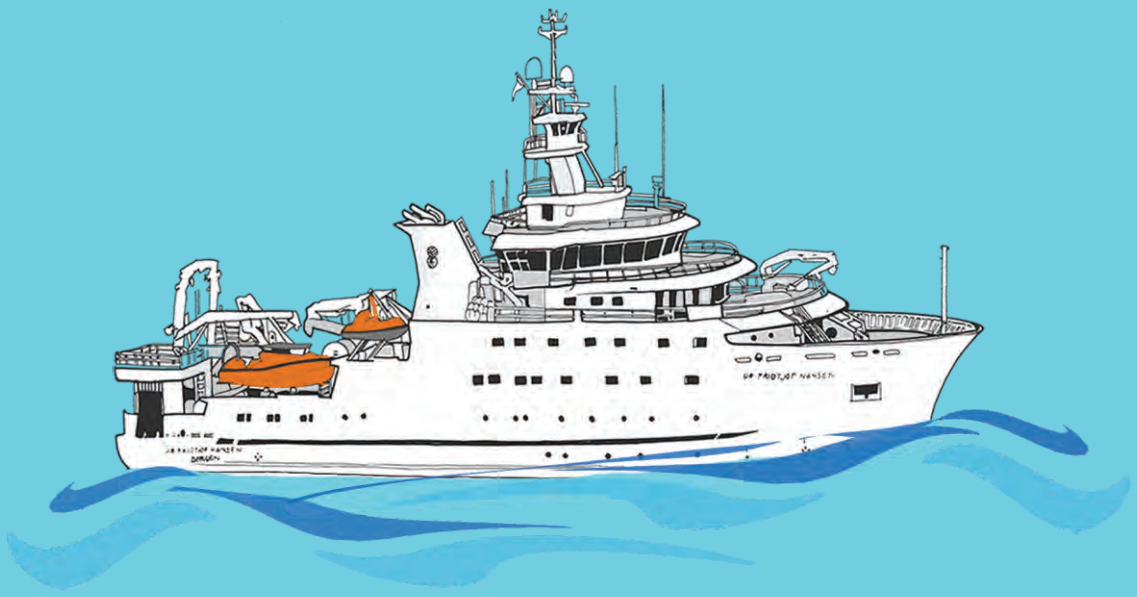
NORAD-FAO PROGRAMME
GCP/GLO/690/NOR

CRUISE REPORTS *DR FRIDTJOF NANSEN*
EAF-Nansen/CR/2017/9



SURVEY OF THE PELAGIC FISH RESOURCES AND ECOSYSTEM OFF WEST AFRICA

Namibia

30 October – 12 Dicember 2017

NatMIRC, Namibia
DAFF, South Africa
INIP, Angola

Institute of Marine Research
Bergen, Norway

The EAF-Nansen Programme

The EAF-Nansen Programme "Supporting the application of the Ecosystem Approach to Fisheries Management considering climate and pollution impacts" (GCP/GLO/690/NOR) aims to further strengthen the knowledge base and the overall institutional capacity for the implementation of the Ecosystem Approach to Fisheries (EAF) in developing countries, with additional attention to the impact of climate variability and change, pollution and other anthropogenic stressors.

The programme, that started implementation in May 2017, builds on earlier phases, and is governed by an agreement between the Food and Agriculture Organization of the United Nations (FAO), the Institute of Marine Research (IMR), Norway and the Norwegian Agency for Development Cooperation (Norad). The three pillars of the new programme are: Science, Fisheries management, and Capacity development. A new state of the art research vessel, *Dr Fridtjof Nansen* is an integral part of the programme. A science plan, covering 11 research themes, guides the programme scientific work.

The programme works in partnership with countries, regional organizations, other UN agencies as well as other partner projects and institutions.

Le Programme EAF-Nansen

Le Programme EAF-Nansen "Appuyer la mise en œuvre de l'approche écosystémique de la gestion des pêches en tenant compte des impacts du climat et de la pollution" (GCP/GLO/690/NOR), vise à renforcer la base de connaissances et les capacités institutionnelles pour la mise en œuvre de l'approche écosystémique des pêches (AEP) dans les pays en développement, en accordant une attention particulière aux effets de la variabilité et du changement climatique, de la pollution et d'autres facteurs de stress anthropiques.

Le programme, qui a débuté en mai 2017, s'appuie sur les phases précédentes et est régi par un protocole d'accord entre l'Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO), l'Institut de recherche marine (IMR) de Norvège et l'Agence norvégienne de Coopération au développement (Norad). Les trois piliers du nouveau programme sont : la science, l'aménagement des pêches et le développement des capacités. Un navire de recherche à la pointe de la technologie, le nouveau *Dr Fridtjof Nansen*, fait partie intégrante du programme. Un plan scientifique, couvrant 11 thèmes de recherche, guide les travaux scientifiques du programme.

Le programme travaille en partenariat avec les pays, les organisations régionales, d'autres agences des Nations Unies ainsi que d'autres projets et institutions partenaires.

Krakstad, J.-O., Ensrud, T., Ostrowski, M., Barrada, A., Michalsen, K., Olsen, M., Bernardes, I. D., Ann Bruck, S., Kalola, M., Shabangu, F.W., 2017. Survey of the Pelagic Fish Resources and Ecosystem off West Africa. Namibia, 30 October – 12 December 2017. NORAD-FAO PROGRAMME GCP/GLO/690/NOR, CRUISE REPORTS DR FRIDTJOF NANSEN, EAF-Nansen/CR/2017/9

CRUISE REPORTS *DR FRIDTJOF NANSEN*

SURVEY OF THE PELAGIC FISH RESOURCES AND ECOSYSTEM OFF WEST AFRICA

Leg 3.2 and Leg 3.4

Namibia

30 October – 12 December 2017

by

Leg 3.2: Jens-Otto Krakstad[1], Tor Ensrud[1], Marek Ostrowski[1] and António Barradas[2]

Leg 3.4: Kathrine Michalsen[1], Magne Olsen[1] , Ines D. Bernardes[1], Sarah Ann Bruck[1], Moses Kalola[4] and Fannie Shabangu[3]

[1] Institute of Marine Research (IMR), P.O. Box 1870 Nordnes, N-5817 Bergen, Norway
[2] Instituto Nacional de Investigação Pesqueira (INIP), Angola
[3] Department of Agriculture, Forestry and Fisheries (DAFF), South Africa
[4] National Marine Information and Research Centre (NatMIRC), Namibia

Institute of Marine Research
Bergen, 2020

CONTENTS

EXECUTIVE SUMMARY

The survey of the pelagic resources and ecosystems in Nambia took place from 30 October to 12 December 2017, as part of a synoptic coverage of the west coast of Africa (Morocco to South Africa) from May to December 2017. In this context, a full regional coverage of the pelagic resources and ecosystems of the southwest coast of Africa, from Gabon to South Africa was also undertaken. The research activities were guided by the EAF-Nansen Programme Science Plan that addresses a number of key research questions related to fishery biology, pollution and climate.

These surveys aim at providing synoptic coverages of the main pelagic resources in the region, providing an opportunity to study various aspects of population biology of the main species. At the same time, these surveys are multididscilinary in nature and sampling is also carried out for aspects of physical, chemical and biological oceanography, marine debris and microplastics and top predators. Results are expected to be published at a later stage as part of progress with the implementation of the EAF-Nansen Science Plan. This report therefore only provides preliminary results. It should be noted that distribution and estimation of biomass for the main pelagic species is the main objective of these surveys.

Cape horse mackerel (*T. capensis)*, was observed in a continuous distribution in the northern part of Namibia from the border with Angola to Cape Cross. Only a small fraction continued into Angolan waters and only a very small proportion overlapped with the Cunene horse mackerel.

The total biomass of Cape horse mackerel was estimated at 1 393 000 tonnes, with 74% of the biomass of fish < 20 cm length, while fish of >19 cm contributed re remaining 26%.

Most pelagic fish was found in the northern region, between 20 - 200 m depth, and the distribution typically extended slightly outside the 200 m depth line, with a more offshore extension at 19°S. The horse mackerel was generally caught with bottom trawls during the day and pelagic trawls during the night, and and the catch was usually mixed with large quantities of jellyfish.

Pilchard, anchovy and round herring were recorded in the northern region, while round herring was also recorded in the southern region south of 25°S. The biomass of each of these species was generally modest, and totalled roughly 283 000 tonnes. It should be noted that the low number of trawl samples introduces some uncertainties in these estimates.

CHAPTER 1. INTRODUCTION

1.1 Survey objectives

The research activities under the EAF-Nansen program are guided by the EAF-Nansen Programme Science Plan. The science plan is intended to ensure good scientific use of the wealth of data generated by the R/V *Dr Fridtjof Nansen* and other related data, addressing key research questions in support of tactical and strategic fisheries management.

The science plan covers 11 research themes, presented in Figure 1.

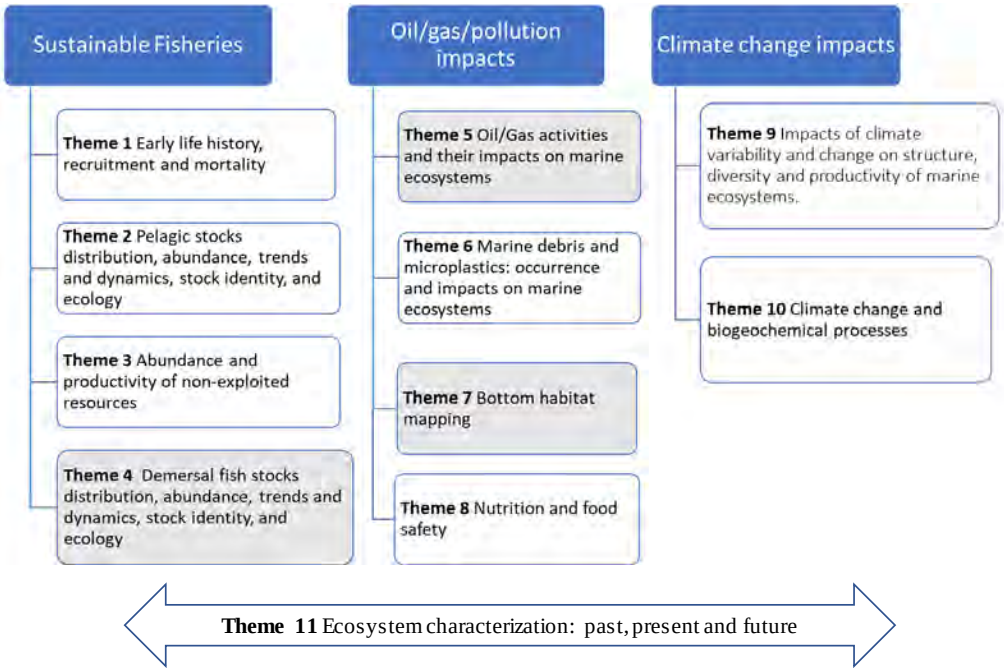


Figure 1. Research themes of the EAF-Nansen science plan.

A special focus of Theme 2 is to provide knowledge on shared resources and contribute to understanding stock structure of pelagic fish along the West African coast, their biology and the environment where they occur. More specific objectives included:

Hydrography:

- To map the hydrographic/environmental conditions (temperature, salinity, oxygen, chlorophyll, nutrients and pH values) in the survey area.

Phytoplankton, zooplankton, ichthyoplankton and jellyfish:

- To establish as far as possible the distribution, abundance and composition of phyto- and zooplankton, and species composition of fish eggs and larvae (data to be used, in part, to understand acoustic backscatter from zooplankton that can be used to refine the target strength for fish and jellyfish targets).

Pelagic stocks:

- To obtain information on abundance, distribution (also by size) of *Sardinops sagax, Trachurus capensis, Engraulis encrasicolus, Etrumeus whiteheadi* and *Scomber*

colias, using acoustic methods and a systematic grid survey strategy;

- To collect samples for genetic analysis and for morphometric studies, for stock identification of *S. sagax, T. capensis , E. whiteheadi, and E. encrasicolus.*
- To obtain information on maturity and fat stages, and to collect stomach samples for analysis of contents and otoliths of *S. sagax, T. capensis and E. whiteheadi*

Mesopelagic fish:

- To identify the main species and collect samples for identification and isotope analysis.

Marine debris and pollution:

- To record occurrence of marine debris (surface);
- To collect samples for analysis of levels of nutrients and contaminants including microplastics;
- To map occurrence of microplastics and describe associated neuston communities.

Contaminants:

- To collect samples of fish species consumed locally for analysis of contaminant levels and nutrient values.

Top predators:

- To conduct observations on the occurrence of sea birds and sea mammals along the cruise track.

1.2 Participation

Institute of Marine Research, Bergen, Norway:

Leg 3.2: Jens Otto Krakstad, Tor Magne Ensrud, Frøydis Bogetveit, Bernardine Everett, Marek. Ostrowski, Geir Landa and Olaf Sørås.

Leg 3.4: Kathrine Michalsen, Magne Olsen, Ines D. Bernardes, Sarah Ann Bruck, Elisabeth Jones, Jan Frode Wilhelmsen, Jan Arne Vågenes.

National Institute of Nutrition and Seafood Research, Bergen, Norway:

Leg 3.2: Vidar Fauskanger

Leg 3.4: Leikny Fjeldstad

Instituto Nacional de Investigação Pesqueira, Angola:

Leg 3.2: António Barradas, Domingas Nsaku, Eusébio dos Santos, Joana de Sousa Pinheiro, Pedro Panzo, Sténia Esmeraldina Kamundongo Isaías da Costa, Marcelina André, Eridson dos Santos, Emanuel Mahongo Kahilo and Ndongala Mbiyavanga Miguel

Leg 3.4: Amaro, Aristoteles Patrice Da Silva

National Marine Information and Research Centre, Namibia:

Leg 3.2: Latoya Shivute, Theopolina Iita, Justine Kakuuai, Chibo Chikwililwa, Bartholomeus Tjandja, Blessing Kamwi, Josephine Edward, Sharon Kahunda, Selma Nuuyoma and Richard Haraeb

Leg 3.4: Ndeenda Ekandjo, Joachim Tjimune, Larkin Sinvula, Moses Kalola, Justina Lungameni, Saskia Kisting, Leevi Mwaala, Unaani Tjaverua, Veronica Kaleinasho Kapula

University of the Western Cape, South Africa:

Leg 3.2: Aseeqah Davids

Department of Agriculture, Forestry and Fisheries, South Africa:

Leg 3.4: Fannie Shabangu, Nandipha Mhlongo, Onele Mahlathi, Yonela Geja, Mzwamadoda Philips

Department of Environmental Affairs, South Africa:

Leg 3.4: Delphine Thibault, Steven McCue

1.3 Narrative

The design of the survey and the sampling followed the agreed design described in the sailing order for Leg 3. This implied a systematic survey track consisting of pseudo-parallel acoustic transect lines perpendicular to the coast line with equally spaced transect lines (10 nautical miles, NM, apart). Namibia has traditionally been divided into three regions. These are Namibia North 17°15'S – 21°S, Namibia Central 21°S-25°S, and Namibia South 25°S-border with South Africa. These regions have also been used during this survey. See Table 1 for the survey effort in the different regions.

The survey off Namíbia was divided in two different legs, i.e. leg 3.2 and leg 3.4. The first leg was a continuation of the survey in Angolan waters. The Southern region of Angola was completed on the early morning of 30th October. The vessel then continued the survey into Namibian waters. The Northern region of Namibia was completed on the 07.11.2017. The first leg of the survey was completed when the vessel reached Walvis Bay on the 11.11.17 in the afternoon at 14:30 local time. There was then a break in the survey due to scheduled maintenance of the vessel and to carry out leg 3.3 of the survey plan, which was a mesopelagic transect into the deep ocean off Walvis Bay. A separate cruise report has been written for the mesopelagic leg. The second leg (3.4) of the survey with coverage of the last part of the central region, and the southern region then continued on the 26th of November, with the vessel leaving Walvis Bay at 18:00 local time (Table 1). Due to a 3 days delay in leg 3.2, it was decided to open up the distance between the transects from 10 NM to 20 NM in the southern part of Namibia (leg 3.4).

Table 1. Overview of the regions covered in of Namibia, number of survey days and dates.

	Total days	Start	Complete
Namíbia North	13	30/10/2017	07/11/2017
Namíbia Central	8	26/11/2017	03/12/2017
Namíbia South	9	03/12/2017	12/12/2017

The weather was generally favourable in leg 3.2, and no days were lost due to bad weather or mechanical problems. However, the cruise did not manage to cover the planned cruise line within the estimated time as the vessel was delayed for 3 days in Walvis Bay. For leg 3.4, one day was lost due to bad weather.

1.4 Survey effort

Table 2 summarizes the survey effort by regions and Figures 2, 3 and 4 show the cruise tracks with fishing, plankton and hydrographic stations for the Northern, Central and Southern regions of Namibia respectively.

Table 2. Survey effort: Distance -distance surveyed (log, NM), number of CTD, Phyto -plankton nets, WP-2 – zooplankton nets, Multi – nets for eggs and larvae, Manta – nets for plastic particles in the surface, BT-bottom trawl and PT- Pelagic trawl hauls.

Region	**Description**	**Distance**	**CTD**	**Phyto**	**WP-2**	**Multi**	**Manta**	**BT**	**PT**
Namibia North	River- Ambrose Bay	2179	48	10	20	12	12	15	10
Namibia Central	Between 21°S and 25°S	1863	28	13	27	17	17	7	17
Namibia South	Between 25°S and South Africa	717	44	16	16	7	11	2	15
Total		**4759**	**120**	**39**	**63**	**36**	**40**	**24**	**42**

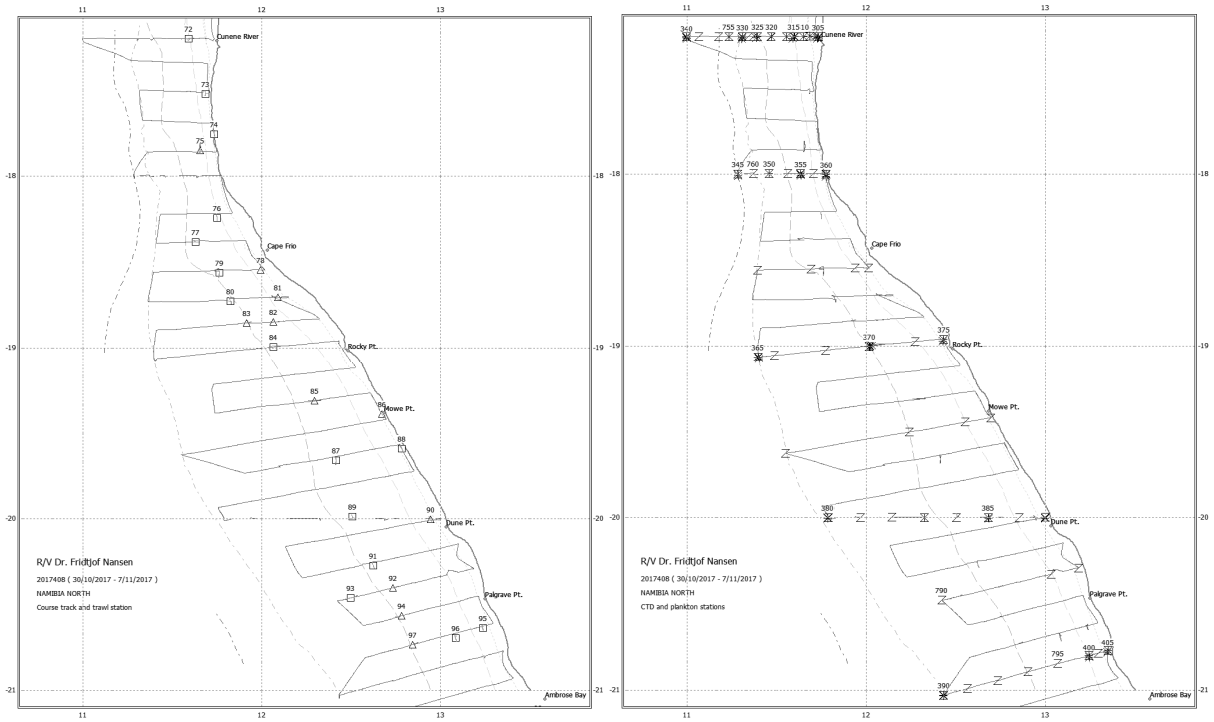
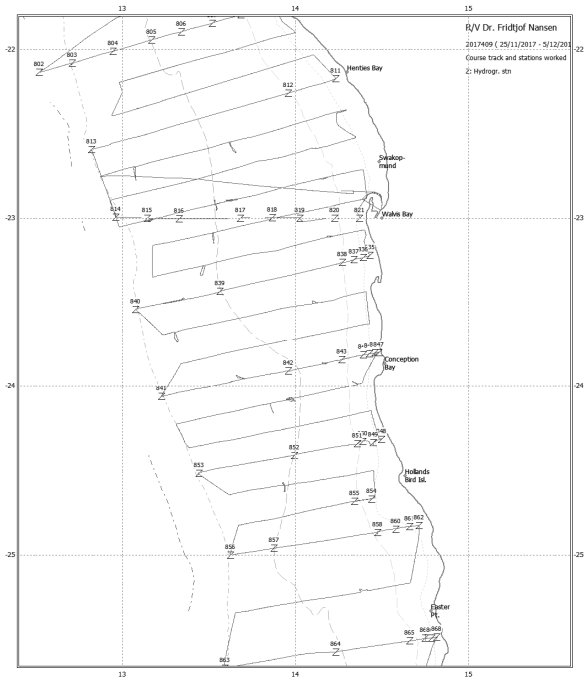
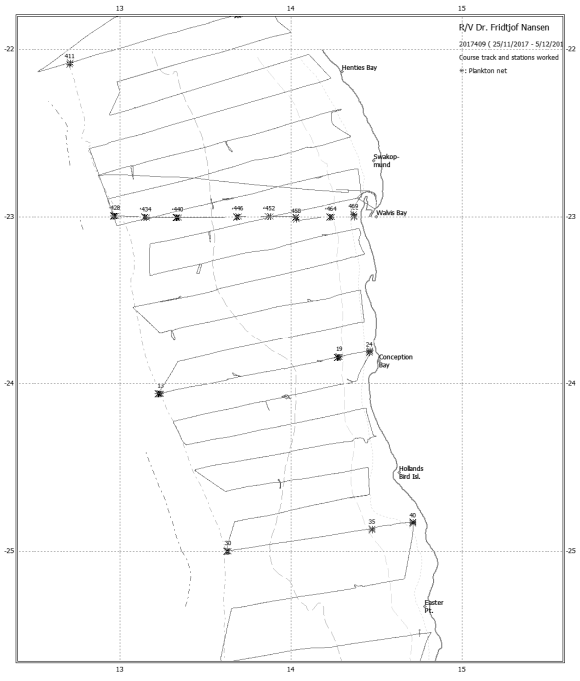


Figure 2. Course track with trawl stations (left panel) and hydrographical and plankton stations (right panel), in Namibia north (River- Ambrose Bay). The various figure legends indicate position of sampling stations; Squares= demersal trawl stations, triangles=pelagic trawl stations, stars=plankton stations and Z=CTD stations. Depth contours at 50, 100, 200, and 500 m.

a)



b)



c)

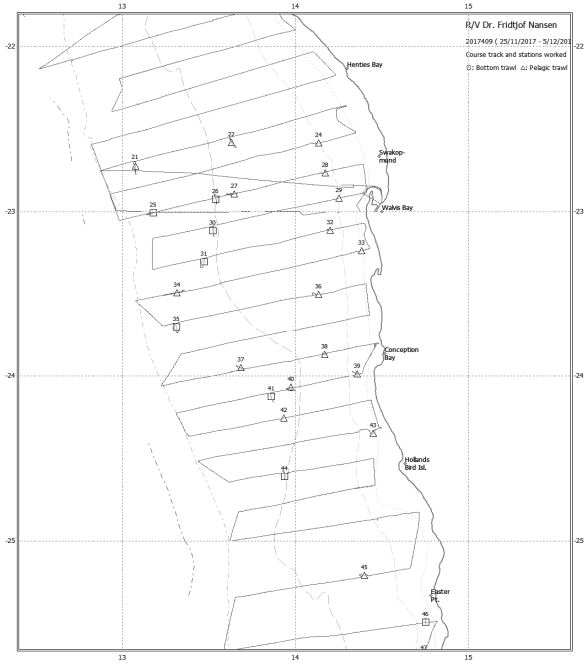
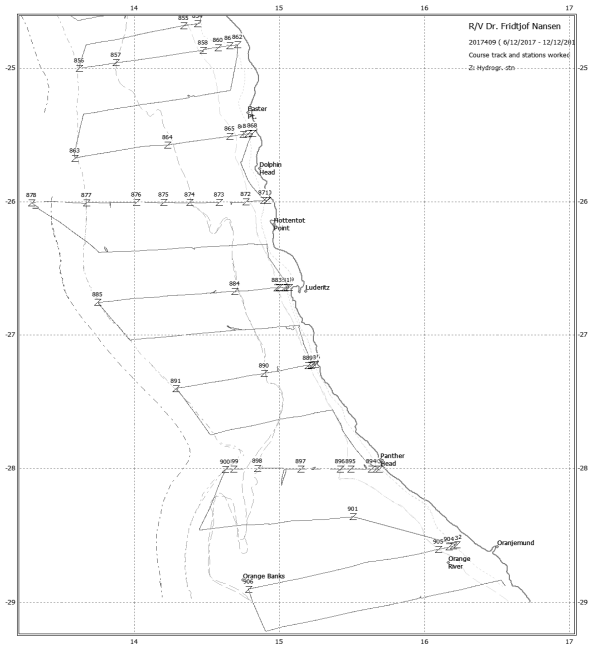
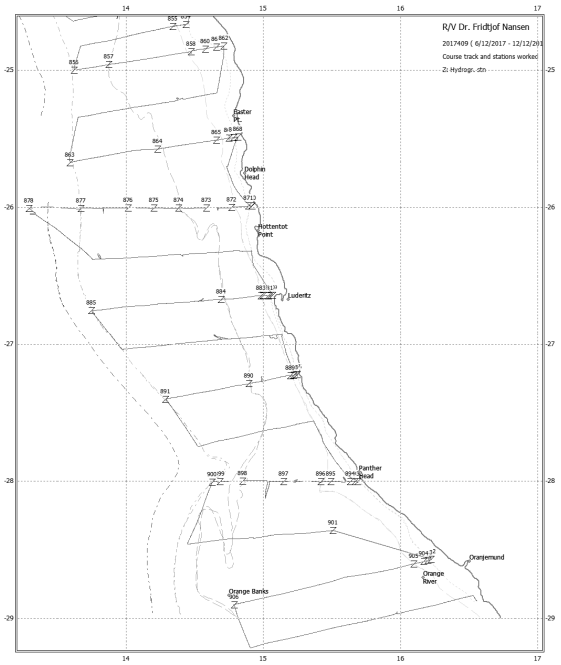


Figure 3. Course track with a) trawl stations, b) hydrographical and c) plankton stations, in Namibia Central (Ambrose Bay and 25°S). The various figure legends indicate position of sampling stations; Squares= demersal trawl stations, triangles=pelagic trawl stations, stars=plankton stations and Z=CTD stations. Depth contours at 50, 100, 200, and 500 m.

a)



b)



c)

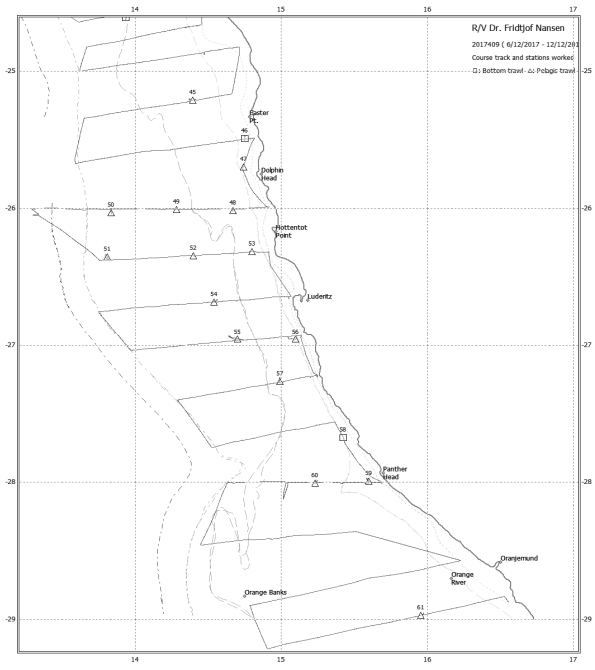


Figure 4. Course track with a) trawl stations, b) hydrographical and c) plankton stations, in Namibia South (25°S-South-Africa). The various figure legends indicate position of sampling stations; Squares= demersal trawl stations, triangles=pelagic trawl stations, stars=plankton stations and Z=CTD stations. Depth contours at 50, 100, 200, and 500 m.

