Saya de Malha Bank – an invisible island in the Indian Ocean. Geomorfology, oceanology, biology.

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Review, November 2008

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Contents

Historical review

History of exploration

The Saya de Malha Bank in the Indian Ocean was investigated from the middle of 19-th to the middle of 20-th century. The first documented visit to the bank was The Percy Sladen Trust Expedition organised by John Stanley Gardiner on board the sailing- steaming RV Sealark in 1905. The geographical focus of the expedition was in the insular areas of the western Indian Ocean, in particular in the areas of Chagos Archipelago, Seychelles, Amirante and Farquhar Islands, Cargados-Carajos Islands, the islands of St. Pierre and Mauritius. Although the emphasis was done on the shallow water and onshore biota, this expedition was the first one which explored the insular slopes of the western Indian Ocean islands. The scientific results of the expedition were published in the Transactions of the Linnean Society of London in between 1907 and 1936 (Regan, I908).

In the early 1960s when a new generation of refrigerating trawlers came to being, the Ministry of Fisheries of USSR considered the western Indian Ocean as an area of the great potential resources which had been for the time being only slightly exploited by coastal artisan fisheries and long-lining but never by ground trawling. From late 1961 to 1964 *VLADIMIR VOROBIEV*, a middle refrigerating trawler of the AzCherNIRO (The Azov and Black Sea Institute for Marine Fisheries and Oceanography, Kerch) performed four cruises in the Gulf of Aden, off East Africa, off the western coast of India, and along the Seychelles – Mascarenas chain with a total number of 617 oceanographical stations, 168 grab stations, and 965 bottom trawlings (Travin, 1968). However the overwhelming majority of benthic samples were collected on the continental shelf and the few ones at the shelf break.

The period from the mid-1960s to early 1980s was the time of the greatest Soviet fisheries expansion in the Indian Ocean (Fig 1). In this time, prior to introduction of the exclusive economic zones a number of reconnaissance cruises in the then *mare liberum* of the Indian Ocean was undertaken by Soviet fisheries institutes in Moscow (VNIRO), Kerch (AzCherNIRO) and Sevastopol (Central Project and Engineering Bureau for Underwater Explorations, later known as the Hydronaut Base) (Travin, 1968; Naumov, 1975; Ivanov, 1994). Along with these national explorations, several fishing cooperation projects with the Indian Ocean nations were conducted within the FAO framework or on bi-lateral agreements with other countries (FAO, 1979).

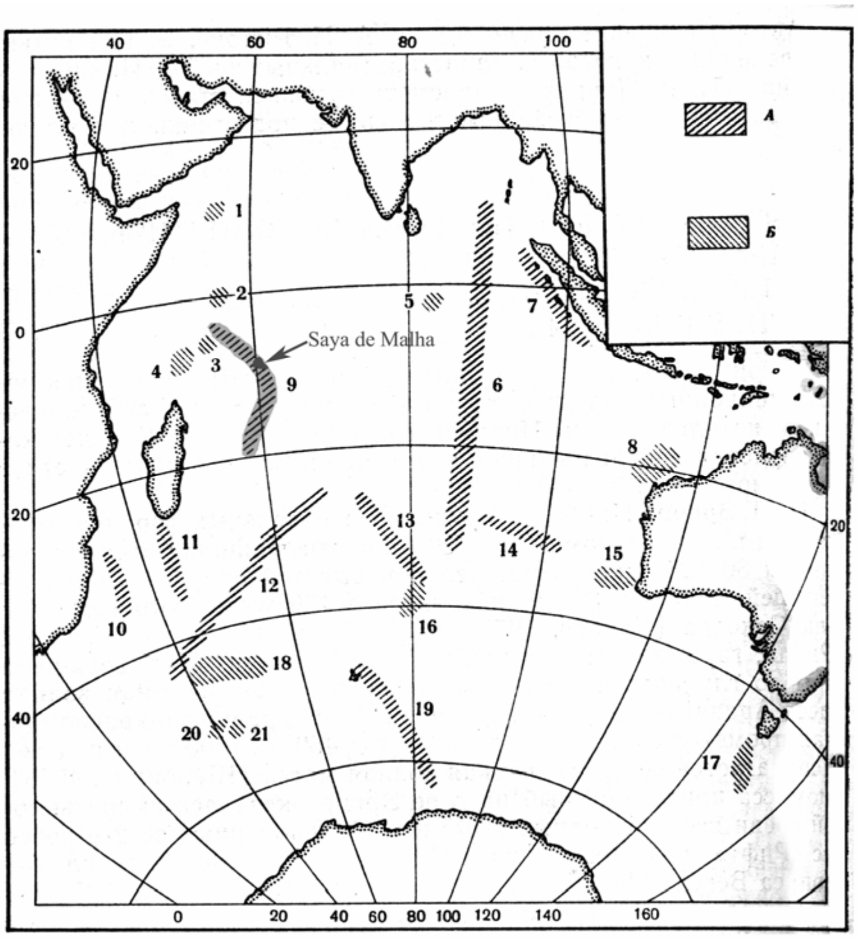


Figure 1. Map of Soviet fisheries expeditions in the Indian Ocean. Middle ocean mountain ridge (A), plateau, underwater rises and seamounts (Б). 1. Error Seamount; 2. mountain Equator; 3. Fred's mountain; 4. mountain ridge of Farcuar; 5. mountain of Anastasiy Nikitin; 6. East-Indian mountain ridge; 7. Mentavay mountain ridge; 8. plateau Ekcmunt; 9. Mascarene mountain ridge; 10. Mozambiquean mountain ridge; 11. Madagascar mountain ridge; 12. . West-Indian mountain ridge; 13 Central-Indian mountain ridge; 14. East- Australian mountain ridge; 15. plateau of naturalist; 16. plateau Amsterdam; 17. mountain Mill; 18. plateau Krose; 19. Kerguelen mountain ridge; 20. mountain Ob; 21. mountain Lena (Scherbachev et. all, 1989).

Some of these expeditions were remarkable because of their extensive coverage of deep trawlings, in particular FAO - VNIRO cruise on R.V. *PROFESSOR MESYATSEV* (December 1975 – April 1976) which surveyed the continental shelf and slope off Kenya, Tanzania, and Mozambique, waters around Seychel Islands and Saya de Malha Bank, cruise of the trawler *VAN GOGH* in the Socotra Island – Gulf of Aden area and off South-east Africa (upper slope off Boa Pas, off Zambezi delta) in 1966, and the cruises of R.V. *SKIF* and R.V. *FIOLENT* (of AzCherNIRO, Kerch) in the area of Kerguelen Islands. Although a total number of Russian fishery research expeditions to the western Indian Ocean is difficult to estimate due to few published reports it was, no doubt, considerable. However most of these expeditions were poorly equipped (Ivanov, 1994) the general organisation of surveys was often frustrating for the scientists on board. The situation was characteristically described by B.G. Ivanov in the unpublished report of the *VAN GOGH* cruise (1966, a copy in the archive of the Zoological Museum of Moscow University): «In reality the exploratory component in *VAN GOGH*'s activity was limited to the assessment of efficiency of such type of a commercial vessels in fishing for tropical crustaceans and in some ship time spent for searching for fish in the unexplored areas off Africa. The exploratory methods were typical for a commercial vessel. As a consequence we were not able to do trawling in transects across the slope. Due to the absence of winches and wire, the oceanographical work was also not possible. Besides of this, a considerable crew (ca. 100 members) which salaries depended on the vessel's production is highly interested in saving fishing time and every spending of ship time for oceanographical work would be painfully perceived».

Besides of the fishery research and exploratory cruises several expeditions to the western Indian Ocean were organised by the institutes of the Aacdemy of Sciences from Moscow and Sevastopol and the Industrial Research Bureau Yuzhmorgeologia, which specialised in the offshore geological recoinaissance. Literatire search yielded in listing 26 expeditions which visited Saya de Malha Bank and contributed to the study of particular aspects of the regional geology, oceanography, seascapes and biodiversity (Table 1).

Table 1. List of Russian expeditions worked at the Saya de Malha bank.

№	Dates	Organising institution or vessel owner	Boat	Details	Reference
1.	1961-1964	AzcherNIRO	Vladimir Vorobjov	Four voyages	Nesis, 1993
2.	1974, 4th cruise	AzcherNIRO	Chatir-Dag		Fedorov et. all, 1980
3.	1975-1977	Production-Search Association of Fish Searching and Research Fleet for the Southern Basin PA SRF(YUGRYBPOISK)	Professor Mesyatsev	Two voyages	Nesis, 1993
4.	1976	AzcherNIRO	Chernomor		Nesis, 1993
5.	1976-03-23 1976-06-12	P.P. Shirshov Institute of Oceanology of the Russian Academy of Sciences (IORAS)	Academik Kurchatov, 22nd cruise		Scherbachev et. all, 1989 Biohydrochimia …,1981
6.	1977, 3rd cruise	AzcherNIRO	Ichtiandr		Fedorov et. all, 1980
7.	1977	Shirshov Institute of Oceanology/RAS (SIORAS)	Ichtiandr, 3rd cruise		Nesis, 1993 Fedorov et. all,1980
8.	1978-01-26 1978-03-31	Association of Fish Searching and Research Fleet for the Southern	Zvezda Krima		Nesis, 1993

		Basin PA SRF(YUGRYBPOISK)			
9.	1980	Production-Search Association of Fish Searching and Research Fleet for the Southern Basin PA SRF(YUGRYBPOISK)	Elsk		Nesis, 1993
10.	1981-12-31 1982-05-16	Production-Search Association of Fish Searching and Research Fleet for the Southern Basin PA SRF(YUGRYBPOISK)	Lesnoy		Nesis, 1993
11.	1981	Marine Hydrophysical Institute of the Ukrainian Academy of Sciences (MHI)	Academik Vernadskiy, 24th cruise		http://zr.molbiol.ru/hydrocharitaceae.html Milchakova et. all, 2005
12.	1982-09-20 1983-03-04	AzcherNIRO	Fiolent		Nesis, 1993
13.	1984	Marine Hydrophysical Institute of the Ukrainian Academy of Sciences (MHI)	Academik Vernadskiy		Milchakova et. all, 2005
14.	1984	Russian Federal Research Institute of Fisheries and Oceanography (RIFO)	Odissey, 33th cruise		Sirenko, 1993
15.	1984-01-12 1984-03-20	Russian Federal Research Institute of Fisheries and Oceanography (RIFO)	Academic Knipovich		Nesis, 1993
16.	1984-01 – 1984 -05	Institute of the Biology of the Southern Seas NASU (Inst.Bio.South.Seas)	Professor Vodjanitski, 16th cruise		Grese, 1988
17.	1986	Institute of the Biology of the Southern Seas NASU (Inst.Bio.South.Seas)	Academik Kovalevskiy		Nesis, 1993
18.	1987-1990	Scientific production association 'UzhMorGeologia' UzhMorGeologia	Issledovatel	Two voyages	Scherbakov, Zhivago, 2001
19.	1987-1990	Scientific production association 'UzhMorGeologia' UzhMorGeologia	17 cjezd profsojusov	Two voyages	Scherbakov, Zhivago, 2001
20.	1989	Shirshov Institute of Oceanology/RAS (SIORAS)	Vitjaz, 17th cruise		Nesis, 1993

The description of field work and the data gathered in these expeditions were not extensively published. Only few published papers provide details of particular expeditions.

Reviews of the work undertaken in particular voyages

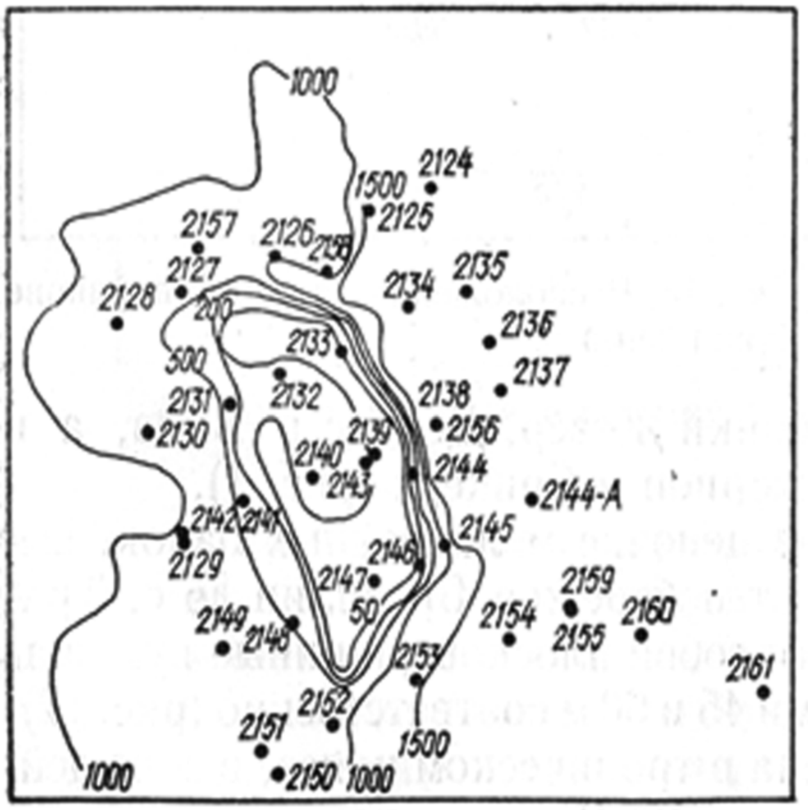
RV “Professor Vodjanickiy” 1984

The expedition on board RV “Professor Vodianitskiy” collected extensive oceanographical and biological material on Saya de Malha Bank in February 1984 (Tab 2, Fig 2).

Table 2. Hydrology and biology stations on the Saya de Malha bank (Grese, 1988):

parameter	method	Number of stations
Oceanography	CTD “Istok” casts	181
	“Kalmar” recorder casts	13
Current measurements	“Disc2” profiller (hour of observations)	53
oxygen	measurements	313
phosphate	measurements	332
ATP microplancton	chemiluminescence (1250, light)	210
chlorophyll a	fluorometric method; spectrocolorimeter Spectrol – 10	235
pheophytin a	fluorometric method; spectrocolorimeter Spectrol – 10	235
Bioluminescence of plankton	Reconnaissance by batiphotometer	227
Quantity of phytoplankton	Botle samples, reverse filtration	122
Quantity of bacterium	Bottle samples, SINPOR-7 filtration	246
Quantity and composition of microzooplankton	Bottle samples, reverse filtration Juday net, gauze 49	273
Quantity and composition of mesozooplankton	Net samples counted	163
Quantity and composition of ichtioplankton	Bogorov-Rass net, gauze 23; BMS net, sieve 11	55

A.



B.

