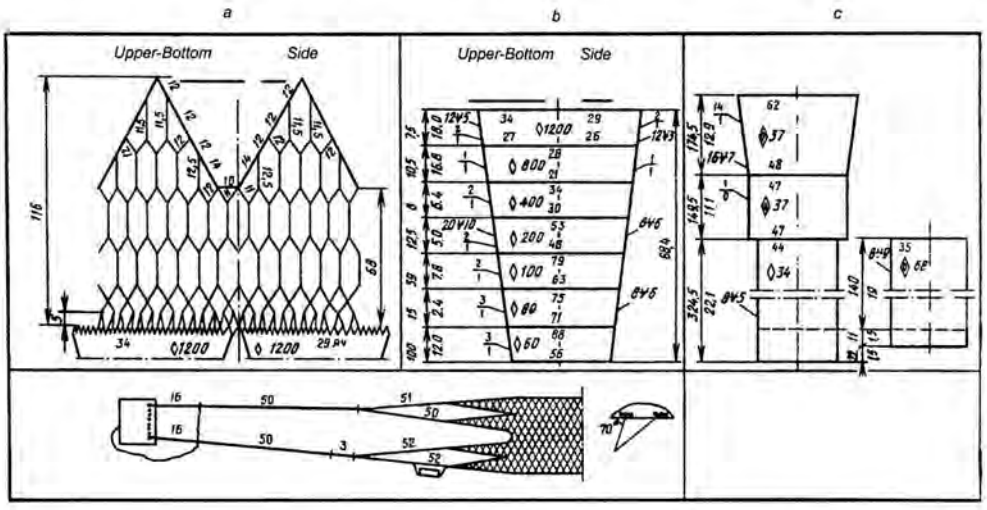
4c Midwater trawl 110-600



4d Midwater trawl 110-600



4e Midwater trawl 110-620



mesh size was 30 mm and it had a nylon (kapron) codend 25 m in length. A midwater trawl was also used that was 99.4 m in length with a minimum mesh size of 30 mm and a codend 27.2 m in length. The principle results are presented in Table 5.1.1. All the ridges depths down to 1 500 m were examined and at the Ninety Eastern Ridge, fishing extended to a depth of 1 840 m.

Table 5.1.1
Results of trawl surveys at the Madagascar, Mozambique and Broken Ridges during the 6th Cruise of the *R.V. Zvezda Kryma*

Seamount	Period of study	No. of trawl hauls	Hours of trawling	Dories	Sharks	Smooth-heads	Grenadiers	Moras	Others
	2 July – 2 August 1976	77	136.5	16.5	38.0	21.6	8.5	6.2	9.2
	6–29 August 1976	29	59.7	64.2	23.0	6.2	1.5	0.6	4.5
	18 September – 4 October	60	112.7	9.2	24.4	23.4	10.7	8.6	23.7

The Seventh Cruise of the RTMA R.V. Zvezda Kryma, December 1976 – May 1977
The objective of the cruise is to search for deepwater fish resources in the region of the underwater seamounts in the Southern Indian Ocean (Mozambique, Madagascar and Southwest Indian Ridge) at the depths down to 1 500–1 800 m. A 326 design bottom trawl of 31.2 m with minimum mesh size 30 mm, a nylon (kapron) codend 25 m in size and a 99.4 m pelagic trawl with a minimum mesh size of 30 mm and nylon (kapron) codend of 27.2 m size were used.

Forty-six deepwater trawl tows were made at depths of 1 200–1 570 m at the Mozambique Ridge. Aggregations of deepwater dory (*Allocyttus verrucosus*) were found at depths of 1 260–1 450 m, which were located within a water stratum with temperatures of 4.6–3.8 °C. Fifty-seven bottom trawl hauls were made on the Madagascar Ridge for a total of 109 hours fishing and in depths ranging from 600–1 500 m. Operations to study the bottom topography and charting of the seabed were carried out. The principle results are presented in Table 5.1.2.