CHAPTER 2. METHODS

2.1 Underway sampling

2.1.1 Meteorological data recording

Meteorological data were logged continuously from the AANDERAA Smartguard meteorological station and included wind direction and speed, air pressure, relative humidity, air temperature and solar radiation. All data were logged to the Nansis tracklog system and averaged for every 60 seconds.

2.1.2 Thermosalinograph

The SBE 21 Seacat thermosalinograph ran continuously during the survey, obtaining measurements of sea surface (at 4 m depth) salinity and relative temperature every 10 seconds. An attached in-line C3 Turner Design Submersible Fluorometer measured turbidity and chlorophyll-*a* levels.

2.1.3 Current speed and direction measurements (ADCP)

Two hull-mounted Acoustic Doppler Current Profiler (ADCP) from RD Instruments ran during the survey. The frequencies of the ADCP are 75 and 150 kHz. The system was run in narrow band mode and data were averaged in 16 and 4 m vertical bins at 75 and 150 kHz respectively and stored on files for post survey processing. The 150 kHz was run continuously while the 75 kHz was turned off in the southern part of Namibia due to interference with the ping rate of the EK80 echosounder.

2.2 Bottom mapping echo sounder

The EM 710 multibeam echo sounder is a high to very high-resolution seabed mapping system. Data acquisition depth starts approximately 3 m below the transducers and the maximum acquisition depth is in practice limited to 1000 – 1500 m on the *Dr Fridtjof Nansen*. Across track coverage (swath width) is up to 5.5 times water depth and may be limited by the operator either in angle or in swath width without reducing the number of beams. The operating frequencies are between 70 and 100 kHz. There are 128 beams with dynamic focusing employed in the near field. The transmitting fan is divided into three sectors to maximize range capability and to suppress interference from multiples of strong bottom echoes. The sectors are transmitted sequentially within each ping and use distinct frequencies or waveforms. The along track beam width is 1 degree. Ping rate is set according to depth. The receiving beam width is 2 degrees. Sound profiles were set manually in the system according to the area of operation. The data was logged to the on-board Olex plotting system.

2.3 Fixed hydrographic sampling

Biological and oceanographic sampling was undertaken every 60 nm, i.e. along every sixth acoustic transect (Transects 6, 12, 18 and so on). Samples were taken at the inshore end of the

acoustic transects, usually at a water depth of between 25 and 30 m, usually at the 100 m isobath and at the outer end of the transects, i.e. at 500 m bottom depth. These stations were referred to as “super-stations”. Additional CTD stations were added at 60-70 m and 200 m depth. The samples collected on these transects are shown in Figure 5.

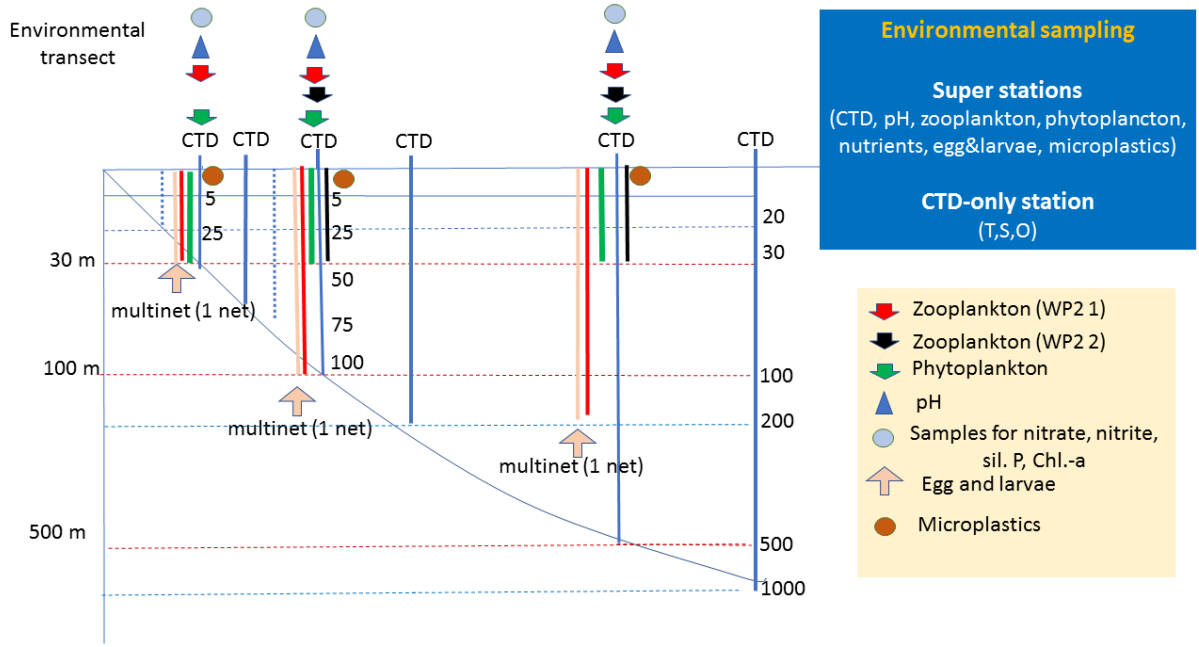


Figure 5. Sampling diagram showing the depth and the equipment used at the super stations transects, from the inshore (left side) towards the deep 500 m stations (right side).

In addition, CTD stations were added every 30 nm, along the intermediary transect lines between the “super-stations”. Due to bad weather and time restrictions the distance between the transects was increased to 20 nm and 40 nm for the southern part of Namibia.

2.3.1 CTD sensors – temperature, salinity, oxygen and fluorescence

Vertical temperature and salinity profiles were obtained by a Seabird 911 CTD, while *in situ* concentrations of dissolved oxygen were measured using a CTD-mounted SBE 43 oxygen sensor. Real time logging and plotting was performed using the Seabird Seasave software. Attached to the CTD was also a Chelsea Mk III Aquatracka Fluorometer, which measures *in situ* fluorescence on a relative scale and a Photosynthetic Active radiation (PAR) sensor to measure downwelling irradiance (in micromole photons m^{-2}).

To verify the salinity values from the CTD conductivity sensor throughout the survey, water samples were collected, placed in the lab for 24 hours for temperature equilibration and measured on board with a Guildline Portasal Salinometer 8410A. Although additional measurements would have been preferred, Figure 6 shows that the CTD salinity values were indeed validated by the collected water measurements. IAPSO salinity standard seawater was used to standardize the salinometer to ensure reliable measurements. The dissolved oxygen

sensor values were also checked via onboard Winkler titrations (Grasshoff *et al.*, 1999) (Figure 7). Any verified offsets with the sensor data are corrected at the Institute of Marine Research.

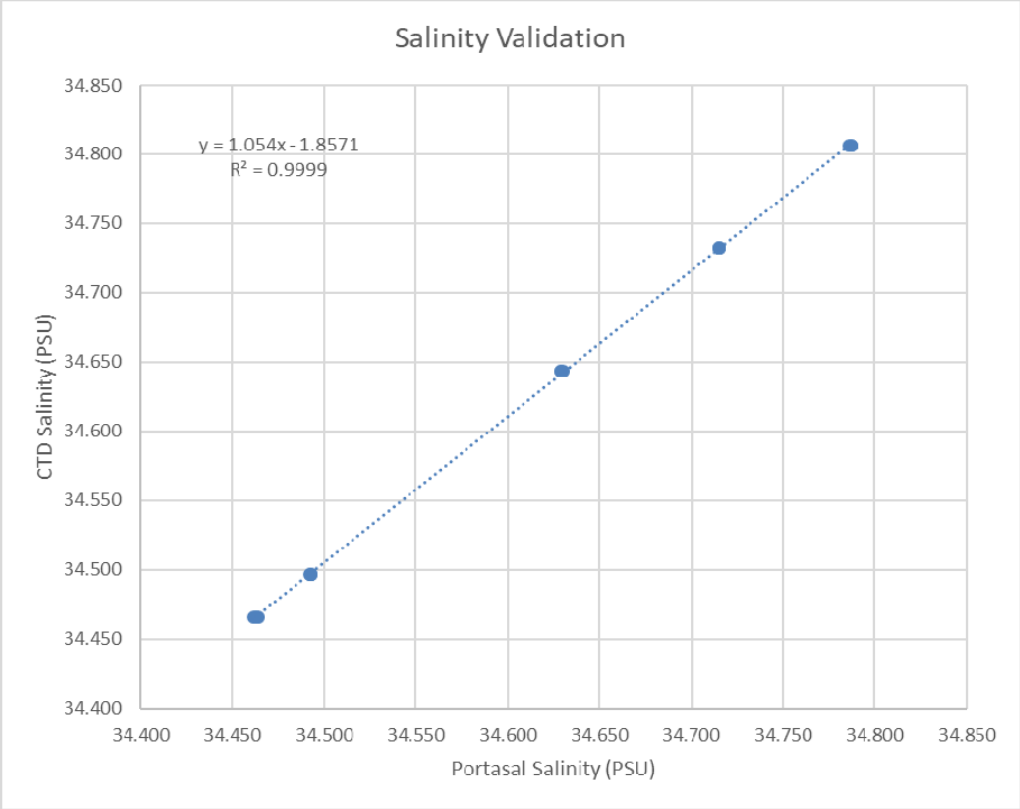


Figure 6. Portasal salinity values compared to CTD salinity values. 6 total samples from stations 878 and 900.

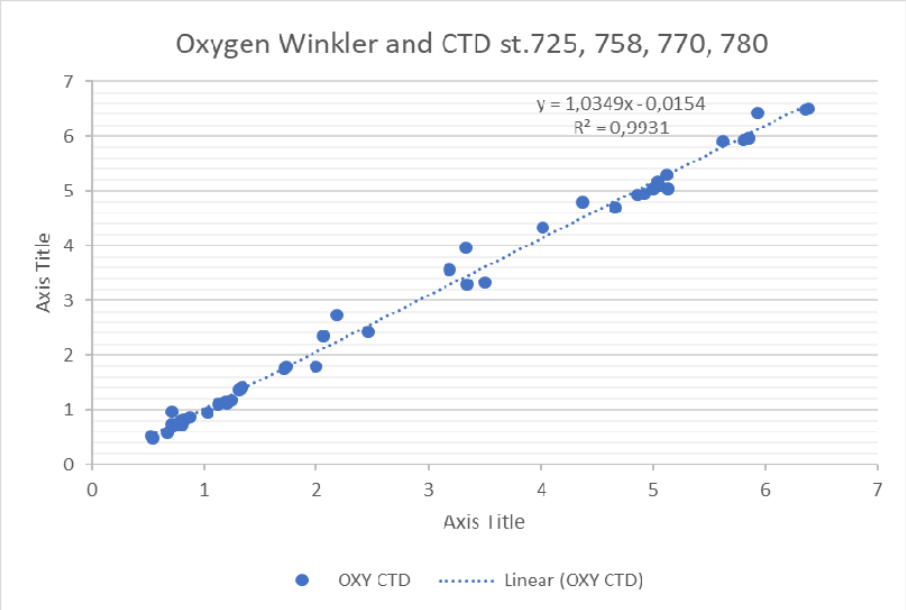


Figure 7. Measured oxygen concentrations plotted against the result from the CTD sensor (47 samples).

2.3.2 Ocean acidification parameters (pH and alkalinity)

The *Dr Fridtjof Nansen* is currently equipped with a CTD rosette holding up to 12 ten-litre Niskin bottles that are used to collect water samples from pre-defined depths. The standard sampling depths were set to: 500, 400, 300, 200, 100, 75, 50, 25, and 5 m and the standard transects were sampled at 30, 100 and 500 meters depths. These samples were used to determine chlorophyll, pH, alkalinity and for nutrient analysis (nitrate, nitrite, silicate and phosphate) as described below.

Seawater samples (250 ml) from the CTD-mounted Niskin-bottles were collected in borosilicate glass bottles using silicone tubing to reduce air exchange. Both pH and alkalinity were analysed on board the vessel. pH was determined using a diode array spectrophotometer and a pH sensitive indicator, m-cresol purple in 2 mM solution, as described by Clayton and Byrne (1993) and Chierici *et al*. (1999). Alkalinity was measured by titration with acid (0.05M HCl) and changes in pH were measured with an electrode (potential in mV) using tiamo software. Further processing of the data will be done at IMR, and will provide information about the marine carbonate system and parameters for ocean acidification.

2.3.3 Nutrients

Seawater samples (20 ml) for nutrient analysis (nitrate, nitrite, silicate and phosphate) were collected from the Niskin water-bottles. The seawater samples were stored in polyethylene vials, conserved with 0.2 ml chloroform, and kept cool and dark in a refrigerator (Hagebø and Rey, 1984). The analyses of the samples were done at the IMR, using a modified Alpkem AutoAnalyzer C (OI Analytical, USA) and following standard procedures (Strickland and Parsons, 1972). Extra standards were added during the analysis to cover the whole measurement range. During quality control of the data, some outlying values that were

obviously wrong were excluded. The quality control included evaluation of the ratios between the different nutrients.

An overview of the data collected is given in Table 3.

Table 3. Overview of the number of samples collected on water chemistry in the 3 different regions of Namibia.

Region	# sampling stations	# nutrients samples	# pH/ Alk samples	# Chl.A samples	# Oxygen samples	# salinity samples
Namibia north	11	98	98	74	46	46
Namibia central	21	123	123	111	0	0
Namibia south	15	85	85	73	11	7
Total	47	306	306	184	57	53

2.4 Atmospheric soundings

Atmospheric soundings were performed by means of instrumented meteorological balloon launches. The instrumentation consists of Vaisala RS92-SGPL sondes, equipped with battery-powered pressure, temperature and humidity sensors, GPS receiver/transducer and UHF radio. A ground station situated on the observation lab of the vessel uses GPS and UHF links to receive, process, display and store measurement and sonde status data in real time during the balloon flight. The ground station has an independent GPS link, and both relative and absolute GPS sonde position information is utilised to obtain sonde horizontal and vertical movement. Since the balloon flight is horizontally Lagrangean with respect to air, the horizontal components of the sonde motion provide wind data. The balloon consists in a thin sheet of highly stretchable pure latex that approximately equates internal and external pressure, resulting in near-constant lift. Ascent velocity and range are determined by air resistance (decreasing with altitude) and balloon elasticity limit. The latter is approached as the internal gas volume increases, until the fabric tears, the lifting gas disperses, and the sonde starts falling. The data acquisition system interrupts data processing and storing when the pressure sensor detects pressure increasing with time, or when the UHF signal is lost (e.g. due to sonde battery exhaustion).

2.4.1 Sampling strategy

The meteorological sounding component had two primary objectives. The first was to provide an *in situ* dataset against which to validate operational analysis and reanalysis products (e.g. JRA-55) in the area of the Benguela eastern boundary upwelling system. The second was to provide observational underpinning or falsification of theoretical hypotheses with regard to the controlling mechanisms for the along-shore surface winds that ultimately drives coastal upwelling.

The first objective constrained soundings to be performed at standard synoptic times, i.e. 00UTC, 06UTC, 12 UTC or 18UTC (i.e. 2am, 8am, 2pm and 8pm LT), with a preference for

00UTC or 12UTC which are common analysis point of all operational and non-operational forecast and climatological products. The second objective required some sampling of the diurnal cycle at fixed locations, some near-synchronous sampling of the spatial structure of the marine PBL, and sampling of particularly marked transition in synoptic or large-scale circulation regime. Both objectives benefit most from observations carried out at 20 nm (i.e. one Rossby radius or one analysis grid-point) or more away from the coast, except at particular locations such as Luderitz were comparison with other *in situ* datasets would be possible. Walvis Bay was a particular point of interest given previous intensive aircraft-based research campaigns. Luderitz is a second point of specific interest thanks to continuous surface wind observations at the Cape Diaz station.

2.5 Phytoplankton sampling

Chlorophyll-*a* was sampled as an indicator of phytoplankton biomass. For chlorophyll-*a* and phaeopigment measurements, seawater was collected from the CTD at the standard depths (not below 200 meters). The water was filtered using a 0.7µm filtration system (Munktell glass-fibre filters Grade: MGF, vacuum 200 mm Hg). The assay is performed by extraction with 90% acetone followed by centrifugation, and analysed using a fluorometer (model 10 AU, Turner Designs Inc., Sunnyvale, Ca., USA), according to Welshmeyer (1994) and Jeffrey and Humphrey (1975). The same assay (but not accredited) will be implemented on board *Dr Fridtjof Nansen* during the fall 2017.

Qualitative phytoplankton samples were collected at super-stations as described above. At each super-station, qualitative phytoplankton samples were collected with a net (35 cm in diameter and mesh-size of 10 µm), hauled vertically at a speed of 0.1 ms^{-1} from the depth of 30 m to the surface (from ca. 5 m above bottom at the 30 m stations). These samples are not quantitative, but used to establish the taxonomic composition of the phytoplankton community.

2.6 Zooplankton sampling

Mesozooplankton were collected with a WP2-net along the hydrographic transects at stations positioned at bottom-depths of approximately 30 m, 100 m and 500 m. The WP2-net (56 cm diameter, mesh size 180 µm, Fraser, 1966, Anonymous, 1968) was hauled vertically at a speed of ~0.5 ms^{-1} at each station. At the shallow and intermediately deep stations (bottom-depths of 30 m and 100 m, respectively) the sampling strata were from near-bottom to the surface (deepest sampling depths of ~25 and 90 m, respectively). At the stations with bottom-depth of ~500 m or greater, the sampling stratum was from the depth of 200 m to the surface.

Furthermore, a second sample with the WP2 net was collected from the upper 30 m at the stations with bottom depths of 100 m and 500 m. The purpose of these additional samples was to enable a direct comparison of the zooplankton composition and concentrations in the uppermost layer of the water-column along the bottom-depth gradient. Each zooplankton sample was divided into two equal parts using a Motoda plankton splitter (Motoda, 1959). The first part of the sample was size-fractioned by using a series of sieves with the decreasing mesh-sizes of 2000 µm, 1000 µm and 180 µm, and the zooplankton retained on each sieve

were dried on aluminium trays at ~60 ºC for 24 h. These samples will be handled by the IMR laboratory, where they will be dried once more, and weighed for estimation of biomass for the different size-groups. The second part of the sample was preserved in seawater with a final solution of 4% formaldehyde buffered with borax for subsequent species identification and quantification, also to be performed at the IMR.

2.7 Fish-eggs and larvae

Sampling for fish eggs and larvae was done at the super-stations with a Hydro-Bios Multinet with mesh-size 405 µm. The net was towed obliquely from ~10 m above the bottom, or from a maximum depth of 100 m, to the surface with a speed of ~1.5 ms^{-1}.

After the multinet had been recovered and secured, the samples were checked for the presence of fish larvae in the sorting tray. After the Multinet had been recovered and secured all fish larvae visible to the naked eye were removed from the total sample, analysed under a stereomicroscope, and measured for standard length. Pictures of the fish larvae were taken. The diameter of the fish egg, oil globule and the yolk were measured using the micrometer. All the fish eggs and fish larvae were saved in vials and the remaining multinet sample was transferred into 100 ml jars, where they were fixed with 4% formaldehyde buffered with borax. When all visible fish larvae had been removed from the Multinet sample, the rest of the sample was preserved as above for reference purposes, and to re-check for any overlooked larvae.

Sorting of fish-eggs and identification of fish larvae will be done at the IMR after the cruise.

2.8 Microplastics

Microplastics are pieces of plastic debris smaller than 5 mm long. Microplastics were collected along the hydrographic transects at all super-stations. At each station, the surface layer was sampled using a Manta-trawl with a rectangular opening of 19 cm × 61 cm (HxW), mesh-size 335 µm, and two wings to keep it balanced and at the surface during the tow. Trawls were hauled horizontally at a speed of ~1.5 ms^{-1} for 15 minutes. The counts from a manual flowmeter attached in the lower part of the trawl opening were recorded at the start and end of each trawl. Trawling was performed some meters away from of the starboard side about mid-ship, attempting to avoid the wake of the vessel.

Once the Manta-trawl was retrieved, the samples were washed in filtered sea-water over a sieve with a mesh-size 180 µm. Microplastic particles were sorted from the sample using a stereo-microscope, and the sorted sample was then checked again to reduce the risk of overlooking the smallest plastic particles. All assumed plastic items were then placed on a gridded petri dish for examination under the stereo-microscope, photographed and, to the extent possible, also measured and described (e.g. length, shape, type and colour). The sorted microplastics were washed with distilled water and dried in pre-weighed aluminium-trays in a drying cabinet at 30 ºC. The trays were packed in aluminium foil and stored in the freezer until transport to the IMR laboratory, where they will be studied in more detail. After

removing the plastics, the remaining part of the samples (mainly biological material) was preserved in formalin for studies of neuston at the IMR after the cruise.

2.9 Food safety

Whole fish, fillet and different organs from various fish that are regularly consumed in the area surveyed were sampled and preserved. All the samples will be analysed for a wide variety of nutrients and contaminants at the NIFES (National institute of nutrition and seafood research) laboratory in Norway (See section 3.7). Tissue samples from mackerel samples will also be analysed for the parasite Kudoa. Some of the samples will also be analysed for correspondence between the microbiota and the metal content of the gut. One pelagic fish sample and two mesopelagic fish samples will be analysed for the content of microplastic particles.

2.10 Top predators observations

The aim of the survey was to get a relative species abundance of top predators encountered on the northern and southern parts of the Benguela Current Large Marine Ecosystem. Observations were done daily from the observation tower above the wheel-house, weather permitting. Observations were conducted during daylight hours, beginning at 07h00 and stopping at 17h30. Weather information was recorded hourly, and effort was recorded as changes occurred. When wind conditions reached 20 knots or fog closed in, off-effort recordings could continue as thought fit, as sighting conditions become too difficult to keep on-effort watch.

Observations were done 180° to the forward section of the vessel. Equipment used was an angle board, to determine the angle of the sighting, binoculars for species identification, and a camera with a 400 mm lens to collect pictures for closer identification. All sightings including abundance estimation, mode of animal identification and behaviour at the time of sighting were recorded on a sighting form. Cape fur seal numbers were not recorded as they were encountered throughout the survey area daily.

Bird observations were done during the day for a period of 10 minutes at a time with a searching angle of 180°. All bird sightings within a 300m distance from the vessel were recorded, and if a bird could not be identified, a picture was taken and a photo number assigned to the sighting to be identified at a later stage. Birds were recorded as in-flight or sitting on the water at the time of the sighting. Birds following the vessels were not recorded.

2.11 Biological trawl sampling

Biological sampling of fish was carried out using pelagic and bottom trawls. In shallow water (<30 m) or at night when pelagic fish was close to the surface, the pelagic trawl with floats or bottom trawl with floats was used for sampling. The MultPelt trawl could not be used due to winch problems, which meant that pelagic trawling was only possible with the small pelagic Harstad trawl. In several instances, especially when the acoustic target was fairly small and

isolated, this made it more difficult to obtain sufficient catches to describe identified acoustic targets. A more detailed description of instruments and fishing gear is given Annex I.

All catches were sampled for composition by weight and numbers of each species caught. For the selected target species length (total length to the nearest cm), weight (to the nearest 0.5 g), sex, gonad maturity stage (according to table in Annex III), and stomach fullness (according to table in Annex III) were recorded. When the size distribution of the target species in the catch was seemingly narrow (similarly sized individuals), a total of 50 individuals were measured for length. Length and weight measurements were used to estimate the length-weight relationship and together with length frequency distributions applied in biomass calculations. In addition, the following biological samples of large fish were taken: otoliths (in paper envelopes), pectoral finclips (max in 96% ethanol) for genetic analysis, stomach and liver samples (frozen in plastic bags), and frozen samples for morphometric analysis (25-30 fish). Instead of attempting to remove otoliths, stomach and liver from small individuals (<10cm, and in most instances all anchovy and sardinella), whole fish were frozen, since it seemed less cumbersome and time consuming to do this on land in well equipped labs.

The target groups used for this survey can be found in Table 4, while the complete records of fishing stations and catches are shown in Annex II. A full list of biological samples per species and trawl station is given in Annex IV.

2.12 Jellyfish collection and preservation

Jellyfish were collected from the trawl catch, and the different species were sorted and subsequently weighed. All jellyfish specimens caught, or a representative random sub-sample (if too numerous), were identified to the lowest possible taxon.

Jellyfish specimens that were in a good condition were photographed (top and bottom sections). A small piece of the oral arm tissue was then removed and preserved in 96% ethanol (EtOH) and stored at -20°C. After 24 hours, the 96% EtOH was then replaced with fresh 96% EtOH, and the sample was stored at -20°C until analysis. These tissue samples were collected for genetic studies, aimed at determining the species and the population structure, and to establish regional and global connectivity.

The rest of the specimen was preserved in 10% formalin and placed in a cooler on board for long-term storage. These samples formed part of a greater morphological identification and taxonomic study.

Due to limited space and storage material, only five to ten of the best representatives of *Rhizostoma* and *Chrysaora* species (species of interest) caught in each trawl were stored as explained above. When species other than the predefined species of interest were caught, the sampling followed the same methodology although only when a species was caught for the first time. This specimen then served as a type specimen. For subsequent occurences only presence was noted.

2.13 Acoustic sampling

2.13.1 Sonar data

A Simrad SH90 Sonar recorded data continuously during the survey for post processing after the survey. The sonar was set to a frequency of 26 kHz, in FM Normal mode. The sonar was operated using bow up/180 degree operation mode with the bearing of the vertical beams 90 degree, perpendicular to the vessel direction with a range of 450 m and with the horizontal beams set to 450 m with a tilt angle of 3 degree. The filters built into the sonar software to improve the school representation (i.e. AGC, RCG and ping to ping) were set to default values except for the Noise filter, which was turned off.

The settings including range and tilt was kept the same during all the surveying except during trawling operations where the sonar was at times used actively to focus in on targets.

No other sonars were used during the survey.