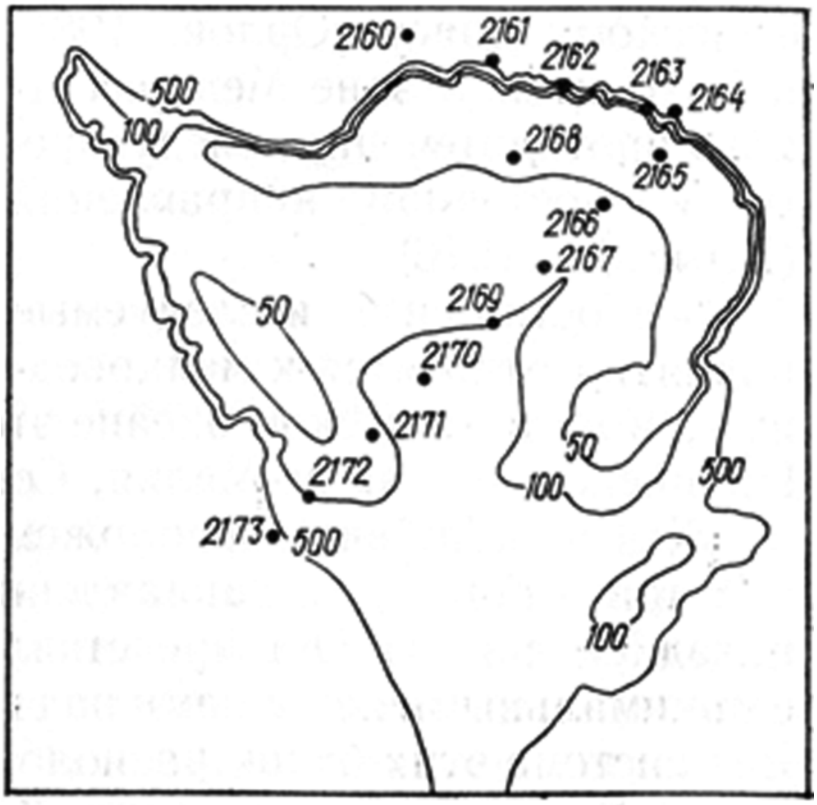


Figure 2. Stations of RV "Professor Vodianitsky" in the North (A) and South (B) parts of Saya de Malha Bank in 1984 (Grese, 1988).

RV "Professor Mesiatsev" cruises 1975-1977

The expeditions on RV "Professor Mesjacev" in 1975 – 1977 partly conducted as part of FAO investigations in the western Indian Ocean. Distribution of sampling in the FAO Cruise is shown in Fig. 3 (Parfenovich, 1980).

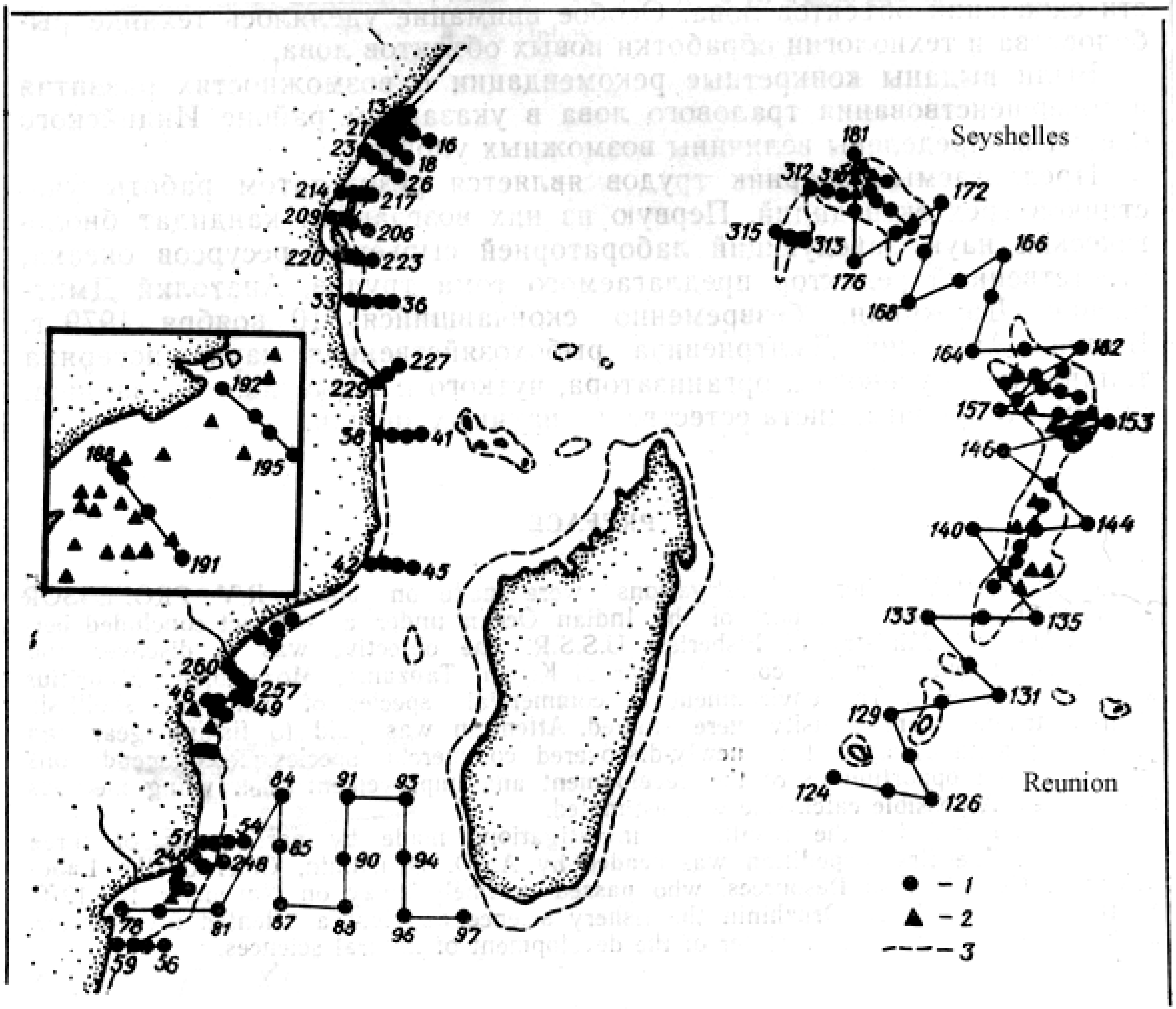
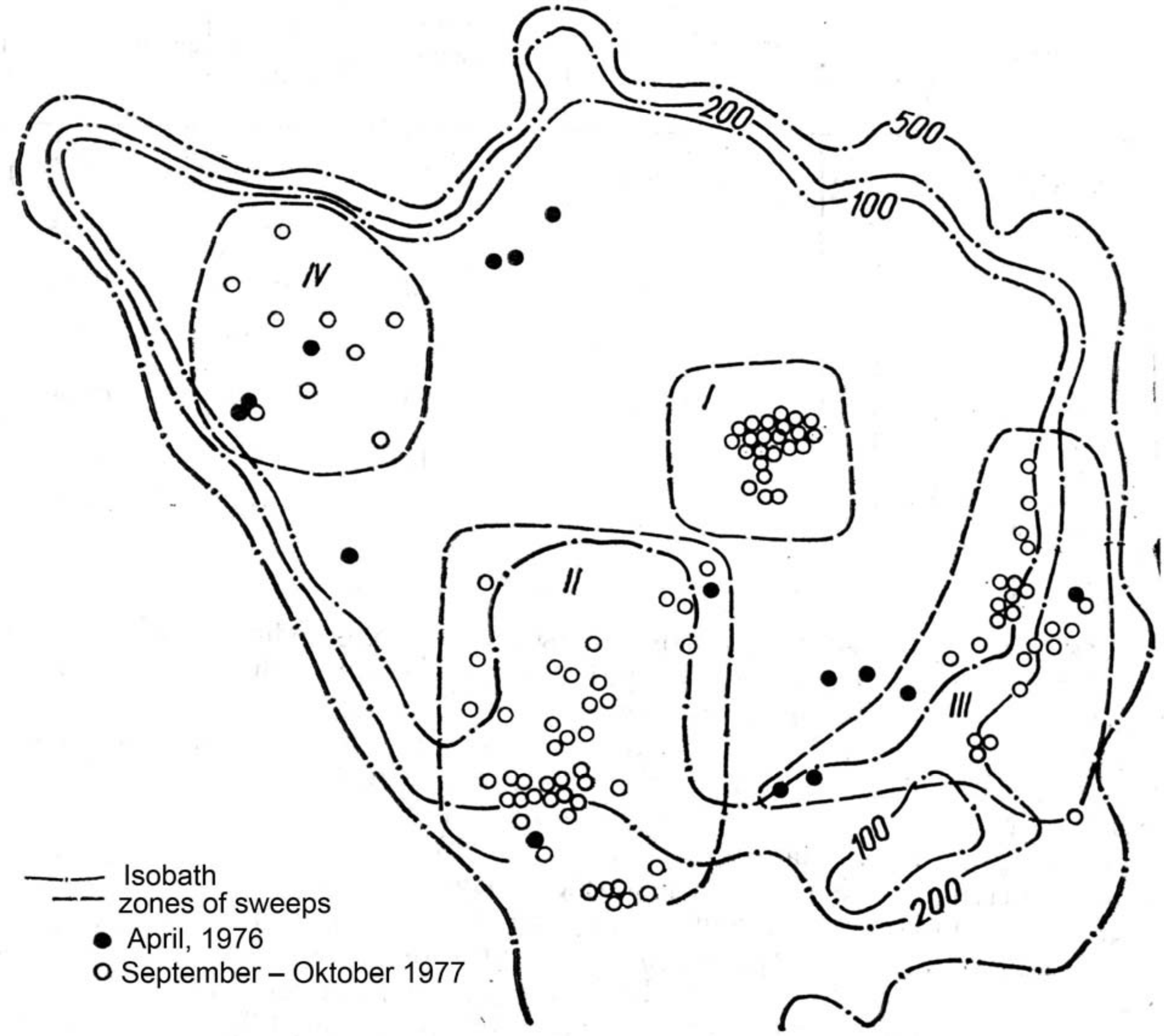


Figure 3. Stations of the FAO expedition on board RV "Professor Mesyatsev"in 1975 - 1976. 1. stations with oceanographic and biological sampling 2. hydrobiological stations associated with commercial trawl hauls 3. 1000 m isobaths (Parfenovich, 1980).

In April 1976 and September – October 1977 74 bottom trawlings and 34 langouste drag-net hauls were conducted on Saya de Malha within 500 m isobath (Fig. 4). The commercial catch amounted to 33 tons of fish and commercial invertebrates.

Figure 4. Trawls in the South part Saya de Malha bank (Karpitenko, Bidenko, 1980).



Geology

Mascarene Plateau

The Mascarene Plateau is a submerged plateau in the Indian Ocean. The plateau extends approximately 2000 km, from the Seyshelles in the north to Reunion in the south (Fig 3). The plateau covers an area of over 115,0 00 km² of shallow water, with depths ranging from 8 to 150 m, plunging to 4000 m to the abyssal plain at its edges. The northern part of the plateau includes the Seychelles, the southern part of the plateau includes the Mascarene Islands (1). The Mascarene Plateau has a several shoals: Mahe, Saya de Malha bank, Nazareth bank. Bottom in the top of plateau formed by debris of corals and coral send, in the slopes bottom formed by foraminifera silt (Kanaev, 1975).

The Saya de Malha bank

Depth and relief

Saya de Malha bank located in the middle of the Mascarene plateau (in latitude 08º30' - 12º0' South; in longtitude 59º30' - 62º30' East). The bank covers an area of 40,808 km². It is in fact composed of two separate structures; the smaller North bank (also called Ritchie bank) and the huge South bank (Fig 5) (1). Size of North bank is 80x25 miles; size of South bank is 150x120 miles (Kanaev et. all, 1975).

Saya de Malha is similar to atolls in the Pacific by the structure. It has a top and lagoon. Tope of the South bank has a difficult structure. It's reprisents as a ring with 20-25 mills in width and 8 m minimum depth. There are a corals on the periphery of the ring. Two flats can be found on the ring: one in the east (30-35 m depth) and anther in the west (50-55 m depth) (Fedorov et. all, 1980).

Lagoon is deeper then other atolls in the Pacific. Medium depth of lagoons on the Pacific is 46 m, on the bank from 70 m (in the north) to 140 m (in the south). There are more then 20 coral hills and ridges up to 30-50 m on the accumulative flat. Hills have similar structure like intralagoon reefs of other atolls. Bottom of the South bank consist of 10 cm width sediment (Fedorov et. all, 1980). Thus the Saya de Malha bank can be related to submerged atolls (Fedorov, Danilov, 1979; Shor, Pollard, 1963).

The shallowest sites known are Poydenot Rock, with a depth of 8 meters, and an unnamed site 145 km further northwest, with a depth of 7 meters (1).

Slops

Two depressions were found in the Saya de Malha bank: one on the south and other on the north with minimum depth 980 m and 455 m accordingly (Fedorov et. all, 1980). Slope on the east region is very steep (Kanaev et. all, 1975) and consist of cavernous reef limestone from 20 to 120 m. Rhythmically foliated limestone were find out on 200-400 m (Fedorov et. all, 1980).

The south slope of the bank formed by a series of narrow shoals, with depths from 9-17 to 20-29 meters on the rim (1, Grese, 1988). The slope of the South bank is steep and drop to 300 m (Scherbakov, Zhivago, 2001). Reef bedded on the thick layer of limestone. Transition from thickly foliated limestone to thinly foliated limestones can be distinguished on 800-1650 m depth (Fedorov et. all, 1980).

The west slope of the bank is steep and concave with angle of 16 degrees in the upper part. The east slope consists of wide levels. Upper part of this slope is steep and concave with angle of 22 degrees (Scherbakov, Zhivago, 2001).

The Nazareth bank is adjacent to the Saya de Malha bank from the South. Depbetween them has a 20 km width and 1100 m depth (Scherbakov, Zhivago, 2001).

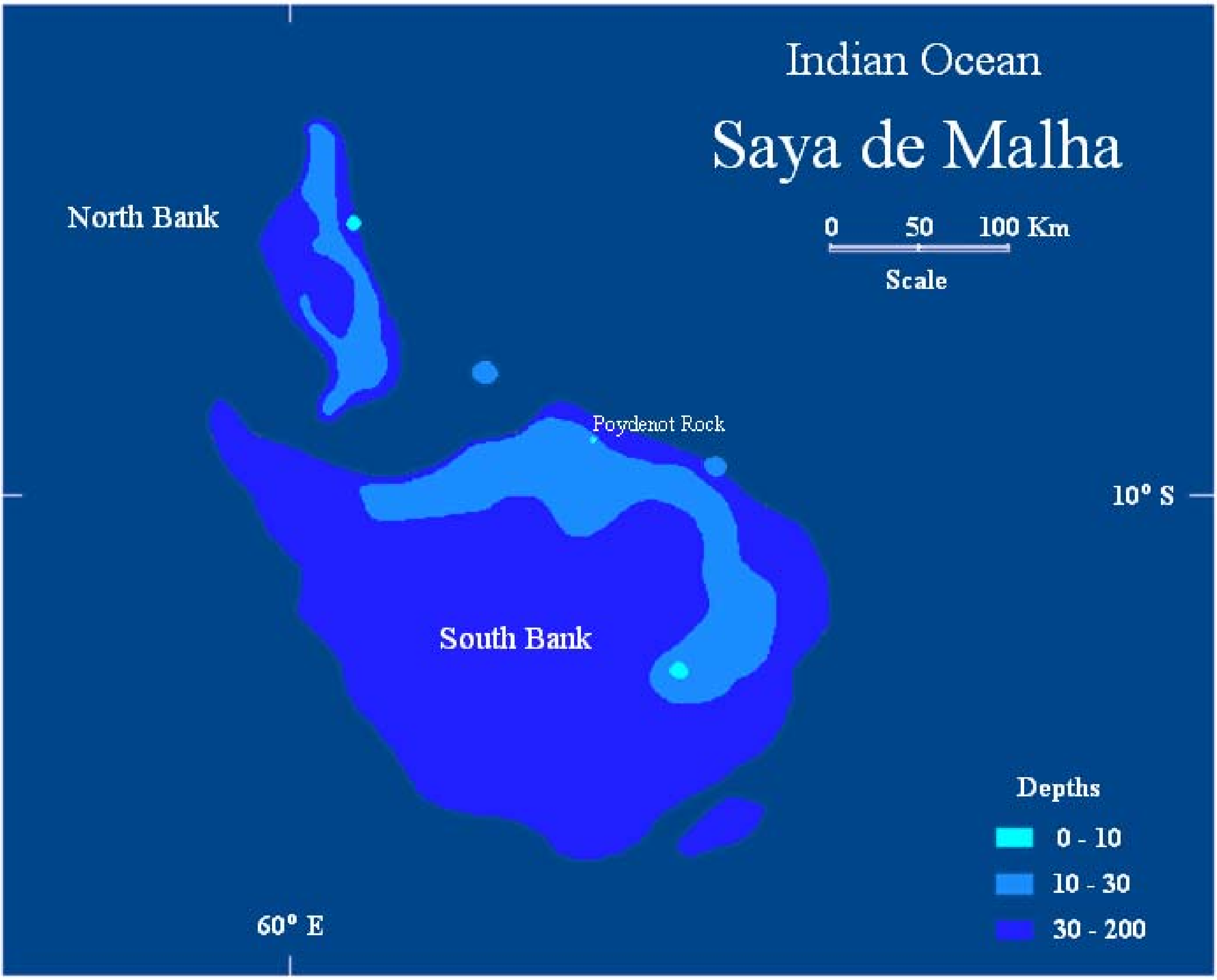
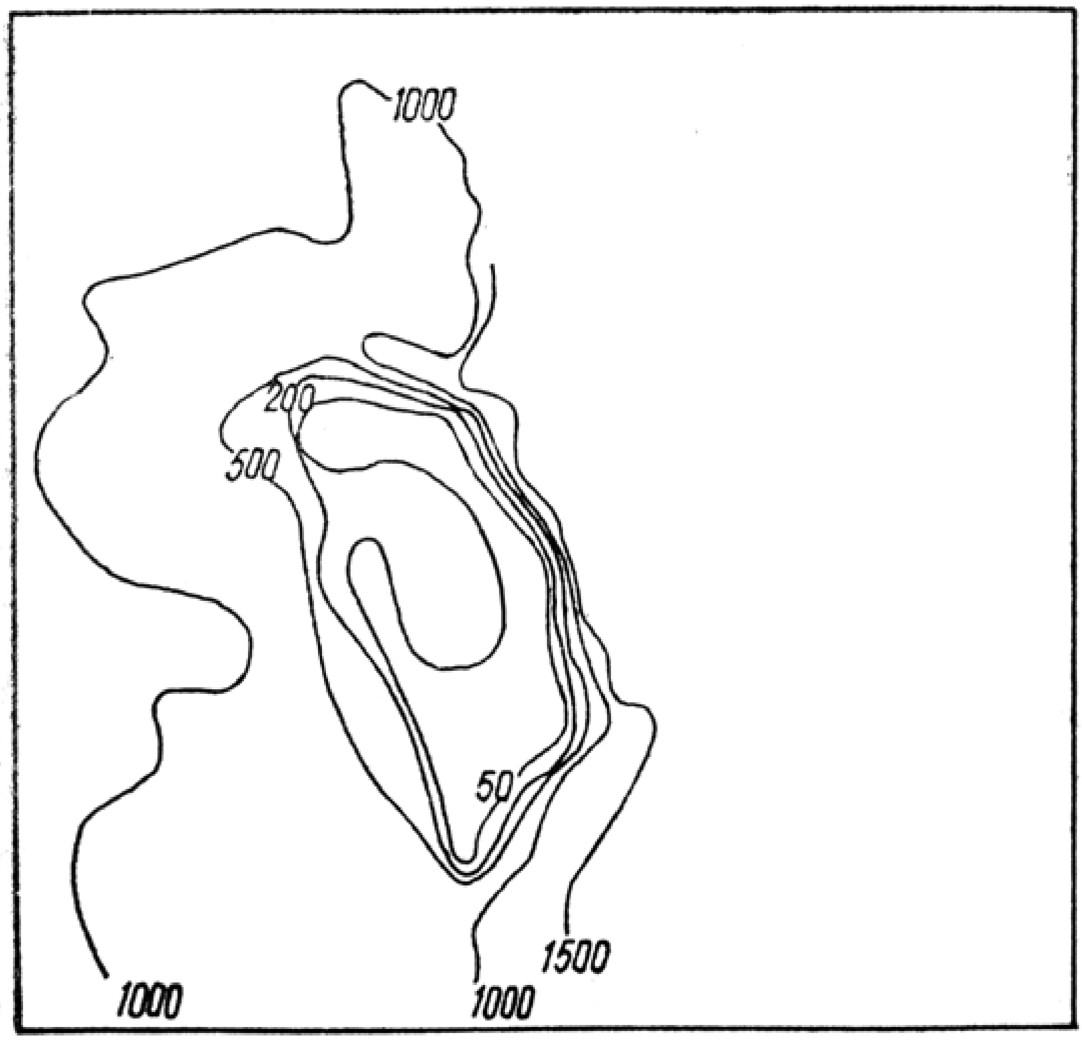
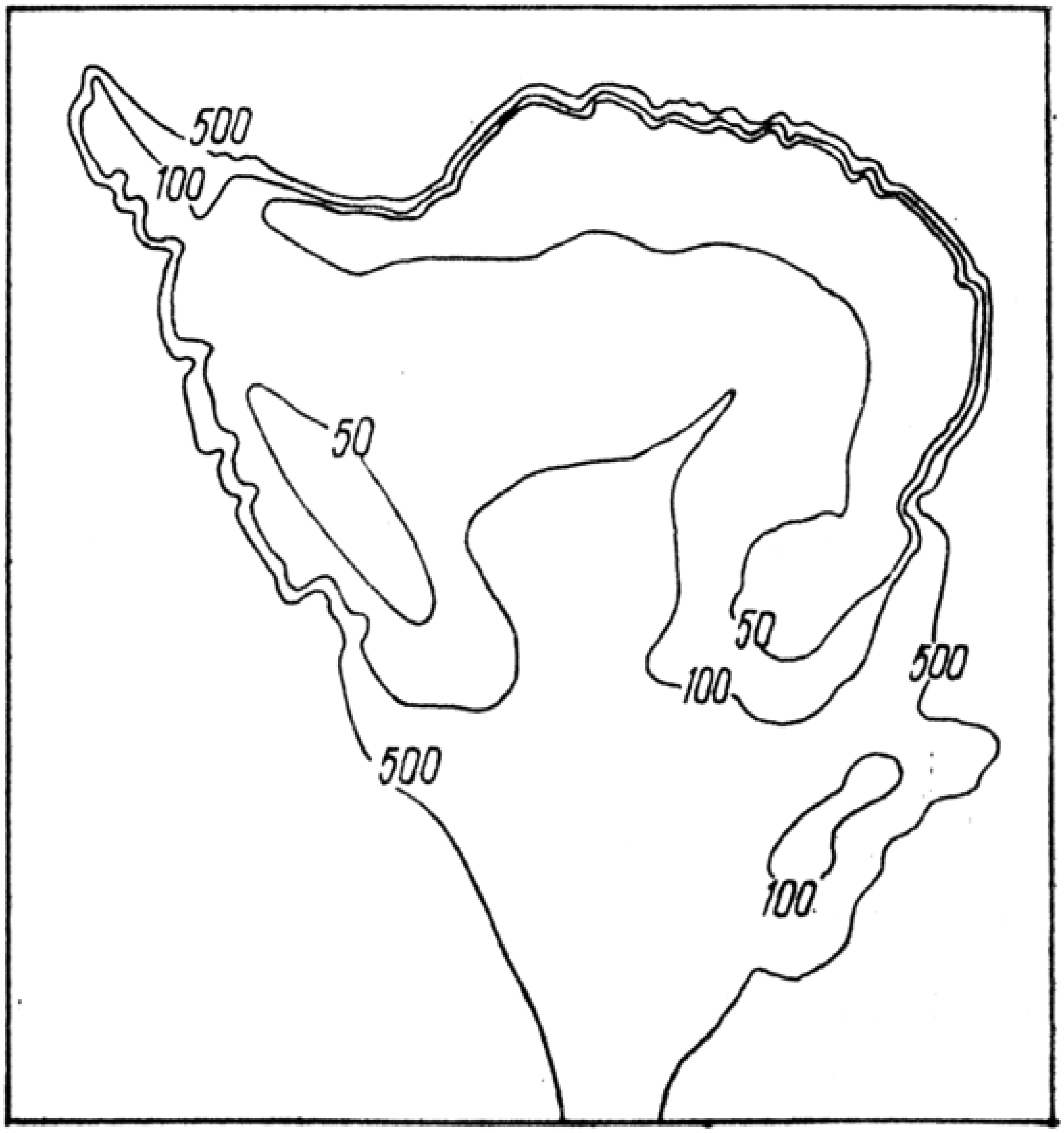


Figure 5. Map of the Saya de Malha bank (1)



A



Б

Figure 6. Batimethry of the North (A) and South (Б) bank (Grese, 1988).

Distribution sediments on the bottom

Sedimentary layer between two banks (Saya de Malha and Nazareth) is about 700 m thikness; it's formed by lime silt in the upper level and chalk with inclusions of silicon in the low levels (Kanaev et. all, 1975).

Pebbly-float stone and gravel coral-algae grounds predominate on the top of the atoll and intralagoon reefs. Reefs usually crusted over with a red-pink litotamnium. Seabed in the inner region of lagoon is composed of acropore's fragments. Seabed in the shallow North bank is composed of large- and small- scale silts. These silts contain a foraminifera shells, pterapods and flaky of calcium carbonate. Seabed in the inner foot of atoll is composed of coral send with fragments of calcareous algae (10-15%), sponge spicules and detritus. In the South bank the bottom of lagoon consists of foraminifera silts. Biocenose of *Anomia ephippium* well developed in the mouth of lagoon so the bottom there is shelly. Sediments on the South bank contain a globigerine shells (Fedorov et. all, 1980).

Structure of sedimentary cover upper layer of crust

Schem of sedimentary cover in Cainozoe of Mascarene Plateau have make using method of time sections, reflection and acoustic methodes (Fig 7, 8).

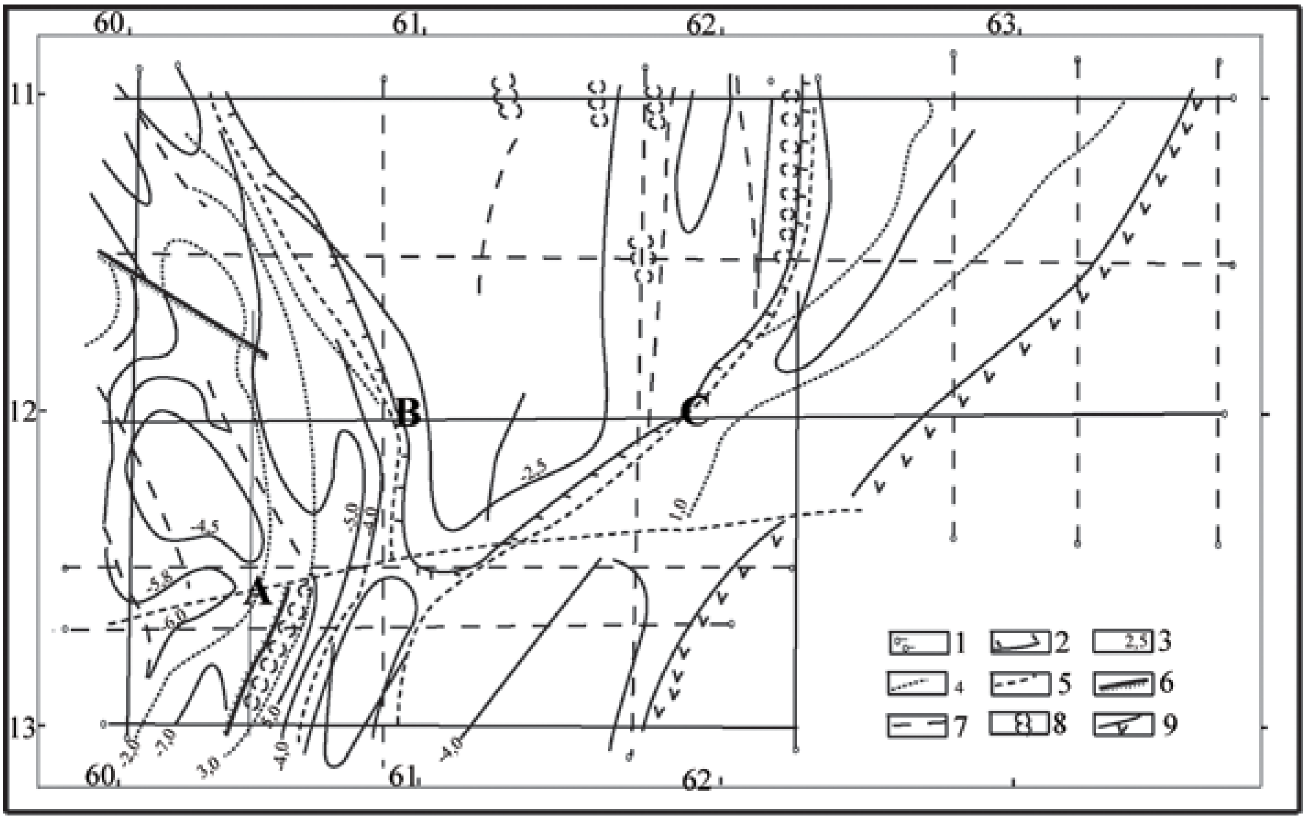


Figure 7. Scheme of Mascarene Plateau's sedimentary cover in Cainozoe. 1 – Profiles of reflection method (a) and acoustic methods (b); 2 – edge of contemporary slope; 3 – isohyps of reflecting horizon II (upper Palaeocene); 4 – powers isopachtytes of Cainozoe crust (layer between bottom and horizon II); 5 – abyssal fractures: North-Nazareth (A), West-Mascarena (B), East-Mascarene (C); 6-7 – explosive disturbance; 8 – reefs; 9 - spreading of crust.

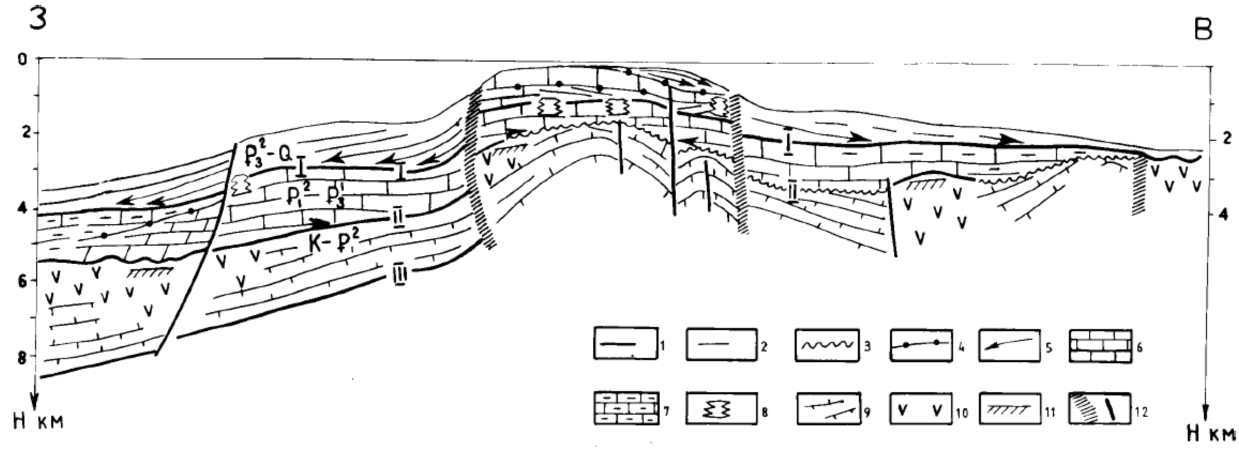


Figure 8. Scheme of acoustic profile of Mascarene Plateau. 1 – key horizon as a border between seismic complexes; 2 – other seismic complexes; 3 – erosive section; 4 – borders of subcomplexes; 5 – regions of ending reflections on the subcomplexes; 6-8 seismic facies: 6 – shallow water carbon facies; 7 – deep-water clayey-carbon facies; 8 – reef facies; 9 – volcanic sedimentary facie of lower complex; 10 – vulcanite; 11 – upper edge of magnetically disturbed masses; 12 – breaking-down disturb.