Table 5.1.2
Results of trawl surveys at the Madagascar and Mozambique Ridges during the 7th Cruise of the *R.V. Zvezda Kryma*

Seamount	Period of study	No. of trawl hauls	Hours of trawling	Catch of principal species %					
				Dories	Sharks	Smooth-heads	Grenadiers	Moras	Others
Madagascar Ridge									
	1–16 January 2–16 March, 6–9 April August 1977	99	208.3	68.5	16.8	7.6	3.1	0.8	3.2
Mozambique Ridge									
	21 January–10 February 1977	57	109.0	9.0	45.5	16.0	7.0	15.0	7.5

1977
The Seventh Cruise of the RTMA *R.V. Fiolent*, May – October 1977
The purpose of the expedition was deep-water research in the area of the Ninety East Ridge and Broken Ridge to locate commercial aggregations of fishes at greater depths. The exploratory trawl

hauls were made with Khek-M, Khek-4M bottom trawls, a 326 design 31 m trawl and a 1625-design 37.2 m trawl and a 99.4 m deepwater trawl. The choice of the fishing gears was related to the principal goal of the expedition – exploration of deepwater fish resources. The vertical open of the nets depended on the trawling speed and varied from 5.5–4.0 m for the Khek-M trawl and from 2.5–3.5 m for the 1625-design trawl.

The Ninety East Ridge Area

An echo sounder survey of this area for sites suitable for the trawling operations was undertaken. This area is peculiar for its bottom topography and unfavorable hydrometeorological conditions (heavy currents, high winds and rough sea conditions), which impeded trawling even at the suitable sites. from 13 to 25 June six trawl hauls were carried out for a total duration of 10.5 hours at the depths of 1 400 – 2 000 m. The majority of catches were marine eels, smoothheads (Alepocephalidae) and grenadiers (Macrouridae).

The Broken Ridge

Trawling operations were carried out from 22 July until 4 August 1977. The permanent strong winds, currents and significant cloudiness limited the ability of the vessel to determine its position using astronomical methods (once or twice a day) and did not allow precise locating of the stations at sites indicated on the charts as favourable for trawling. Nine deepwater trawl hauls were undertaken at depth ranging from 1 050 to 1 350 m. The total duration of trawling was 18 hours. The catch consisted of smoothheads, dories (*Allocyttus* spp.), grenadiers and sharks. The catch levels were not of commercial interest. However, comparing the trawling results with the catches of the RTMA *Zvezda Kryma* which had operated in the area in 1976, it should be noted that the catches of the *Fiolent* were slightly higher. It was concluded that the area had potential for commercial fisheries but required more in-depth study. Data on the principal operations are shown in Table 5.1.3.

The Eighth Cruise of the RTMA *R.V. Zvezda Kryma*, June – December 1977

The purpose of the expedition was to support operations of the fishing fleet through studies of the Agulhas Shoal (1st stage) and studies of deepwater fish resources of Mozambique, Madagascar, and the Southwest Indian Ridges (2nd stage). During the search operations from 14 September until 5 November, though interrupted by breaks, of the Southwest Indian Ridge, areas suitable for bottom trawling were not found on all the seamounts examined, at least in depths to 2 000 m. No fish aggregation were observed in the pelagic zone.

Goblin shark (*Mitsukurina owstoni*), is found on outer continental shelves and upper slopes. It has highly specialized jaws for rapid projection from the head to snap up its prey of pelagic octopus and crabs. Slow-moving and neutrally buoyant it may be used dried and salted.

No commercial fish aggregations were found during 37 days of operations on the Madagascar Ridge, however two potentially productive spots, based on fish distribution and catches, located. The first was in the region of 32°40'–32°50'S and 44°44'–44°56'E in depths of 900–1 250 m. The catches consisted of moras, sharks, grenadiers and smoothheads. The second areas was in the region 33°06'–33°22'S and 43°56'–44°16'E in depths of 720–760 m, south-eastwards from Walters shoals. The dominant species taken was armourhead (*Pseudopentaceros richardsoni*) (from 30 to 80% of the catch), sharks, stargazers (Uranoscopidae) and rockfishes (Scorpaenidae). The main results are presented in Table 5.1.4.