2.13.2 Echo sounder

Acoustic data was recorded using a Simrad EK80 scientific split beam echo sounder mounted on the drop keel operating at nominal frequencies of 18, 38, 70, 120, 200 and 333 kHz. Annex I gives the details of the echosounder settings used during the survey.

2.13.3 Allocation of acoustic energy to species group

Acoustic data was post-processed on board using the latest acoustic data post-processing software, the Large-Scale Survey System (LSSS) Version 2.0.

Scatters were displayed on echograms at 38 kHz. The mean 5 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 and stored as mean values per 1 nautical mile (nm). Allocation of acoustic densities to species groups and respective species are listed in Table 4. Ground truthing and estimation of mean length and weight were accomplished by means of targeted pelagic and demersal trawling. In cases where the integrated echo contained more than one category of fish (see Table 4), the mean s_A-value allocated to each category was in the same ratio as their contribution to the abundance in trawls in that area.

The acoustic backscatter was scrutinized daily and allocated to the various target groups. The s_V threshold used when sardinellas occurred to filter out other species and plankton was -45 dB, or in regions where the plankton layer was extremely dense and even lower threshold had to be used. For Pelagic I, Pelagic II and “other pelagic species” -50 dB was used. To identify mesopelagic layers a threshold of -60 dB was used. To identify jellyfish layers a threshold of -60 dB was used for high concentrations, while -70 dB was used for more dispersed layers. Biomass can only be estimated for those acoustic groups in which length and weight were recorded (see Table 4).

Table 4. Species groups used for allocation of acoustic densities.

Group	Taxon	Species
Sardinella	*Sardinella* sp.	*S. aurita*
		S. maderensis
Horse mackerel	*Trachurus* sp.	*T. trecae*
		T. capensis
Mackerel	Scombridae	*Scomber colias*
Pilchard	*Sardinops*	*S. sagax*
Pelagic species 1	Other Clupeiformes[1]	*Etrumeus whiteheadi*
		Engraulis encrasicolus
Pelagic species 2	Other Carangidae[2]	*Selene dorsalis*
		Chloroscombrus chrysurus
		Decapterus rhonchus
		Seriola carpenteri
	Other Scombridae	*Auxis thazard*
		Sarda sarda
	Others	
		Trichiurus lepturus
		Lepidopus caudatus
Demersal species		
		Dentex macrophthalmus
		Saurida brasiliensis
		Ariomma bondi
		Pomadasys incisus
		Galeoides decadactylus
		Merluccssius capensis
		M. paradoxus
		Diaphus dumerili
		Maurolicus muelleri
		Trachinocephalus myops
		Calanus sp**.**
		Meganyctiphanes sp.
Mesopelagic species	Myctophidae$_3$	*Chrysaora fulgia*
	Other mesopelagic fish	*Aequorea forskala*
Plankton	Calanoidae	
	Euphausiidae	
	Other plankton	
Jellyfish		

[1]other than *Sardinops* sp.; [2] other than *Trachurus* sp.; [3] main taxon in group.

2.13.4 Estimation of biomass

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 corresponds to:

TS = 20 log L – 72 (dB) (1)

Or in the simplest form $$CF = \frac{1.2612 \cdot 10^6}{\bar{L}^2} \quad (2)$$

where *CF* is the conversion factor from acoustic density to fish biomass and $\bar{L}^2$ is the mean of squared fish lengths. This target strength function was originally established for North Sea herring, but has later been attributed to clupeids in general (Foote *et al*., 1986; Foote, 1987).

No specific target strength relations are presently available for the species at hand, and equation (3) has therefore been applied for all targeted species in this time series. The biomass was calculated by multiplying the number of fish by the expected length at weight, estimated by regression of the log-length (total) against total weight. Separate length-weight relationships were worked for each region (north, central, south), pooling all data within each region.

The boundaries of encountered fish aggregations (post strata) were determined by means of contouring within the inner and outer zero-value limits of the transect lines. The strata contours were digitized using Nansis Maptool Version 2.1.4. Sub-stratification was used to isolate areas of similar densities, using the following pre-defined, standard categories:

1: $0 < s_A < 300$; 2: $300 \le s_A < 1000$; 3: $1000 \le s_A < 3000$;
4: $3000 \le s_A \le 10000$; 5 : $10000 \le s_A \le \infty$ (m^2/NM^2)

The basis for contouring is averages of five 1nm values along transects. At the end of transects and in connection with trawl stations the averaging may include fewer values(from 1 to 4 single NM observations). This is a source of bias, however the bias is limited due to observations within strata having similar values. Other sources of bias of concern are the shallow distribution pattern (above integration limit), vessel avoidance behaviour of sardinella (Misund and Aglen, 1992), and inshore distribution (at depths smaller than 20meters). All estimates should consequently be considered as relative indices of abundance.

The overall length frequency distributions within strata were estimated by weighting the sample-distributions with the nearest valid 1 NM integrator value, or the average of two adjacent values.

The total number of fish in each length group was estimated as:

$$\rho_i = \frac{< s_A > t_{i,j} \cdot u_i}{\sum_i \frac{u_i}{C_{Fi}}} \cdot A_s = \frac{10^{7.2} \cdot t_{i,j} \cdot u_i \cdot < s_A > \cdot A_s}{4\pi \sum_i u_i \cdot (L_i + 0.5)^2} \qquad (4)$$

where: ρ_i = estimated number of fish in length group i

$<s_A>$ = mean recorded area backscattering coefficient (m^2/NM^2)

$t_{i,j}$ = proportion of species j in length group i

u_i = proportion of sampled fish in length group i

A_s = horizontal area of stratum s

C_{Fi} = conversion factor for length group i

L_i = length group i (nearest full cm below total length)

$L_i+0.5$ = mean length in L_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 was therefore important to get representative length distributions from the key species groups in the whole distribution area.

When the size classes (of e.g. young fish and older fish) were well mixed, the various length distributions were pooled together with equal importance. Otherwise, when the size classes were segregated, the total distribution area was post-stratified, according to length distributions, and separate estimates were made for the strata containing fish with equal size.

For a stratum representing a distribution of a target group, the following basic data are needed for the estimation of abundance;

1) The average s_A-value for the region,
2) The surface area (usually square nautical miles, NM^2), and
3) A representative length distribution of the fish in the region.

If the targeted fish was a mixture of more than one species, for example sardinellas, representative distributions of all the species within the stratum, as shown in the trawl catches, was used. Length distributions representing the various species for each catch was calculated and normalized to a unit number (usually 100). These were then averaged without weighting. Very small catches (normally less than about 20 fish) were not included. The total catch of each species from all the trawls in a stratum was used as a proxy for estimating the proportion of the total biomass of each species present. While it is recognised that catch is a poor indicator of relative abundance, especially for pelagic fish, no other method is accessible from the data available.

The process followed was therefore to

a) divide the s_A-value between groups of fish and/or species,

b) produce pooled length distributions of a target species/category for use in the above equation and

c) calculate the biomass estimates for a region,

using the following procedure:

- The length-frequency samples of the species in the category were respectively pooled together with equal importance (normalized).
- The mean back scattering strength (ρ/s_A) of each length frequency distribution of the target group/ species was calculated and summed. This was automatically done in an Excel spread-sheet made available for acoustic abundance estimation on board.
- The pooled length distribution was used together with the mean s_A-value to calculate the density (numbers per square NM) by length groups and species, using the above formula. The total number by length group in the area was obtained by multiplying each number by the area.
- The numbers were then converted to biomass using the estimated weight at length.

2.13.5 Acoustic properties for Jellyfish

The jellyfish scattering layers are typically recorded at Sv (dB) densities of -65 to -50 dB at 38 kHz (Brierley *et al*. 2001). Recorded densities may sometimes be confounded by other scatterers such as dense plankton (Brierley *et al*. 2004, 2005). During scrutinizing these must be identified and isolated from jellyfish targets in the echograms using e.g. thresholding and multifrequency separation techniques.

The target strength relationships for *C. fulgida* and *A. forskalea* at 38 kHz are:

by size:

$TS_{38\ kHz}$ (dB) = 29.8 $\log_{10}$ (umbrella diameter, cm) - 32.9 (Brierley *et al*. 2001)

or by mass:

$TS_{38\ kHz}$ (dB) = 10.24 $\log_{10}$ (wet mass, g) –80.96 (Lynam *et al*. 2006).

CHAPTER 3. RESULTS - OCEANOGRAPHY

3.1 Underway sampling

The weather station was unfortunately not working properly so only hydrographic data will be presented while incoming solar radiation and wind vectors are omitted.

3.1.1 Thermosalinograph

The near surface conditions (5m depth) show a gradient of decreasing salinity and temperature from north to south. (Figure 8). Also, there is a gradient from the coast with relative colder and less saline water due to coastal upwelling that is also reflected in elevated levels of fluorescence.

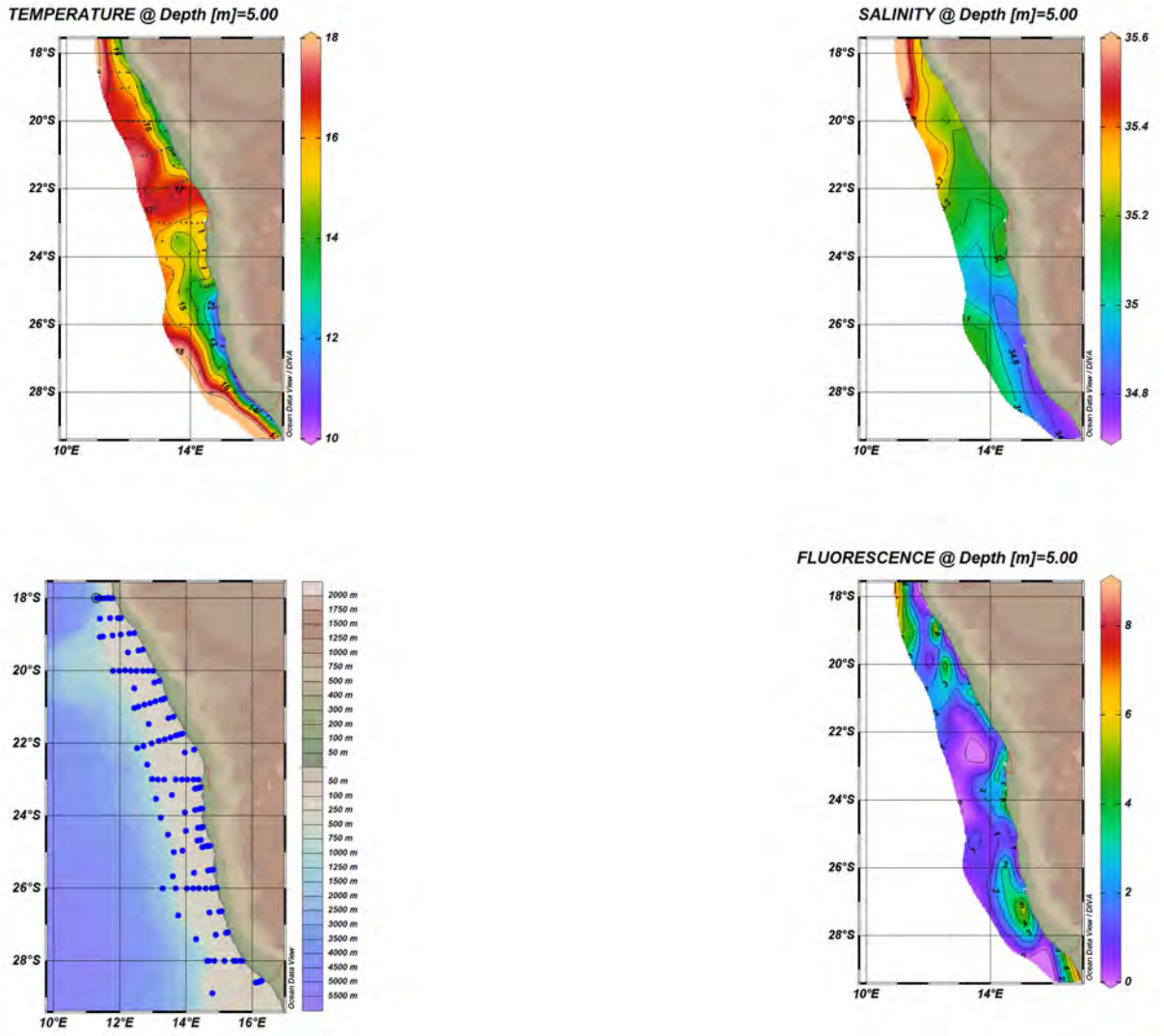


Figure 8. Near surface conditions at 5m depth from the *Dr Fridtjof Nansen* during the period 30 Oct-12 Dec 2017 including temperature, salinty, and fluorescence.

3.2 Hydrography

The continental shelf off Namibia is typically of the order 30-40 nm defined as depth less than 250 m, before a relative steep continental slope toward a basin of 1500-2000 m. However, in the southern region, the Orange Banks, the bottom profile is nearly flat in the depth range of 165-200 m. The bottom surface of this underwater plain is corrugated with numerous depressions and grooves in its central section. The underwater plane ascents and broadens gradually from it southern boundary at 30°S towards the north. It terminates abruptly at 28°15'S by an underwater cliff off the Panther Head headland with the sea floor depth falling down instantly by 200 m. Hydrographic variables were measured in sections normal to the coastline about every 30 nm, except in the southern region where they were measured every 40 nm (Figure 9).

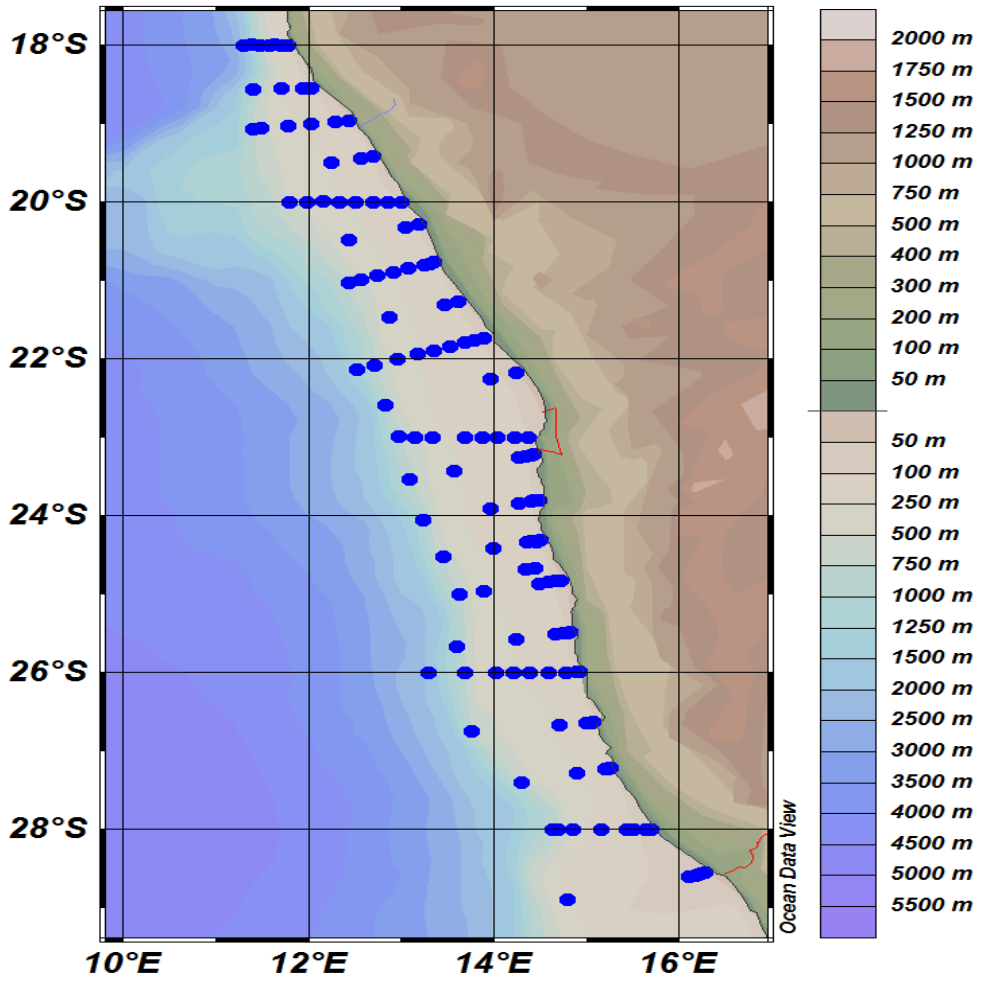


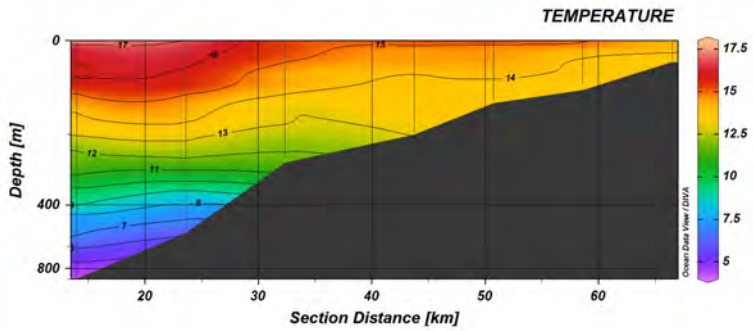
Figure 9. Positions of the CTD stations. Transects with superstations used to produce vertical profiles of salinity, temperature, oxygen, PAR and fluorescence were positioned close to every degree latitude (18 to 28 degrees South).

3.2.1 Temperature

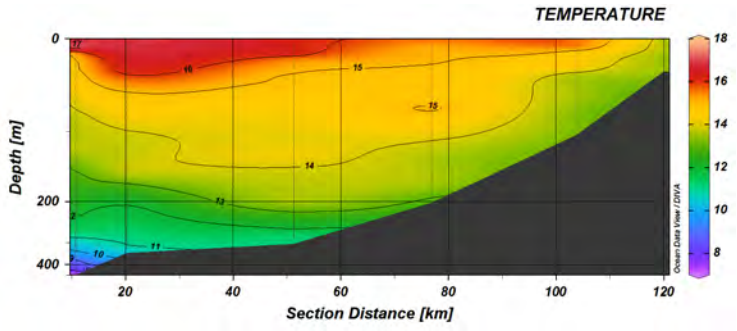
Figures 10 a-h show the vertical distribution of temperature as recorded on the 8 main hydrographic transects in the northern and centrak regions. All sections showed a warmer upper layer with temperatures exceeding 16 ^{o}C offshore. The thermocline shoaled towards the coast and surface layer temperature decreased to 12-14 ^{o}C. Colder waters with temperatures less than 8 ^{o}C were found offshore between 400-500 m depth. Exceptions were sections at 23, 24 and 25 ^{o}S where the surface layer was more homogenous across the whole section as temperatures were around 15 ^{o}C from offshore to the coast. The section at 18 ^{o}S showed temperatures were less than 5 ^{o}C at 1000 m depth.

Figures 10 i-l show the vertical distribution of temperature as recorded on the 4 main hydrographic transects sampled during this survey in the southern region. Similarly to the northern and central sections, the vertical distribution of temperature showed a warmer upper layer with temperatures exceeding 16 ^{o}C offshore. The thermocline shoaled towards the coast and the vertical gradient increased towards the south with surface layer temperaturs of 10-11 ^{o}C. There was a southward decrease in surface temperatures. Colder waters with temperatures less than 8 ^{o}C were found offshore between 400-500 m depth. The section at 26 ^{o}S showed temperatures less than 4 ^{o}C in waters around 1000 m depth.

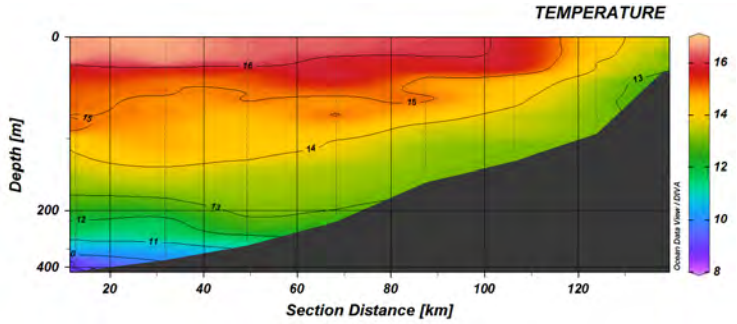
a) 18^{o}S



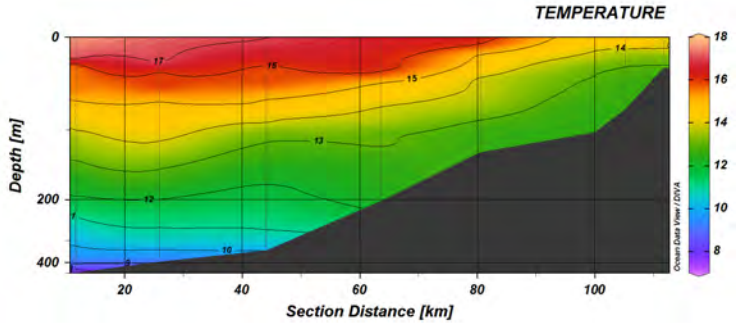
b) 19^{o}S



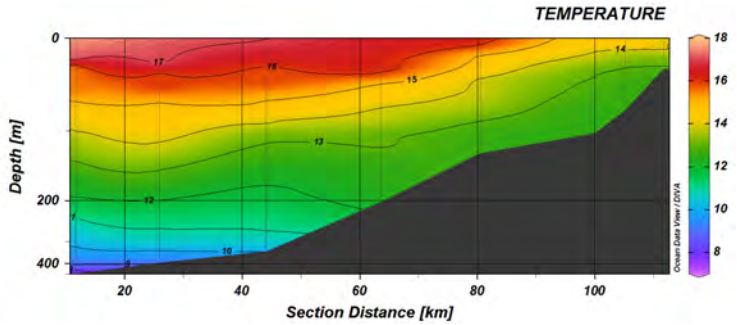
c) 20 ^{o}S



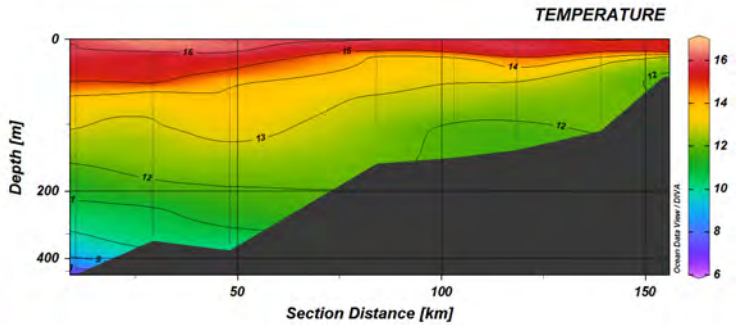
d) 21^{o}S



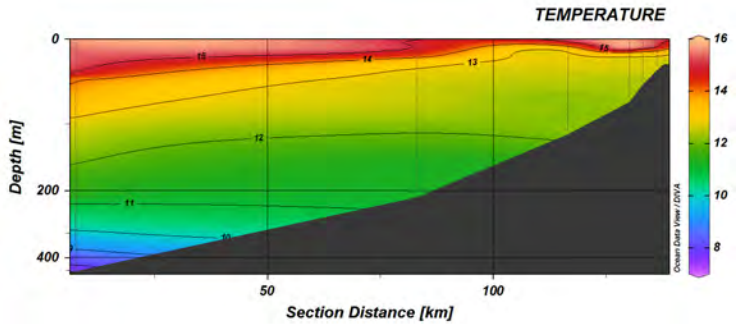
e) 22^{o}S



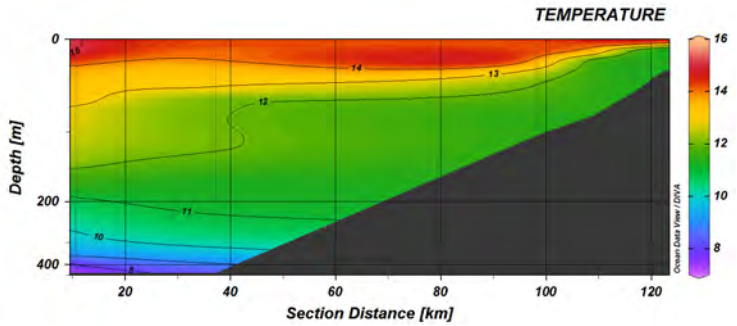
f) 23^{o}S



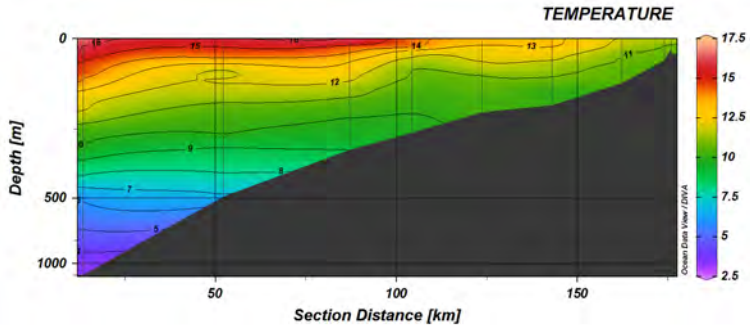
g) 24 ^{o}S



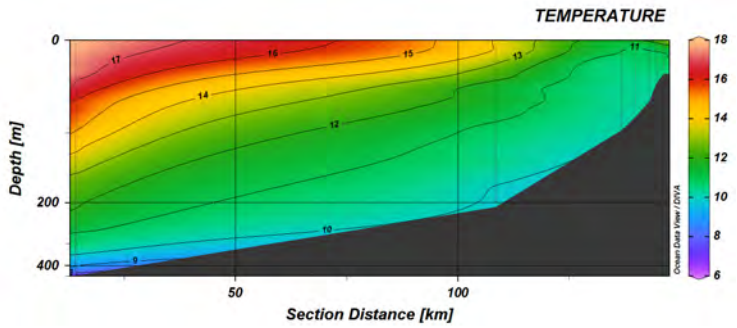
h) 25 ^{o}S



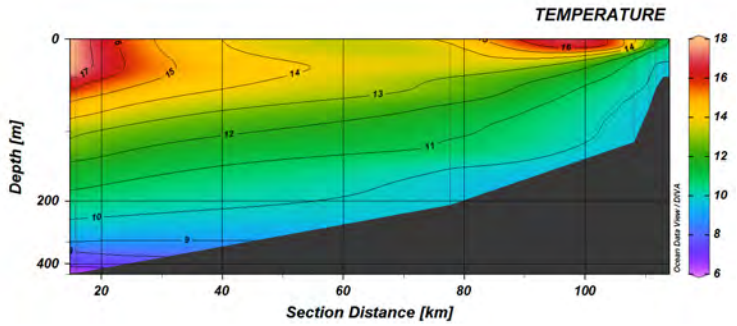
i) 26 ^{o}S



j) 27 ^{o}S



k) 27.30 °S



l) 28 °S

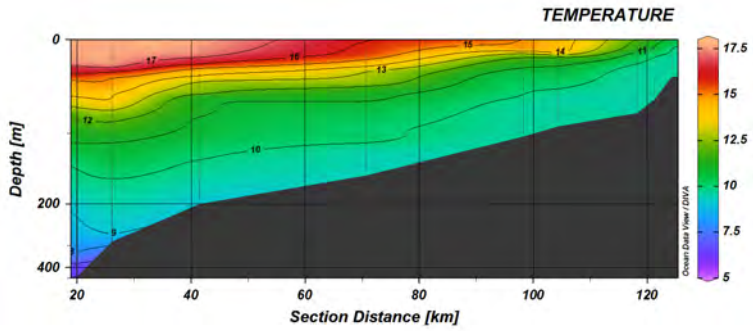


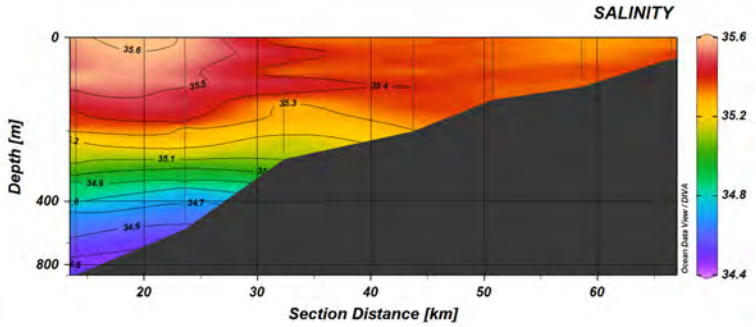
Figure 10 (a-h). Cross section of temperature from north to south based on the CTD data. See Figure 9 for positions of the sections.

3.2.2 Salinity

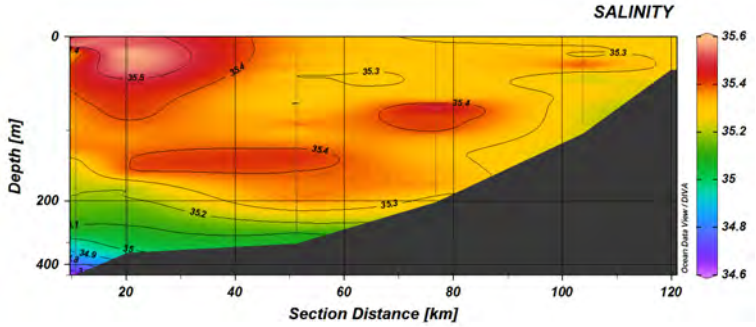
Figures 11 a-h show the vertical distribution of salinity as recorded on the 8 main hydrographic transects in the northern and central regions. Highest salinities around 35.5 were oserved in the offshore part of the sections. The salinity maximum became more of a subsurface feature between 100/200 m depth south of 20 °S. Less saline waters of around 34.5 were found offshore between 400-500 m depth.

Figures 11 i-l show the vertical distribution of salinity as recorded on the 4 main hydrographic transects in the southern region. Saline waters around 35.1 were found in the surface layer offshore. The latitudinal gradient to less saline waters of 34.8 in the near shore region was less pronounced. Deepest waters between 400-500 m depth, and to 1000 m depth at 26 °S were characterized by less saline waters around 34.4.

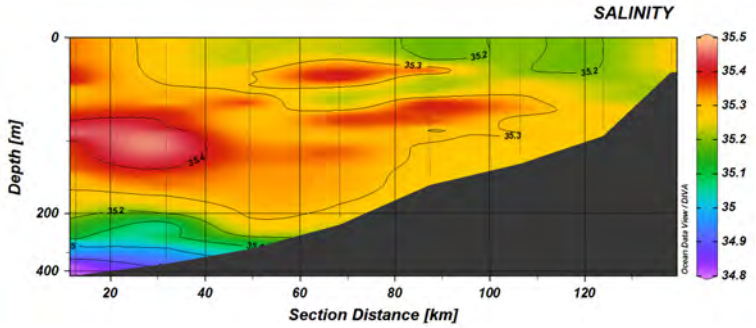
a) 18 °S



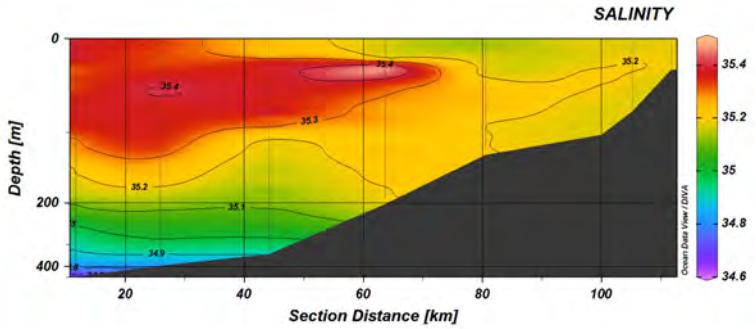
b) 19°S



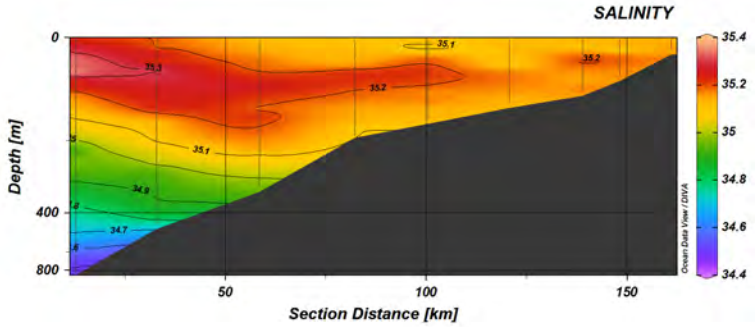
c) 20 °S



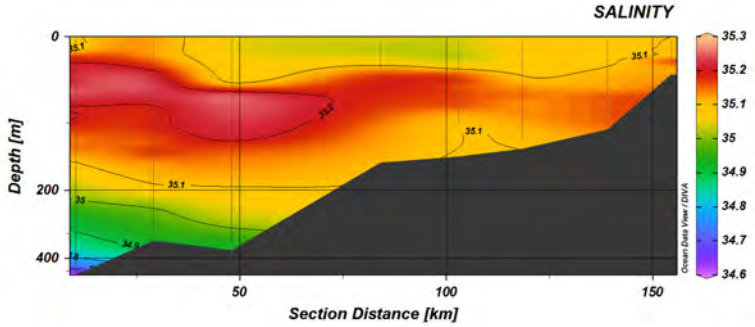
d) 21 °S



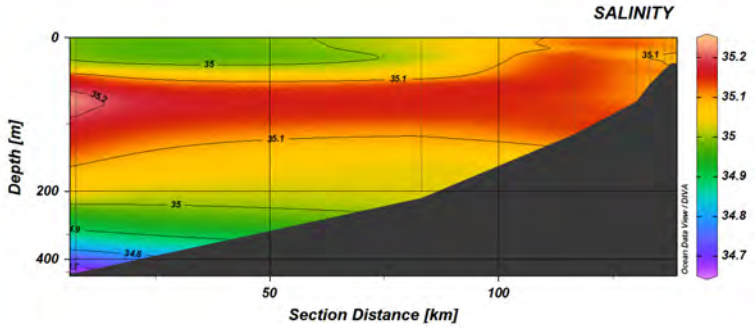
e) 22 °S



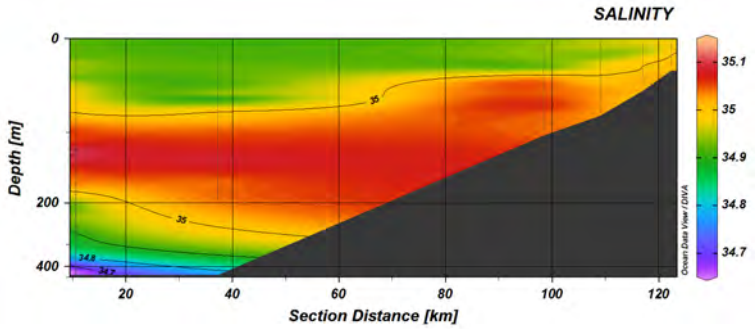
f) 23 °S



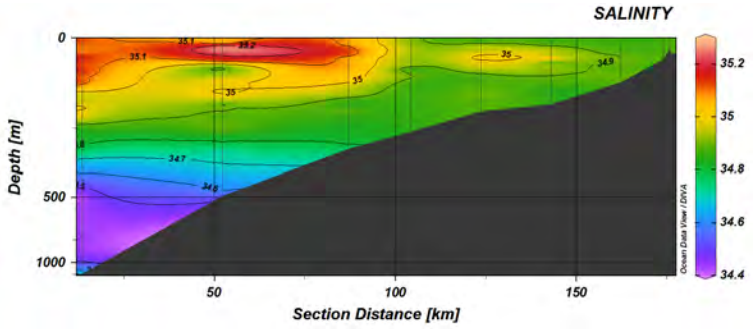
g) 24 °S



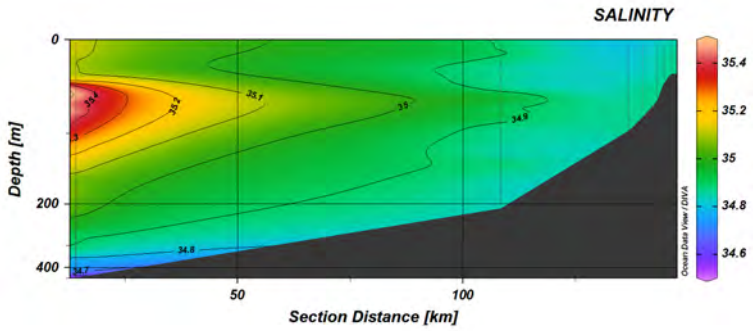
h) 25 °S



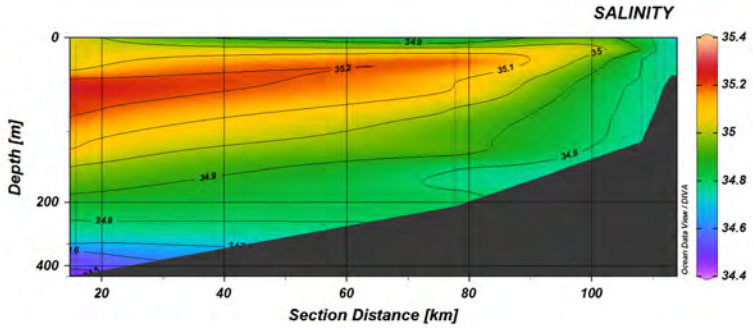
i) 26 °S



j) 27 °S



k) 27.30 °S



l) 28 °S

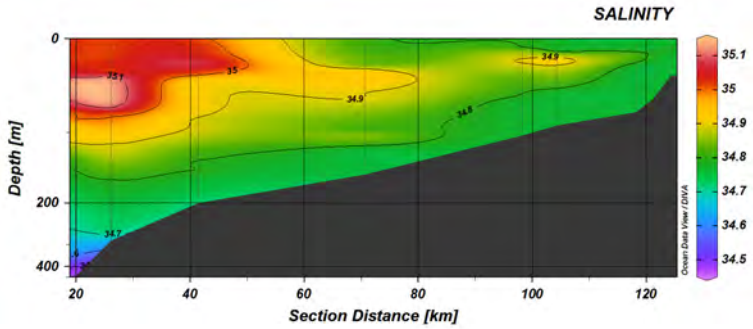


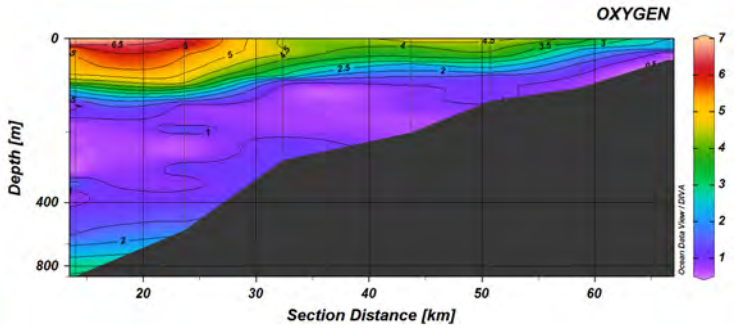
Figure 11 (a-l). Cross section of salinity from north to south based on the CTD data. See Figure 10 for positions of the sections.

3.2.3 Oxygen

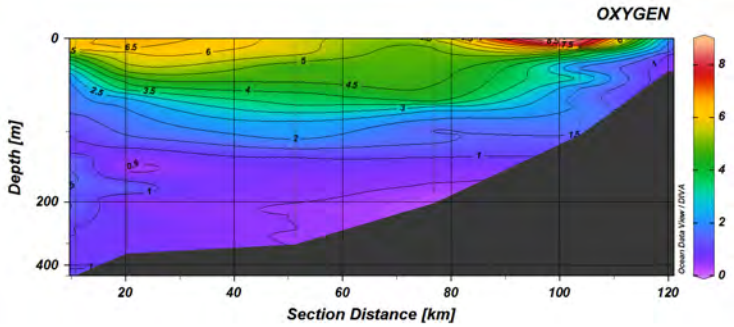
Figures 12 a-h show the vertical distribution of dissolved oxygen as recorded on the 8 main hydrographic transects. Typically, all sections revealed highest oxygen concentrations in the surface layer, with surface layer maxima exceeding 6 ml l^{-1} offshore. Oxygen values decreased to 1-2 ml l^{-1} in subsurface waters to form a pronounced oxygen minimum zone (OMZ). Values increased again to 3-4 ml l^{-1} at 400-500 m depth. Towards the coast, shoaling isolines created stronger vertical and horizontal gradients in oxygen concentrations, where values were around 3 ml l^{-1} in the upper 100 m.

Figures 12 i-l show the vertical distribution of dissolved oxygen as recorded on the 4 main hydrographic transects sampled in the southern region. The highest oxygen concentrations were found in the surface layer with high values exceeding 6 ml l^{-1} offshore. Subsurface waters typically had values in the range 1-2 ml l^{-1}, which decreased towards the inshore region as waters were almost oxygen depleted on the shelf south of 25 ^{o}S.

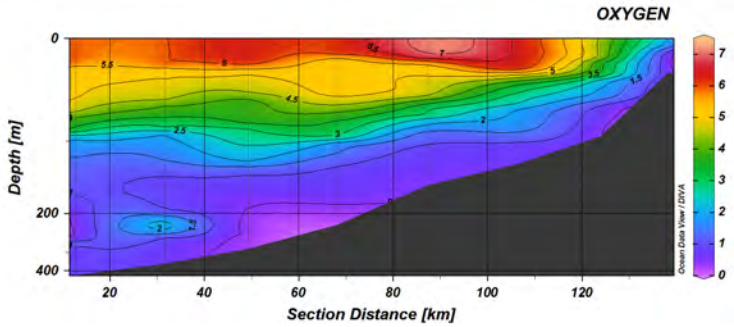
a) 8 ^{o}S



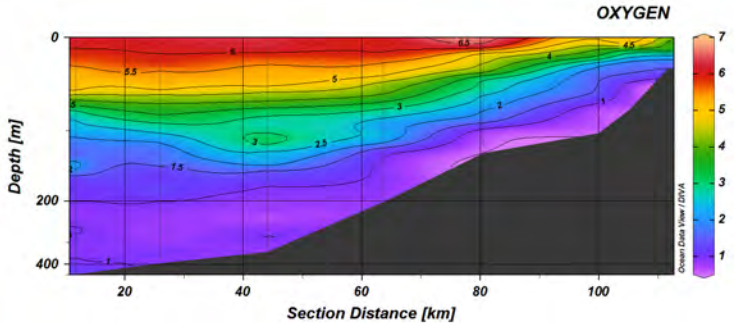
b) 19 ^{o}S



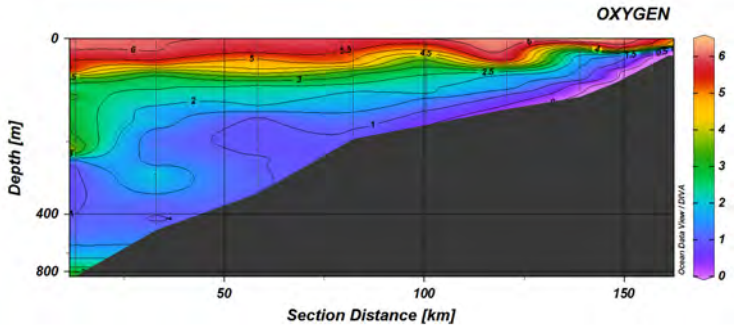
c) 20 ^{o}S



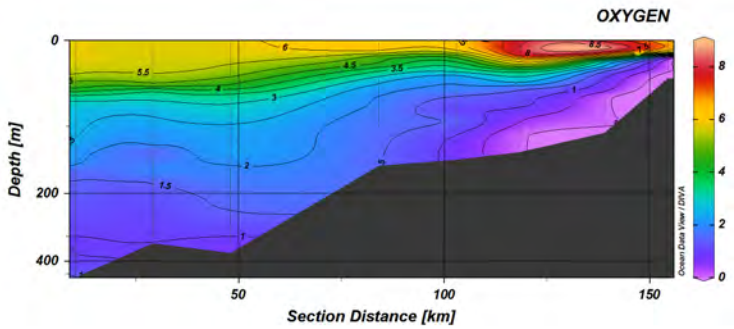
d) 21 °S



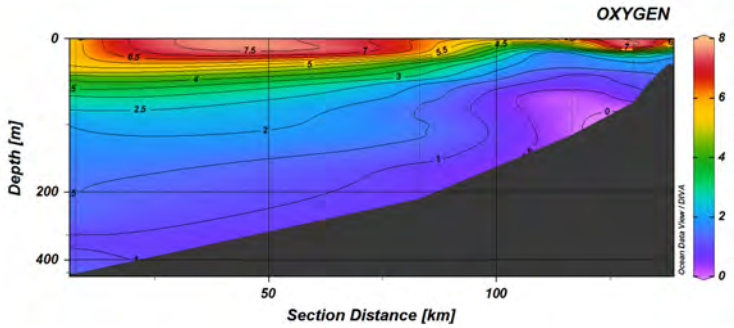
e) 22 °S



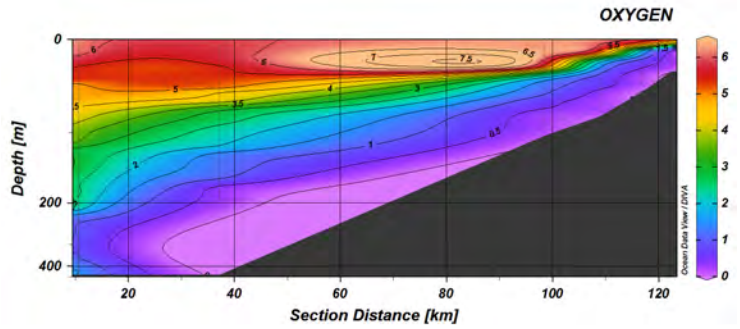
f) 23 °S



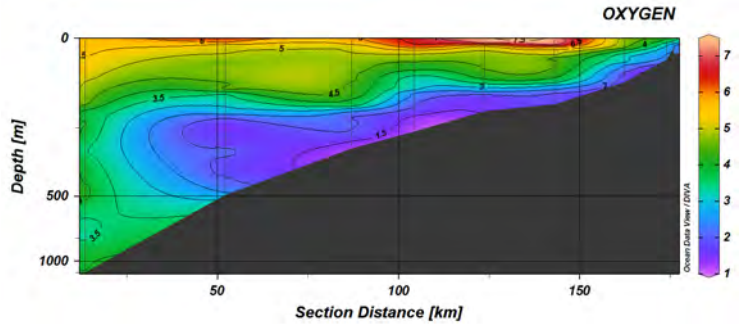
g) 24 °S



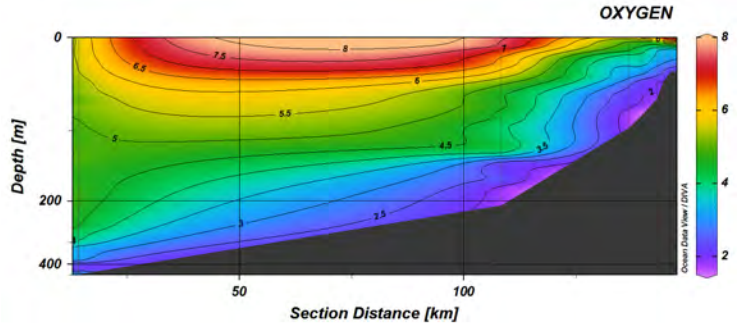
h) 25 °S



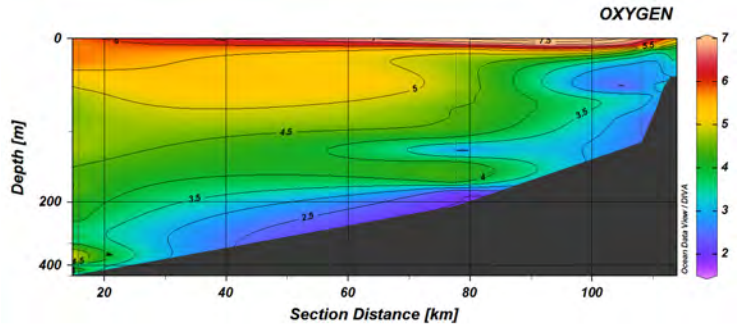
i) 26 °S



j) 27 °S



k) 27,30 °S



l) 28 °S

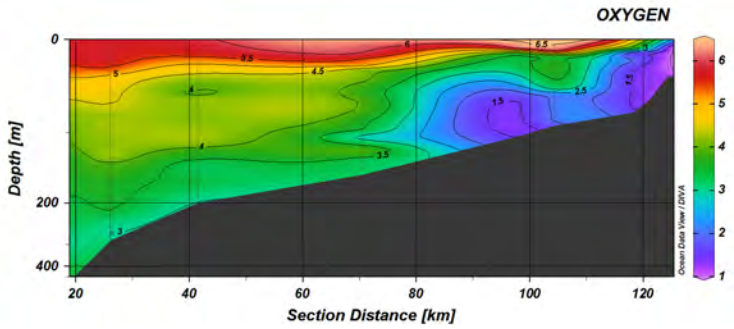


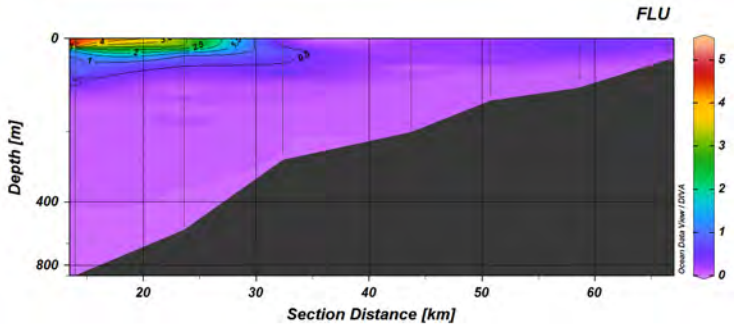
Figure 12 (a-l). Cross section of oxygen from north to south based on the CTD data. See Figure 9 for positions of the sections.

3.2.4 Fluorescence

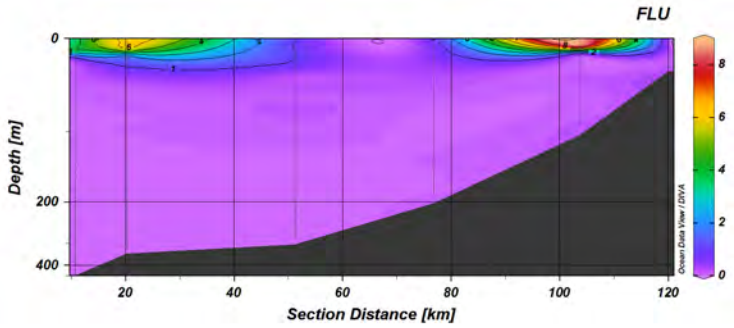
Figures 13 a-h show the vertical distribution of fluorescence as recorded on the 8 main hydrographic transects in the northern and central regions. Relatively high values were found in the upper 50 m with a patchy distribution and some surface maxima evident, e.g., at 23 °S close to the coast.

Figures 13 i-l show the vertical distribution of fluorescence as recorded on the 4 main hydrographic transects in the southern region. Similarly to the central sections, relatively high values were found in the upper 50 m with a more homogenous distribution across the whole surface layer.

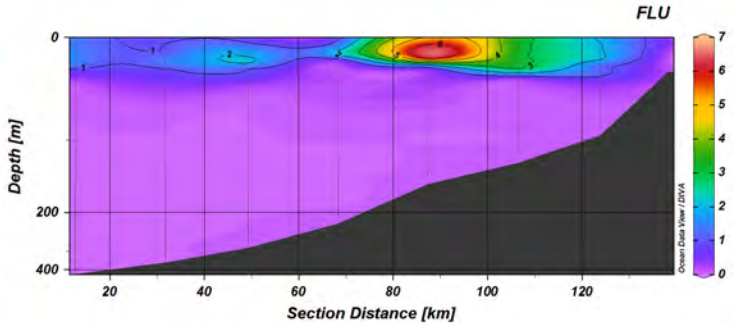
a) 18 oS



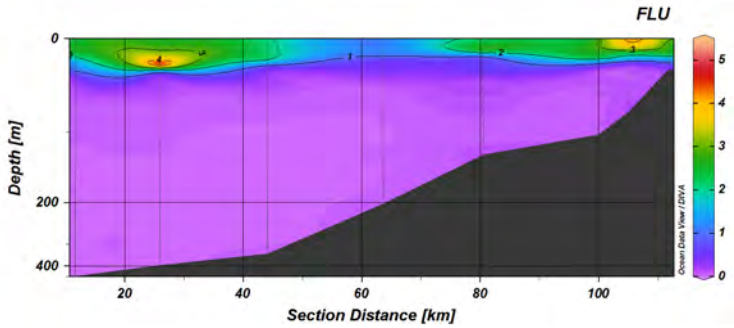
b) 19 °S



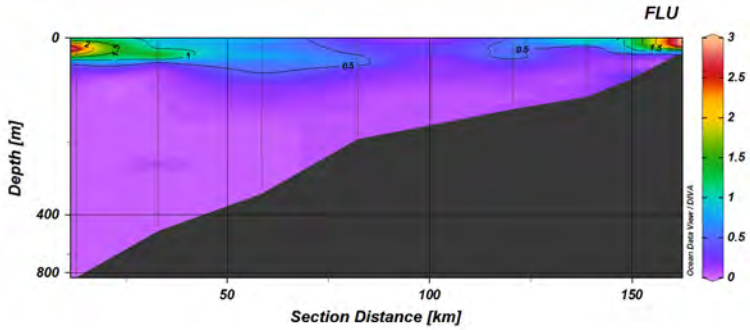
c) 20 °S



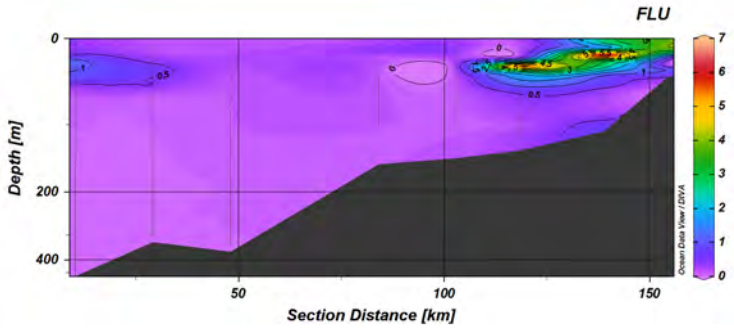
d) 21 °S



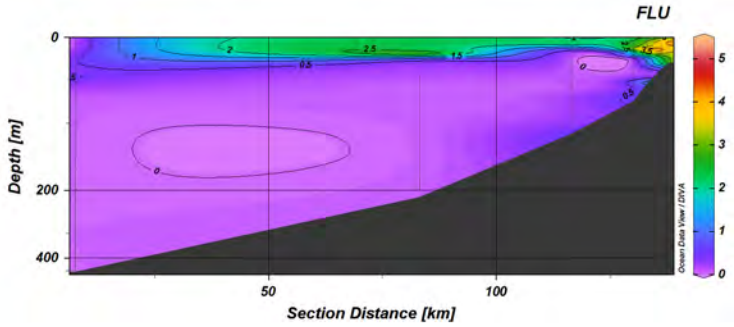
e) 22 °S



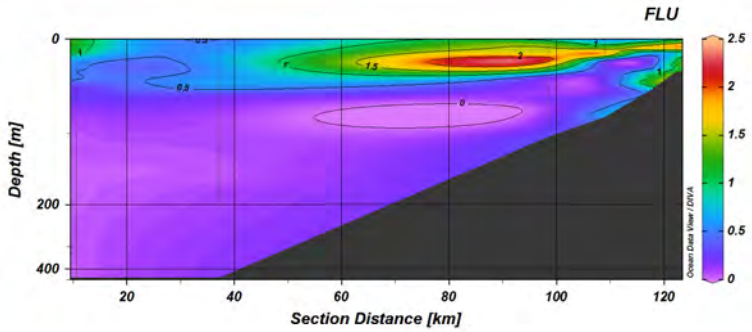
f) 23 °S



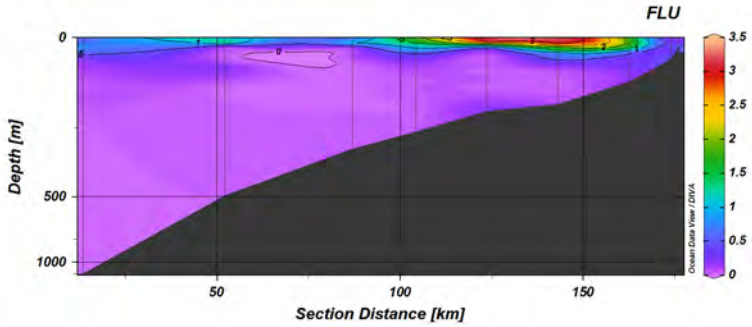
g) 24 °S



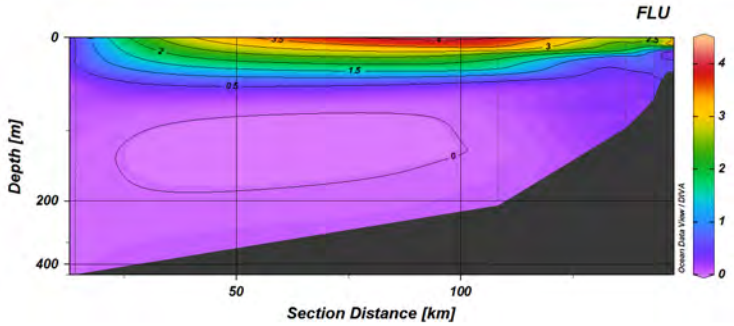
h) 25 °S



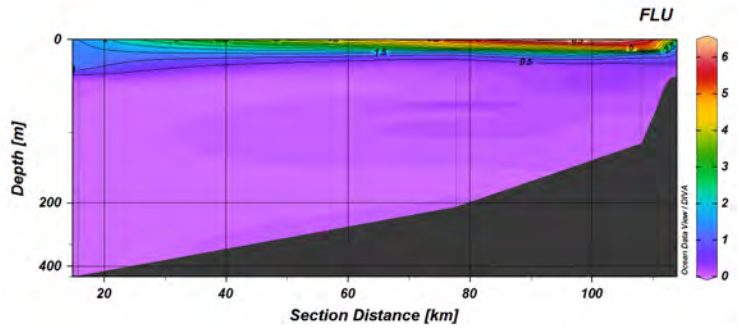
i) 26 °S



j) 27 °S



k) 27,30 °S



l) 28 °S

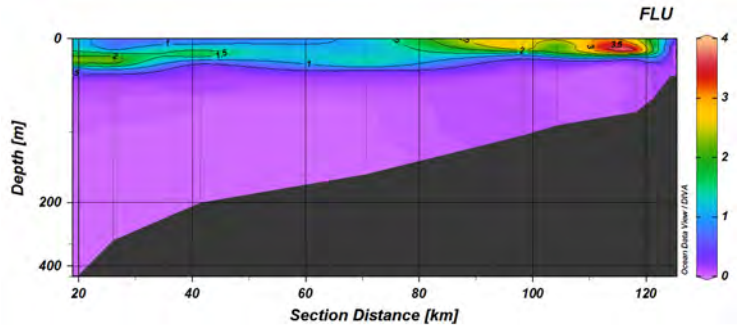


Figure 13 (a-l). Cross section of fluorescence, from north to south based on the CTD data. See Figure 9 for positions of the sections, note different vertical scale.

3.2.5 Horizonal distribution of pH and fluorescence (PAR)

Figure 14 shows the vertical distribution of pH (measured at 25 °C) as recorded along the section at 23 °S in the Namibia central region. Relatively high values were found in the upper 20 m across the whole section. Values decreased to lowest pH in subsurface waters, most notably close to the coast at 50-100 m depth. Deep water pH values increased 400-500 m offshore.

The sea surface (5 m) distribution fluorescence shows patches of higher values along the central and southern Namibian coastal regions (Figure 15). Highest values typically occurred in more coastal parts of the surveyed area. In the deep water the values are low. Changes in the vertical profiles of measured light levels (PAR) are presented in Figure 16. In the northernmost station the water was dark, with high absorbance of light, and hence production and use of nutrient occured only in the upper some 10-20 m.

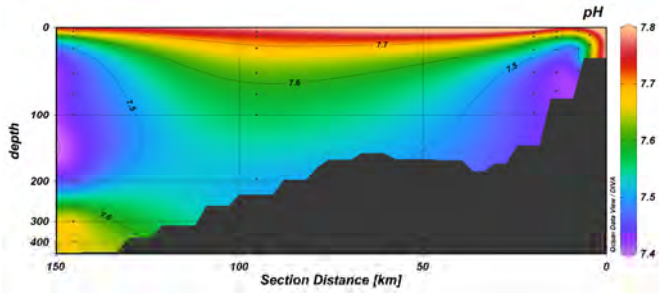


Figure 14. Vertical distribution of pH recorded along the section at 23 ^{o}S in the Namibia central region.

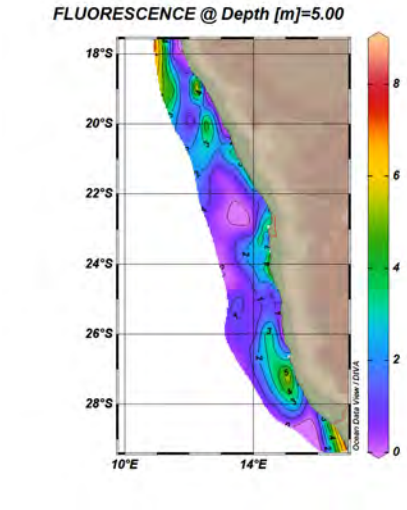


Figure 15. Horizontal distribution of fluorescence off Namibia at 5 m depth.

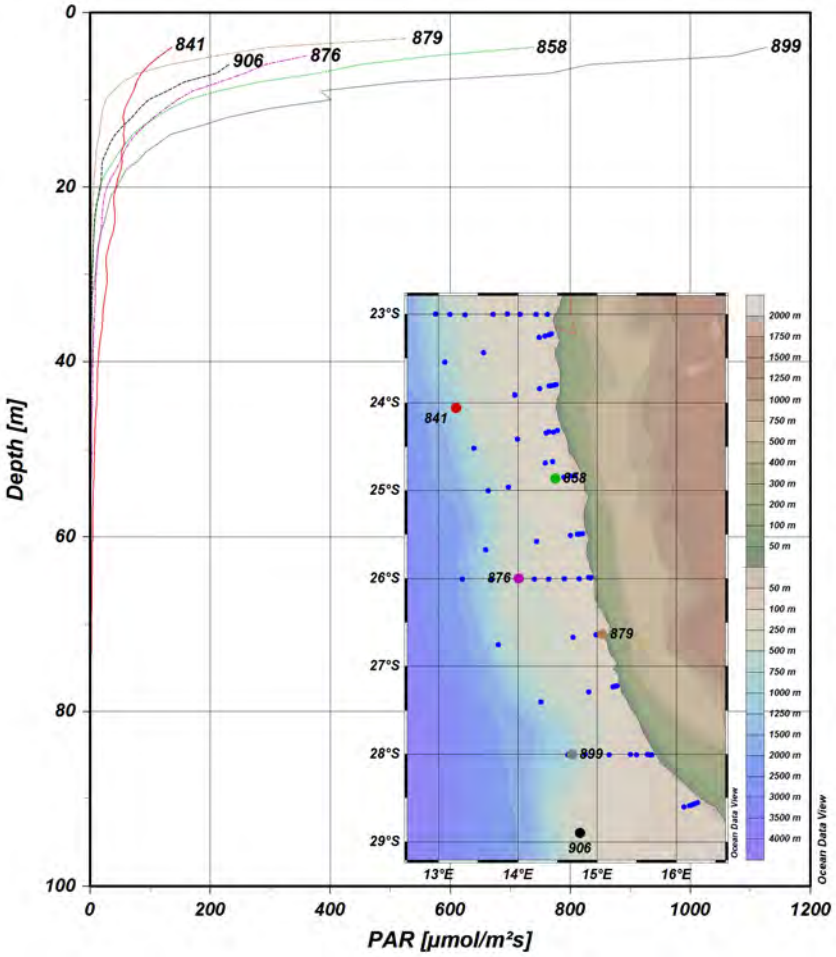


Figure 16. Vertical profiles from the PAR sensor mounted on the CTD for selected station during day time. Locations of the profiles are shown on the map.

3.3 Atmospheric soundings

Figure 17 and the Table 5 give an overview of the atmospheric soundings performed during the cruise. Figure 17 shows the location of all at least partially successful soundings, together with their validity time of day. In Table 5, instances in red indicate incidents, in bold when they resulted in total or partial data loss. Other comments in black indicate operational difficulties without consequences for data retrieval.

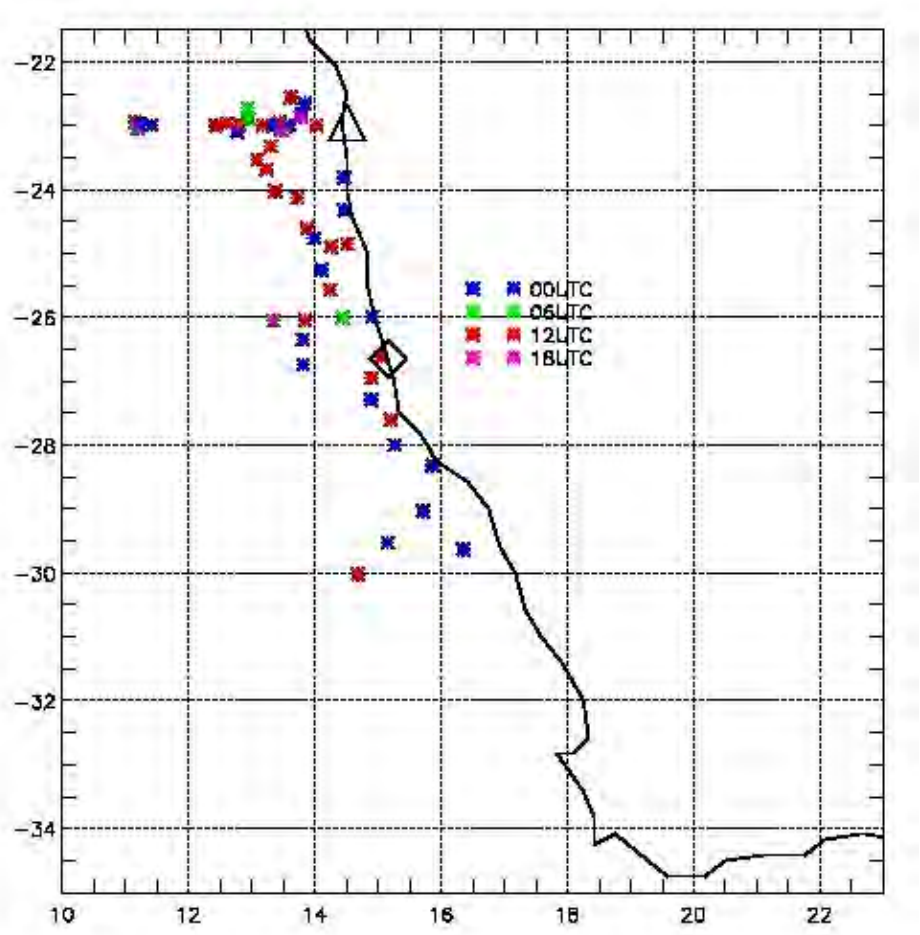


Figure 17. Overview of the atmospheric soundings performed during the cruise. The figure shows the location of all soundings, together with their time of day.

Table 5. Location of all at least partially successful soundings, together with their validity time of day. Instances in red indicate incidents, in bold when they resulted in total or partial data loss. Other comments in black indicate operational difficulties without consequences for data retrieval.

	00 UTC	06 UTC	gradient	12 UTC	18 UTC	
LEG 3.3						
Thu 16/11/17				Xx (!)		**1; Launch failed, sonde caught in ship wake turbulence and striking cranes.**
Fri 17/11/17	Xx			Xx		2
Sat 18/11/17	Xx	Xx		Xx	Xx	4; (18UTC: initial funnel exhaust)
Sun 19/11/17	Xx (!)			Xx		2; **00UTC: GPS failed, no wind data**; GPS antenna fixed for 12UTC launch
Mon 20/11/17	Xx	Xx		Xx (!)	Xx	4; Connector broken while changing bottle, re-fit; discarded bottle (01651237) not empty (~5200psi); corrosion in amplifier, signal weak; electric connectors cleaned, wiring re-laid, amplifier cleaned; 12UTC delayed (20 min), spool not unwinding at launch.
Tue 21/11/17	Xx			Xx		2; Antenna re-rigged on radar bridge, line of sight partly impeded by radar shielding, signal weak.
Wed 22/11/17	Xx		Xx (9:30 UTC)	Xx (!)		3; 12UTC: signal loss in initial part of ascent
Thu 23/11/17				Xx		1; antenna rer-rigged onto crow's nest railing, signal OK
Fri 24/11/17						
9 days						**19 launches, 17 successful soundings,** 1 partial data loss, **1 failed**
LEG 3.4						
Sun 26/11/17						
Mon 27/11/17	Xx	Xx		Xx		3
Tue 28/11/17	Xx (!)	Xx			Xx	3; DIGICORA/XP failed (sonde #N1053404); sounding recovered by Vaisala using processing file and parameter info from 20171127_0UTC launch (possible inaccuracies).
Wed 29/11/17				Xx		1; bottle change: #01651239 used up
Thu 30/11/17			Xx (14UTC)	Xx		2
Fri 01/12/17				Xx (!)		1; DIGICORA/XP failed (sonde #N1113140); recovered with full info
Sat 02/12/17	Xx			Xx		2
Sun 03/12/17	Xx			Xx		2
Mon 04/12/17	Xx		Xx (09UTC)	Xx		3
Tue 05/12/17	Xx (!)			Xx (!)		2 **+1; 00UTC (N1053060) failed. sonde touched water;** launch repeated with request to 1st officer to slow down and turn vessel. Balloon inflation +50%. 8.30UTC bottle change: #01651238 used up. 12UTC (N1053277) battery pack cover lost through impact with forecastle and antennas, sonde in apparent working conditions sending back data, battery failed at 110 hPa.
Wed 06/12/17	Xx (!)	Xx		Xx	Xx (!)	4 **+1; 0UTC, sonde #N1053402: GPS failed (PTU OK), no wind data** (fog, heavy drizzle affecting GPS antenna; cleaned and protected); **18UTC (N1053315) failed, T sensor damaged by collision with balloon**; launch repeated (18:24UTC) with request to slow down vessel.
Thu 07/12/17	Xx			Xx		2; 00UTC launch delayed (trawl) 00:30 UTC
Fri 08/12/17	Xx			Xx		2
Sat 09/12/17	Xx			Xx		2
Sun 10/12/17	Xx					1; bottle change,: #0981258 used up
Mon 11/12/17	Xx					1; spool not unwinding at launch (flight smooth, data OK)
Tue 12/12/17	Xx					1
Wed 13/12/17	Xx			Xx		2; 12UTC: long wait for net after CTD
Thu 14/12/17	Xx					1; poor gps signal
Fri 15/12/17						
Sat 16/12/17						
21 days						**37 launches, 34 successful soundings,** 1 partial data loss, **2 failed**

The main objective of this sampling was to detect and quantify the importance for the surface winds of the coastal low-level jet, an inversion-level thermal wind which can be theoretically expressed by the equation $\partial_z v \approx \frac{N_i^2}{fg\rho_i}(\partial_x p_i)_p$, where v is the meridional component of wind, z is height, x is distance along a geographic parallel, N is the Brunt-Väisälä frequency, f the inertial frequency, g the acceleration of Earth's gravity, ρ air density, p hydrostatic air pressure, and the subscript i indicates quantities evaluated at the inversion. The latter is assumed to be geometrically thin, i.e. the vertical distance Δz over which air temperature increases with height is much smaller than any horizontal scale; this is well satisfied with typically $\Delta z \approx 100$m and $\Delta x \approx 10$km. The significance of this relationship is in expressing an increase in southerly wind strength from its free-tropospheric value when approaching the marine PBL if there is a westward slope of the PBL inversion. The size of the southerly wind increase towards the surface thus depends on the contrast in thermodynamic properties of the air masses in the marine PBL and in the free troposphere, and the decrease in PBL thickness towards the eastern ocean boundary (i.e. the west coast of Africa). The surface wind results from this thermal wind component (which we will refer to as "inversion wind" hereafter) added to any existing large-scale wind component controlled by large-scale pressure gradients associated with synoptic systems or planetary-scale circulations ("synoptic wind").

The contribution from inversion and synoptic wind to the surface wind can be quantified from each atmospheric soundings taken during the cruise. A few “gradient” measurements (indicated in the Table) were also carried out in order to explicitly verify the theoretical relationship between inversion slope and inversion wind. One (out of three) of these samplings in fact resulted in falsification, as the two soundings (at 12UTC and 14UTC on 300 November 2017) were taken during the passage of a synoptic-scale frontal wave that produced a marked change in both low-level wind and atmospheric stratification. The importance of synoptic-scale forcing was further confirmed in other soundings, especially in the southern Benguela (south of Luderitz). Nevertheless the majority of soundings confirm a broad dominance of the inversion wind in determining near-surface conditions, although the detailed analysis and quantification of this contribution has not been carried out yet at the time of writing this report.

Here we can present the result of a gradient measurement carried out on 22 November, the analysis of which also addresses issues of data integrity associated with some of the technical problems mentioned above. The 12UTC sounding is in fact the worst affected by data corruption among successful balloon ascents, excluding the two that did not return any wind information (00UTC on 19 November and 00UTC on 6 December). Profile information from this sounding was recovered from the raw data, removing bad data points by hand before corrections and interpolations. The results are shown in the Figure 18 (panels b1-b3) together with the 14UTC sounding (panels a1-a3).

The inversion wind equation given above can be integrated over height to give the meridional wind increase at the base of the inversion layer with respect to the free-tropospheric value at the top of the inversion layer: $\Delta v \approx \frac{(\Delta\theta)_i}{f\theta\rho_i}\frac{\Delta p_i}{\Delta x}$ where θ indicates air potential temperature. The last factor is the horizontal slope of the inversion layer. Comparing the inversions heights at the two soundings (966hPa and 948hPa, respectively) and their positions (22º58'15"S, 12º48'04"E and 22º58'12"S, 13º11'24"E, respectively) we obtain $\Delta v \approx 15$ m/s, which fits the measured wind speed profiles quite well (wind direction was constant through the section of the atmosphere shown in the figure). This verifies our theoretical relationship, and compares with about 5 m/s synoptic-scale wind showing that about 75% of surface wind is generated by inversion dynamics in this case.

In general, the inversion slope itself is controlled by synoptic-scale dynamics as it depends on lower tropospheric subsidence. The analysis of the relationship between synoptic-scale flow (as obtained from reanalysis products) and the measured properties of the Benguela inversion and the associated low-level jet will be carried out in the near future.

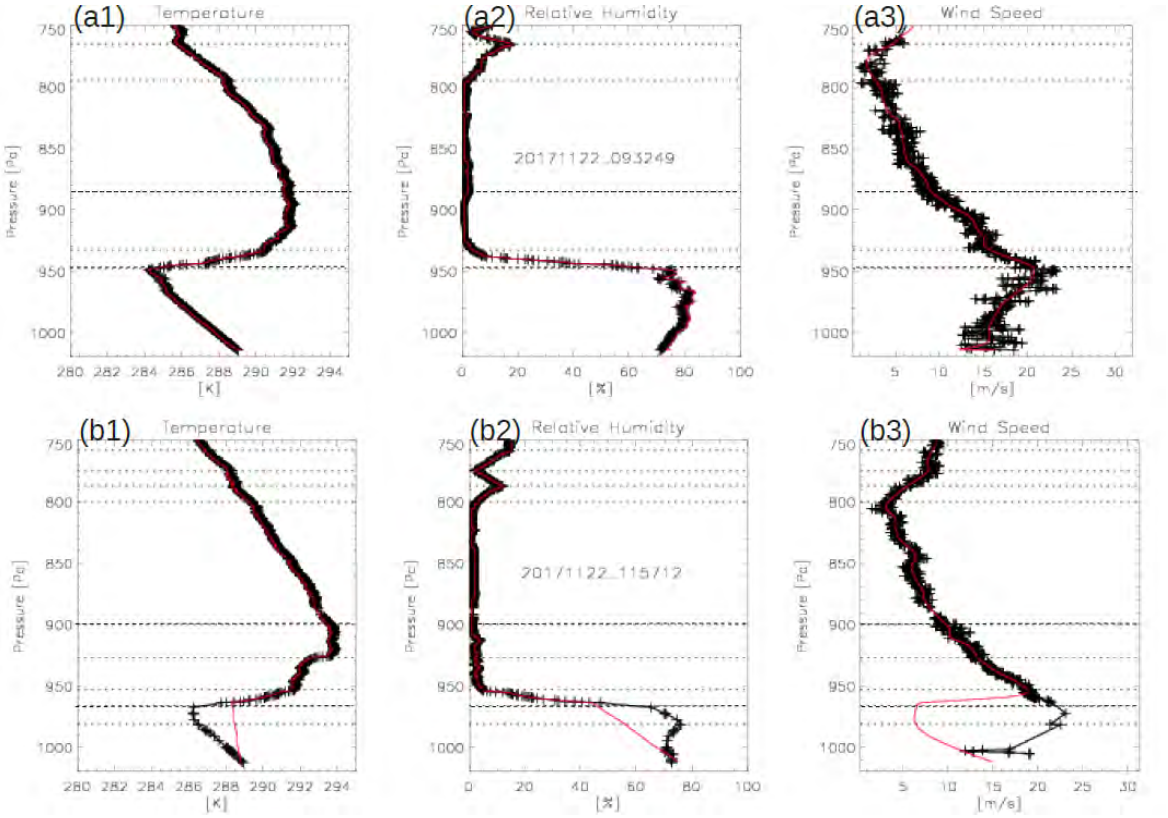


Figure 18. Gradient wind measurement carried out on 22 November at 14UTC (a1-a3) and at 12 UTC (b1-b3). Profile information from the 12 UTC sounding was recovered from the raw data, removing bad data points by hand before corrections and interpolations. The crosses indicate raw data point, the red lines are the results from automatic interpolation with the DIGICora software.It can be seen that the latter failed in the lower part of the 12UTC sounding, but individual raw data point supply sufficient information to pinpoint the inversion and for the calculation of the inversion wind.

3.4 Phyto and zooplankton samples

Samples containing phytoplankton and zooplankton were collected from the phytoplankton vertical haul net and the WP2 net (also vertical haul). These samples will be analysed later and the results will be reported separately.

A total of 98 zooplankton samples for taxonomic analysis were sampled on the Namibian shelf from north to south (Table 6).

Table 6. Number of samples of phyto- and zooplankton collected.

Country	**Phytoplankton**	**Zooplankton from 200 m**		**Zooplankton from 25 m**	
	Formalin	Formalin	Dried	Formalin	Dried
Namibia north	13	11	37	16	47
Namibia central	14	4	13	12	41
Namibia south	11	8	25	13	40
Total	38	98	116	169	128

3.5 Fish eggs and fish larvae

In Namibia Central the multinet was deployed 7 times, with 4 stations containing a total of 172 fish larvae (Table 7). The samples were superficially checked for eggs onboard, but no eggs were found. Out of 10 multinet samples deployed in Namibia South only 1 single fish larvae was found. The whole sample was preserved in formalin for further investigations in Namibia. In total the Multinet was deployed at 34 stations with bottom depths ranging from 30 m-2000 m. The net was towed obliquely from 10 m above the bottom or from a maximum depth of 200 m in deeper stations.

There was not enough time to fully identify all the fish eggs or fish larvae to species level. The samples were therefore preserved in formalin for further investigation onshore. Figure 19shows one example of a fish larve collected with the multinet.

Table 7. Summary of fish larvae sampling stations.

Country	**No. of sampling stations**	**No. of stations with fish larvae**	**Total No. of fish larvae**	**Samples preserved**
Namibia north	17	11	100	11
Namibia central	7	4	172	4
Namibia south	10	1	1	1
Total	34	16	273	16

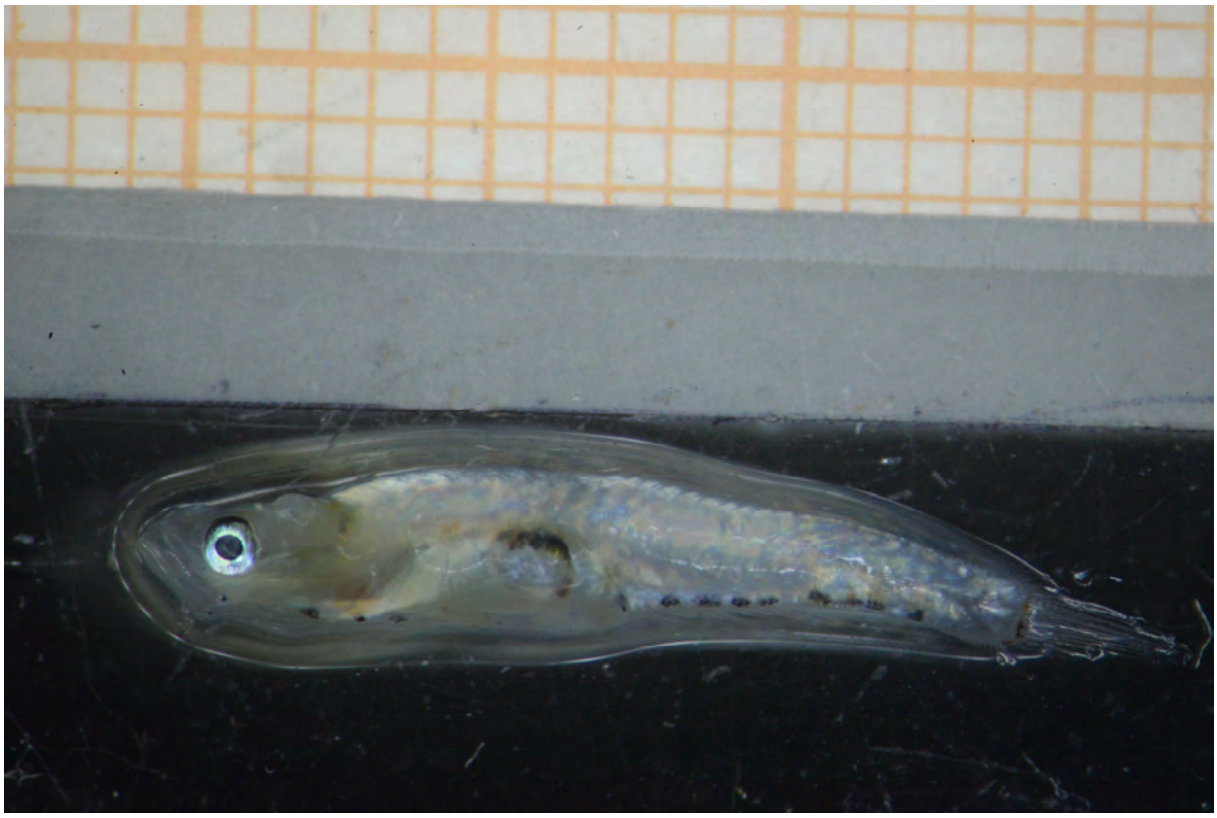


Figure 19. Fish Larva sampled in Multinet, station 843, in Namibia Central.

CHAPTER 4. RESULTS - ACOUSTIC ABUNDANCE AND GEOGRAPHIC DISTRIBUTION OF PELAGIC FISH

4.1 Biology of target species

With the expanding scope of the research to be carried out in the context of the EAF-Nansen Programme, the survey objectives and related sampling strategy have been expanded to supporter research on life cycles, stock identity, and trophic relationships of pelagic fish.

Biological parameters were collected throughout the survey area (Tables 8 to 10). These biological parameters will be used for post-survey age and growth, stock structure, population biology and trophic interaction studies.

Table 8. Total number of individuals for each target species analyzed for biological parameters in Namiba North.

Species	Length/ Weight	Sex	Maturity	Stomach	Liver	Fin clips	Otoliths
Argyrosomus inodorus	100	30	30	30	30	30	30
Engraulis capensis	579						
Etrumeus whiteheadi	241						
Sardinella aurita	0	2	2	2	2	2	2
Sardinops sagax	463	171	171	171	171	171	74
Scomber colias	120						
Sufflogobius bibarbatus	30						
Trachurus capensis	1787	547	547	547	547	547	187
Total	3320	750	750	750	750	750	293

Table 9. Total number of individuals for each target species analyzed for biological parameters in Namiba Central.

Species	Length/ Weight	Sex	Maturity	Stomach fulness	Liver	Fin clips	Otoliths
Trachurus capensis	613	120	120	120	90	90	30
Engraulis encrasicolus	15						
Sardinops sagax	27	27	27	27	27	27	14
Etrumeus whiteheadi	82						
Thyrsites atun	80						
Sufflogobius bibarbatus	85						
Aequorea forskalea	872						
Chrysaora fulgida	708						
Chrysaora africana	40						
Discomedusa lobata	16						
Merluccius (juveniles)	14						
Merluccius capensis	627						
Myctophidae	50						
Lampanyctodes hectoris	60						
Total	3289	147	147	147	117	117	44

Table 10. Total number of individuals for each target species analyzed for biological parameters in Namiba South.

Species	Length/Weight	Sex	Maturity	Stomach fulness	Liver	Fin clips	Otoliths
Etrumeus whiteheadi	533	150	150	150		120	
Chrysaora fulgia	119						
Aequorea forskalea	574						
Thyrsites atun	59						
Merluccius capensis	90						
Trachurus capensis	21	21	21	21			
Sardinops sagax	8	8	8	8			
Total	1404	179	179	179	0	120	0

4.2 Jellyfish

A number of jellyfish species were found in Namibian waters. However, the medusae of three species were particularly abundant and commonly encountered, i.e the scyphozoans *Chrysarora fulgida* (previously *C. hysoscella*) and *Chrysarora africana*, and the hydrozoan *Aequorea forskalea* (previously *A. aequorea*).

Both *C. fulgida* and *A. forskalea* were distributed widely in Namibian waters from the Cunene River in the north to the Orange River in the south, from inshore to about 350 m depth. *C. fulgida* is generally most common inshore, while *A. forskalea* is most common further offshore although this general pattern may vary across seasons (Sparks *et al*. 2001).

The typical vertical distribution was found in the presence of a persistent, often undulating, scattering layer from around 15-20 m water depth extending about 20-30 m downwards during daylight hours. At night these layers became more diffuse, often extending their upper boundary towards the surface, presumably as some of them migrate upwards (Brierley *et al*. 2001). For *C. Fulgida* there are clear trends of increasing size along the north-south and inshore-offshore gradient, consistent with their vertical migrations utilizing the offshore surface Ekman transport and the onshore compensation current to maintain their cross-shelf distribution pattern (Sparks *et al*. 2001, 2005).

In terms of abundance *C. fulgida* and *A. forskalea* dominate (Lynam *et al*., 2006), while *C. Africana* is only caught incidentally in inshore waters. Due to methodological limitations the biomasses of jellyfish have historically not been monitored systematically and therefore the changes in stock abundance are poorly known (but see Flynn *et al*., 2014 for a review). Following recent advances in the hydroacoustic technology and the use of multifrequency acoustics for target identification it is now possible to estimate the abundance of jellyfish acoustically (Brierley *et al*., 2001, 2004, 2005). Analysing data from 2003, Lynam *et al*. (2006) estimated the combined biomass of *C. fulgida* and *A. forskalea* in Namibian waters between River and Orange River to be markedly higher than those of fish combined.

The animal tissue density has been estimated at 0.996 kg l^{-1} for *C. fulgida* and 1.014 kg l^{-1} for *A. forskalea (*Brierley *et al*., 2001, Buecher *et al*., 2001). *A. forskalea* has a very fragile umbrella margin which was usually missing or substantially damaged in most individuals

recovered from the trawls. In *A. forskalea* the central disk has been estimated to contribute 56 % (± 9 %) to total diameter and 44 % (± 12 %) to total wet mass (Brierley *et al*., 2001), with an outer to inner umbrella ratio corresponding to: Outer diameter = (0.96 x Inner diameter) + 14. 0 (R^2=0.69) (Brierley *et al*., 2004). Thus for *C. fulgida* the size distributions are estimated by measuring the diameter of the umbrella, while for *A. forskalea* only the inner disks are measured and subsequently converted to disk diameter and disk or total animal mass using the relations established above.

Jellyfish were caught in most of the trawls in Namibia. Five different species of jellyfish were caught, of which *Chysaora fulgida* was the most frequent, followed by *Aequorea forskalea* and *Chrysaora africana*.

4.3 Distribution, size composition and biomass estimates

4.3.1 Namibia North (Cunene River-Ambrose Bay)

4.3.1.1 Pilchard

Pilchard (*Sardinops sagax*) was patchily distributed in shoals along the northern region of Namibia, from Cunene River to Ambrose Bay. Pilchard was found distributed with low densities ($0<s_A<300$ m^2/NM^2) north of Cape Frio to Mowe Point. Between Dune Point and Palgrave Point, medium densities was found ($301<sA<1000$ m^2/NM^2). The fish were mainly distributed inside the 200 m depth line. A small high-density area was located inshore between Rocky Point and Mowe Point ($3001<sA<10000$ m^2/NM^2) (Figure 20).

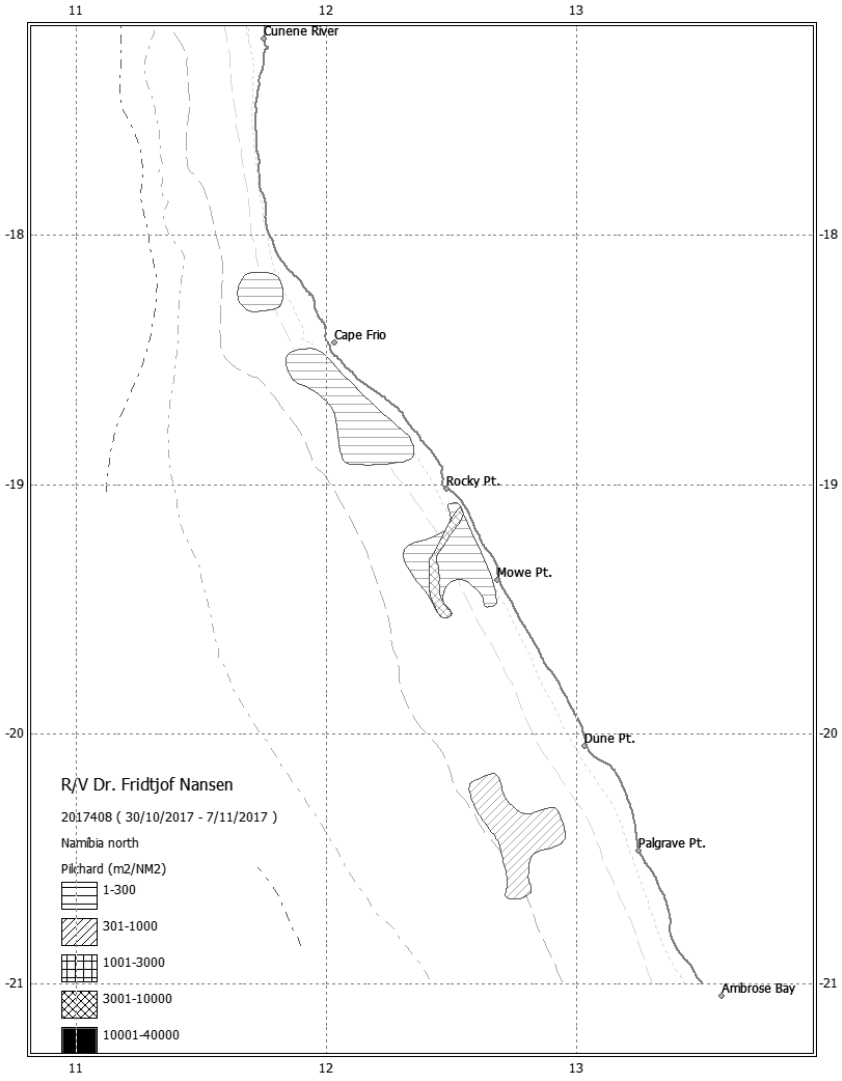


Figure 20. Distribution of *Sardinops sagax*, Cunene River-Ambrose Bay. Depth contours at 20, 50, 100, 200, and 500 m.

Figure 21 shows the length distribution of pilchard in the northern region. Pilchard had a length range of 10 to 22 cm TL and showed two modal peaks, at around 16 and 20 cm TL. The biomass of pilchard was estimated to be 142 000 tonnes (Table 11), with 44.5% of biomass belonging to fish of < 20 cm length, while the fish of >20 cm contributed 55.5% of the biomass. However it should be noted that this results are not comparable to the annual pilchard directed survey results, conducted by RV Mirabilis during October. This is mainly due to larger distance between the transects in the Nansen survey design compared to the survey design used on Mirabilis, where they focus on covering the pilchard distribution.

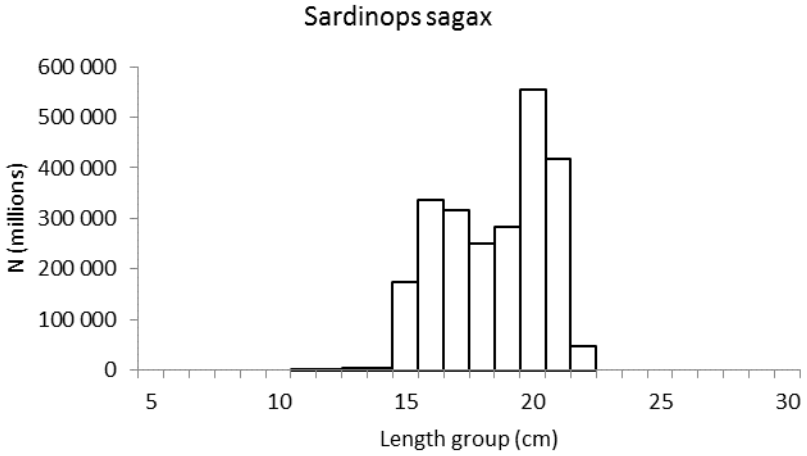


Figure 21. Total length distribution of *Sardinops sagax*, Cunene River-Ambrose Bay.

4.3.1.2 Horse mackerel

Cape horse mackerel (*T. capensis)*, was observed in a continuous distribution along the northern region of the Namibian coast, from Cunene River to Ambrose Bay (Figure 22). Horse mackerel was found in low ($1<sA<300$ m^2/NM^2), medium ($301<sA<1000$ m^2/NM^2), high-densities ($1001<sA<3000$ m^2/NM^2) and very high-densities ($3001<sA<10000$ m^2/NM^2).

Low densities were recorded in most of the area from Cunene River to Ambrose Bay, with overlapping medium and high-density areas. The medium and high density areas were distributed in small patches from Cunene River to Ambrose Bay. Very high-densities of Cape horse mackerel were found north of Cape Frio, up to Mowe Point.

During this survey, most fish was captured between 20 - 200 m depth, and the distribution typically extended slightly outside the 200 m depth line, with a more offshore extension at 19°S. The horse mackerel was generally caught with bottom trawls during the day and pelagic trawls during the night, and the catches were usually mixed with relatively large quantities of jellyfish (increasingly southwards).

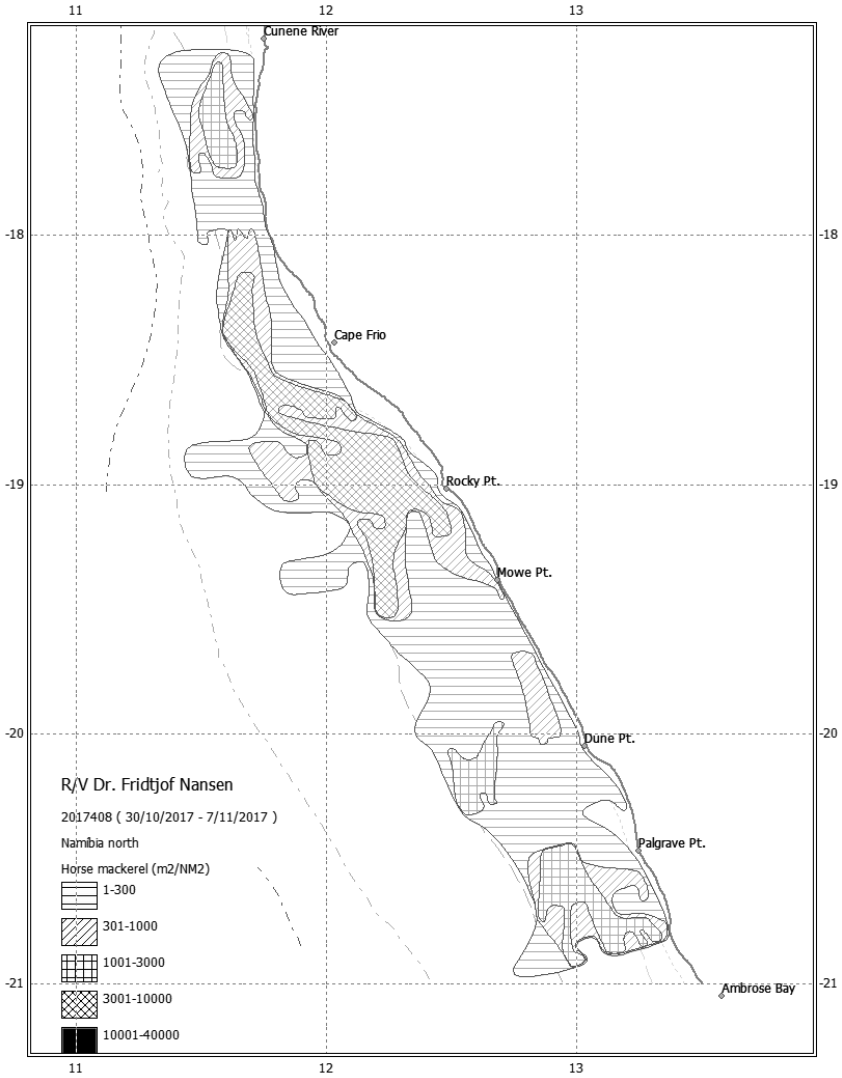


Figure 22. Distribution of Cape horse mackerel (*Trachurus capensis*), Cunene River-Ambrose Bay. Depth contours at 50, 100, 200, and 500 m.

The length frequency of Cape horse mackerel, *T. capensis*, showed two modal peaks, around 12 and 17 cm TL, and a less pronounced peak around 20 cm (Figure 23).

The biomass of Cape horse mackerel was estimated to be 1 219 000 tonnes (Table 11), with 75% of the biomass consisting of fish < 20 cm length, while the fish >19 cm contributed 25% of the biomass.

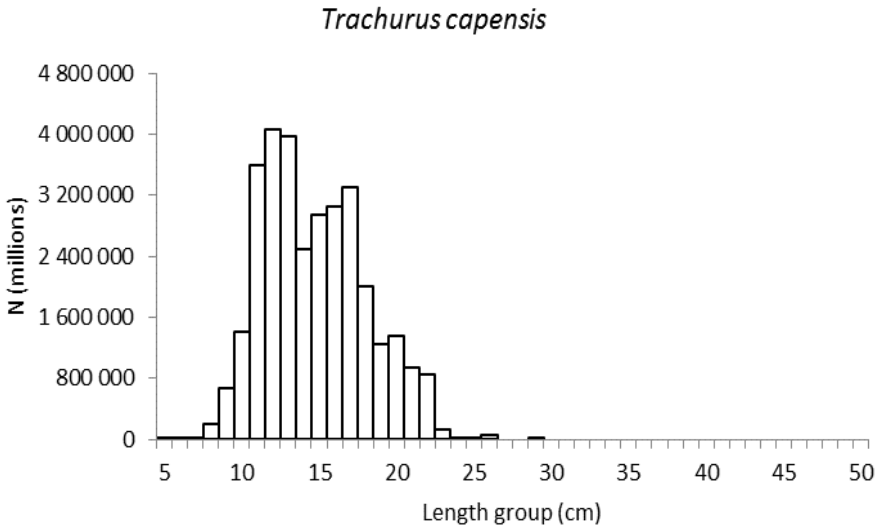


Figure 23. Total length frequency distribution of Cape horse mackerel, Cunene River-Ambrose Bay.

Of the 514 biological samples of *Trachurus capensis* from the northern region, 30% of the fish were found to be mature, whilst 70% were immature. Male fish were dominating in maturation stages I and III, whilst females were dominant in stages II and IV. In stage V only females were found, however the numbers were low. The length at 50% maturity of *Trachurus capensis*, from this region, was 17 cm (Figure 28).

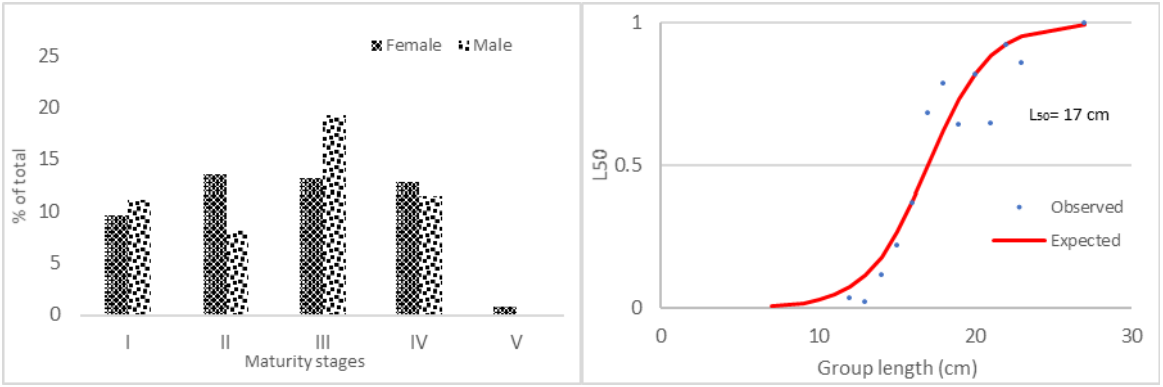


Figure 24. Maturity stages by sex (left) and first length at maturity of *Trachurus capensis* in the Northern region (right).

4.3.1.3 Pelagic species Group 1

During the survey, two species, anchovy (*Engraulis encrasicolus*) and round herring (*Etrumeus whiteheadi*) belonging to the Pelagic Species Group 1 (P1), were found in patches along the northern region, between Cunene River and Ambrose Bay. Anchovy was the most abundant species caught, whilst round herring was only found at four stations in very small quantities. The two species were found in low ($1<sA<300$ m^2/NM^2), medium ($301<sA<1000$ m^2/NM^2) and high densities ($1001<sA<3000$ m^2/NM^2) all along the northern region (Figure 25). The separation between pilchard and P1 in the northern region was at times difficult as they were schooling together in large parts of their distribution area.

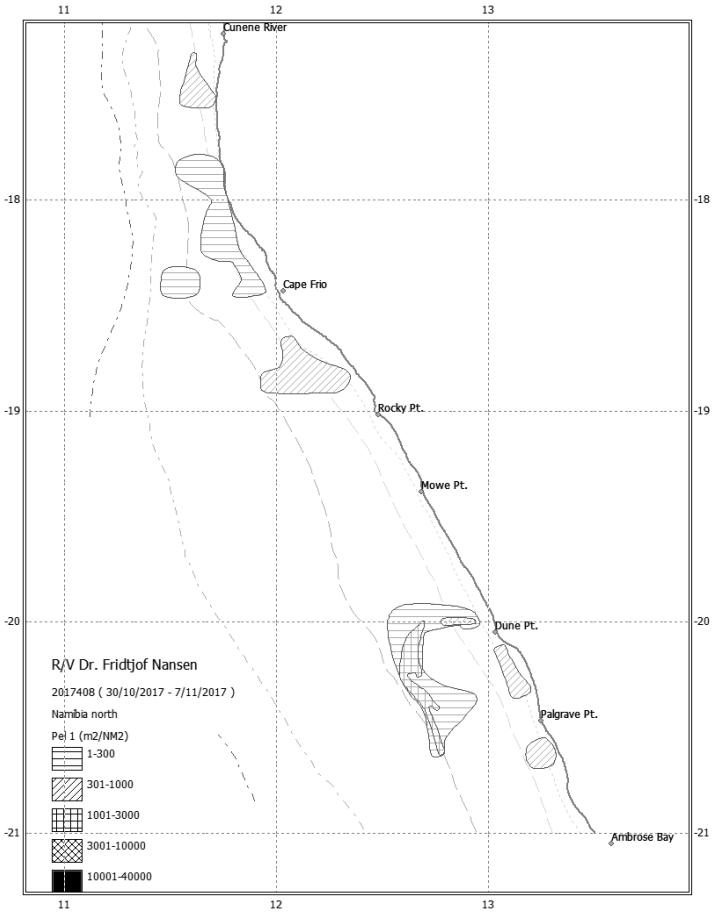


Figure 25. Distribution of P1, Cunene River-Ambrose Bay. Depth contours at 50, 100, 200 and 500 m.

The length distribution of anchovy in the northern region ranged from 9 to 15 cm and showed a modal peak around 11 cm TL, while for round herring length ranged from 13 to 19 cm TL with a modal peak at about 16 cm TL. The total biomass of P1 was estimated to 74 532 tonnes (Table 11). Anchovy contributed 75% of the total biomass with 56 260 tonnes, while round herring contributed the remaining 25% (18 271 tonnes)**.**

Table 11 shows the abundance estimated of main commercial species in north region.

Table 11. Estimated abundance of pelagic fish (tonnes), Cunene river-Ambrose Bay.

Sardinops sagax	*Trachurus capensis*	Pelagic 1
142 000	1 219 000	75 000

4.3.2 Namibia Central (21°S - 25°S)

4.3.2.1 Pilchard

Pilchard (*Sardinops sagax*) was recorded in one single patch south of Ambrose Bay in medium density (301<sA<1000 m^2/NM^2). The fish were distributed inside the 100 m depth line (Figure 26).

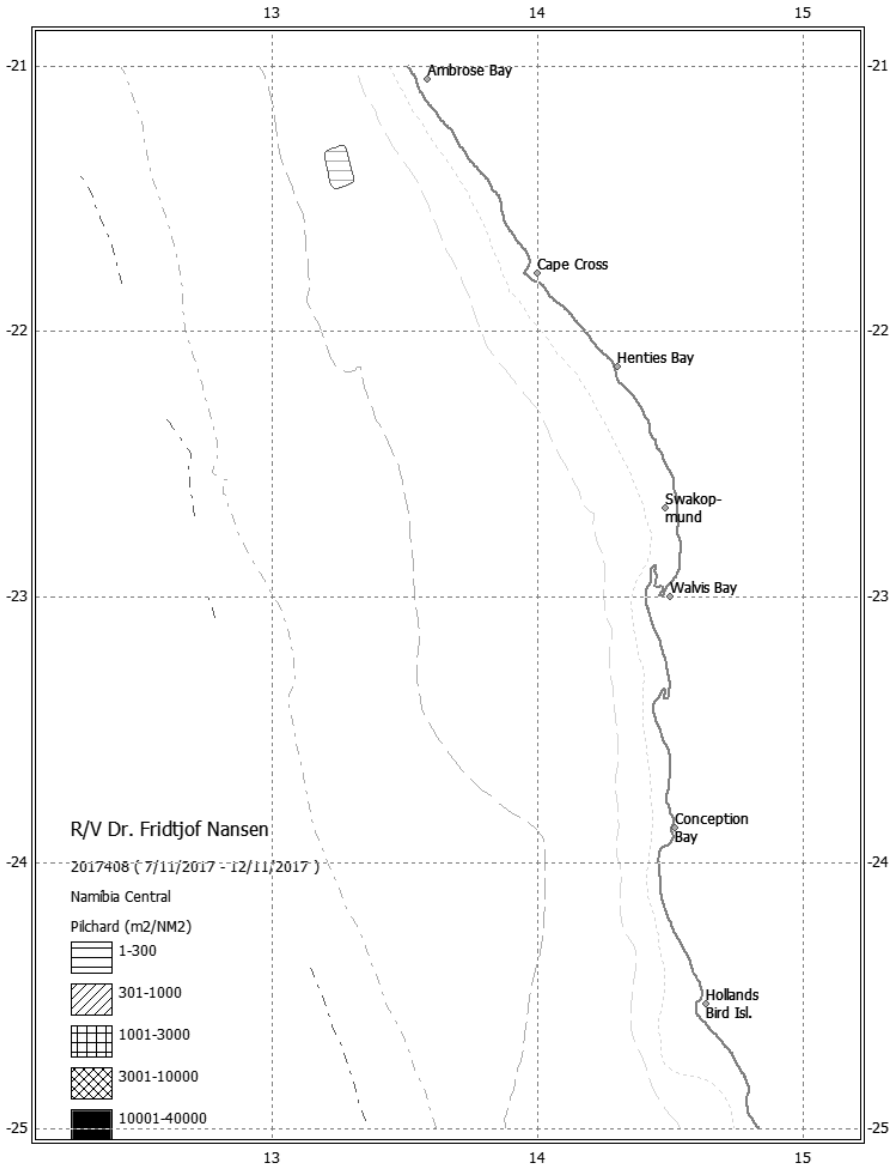


Figure 26. Distribution of *Sardinops sagax*, between 21°S and 25°S. Depth contours at 20, 50, 100, 200, and 500 m.

4.3.2.2 Horse mackerel

Cape horse mackerel (*T. capensis)*, were observed in an area south of Ambrose Bay (Figure 27). Horse mackerel was found in low (1<sA<300 m^2/NM^2), medium (301<sA<1000 m^2/NM^2), high densities (1001<sA<3000 m^2/NM^2) and very high densities (3001<sA<10000 m^2/NM^2).

During this survey, most fish were captured between 20 and 200 m depth, and the distribution typically extended slightly outside the 200 m depth line, with a more offshore extension at 21°S. The horse mackerel was generally caught with bottom trawls during the day and pelagic trawls during the night, and the catch was usually mixed with large quantities of jellyfish.

South of Walvis Bay a few relatively large horse mackerel was caught in bottom trawl in deep waters >200 m. However, these are not included in the biomass analysis nor the distribution maps as they were impossible to observe acoustically.

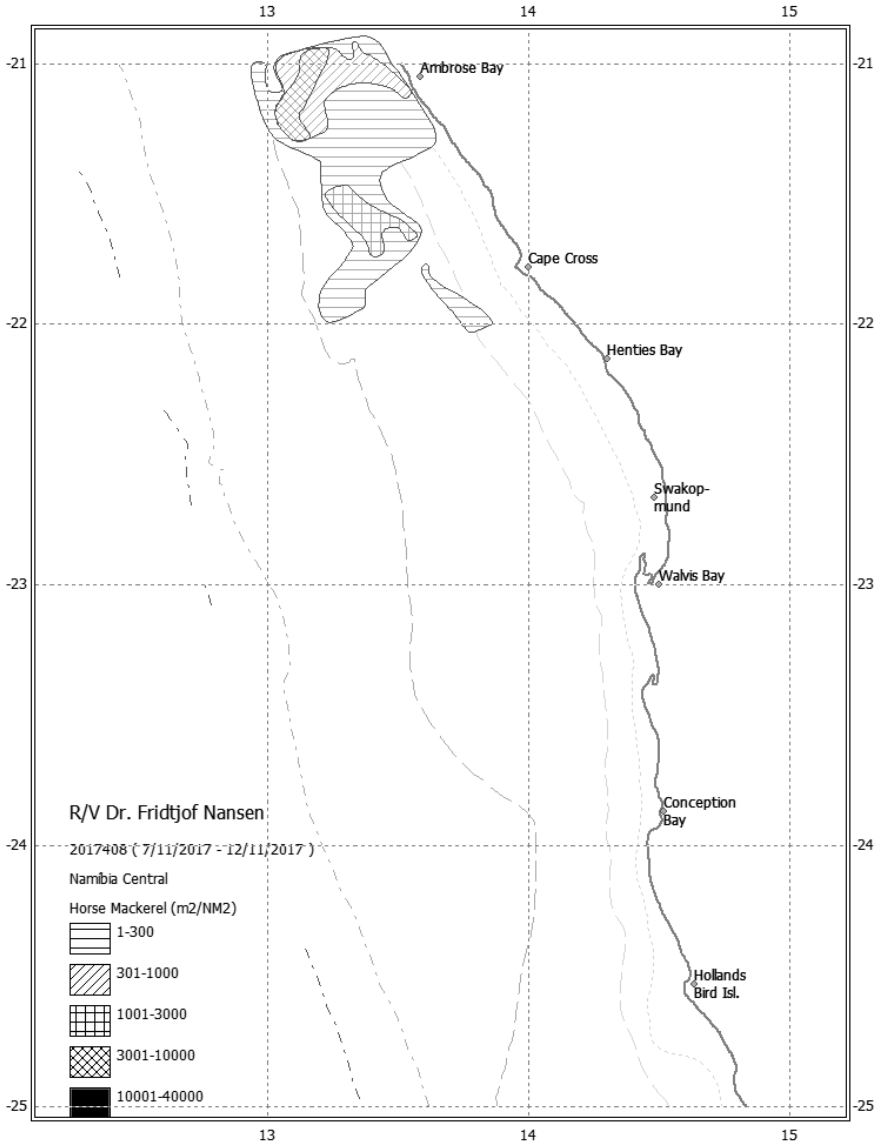


Figure 27. Distribution of Cape horse mackerel (*Trachurus capensis*), between 21°S and 25°S. Depth contours at 50, 100, 200, and 500 m.

The length frequency of Cape horse mackerel, *T. capensis*, indicates three modal peaks, around 11 and 16 cm and 21 cm TL (Figure 28).

The biomass of Cape horse mackerel was estimated to be 173 000 tonnes in the central region (Table 12). 69% of the biomass belongs to fish of < 20 cm length, while the fish of >19 cm contributed with 31% of the biomass.

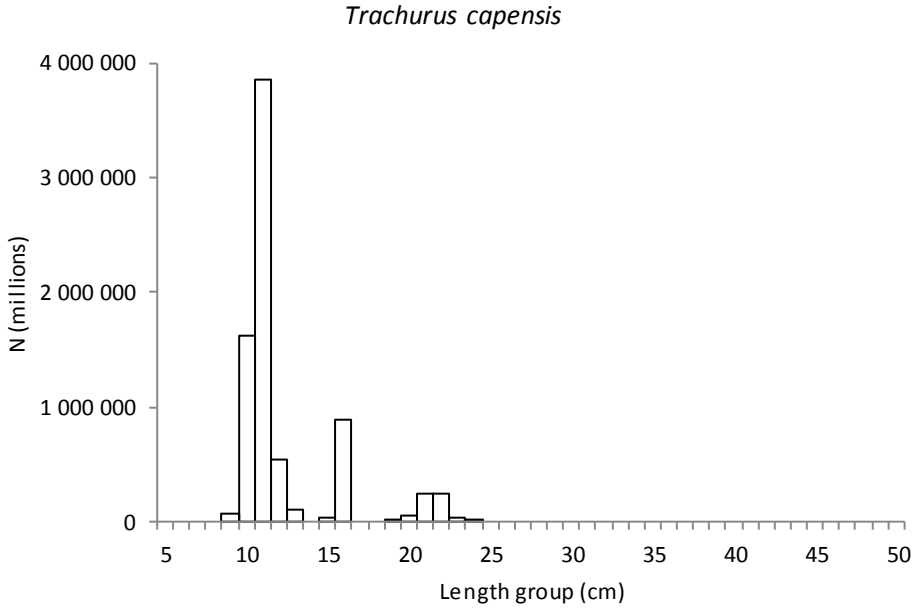


Figure 28. Total length frequency distribution of Cape horse mackerel, Cunene River-Ambrose Bay.

Of the 305 (90 samples for maturity) biological samples of *Trachurus capensis* from the central region, 30% of the fish were found to be mature, whilst 71% were immature. Most of the fish analysed was maturity stage IV. Male fish were dominating. In stage V only females were found, however the numbers were low (Figure 29). The length at 50% maturity of *Trachurus capensis*, from this region was not possible to calculate due to insufficient biological samples.

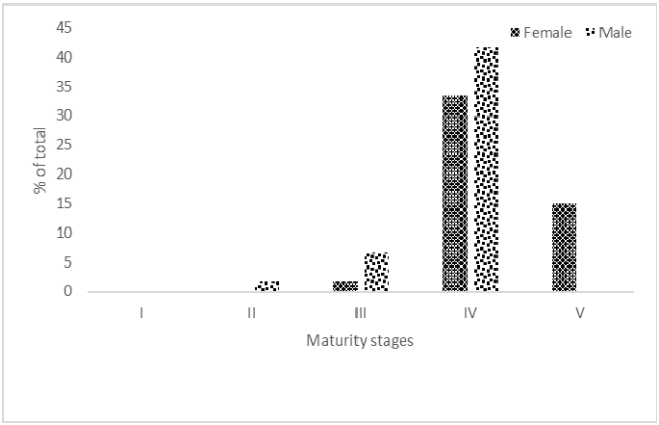


Figure 29. Maturity stages by sex of *Trachurus capensis* in the Central region.

Table 12 shows an overview of the biomass of pelagic fish in the central region of Namibia. Only horse mackerel was caught in such amounts that a biomass estimate was appropriate to calculate.

Table 12. Estimated abundance of pelagic fish (tonnes), Cunene River-Ambrose Bay.

Sardinops sagax	*Trachurus capensis*	Pelagic 1
0	173 000	0

4.3.2.3 Jellyfish

The central region was totally dominated by the two species of jellyfish (the scyphozoans *Chrysarora fulgida and* the hydrozoan *Aequorea forskalea*). Even though *C. fulgida* is generally most common inshore, while *A. forskalea* is most common further offshore, it is not possible to distinguish the acoustic recordings for these and their distribution is therefore presented in the same map (Figure 30). They were found in very high densities s_A> 3000-10 000 m^2/Nm^2 from inshore out to 500 m depths.

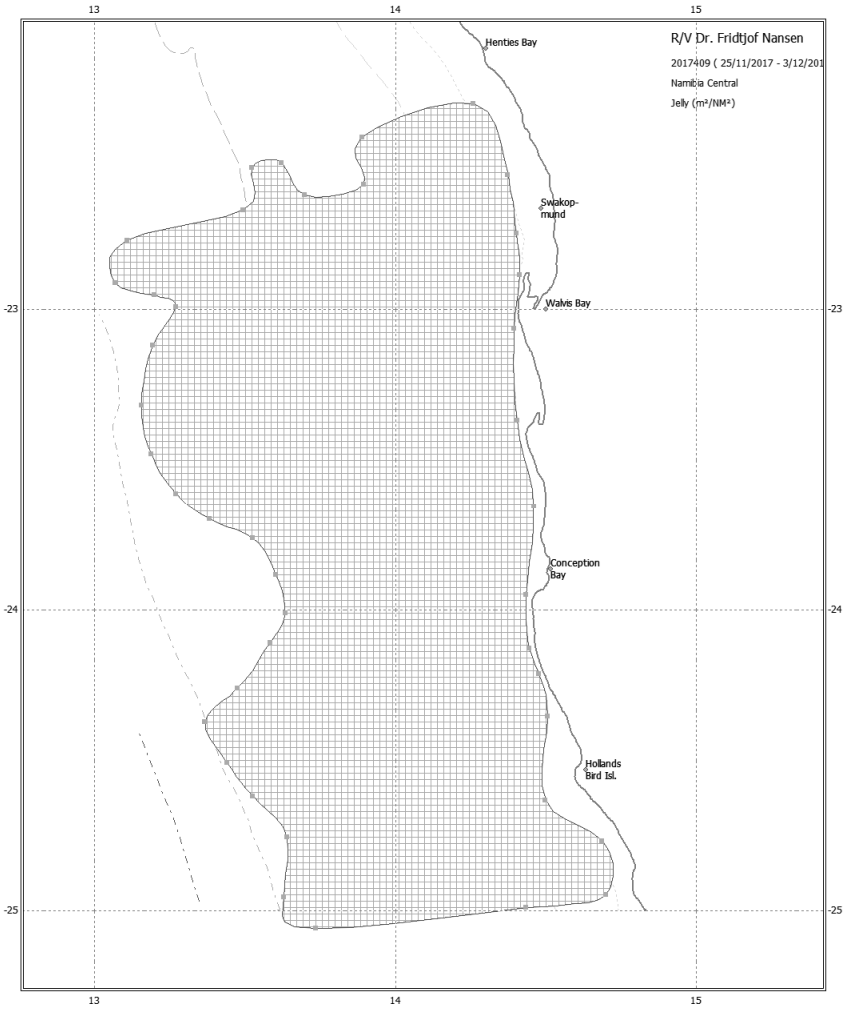


Figure 30. Distribution of jellyfish (between 21°S and 25°S). Depth contours at 50, 100, 200 and 500 m.

4.3.3 Namibia south (25°S – Orange River)

In the Southern region of Namibia there were few acoustic recordings and those that did occur mostly come from the species *Etrumeus whiteheadi*, belonging to the Pelagic Species Group 1 (P1), from jellyfish, and from mesopelagic fish. Round herring was only found at a few stations in very small quantities and in low acoustic densities (1<sA<300 m^2/NM^2, Figure 31). The total biomass of P1 was estimated to 62 862 tonnes where round herring to 100% of the total biomass.

Jellyfish were found in two main patches along the southern region, between (Figure 31), while mesopelagic fish were found over the whole region 33, respectively). Mesopelagic fish were found in low (1<sA<300 m^2/NM^2), medium (301<sA<1000 m^2/NM^2), high densities (1001<sA<3000 m^2/NM^2) and very high densities (3001<sA<10000 m^2/NM^2).

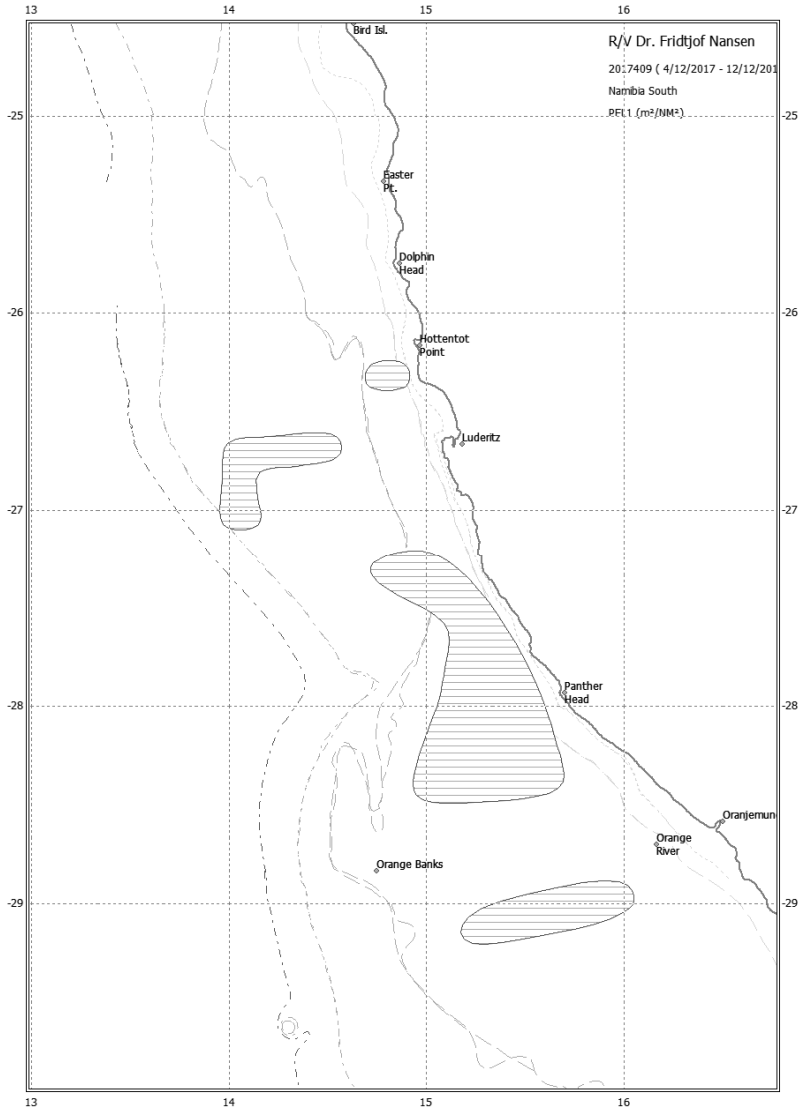


Figure 31. Distribution of P1, (25°S – Orange River). Depth contours at 50, 100, 200 and 500 m.

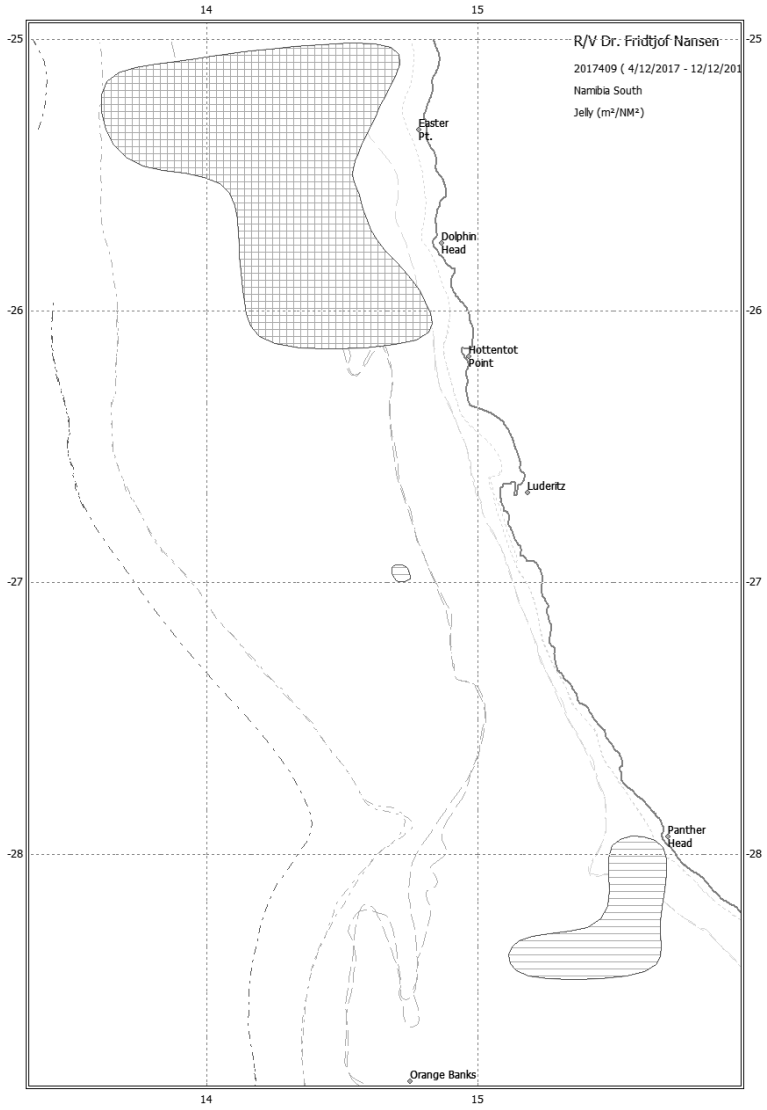


Figure 32. Distribution of jellyfish (between 21°S and 25°S). Depth contours at 50, 100, 200 and 500 m.

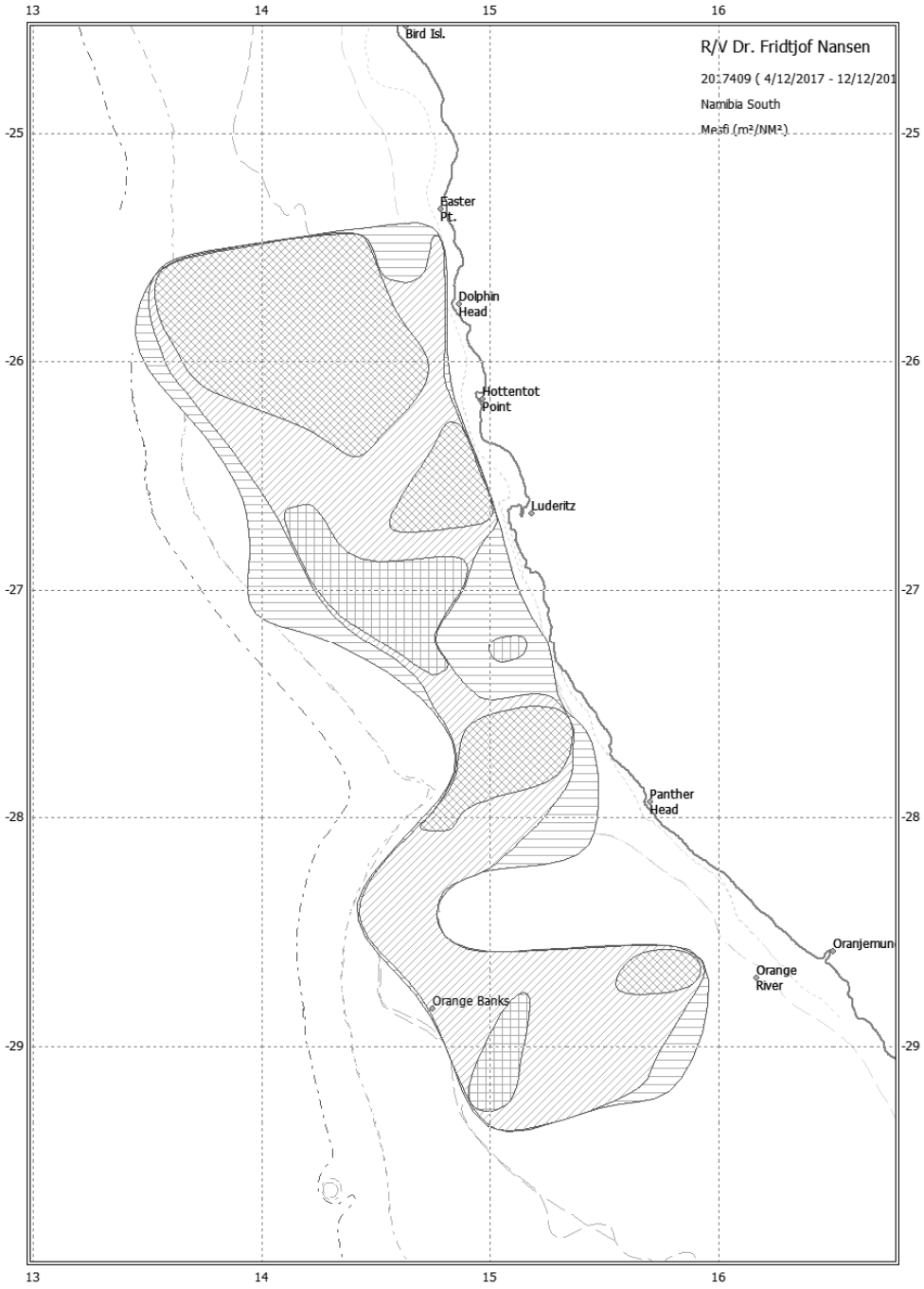


Figure 33. Distribution of mesopelagic fish (between 21°S and 25°S). Depth contours at 50, 100, 200 and 500 m.

CHAPTER 5. RESULTS - MICROPLASTICS AND DEBRIS

Microplastics were sampled from the surface at 38 stations, using a Manta Trawl Net. Out of 38 stations, 19 stations had samples containing microplastics (Table 13). Plastics were found only at 3 stations out of 21 stations in Namibia central and Namibia south. However, pieces of paint were found in almost every sample (Table 13). The results show that stations closer to shore had a higher abundance of microplastics than stations offshore. The following stations had the highest concentration of microplastics at ST_642, ST_645 (Capo São Braz) which is a retention area, and ST_745 just off the river.

Table 13. Summary of microplastics sampling stations.

Country	**No. of sampling stations**	**No. of samples with visible microplastics**	**Total no. of plastic objects**	**No. of samples preserved in formaldehyde**	**No. of samples preserved by freezing**
Namibia North	17	16	103	0	16
Namibia Central	11	3	15	0	3
Namibia South	10	0	0	0	0
Total	38	19	118	0	19

CHAPTER 6. RESULTS - FOOD SAFETY

Table 14 shows the number of samples collected for different kinds of analysis of fish for food safety. The analysis will be carried out at IMR lab in Norway. Typical analysis will include

- Nutrition: Energy, water content, total fat, proteins, ash, fatty acids, cholesterol, amino acids, tryptophan, vitamins (D, A, E, K, C, thiamine, riboflavin, B6, B12, folate, niacin, pantotene, biotin), iodine, selenium and other minerals.
- Contaminants: Heavy metals, Inorganic arsenic, PAH, PBDE, PCB, dioxins, furans, PFAS, pesticides, HBCD, TBBPA.

Table 14. The sampling done for analytical work for each species.

AREA 5020

SMALL FISH GROUP

Date	Species	Number of Fish		Journal number	B-sample?	Tissue	# freecedryed samples	Survey	Station No.	Position	Country
		Large Fish	Small Fish								
	No samples from small fish group										Namibia

BIG FISH GROUP

Date	Species	Number of Fish		Journal number	B-sample?	Tissue	# freecedryed samples	Survey	Station No.	Position	Country
		Large Fish	Small Fish								
28.11.2017	Merluccius capensis	25		2017-1349	Yes	5 Muscel, 15 liver, 3 faeces mix (1-5, 6-10, 11-15	56	2017409	25	23.01S 13.18E	Namibia
28.11.2017	Trachurus capensis	25		2017-1703	No	5 Muscel, 15 liver, 3 faeces mix (1-5, 6-10, 11-15	21	2017409	26	22.92S 13.54E	Namibia
30.11.2017	Trachurus capensis	25		2017-1704	Some	5 Muscel, 15 liver, 3 faeces mix (1-5, 6-10, 11-15	37	2017409	35	23.7S 13.31E	Namibia
02.12.2017	Merluccius capensis	25		3017-1705	Yes	5 Muscel, 15 liver, 3 faeces mix (1-5, 6-10, 11-15	55	2017409	41	24.13S 13.86E	Namibia

CHAPTER 7. RESULTS - TOP PREDATOR OBSERVATIONS

Marine mammals observed during the Namibian leg of the cruise are listed in Table 15. A total of 16 sightings were recorded for the area from Walvis Bay to north of the Orange River. Dusky dolphins *Lagenorhynchus obscurus* had the highest animal count, followed by long-finned pilot whales *Globicephala melas* as second, and minke whales *Balaenoptera acutorostrata* as least abundant (Figure 34). A rare sighting of southern right whale dolphin *Lissodelphis peronii* was made next to a pod of long-finned pilot whales in the offshore waters (Figure 35 a and b) at a water depth of 250 m. A total sighting seabird effort of 511 minutes was conducted and ten seabird species were sighted. About 18 different species of seabirds were sighted in Namibian waters (Table 16) including the endangered African penguin *Spheniscus demersus*, Cape gannet *Morus capensis*, common tern *Sterna hirundo*, and some albatross (Figure 36). Numerous Cape fur seals *Arctocephalus pusillus pusillus* were sighted throughout the coast of Namibia. Off-effort sightings included two minke whales *Balaenoptera acutorostrata* and an unidentified whale on the 28/11/2017.

Table 15. Marine mammal species observed in Namibian waters.

Date	Sighting no.	Latitude (S)	Longitude (E)	Species
28/11/2017	1	22° 55’ 39”	13° 29’ 34”	Dusky dolphin
28/11/2017	2	22° 53’ 36”	13° 37’ 43”	Minke whale
30/11/2017	3	23° 32’ 28”	13° 04’ 33”	Long-finned pilot whale
01/12/2017	4	24° 03’ 44”	13° 13’ 23”	Long-finned pilot whale
01/12/2017	5	24° 03’ 44”	13° 13’ 23”	Long-finned pilot whale
02/12/2017	6	24° 07’ 12”	13° 46’ 06”	Unidentified dolphin species
02/12/2017	7	24° 20’ 10”	13° 28’ 58”	Long-finned pilot whale
02/12/2017	8	24° 20’ 10”	13° 28’ 58”	Southern right whale dolphin
03/12/2017	9	24° 37’ 53”	13° 40’ 09”	Long-finned pilot whale
04/12/2017	10	24° 58’ 55”	13° 44’ 47”	Minke whale
06/12/2017	11	26° 00’ 09”	13° 33’ 09”	Long-finned pilot whale
06/12/2017	12	26° 00’ 05”	13° 33’ 22”	Long-finned pilot whale
06/12/2017	13	26° 00’ 04”	13° 32’ 02”	Southern right whale dolphin
07/12/2017	14	26° 30’ 48”	14° 57’ 48”	Humpback whale
07/12/2017	15	26° 38’ 22”	14° 59’ 00”	Humpback whale
11/12/2017	16	28° 37’ 48”	15° 58’ 56”	Humpback whale

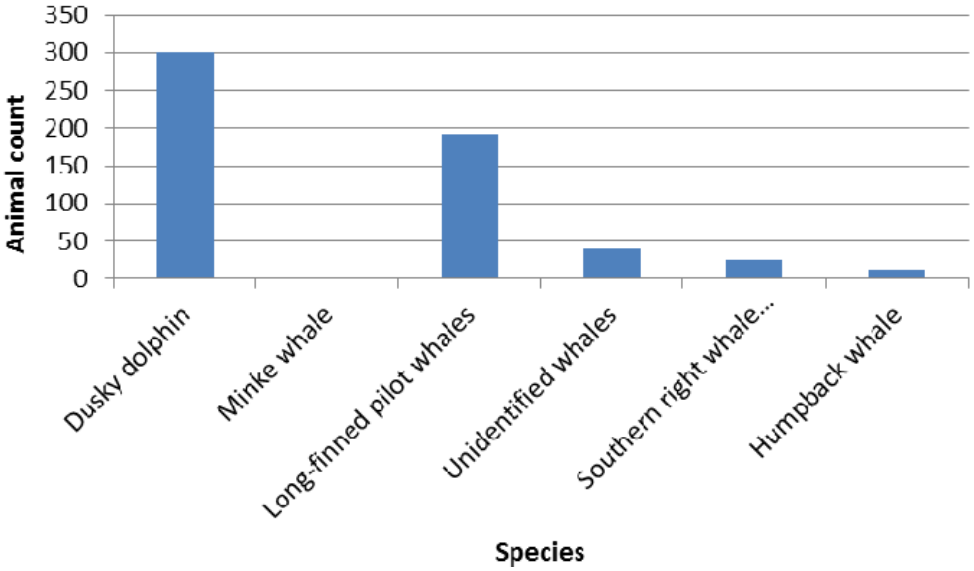


Figure 34. Number of marine mammals sighted in Namibian waters.

Figure 35. Southern right whale dolphin (a) and a pod of long-finned pilot whales (b) encountered in Namibian waters. Photos by Steven McCue.

Table 16. Seabird species observed in Namibian waters.

Species	Animal count
Cory's shearwater	114
Sooty shearwater	40
Damara tern	61
Atlantic yellow-nosed albatross	33
Unidentified albatross	29
Cape gannet	26
Pomarine skua	8
Subantarctic skua	4
Unidenitified skua	1
Polar skua	1
White chin petrel	210
Wilson’s storm petrel	2
Kelp gull	25
Cape cormorant	100
African penguin	7
Northern giant petrel	2
Heartlab gull	2

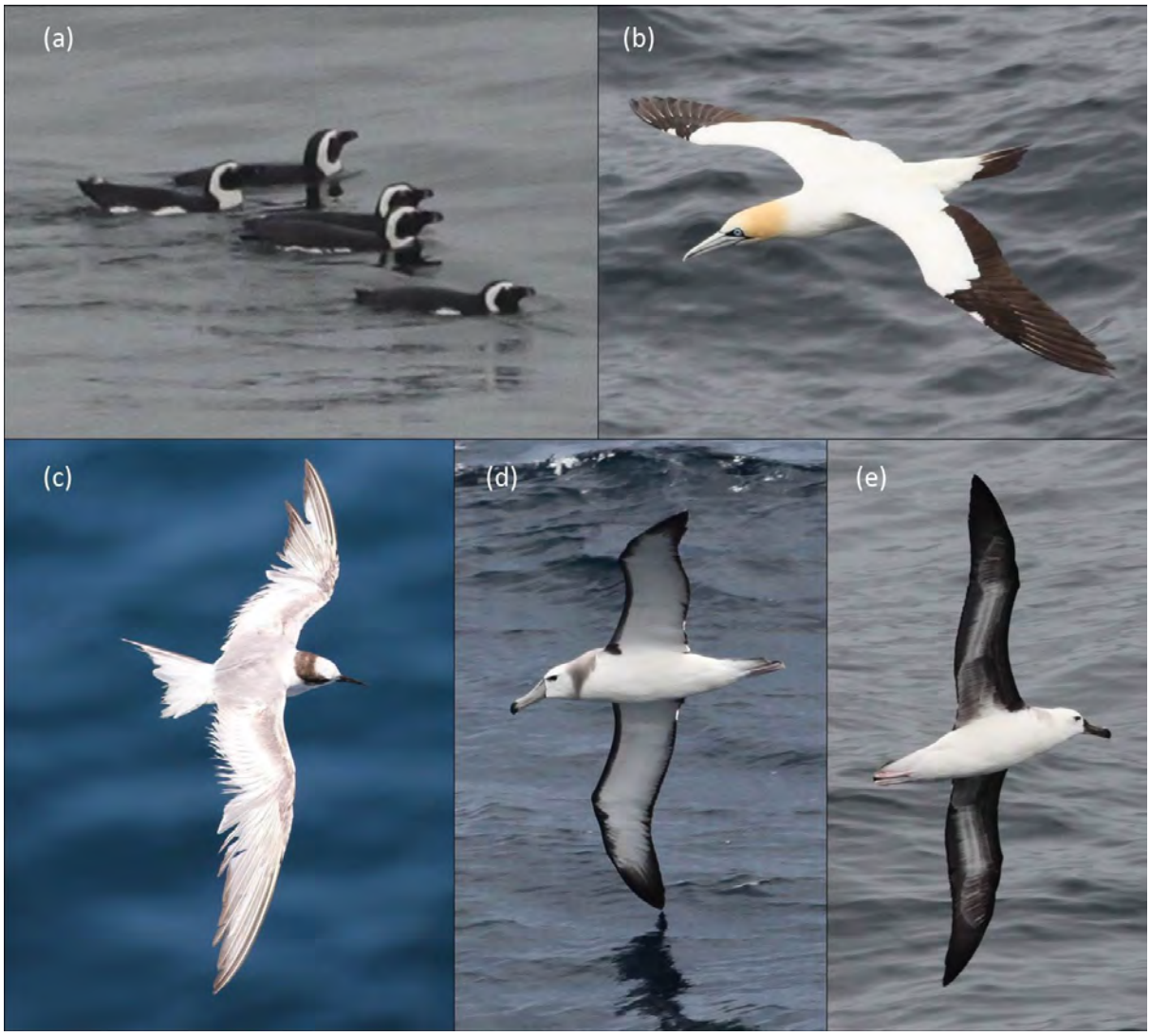


Figure 36. Seabirds sighted in Namibian waters included African penguins (a), Cape gannets (b), common tern (c), Atlantic yellow-nosed albatross (d) and juvenile black-browed albatross (e). Photos by Steven McCue.

CHAPTER 8. SUMMARY OF SURVEY RESULTS

Cape horse mackerel (*T. capensis*) was observed in a continuous distribution in the northern part of Namibia from the border with Angola to Cape Cross, with a small proportion into Angolan waters and overlapping with the Cunene horse mackerel.

The total biomass of Cape horse mackerel was estimated at 1 393 000 tonnes, with 74% of the biomass belonging to fish of < 20 cm length, while the fish of >19 cm contributed with 26% of the biomass.

During this survey, most fish was caught in the northern region, between 20 - 200 m depth, and the distribution typically extended slightly outside the 200 m depth line, with a more offshore extension at 19°S. The horse mackerel was generally caught with bottom trawls during the day and pelagic trawls during the night, and and the catch was usually mixed with large quantities of jellyfish.

Pilchard, anchovy and round herring were recorded in the northern region, while round herring was also recorded in the southern region south of 25°S. The biomass of each of these species was generally modest, but all together with a total biomass of roughly 283 000 tonnes.

CHAPTER 9. REGIONAL OVERVIEW

Most pelagic species have a transboundary distribution and trends in biomass estimates are usually most meaningful if done at population level especially when there is evidence of migration across national boundaries. The EAF-Nansen Programme aims at supporting collaborative work by coastal countries to assess if and to what extent resources may be shared and the results from these surveys will be further analysed at the regional level.

Table 17 provides an overiew of the biomass estimates of the main pelagic species in the region Gabon to southern Namibia. The categories Pelagic Fish 1 and Pelagic fish 2 are not included as the species composition is rather different at different latitudes and a regional overview is therefore less meaningful.

Table 17. Regional biomass estimates of main species of pelagic fish (1000 tonnes), Gabon-Namibia.

Species	**Congo-Gabon**	**Angola**			**Namíbia**			
	Total	**North**	**Central**	**South**	**North**	**Central**	**South**	**Total**
Trachurus trecae	14.8	156.0	16.5	56.5	-	-	-	244
Trachurus capensis	-	-	-	42.9	1 219	173	-	1435
Sardinella aurita	4.8	83.6	134.9	35.5	-	-	-	259
Sardinella maderensis	37.7	309.3	192.1	24.6	-	-	-	564
Sardinops sagax		-	-	-	142	3	-	145

REFERENCES

ANON. 1968. Smaller mesozooplankton. Report of Working Party No. 2. Pp. 153-159 in: Tranter, D.J. (ed.) Zooplankton sampling. (Monographs on- oceanographic zooplankton methodology 2.). UNESCO, Paris. 174 pp.

Brierley AS, Axelsen BE, Boyer DC, Lynam CP and 5 others. 2004. Single-target echo detections of jellyfish. ICES J Mar Sci 61:383–393.

Brierley AS, Axelsen BE, Buecher E, Sparks CAJ, Boyer H, Gibbons MJ. 2001. Acoustic observations of jellyfish in the Namibian Benguela. Mar Ecol Prog Ser 210:55–66

Brierley, Andrew & C. Boyer, David & Axelsen, Bjørn Erik & Lynam, Christopher & Sparks, Conrad & J. Boyer, Helen & Gibbons, Mark. (2005). Towards the acoustic estimation of jellyfish abundance. Marine Ecology-progress Series - MAR ECOL-PROGR SER. 295. 105-111. 10.3354/meps295105.

Chierici, Melissa & Fransson, Agneta & G. Anderson, L. 1999. Influence of m-cresol purple indicator additions on the pH of seawater samples: Correction factors evaluated from a chemical speciation model. Marine Chemistry - MAR CHEM. 65. 281-290. 10.1016/S0304-4203(99)00020-1.

Clayton, T.D., Byrne, R.H. 1993. Spectrophotometric seawater pH measurements: total hydrogen ion concentration scale calibration of m-cresol purple and at-sea results. Deep-Sea Res., 40 (1993), pp. 2115-2129.

Foote, K. G. 1987 — Fish target strengths for use in echo integrator surveys. J. Acoust. Soc. Am. 82(3): 981-987.

Foote, K. G., Aglen, A. and Nakken, O. 1986. Measurements of fish target strength with a split-beam echo sounder. J. Acoust. Soc. Am. 80 (2): 612-621.

Fraser, J.H. 1966. Zooplankton sampling. Nature, 211: 915-916.

Grasshoff K., Erhardt M., Kremling K. (eds.). 1983. Methods for sea water analysis, Verlag Chemie, Weinheim, 63-97, 127-187.

Hagebø, M. and Rey , F. 1984. Lagring av sjovann ti1 analyse av naeringssalter. Storage of seawater for nutrients analysis. Fisken Hav., 1984-(4): 1-12.

Misund, O. A. and Aglen, A. 1992. Swimming behaviour of fish schools in the North Sea during acoustic surveying and pelagic trawl sampling. *ICES J. Mar. Sci.* 49: 3.

Motoda**,** S. 1959. MotodaDevices of simple plankton apparatus. Mem. Fac. Fish., Hokkaido Univ., 7 (1-2), 73-94. Issue Date. 1959-12. Doc URL

Sparks, C., Brierley, A., Buecher, E., Boyer, D., Axelsen, B., and Gibbons, M. 2005. Submersible observations on the daytime vertical distribution of *Aequorea forskalea* off

the west coast of southern Africa. Journal of the Marine Biological Association of the United Kingdom, 85(3), 519-522. doi:10.1017/S0025315405011446.

Strickland, J.D.H. and Parsons, T.R. 1972. A Practical Hand Book of Seawater Analysis. Fisheries Research Board of Canada Bulletin 157, 2nd Edition, 310 p.

ANNEX I. DESCRIPTION OF ACOUSTIC INSTRUMENTS AND FISHING GEAR

Acoustic instruments

The Simrad EK80/18, 38, 70,120, 200 and 333 kHz scientific sounder was run during the survey. Scrutinizing was done in LSSS using the data from the 38-kHz transducer. Last standard sphere calibrations were checked on the 23.01.2017 in Sandviksflaket, Bergen, Norway using Cu64 for the 18 kHz, Cu60 for the 38 kHz, WC38.1 for the 70, 120 and 200 kHz, and the WC22 for the 333 kHz. The details of the settings for the 38-kHz echo sounder were as follows:

Transceiver2 menu (38 kHz)	
Transducer depth	5 8 m
Absorption coeff.	8.3 dB/km
Pulse duration	medium (1,024ms)
Bandwidth	2.43 kHz
Max power	2000 Watt
2way beam angle	20.6dB
Gain	26.95 dB
SA correction	0.03 dB
Angle sensitivity	21.9
3 dB beamwidth	6.22º along ship
	6.28 athwart ship
Alongship offset	0.10º
Athwardship offset	0.06º
Bottom detection menu	Minimum level 50 dB

Fishing gear

The vessel has one small four-panel Åkrahamn pelagic trawl, one MultPelt 624 trawl (Figure I1, new in 2017) and one 'Gisund super bottom trawl'. The multpelt trawl was not used during the survey due to a problem on the winch system. The smallest pelagic trawl has 8 to 12 m vertical opening under normal operation, whereas the MultPelt 624 trawl has 25 to 35 m opening.

The bottom trawl has a 31-m headline and a 47-m footrope fitted with a 12" rubber bobbins gear. The codend has 20 mm meshes, and has an inner net with 10 mm mesh size. The vertical opening is about 5.5 m. The distance between the wing tips is about 18 m during towing. The sweeps are 40 m long. The trawl doors are 'Thyborøen' combi, 8 m^2 and weigh 2000 kg. The door spreading is about 45 m when using restraining rope. Trawling was conducted for species identification only and no restraining rope was therefore used during the survey.

The SCANMAR system was used during all trawl hauls. This equipment consists of sensors, a hydrophone, a receiver, a display unit and a battery charger. Communication between sensors and ship is based on acoustic transmission. The doors are fitted with sensors to provide information on their interdistance and angle, while a height sensor is fitted on the bottom trawl to measure the trawl opening and provide information on clearance and bottom contact.

The all trawls are equipped with a trawl eye that provides information about the trawl opening and the distance of the footrope to the bottom. A pressure sensor is used to show the depth on the headline.

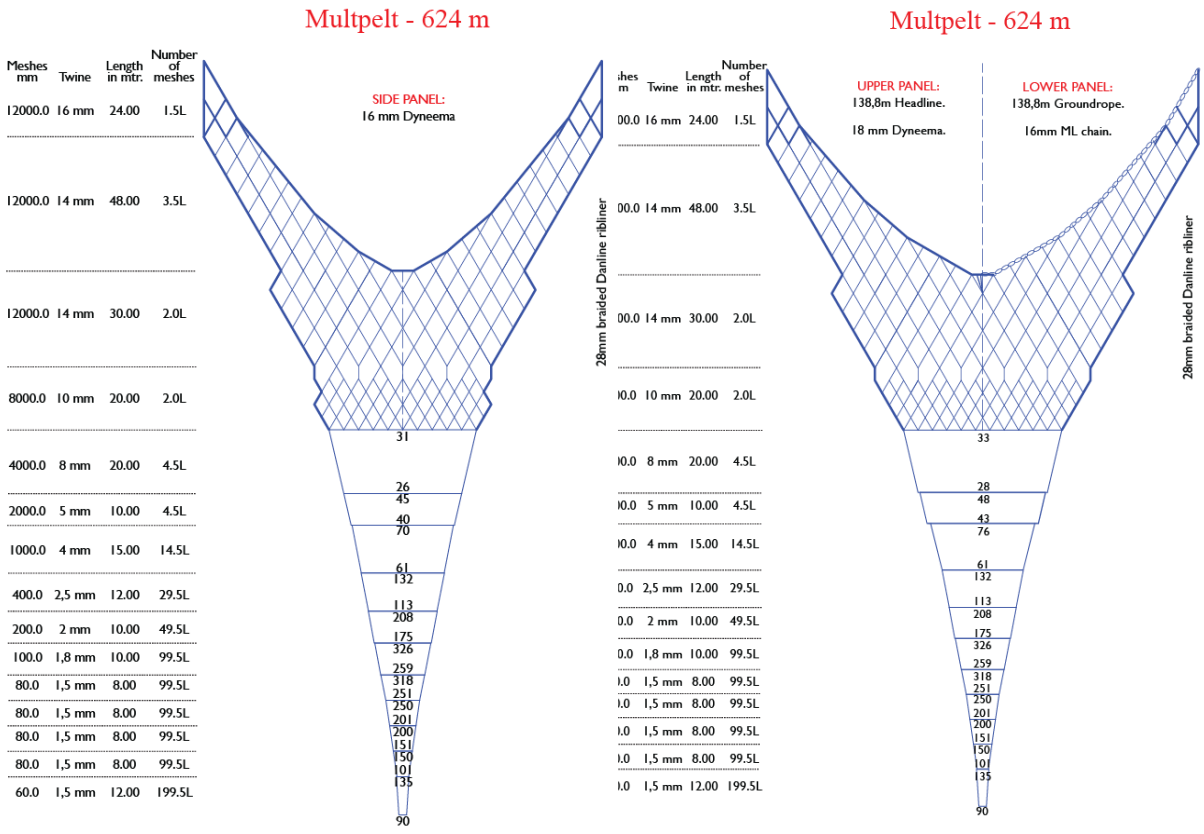


Figure I.1. Schematic drawing of the MultPelt 624.

LITEN PELAGISK ÅKRATRÅL

HEL MASKER M/M	TRÅD NR.	LENGDE I METER	MASKER I EVING
400	64	38,5	4
400	48	14	4
200	32	10,0	4
100	24	20,0	4
38	12	11,4	4
38	18	3,76	4

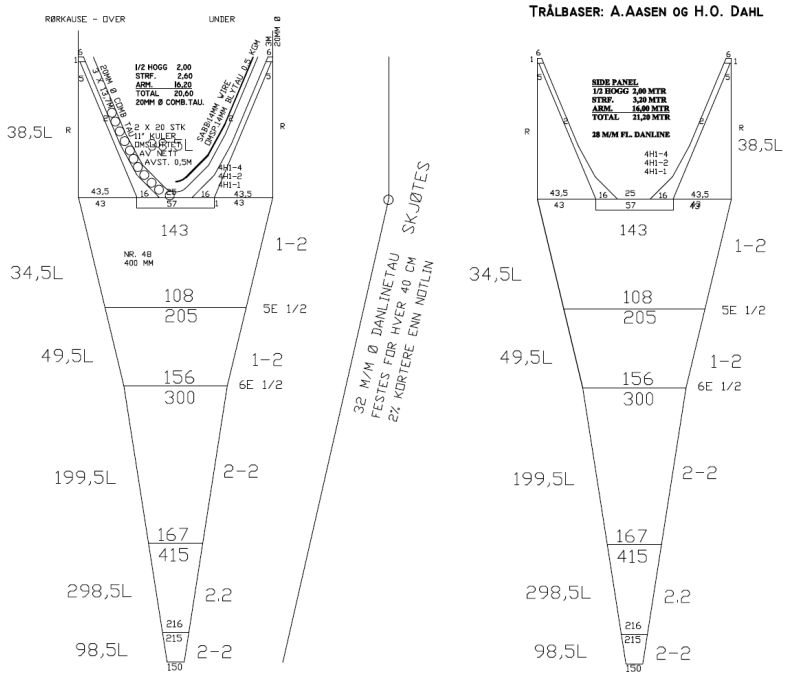


Figure I.2. Schematic drawing of the small pelagic Åkratrawl.

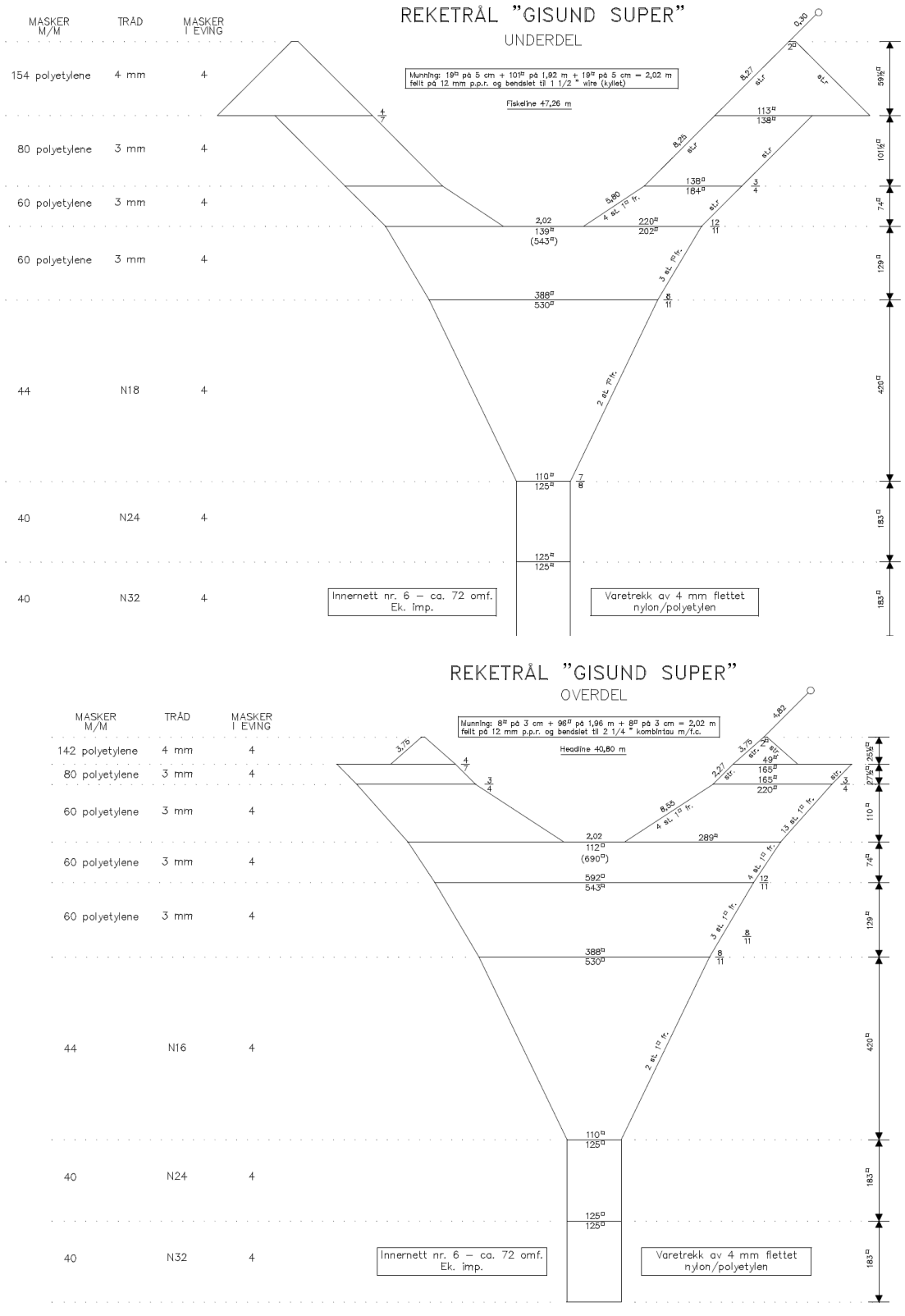


Figure I.3. Schematic drawing of the Super Gisund bottom trawl.

ANNEX II. RECORDS OF FISHING STATIONS

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 73
DATE :30/10/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 17°31.42
start stop duration Lon E 11°41.09
TIME :08:12:58 08:18:45 5.8 (min) Purpose : 1
LOG : 5075.00 5075.26 0.3 Region : 5010
FDEPTH: 74 74 Gear cond.: 6
BDEPTH: 74 74 Validity : 5
Towing dir: 0° Wire out : 210 m Speed : 2.7 kn
Sorted : 159 Total catch: 159.22 Catch/hour: 1652.76

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
JELLYFISH	646.51	696	39.12	
B I V A L V E S	332.35	250090	20.11	
P O L Y C H A E T A	232.63	63145	14.08	
Trachurus capensis	164.01	13038	9.92	224
Engraulis capensis	146.57	11045	8.87	227
Dentex macrophthalmus	54.60	2201	3.30	
Dicologoglossa cuneata	22.42	747	1.36	
Sepia orbignyana	15.36	10	0.93	
Loligo vulgaris	7.89	176	0.48	
Chelidonichthys capensis	6.23	21	0.38	
Merluccius capensis	6.23	83	0.38	
Etrumeus whiteheadi	5.19	135	0.31	226
Chelidonichthys queketti	4.57	31	0.28	
Ophisurus sp.	3.53	62	0.21	
Pterothrissus belloci	1.66	218	0.10	
C R A B S	0.93	218	0.06	
Octopus vulgaris	0.62	10	0.04	
Sardinops sagax	0.62	31	0.04	225
Umbrina canariensis	0.42	10	0.03	
Sufflogobius bibarbatus	0.21	42	0.01	
Synagrops microlepis	0.10	21	0.01	
Squilla cadenati	0.10	10	0.01	
Total	1652.76		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 74
DATE :30/10/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 17°45.49
start stop duration Lon E 11°44.12
TIME :16:06:16 16:15:43 9.4 (min) Purpose : 1
LOG : 5135.13 5135.61 0.5 Region : 5010
FDEPTH: 48 48 Gear cond.: 0
BDEPTH: 48 48 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.1 kn
Sorted :1245 Total catch: 1245.40 Catch/hour: 7907.28

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Argyrosomus inodorus	6083.03	3060	76.93	232
Engraulis capensis	733.21	45244	9.27	230
JELLYFISH	318.98	2984	4.03	
Callorhinchus capensis	236.83	171	3.00	
Raja sp.	165.84	6	2.10	
Chelidonichthys capensis	96.76	178	1.22	
Rhinobatos annulatus	85.08	70	1.08	
Arius latiscutatus **	71.49	229	0.90	
C R A B S	44.44	3060	0.56	
Sardinops sagax	34.79	1257	0.44	228
Dicologoglossa cuneata	26.41	927	0.33	
Trachurus capensis	7.87	89	0.10	229
Holothuria spp.	1.02	140	0.01	
Ophisurus sp.	1.02	13	0.01	
Sardinella aurita	0.51	13	0.01	231
Total	7907.28		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 75
DATE :30/10/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 17°51.22
start stop duration Lon E 11°39.43
TIME :18:25:12 18:56:09 31.0 (min) