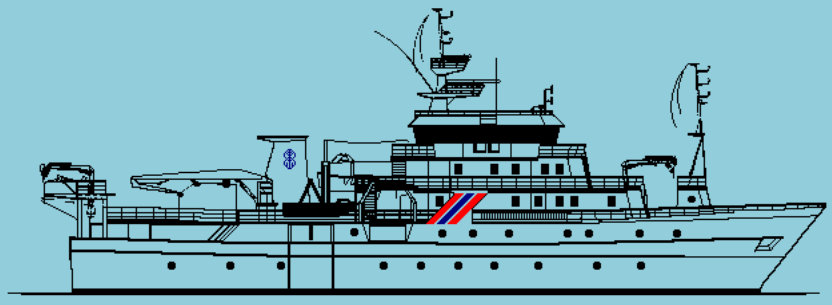


SURVEY OF THE SOUTHERN INDIAN OCEAN
JAKARTA TO PORT LOUIS, IOS leg 1

26 June – 16 July 2015

Bergen, 2015

CRUISE REPORTS 'DR FRIDTJOF NANSEN'

SURVEY OF THE SOUTHERN INDIAN OCEAN
JAKARTA TO PORT LOUIS, IOS leg 1

26 June – 16 July 2015

by

Reidar Toresen
Bernerd M. Fulanda
Francois Dufois
Melody Puckridge
Michelle Fernandes
Ainhoa Bernal Bajo
Espen Bagøien
Riaan Cedras
Pazi Semili
Indah Lutfiyati
Andria Ansri Utama
Nasirin
Patsy Theresine
Aina Le Don Nomenisoa
Kristine Nilsen Torkildson
Alexander Beck

Table of Contents

CHAPTER 1 INTRODUCTION

1.1 Scientific rationale

The International Council for Science's Scientific Committee on Oceanic Research (SCOR) and UNESCO's Intergovernmental Oceanographic Commission (IOC-UNESCO) are coordinating a new phase of international research beginning in late 2015 and continuing through 2020 as part of the second International Indian Ocean Expedition - IIOE-2. The EAF-Nansen Project of FAO has scheduled a demonstration survey across the southern Indian Ocean this year (2015) as an early contribution towards the expedition with likely follow up in the next phase of the EAF-Nansen Project. There will be two legs to the survey; Leg 1 started from Jakarta, Indonesia on the 26th of June, and ended in Port Louis, Mauritius, on the 16th of July. This leg focused on the exploration of the southern Indian Ocean Gyre.

In the first leg, information at an ecological level has been recorded in the southern Indian Ocean gyre and, especially, investigated the role of mesopelagic fish across the gyre. We will also try to verify to what extent the gyre functions as an aggregation location for floating plastics.

The official owner of the data is FAO. The survey will be carried out in international waters only.

1.2. Objective of the survey

The overall aim of the survey is to investigate ecological features in the survey area. Oceanographic data (temperature, density, oxygen and currents based on LADCP) will be monitored along transects, and nutrient salts and chlorophyll will be sampled and measured for to study biological productivity.

The distribution and density of plankton and mesopelagic fish will also be recorded by acoustic methods combined with plankton nets and pelagic trawls at the main scatter layers at day- and nighttime.

An additional goal for the survey is to sample plastic and micro-plastic particles. Diverse previous models have shown that litter and plastics could concentrate in the Southern Indian Ocean gyre. In order to verify/test these modeling results, the sampling of plastics has been performed across the whole transect using a Manta-trawl (details will be provided in the method section).

Drifters were deployed in selected sections to determine broad scale currents and other oceanographic parameters.

1.2 Participation

The participants of the survey were:

Francois DUFOIS, Commonwelth Scientific and Industrial Research Organization, CSIRO, Australia
Melody PUCKRIDGE, University of Queensland, Australia

Indah LUTFIYATI, Marine Survey and Technology – BPPT, Indonesia
NASIRIN, Jakarta Fisheries University (JFU), Indonesia
Andria Ansri UTAMA, Research Center for Fisheries Management and Conservation (RCFMC), Indonesia

Michelle FERNANDES, India

Bernerd FULANDA, Pwani University, Kenya

Pazi SIMILI, University of Dar es Salaam, Tanzania

Patsy THERESINE, Seychelles National Park Authority (SNPA), Seychelles

Aina Le Don NOMENISOA, Institut Halieutique et des Sciences Marines (IH.SM), Madagascar

Riaan B. CEDRAS,., University of the Western Cape, Bellville, South Africa

Ainhoa BERNAL Bajo, Spain

Kristine Nilsen TORKILDSON, University of Bergen UiB, Norway

Reidar TORESEN, IMR, Bergen, Norway
Espen BAGØIEN, IMR, Norway
Alexander BECK, IMR, Bergen, Norway
Tore MØRK, IMR, Bergen, Norway
Ole Sverre FOSSHEIM, IMR, Bergen, Norway

All participants contributed very well

1.3 Narrative

The course tracks with the fishing and hydrographical stations are shown in Figure 1.a-c.

The vessel left Jakarta on the evening of th 26st of June. The vessel steamed to Christmas Island to get part of the scientific equipment on-board, and left the island the same day. The field work started on the 29th of June at international waters. The onset of the transect was southwest off Christmas Island (20 00.00 S, 95 00.00 E), and continued westwards along the 20th degree S to 70 00^{o} E, and then a southwest course was chosen to increase the sailing distance in international waters for the collection of more data. The collection of data carried out by sampling three different types of stations:

Station type 1: CTD, water sampling, phytoplankton net, Multinet, Manta-trawl

Station type 2: CTD, water sampling, Mantatrawl.

Station type 3: Pelagic Trawl station, CTD, Mantatrawl.

In addition, two types of drifters/Argo buoys were deployed, Iridium drifters and Argo buoys (four of each type). The stations were carried out, type 1 and 2 alternating, about 100 NM apart. At the transect along the 20th degree S, the spacing between the stations were 150 NM.

Alltogether 3400 NM were sailed during the survey. For sampling of data , 42 CTD stations, 11 plankton stations and 19 trawl stations were carried out. Details on survey effort is given in Table 1.

Survey tracks and stations are shown in Figure 1 a-d.

Table 1. Survey effort.

	Oseanographic				Biological								
						Zooplankton							
	CTD	Oxygen	Salinity	Nutrients	Phytoplankton	Multinet	WP2	Chlorophyll	Length freq	Stomachs	Pelagic trawls	Manta	NM
Day	19	19	19	19	3	6	1	19			8	16	1700
Night	23	23	23	23	4	5	2	23			11	19	1700
TOTAL	42	42	42	42	7	11	3	42			19	35	3400

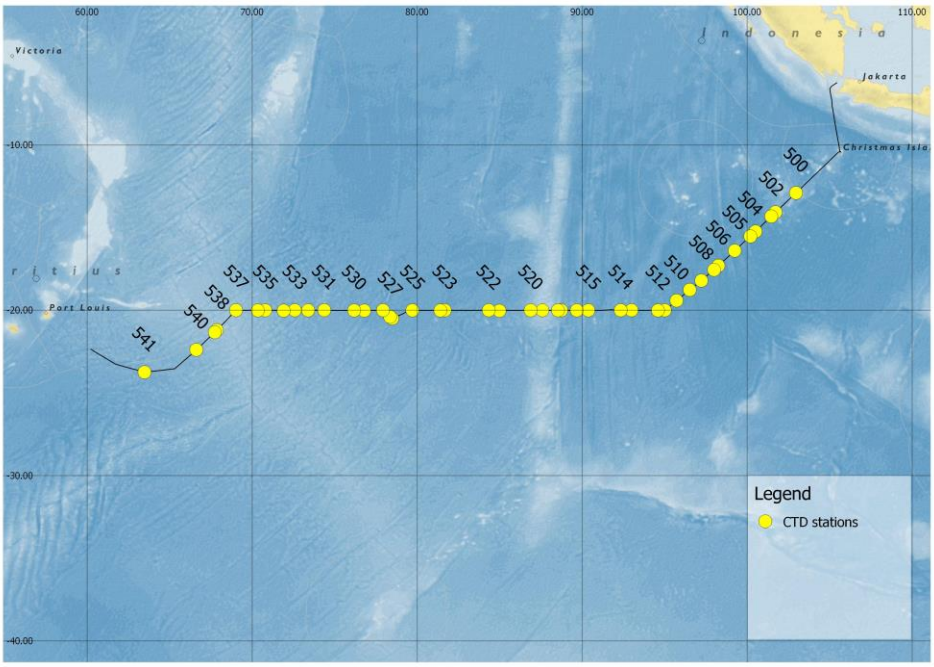


Figure 1 a. CTD stations.

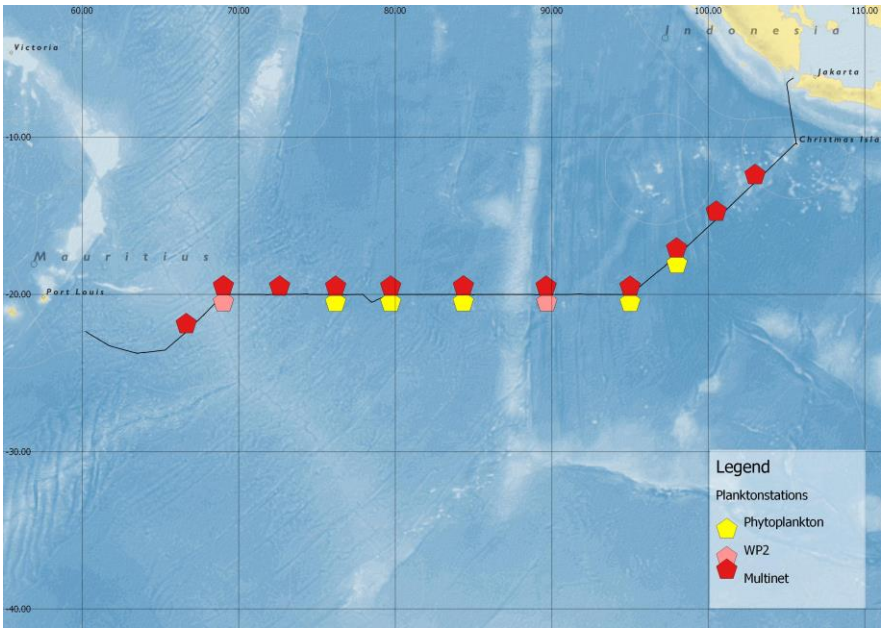


Figure 1 b. Plankton stations.

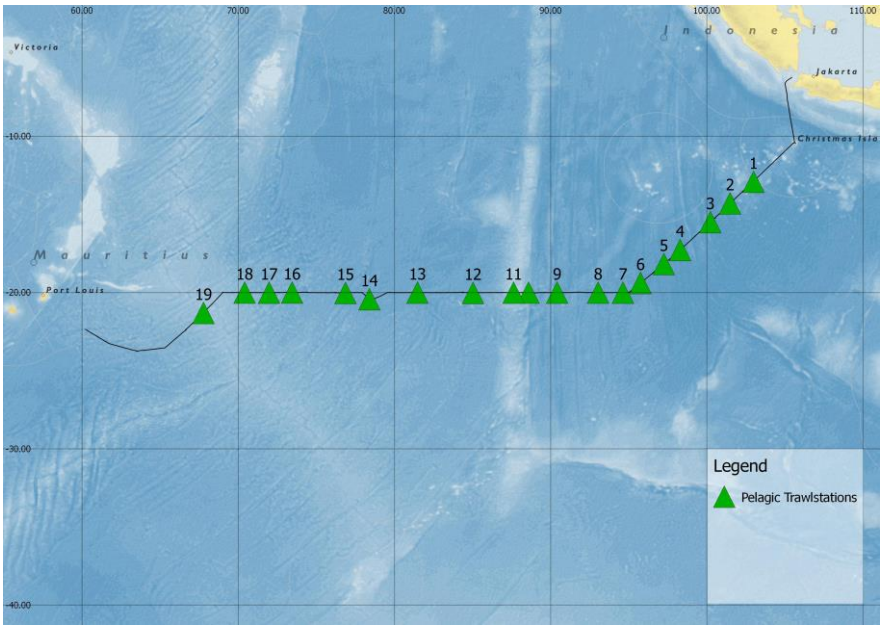


Figure 1 c. Trawl stations.

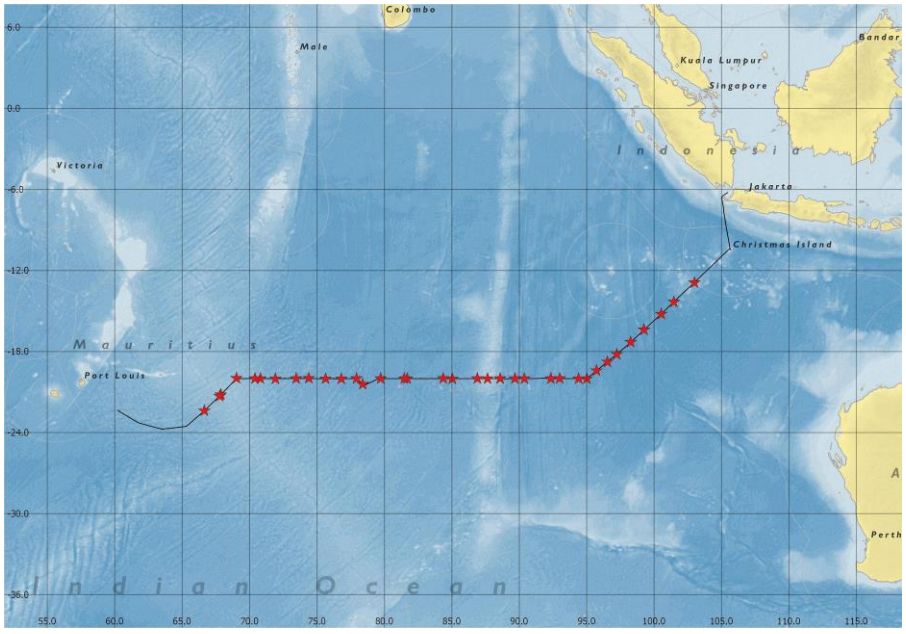


Figure 1 d. Manta or neuston surface trawl

CHAPTER 2 SAMPLING AND ESTIMATION METHODS

2.1 Hydrographical sampling

One of the objectives of the cruise was to gather physical and biogeochemical data in order to gain a better understanding of the properties of the Indian Ocean subtropical gyre. The Indian Ocean in general and the subtropical gyre more particularly have been under-sampled within the last few decades, and numerous questions remain about the variability of the biogeochemical cycle. Concerning primary production, both spatial and temporal variability are somewhat unclear. For instance, although the surface water seasonal cycle has been described through satellite observations, yet the seasonal cycle within the DCM (Deep Chlorophyll Maximum) has never been investigated. The origin and variability of the oxygen minimum below the DCM is another topic which also deserves to be tackled.
During this cruise, one of the main focus has been to look into the spatial variability within the subtropical gyre. Figure 2 represents the position of the mean gyre during the last 12 months. The cruise track started from the eastern edge of the gyre, and surveys across the centre part of the gyre, and is expected to provide us with a synoptic view of the gyre across an east-west transect. We can however note that the gyre cannot be easily identified if looking at the sea surface height at a specific time (Figure 3). This is mostly due to the fact that mesoscale features are distorting the mean gyre. Those mesoscale features ranging from 50 to 150 km of radius, called eddies, not only impact the flow regime within the subtropical gyre but also impact its productivity. Using satellite data, it has been showed previously that the impact of eddies on surface chlorophyll is very peculiar in that region. Yet the processes driving the increase of surface chlorophyll in anticyclonic eddies (spinning anti-clockwise) are not fully understood. The impact of those eddies on the biogeochemical cycle at depths below the surface has not been tackled due to lack of data in that region. One of the key purpose of the cruise is therefore to identify the processes modulating primary production in eddies using various sampling strategies (water sampling, CTD, Bio-Argo floats).

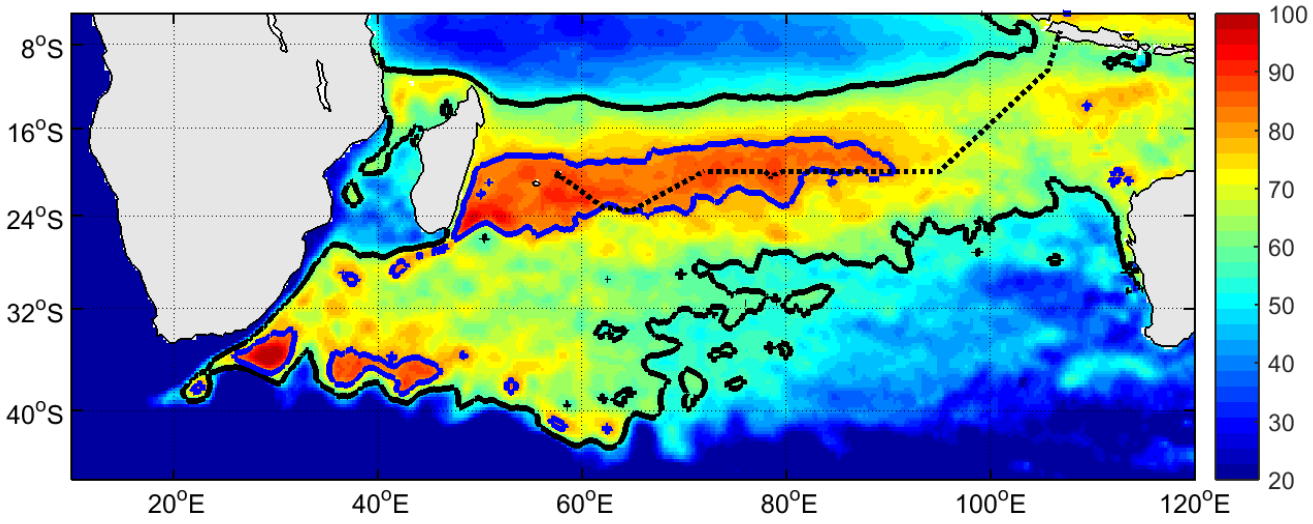


Figure 2. Mean Sea Surface height (cm) within the last 12 months (July 2014-June 2015). The main black and blue contours highlight the outer edge and the centre part respectively, of the South Indian Ocean subtropical gyre. The dotted line represents the cruise track.

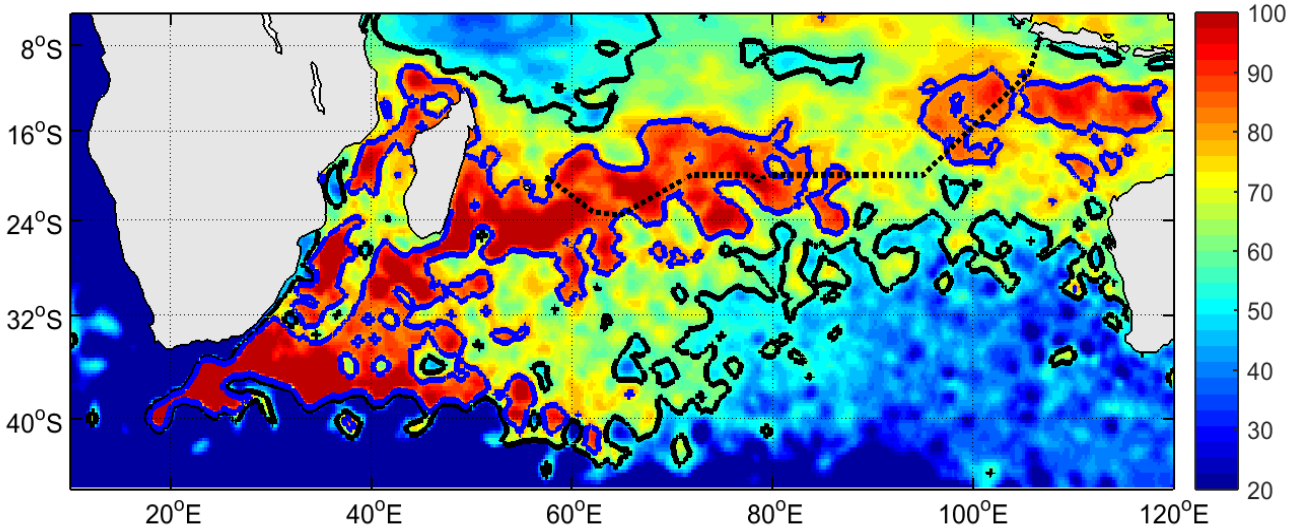


Figure 3. Mean Sea Surface height (cm) during the cruise on the 09/07/2015. The dotted line represents the cruise track.

Sampling

CTD

A Seabird 911+ CTD probe was used to obtain vertical profiles of the temperature, salinity and oxygen. Real time logging was carried out using the PC based Seabird Seasave software. CTD casts were conducted at two transects, 700 and 2000 NM long. The casts were stopped at 2000 meters. Additional CTD stations were added on the trawl stations and Argo float deployment stations.

Niskin water-bottles (5 L) attached to a CTD-mounted rosette were used to collect water at predefined depths. Bottles were fired on the way up at standard depths (2000, 1000, 500, 250, 150, 100, 75, 50, 25, 10 m and surface) after a 20 s stop. The remaining bottle was always fired at the deep chlorophyll maximum depending on the downcast readings of the CTD.
For validation of the salinity (conductivity) measurements of the CTD, the salinity of seawater collected at all 12 depths was analyzed using a Portasal salinometer (mod. 8410A) onboard the vessel. The validation was carried out at 2 stations, one early and the other late in the cruise. The salinometer was generally in good agreement with the CTD sensor readings, in most cases with a difference < 0.01 (PSU), which would be < 0.05% of the CTD reading. See Annex 5 for results of validation.

To validate the oxygen-measurements from the CTD-mounted sensor, concentrations of dissolved oxygen in seawater-samples from the Niskin-bottles were analyzed in the ship laboratory during the cruise using Winkler redox titration method (see Annexe IV for details). The samples were collected from 24 stations, and represented 288 depths within the range of 2.5 to 2000 m. The oxygen-concentrations calculated from the Winkler method were largely in agreement with the values from the oxygen sensor (See Annex IV for details).

We also performed onboard measurements of chlorophyll using Turner's fluorometer (see Annexe IV for details). The samples were collected from 24 stations, and represented 210 depths within the range of 2.5 to 500 m. Those data will be used eventually to calibrate the WETLabs fluorometer attached to the CTD. The calibration process is still underway, and we only present in this report uncalibrated fluorescence data. Those values should be treated as

relative values. Indeed the pre-calibration proposed in Annex IV show that the relative patterns can be trusted, but the absolute values of fluorescence are questionable.

Nutrients analysis (nitrate, phosphate, ammonia, nitrate, silicate) will be performed after the cruise using an auto-analyser.

Thermosalinograph

The SBE 21 Seacat thermosalinograph was running routinely during the survey, obtaining samples of sea surface salinity (in PSU) and relative temperature and fluorescence (5 m depth) every 10 sec. An attached in-line Turner Design SCUFA Fluorometer was continuously measuring Chlorophyll levels [RFU] at 5 m below the sea surface during the entire cruise. The instrument was configured with a bright blue photodiode, a 420 nm Excitation filter and a 680 nm Emission filter. It was calibrated against the secondary orange standard dye. The maximum output was equivalent to 5 Volt = 100%. It had a linear temperature compensation of 2.14% per °C.

We performed a first calibration for the thermosalinograph fluorescence sensor (annex IV). However this calibration process needs some further work. We only present in this report uncalibrated fluorescence data.

Meteorological observations

Meteorological data were logged by the Norwegian Meteorological Institute's (DNMI) meteorological station onboard included air temperature, humidity, air pressure, wind direction and speed, and sea surface temperature (SST). All data were averaged by unit distance sailed (1 nautical mile, NM).

Bio-Argo float deployments

During the cruise a total of 4 non-retrievable Bio-Argo floats were deployed in mesoscale eddies. The floats have a lifespan of between 6 and 12 months. During this time they profile the water column from the surface to 500 m on a daily to weekly basis, and transfer their data through satellite.

The deployment strategy consisted in deploying the floats in the most interesting eddies along the cruise track. To do so, daily updated satellite maps of chlorophyll, sea surface temperature, sea surface height and geostrophic currents were received onboard. Daily analysis of those data allowed us to pick up eddies highlighting different water mass properties from the surrounding water.

A first set of two similar floats including CTD, dissolved oxygen, fluorescence and backscatter sensors were deployed in a pair of eddies (one anticyclonic and one cyclonic eddy). The position of deployment is showed on Figure 4. The last two floats were deployed in the same anticyclonic eddy at the same location (Figure 5). Those floats carry more electronics, with one of them having 4 backscatter channels and radiometers, and the second one having a nitrate sensor on top of the usual Bio-Argo sensors.
The calibration of the floats will be achieved using CTD data and water sampling at the location of deployment and around. To allow for calibration of the backscatter and radiometer sensors, some extra sensors (9 channels Hydroscat backscatter sensors from HydroLabs and HyperOCR radiometers from Satlantics-SeaBird) have been deployed in profiling mode from 0 to 180 m after some selected CTD casts (see details in Annex IV)

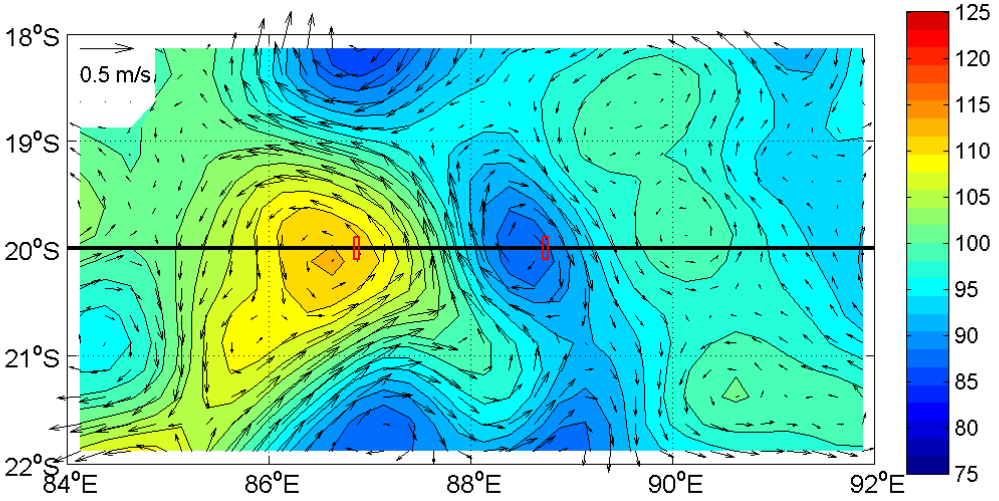


Figure 4. Sea Surface Height (cm) and geostrophic velocities from AVISO on the 09/07/2015. The black line corresponds to the cruise track. The red rectangles correspond to the positions where the Argo floats were deployed.

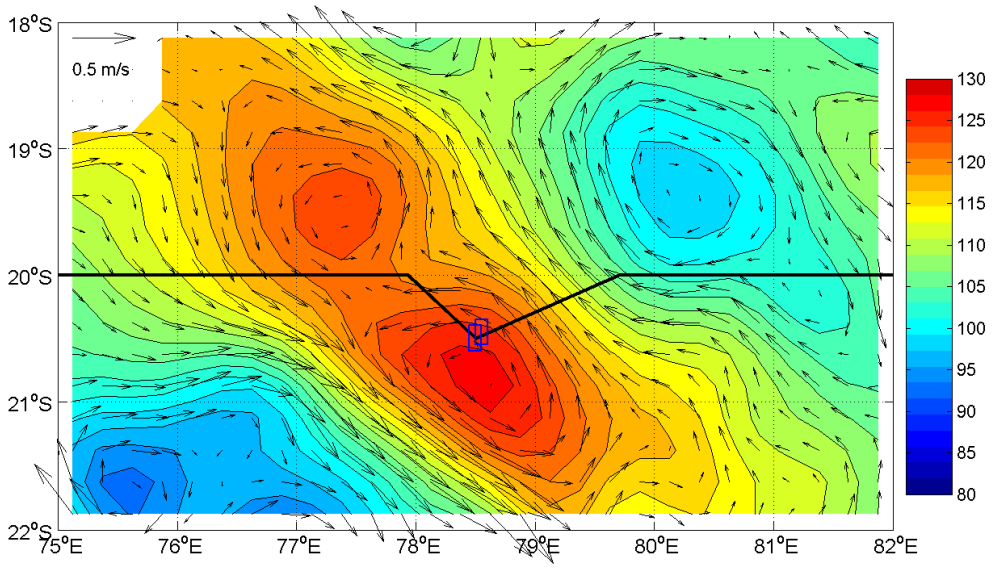


Figure 5. Sea Surface Height (cm) and geostrophic velocities from AVISO on the 09/07/2015. The black line corresponds to the cruise track. The blue rectangles correspond to the positions where the Argo floats were deployed.

Iridium Surface drifters

During the cruise four Surface Velocity Profilers (SVP) were deployed. It was deployed in section 1 of the cruise at a point where we had a steep sea surface height (SSH) gradient. These drifters collect data for 18 months where they track the ocean currents at 15 m depth. The SVP measures sea surface temperature (SST) and barometric pressure (BP). The drifter transmit data through Iridium Satellite System. Figure 6 shows the drifter tracks 2 weeks after deployment.

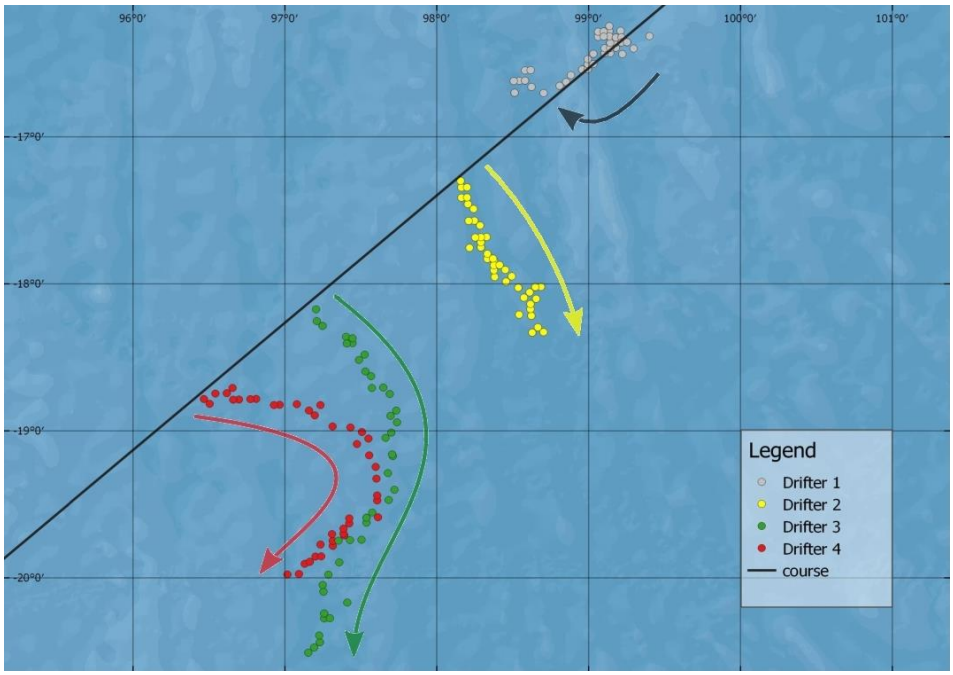


Figure 6. Drifter tracks of the SVP

2.2 Biological sampling

Plankton sampling

Phytoplankton –qualitative method

Qualitative phytoplankton samples were collected with a phytoplankton net (mouth opening diameter 0.35 m, opening area 0.1 m^2, mesh-size 10 µm) at "type 1"stations. The net was hauled vertically at a speed of ~ 0.1 ms^{-1} from 50 m to the surface (Figure 7). These net samples, though not quantitative, are meant to catch both frequent and rare species in the upper part of the water-column. The aim here was to sample phytoplankton from volumes much larger than those obtained from the CTD Niskin bottles (see quantitative method below), which may increase the probability of detecting "rare species". This is highly relevant in oligotrophic waters such as along our cruise track in the Indian Ocean. The net samples were preserved in dark 100 ml glass bottles in a final solution of 0.8 % formalin for subsequent taxonomic analyses at the University of Dar es Salaam. Taking into account the volume of seawater filtered through the net and the volume collected, aliquots corresponding to water column volumes of between 500 and 5000 mL will be examined using appropriate microscope. A total of 7 net samples will be inspected under the microscope in the laboratory on shore.

Phytoplankton – quantitative method

For determination of phytoplankton abundances and later biovolume (wet biomass), at each "type 1"stations, sea water samples were collected at various depths including the surface, above Depth Chlorophyll Maxima (DCM), in DCM, and below DCM with a CTD-rosette sampler fitted with 5 L Niskin bottles. Depth intervals of 10 m, 25 m, 50 m, DCM and 150 m were permanent sampling depths for phytoplankton during the entire cruise. The DCM varied from 75 to 140 m depths throughout the survey.

Sea water samples from Niskin bottles collected at each depth were divivded into three subsamples, that were treated separately. The first subsample was obtained by collecting 1 liter of unfiltered sea water from Niskin bottles at 10 m, 25 m, 50 m, 75 m, DCM and 150 m depths and preserving this with 20 mL acid Lugol's solution in 1-liter amber glass bottles and stored in the dark. While onboard, after 72 hours the samples were concentrated to 100 ml by removing the supernatant using hand siphoning method. The samples were kept in 100 ml amber glass bottles and stored in dark, after adding few drops of formalin (4%) for longer storage.

The second subsample was obtained by concentrating 1 – 3 liters of sea water from Niskin bottles to 100 ml using a plankton net (10 -µm-pore-size mesh) by gravity filtration method. This concentrate was then preserved in formalin (0.8% final concentration). Aliquots (5–50 mL) of these subsamples will be settled in sedimentation chambers and examined with an inverted microscope on shore following Utermo¨hl method (1958). Additional sea water samples (3-10 liters) was collected at the surface by using a bucket and filtered through 10 µm net for species identification and abundance dtermination on shore. The samples were preserved in formalin (0.8% final concentration).

The third subsample was obtained by collecting 100 ml of unfiltered sea water from Niskin bottles and preserved with formalin (0.8% final concentration) in amber glass bottles for later analysis on shore.

To determine depth-integrated values of phytoplankton abundance and biomass in photic zone, sea water samples were collected from the interval of 2.5 – 50 m, and mixed. This was done in four "type II" stations (526, 531, 535 and 538). Equal volumes (1- 4 L) of sea water from 2.5 m, 10 m, 25 m and 50 m were dispensed into a 20 L container and gently mixed to obtain a combined sample of the photic layer. The combined sample was concentrated to 100 ml using a phytoplankton net of 10 µm mesh size and preserved in formalin (0.8% final concentration). These samples will be examined in detail on shore under the microscope for species identification as well as cell counting. Phytoplankton species composition and densities will be estimated within 3 months of collection using inverted and compound microscope.

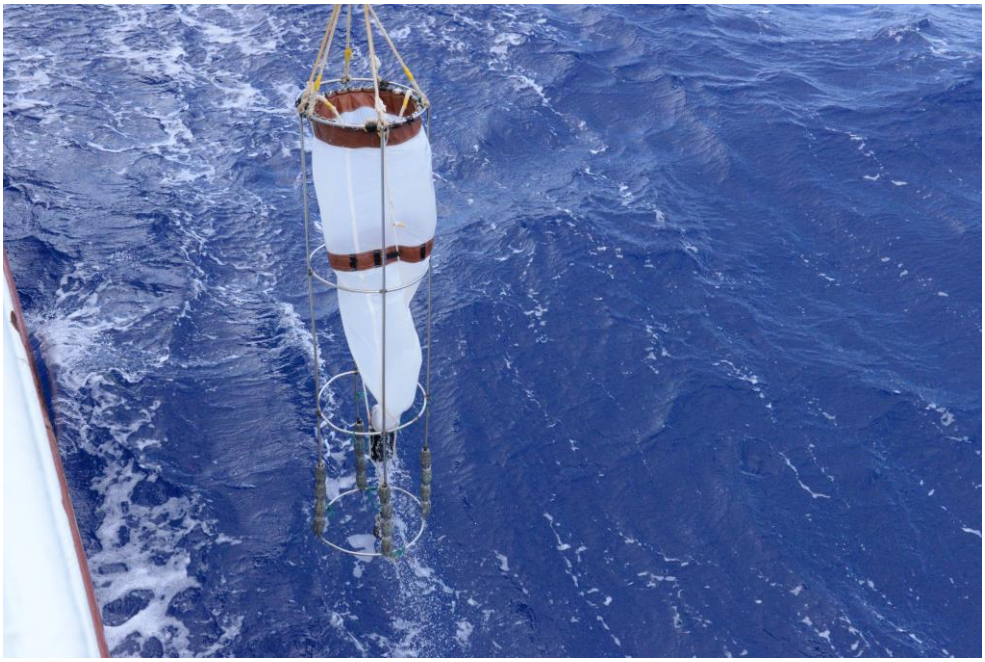


Figure 7. Deployment of the Plankton net from the *Dr Fridtjof Nansen*.

Microbial communities

Microbial communities play an important role in driving physical oceanographic parameters. These were filtered from 2 L of surface water into a sterivex filter using water from the CTD Niskin bottles for each station. At standard CTD stations, 2 L from the chlorophyll maximum was also targeted. These samples were then stored frozen pending genetic analysis at CSIRO laboratories in Hobart, Australia.

Zooplankton

Zooplankton were collected with a Hydro-Bios Multinet (Anonymous 1990) at 10 "type 1" stations throughout the cruise (see Annex IV for details). The Multinet has a square mouth-opening area of 0.25 m^2, 5 nets of mesh-size 180 μm, a pressure sensor, and two electronic flowmeters mounted inside and outside the net-opening (Figure 8). Each haul provides 5 depth-stratified samples. The Multinet samples were collected obliquely during upcast, with the typical towing speed of the net being ca. 0.75 m s^{-1} as measured by the flowmeter inside of the mouth-opening (overall median speed 0.76 ms^{-1}, overall average speed 0.81 ms^{-1},

overall stdev 0.23 ms^{-1}). Current and wind conditions constrained the lower possible sampling speed at a couple of the stations. Results from the CTD cast were used to determine the 5 standardized sampling-depths which were as follows: 600-400 m, 400-200 m, 200-100 m, 100m to depth-of-thermocline, and depth-of-thermocline to 0 m. In addition, the WP2-net (opening diameter 0.56 m, mouth-opening area 0.25 m^2, mesh-size 180 µm) (Frazer 1966; Anonymous 1968) was applied at 3 "type 1" stations to allow for comparison with the zooplankton abundances that will be estimated on basis of the Multinet sampling. The WP2-net was hauled vertically from 600 – 0 m with a speed of ca. 0.5 ms^{-1}.

After each haul, zooplankton samples were preserved with borax-buffered formalin resulting in a 4% final concentration, to allow for taxonomic identification of zooplankton. After 24 hours, the approximate volume of zooplankton in each sample was recorded using a ruler (in mm). The main zooplankton taxa observed in each sample were identified. A more comprehensive estimation of zooplankton bio-volumes and taxonomic work will be performed at the University of the Western Cape.

In addition, neuston samples were obtained *ad hoc* from the Manta trawl (see description in Microplastics section). Alternate stations were fixed in formalin and 96% ethanol. In total, 95 samples were collected along the cruise transect. This enables subsequent identification and possibly quantification of zooplankton inhabiting the surface waters of the southern Indian Ocean. The samples will be analyzed at the University of the Western Cape.

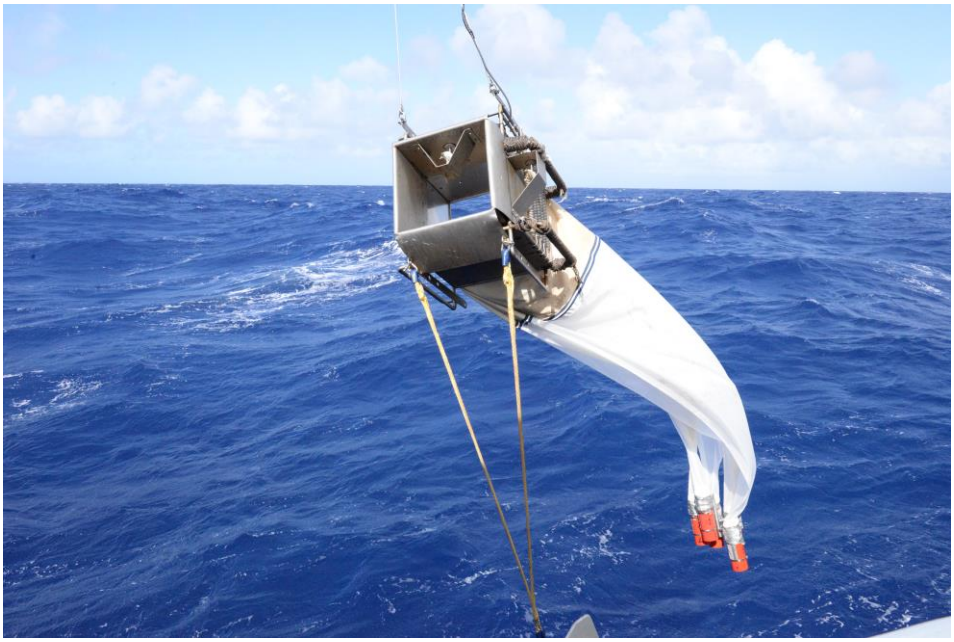


Figure 8. Deployment of the HYDRO-BIOS Multinet from *Dr Fridtjof Nansen*.

Fish sampling

Fish sampling for dietary, genetic and isotope analysis covered a total of 18 of the 25 stations within the international waters of the Southern Indian. Sampling stations were selected along four transects based on bathymetry and hydrographic factors from latitudes 10^0 00′ S and 30^0 00′ S and longitudes 55^0 00′ E to 105^0 00′ E as described below:

Transect 1: from waters off Christmas Island (102.9918 E and -12.9120 S to 95.7583E and -19.3897S) along a south-west course covering Stations 1-6. Water depths within this stratum ranged from 4600-5600 m with mean water depth of 5248±389 m depth See Figure 1.

Transect 2: from 94.6312E and -20.0065S along the 20th degree to 70° E, Stn7 to Stn 18. Water depths within this stratum ranged from ~1800-5300 m with mean water depth of 4234±1131.9 m depth.

Transect 3: from 20 00° S and 70 00° E along a Southwest transect covering station Stn 19.

Sampling was carried out basically by means of a large Aakrataal Pelagic Trawl (mouth opening 320 m^2; 22 mm mesh size at cod-end) without opening or closing systems, thus, to reduce the change of fish to scape and avoid contamination, the nets were lowered and hoisted decreasing the vessel speed. For the shallowest catches (0-35 m depth), an additional small Pelagic Trawl was deployed (22mm mesh size at cod-end, with an inner net fitting of 15mm). Both pelagic trawls were equipped with sweeps measuring 40m long and 12" rubber bobbins gear with the net mouth fanned by 7.4m2- 1600kg "Egersund" combi-doors. The depth for each haul was chosen based on the depth estimation of a SCANMAR sensor (BP9-50, USA) to keep the same bathymetric level across the entire trawling time and also to determine the mouth area. Data logging on the SCANMAR was set at 1-min polling frequency. A description of the fishing gear is provided in Annex II. Hauls were executed at the strongest acoustic layers across the water column, usually located at the near surface, between 30 and 100 m depth during the night, and at 300–500 m depth during the day. The ship speed was always near to 3 knots and the last of each haul was 30 min or an hour depending on the density of fish observed from the echograms. Additionally, a Mantatrawl used for sampling of microplastics (details are provided in another specific section for plastic sampling) was assessed to catch larvae and juvenile stages of mesopelagic fish. However, for this survey, the Mantatrawl was not specifically targeted at collection of mesopelagic fish samples.

Figure 9. Bringing the trawl on deck after a haul.

The biomass estimates for the mesopelagic fish were conducted using the integrated eco-sounder values for mesopelagic fish and mesozooplankton (mainly krill, shrimps, gelatinous zooplankton such as jellyfish).

The details of sampling stations, trawl and bottom depths, and catch rates (kg/hr) are shown in Table 2.

Table 2. Details of Sampling Stations, Trawl depth and Duration, Trawl Speed and Catch in kg/hr for mesopelagic fish species in the Southern Indian Ocean.