Table 5.1.3
Results of trawl surveys at the Ninety East and Broken Ridges during the 7th Cruise of the *R.V. Fiolent*

Seamount	Period of study	No. of trawl hauls	Hours of trawling	Catch of principal species %							
				Alfonsinos	Cardinalfish	Rubyfishes	Butterfisshes	Armourhead	Dories	Sharks	Others
Ninety East Ridge											
–	13–25 June 1977	6	10.5	–	–	–	–	–	+	+	+
Broken Ridge											
–	22 July–4 August 1977	19	38.8	–	–	–	–	–	+	+	+

Table 5.1.4
Results of trawl surveys at the Madagascar and Mozambique Ridges during the 7th Cruise of the *R.V. Zvezda Kryma*

Seamount	Period of study	No. of trawl hauls	Hours of trawling	Catch of principal species %						
				Dories	Sharks	Smoothheads	Grenadiers	Armourhead	Stargazers	Others
	5 October–17 November 1977	113	371	–	37.1	0.5	0.9	50.9	4.1	4.0

1979

The Eleventh Cruise of the RTMA *R.V. Fiolent*, February – July 1979

The **R.V. Fiolent** undertook surveys of the Madagascar and Southwest Indian Ridges during two short periods enroute to and from its principal area of research, which was the Ob and Lena Banks and the Agulhas Bank. In this connection the fishing operations were experimental in nature. The fishing gears used during the surveys were a 1625-A design bottom trawl, a 55 m bottom (lobster) trawl, midwater trawls of 130.6 m and 99.4 m and trawl for fishing capelin of 81.6 m. HAG-331, HAG-432 and Simrad EQ-120 acoustic equipment were used during the fishing operations.

Eight bottom trawl hauls (13.09 hours of trawling) were undertaken in the area of the Madagascar Ridge during 13–15 July in depths of 720–1 050 m. The catches obtained were small and consisted of dogfishes, moras and other not specified species. A total of 6 trawl hauls of one hour duration each were undertaken with a bottom trawl from 31 March until 2 April and from 4 to 8 May in the area of the Southwest Indian Ridge. The catches taken were small. Three trawl sets (also of one hour duration each) were undertaken with a midwater trawl in depths of 18–60 m and 280–300 m but were not successful and took only small catches of Myctophidae, Chauliodontidae and Gonostomatidae.

The Twelfth Cruise of the RTMA *R.V. Fiolent*, August 1979 – January 1980

The *R.V. Fiolent* surveyed the Madagascar Ridge area during a short period at the start of its cruise *en route* to its principal area of research, the Agulhas Bank. Due to a trawl winch failure fishing operations were stopped. A total of three bottom trawl hauls and five pelagic trawl hauls were undertaken from 22 August to 9 September. The catches taken were small and deepwater dories and dogfishes predominated in the catch. The fishing gears used during the expeditions were a 1625-A design bottom trawl, a 55 m bottom (lobster) trawl, midwater trawls 130.6 m and 99.4 m and a capelin trawl of 81.6 m. HAG-331, HAG-432 and Simrad EQ-120 acoustic systems were used during fishing operations.

1980

The First Cruise of the RTMS *R.V. Geroevka*, March – August 1980

The goal of the first expedition of the *R.V. Geroevka* was to search for prospective fishing areas in the Antarctic part of the Indian Ocean, Southern Indian Ocean and in waters adjacent to the EEZs of Mozambique and South Africa. The vessels used 110/560 pelagic trawls (vertical opening of 35 m) at the trawling speed six knots with a vertical opening of 45–47 m at a trawling speed of 4.5 knots and a 110/468 trawl with a vertical opening of 45–47 m at a trawling speed of six knots, and an opening of 60 m at a trawling speed of 4.5 knots. Bottom trawling was undertaken with a 1125-design 50.8 m trawl. The southern part of the Madagascar Ridge was surveyed from 6 June until 2 July. In this time 74 trawl hauls (36 bottom and 38 midwater) were completed. The main catch of the midwater trawl catches were jack mackerel (*Trachurus longimanus*). No positive results were achieved from the bottom stations. Searching operations at the Southwest Indian Ridge were carried out from 4–5 June and 27 July–13 August 1980. Seamounts 422, 360, 250 and 150 were surveyed. The results from the operations on the most important seamounts are given in Table 5.1.5.