Bearing seismic borders I and II can be distinguished on the time seciones of Mascarene Plateau. Border I and II concern to middle Oligocene and upper Pleistocene accordenly.

Structure of sedimentary cover of slopes the Saya de Malha bank was investigated in detail using reflection and acoustic methods. These methods make it clear that most part of section consists of vulcanites. Data of the well-boring confirms a presence of basalts on 2430 m bepth. So the seismic border II of Mascarene Plateau is a basis of a sedimentary level.

Formation of slopes Saya de Malha Bank

Seismoacoustic methods show crossbedded structure in the east region of the Bank (Fig 9) that assume slopes formation in unstable hydrodynamic condition and shallow water. Wave pattern near the upper edge can be explaied by exist of barrier reef.

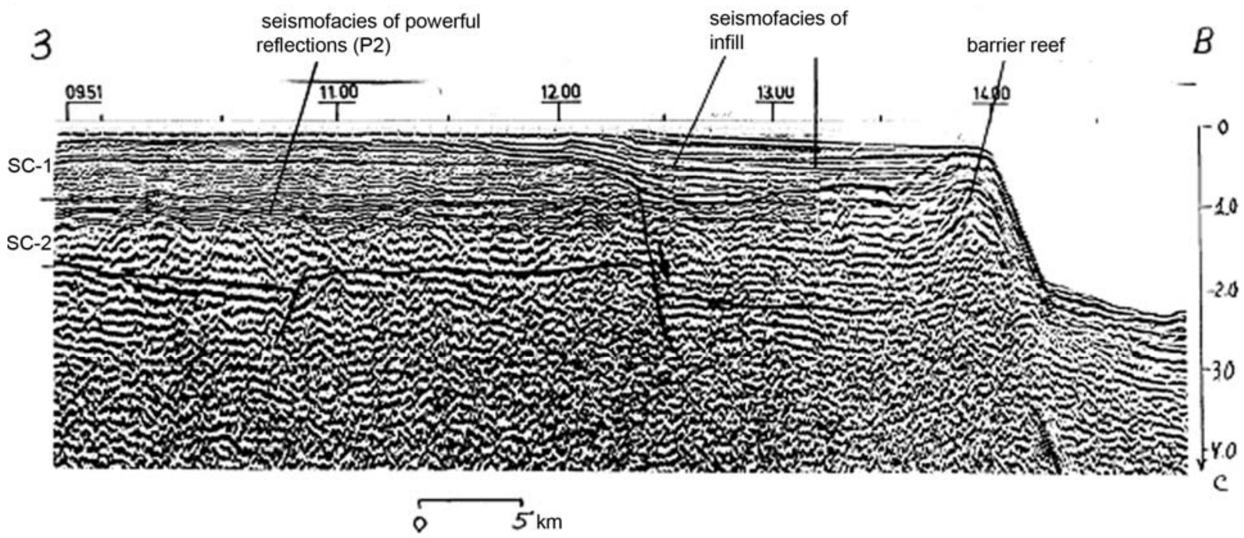


Figure 9. East slope of the Bank (11º S). SC – seismic complexes. Vertical scale bare – double time of signal passes in sec.

Deep seated horizon can be distinguished in the lower complex of west slope of the Bank and Mascarene Plateau (Fig 10) that records on more than 20 km.

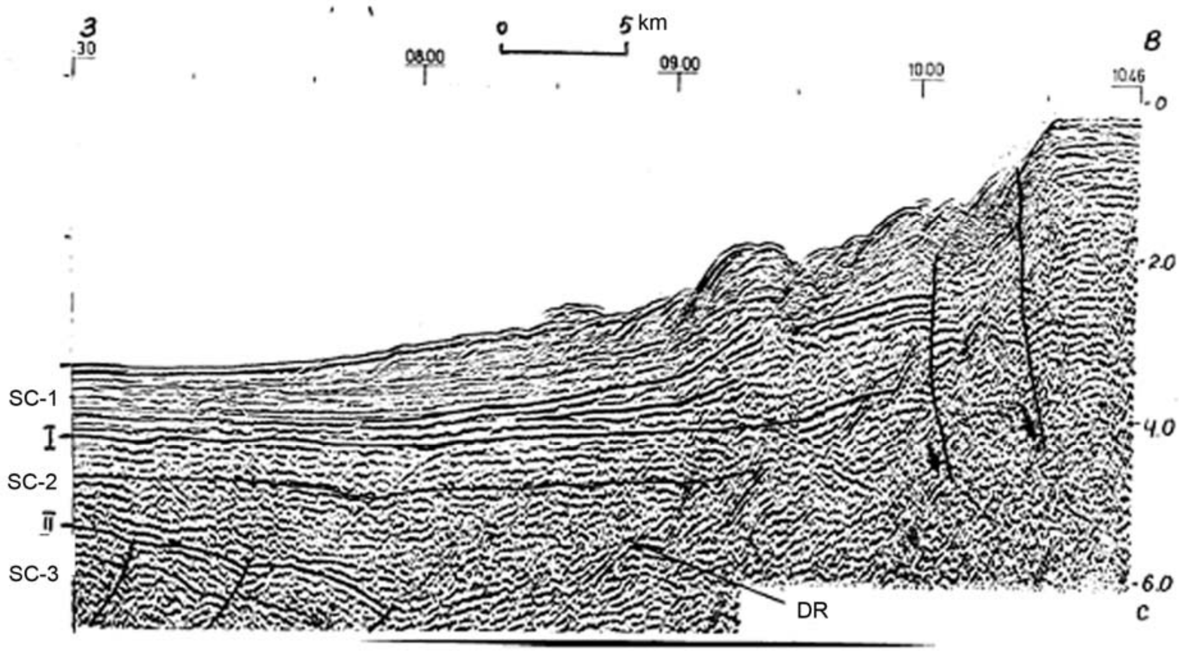


Figure 10. West slope of the Saya de Malha Bank. SC – seismic complexes, DR – double reflection (“second bottom”). Vertical scale bare – double time of signal passes in sec.

There are several regional and local explosive disturbances in Mascarene Plateau. North-Nazareth sublatitudinal break split Mascarena Plateau into two blocks: Nazareth Bank and Saya de Malha Bank. These blocks have most differences in the east slope. Nazareth Bank has a normal crossbedded sedimentary while east slope Saya de Malha consist of vulcanite.

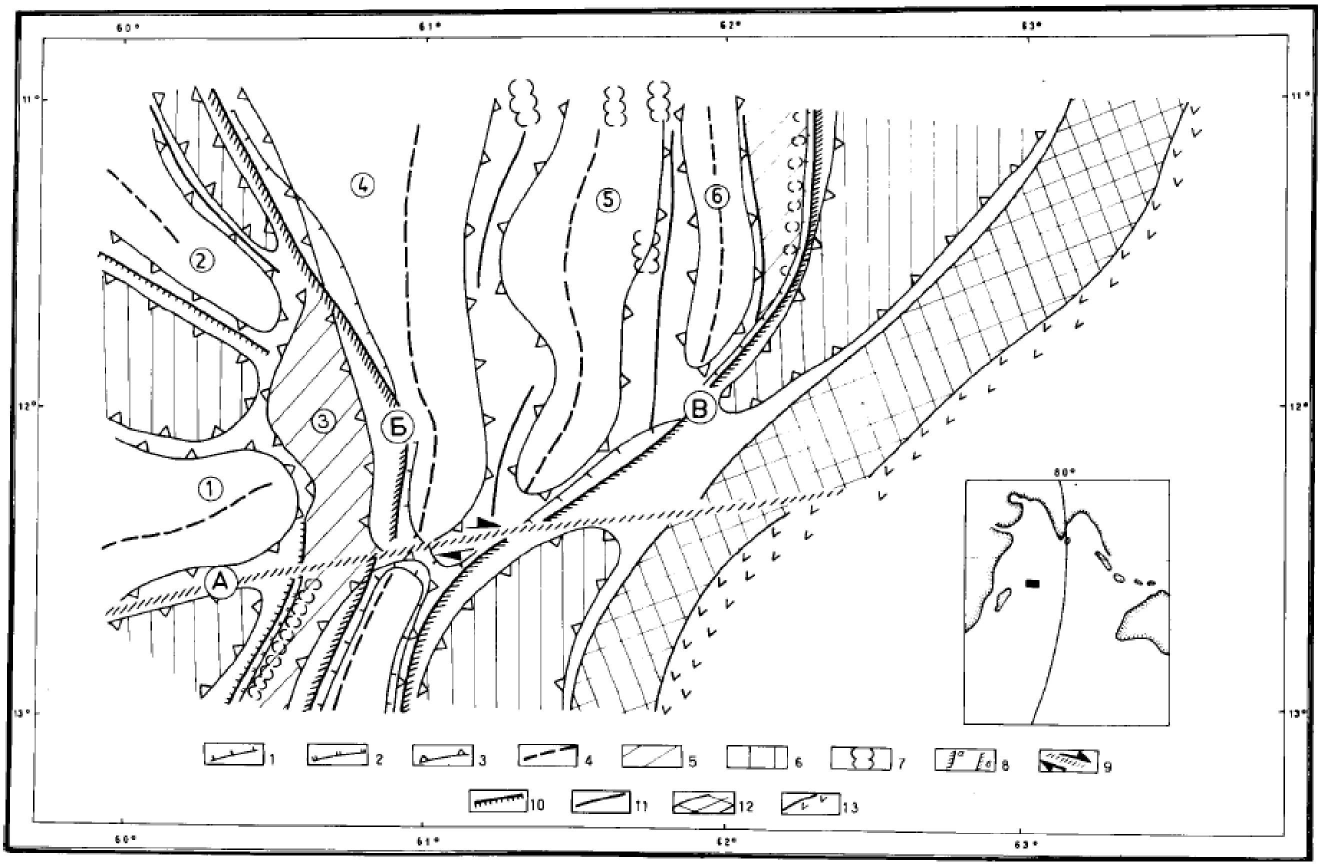


Figure 11. Scheme of tectonic zoning till Cainozoe structure level of Mascarene Plateau. 1 – edge of contemporary slope; 2 – edge of late Oligocene slope; 3 – main structures second order; 4 – axis of raises; 5 – steps; 6 – negative structure elements; 7 – reefs in Cainozoe; 8 – 9 – deep breaks; 10 – ledges; 11 – tectonic disturbances; 12 – transitional crust; 13 – spreading crust. А, Б, В – main breaks: 1 – South; 2 – North; 3 – West-Mascarene step; 4 – east raise on Saya de Malha Bank; 5 – central raise; 6 – East raise.

History of formation

Mascatene Plateau represents a morphostructure of continental type located in the middle of development ocean crust (Leontjev, 1982). The mantle plume-derived volcanic rocks of India's Deccan Traps first appeared near the Cretaceous-Tertiary boundary. The Seychelles began to separate from India in the early Paleocene. By the close of the Paleocene, a broad expanse of oceanic crust separated the Seychelles and western India and the mantle plume formed an extensive oceanic ridge that would become the Laccadives-Maldives-Mascarene Plateau. The ongoing spread center broke apart the oceanic ridge, beginning in the Eocene and continuing through the Oligocene. North of the spread center, plume activity extended the Laccadives-Maldives to include the Oligocene-age Chagos Archipelago, while south of the spread center, the Mascarene Plateau basalts continued as the Saya de Malha and Nazareth Banks. Plume extrusion continued to the south as the plate moved northward, creating Mauritius

Island during the Miocene and Reunion Island during Pliocene-Recent (Bill St. John Tectonics of the Western Indian Ocean).

Banks of Mascarene Plateau represent a part of continental shelf introduced to the ocean (Leontjev, 1982). Reef formation began at final phase of geology development (Fedorov et. all, 1980).

Bottom of the South region

Distribution of the trophic groups depends of bottom's type. Nonpredatory invertebrates inhabit homogeneous sediment. Macrophyts, corals and immovable seistonophage occupy top of the reef with large debris bottom and actively hydrodynamic. Underwater investigations display irregular distribution of coral reefs in the circular top of the Bank (2-10 m from each ather). Most frequently occurring taxa are acropores, pocilopores, big *Porites* sp. and *Heliopora* sp. (Karpitenko, Bidenko, 1980) (Fig 12).

Red calcareous coralline and halimeda algae are more frequently than corals in the low terrace. Immovable sestonfeeders as a spongy, bryozoans and tunicate dominate in the slopes. East slop inhabits horny coral (Gorgonaria) that needs strong current. Abrupt change of assemblage can be observed on the border between slop and bottom. Depositefeeders (*Spatangus purpureus* (Echinoidea) and *Priapulus* sp. (Priapulida)) dominate in this region. These animals feed on destroyed algae washed away from the tot of reef. Depositefeeders have irregular distribution from high density (14 ind/m^2) to low density (1 ind/5 m^2), average biomass 280 g/ m^2 (Karpitenko, Bidenko, 1980).

Central part of lagoon contains fine-dispersed planctonogenic detritus. In this region dominate collecting depositefeeders. Foot of reef contains a bentogenic detritus. In this region dominate unselective depositefeeders (*Brisaster* sp. (Echinoidea) and *Trochostoma* sp. (Holoturoidea)) (Karpitenko, Bidenko, 1980).

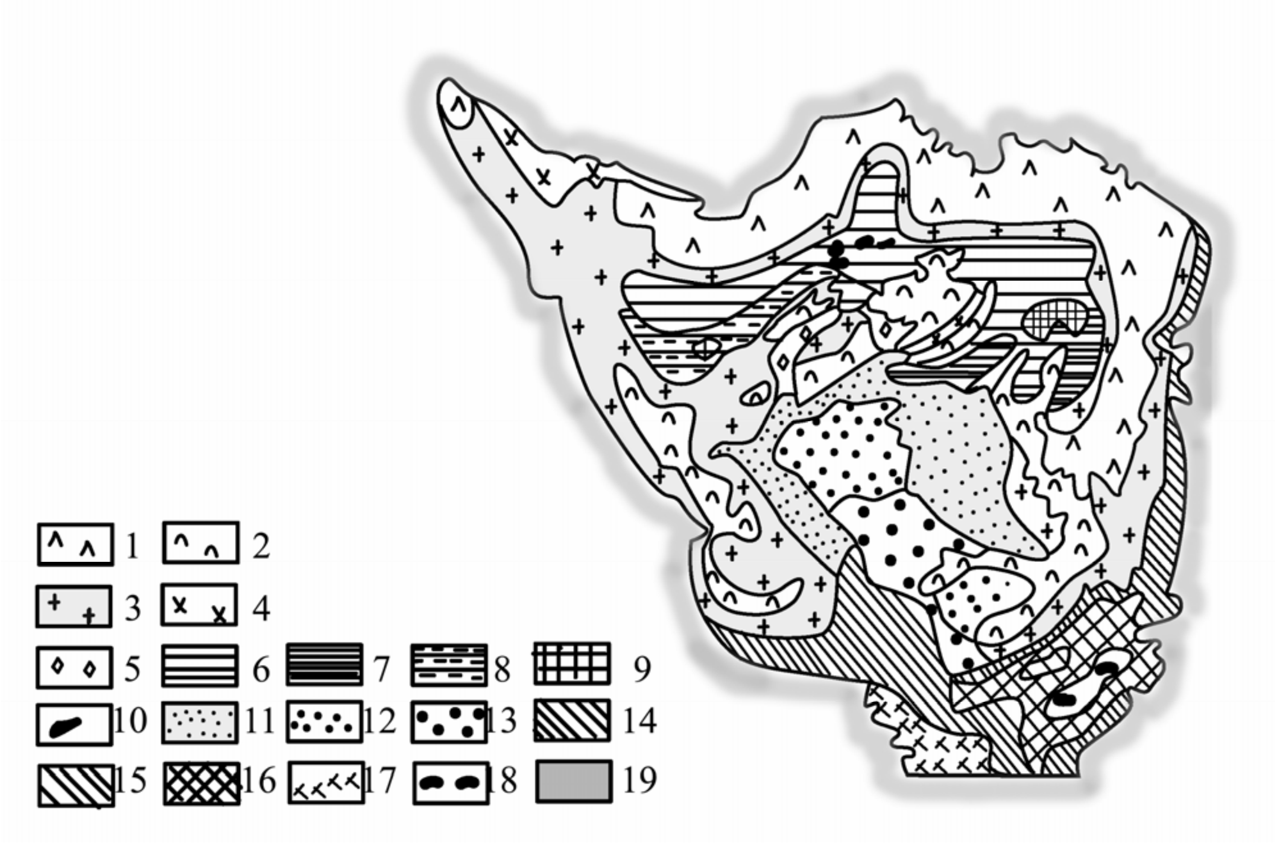


Figure 12. Landscape of Saya de Malha Bank. **Landscape of submerged circular reef.** 1. Upper terrace. Bottom consists of float stone – gravel – pebble. Dominants: macrophyte, madreporarian corals (Madreporaria), Spongia. 2. Low terrace. Bottom consists of send – gravel foraminifera – algae ground. Dominants: calcareous algae, benthic foraminifera. 3. Slopes and foot of reef. Bottom consists of foraminifera – algae send. Dominants: *Spatangus purpureus* (Echinoidea), *Priapulus* sp. 4. Slopes of reef. Bottom consists of silt – send. Dominants: *Spiophanes soderstromi*. 5. Shallow gullies. Bottom consists of silt – send. Dominants: *Prionospio* sp. **Landscape of shallow coral lagoon.** 6. Bottom accumulative flat. Bottom consists of fine-dispersed silt. Dominants: *Brisaster* sp. (Echinoidea) and *Trochostoma* sp. 7. Bottom accumulative flat. Bottom consists of silt. Dominants: *Prionospio* sp. 8. Bottom accumulative flat. Bottom consists of sound – silt. Dominants: *Prionospio* sp. 9. Bottom accumulative flat. Bottom consists of sound – silt and fine-dispersed silt. Dominants: *Pelosina* sp. 10. Intralagoon coral mount and ridge. Bottom consists of coral – algae gravel and pebble. Dominants: acropores, tunicates, spongy, calcareous algae. **Landscape of deep coral lagoon.** 11. Bottom-dwelling accumulative flat. Bottom consists of silt – send. Dominants: *Prionospio* sp. 12. Bottom-dwelling abrasive flat. Bottom consists of foraminifera send. Dominants: collecting detritophage. 13. Bottom-dwelling abrasive flat. Bottom consists of mollusk-algae send. Dominants: *Anomia ephippium* (Bivalvia). **Landscape of the reef top.** 14. Limestone flat. Bottom consists of thin layer foraminifera send. Dominants: *Spiophanes soderstromi*. 15. Limestone flat. Bottom consists of gross calcareous – algae send. Dominants: *Spatangus purpureus* и *Priapulus* sp. 16. Limestone flat. Bottom consists of rock with thin layer algae – foraminifera send. Dominants: immovable seistonophage. 17. Limestone flat. Bottom consists of foraminifera send. Dominants: horny coral. 18. Intralagoon rises. Bottom consists of coral limestone with gravel – pebble algae ground. Dominants: calcareous algae and spongia. **Landscape of slopes.** 19. Slopes with steep steps. Bottom consists of send. Dominants: *Spiophanes soderstromi* (Method recommendations…1982).

Four propitious for a trawl regions can be distinguished by results of bottom trawl (Fig 13). The first is a central part of the Bank. It characterized by small gradient in the west direction from 70 to 100 m depth, send – silt ground. The second is a south-central part of the Bank. It characterized by 100 – 180 m depth and shell limestone ground. The third is a south – east and east part of the Bank with rock ground. The forth is a west part of the Bank characterized by 40 – 80 m depth and compound relief. Rock – coral ground predominates in the 60 m depth. Shell limestone ground with numerous spongy predominates deeper then 60 m (Karpitenko, Bidenko, 1980).

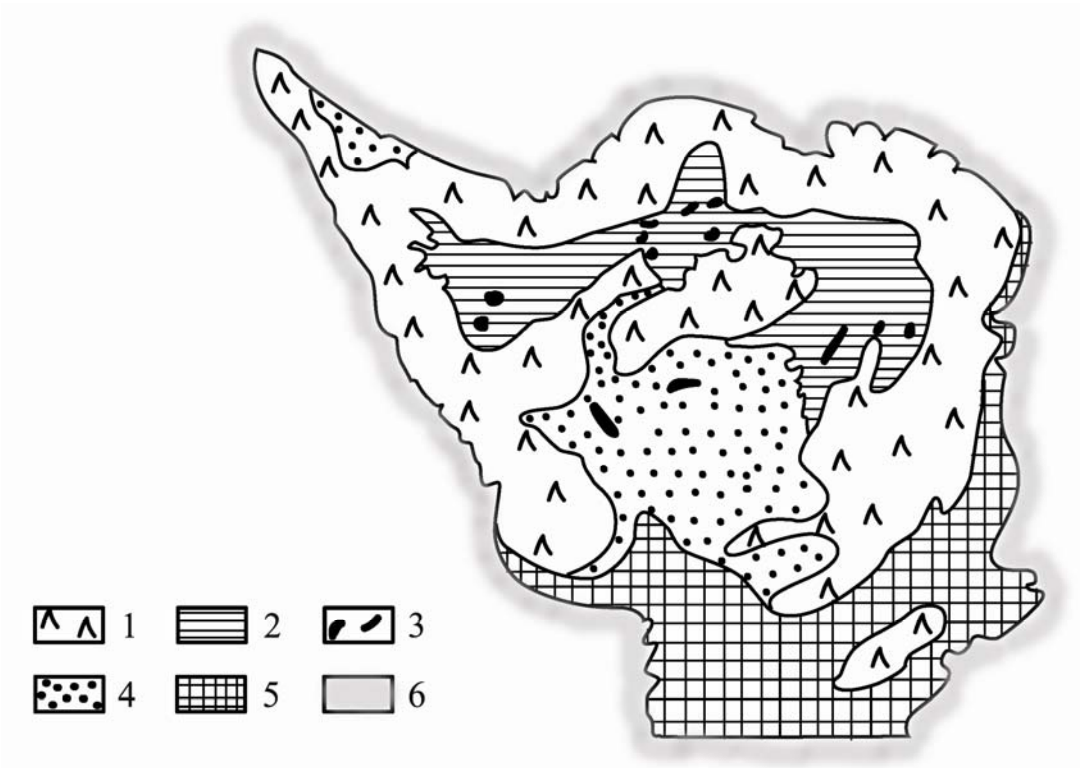


Figure 13. Zoning of Saya de Malha Bank by results of trawl. 1. coral reefs. 2. shallow lagoon 3. coral rises. 4. shallow lagoon and accumulative slopes. 5. limestone flat of the reef. 6. Slopes with steep steps (Methodical recommendations…1982)

Oceanography

The flow of the South Equatorial Current (SEC, direction is between 5° – 23° S, speed 0, 5 – 1, 5 kn (Kolodnitsky, 1978)) across the plateau is highly dependent on the complex structure of the banks which make up the plateau, and that a large part of the flow is channelled between the Saya de Malha and Nazareth Banks (New et. all, 2005). Furthermore, the SEC forms a sharp boundary between subtropical water masses from further south, which are low in nutrients, and waters from further north, which are relatively nutrient rich. Overall, the SEC delivers relatively high levels of nutrients to the near-surface waters of the central and northern regions of the plateau, compared with the southern regions of the plateau. This is partly due to uplifting of density surfaces through Ekman suction on the northern side of the SEC, and partly due to the higher levels of nutrients on those density surfaces on the northern side of the SEC. This may drive increased production of phytoplankton in these areas, which would in turn be expected to fuel increased abundances of zooplankton and higher levels of the food chain (New et. all, 2005)

In the region of the Saya de Malha bank water masse can be stratify to following layers: the south tropical upper layer (100 – 130 m depth, 20 – 28º water temperature, 34,8 – 35,2 ppm), subtropical subsurface layer (from 100 – 130 to 300 – 400 m depth, 10 – 18 º water temperature, 35,1 – 35,4 ppm) (Kolodnitsky, 1978).

The most productive region locates in the south-east slope of the bank because in this place presents wide canyon. Subsurface fortified layer of water impact on and ascends along canyon and mixes with upper poor water (Kolodnitsky, 1978).

Most probably hydrodynamic on the bank differs from season to season. Some investigations content that upwelling presents in north – east and south – west slopes (Grese, 1988).

Intensive local sinking of temperature isolines can be evidence of water sinking in the west slope (Fig 14) (Grese, 1988).

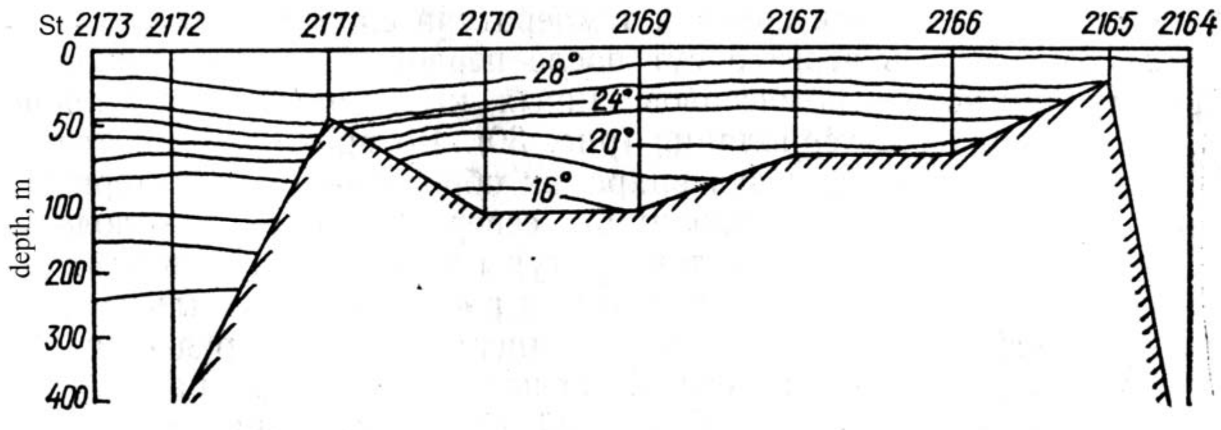


Figure 14. Distribution of water temperature across south part of the Bank, February 1984 (RV “Professor Vojadnickiy”). St – stations (Grese, 1988).

South bank. Upper layer of water (10 m depth) is characterized by homogenous distribution of oxygen and inorganic phosphate. Concentration of oxygen decreases and concentration of phosphate increases with increase of depth. Maximum gradient of change may be observed in thermocline (10 – 50 m depth) (Tab 3).

Table 3. Concentration of phosphate and oxygen in the Bank, February 1984 (RV “Professor Vojadnickiy”) (Grese, 1988).

Depth, m	$P - PO_2$			O_2		
	average	range of concentration	number of stations	average	range of concentration	number of stations
0	0,15	0,09 – 0,41	47	4,65	4,48 – 4,81	46
10	0,18	0,07 – 0,60	44	4,55	3,72 – 4,88	44
25	0,43	0,12 – 1,05	42	4,24	2,56 – 5,02	42
50	1,04	0,16 – 1,43	40	2,77	1,88 – 4,34	40
75	1,37	0,72 – 1,64	36	2,15	1,70 – 3,50	36
100	1,44	1,19 – 1,61	33	2,10	1,47 – 2,69	36
150	1,49	1,15 – 1,79	33	2,39	1,70 – 3,16	33

North bank. Isolines of phosphate and oxygen rise near the Northbank. It can be evidence of rising subsurface layer of water with low concentration of oxygen and fortified of phosphate (Fig 15).

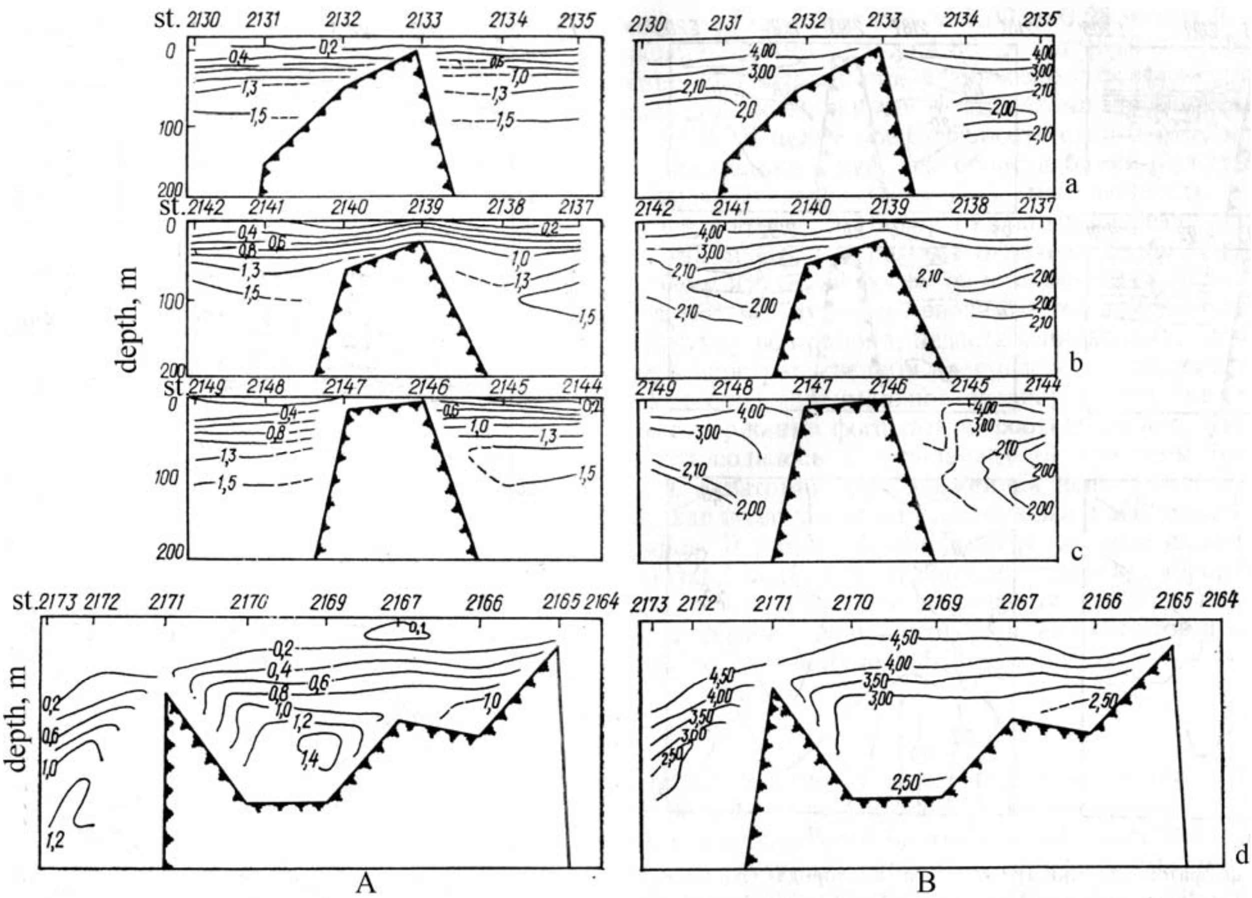


Figure 15. Distribution of phosphate (A) and oxygen (B) on the North (a – c) and South (d) bank. February 1984 (RV “Professor Vojadnickiy”) (Grese, 1988).

Plankton

Plankton biomass on the bank is rather low (about 50 mg/m^3). It's below average measure in the West Indian Ocean that can be evidence of oligotrophic conditions of the Bank (Bogorov & Vinogradov, 1961; Travin, 1968). Neritic plankton consists of Calanoida, euphausiids (Euphausiacea), Doliolida, Salpae, arrow worm (Sagitta). The most part contain pelagic larvae of benthic invertebrate (Polychaeta, Echinodermata) and coastal fishes (Kanaev et. all, 1975).

Bioluminescence measures differ in upper layer (0 – 50 m depth) and subsurface layer (50 – 100 m depth). It's twice higher then average in the upper layer and twice lower then average in the subsurface layer. Maximum of bioluminescence observes above deep chute between north and south regions of the Bank (Grese, 1988).

Concentration ATP of microplankton increase on the 25 m depth (data of the North region of the Bank). Maximum of concentration ATP records in the rises of water in the south-west slope of North region of the Bank and in the north-east slope of the South region of the Bank (Grese, 1988).

Distribution of bacterium in the water following: decrease on the top and increase on the slopes of North region. High concentration records on the topes and in the lagoon of South bank (Grese, 1988).

Distribution of chlorophyll "a" in the North bank is heterogeneous with maximum concentration on 25 m depth and regular distribution in other layers. High concentration of chlorophyll "a" can be found in the East slope and between two topes of South region of the Bank (Fig 16, 17).

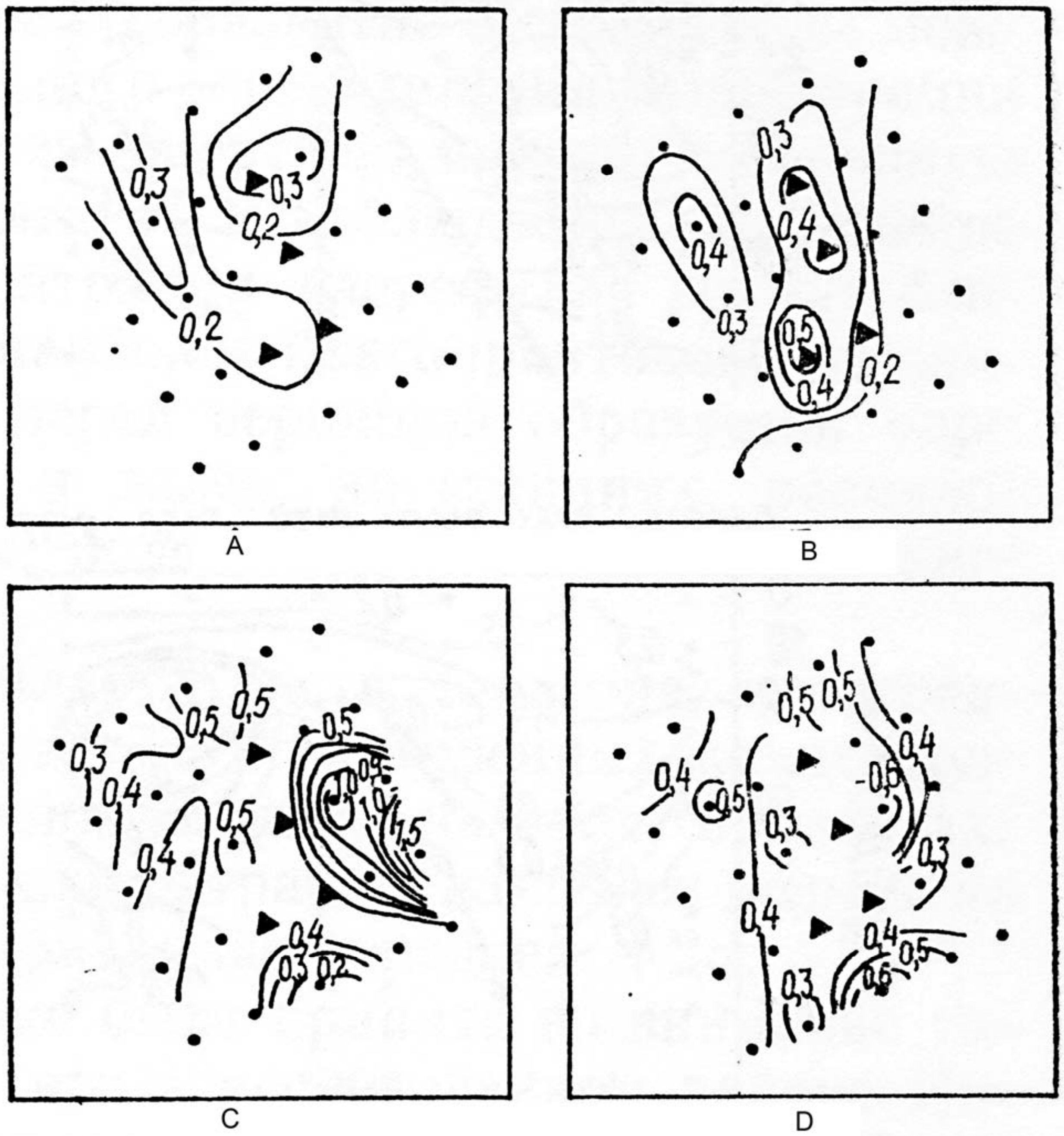


Figure 16. Distribution of chlorophyll “a” (mg/m^3) on the Saya de Malha Bank. February 1984 (RV “Professor Vojadnickiy”) (Grese, 1988).

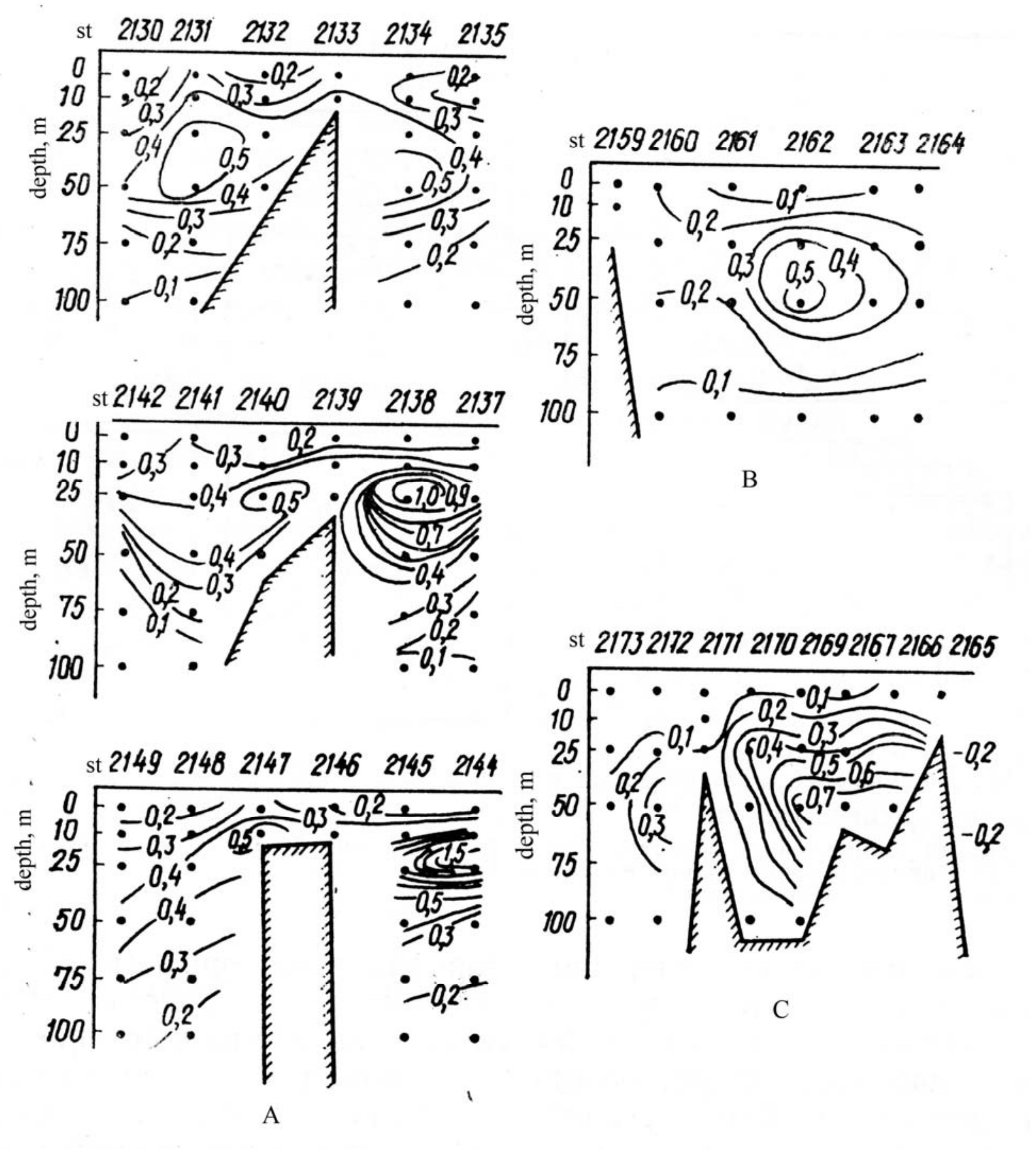


Figure 17. Distribution of chlorophyll “a” (mg/m^3) on the shallow tops of the Bank. A – on the North region of the Bank. B – along north-east slope. C – along South region of the Bank/ February 1984 (RV “Professor Vojadnickiy”) (Grese, 1988).

Phytoplankton on the Bank constitutes a real oceanic complex with small algae-Peridiniates and kokolitoforid. Quantity in February of 1984 was higher then on other tops of Mascarene Plateau (16,6 mln.cl/m^3). Maximum registered on 25 – 50 m that twice more then in the upper layer. The most concentration observed on 25 m and 50 m depth along east and north-east slopes (zone of increased production) and above the top on 10 m depth (more then average on 100 – 480 %).

Zooplankton on the Bank separate into two gropes. The first is a neritic zooplankton which contains bivalvia larvae, decapods, cladocera *Pleopis tergectina*, ostracods, epipelagic copepods g. *Paracalanus*, larvae of lancelet (Amphioxus, Branchiostoma). The second grope is open ocean zooplankton as *Eucalanus*, *Rhincalanus*, *Mecynocera clause* and absent at all: *Aetideus acutus*, *Heterirhabdus papilloger* (Tab 4).

Table 4. Zooplankton on the Bank. Upper layer (0 – 50 m depth). February 1984 (RV "Professor Vojadnickiy") (Grese, 1988).

Species	Central		Periphery	
	ind/m^3	%	ind/m^3	%
Eucalanus subtenius	9	0,27	137	3,95
sp., sp	0,7	0,02	29	0,84
Rhincalanus rostifrons	1,2	0,04	12	0,37
Paracalanus aculeatus	307	9,25	81	2,34
Clausocalanus furcatus	3	0,09	19	0,55
Aetideus acutus	-	-	0,3	0,01
Heterorhabdus papilliger	-	-	1.3	0,04
Hemicalanus longicornis	1	0,03	-	-
Acartia negligens	21	0,63	166	4,8
Nauplii	338	10,2	220	6,65
Pileatus targestina	4	0,12	0,5	0,01
Ostracoda	175	5,27	5	0,15
Larvae Bivalvia	68	2,05	5	0,15
Decapoda	4,5	0,14	0,8	0,02
Amphioxus	0,2	0,01	-	-
Radiolaria	-	-	29	0,84

Ichthyoplancton. Average quantity of fish larvae on the North bank is 10 ind/100 m^3, biomass 22 mg/ 100 m^3. On the South is 28 ind/100 m^3. Maximum – 40 ind/100 m^3.

Larvae of ocean species predominate on east slope (86,6%). In the main it's a *Vinciguerria nimbaria* and *Diogenichthys panurgus*. Larvae of neritic fishes predominate on west slope of the Bank. It's larvae of following families: Serranidae, Carangidae, Lutjanidae, Sparidae, Labridae, Callionymidae, Gobiidae, Scorpaenidae, Triglidae. Quota of neritic species increases in the South region of the Bank (63%) which belong to Carangidae, Lutjanidae, Sparidae, Labridae, Gobiidae, Triglidae, Bothidae. Larvae of family Myctophidae is constituted only 5% from all quantity (Grese, 1988).

Benthos

Mollusca

The total number of Mollusca described from the Saya de Malha is 142, Gastropods is 89: 67 species were found on the depth 12-15 m, 15 species from 70 m, 2 from 200 m. Seven species of Bivalvia were found from 12-15 meters.

Eleven new species of mollusks have been described from the Bank (four gastropods, three bivalves, four cephalopods). All new species are endemic to the Bank or Mascarene Plateau (Sirenkj, Scarlato, 1993 (a), (b)).

Tridacna rosewateri described from the Saya de Malha Bank is endemic of the bank. *T.maxima* seems to have inhabited, in the end of the Cenozoic, all shallow waters in the western part of the Indian Ocean, including Saya de Malha where reef and islands rose above water surface until transgression in the second part of the Pliocene. There processes produced to morphological changes in *T.maxima* inhabiting in bank and stable geographical isolation of this population. These factors lead to form a new species (Sirenco, Scarlato, 1991).

Cephalopoda

Fauna of Cephalopoda consist of two groups which contain approximately equal number of species. The first is fauna of underwater mountains on 100 – 400 m depth with following species: bottom octopus *Scaeurgus* that habitat tops, squids *Abralia* and *Enoploteuthis* inhabited slopes, bottom squids *Moroteuthis*, *Ancistrocheirus*, *Histiotheuthis*, *Todaropsis*, *Nototodarus, Ornithoteuthis*, near-bottom *Heteroteuthis* and *Alloposus*, near-bottom octopuses *Opisthoteuthis*, *Grimpoteuthis*, *Benthoctopus*. Distribution by the depth: *Scaeurgus* 175 – 250 m, *Todaropsis*, *Nototodarus* 170 – 400 m, *Ancistrocheiru, Moroteuthis*, *Histiotheuthis*, *Ornithoteuthis* 518 – 1720 m, *Ornithoteuthis*, *Grimpoteuthis*, *Benthoctopus, Alloposus* 960 – 1650 m. Remaining species inhabit up to 200 m depth.

The second group is a shallow water species which connect with reef. These are following genes: *Sepia, Sepiola, Sepioteuthis, Loligo* and *Octopus.*

Thirty two species of Cephalopoda were collected in the Bank (Fig 18).

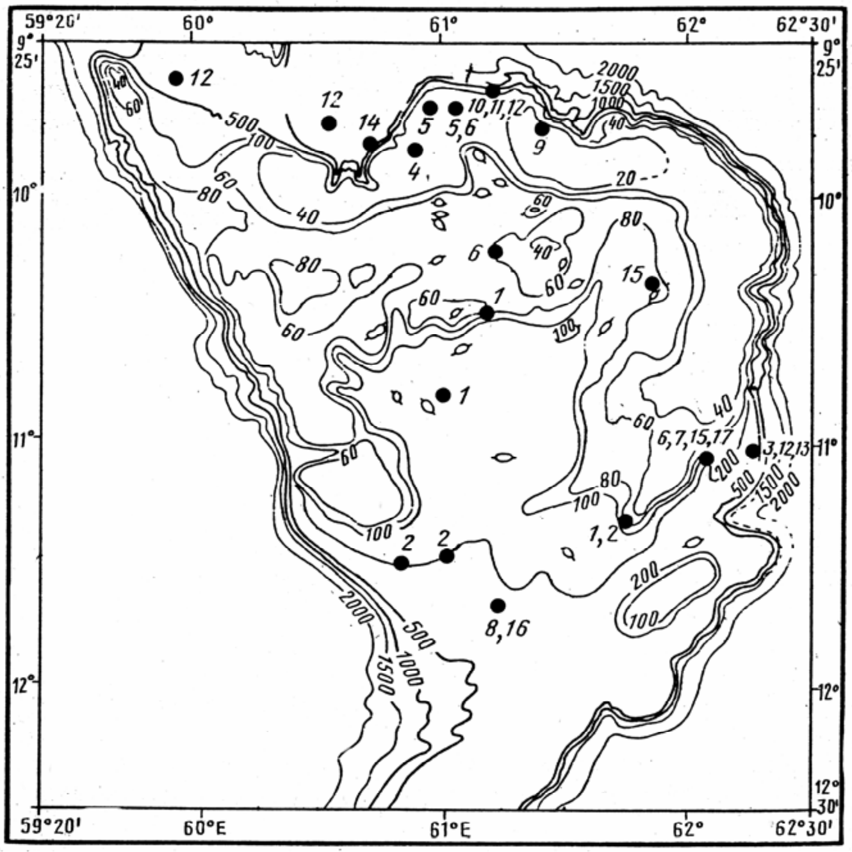


Figure 18. Distribution of Cephalopoda in the South region of Saya de Malha Bank. **Cuttlefishes** (Sepiidae, Sepiolidae): 1. *Sepia saya;* 2. *S. mascarensis*; 3. *Sepia* sp.; 4. *S. officinalis*; 5. *S. platyconchalis*; 6. *S. papillata*; 7. *Sepiola trirostrata*; 8. *Heteroteuthis dagamensis*. **Squids:** 9. *Sepioteuthis lessoniana*; 10. *Loligo chinensis*; 11. *Enoploteuthis reticulate*; 12. *Abralia steindachneri*; 13. *Nototodarus hawaiinensis*. **Octopuses**: 14. *Grinpoteuthis cf. meangensis*; 15. *Octopus aegina*; 16. *O. defilippi*; 17. *O. robsoni*.

Mixing of these two faunal groups is a unique feature of the Saya de Malha Bank unusual for other raises. The most species inhabit the Bank has indopacific origin. Wide distribution has 18 – 19 species. Non indopacific distribution has 10 species (3 genus): *Sepia*, *Heteroteuthis* and *Todaropsis*. Cuttlefishes (8 species) have aspecial distribution: 4 – endemics of the Bank, 2 was note in the Bank only and 2 species was record in the Saya de Malha and Nazareth Banks only.

Wide distributed species in Indian ocean of Cephalopoda as *Sepia pharaonis, S. prashadi, S. stellifers, S. acuminate, S. sewelli, S. socotriensis, S. mirabilis* weren't note the Bank (Nesis, 1993).

Corals

Saya de Malha Bank includes a handful of coral specimens from 13 genera (Rosen, 1971). On the north Bank however an entirely different ecosystem was found, dominated by large stands of a single species of branching *Acropora* corals (Hagan & Robinson, 2001), Madrepora corals, most frequently of genus *Acropora*, *Pocillipora*, *Montripora*. The bottom covering by *Heliospora* sp. (Sirenko, 1993 (b)).

Ichtiology

Nine families of fishes were recorded on the Saya de Malha Bank.

Basis of talasosublittoral fauna consists of jackscads fished (**Carangidae**). Eight species were record in the Bank with dominant *Trachurus indicus* Nekrassov, 1966. *T. Indicus* inhabits 40 – 290 m depth in winter and 10 – 80 m depth in summer (Rasumovskaja, 1989). Average size of specimens eight years old varies from 10 cm to 35 cm. *T. Indicus* come to puberty in two years old. Spawning begins in May and finishes in October (Nekrasov, 1987). According to other investigations maximum depth of habit *T. indicus* is 100 m, maximum size – 28 cm with 0, 18 kg of mass (Shubnikov, 1980). Arabian cigar jackscad (*Decapterus kiliche* Val., 1839) habitats shelf zone from 10 to 280 m depth and constitute 34% of haul. In addition were found three species of jackscads: *Decapterus macarellus* Cuvier, 1833 (Rasumovskaja, 1989), *D. rasselli* (Scherbachev, 1984), *Carangoides equula* (Karpitenko, Bidenko, 1980).

Fifteen species (3 genus) of flintperch (**Trachichthyidae**) distributed in the Indian Ocean. Eight species notes on the Bank: *Hoplostethus atlanticus*, *H. latus*, *H. shubnicovi*, *H.tenebricus*, *H.rubelopterus*, *H.mediterraneus*, *Paratrachichthys sajademalensis*, *Gephyroberyx darwini* (Ivanin, 1989; Kotlar, 1980).

Ten species of **Lethrinidae** collected from the bank. Usually they inhabitat 50 m depth (Chomenko et. all, 1989). One species from family **Stromateoidei** – *Cubiceps squamiceps* also noted. Average size of *C. squamiceps* is 6 – 15 cm, mass – 6,4 – 38,8 g. Basis of food composed euphasiides, salps and copepods (Piotrovsky et. all, 1989).

Considerable quota of haul on 70 – 100 m depth constitutes *Saurida undosquamis* **(Synodontidae)** and *Nemipterus peronii* **(Nemipteridae)**. *S. undosquamis* has 33 – 45 cm lenght and 0,33 kg of mass (Scherbachev, 1984; Karpitenko, Bidenko, 1980) (from Scherbachev et. all, 1989).

High density of *Polysteganus coeruleopunctatus* (**Sparidae**) was record in September – October of 1977. *P. coeruleopunctatus* inhabitat 105 – 250 m depth and has 9,8 – 27 cm length (Busachin, 1980; Karpitenko, Bidenko, 1980).

Chlorophthalmus sp. (**Chlorophthalmidae**) and *Malacocephalus laevis* (**Macrouridae)** distributed on 500 – 560 m depth (Scherbachev, 1984). *Chimera monstrosa* (**Chimaeridae)** was foun on 800 – 1300 m (Scherbachev et. all, 1982).

Helminthes of fishes

The data on investigation of 8 species of commercial fishes from Saya de Malha bank (the Indian Ocean) are presented. 43 helminth species were identified: 10 Monogenea species, 18 trematode, 7 cestode and 8 nematode species. The mature worms are observed to be related to a certain host, whereas the nematode and cestode larvae have wide specificity. High infestation degree by Anisakis larvae is found in fishes, especially in Carangidae. At the bank area fishes are found to be free from Acanthocephala while those Acanthocephala are found in fishes from other areas of the Indian Ocean which may be attributed to the specific diet at the Saya de Malha bank. On the whole the helminth fauna of fishes examined at the Saya de Malha bank does not demonstrate the endemic pattern. The most specific helminth species were found in some fish specie (Parukhin, 1988)

Plants

A significant of the bottom itself is density colonized by *Thalassodendron ciliatum* (Sirenko, 1993).

Conclusion

Saya de Malha bank is the largest seamount of the Mascarenas Ridge in the south-western Indian Ocean and the largest shallow water habitat in the waters beyond the national jurisdiction. The history of its study began with the "Percy Sladen Trust Expedition" organized and led by Stanley Gardiner in 1905. Beginning from the 1960s Saya de Malha became the area regularly visited by the Soviet expeditions which studied the bank and the surrounded waters first of all as a potential fishing ground but also brought extensive although scattered material on geology, oceanography and biology of the bank area. This period of active exploration ceased in 1991 with the collapse of USSR. We were able to detect 28 Soviet cruises of 20 vessels having conducted research in the Saya de Malha area for which references in the scientific literature (mostly in Russian) were found. Recently the area of the bank was visited by British Royal Geographical Society's Shoals of Carpicorm Expedition in 1997 and 2000, and the Lighthouse Foundation expedition in 2002.

The present report reviews the principal results of the up to date studies of Saya de Malha. From the marine geology standpoint the bank is a submerged atoll having the minimum depth 7-10 m and consistsing of two areas separated by greater depth. From the east the slopes of Saya de Malha confronts the South Passate Current. Complex interation with the bottom topography lead to upwelling and increasing oceanic productivity in the otherwise oligotrophic area. .

Distribution of bottom landscapesof the bank is determined by structural characteristics of the bank: the fringing reef, the lagoon and the slopes. Seagrass (with the dominance of four species of *Thalassodendron*) and macroalgae beds extend over 80-90% of the fringing reef area. Stony corals projective coverage is estimated to be in the range of 10-20% of the reef area. The bottom of the lagoon is a relatively flat accumulative bed. Information on species commonly occurring in particular biotopes is limited: in the lagoon deposit feeders dominate, but generally only 1-2 taxa dominating in particular biotopes are listed in the literature.

Species diversity assessments are compiled for particular taxonomic groups. The most comprehensive data sets are available for fishes, mollusks (especially cephalopods) and decapod crustaceans. In the Saya de Malha area 43 fish species are known, 7 species (from 5 families) dominate. This number is low compared to Madagascar (160 species, 66 families), Seychelles (124 species, 16 families), and Mozambique (109 species, 54 families). However, most of specimens from Saya de Malha were obtained from areas suitable for trawling while the reef fish fauna remained practically unstudied.

On the Saya de Malha Bank 142 species occur (102 from 36 families of the Gastropoda, 32 species (from 10 families of the Cephalopoda, and 8 species from 3 families of Bivalvia). For the western Indian Ocean in general 2500 species (75 families) of the Gastropoda, 667 species (49 families) of the Bivalvia, and 39 species (6 families) of the Polyplacophora are reported.

Other groups of invertebrates are poorly studied: only 4 genera of Anthozoa, 2 speices of the Annelida, and 3 species of Echinodermata are reported for Saya de Malha. At the same time only for Seychelles 151 echinoderm species are known while 419 live in the entire western Indian Ocean. Many taxonomic groups do not have any records for Saya de Malha (Poriphera, Nematoda, Nemertini, Tunicata, Chemichordata). Unidentified zoological collections from the area which include various groups of invertebrates are deposited in the Zoological Institute of the Russian Academy of Sciences in St. Petersburg, the collection of the P.P. Shirshov Institute of Oceanology of the Russian Academy of Sciences and the Zoological Museum of the Moscow University. In particular, the ZISP collection contains abundant material of small gastropods collected by B.I. Sirenko which identification may at least double the number of known species from this taxon for Saya de Malha. However, species diversity of Saya de Malha is clearly underestimated. In particular, no special methods of collecting taxa inhabiting sea grass biotopes were applied.

Several species described from Saya de Malha as new for science have not been recorded elsewhere and may be considered as conventional endemics of the area. These include 2 species of cephalopods (+ another 2 for southern part of the Mascarene Ridge), 1 species of giant *Tridacna* clam (Bivalvia) and 5 species of fish. Some taxa may be endemic for the entire

Mascarene Ridge area (as shown for 2 species of swimming crabs). For the studied groups this yields a figure of 5% endemism at the species level. Taking into account the limited knowledge of the Saya de Malha and the neighboring insular areas / underwater rises biota, the level of endemism may be higher, especially for the groups which do not have long-lived planktonic larva (i.e. some fish and crustaceans with parental care of offspring).

Event at the current, by far not sufficient level of knowledge several characteristics of natural history of Saya de Malha may be considered as unique, first of all the most extensive sea grass biotopes in the middle of the open ocean. Increased productivity of the area and the occurrence of several commercial fish species and invertebrates make Saya de Malha an attractive fishing ground. Russian fishery investigations revealed the areas suitable and safe for trawling. Bottom trawling in the limited area where no regulation exist may irreversibly destroy seagrass and coral biotopes and cause depletion of particular species. Although Russia now is revitalizing its distant water fishery it is unlikely that either Russian Federation or Ukraine as another country which has inherited Soviet oceanic fishery tradition come back to the western Indian Ocean as fishing nations. However increasing development of the international "flag of convenience" fishery poses a serious potential (or even actual as we know very little about the present situation) threat to Saya de Malha.

Further work on the assessment and development of a management plan for Saya de Malha as a potential High Seas marine protected area should focus on the following priorities:

- Further inventory of available collections and material in the archives of research institutions
- Organisation of an international expedition to assess the current status of coral and seagrass biotopes to compare to historical data
- Development of remote sensing approach to the assessment of major biotopes and monitoring of visiting the Saya de Malha Bank by vessels (Radarsat images)
- Detailed assessment of potential threats to Saya de Malha biodiversity from fishery and other factors (i.e. climate change)
- Proposing framework for management partnership for Saya de Malha.

Acknowledgments

This project was support by Lighthouse Foundation. Author much indebted to Dr. Spiridonov for a help with translation and ideas, Dr. Tzetlin for an advice and Dr. Sirenko for a help with data accessing.

Faunal list

	Group	Species	Reference
Vertebrate	Pisces		
	Trachichthyidae	*Hoplostethus atlanticus*	Ivanin, 1989
		H. latus	
		H. shubnicovi	
		H.tenebricus	
		H.rubelopterus	
		H.mediterraneus	Kotlar, 1980; Ivanin, 1989
		Paratrachichthys sajademalensis	Kotlar, 1980; Ivanin, 1989
		Gephyroberyx darwini	Kotlar, 1980; Ivanin, 1989
	Carangidae	*Trachurus indicus* Nekrassov	Nekrasov, 1987; Rasumovskaja, 1989
		Decapterus kiliche Val.,1839	Rasumovskaja, 1989; Scherbachev, 1984
		Decapterus macarellus Cuvier, 1833	
		Decapterus rasselli (Rup)	Scherbachev, 1984
		Carangoides equula (белоперая кавала)	Karpitenko, Bidenko, 1980
	Chlorophthalmidae	*Chlorophthalmus* sp.	Scherbachev, 1984
	Stromateoidei	*Cubiceps squamiceps*	Piotrovsky et. all, 1989
	Synodontidae	*Saurida undosquamis*	Busachin, 1980
	Nemipteridae	*Nemipterus peronii*	Busachin, 1980
	Sparidae	*Polysteganus coeruleopunctatus*	Busachin, 1980
	Pleuronectiformes	*Engyprosopon hensleyi (*)* *Arnoglossus sayaensis(*)* *Parabothus malhensis*	Amaoka,Hisashi Imamura, 1990 Arai, Amaoka. 1996
		Bothidae *Chascanopsetta elski*	Foroshchuk, 1991
		Poecilopsetta normani(*)	Foroshchuk, Fedorov, 1992
	Cynoglossidae	*Trulla versicolor* (Alcock, 1890)	Smith, 1967
		T. sealarki	Regan, 1908
	Chimaeridae	*Chimera monstrosa*	Scherbachev et. all, 1982
	Paraulopidae	*Paraulopus oblongus*	Tomoyasu Sato,

			Tetsuji Nakabo, 2003
		Aprion virescens	Grandcourt, 1995
	Sebastes	*Pristipomoides filamentosus* *Epinephelus chlorostigma* *Epinephelus morruha* *Variola louti* *Lethrinus elongates*	Grandcourt, 1995
		Lethrinus enigmaticus	Lebeau, Cueff, 1975 Mees, 1996
		Lethrinus mahsena	Bertrand, 1986
	Carangidae	*Carangoides gymnosthesus* *Carangoides sp.* *Scomberoides sp.*	Grandcourt, 1995
	Scombridae	*Thunnus sp.* *Gymnosarda sp.*	Grandcourt, 1995
	Coryphaenidae	*Coryphaena hippurus* (Linnaeus, 1758)	Grandcourt, 1995
	Scorpaenidae	*Scorpaenopsis venosa*	Motomura, 2004
	Mullidae	*Parupeneus procerigena (*)*	Kim, Amaoka,2001
	Triglidae	*Petrygotrigla (Otohime) amaokai sp. nov. (*)*	Richards et.all, 2003
	Total number of Pisces: 43		
Invertebrate	**Crustacea** **Decapoda**	*Peurulus carinatus*	George R. W., Main A. R., 1967 Karpitenko, Bidenko, 1980
	Caridae	*Thalassocaris crinita* (Dana, 1852)	Xinzheng Li, Tomoyuki Komai, 2003
	Brachiura	*Charybdis* (Charybdis) *hawaiiensis* Edmondson 1954	Neumann, Spiridonov, 1999
		Lupocyclus quinquedentatus Rathbun 1906	Neumann, Spiridonov, 1999
		Portunus petreus Alcock 1899	Neumann, Spiridonov, 1999
		Charybdis (Charybdis) natator natator (Herbst 1789)	Neumann, Spiridonov, 1999
		Charybdis (Goniohellenus) smithii MacLeay 1838	Neumann, Spiridonov, 1999
		Thalamita coeruleipes Jacquinot 1852	Neumann, Spiridonov, 1999
		Thalamita philippinensis Stephenson & Rees 1967 ssp. *occidentalis* Crosnier 1984	Neumann, Spiridonov, 1999

		Thalamitoides quadridens A. Milne-Edwards 1869	Neumann, Spiridonov, 1999
		Cymo andreossyi (Audouin 1826)	Neumann, Spiridonov, 1999
		Cymo quadrilobatus Miers 1884	Neumann, Spiridonov, 1999
		Banareia acies (Rathbun 1911)	Neumann, Spiridonov, 1999
		Liomera rugipes (Heller 1861)	Neumann, Spiridonov, 1999
		Pseudoliomera helleri (A. Milne-Edwards 1865)	Neumann, Spiridonov, 1999
		Pseudoliomera speciosa (Dana 1852)	Neumann, Spiridonov, 1999
		Pilodius flavus Rathbun 1894	Neumann, Spiridonov, 1999
		Tetralia cinctipes Paulson 1875	Neumann, Spiridonov, 1999
		Tetraloides heterodactyla (Heller 1861)	Neumann, Spiridonov, 1999
		Trapezia cymodoce (Herbst 1799	Neumann, Spiridonov, 1999
		Trapezia digitalis Latreille 1825	Neumann, Spiridonov, 1999
		Trapezia ferruginea Latreille 1825	Neumann, Spiridonov, 1999
		Trapezia guttata Rüppell 1830	Neumann, Spiridonov, 1999
		Trapezia rufopunctata (Herbst 1799)	Neumann, Spiridonov, 1999
		Trapezia tigrina Eydoux & Souleyet 1842	Neumann, Spiridonov, 1999
		Domecia hispida Eydoux & Souleyet 1842	Neumann, Spiridonov, 1999
		Carpilius convexus (Forsskal 1775)	Neumann, Spiridonov, 1999
	Calappidae	*Mursia sp. aff. danigoi* Galil, 1993	Spiridonov, Apel, 2007
	Total number of Crustacea: 28		
Mollusca	**Gastropoda** **Prosobranchia** **Haleotidae**	*Haliotis* cf. *varia* L., 1758	Sirenko B.I., 1993 (a)
	Fissurellidae	*Scutus sinensis* (Blainville, 1895)	Sirenko B.I., 1993 (a)
	Trochidae	*Trochus* cf. *histria* Reeve, 1848 *Tr.* cf. *virgatus* Gmelin, 1791 *Tectus pyramis* form. *noduliferus* (Lamark, 1822)	Sirenko B.I., 1993 (a)

		Clancus cf. *pharaonius* (L., 1758) *Callistoma* sp.	
	Stomatellida	*Stomatella* cf. *auricular* *Granata* sp.	Sirenko B.I., 1993 (a)
	Turbinidae	*Turbo argyrostoma* *Turbo* sp. *Astreae* sp.	Sirenko B.I., 1993 (a)
	Phasianellidae	*Phasianella* cf. *variegate* Lamarck, 1822	Sirenko B.I., 1993 (a)
	Neritidae	*Smaragdia rangiana* Reclus, 1842	Sirenko B.I., 1993 (a)
	Cerithiidae	*Cerithium columna* Sowerby, 1834 *C. citrinum* (Sowbery, 1855)	Sirenko B.I., 1993 (a)
	Hypponicidae	*Hipponix conicus* Schumacher, 1817 *Sabia prionocidaricola* Hade, Kanazava, 1991	Sirenko B.I., 1993 (a)
	Xenophoridae	*Xenophora cerea* (Reeve, 1845)	Sirenko B.I., 1993 (a)
	Strombidae	*Strombus pipus* Roding, 1845 *Lambis violacea* Swainson, 1821 *L. crocata* (Link, 1807)	Sirenko B.I., 1993 (a)
	Cypraeidae	*Cypraea lentiginosa* Gray, 1825 *C. talpa* L., 1785 *C. fimbriata* Gmelin, 1791 *C. mappa* L., 1785 *C. isabella* L., 1785 *C. carneola* L., 1758 *C. helvola* L., 1758 *C. staphylaea* L., 1758	Sirenko B.I., 1993 (a)
	Triviidae	*Trivirostra* sp.	Sirenko B.I., 1993 (a)
	Tonnidae	*Eudolium bairdii* (Verrill, Smith, 1881) *E. pyriforma* (Sowerby, 1914) *Tonna cepa* (Roding, 1798) *T. perdix* (L., 1758) *Malea pomum* (L., 1785)	Sirenko B.I., 1993 (a)
	Cassidae	*Casmaria erinaceus* (L., 1785) *Phalium* cf. *kurodai* Abbott, 1968 *Ph.* cf. *microstoma* (Von Martens, 1903) = *Semicassis boudarevi* *Ph.* cf. *canaliculatum* Bruguiere, 1792 *Morum* (*Cancellomorum*) sp. *Cypraecassis rufa* (L., 19785)	Sirenko B.I., 1993 (a)
	Ranellidae	*Cimatyum vespaceum* (Lamarck, 1822) *C. caudatum* Abbot, 1968 *C. rubeculum* (L., 1758) *C.* cf. *aquatile* (Reeve, 1844) *C.* cf. *exite* (Reeve, 1844) *Gyineum* cf. *pussilum* (Broderip, 1832)	Sirenko B.I., 1993 (a)
	Bursidae	*Bursa rana* (L., 1785) *B. cruentata* (Sowerby, 1841) *Pisania* sp.	Sirenko B.I., 1993 (a)

	Columbellidae	*Oiyrene* sp.	Sirenko B.I., 1993 (a)
	Harpidae	*Harpa amouretta* (Roding, 1798)	Sirenko B.I., 1993 (a)
	Marginellidae	*Marginella* cf. *sarda* Kiener, 1834	Sirenko B.I., 1993 (a)
	Turridae	*Turridrupa* sp. *Lophiotoma* cf. *albina* (Lamarck, 1822)	Sirenko B.I., 1993 (a)
	Architectonicidae	*Arhitectonica* sp.	Sirenko B.I., 1993 (a)
	Patellidae	*Patella flexuosa* Guoy at Gaimard, 1834	Sirenko B.I., 1993 (b)
	Turritellidae	*Turritela* sp.	Sirenko B.I., 1993 (b)
	Cerithteiidae	*Cierithium echinatum* Lamarck, 1822 *C. torresi* E.A.Smith, 1884 *C. rubeculum* (L., 1758) *C.* cf. *nesioticom* Pilsbry et Vanatta, 1906	Sirenko B.I., 1993 (b)
	Naticidae	*Polinices simiae* (Deshayes in Deshayes&Edwards, 1835)	Sirenko B.I., 1993 (b)
	Bursidae	*Bursa venustula* (Reeve, 1844) *B. rhodostoma* (Sowerby, 1835)	Sirenko B.I., 1993 (b)
	Muricidae	*Chicoreus microphillum* (Reeve, 1844) *Drupa rubusidaeus* Roding, 1798 *Drupella cornis* Roding, 1798 *Nassa francolina* (Bruguiere, 1789) *Morula spinosa* (H. cf. A.Adams, 1853)	Sirenko B.I., 1993 (b)
	Coralliophilidae	*Coralliophillia neritoides* (Lamarck, 1816) *C. erosa* (Roding, 1798) *C. costularis* (Lamarck, 1816) *Quoyula madreporarum* Sowerby, 1832 *Babelomurex lischkeanus* (Dunker, 1882) *B. deburghiae* (Lightfood, 1786)	Sirenko B.I., 1993 (b)
	Buccinidae	*Cantharus* sp. 1 *Cantharus* sp. 2 *Phos* cf. *roseatus* (Hinds, 1844) *Colubraria muricata* (Lightfood, 1786) *Pisania* sp.	Sirenko B.I., 1993 (b)
	Fasciolariidae	*Latirus* cf. *polygonus* (Gmelin, 1791) *Latirus* sp. *Dolicholatirus* sp. *Peristernia forskalii* Tapparone Canefri, 1879 *Fusinus* cf. *colus* (L., 1758) *Fusinus* sp.	Sirenko B.I., 1993 (b)
	Nassariidae	*Nassarius gaudiosus* (Hinds, 1844) *N. conoidalis* (Deshayes in Belonger, 1832)	Sirenko B.I., 1993 (b)
	Mitridae	*Subcancilla* cf. *annulata* (Reeve, 1844)	Sirenko B.I., 1993 (b)
	Costellariidae	*Vexillum* sp.	Sirenko B.I., 1993

			(b)
	Conidae	*Conus teruistriatus* Sowerby, 1875 *C. tulipa* L., 1751 *C. bullatus* L., 1758 *C. namocanus* Hwass, 1792 *C.* cf. *acutangulus* *C.* cf. *aulicus* L., 1758 *Conus* sp.	Sirenko B.I., 1993 (b)
	Turridae	*Xenoturris cingulifera* Lamarc, 1822 *Comitas* sp. *Gemmula* sp.	Sirenko B.I., 1993 (b)
	Bivalvia **Pectinidae**	 *Excellichlamus* cf. *spectabilis* (Reeve, 1853) *Chlamys* sp. 1 *Chlamys* sp. 2 *Chlamys* sp. 3	Sirenko B.I., 1993 (b)
	Chamdae	*Chama lazarus* L., 1758 *Chama pacifica* Broderip, 1835	Sirenko B.I., 1993 (b)
	Tridacnidae	*Tridacna rosewateri* Sirenko&Scarlato, 1991 *(*)*	Sirenko B.I., 1993 (b)
		Anomia ephippium	Fedorov et.all, 1980
	Cephalopoda **Sepiidae**	 *Sepia (Doratosepia) saya* Khromov, Nikitina et Neslin, 1991*(*)* *Sepia (D.) mascarensis* Nikitina et Khromov, 1991 *Sepia (D.)* sp. *(*)* *Sepia(D.) trigonina* Rochebrune *Sepia (Acanthosepion) zanzibarica* Pfeffer *Sepia (Sepia) officinalis vermiculata* Quoy et Gaimard *Sepia (S.) platyconchalis* Filippova et Khromov *Sepia (S.) papillata* Quoy et Gaimard	Nesis, 1993
	Sepiolidae	*Sepiola trirostrata* Vos *Heteroteuthis (Stephanoteuthis) dagamensis* Robson	Nesis, 1993
	Loliginidae	*Sepioteuthis lessoniana* Lesson *Loligo singhalensis* Ortmann *Loligo chinensis* Gray *Loligo pickfordae* Adam	Nesis, 1993
	Enoploteuthidae	*Enoploteuthis reticulate* Ranculer *Abralia (Stenabralia) steindachneri steindachneri* Weidl *Ancistrocheirus alessandrinii* Verany	Nesis, 1993
	Onychoteuthidae	*Moroteuthis loennbergi* Verany	Nesis, 1993
	Histioteuthidae	*Histioteuthis celetaria pacifica* (Voss) *Histioteuthis miranda miranda* (Berry)	Nesis, 1993

		Histioteuthis meleagraoteuthis (Chun)	
	Ommastrephidae	*Todaropsis eblanae* (Ball) *Nototodarus hawaiiensis* (Berry) *Ornithoteutis volatilis* (Sasaki)	Nesis, 1993
	Opisthoteuthidae	*Opistoteutis extensa* Thiele ? *Grimpoteuthis* cf. *meangensis* (Hoyle)	Nesis, 1993
	Octopodidae	*Octopus aegina* Gray *Octopus defilippi* Verany *Octopus robsoni* Adam *Scaeurgus unicirrhus* (delle Chiaje in d'Orbigny) *Benthoctopus* n. sp. aff. *profundorum* Robson	Nesis, 1993
	Alloposidae	*Alloposus mollis* Verrill	Nesis, 1993
	Total number of Mollusca: 142		
Echinodermata	**Echinoidea**	*Spatangus purpureus*	Fedorov et. all, 1980
		Brisaster sp.	Fedorov et. all, 1980
	Holoturoidae	*Trochostoma* sp.	Fedorov et. all, 1980
Cephalorhynhi	**Priapulidae**	*Priapulus* sp.	Fedorov et. all, 1980
Annelida	**Spionidae**	*Spiophanes soderstromi*	
		Prionospio sp.	
Plankton	**Crustacea** **Calanoida**	 *Eucalanus subtenius sp., sp* *Rhincalanus rostifrons* *Paracalanus aculeatus* *Clausocalanus furcatus* *Aetideus acutus* *Heterorhabdus papilliger* *Hemicalanus longicornis* *Acartia negligens*	Grese, 1988
	Copepoda	*Nauplii* *Pileatus targestina*	Grese, 1988
	Ostracoda		Grese, 1988
	Larvae Bivalvia		Grese, 1988
	Decapoda		Grese, 1988
	Amphioxus		Grese, 1988
	Radiolaria		Grese, 1988
Algae	**Rhodophyta**	*Kappaphycus cottonii*	Fredericq et.all, 1999

		Neogoniolithon *Hydrolithon* *Sporolithon* *Mesophyllum* *Lithophyllum*	Отчет о 2002 г экспедиции
Plants		*Thalassodendron ciliatum* (forsskal) den Hartog	http://zr.molbiol.ru/hydrocharitaceae.html Milchakova et.all, 2005
		Halophila decipiens Ostenfeld	http://zr.molbiol.ru/hydrocharitaceae.html Milchakova et.all, 2005
		Enhalus acoroides (L.) Royle	http://zr.molbiol.ru/hydrocharitaceae.html Milchakova et.all, 2005

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