Trawl N	Longitude (deg.)	Latitude (deg)	Trawl type	Day Period	Catch Time (UTC)	Duration (min)	Trawl Depth (m) (Mean ± SD)	Bottom Depth (Mean ± SD)	Trawl Speed (knots)	Catch weight (kg)
1	102.9918	-12.9120	b	Night	12:48	28	110 ± 4.1	4681 ± 7.8	3.1	1.5
2	101.4887	-14.2913	b	Day	03:10	30	360 ± 14.1	4689 ± 319.6	2.9	0.7
3	100.2275	-15.4940	b	Night	18:58	30	115 ± 21.2	5300 ± 65.1	3.3	4.0
4	98.2940	-17.2790	b	Night	13:41	34	105 ± 7.1	5599 ± 4.9	3.2	3.3
5	97.2483	-18.1733	b	Day	04:11	31	415 ± 21.2	5539 ± 41.7	2.8	0.8
6	95.7583	-19.3897	a	Night	19:49	30	138 ± 3.5	5397 ± 11.3	3.5	0.8
7	94.6312	-20.0065	b	Day	10:01	30	460 ± 14.1	5041 ± 45.3	2.9	1.5
8	93.0400	-20.0032	b	Night	20:18	29	153 ± 10.6	4195 ± 396.0	3.5	1.8
9	90.4152	-20.0058	b	Night	14:43	30	95 ± 21.2	5210 ± 31.8	3.3	2.3
10	88.5847	-20.0012	b	Day	09:03	30	507 ± 10.6	2867 ± 90.5	3.1	0.6
11	87.6277	-20.0062	a	Night	16:08	30	35 ± 7.1	1821 ± 30.4	3.1	0.3
12	85.0303	-20.0253	b	Day	11:14	30	450 ± 70.7	4935 ± 22.6	3.2	0.3
13	81.4727	-20.0047	b	Night	15:59	60	50 ± 7.1	4945 ± 123.0	3.2	1.1
14	78.3952	-20.4297	b	Night	16:48	30	72.5 ± 10.6	4670 ± 89.1	3.7	4.32
15	76.8615	-20.0240	b	Day	06:07	61	453 ± 10.6	4420 ± 739.6	3.1	0.62
16	73.4450	19.9983	a	Night	14:29	61.7	35±7.1	4447.5±84.1	2.8	FAILED
17	71.9733	20.0033	b	Day	04:45	60.4	465±21.2	4078.5±50.2	3.1	0.44
18	70.4050	20.0066	b	Night	17:53	53.6	45±7.1	6158.97±2.1	3.4	4.1

19	21.3050	67.7733	b	Night	20:27	59.8	37±7.1	6348.6±2.0	2.81	1.4

[a] – Small Aakratraal Pelagic Trawl and; [b] = Large Aakratraal Pelagic Trawl.

All sampling and catch record procedures were conducted according to Sparre and Venema (1998), using standardized protocols, in order to obtain the species composition by weight and species number. Thus, the total weight for each haul was measured on an electronic balance (Marel M2200-M02, Marel, Iceland). The sorting of the catches to species level was performed for each haul, and the total number of individuals of each species was recorded Records of catch rates are given in Annex I. All the fish specimens of each species were measured to the nearest 1 mm Standard Length (SL) and weighted (±0.1 g) (or at least a 100 individuals of each subsample, if possible) for key species group of Myctophiformes and Stomiiformes. The species identification was achieved using essential literature, mainly by Bekker (19XX), Hulley and Paxton (19XX), Kawaguchi (1978).

Finally, all the samples were rapidly stored in the freezer (-18º C) or preserved in 5% buffered formalin for specific analyses on the diet and feeding habits, stable isotopes of C and N to estimate the trophic levels in the mesopelagic community,, genetics and further identification of the individuals that could not be identified to the lowest taxonomic level onboard. The records of the overall catch rates by each station are given in Annex I.

Sampling for specific data and preservation of the samples

1.) Stomach content analysis

Fish samples for stomach contents of the most frequent and abundant mesopelagic species, at least 20 individuals per catch when possible, were chosen across all the trawl stations (19). Each stomach will be removed by cutting at the beginning of the esophagus, and placing the contents on a Petri dish with a mixture of glycerin 50% and distilled water[1]. The frequency of occurrence (%F) and the percentage of abundance (%N) of the diet items examined will be calculated. The number of empty stomachs can be recorded in terms of determining the feeding incidence of each species at day and nighttime. Stomach fullness will be determined using the following qualitative scale: 0: empty stomach; 1: less than 25% of the stomach full; 2: 50% full; 3: 75% full, and 4: 100% full, and also recording wet weight of the stomach content.

Prey items will be identified to the lowest possible taxonomic level under the power resolution of the binocular microscope. The abundance of each prey item in number (%N)

[1] A high number of stomach eversions was detected in some individuals, mostly sternopthychids from de deep catches.

will be determined as the percentage of total prey number per species, and the frequency of occurrence (%F) as the number of times that a prey item appears in the species stomachs against the total number of stomachs for each species.

2.) Stable isotopes for trophic models

After identification to species level, the species were further sorted by size classs and part of the dorsal muscle obtained and dried to grindable samples in an oven and labeled for each species and size class. The samples were preserved wrapped on alluminium foils in ziplock bags awating transfer to a select laboratory for analysis of the stable isotopes and trophic levels.

2.3 Acoustic sampling

Acoustic equipment

Acoustic data were recorded using a Simrad ER60 scientific echo sounder equipped with keel-mounted transducers at nominal operating frequencies of 18, 38, 120 and 200 kHz. The survey was started without *a priori* calibration.

Acoustic data were logged and post-processed using the latest acoustic data post-processing software, the Large Scale Survey System (LSSS) Version 1.25. The technical specifications and operational settings of the echo sounder used during the survey are given in Annex II.

Allocation of acoustic energy to species group

The acoustic data were scrutinized using the LSSS version 1.6.1. Scatters were displayed at 38 kHz. The 1 nautical miles (NM) area backscattering coefficient s_A (m^2/NM^2) was allocated to a predefined set of species groups on the basis established echogram features. Acoustic groups and respective species are listed in Table 3. Ground truthing and estimation of mean length and weight were accomplished by means of targeted pelagic trawling.

The following target groups were used:

1) mesopelagic fish,
2) plankton

Estimation of abundances indices

The target strength (TS) function used to convert mean area backscattering coefficient s_A (m^2/NM^2) at 38 kHz to number of fish (Ona 2014) corresponds to:

$$TS = 20 \log L - 71 \text{ (dB)} \quad (1)$$

or

$$C_F = 1.26\ 10^6\ L^{-2} \quad (2)$$

where C_F is the conversion factor from acoustic density to fish biomass and L is the mean total fish length.

In order to split and convert the allocated s_A – values (m^2/NM^2) to fish densities (numbers per length group per NM^2), the following formula is generally used:

$$\rho_i = S_A \cdot \frac{p_i}{\sum_{i=1}^{n} \frac{p_i}{C_{F_i}}}$$

where

ρ_i = density of fish in length group *i*

S_A = mean integrator value

p_i = proportion of fish in length group *i*

$\sum_{i=1}^{n} \frac{p_i}{C_{Fi}}$ = the relative back scattering cross section (m^2) of the length frequency sample of the target species, and

C_{fi} = reciprocal back scattering cross section (σ_{bs}^{-1}) of a fish in length group *i.*

The above equations show that the conversion from s_A-values to number of fish is dependent on the length composition of the fish. It is therefore important to get representative length distributions from the stock in the whole distribution area. However, in the surveyed area there was a mixture of many species of mesopelagic fishes, and the data are too inaccurate to make separate estimates of the abundance of each of them. Therefore, in this survey, one mean length of mesopelagic fish (5 cm) was chosen for the purpose of converting the Sa-values to density of fish per square nautical mile.

2.4 Sampling of plastics

Plastic particles were sampled from the surface waters using a neuston surface trawl 'Manta' net at standard CTDO stations and to coincide with fish trawling stations. The net is designed to sample continuous-flow surface waters and as such, the frame is supported by a long panel at the top of the net that protrudes forward to funnel these surface waters into the net opening (see Figure 10). The net was tethered to the forward part of the vessel via a boom rod on the starboard side of the vessel. The net bridle was constructed with one long and one short arm angled away from the vessel so that sampling was carried out to minimise contamination coming from the ship. Sampling followed protocols outlined in Annex IV and consisted of three 15 minute trawls at target speeds of 2 to 3 knots (depending on weather conditions). Samples were sorted in 180 uM sieves inside a white bucket with water in the bottom to allow plastics to float to the surface. However, sorting through the neuston communities was also routine as particles often stick together with biological material when collected in the cod end of the net. Samples were then characterised under a microscope, recorded and stored in foil. The neuston samples were then stored as detailed in section 2.2.

At five stations inside the gyre, two replicate plastic particles were sampled for genetic and microscopic analyses to understand the communities living on the surface of these particles. Each piece was halved, one for genetic analysis and the other for microscope analysis. In addition to this, 2 L of surface seawater was filtered into a sterivex filter to allow for comparison with the surrounding environment. These samples will be processed by a research group in Woods Hole (Linda Amaral-Zettler).

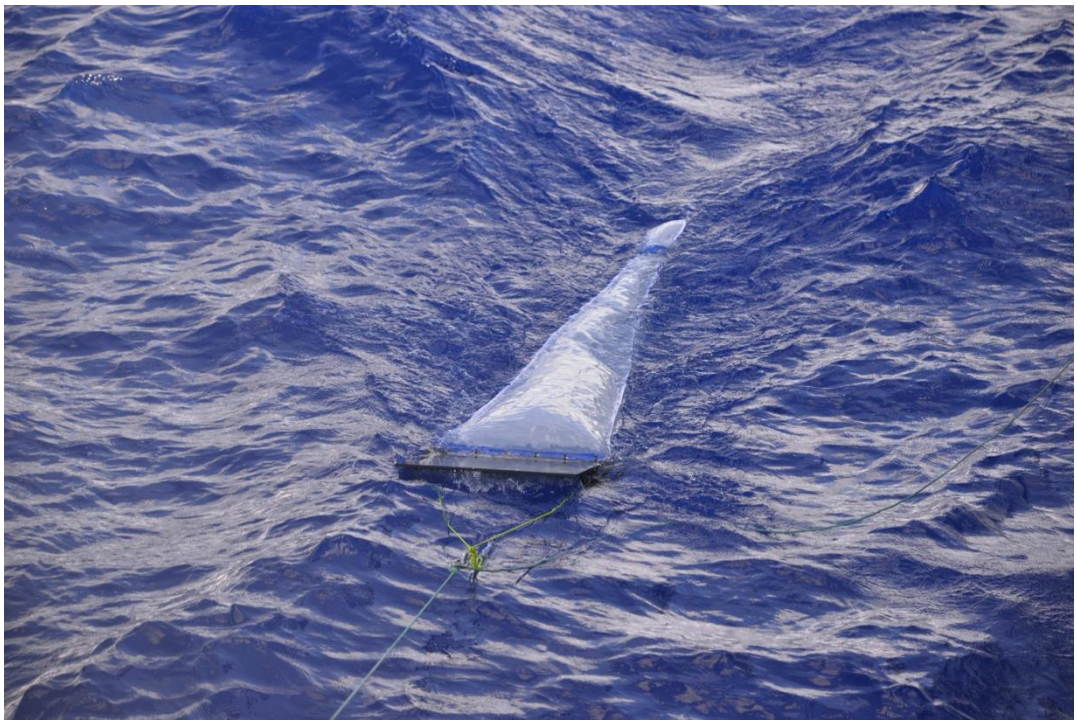


Figure 10, Manta Trawl sampling surface waters for microplastics and neuston communities. Note that the trawl used here does not have the flanking aquaplane panels typical of a manta design.

CHAPTER 3 SURVEY RESULTS

3.1 Hydrography

3.1 Hydrography

We hereafter present the CTD and thermosalinograph data along two different sections. The first section correspond to a north-east/south-west transect, while the second corresponds to an east-west transect (Figure 10).

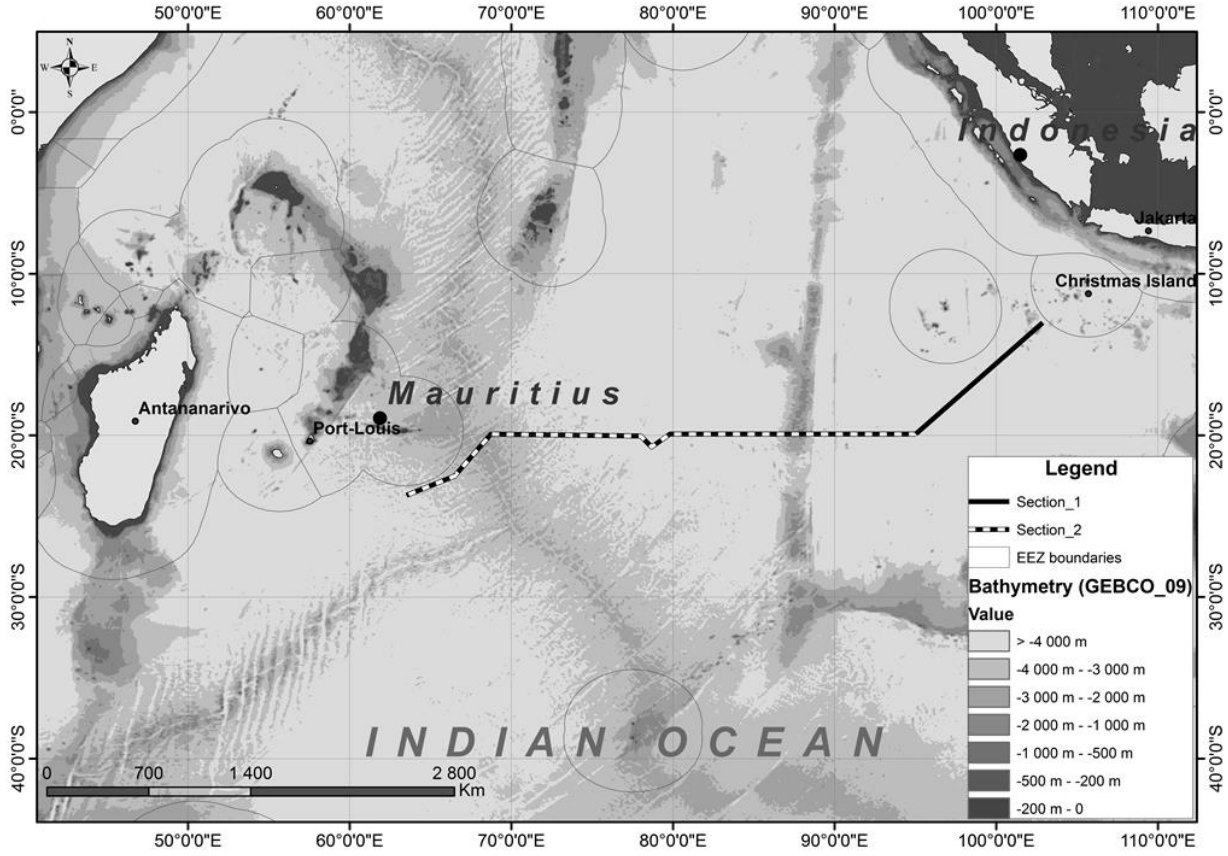


Figure 11. Map of the Indian Ocean showing the bathymetry in the area. The 2 sections used to represent the CTD data are highlighted (section 1= black line, section2= dotted line).

Hydrography of Section 1 (station # 500 to 511; Long 105 to 95°E)

Surface temperature ranged from 24 to 28.6ºC (Figure 12 and 13 a), while surface salinity ranged from 33.9 to 35.5 (Figure 13 a). Within the mixed layer, temperature decreased southward, while salinity increased. A layer of higher salinity developed around 250 m while cruising southward. With relation to fluorescence, a slight southward decrease was observed at the surface. At deeper depths, a DCM (Deep Chlorophyll Maximum) was well developed

along the whole section with depths ranging from 81 to 112 m (table and figure). Two water masses of low oxygen were observed along the entire section: (1) below the DCM and (2) at deeper depths between 700 and 1000 m. In between these two low oxygen water masses, an oxygen-rich layer was observed around 500 m (Table 1 and Figure 13 a). While travelling southward, the two low oxygen masses progressively decreased while the oxygen-rich layer increased.

Hydrography of Section 2 (station # 512 to 541; Long 95 to 65°E)

Surface temperature ranged from 23.2 to 25.8ºC (Figure 12 and 13 b), while surface salinity ranged from 34.2 to 35.5 (Figure 13 b). Within the mixed layer, temperature increased westward from 95° to 75° E, while salinity decreased. A layer of higher salinity was still present around 250 m along the whole section. Further, at deeper depths, less saline water masses were found ranging between 600 and 1000 m. With relation to fluorescence, surface values are quite stable from 95° to 70° E, and then started to increase to 65°E. At deeper depths, a DCM was well developed along the whole section at depths ranging from 48 to 153 m (table and figure). Two water masses of low oxygen were observed along the entire section: (1) below the DCM and (2) at deeper depths between 1000 and 1500 m. The low-oxygen layer below the DCM was however less pronounced than in Section 1. In-between these two low oxygen water masses, an oxygen-rich layer was observed sitting between 470 to 621 m (Table 3 and Figure 13 b).

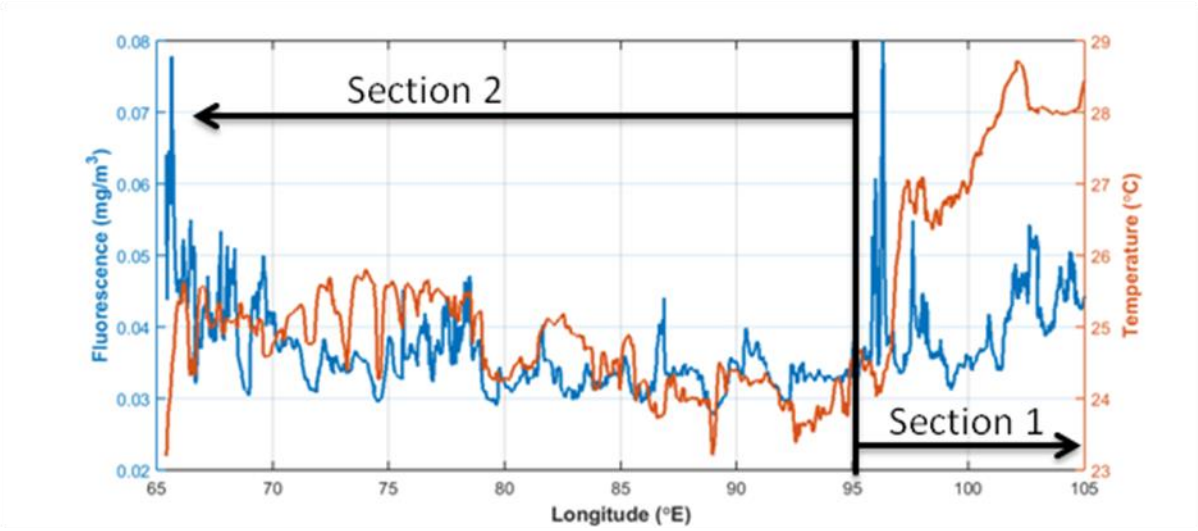


Figure 12. Fluorescence (not calibrated) and temperature at 5 m from the thermosalinograph along the whole cruise transect.

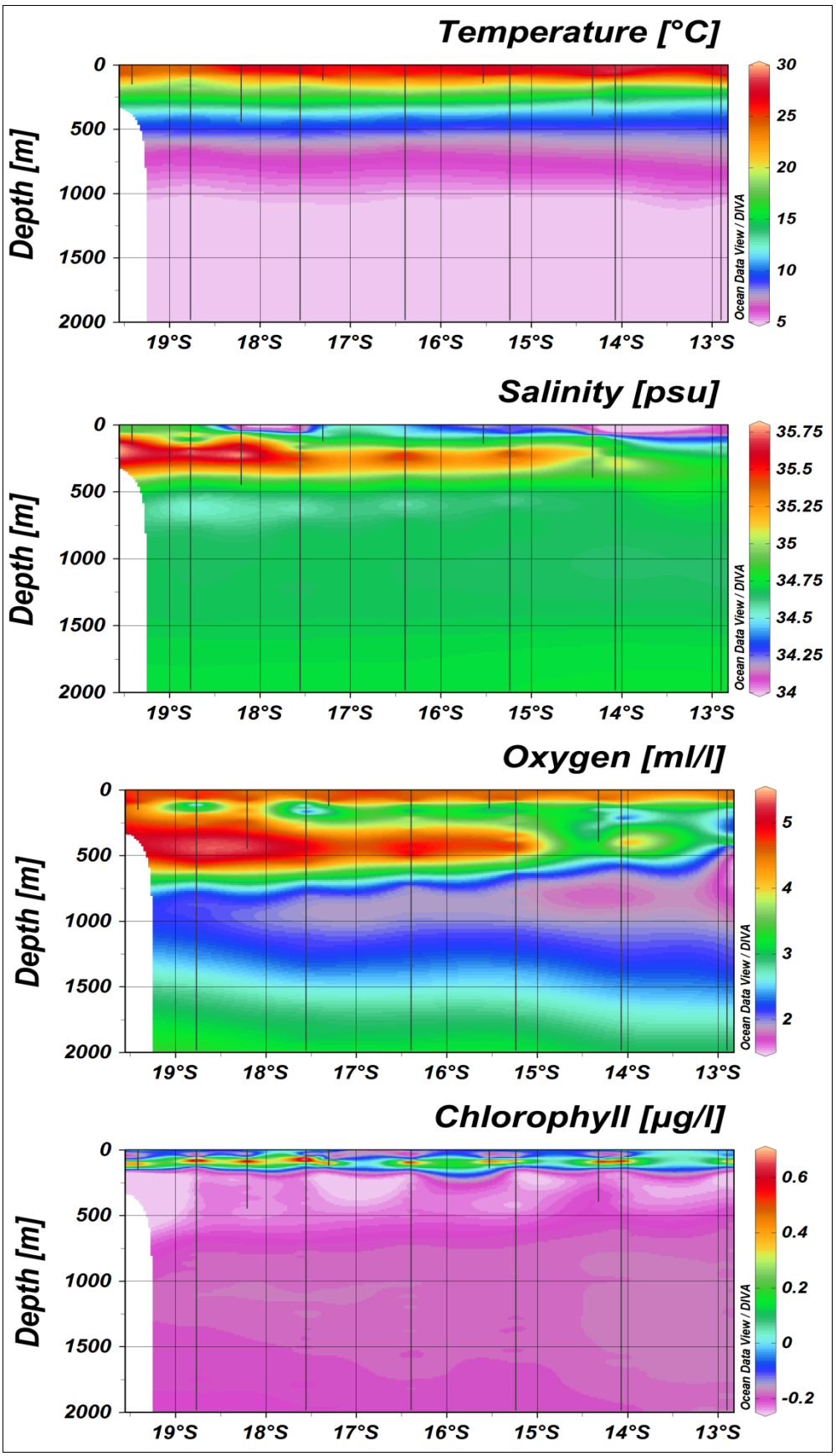


Figure 13 a. **SECTION 1:** Temperature, salinity, dissolved oxygen and fluorescence. Note that the fluorescence has not been calibrated (calibration will be performed later).