Table 5.1.5
Results of trawl surveys at the Southwest Indian Ridge during the 1st Cruise of the *R.V. Geroevka*

Seamount	Period of study	No. of trawl hauls	Hours of trawling	Catch of principal species %				
				Rubyfishes	Armourhead	Jack mackerel	Electron subantarctic, Lightfishes	Others
Madagascar Ridge								
Walters shoals	6 June–2 July1980	36	62.5			95.0		+
Deepwater area		25	51.45		9.0			91.0
Southwest Indian Ridge								
422	27–31 June 1980	11	29.58				97.6	2.4
150	8–13 August 1980	18	29.41	54.6		45.4		
360	June 1980	6	6.67				91.9	8.1

The Second Cruise of the RTMS *R.V. Novoukrainka*, July – December 1980

Operations were carried out from 14 September until 23 November 1980 of seamounts of the Southwest Indian and Mid-Indian Ridges. For the first time commercial aggregations of fish were found and explored at Seamounts 251, 260 and 336. Search and fishing operations were carried out at the aggregations found earlier at Seamounts 102 and 150. A midwater 110/468 trawl was used. Towing speed was in the range 4.8–5.3 knots; the vertical opening of the trawl was generally 50 m. The trawl ground rope was usually located at depths between 110–170 m, and best catches were

observed if the ground rope was located 20–30 m deeper than the fish schools as indicated by the echo sounder records, i.e. in the close vicinity to the bottom. Daily catches were only limited by the vessel's fish processing capacity. The catch consisted of rubyfishes (77.6%), *E. nitidus* (29.2%) and *P. rubiginosus* (48.4%). The percentage of butterfishes varied from 5 to 25% in several hauls, and was 12.9% on average. The catch of jack mackerel varied in the range 5–20%; and was on average 9.6% (Table 5.1.6).

Table 5.1.6
Results of trawl surveys at the Southwest Indian and Mid–Indian Ridge Seamounts during the 2nd Cruise of the *R.V. Novoukrainka*

Seamount	Period of study	No. of trawl hauls	Hours of trawling	Catch of principal species %				
				Alfonsinos	Rubyfishes	Butterfishes	Jack mackerel	Oilfish
Southwest Indian Ridge								
150	16–25 September 1980	31	55	–	77.6	12.8	9.6	
102	27 September–4 October 1980	20	17	–	56.8	41.8	1.4	
251	6–13 October 1980	10	11	–	53.4	35.8		10.8
Mid–Indian Ridge								
260	20 October–1 November 1980	26	49	6.0	90.6	3.4		
336	2–4 November 1980	5	11	4.5	95.5			

The Fifteenth Cruise of the RTMA *R.V. Chatyr-Dag*, August 1980 – February 1981
Surveying of Seamounts 150 and 102 of the Southwest Indian Ridge were undertaken from 27 August 1980 until 20 January 1981. A 74/360 m midwater rope trawl with a vertical opening of 35 m was used together with warps pf 250–300 m and a towing speed of 3.0–3.8 knots. KhAG-432 and KhAG-331 echo sounders were used to locate fish concentrations. The results of operations over the most important seamounts are given in Table 5.1.7.

Table 5.1.7
Results of trawl surveys at the Southwest Indian Ridge Seamounts during the 15th Cruise of the *R.V. Chatyr–Dag*

Seamount	Period of study	No. of trawl hauls	Hours of trawling	Catch of principal species %							
				Alfonsinos	Cardinalfish	Rubyfishes	Butterfishes	Armourhead	Jack mackerel	Scabbardfish	Others
150	26 August 1980– 20 January 1981	83	213			83.0	2.0	–	13.0	–	2.0
102	21 September 1980– 8 January 1981	45	64	11.0	12.0	18.0	58.4	–	0.3	–	0.3