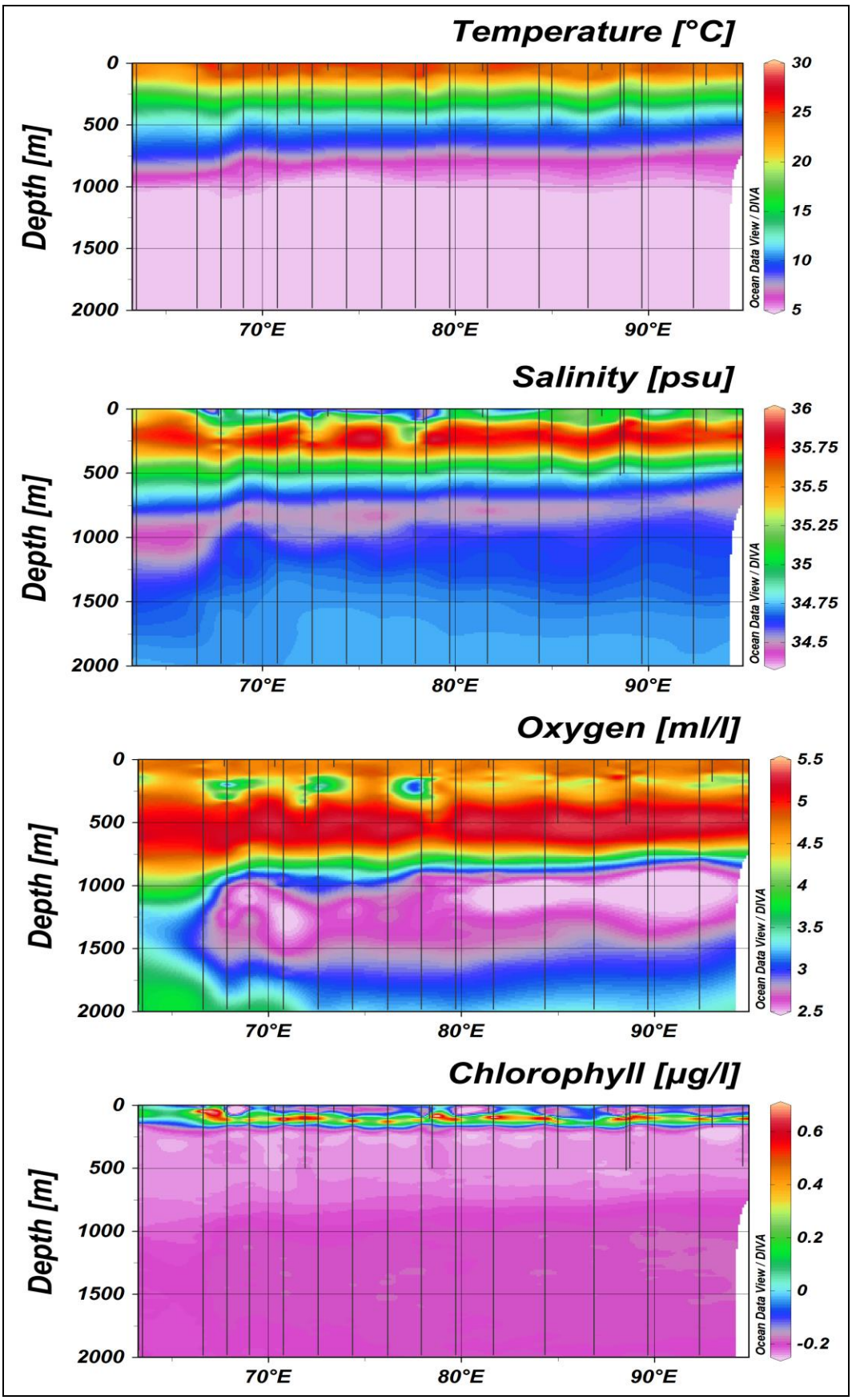


Figure 13 b. **SECTION 2:** Temperature, salinity, dissolved oxygen and fluorescence. Note that the fluorescence has not been calibrated (calibration will be performed later).

Table 3. Depth and values for oxygen maxima and chlorophyll maxima from the deep CTD casts.

Station	Year	Month	Day	Hour	Minute	latitude (deg)	Longitude (deg)	CTD Depths (m)	MLD (m)	Depths of DO max (m)	DO max value (mL/L)	Chl Max (µg l-1)	Depths of Chl max (m)	Avg Chl 0 to 150 m (µg l-1)	Avg Chl in the Mixed layer (µg l-1)
500	2015	6	29	8	17	-12.90	102.96	2005	80	4	4.50	0.62	82	0.05	0.00
501	2015	6	29	23	44	-14.07	101.72	2004	72	3	4.49	0.75	83	0.07	-0.09
502	2015	6	30	4	12	-14.32	101.46	396	38	52	4.50	0.69	90	0.05	-0.14
503	2015	6	30	13	16	-15.24	100.51	2005	62	430	4.73	0.66	85	0.00	-0.13
505	2015	7	1	3	37	-16.40	99.24	2003	51	489	4.94	0.81	92	0.04	-0.18
507	2015	7	1	17	55	-17.55	97.99	2005	56	448	4.98	0.76	68	0.15	-0.06
508	2015	7	2	5	12	-18.21	97.23	449	43	441	5.28	0.73	81	0.12	-0.12
509	2015	7	2	11	36	-18.77	96.52	2002	54	458	5.31	0.84	78	0.08	-0.13
511	2015	7	3	3	21	-20.00	95.01	2002	27	455	5.31	0.68	112	0.03	-0.09
512	2015	7	3	11	1	-20.01	94.59	486	45	470	5.29	0.65	104	0.05	-0.14
514	2015	7	4	1	55	-20.00	92.33	2003	71	473	5.33	0.60	104	0.05	-0.14
516	2015	7	4	20	26	-20.00	89.67	2006	76	496	5.30	0.58	92	0.09	-0.12
517	2015	7	5	6	57	-20.00	88.73	503	68	484	5.30	0.80	85	0.13	-0.16
518	2015	7	5	10	9	-20.00	88.53	522	62	491	5.30	0.92	107	0.10	-0.14
520	2015	7	5	21	48	-20.00	86.88	2004	143	542	5.31	0.27	153	-0.02	-0.03
521	2015	7	6	12	15	-20.03	84.99	506	105	496	5.33	0.60	132	0.01	-0.12
522	2015	7	6	16	44	-20.00	84.34	2002	35	539	5.30	0.75	107	0.08	-0.12
523	2015	7	7	12	44	-20.00	81.67	2003	61	523	5.29	0.94	95	0.15	-0.12
525	2015	7	8	3	5	-20.01	79.71	2004	81	517	5.25	0.71	114	0.06	-0.17
526	2015	7	8	14	18	-20.49	78.49	503	81	491	4.97	0.74	85	0.14	0.05
528	2015	7	8	21	56	-20.00	77.93	2004	111	562	5.19	0.52	112	0.02	-0.06
530	2015	7	9	12	43	-20.01	76.18	2007	49	541	5.28	0.80	131	0.04	-0.17
531	2015	7	10	6	10	-19.99	74.37	2006	27	493	5.29	0.74	121	0.03	-0.16
533	2015	7	10	20	56	-20.00	72.58	2004	68	565	5.24	0.58	111	0.11	-0.13
534	2015	7	11	6	16	-20.02	71.91	504	21	480	5.09	0.69	100	0.14	-0.15
535	2015	7	11	13	45	-20.00	70.79	2002	83	520	5.26	0.79	111	0.13	-0.08
537	2015	7	12	3	8	-20.00	69.02	2004	78	517	5.19	0.48	116	0.10	-0.03
538	2015	7	12	17	22	-21.20	67.86	2004	113	573	5.20	0.63	120	0.12	0.05
540	2015	7	13	7	0	-22.39	66.62	2006	25	542	5.19	0.87	48	0.26	-0.09
541	2015	7	14	6	55	-23.75	63.48	2358	96	621	5.15	0.24	92	0.07	0.13

Variability along the cruise track

During this cruise, a significant variability from one station to the next was observed for most hydrographic variables, and this variability appeared to be greater than the gyre scale/large scale variability, especially along Section 2. This smaller scale variability is partly due to the presence of oceanic eddies and is usually referred to as “mesoscale variability”. This variability is for instance noticeable in the dissolved oxygen along section 1 (Figure 13 a). The mesoscale variability can be tracked from space using satellite imagery of the Sea Surface Height (SSH) (cf. SSH anomaly on Figure 14). It can be observed in Figure 14 that most of the major SSH anomalies correspond to a peak in fluorescence at 5 m deep (i.e positive SSH anomaly=anticyclonic eddy => fluorescence peak and negative SSH anomaly=cyclonic eddy => fluorescence low). The mixed layer depth also seems to be linked with the SSH anomaly with deeper mixing within regions of positive SSH anomalies. Within the water column the impact of the mesoscale variability on fluorescence is also noticeable. In particular, the region with deeper mixing around stations 520 and 528 highlight higher fluorescence within the mixed layer than anywhere else along section 2, while the DCM tends to be smaller. The processes responsible for that behaviour will later be assessed using the data provided by the Bio-Argo floats deployed in the vicinity of eddies close to stations 520 and 528.

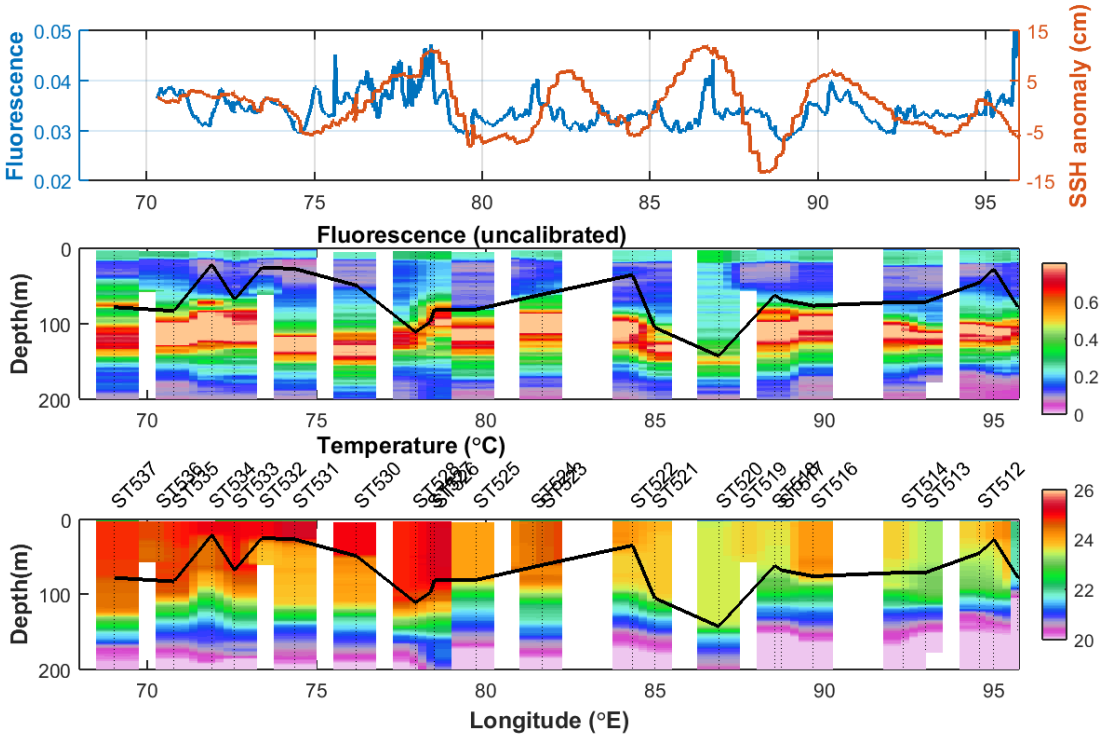


Figure 14. Upper panel: Chlorophyll data (not calibrated) along the cruise track from the thermosalinograph and sea surface height anomaly along the cruise track from AVISO on the 9th of July 2015. Middle panel: uncalibrated fluorescence and mixed layer depth computing using temperature profiles (black line). Lower panel: temperature and mixed layer depth (black line).

3.2 Plankton

Phytoplankton

Phytoplankton constitutes the base of the marine pelagic food chain, and is therefore the basis for production at all higher trophic levels. Onboard, it was extremely difficult to undertake detailed analysis of phytoplankton samples. Detailed analysis of phytoplankton species composition and densities, and later wet biomass (biovolume) will be done within 3 months of sample collection. However, the following are preliminary results of phytoplankton species composition based on the few samples examined under a compound microscope.

About 17 species of phytoplankton were identified in the Southern Indian Ocean waters. Out of these 17 species recorded, 10 belongs to diatoms (Bacillariophyceae) and 5 species to dinoflagellate (Dinophyceae). Silicoflagellate (Dictyochophyceae) and Mediophyceae each was represented by one species. The most important groups of phytoplankton in fresh waters, namely blue-green (Cyanophyceae) and green (Chlorophyceae) were not observed in the deep sea waters. These results are similar to the other work carried out in other open waters.

A few phytoplankton species observed during the survey are presented in Figures 15 a-d. The single most abundant diatom species during the investigation was *Chaetoceros* spp, which comprised >40% of total number of species identified. *Coscinodiscus* spp was the second dominated species in terms of diversity (number of species). Other identified general of diatoms include *Chaetoceros, Coscinodiscus, Rhizosolenia, Navicula, Asterompra, Nitchia, Asteromphalus* and *Diploneis*. Dinoflagellates constituted the second most abundant group, recored only one genus, *Ceratium*.

Conclusions

From this study, it is obvious that the study provides baseline knowledge on the phytoplankton community structure. More analysis when done, will give us full picture on the community and quantity of phytoplankton biomass available for marine food web with respect to various environmental conditions, which could give a new insight to the future ecological assessment in the Southern Indian Ocean waters.

Figure 15 a. *Navicula* sp. (Diatom)

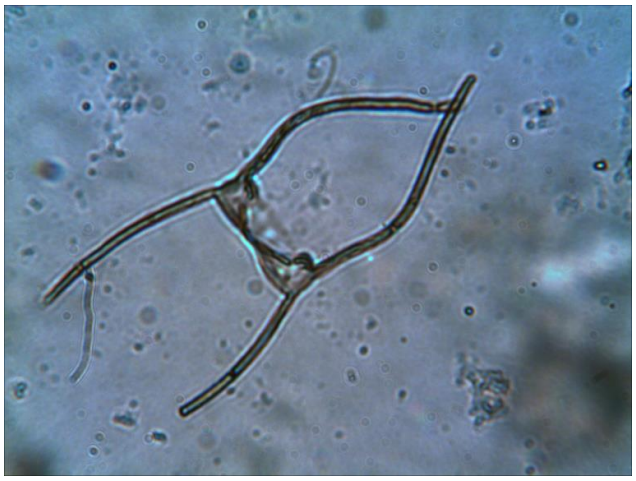


Figure 15 b. Unidentified phytoplankton

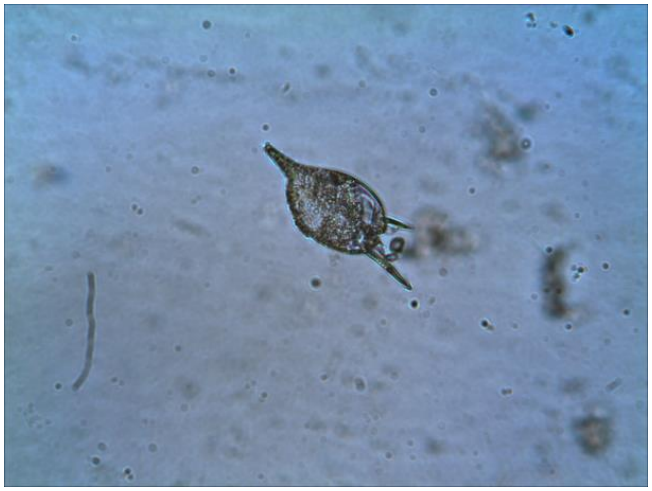


Figure 15 c. *Ceratium* sp. (Dinoflagellate)

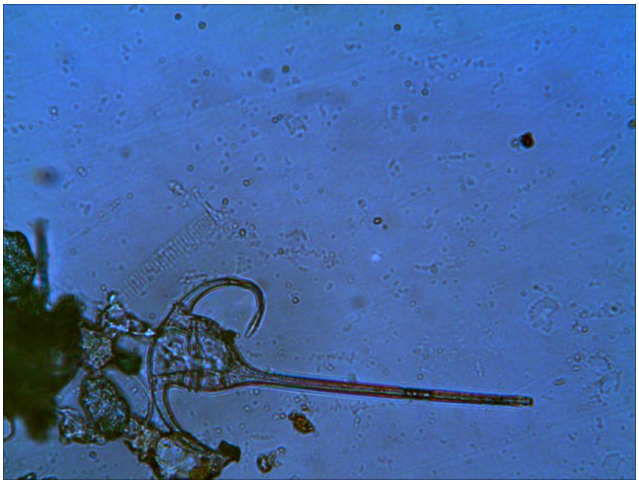


Figure 15 d. *Ceratium* sp. (Dinoflagellate)

Zooplankton

Zooplankton composition and abundance is important in its' own right, but is also by representing the main source of food for larger pelagic organisms such as fish. To assess the abundances, vertical distributions and species composition of zooplankton along the cruise track, two types of nets were used. The advanced Multinet (mesh-size180µm) provided depth-stratified samples down to a maximum depth of 600 m and was successfully deployed at 10 stations, and will be used to assess vertical distributions, species composition and diversity, as well as species abundances of mesozooplankton. The much simpler WP2 (180 µm), which was used on 3 occasions, will provide data to be used for validation of zooplankton

abundances estimated from the Multinet. Taxonomic identification and enumeration of zooplankton from plankton samples is time- and labor-intensive, and must be performed on shore after the cruise. Hence, detailed results for the zooplankton collected were not ready by the time of writing of this report. Still, we can already now present preliminary results on absence/presence of selected zooplankton taxa of importance, as well as vertical distributions of zooplankton volumes in the samples collected across the southern Indian Ocean (Table 4 and Figure 17). And the copepod species from the manta trawl (Figure 16). An overview of samples of zooplankton is given in Annex V.

Figure 16. Pontellidae (Family)***: Genus* Anomalocera**

Table 4. Presence (+) and absence (-) of various zooplankton taxa in the water-column in the depth-specific Multinet samples.

Station	Depth(m)	Cope-	Euphausiacea	Amphi-	Chaeto-	Hydro-	Siphono-	Fish	Ostra-	Polychaete	Doliolida	Salpida	Ptero-	Gastropod	Cephalopod
500	602.5 - 398	+	+	+	-	-	-	+	+	-	-	-	-	-	-
500	397.9 - 200.9	+	+	-	-	-	-	+	+	-	-	-	-	-	-
500	200.5 - 100.4	-	+	-	-	+	-	+	+	+	-	-	-	-	+
500	100.2 - 80.4	+	+	-	+	+	-	+	+	+	-	-	-	-	-
500	81.4 - 0	-	+	+	-	+	+	+	+	-	-	-	+	-	+
503	603 - 400	+	+	-	-	-	-	+	-	-	-	-	-	-	+
503	399.7 - 199.6	+	+	+	+	-	+	-	-	+	-	-	-	-	-
503	199.3 - 100.6	+	+	+	+	-	-	+	-	-	-	-	-	-	-
503	100.9 - 80.2	+	+	+	+	-	-	+	+	+	-	-	-	-	-
503	80.9 - 0. 1	-	+	+	-	+	+	+	+	+	+	-	+	+	+
507	601.1 - 401.5	+	+	+	+	+	+	+	+	+	-	-	-	-	-
507	401.3 - 199.4	+	+	+	+	+	+	+	+	-	-	+	-	-	-
507	199.5 - 101.4	+	+	+	+	-	-	+	+	+	-	-	-	-	+
507	101.1 - 52.3	+	+	+	+	+	+	+	+	+	+	+	+	-	+
507	52.5 - 0	+	+	+	+	+	+	+	+	+	+	+	-	-	+
511	602 - 400.2	+	+	+	+	+	+	+	+	-	-	-	-	-	-
511	400.3 - 200.5	+	+	+	+	+	+	+	+	-	-	-	+	-	-
511	201 - 79.9	+	+	+	+	+	+	+	+	+	+	-	-	-	-
511	79.7 - 29.8	+	+	+	+	-	-	-	-	+	-	-	-	-	-
511	29.8 - 1.8	+	+	+	+	-	-	+	-	-	-	-	+	+	-
516	579.6 - 401.9	+	+	+	+	-	+	+	+	-	-	-	-	-	-
516	401.7 - 201	+	+	+	+	+	+	+	+	-	+	-	+	-	-
516	201.3 - 150.3	+	+	-	+	-	+	-	+	-	-	-	-	-	-
516	150.4 - 50.8	+	-	+	+	-	+	-	+	+	-	-	-	-	-
516	50.9 - 2.9	+	+	-	+	-	-	+	+	+	-	-	-	-	-
525	603.7 - 401.1	+	+	+	+	+	-	+	+	-	-	-	+	-	-
525	401.2 - 151.3	+	+	+	+	+	-	-	+	+	-	-	+	-	-
525	201.2 -151.3	+	+	-	+	-	-	-	+	+	-	-	+	-	-
525	151.6 - 80.6	+	+	-	+	-	+	+	+	-	-	-	-	-	-
525	80.1 - 0.8	+	+	+	+	+	+	-	+	-	-	-	-	-	-
530	599.8 - 398.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
530	398.2 - 198.7	+	+	+	+	-	+	-	+	-	-	-	-	-	-
530	198.2 - 98.9	+	+	+	+	-	+	-	+	+	-	-	+	-	-
530	100 - 45	-	-	-	-	-	-	-	-	-	-	-	-	-	-
530	46 - 1.3	+	+	+	+	+	+	-	+	+	+	-	+	-	-
533	600.2 - 401.6	+	-	-	-	+	-	+	+	-	-	-	-	-	-
533	401.4 - 200.6	+	+	-	+	-	-	-	+	-	-	-	-	-	-
533	200.8 - 102.7	+	+	+	+	+	-	-	+	-	-	-	-	-	-
533	103.3 - 66.8	+	+	+	+	+	+	-	+	-	-	-	-	-	-
533	66 - 0.3	+	+	+	+	-	-	+	-	-	-	-	-	-	-
537	601.3 - 401.3	+	+	-	+	-	+	+	+	-	-	+	-	-	-
537	401.9 - 200.8	+	+	+	+	+	+	-	+	+	-	-	-	-	-
537	200.6 - 100.6	+	+	-	+	+	-	-	+	+	+	-	-	-	-

537	**100.6 - 41.7**	+	+	-	+	-	+	-	+	+	-	-	-	-	-	-
537	**42.5 - 0.2**	+	-	-	+	-	+	+	+	-	-	-	-	-	-	-

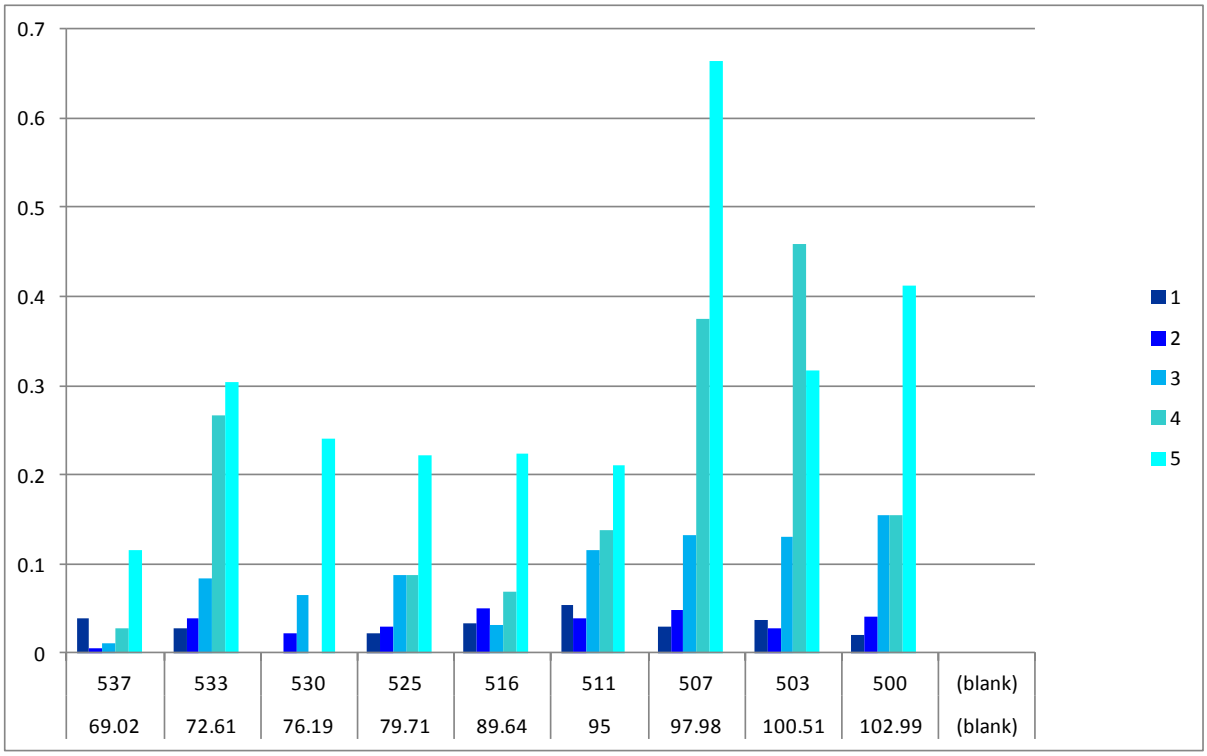


Figure 17. Preliminary estimates of zooplankton volumes (cubic centimeters per cubic meter) from the different Multinet tows (1-5) at the stations sampled across the southern Indian Ocean (westernmost stations shown at the left side). Lowermost numbers along X-axis denote CTD station numbers, while vertical numbers along the same axis indicate longitude (°E).

3.3 Mesopelagic fish

Densities of meso-pelagic fish

The estimated densities of mesopelagic fish along the cruise track is shown in Figure 18, and Figure 19. The density was at the highest at the start of the survey and decreased steadily along the first transect. The density further decreased along the second transect through the gyre. Towards the end of the survey, the densities increased again.

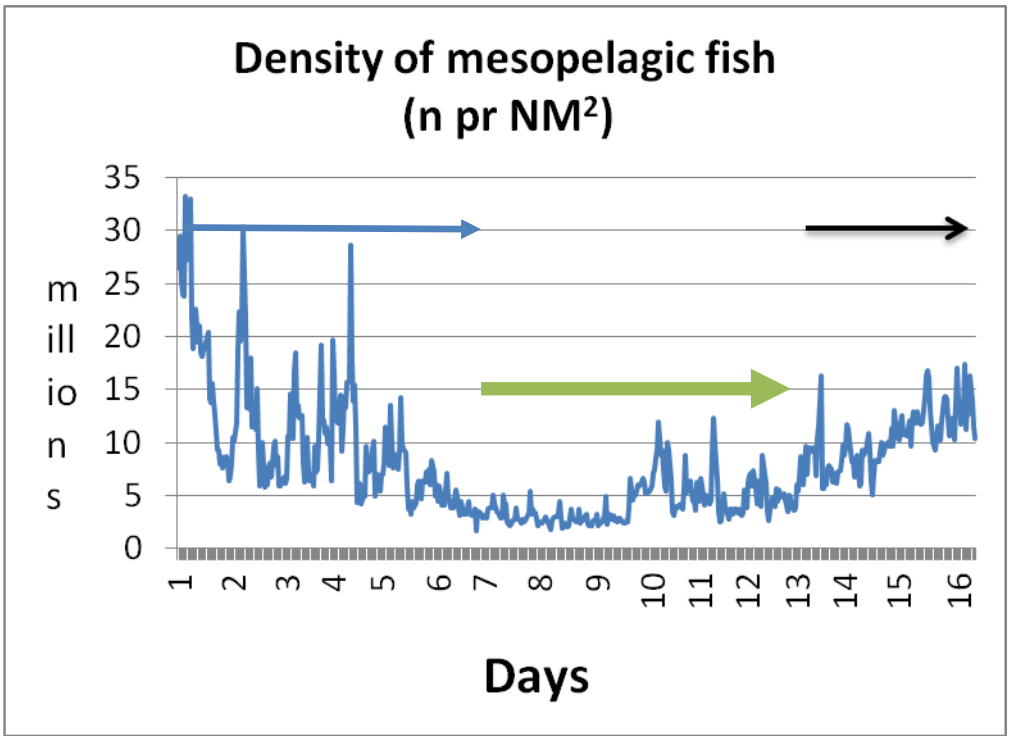


Figure 18. Density of mesopelagic fish during the survey expressed as millions per square nautical mile. Blue arrow – to the east of the gyre, Green arrow – in the gyre, and black arrow – west of the gyre.

The densities of meso-pelagic fish was highest during night-time, when the fish was concentrated in the upper 100 m, or above the maximum depth of chlorophyll. During daytime, the fish descended to about 400 to 600 m depth in the maximum oxygen zone. The fish was less concentrated during daytime. Figure 20 shows an example of echo sounder printout of diurnal migration of mesopelagic fish and plankton.

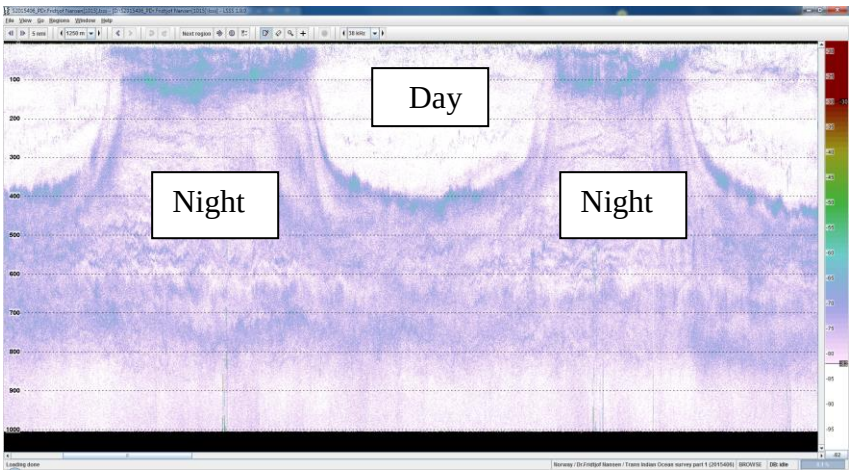


Figure 20. Typical patterns of day and night migrations of fish and plankton.

The myctophiformes (Fam. Myctophidae) were by far the largest group of species in the large group defined as mesopelagic fish during this survey. The most abundant species collected during the night catches in the surface layer (up to 100 m depth) belong to the Myctophiformes (*Ceratoscopelus warmingii* followed by *Diaphus effulgens*, *Diaphus* spp., *Diaphus brachycephalus*, *Symbolophorus evermanni*, *Lobianchia gemellari* and *Lampanyctus* spp.) and, for the deep catches (300-500 m depth) during the daytime, to the Stomiiformes (*Argyropelecus aculeatus, A.hemigymnus, Vinciguerria nimbaria, V. attenuata*).

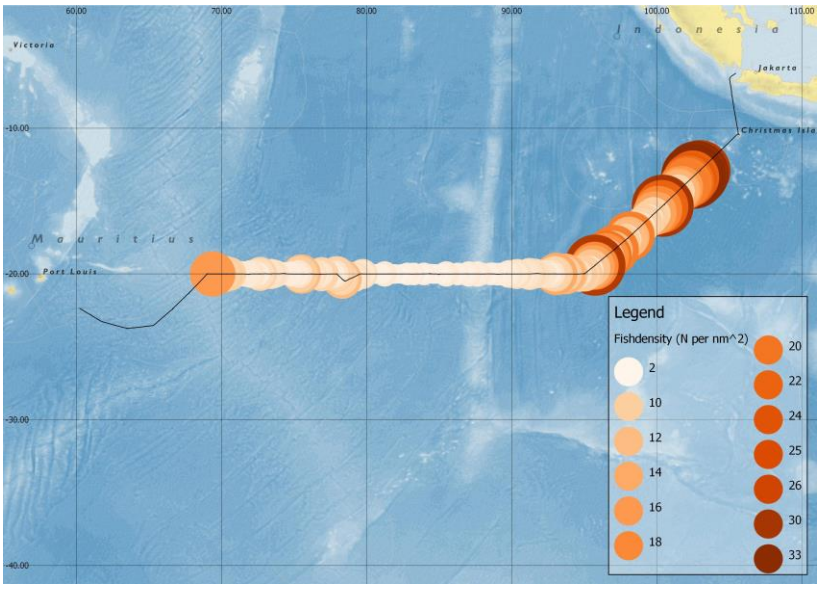


Fig. 19. Densities of mesopelagic fish along the cruise track.

The length frequencies of most abundant and frequent species (*Ceratoscopelus warmingii, Diaphus effulgens, Diaphus* spp., and *Symbolophorus evermanni*, *Lampanyctus* spp. and *Bolinichtys indicus* belonging to Myctophidae, and *Vinciguerria nimbaria*, belonging to Phosichthyidae (stomiiforms)) are presented in Annex III. The sizes of these fish ranged from 10 mm SL (*Lampanyctus* sp.) to 205 mm SL (*Idiacanthus* sp.).

The catch rates of mesopelagic fish, cephalopods, shrimps and crustacean for both day- and nighttime, are presented in Annex I. The catch rates were much higher during the night than during the day.

As could be appreciated by using the acoustic methods, a large number of individuals from the mesopelagic fish community, mainly myctophid and a very scarce number of stomiiformes, undertook large vertical displacements to the first hundred meters of the water column at night, where they aggregated in the mix zone and above the chlorophyll maximum layer. At daytime, the highest acoustic frequency was detected at 400-600 m depth, in the Deep Scattering Layer and the catches were compound by a lower number of fish individuals of basically stomiiformes distributed close to the oxygen maximum layer. The nighttime S_A – values were higher than the daytime values, which indicate that the mesopelagic fish not only move upwards to the surface during night, but also concentrate in the upper 100 m zone. Some species of myctophids, such as *Myctophum selenops* and *M. phengodes* appeared to be practically absent in the surface night trawls, but occurred in the depths at night along with other species of stomiiformes tipically occurring at the Deep Scattering Layer, i.e. *Argyropelecus* spp., *Vinciguerria* spp. and *Icthyococcus ovatus.* This seems to point out that those myctophid species do not migrate to the surface at daytime or they do it at other times. The most diverse genus of this survey was *Diaphus,* with at least 10 different species reported, mainly in night catches, but also in some day catches.

The mesopelagic fishes compound a widely diverse group, where those belonging to Myctophidae constitute an important component of the food web structure and the ecosystem,

and often make up a sizeable fraction of the biomass. In addition, fish belonging to Gonostomatidae and Phosichthyidae (such as *Cyclothone* spp.,*Vinciguerria nimbaria, V. attenuata,* and *Maurolicus muelleri*, for example) can be numerically important, and it is believed that, the genus *Cyclothone* is the world's most abundant fish, in terms of number of specimens..

The mesopelagic fishes are loosely defined as fishes that have their main daytime depth of residence in the mesopelagic zone. The mesopelagic zone is usually found to be in the depth range of 200 m to1000 m, but it is technically defined as pelagic waters the depth strata where daylight penetrates, but also very low the primary productivity. The mesopelagic fishes are made up of relatively small fishes, most of the time occurring in relatively low densities, but since the volume of their biotope, given by a large horizontal as well as vertical dimension (200-1000m), is enormous, it follows that the world biomass of this group is enormous. Gjøsæther and Kawaguchi (1980) estimated the worldwide biomass at around 1000 million tons, but more recent work has suggested that this is likely to be a very conservative estimate (Kaartvedt et al. 2012). In the Indo-Pacific region a good deal of work on the abundance, distribution and ecology of the mesopelagic fish has been performed in the vicinity of the Arabian Sea, which has been reported to be one of the mains regions housing the highest densities of mesopelagic fish (Gjøsæter and Kawaguchi (1980).

Nowadays, the level of direct commercial exploitation of mesopelagic fishes is low, though they have been suggested as the target of commercial fisheries (Gjøsæter 1984). However, mesopelagic fish feature prominently in the diet of many commercially important species, such as tunas, billfishes, and demersal species of commercial value. In addition, mesopelagic fish are important in the diet of cephalopods, marine mammals and marine birds. Some of these species gain access to mesopelagic fish by foraging in the mesopelagic zone themselves, but some, such as billfishes and tuna have high oxygen requirements, and may be excluded from foraging at mesopelagic depths (Prince and Goodyear 2006) in areas minimum oxygen at midwater depths. Thus, these pelagic species forage on mesopelagic fishes during

night, when the mesopelagic fishes typically venture close to the surface themselves to feed on plankton (refs.).

Since most of the mesopelagic fish migrate from their daytime residence depths in deeper waters to the surface, they are important vectors of active carbon transport through the water column. While their numbers typically are lower than that of migrating meso- and macrozooplankton, the extent of the migrations that some species and active individuals perform are larger , which implies an important importation of carbon to the impoverished deep waters. Currently, the ecology of mesopelagic fish is very poorly understood to provide a properly assess of their importance in the global carbon pump.

Fish biodiversity

Biodiversity is the variety of living organisms in all their forms and defined in terms of genetic diversity, species diversity and ecosystem diversity and the interrelations between genes, species and ecosystems. The scope of this section is more modest in trying to highlight the main trends found. Since this is a mesopelagic survey, one of our main goals is to have a closer look at the vertical migration of the different species present in this group. However, we are conscious that this species diversity is limited to the scatter layers with the highest frequency values at concrete time periods of the day.

The survey had a total of 19 fishing stations, 7 performed during day time and 12 during night time. More than 76 teleosts species (at least 66 occurring in the night trawls, and 33 in the day trawls.

Regarding to the species composition by trawl station across the whole survey track (Fig. 9), we could appreciate that, at least for the nighttime, the number of fish species dropped as we get closer to the gyre (trawl stations from 9 to 13), and were the surface waters were more oligotrophic compare to the number of species at the first and last transect.

However, there was a compromise in attempting to sample at shallow depths (0 – 35 m) as the main trawl was not suitable for sampling so close to the surface. However, due to the mesh size and complications with the gear, these catches did not sample adequately and severely compromised our ability to characterize the mesopelagic species composition for those trawling stations.

For analyses purposes, the fishing stations have been divided according to the light hours in day and night time stations. Being day stations those taken between 0600 and 1800, and night stations between 1800 and 0600 hours.

The total and mean values of biomass and abundance, together with the number of species and fishing stations, by time of the day, are shown in Annex I. Figure 21 shows that the number of species in the trawl catches is higher during night time than at day. Figure 22 shows a common mesopelagic fish caught during daytime.

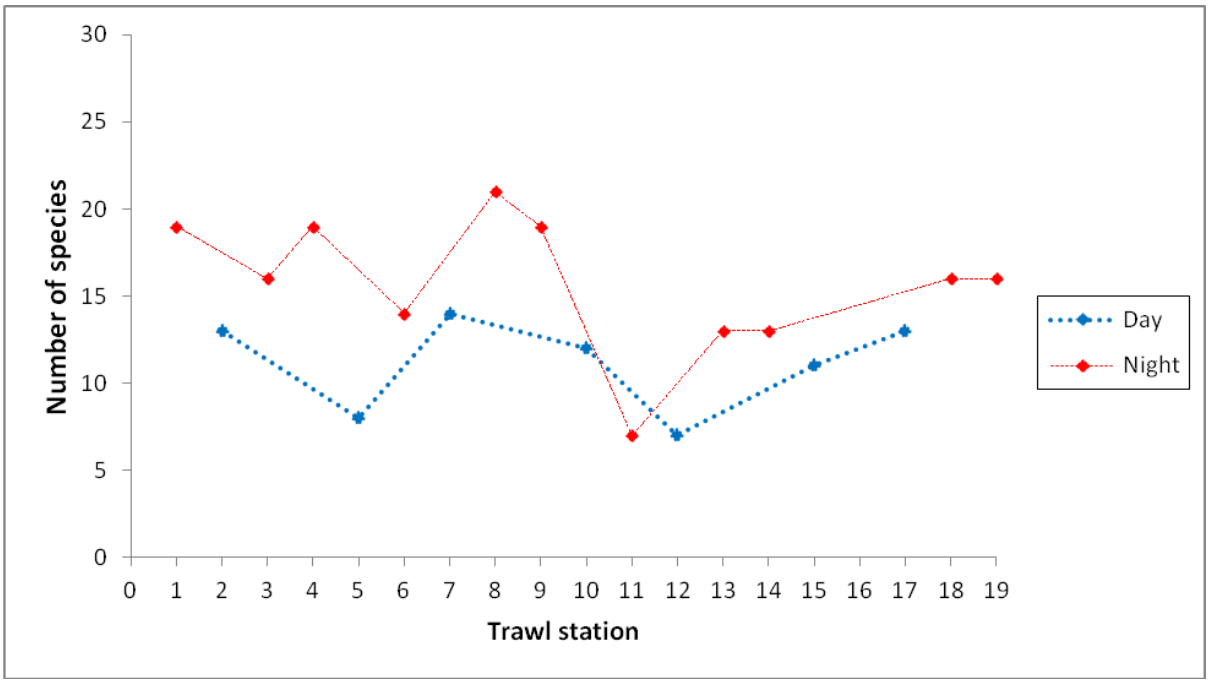


Figure 21. Number of species by stations.

Figure 22. *Argyropelecus aculeatus,* - a common mesopelagic species occurring in trawl catches during daytime

3.4. Plastic particles

Manta trawls were taken at 35 stations (Figure 1.d) with considerable variation in plastic particles present in the samples (Figure 23). Initial observations suggest this variation appears to correlate to distance from land (i.e. more plastic particles present closer to the coasts than inside the gyre), weather conditions (wave height and wind speed) negatively affect plastic particles and tow speed (i.e. sampling effort). However, in some instances, even a small volume of water filtered through the net, when travelling at less than 2 knots, could yield pieces of plastic particles. In fact, there were very few sampling stations (less than 3) where there were no plastic particles observed. The highest numbers of particles in a single trawl were found on leg one with more than 90 pieces observed, however this may be amplified by the breakdown of individual pieces inside the cod end during sampling and so requires further analyses to verify this. However, this was an exceptional example with many other stations

showing far fewer particles (less than 50 pieces per station). Nonetheless, the size of particles also appears to negatively correlate to distance from land with larger particles generally found on either side of the Indian Ocean and smaller pieces sampled across the main part of the gyre. Variation in numbers of plastic particles between the three tows at each station also highlights fine scale aggregations of plastic across the survey area. See figure 24 for an example of the plastic particles sampled.

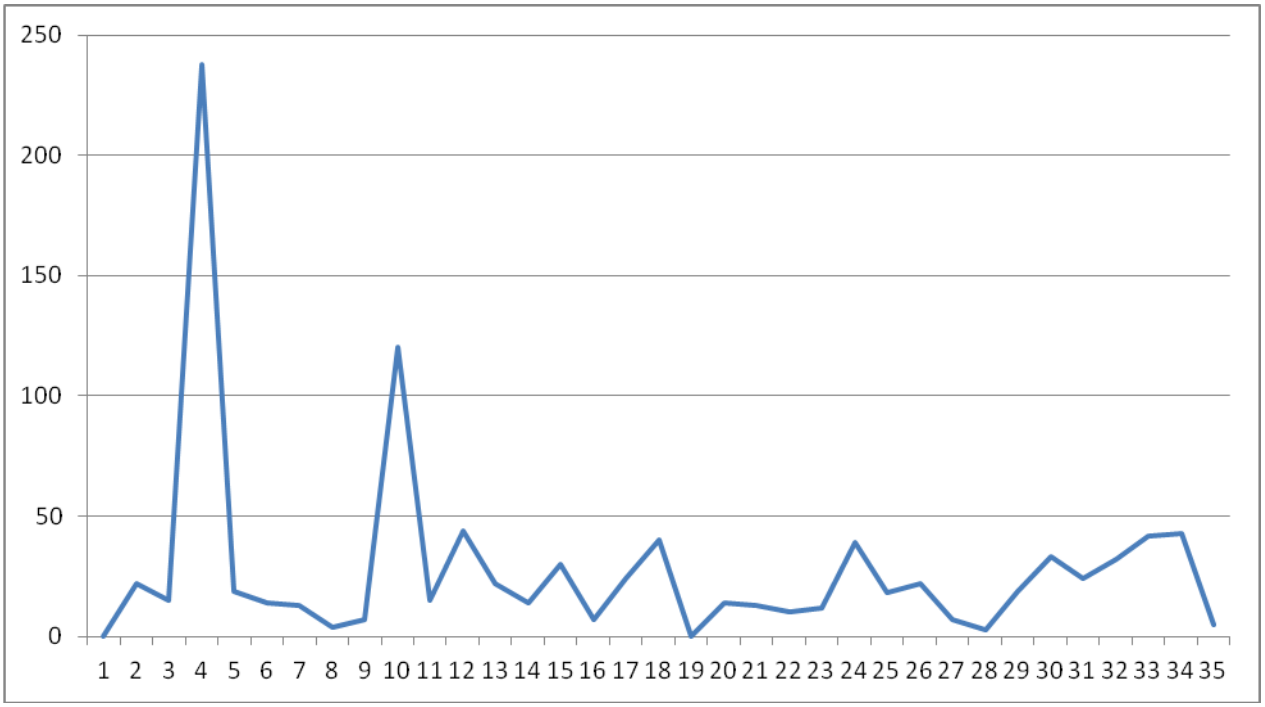


Figure 23. Number of particles likely to be of plastic in the Manta trawl catches (3 x 15 minutes towing time per station) during the survey.

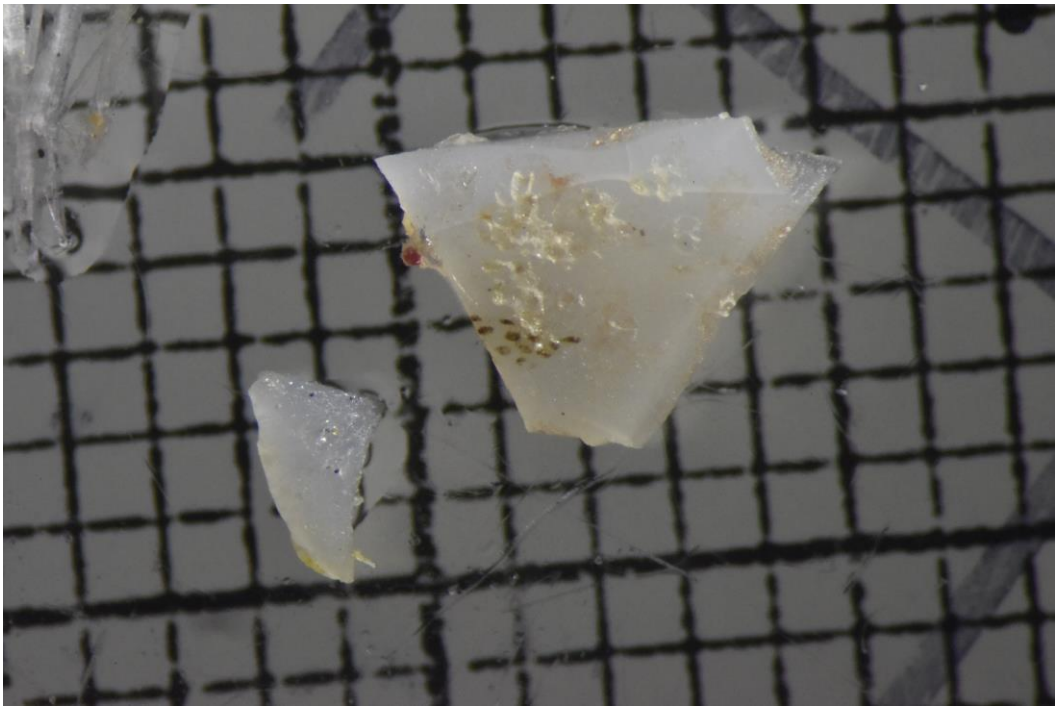


Figure 24. Example of plastic particle sampled from the manta trawl.

CHAPTER 4 SUMMARY OF RESULTS

Hydrography

This study area in the Southern Indian Ocean has almost been unvisited in the past. Thus the physical and biogeochemical data obtained would help gain a better understanding of the properties of the Indian Ocean subtropical gyre. Various sampling techniques combining the CTD hydrocasts, classical chemicals analyses, Bio-Argo floats and surface drifters were attempted in this survey. This helped us to simultaneously study both spatial and temporal bio-physical features. This dataset is of key importance to indicate some of the processes responsible for primary productivity in this oligotrophic part of the ocean. In particular, our observations highlighted the importance of the mesoscale (50 to 200 km) variability which seems to modulate the productivity in the subtropical gyre.

Plankton

The preliminary results of the survey show that diatoms and dinoflagellates are the main groups of micro-phytoplankton community in the Southern Indian Ocean waters. In addition, zooplankton samples were collected to describe the calanoid copepod community of the southern Indian Ocean gyre and to estimate the effects of the gyre and environment on the species composition of the pelagic realm. Our activities will shed light on the mesozooplankton community of a poorly surveyed part of the Indian Ocean.

Fish

The survey covered a section through the high seas of the southern Indian Ocean. Altogether, 19 pelagic-trawl stations were carried out, mainly to identify species composition of mesopelagic fish in the main scattering layers of water column. The dominating species were of the family

Myctophidae. The densities were generally low, but highest on both sides of the Ocean. The fish made diurnal migrations, to the upper water layers during night and to deeper waters during daytime.

Plastic particles

ANNEX I. FISHING STATIONS

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 1
DATE :29/06/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 12°54.72
start stop duration Lon E 102°59.51
TIME :12:48:38 13:16:57 28.3 (min) Purpose : 1
LOG : 4044.40 4045.87 1.5 Region : 20000
FDEPTH: 100 120 Gear cond.: 0
BDEPTH: 4675 4686 Validity : 0
Towing dir: 0° Wire out : 250 m Speed : 3.1 kn
Sorted : 0 Total catch: 0.72 Catch/hour: 1.53

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Loligo sp.	0.06	121	3.61	7
Astronesthes trifibulatus	0.20	2	13.32	10
Diplophos sp.	0.06	4	4.17	15
Antigonia 'deep'	0.06	4	3.61	5
Unidentified crustacean	0.04	11	2.78	
Oplophorus grimaldii	0.13	189	8.33	3
Solenocera sp.	0.02	6	1.39	9
Bothidae - juvenile	0.03	8	1.81	17
Scombrolabrax heterolepis	0.11	4	6.94	2
Leptocephalus	0.09	40	6.11	12
Apogon - juvenile	0.06	2	3.61	22
Maurolicus sp.	0.00	6	0.28	4
Lampanyctus sp.	0.01	8	0.42	21
Sergestes sp.	0.02	23	1.53	20
Jellyfish	0.02	0	1.53	
Jelly squid	0.04	8	2.50	
Acanthephyra sp.	0.25	110	16.39	11
Abraliopsis gilchristi	0.03	4	1.67	8
Melanostomias sp.	0.01	2	0.97	6
PARALEPIDIDAE	0.06	6	3.61	13
Ceratoscopelus warmingii	0.03	64	2.08	14
Decapterus sp.	0.00	4	0.28	16
Astronesthes cf indicus	0.01	4	0.97	18
Leptocephalus *	0.09	34	6.11	19
Hygophum hygomii	0.03	11	2.22	23
Symbolophorus evermanni	0.01	4	0.97	27
Bolanichthys indicus	0.04	40	2.78	26
Total	1.53		99.99	

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 2
DATE :30/06/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 14°17.48
start stop duration Lon E 101°29.32
TIME :03:10:22 03:40:26 30.1 (min) Purpose : 1
LOG : 4165.89 4167.32 1.4 Region : 20000
FDEPTH: 350 370 Gear cond.: 0
BDEPTH: 4463 4915 Validity : 0
Towing dir: 0° Wire out : 750 m Speed : 2.9 kn
Sorted : 0 Total catch: 0.33 Catch/hour: 0.65

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP

Argyropelecus sladeni	0.03	30	0.00	37
Loligo sp.	0.05	24	0.00	40
Myctophum selenops	0.02	4	0.00	32
Nemichthys curvirostris	0.01	2	0.00	41
Ichthyococcus ovatus**	0.01	6	0.00	38
Margrethis cf obtusirostra	0.02	18	0.00	34
Vinciguerria cf attenuata	0.00	8	0.00	39
Leptocephalus	0.01	2	0.00	36
Lolligoncula mercatoris	0.08	2	0.00	35
JELLYFISH	0.12	66	0.00	
Myctophum sp.	0.01	6	0.00	33
Sergestes sp.	0.01	4	0.00	42
Polymetme corythaeola	0.13	20	0.00	43
Illex coindetii	0.02	8	0.00	25
Opisthoproctus sp.	0.03	6	0.00	30
Oplophorus grimaldii	0.00	4	0.00	31
Argyropelecus aculeatus	0.06	28	0.00	28
Photichthys sp.	0.01	2	0.00	29
Unidentified crustacean larvae	0.01	46	0.00	
Amphipods	0.01	2	0.00	
Maurolicus muelleri	0.02	6	0.00	44

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 3
DATE :30/06/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 15°29.64
start stop duration Lon E 100°13.65
TIME :18:57:46 19:27:53 30.1 (min) Purpose : 1
LOG : 4274.65 4276.32 1.7 Region : 20000
FDEPTH: 100 130 Gear cond.: 0
BDEPTH: 5346 5254 Validity : 0
Towing dir: 0° Wire out : 250 m Speed : 3.3 kn
Sorted : 0 Total catch: 1.99 Catch/hour: 3.97

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Diaphus sp.	0.84	167	21.13	54
Melanostomias sp.	0.03	4	0.75	62
Leptocephalus	0.05	20	1.31	46
Lestrolepis intermedia	0.06	22	1.51	58
Loligo sp.	0.35	80	8.73	61
Nemichthys sp.	0.02	6	0.55	45
Unidentified crustacean	0.02	2	0.40	
Diplophos taenia	0.07	12	1.66	50
Vinciguerria cf. nimbaria	0.00	2	0.10	59
Myctophum sp.	0.03	4	0.70	51
Ceratoscopelus warmingii	1.58	627	39.86	53
Lampanyctus sp.	0.07	6	1.76	56
Symbolophorus evermanni	0.28	74	7.03	57
Bolanichthys indicus	0.13	110	3.16	52
Astronesthes cf indicus**	0.31	2	7.83	47
Decapterus sp.	0.02	4	0.45	48
Solenocera sp.	0.02	6	0.50	60
Drepane sp.	0.01	4	0.35	49
JELLYFISH	0.06	0	1.41	
Hygophum sp.	0.03	16	0.80	55
Total	3.97		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 4
DATE :01/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 17°16.74
start stop duration Lon E 98°17.64

TIME :13:41:43 14:15:14 33.5 (min) Purpose : 1
LOG : 4433.23 4434.99 1.8 Region : 20000
FDEPTH: 100 110 Gear cond.: 0
BDEPTH: 5602 5595 Validity : 0
Towing dir: 0° Wire out : 250 m Speed : 3.2 kn
Sorted : 0 Total catch: 1.85 Catch/hour: 3.30

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Jellyfish	0.38	0	11.48	
Diplophos taenia	0.19	50	5.69	86
Lobster larvae	0.04	2	1.35	
Astronesthes sp.	0.01	4	0.33	65
Astronesthes cf indicus**	0.01	2	0.22	66
Loligo vulgaris	0.07	45	2.17	67
Symbolophorus evermanni	0.22	61	6.55	68
Diaphus effulgens	0.59	138	17.88	81
Ceratoscopelus warmingii	0.63	376	19.07	75
Nemichthys sp.	0.00	4	0.08	71
Loligo sp.	0.04	25	1.19	72
Leptocephalus	0.01	4	0.38	73
Leptocephalus *	0.01	14	0.44	74
Lestrolepis intermedia	0.00	2	0.02	85
Myctophum selenops	0.00	2	0.11	78
Hygophum sp.	0.01	13	0.19	92
Solenocera sp.	0.02	5	0.49	82
Acanthephyra sp.	0.01	5	0.22	83
Vinciguerria cf. nimbaria	0.01	27	0.22	70
Hygophum reinhardtii	0.09	13	2.87	87
Lampanyctus sp.	0.00	2	0.11	89
Eucleoteuthis luminosa	0.44	7	13.38	69
Ceratoscopelatus cf maderensis	0.01	4	0.43	76
Bolanichthys sp.	0.39	30	11.92	84
Unidentified crustacean larvae	0.01	0	0.38	
Unidentified crustacean	0.02	0	0.60	
Diaphus sp.	0.05	66	1.63	91
Sergestes sp.	0.00	7	0.11	79
Diaphus richardsoni	0.01	9	0.43	90
Beryx splendens	0.00	2	0.05	80
Total	3.30		99.98	

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 5
DATE :02/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 18°10.40
start stop duration Lon E 97°14.90
TIME :04:11:10 04:41:44 30.6 (min) Purpose : 1
LOG : 4515.13 4516.53 1.4 Region : 20000
FDEPTH: 400 430 Gear cond.: 0
BDEPTH: 5509 5568 Validity : 0
Towing dir: 0° Wire out : 800 m Speed : 2.8 kn
Sorted : 0 Total catch: 0.40 Catch/hour: 0.78

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Myctophum selenops	0.02	10	0.00	102
Opisthoproctus grimaldii	0.00	12	0.00	99
Jellyfish	0.02	0	0.00	
Loligo sp.	0.11	59	0.00	103
Vinciguerria cf. nimbaria	0.04	8	0.00	100
Maurolicus muelleri	0.00	4	0.00	96
Diaphus sp.	0.03	33	0.00	104
Brachioteuthis picta	0.04	41	0.00	101

Eucleoteuthis luminosa	0.38	4	0.00	95
Solenocera sp.	0.03	14	0.00	105
Histioteuthis sp. *	0.02	4	0.00	106
Diaphus effulgens	0.03	4	0.00	93
Ariomma sp.	0.02	6	0.00	97
Diaphus cf. brachycephalus	0.01	2	0.00	98
Lobster larvae	0.01	2	0.00	

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 6
DATE :02/07/15 GEAR TYPE: PT NO: 1 POSITION:Lat S 19°23.38
start stop duration Lon E 95°45.50
TIME :19:48:43 20:18:42 30.0 (min) Purpose : 1
LOG : 4628.80 4630.52 1.7 Region : 20000
FDEPTH: 135 140 Gear cond.: 0
BDEPTH: 5405 5389 Validity : 0
Towing dir: 0° Wire out : 330 m Speed : 3.5 kn
Sorted : 0 Total catch: 0.40 Catch/hour: 0.79

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Leptocephalus	0.04	6	0.00	113
Diplophos taenia	0.05	2	0.00	114
Diaphus effulgens	0.13	18	0.00	111
Chauliodus sloani	0.03	4	0.00	109
Ceratoscopelus warmingii	0.20	66	0.00	110
Loligo sp.	0.02	18	0.00	107
Jellyfish	0.05	0	0.00	
Eucleoteuthis luminosa	0.03	2	0.00	119
Unidentified crustacean	0.01	2	0.00	
Astronesthes trifibulatus	0.04	4	0.00	112
Solenocera sp.	0.01	4	0.00	108
Sergestes sp.	0.03	70	0.00	115
Symbolophorus evermanni	0.03	8	0.00	94
Lampanyctus alatus	0.03	30	0.00	116
Hygophum reinhardtii	0.01	2	0.00	117
Lobianchia gemellarii	0.07	54	0.00	118
Balistes sp.	0.00	2	0.00	120
Myctophum phengodes	0.01	2	0.00	121
Vinciguerria cf attenuata	0.02	14	0.00	122
Bonapartia pedaliota	0.00	2	0.00	123

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 7
DATE :03/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 20°0.39
start stop duration Lon E 94°37.87
TIME :10:00:37 10:30:35 30.0 (min) Purpose : 1
LOG : 4712.01 4713.48 1.5 Region : 20000
FDEPTH: 450 470 Gear cond.: 0
BDEPTH: 5009 5073 Validity : 0
Towing dir: 0° Wire out : 950 m Speed : 2.9 kn
Sorted : 0 Total catch: 0.76 Catch/hour: 1.53

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Solenocera sp.	0.02	4	1.05	135
Oplophorus grimaldii	0.02	16	1.57	136
Sergestes sp.	0.03	14	1.97	137
Opisthoproctus grimaldii	0.01	2	0.66	138
Hygophum reinhardtii	0.03	24	1.83	139
Diaphus effulgens	0.05	10	3.01	140

Lobianchia gemellarii	0.07	56	4.46	141
Myctophum phengodes	0.01	4	0.52	142
Diaphus sp.	0.01	6	0.52	143
Loligo sp.	0.01	2	0.52	124
Eucleoteuthis luminosa	0.01	2	0.66	125
Argyropelecus hemigymnus	0.02	14	1.18	126
Argyropelecus aculeatus	0.01	2	0.92	127
Lampanyctus alatus	0.00	2	0.26	129
SALPS	1.07	0	69.99	
Sternoptyx pseudobscura	0.00	2	0.26	130
Vinciguerria cf attenuata	0.04	24	2.36	131
Unidentified crustacean larvae	0.00	2	0.00	
Unidentified crustacean	0.05	12	3.54	
Myctophum selenops	0.03	2	1.97	132
Gonostoma sp.	0.02	18	1.31	133
Melanostomias sp.	0.02	2	1.31	134
Total	1.53		99.87	

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 8
DATE :03/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 20°0.19
start stop duration Lon E 93°2.40
TIME :20:18:19 20:47:34 29.3 (min) Purpose : 1
LOG : 4801.89 4803.57 1.7 Region : 20000
FDEPTH: 145 160 Gear cond.: 0
BDEPTH: 4475 3915 Validity : 0
Towing dir: 0° Wire out : 330 m Speed : 3.5 kn
Sorted : 0 Total catch: 0.90 Catch/hour: 1.84

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Lobianchia sp.	0.26	209	13.95	159
Leptocephalus	0.00	4	0.22	161
Lampanyctus sp.	0.13	178	6.92	160
Ceratoscopelus warmingii	0.29	152	15.51	158
Jellyfish	0.30	0	16.07	
Lestrolepis intermedia	0.02	31	1.12	162
Astronesthes trifibulatus	0.01	2	0.78	163
Amphipods	0.01	6	0.33	
Unidentified crustacean larvae	0.02	10	1.23	
Myctophum selenops	0.01	2	0.67	150
Chauliodus sloani	0.01	2	0.45	151
Solenocera sp.	0.02	10	1.23	152
Oplophorus grimaldii	0.07	349	4.02	153
Vinciguerria nimbaria	0.11	421	6.03	154
Lampanyctus alatus	0.00	6	0.22	155
Scopelosaurus sp.	0.00	2	0.11	156
Bregmaceros sp.	0.00	2	0.11	157
Loligo sp.	0.14	185	7.81	64
Symbolophorus evermanni	0.03	12	1.56	77
CARIDEA	0.00	55	0.22	143
Krill	0.02	199	1.23	144
Diaphus effulgens	0.16	74	8.59	145
Diaphus lucidus	0.03	45	1.79	146
Diaphus sp.	0.00	8	0.22	147
Lobianchia gemellarii	0.06	78	3.35	148
Diaphus taaningi	0.01	4	0.33	149
Myctophum phengodes	0.01	18	0.56	164
Diaphus richardsoni	0.02	53	1.23	165
Benthosema sp.	0.07	53	4.02	166
Caristius sp.	0.00	2	0.11	168

Total	1.84	100.00	

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 9
DATE :04/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 20°0.35
start stop duration Lon E 90°24.91
TIME :14:43:14 15:13:19 30.1 (min) Purpose : 1
LOG : 4951.02 4952.66 1.6 Region : 20000
FDEPTH: 80 110 Gear cond.: 0
BDEPTH: 5187 5232 Validity : 0
Towing dir: 0° Wire out : 240 m Speed : 3.3 kn
Sorted : 0 Total catch: 1.14 Catch/hour: 2.26

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Symbolophorus evermanni	0.27	76	11.89	189
Diaphus effulgens	0.48	152	21.41	190
Loligo sp.	0.20	90	8.72	170
Krill	0.11	4	4.93	
Lampanyctus alatus	0.01	4	0.44	175
Gonostoma sp.	0.01	6	0.44	176
Oplophorus grimaldii	0.01	8	0.26	171
Solenocera sp.	0.01	2	0.26	174
Acanthephyra sp.	0.01	104	0.53	172
Ceratoscopelus warmingii	0.09	38	3.79	179
Lobianchia gemellarii	0.04	60	1.85	194
Hygophum reinhardtii	0.09	38	4.05	169
Lampanyctus tenuiformis	0.02	30	0.88	178
Diaphus taaningi	0.00	4	0.18	177
Diaphus cf. brachycephalus	0.00	2	0.09	181
Myctophum phengodes	0.01	4	0.26	191
Astronesthes indicus	0.04	2	1.59	192
Eucleoteuthis luminosa	0.08	4	3.61	187
Paralepidae	0.00	2	0.09	183
Ranzania laevis	0.05	20	2.11	184
Illex coindetii	0.00	14	0.07	173
SALPS	0.59	12	25.90	
Notoscopelus resplendens	0.12	28	5.37	188
Scopelosaurus ahlstromi	0.01	4	0.53	185
Bregmaceros sp.	0.01	22	0.44	186
Benthosema sp.	0.00	6	0.09	180
Bolanichthys indicus	0.00	2	0.18	182
Total	2.26		99.98	

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 10
DATE :05/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 20°0.07
start stop duration Lon E 88°35.08
TIME :09:02:33 09:32:09 29.6 (min) Purpose : 1
LOG : 5057.69 5059.20 1.5 Region : 20000
FDEPTH: 500 515 Gear cond.: 0
BDEPTH: 2803 2931 Validity : 0
Towing dir: 0° Wire out : 1025 m Speed : 3.1 kn
Sorted : 0 Total catch: 0.29 Catch/hour: 0.58

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Sergestes sp.	0.10	128	0.00	195
Unidentified crustacean larvae	0.01	0	0.00	
Jellyfish	0.06	0	0.00	
Argyropelecus aculeatus	0.04	8	0.00	196
Argyropelecus hemigymnus	0.02	10	0.00	197

Krill	0.02	0	0.00	
Leptocephalus *	0.01	8	0.00	198
Sternoptyx diaphana	0.01	4	0.00	199
Valenciennellus tripunctulatus	0.00	2	0.00	200
Solenocera sp.	0.01	2	0.00	201
PARALEPIDIDAE	0.01	4	0.00	63
Amphipods	0.00	2	0.00	
Vinciguerria nimbaria	0.01	2	0.00	202
Polymetme corythaeola	0.01	24	0.00	203
Diaphus cf. brachycephalus	0.03	53	0.00	205
Lobianchia gemellarii	0.01	12	0.00	204
Diaphus sp.	0.00	2	0.00	206
Myctophum selenops	0.00	2	0.00	207
Brachioteuthis picta	0.23	170	0.00	208

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 11
DATE :05/07/15 GEAR TYPE: PT NO: 1 POSITION:Lat S 20°0.37
start stop duration Lon E 87°37.66
TIME :16:08:17 16:38:12 29.9 (min) Purpose : 1
LOG : 5111.73 5113.27 1.5 Region : 20000
FDEPTH: 30 40 Gear cond.: 0
BDEPTH: 1799 1842 Validity : 0
Towing dir: 0° Wire out : 110 m Speed : 3.1 kn
Sorted : 0 Total catch: 0.15 Catch/hour: 0.31

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Loligo sp.	0.04	32	0.00	209
Symbolophorus evermanni	0.09	14	0.00	210
Leptocephalus	0.00	4	0.00	211
Diaphus effulgens	0.01	14	0.00	214
Ceratoscopelus warmingii	0.09	80	0.00	213
Krill	0.00	14	0.00	
Solenocera sp.	0.01	2	0.00	212
PYROSOMIDAE	0.01	0	0.00	
Plankton	0.02	10	0.00	
Hygophum hygomii	0.01	2	0.00	217
Benthosema sp.	0.01	22	0.00	215
Hygophum reinhardtii	0.01	8	0.00	216

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 12
DATE :06/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 20°1.52
start stop duration Lon E 85°1.82
TIME :11:13:55 11:43:35 29.7 (min) Purpose : 1
LOG : 5261.81 5263.40 1.6 Region : 20000
FDEPTH: 400 500 Gear cond.: 0
BDEPTH: 4919 4951 Validity : 0
Towing dir: 0° Wire out : 850 m Speed : 3.2 kn
Sorted : 0 Total catch: 0.15 Catch/hour: 0.29

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Argyropelecus aculeatus	0.05	24	0.00	218
Sternoptyx diaphana	0.00	2	0.00	219
Argyropelecus hemigymnus	0.00	6	0.00	220
Vinciguerria nimbaria	0.01	26	0.00	221
Krill	0.01	0	0.00	
Jellyfish	0.08	0	0.00	
Plankton	0.00	0	0.00	

Solenocera sp.	0.01	2	0.00	224
Sergestes sp.	0.08	214	0.00	225
Diaphus richardsoni	0.03	28	0.00	222
Lobianchia gemellarii	0.01	22	0.00	223
Myctophum selenops	0.00	2	0.00	226
Loligo sp.	0.00	6	0.00	227

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 13
DATE :07/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 20°0.28
start stop duration Lon E 81°28.36
TIME :15:59:28 16:59:49 60.4 (min) Purpose : 1
LOG : 5476.26 5479.45 3.2 Region : 20000
FDEPTH: 45 55 Gear cond.: 0
BDEPTH: 4858 5032 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.2 kn
Sorted : 0 Total catch: 1.70 Catch/hour: 1.69

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Krill	0.13	0	7.52	
Loligo sp.	0.18	187	10.92	241
Diaphus effulgens	0.34	143	20.38	242
Solenocera sp.	0.02	7	1.06	239
Eucleoteuthis luminosa	0.12	3	7.16	240
Astronesthes indicus	0.01	5	0.70	237
Plankton	0.00	0	0.06	
Astronesthes trifibulatus	0.00	1	0.12	238
Bolanichthys indicus	0.00	1	0.06	235
Bregmaceros sp.	0.00	11	0.23	236
Notoscopelus resplendens	0.01	8	0.47	233
Symbolophorus evermanni	0.05	19	2.99	234
Hygophum hygomii	0.05	22	2.70	231
Lampanyctus sp.	0.01	32	0.76	232
Acanthephyra sp.	0.03	544	1.76	229
Symplectoteuthys oualaniensis	0.09	1	5.28	228
Sergestes cf. seminudus	0.02	47	1.47	230
Melanostomias sp.	0.00	1	0.12	244
Diaphus splendidus	0.01	7	0.70	245
Diaphus sp.	0.01	8	0.76	246
Ceratoscopelus warmingii	0.59	346	34.76	248
Total	1.69		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 14
DATE :08/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 20°25.78
start stop duration Lon E 78°23.71
TIME :16:48:05 17:18:17 30.2 (min) Purpose : 1
LOG : 5663.75 5665.61 1.9 Region : 20000
FDEPTH: 65 80 Gear cond.: 0
BDEPTH: 4733 4607 Validity : 0
Towing dir: 0° Wire out : 160 m Speed : 3.7 kn
Sorted : 0 Total catch: 1.48 Catch/hour: 2.95

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Diaphus effulgens	1.10	469	37.49	265
Eucleoteuthis luminosa	0.07	4	2.43	260
Symbolophorus evermanni	0.14	56	4.86	261
Symplectoteuthys oualaniensis	0.04	4	1.21	262
Ceratoscopelus warmingii	1.30	1723	44.10	263

Bolanichthys indicus	0.01	8	0.34	264
Diaphus cf. brachycephalus	0.01	8	0.20	266
Hygophum sp.	0.04	24	1.35	267
Lampanyctus sp.	0.13	223	4.32	258
Notoscopelus resplendens	0.01	8	0.47	259
Solenocera sp.	0.01	4	0.20	249
Krill	0.01	0	0.34	
Eustomias sp.	0.00	6	0.13	250
Illex coindetii	0.01	2	0.34	251
Leptocephalus *	0.01	2	0.20	252
Sergestes cf. seminudus	0.02	58	0.74	253
Black paralepidae	0.00	2	0.07	254
Acanthephyra sp.	0.03	149	0.94	256
Astronesthes cf indicus**	0.00	2	0.13	257
Idiacanthus sp.	0.00	2	0.13	255
Total	2.95		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 15
DATE :09/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 20°1.44
start stop duration Lon E 76°51.69
TIME :06:06:39 07:07:33 60.9 (min) Purpose : 1
LOG : 5762.25 5765.37 3.1 Region : 20000
FDEPTH: 445 460 Gear cond.: 0
BDEPTH: 4943 3897 Validity : 0
Towing dir: 0° Wire out : 955 m Speed : 3.1 kn
Sorted : 0 Total catch: 0.56 Catch/hour: 0.55

SPECIES	CATCH/HOUR weight	% OF TOT. C numbers		SAMP
Jellyfish	0.04	0	7.53	
Diaphus cf. brachycephalus	0.01	5	1.79	276
Valenciennellus tripunctulatus	0.00	6	0.36	277
Krill	0.02	0	3.23	
Eustomias sp.	0.00	1	0.18	274
Vinciguerria nimbaria	0.00	5	0.36	275
Ichthyococcus ovatus**	0.00	2	0.18	272
Lobianchia gemellarii	0.00	2	0.18	273
Acanthephyra sp.	0.02	8	3.23	268
Polymetme corythaeola	0.02	19	4.48	269
Unidentified crustacean	0.00	0	0.18	
Diaphus mollis	0.00	1	0.18	270
Loligo sp.	0.33	126	59.50	271
Argyropelecus aculeatus	0.01	1	1.97	280
Argyropelecus hemigymnus	0.03	13	5.02	281
Myctophum selenops	0.03	5	5.38	278
Sergestes sp.	0.03	65	6.27	279
Total	0.55		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 16
DATE :10/07/15 GEAR TYPE: NO: 0 POSITION:Lat S 19°59.92
start stop duration Lon E 73°26.73
TIME :14:28:36 15:30:16 61.7 (min) Purpose : 1
LOG : 5974.55 5977.38 2.8 Region : 20000
FDEPTH: 30 40 Gear cond.: 0
BDEPTH: 4388 4507 Validity : 0
Towing dir: 0° Wire out : 100 m Speed : 2.8 kn
Sorted : 0 Total catch: 0.00 Catch/hour: 0.00

SPECIES	CATCH/HOUR	% OF TOT. C	SAMP

	weight	numbers	
N O C A T C H	0.00	0	0.00

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 17
DATE :11/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 20°0.43
start stop duration Lon E 71°58.45
TIME :04:44:38 05:44:59 60.4 (min) Purpose : 1
LOG : 6066.72 6069.78 3.1 Region : 20000
FDEPTH: 450 480 Gear cond.: 0
BDEPTH: 4114 4043 Validity : 0
Towing dir: 0° Wire out : 950 m Speed : 3.1 kn
Sorted : 0 Total catch: 0.33 Catch/hour: 0.33

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Myctophum selenops	0.01	3	0.00	282
Argyropelecus hemigymnus	0.02	30	0.00	283
Loligo sp.	0.01	2	0.00	284
Argyropelecus aculeatus	0.04	6	0.00	285
Sternoptyx diaphana	0.00	1	0.00	286
Valenciennellus tripunctulatus	0.00	25	0.00	287
Krill	0.03	0	0.00	
Oplophorus grimaldii	0.00	1	0.00	288
Ichthyococcus ovatus**	0.00	3	0.00	289
Sergestes sp.	0.10	63	0.00	290
Diaphus cf. brachycephalus	0.01	9	0.00	291
MOLIDAE	0.00	2	0.00	292
SALPS	0.07	0	0.00	
Vinciguerria sp.	0.00	1	0.00	294
Vinciguerria nimbaria	0.00	1	0.00	293
Lobianchia gemellarii	0.00	3	0.00	295
Amphipods	0.00	0	0.00	
Vinciguerria cf attenuata	0.01	24	0.00	296
Diaphus sp.	0.00	1	0.00	297

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 18
DATE :11/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 20°0.17
start stop duration Lon E 70°24.31
TIME :17:53:17 18:46:52 53.6 (min) Purpose : 1
LOG : 6157.46 6160.47 3.0 Region : 20000
FDEPTH: 40 50 Gear cond.: 0
BDEPTH: 3278 3117 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.4 kn
Sorted : 0 Total catch: 3.46 Catch/hour: 3.87

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Eucleoteuthis luminosa	0.11	1	2.89	298
Symplectoteuthys oualaniensis	0.56	4	14.33	299
Opisthoproctus grimaldii	0.00	1	0.06	300
Diplophos taenia	0.00	1	0.03	301
Hygophum hygomii	0.01	6	0.29	302
Krill	0.14	0	3.58	
Lampanyctus sp.	0.13	278	3.35	303
Diaphus problematicus	0.45	166	11.56	304
SALPS	0.01	0	0.29	
Astronesthes sp.	0.02	3	0.43	305
Diaphus sp.	0.01	6	0.29	306
Ceratoscopelus warmingii	0.98	287	25.31	307

Diaphus effulgens	0.52	179	13.52	308
PYROSOMIDAE	0.02	0	0.46	
Solenocera sp.	0.00	1	0.03	
Bolanichthys indicus	0.01	21	0.35	309
Amphipods	0.00	0	0.03	
Unidentified crustacean	0.01	0	0.14	
Illex coindetii	0.04	19	0.95	310
Abraliopsis gilchristi	0.04	1	1.01	311
Benthosema sp.	0.00	6	0.06	312
Leptocephalus *	0.01	6	0.20	313
Leptocephalus	0.01	4	0.29	314
Acanthephyra sp.	0.10	313	2.57	315
Oplophorus grimaldii	0.01	4	0.17	316
Sergestes cf. seminudus	0.25	273	6.39	317
Symbolophorus evermanni	0.44	161	11.33	318
Bregmaceros sp.	0.00	1	0.03	319
Scopelosaurus ahlstromi	0.00	2	0.06	320
Total	3.87		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2015406 STATION: 19
DATE :12/07/15 GEAR TYPE: PT NO: 2 POSITION:Lat S 21°18.27
start stop duration Lon E 67°46.40
TIME :20:27:19 21:27:08 59.8 (min) Purpose : 1
LOG : 6347.19 6350.00 2.8 Region : 20000
FDEPTH: 32 42 Gear cond.: 0
BDEPTH: 3186 3158 Validity : 0
Towing dir: 0° Wire out : 100 m Speed : 2.8 kn
Sorted : 0 Total catch: 0.90 Catch/hour: 0.90

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Diaphus effulgens	0.03	61	3.67	321
Astronesthes cf indicus**	0.00	4	0.33	322
Eustomias sp.	0.00	2	0.22	323
Ceratoscopelus sp.	0.01	31	0.89	324
Plankton	0.00	0	0.11	
Lobster larvae	0.00	0	0.11	
Jellyfish	0.09	0	10.00	
SALPS	0.02	0	1.78	
Bolanichthys indicus	0.01	30	1.56	325
Unidentified crustacean	0.00	0	0.44	
Unidentified crustacean	0.01	0	0.67	
Unidentified crustacean larvae	0.01	0	0.89	
Hygophum hygomii	0.02	5	2.44	326
Diplophos sp.	0.01	1	0.89	327
Myctophum phengodes	0.01	3	1.33	328
MOLIDAE	0.01	3	1.11	329
Benthosema sp.	0.01	44	0.89	330
Ceratoscopelatus cf maderensis	0.01	49	1.44	331
Leptocephalus	0.16	0	18.00	
Krill	0.03	0	2.78	
PYROSOMIDAE	0.11	0	12.33	
Sergestes cf. seminudus	0.02	41	1.67	332
Symbolophorus evermanni	0.03	8	2.89	333
Loligo sp.	0.13	0	14.67	
Solenocera sp.	0.02	10	2.00	334
Acanthephyra sp.	0.00	3	0.33	335
Bothidae - juvenile	0.00	1	0.11	336
Ceratoscopelus warmingii	0.01	6	0.89	338
Lampanyctus sp.	0.12	122	13.33	339
Diaphus sp.	0.02	15	2.22	340

Total	0.90	100.00

ANNEX II Instruments and fishing gear used

Fishing gear

Fish sampling was conducted using two different sized "Akrahamm" pelagic trawls:

i) Small Pelagic Trawl measuring 98.5m in length, headline of 20.6m, and 38mm at and 22mm meshsize at body and codend, respectively.

ii) Medium size Pelagic Trawl measuring 105m in length, headline of 29.0m, , and 38mm and 22mm meshsize at body and codend, respectively, with an inner net fitting of 15mm.

Both pelagic trawls were equipped with sweeps measuring 40m long and 12" rubber bobbins gear with the net mouth fanned by 7.4m^2- 1600kg "Egersund" combi-doors. A sensor was attached on the headrope (BP9-50, Scanmar, USA) for estimation of fish flow into the net as well as measurement of the mouth opening height. The wingspread was measured using two door sensors (SS4-D-VTLA, Scanmar, USA). The depth of the trawl was measured using a depth sensor (SS4-P-VTL, Scanmar, USA). A full description of the fishing gears is appended in Annex II.

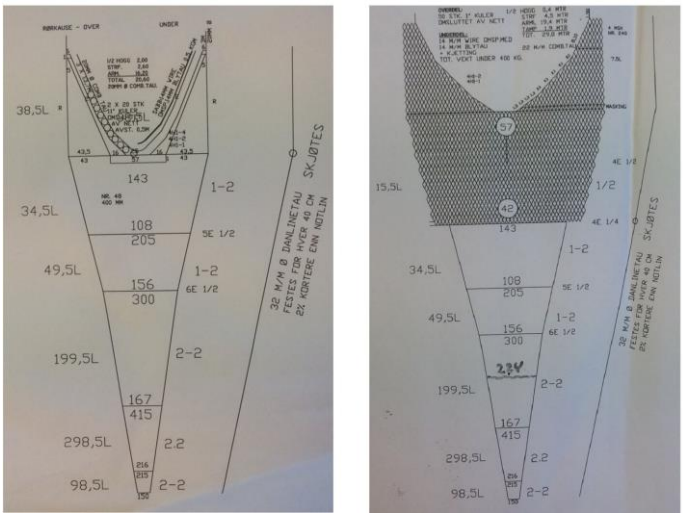


Figure 1. The trawl gear used for the survey of mesopelagic fish in the southern Indian Ocean; the Lite Pelagic trawl and the Mellomstor Pelagic Trawl (left/right, respectively).

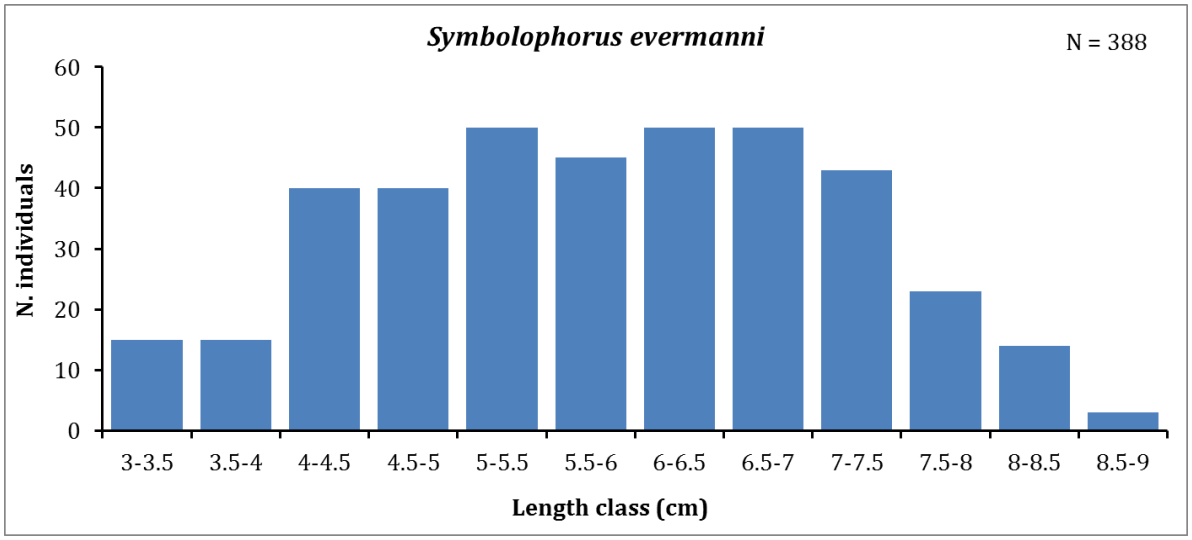
Acoustic instruments

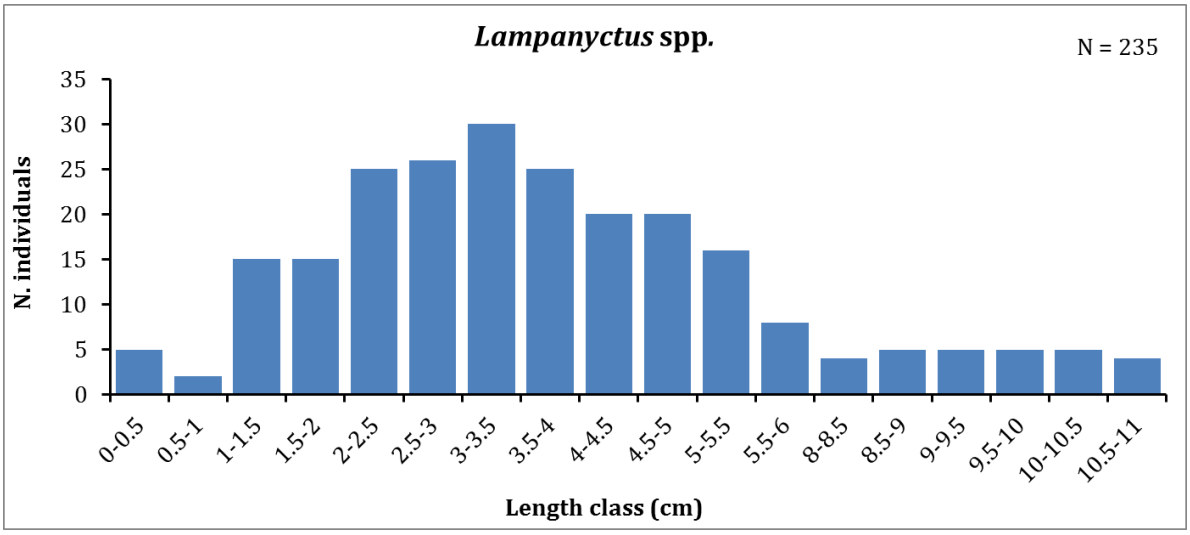
The Simrad ER-60/18, 38, 120 and 200 kHz scientific sounder was run during the survey only for observation of fish and bottom conditions. No scrutinizing of the recordings was done. Last standard sphere calibrations was checked on the 07.07.2013 in Baía dos Elefantes using Cu-64, Cu-60, WC-38.1 add WC-38.1 spheres for 18, 38, 120 and 200 kHz, respectively. The details of the settings for the 38 kHz echo sounder were as follows:

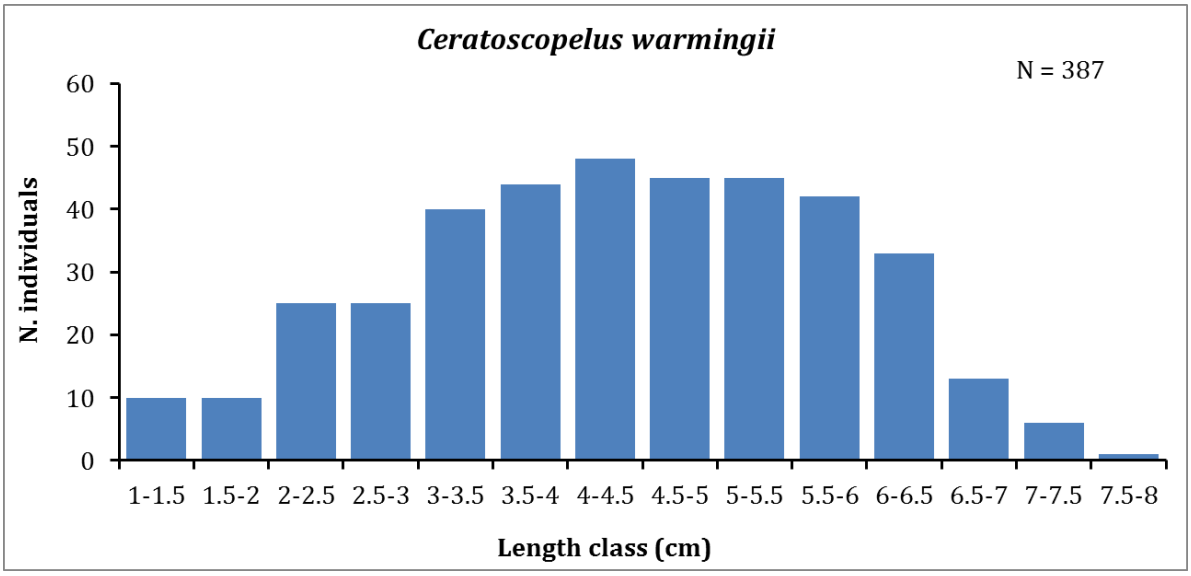
Transceiver-2 menu (38 kHz)	
Transducer depth	6.50 m
Absorbtion coeff.	9.6 dB/km
Pulse duration	medium (1,024ms)
Bandwidth	2.43 kHz
Max power	2000 Watt
2-way beam angle	-20,6dB
gain	25,11 dB
SA correction	-0.60 dB
Angle sensitivity	21.9
3 dB beamwidth	7.43º along ship
7.38º athwardship	
Alongship offset	0.06º
Athwardship offset	0.04º

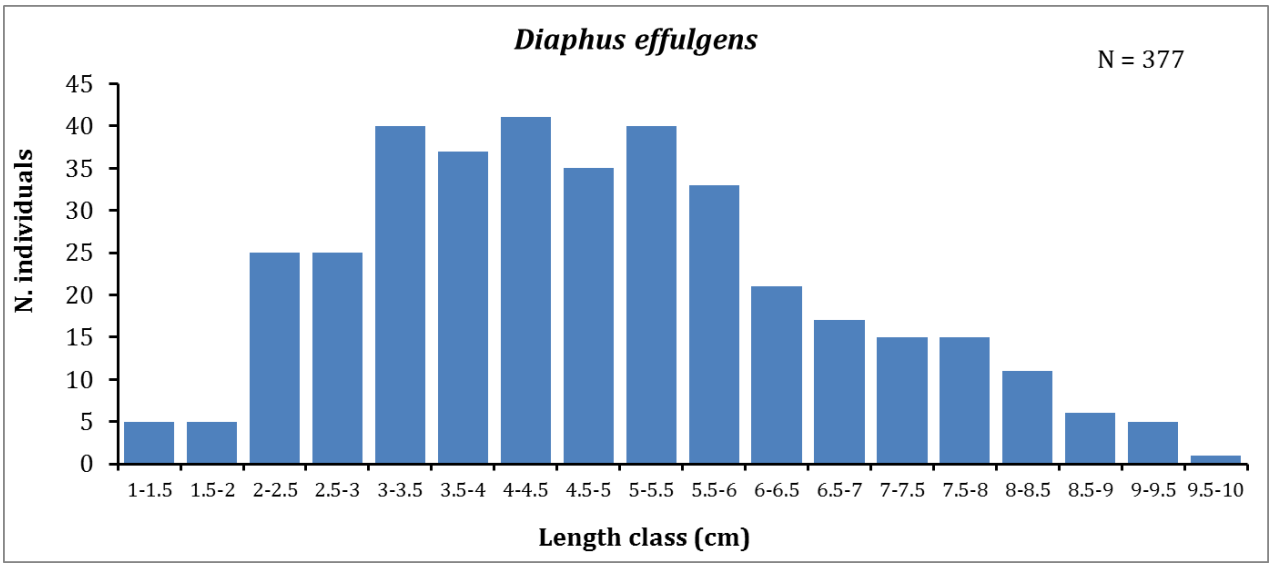
Bottom detection menu Minimum level -40 dB

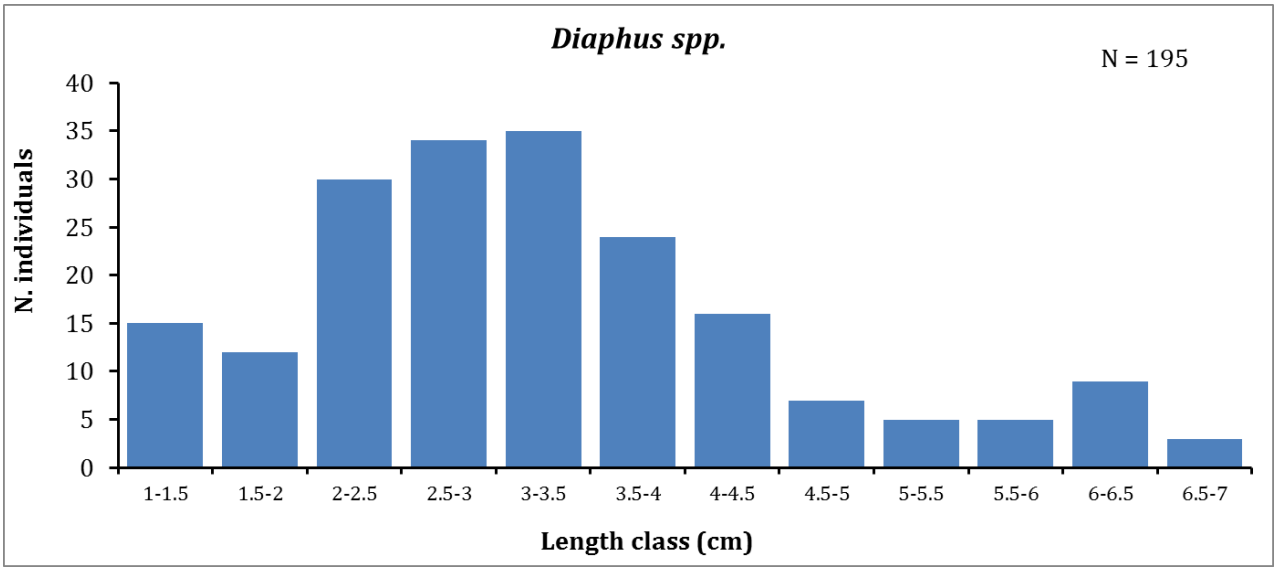
ANNEX III LENGTH FREQUENCY DISTRIBUTIONS

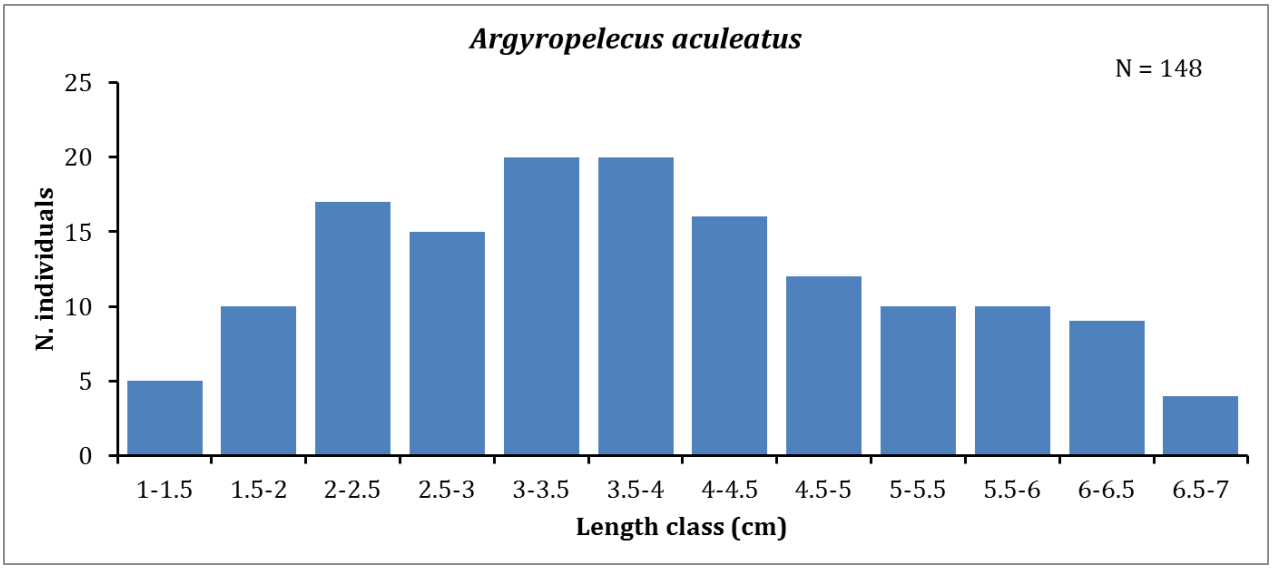


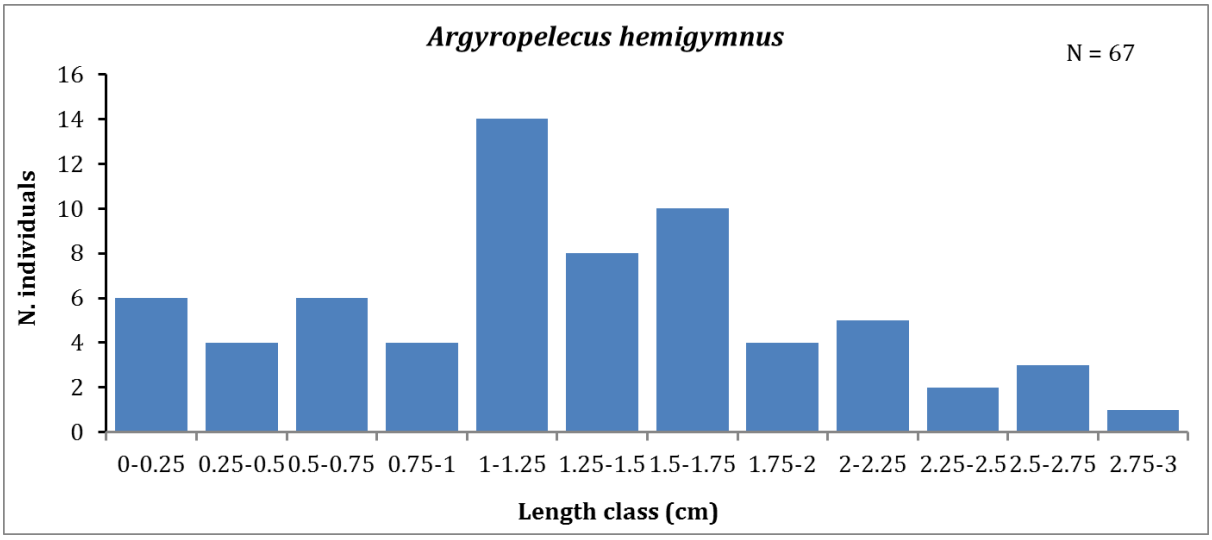


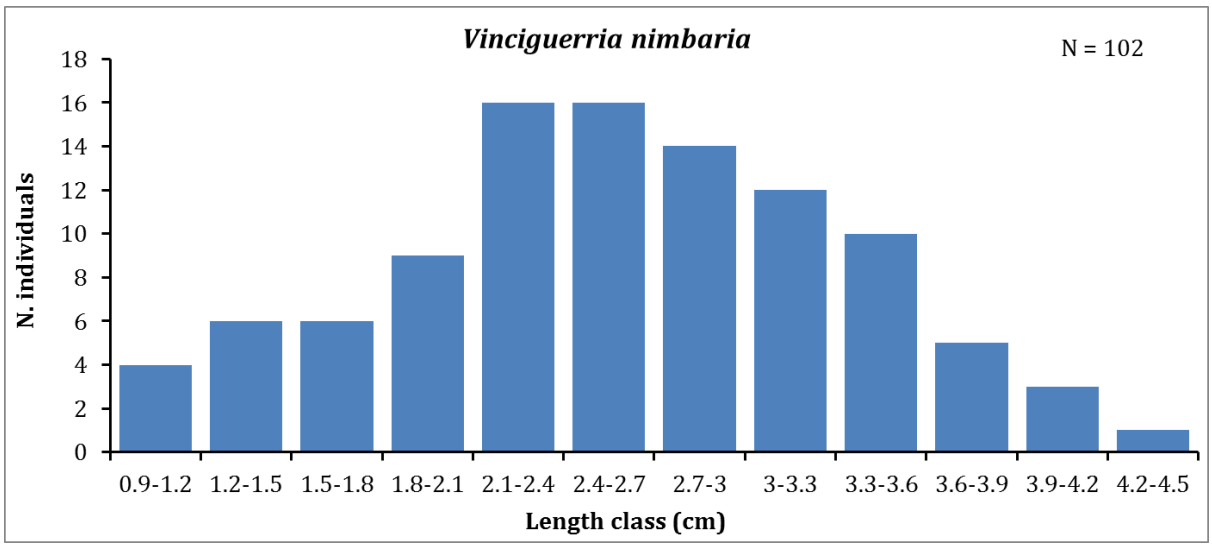



Diaphus effulgens
N = 377
N. individuals
45
40
35
30
25
20
15
10
5
0
1-1.5
1.5-2
2-2.5
2.5-3
3-3.5
3.5-4
4-4.5
4.5-5
5-5.5
5.5-6
6-6.5
6.5-7
7-7.5
7.5-8
8-8.5
8.5-9
9-9.5
9.5-10
Length class (cm)

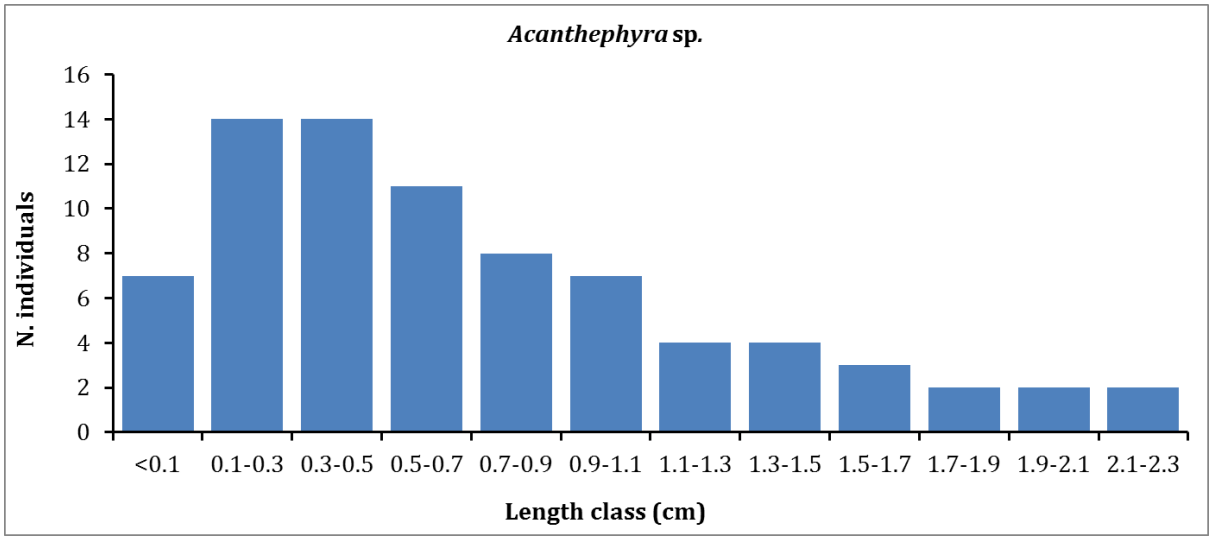

Diaphus spp.
N = 195
N. individuals
40
35
30
25
20
15
10
5
0
1-1.5
1.5-2
2-2.5
2.5-3
3-3.5
3.5-4
4-4.5
4.5-5
5-5.5
5.5-6
6-6.5
6.5-7
Length class (cm)


Argyropelecus aculeatus
N = 148
N. individuals
25
20
15
10
5
0
1-1.5
1.5-2
2-2.5
2.5-3
3-3.5
3.5-4
4-4.5
4.5-5
5-5.5
5.5-6
6-6.5
6.5-7
Length class (cm)


Argyropelecus hemigymnus
N = 67
N. individuals
16
14
12
10
8
6
4
2
0
0-0.25
0.25-0.5
0.5-0.75
0.75-1
1-1.25
1.25-1.5
1.5-1.75
1.75-2
2-2.25
2.25-2.5
2.5-2.75
2.75-3
Length class (cm)


Vinciguerria nimbaria
N = 102
N. individuals
18
16
14
12
10
8
6
4
2
0
0.9-1.2
1.2-1.5
1.5-1.8
1.8-2.1
2.1-2.4
2.4-2.7
2.7-3
3-3.3
3.3-3.6
3.6-3.9
3.9-4.2
4.2-4.5
Length class (cm)

Krill


Acanthephyra sp.
N. individuals
16
14
12
10
8
6
4
2
0
<0.1
0.1-0.3
0.3-0.5
0.5-0.7
0.7-0.9
0.9-1.1
1.1-1.3
1.3-1.5
1.5-1.7
1.7-1.9
1.9-2.1
2.1-2.3
Length class (cm)

ANNEX IV SAMPLING PROTOCOLS FOR MICROPLASTICS

Net: Manta or neuston surface trawl

Trawl duration: 3 x 15 minute trawls

Towing speed: 2 – 3 knots

Tow position: Outside the wake of the vessel

Prior to deploying:

Check a clean cod end is attached

Attach flow meter to net ensuring the propeller will run free and flow meter is facing in the direction of the trawl.

Record the flow meter

Record the weather conditions, wind speed, direction, wave height and vessel direction.

Record the time, date and location (lat/long)

Deployment:

Deploy the trawl gently – do not drop the net as it can damage the flow meter. Once it is in the water, start timing on a stopwatch

Monitor the performance of the net and adjust boat speed if the net is affect by the wake of the vessel.

At ~ 14 mins 30 seconds start getting ready to retrieve the net. It should break the surface at approximately 15 minutes.

Record the stop position

Record the flow meter. Calculate the difference between the start and stop reading.

Wash the net down.
Remove the cod end and gently rinse contents into a sorting tray. Alternatively, can leave contents inside cod end to dry and then empty these contents into a ziplock bag for sorting at a later date.

Wash net and cod ends thoroughly before redeployment to ensure no cross contamination.

Sorting:

Using a head torch and forceps, place all suspected plastic items on a gridded petri dish for examination under microscope (watch for shell fragments and jellyfish film etc)

Photograph gridded petri dish with a label and scale

Record debris items on datasheet

Wrap debris items in foil and label

Annex V Samples and responsibilities of them after the survey

List of Samples:

Type	Number/Type	Responsible
Nutrient Samples	Type of sample: Seawater No. Of samples: 288 Volume per unit: 60 ml Total volume: 17,280 ml Stations: Collected at all CTD hydrocast stations (Stations 500 to 541, Total 24 stations)	**Michelle Fernandes** CSIR-National Institute of Oceanography, Goa, India
Phytoplankton samples	Type of sample: Phytoplankton No. of samples: 188 Volume per unit: 100 ml Total volume: 18,800 ml Stations: Collected at type 1 and selected type 2 stations (Stations 500 to 540)	**Pazi Semili** UDSM- University of Dar-es Salaam, Dar-es Salaam, Tanzania
Zooplankton samples	Type of sample: Zooplankton No. of samples: 51 Volume per unit: 100 ml Total volume: 5,100 ml Stations: Collected at all type 1 stations (Stations 500 to 540, Total 10 stations)	**Riaan Cedras** UWC- University of the Western Cape, Cape Town, South Africa
Neuston samples	Type of sample: Zooplankton No. of samples: 95 Volume per unit: 100 ml Total volume: 95,100 ml Stations: Collected at all mantra trawl stations (Stations 500 to 540)	**Riaan Cedras** UWC- University of the Western Cape, Cape Town, South Africa
	Type of sample: Plastic particles	**Melody Puckrigde**

Microplastic samples	No of samples: <105 with or without plastics Stations: 35 manta trawl stations	CSIRO marine and atmospheric research Brisbane, Australia
Microplastic samples	Type of sample: Plastic particles and seawater No of samples: 5 Stations: 5 manta trawl stations	**Linda Amaral-Zettler** Marine Biological Laboratory, Woods Hole, United States
Seawater samples	Type of sample: Seawater samples No of samples: 35 Stations: CTDO stations	**Levente Bodrossy** CSIRO marine and atmospheric research, Hobart, Australia
Fish samples	Type of sample: Mesopelagic fish No. of samples: 285 Total volume: Samples fixed in 30 L 5% buffered formalin. Stations: 19 trawl stations.	**Melody Puckrigde** CSIRO marine and atmospheric research Brisbane, Australia
	Stable isotope samples / #195 samples oven-dried	**Bernerd M. Fulanda** Pwani University, Kenya
Acoustic Data	Type of sample: Raw acoustic data and post-processed LSSS No. Of samples: all transects Volume per unit: - Total volume: - Stations: all transects	**Andria Ansri Utama** Research Center for Fisheries Management and Conservation (RCFMC), Indonesia

ANNEX VI PROPOSED ARTICLES

Hydrography

Discussion around paper writing:

The overall feeling is that the sampling strategy was mostly designed for biological studies and therefore did not allow studying the physical properties of the ocean in much detail. However, the dataset proved to be of high interest, and there may be opportunities for publications. A descriptive oceanography paper might be hard to get published on their own, and we would benefit from publishing in a special issue, where a descriptive paper will receive a greater interest.

1st paper: focusing on a description of the hydrology of the Indian Ocean subtropical gyre. Michelle would take the lead on this one.

2nd paper: focusing on the impact of mesoscale activity on the Indian Ocean subtropical gyre. Francois would take the lead on this one.

Fisheries group – Proposed publications

1. Spatial distribution and composition and of mesopelagic fish species across the Southern Indian Ocean gyre: Results from the Dr. Fridtjof Indian Ocean Surveys 2015 (Pelagic Trawl and Acoustics)

2. Factors driving species mesopelagic fish assemblages across the Southern Indian Ocean gyre: Results from the Dr. Fridtjof Indian Ocean Surveys 2015 (Trawl and Oceanographic data / productivity data etc.)

3. Diet and feeding habits of mesopelagic fish in the Southern Indian Ocean gyre: Results from the Dr. Fridtjof Indian Ocean Surveys 2015 (Pelagic Trawl and diet analysis)

4. Distribution and composition of microplastics across the Southern Indian Ocean gyre: Results from the Dr. Fridtjof Indian Ocean Surveys 2015 (Manta trawls)

5. Role of mesopelagic fish in distribution (vertical/spatial) of micro-plastics across the Southern Indian Ocean gyre; inferences from the Dr. Fridtjof Indian Ocean Surveys 2015 (Manta trawls)

6. Trophic structure of mesopelagic fish across the Southern Indian Ocean gyre: Inferences from stable isotope analysis (Stable isotopes / diet analysis)

7. Diurnal variations in vertical distribution of mesopelagic fish Southern Indian Ocean

8. Diet vertical migration of mesopelagic fish in relation to physical environment and food in the Southern Indian Ocean

9. Potential acoustic discrimination within mesopelagic fish assemblage in Southern Indian Ocean

10. Otolith and aging in mesopelagic fish across the Southern Indian Ocean gyre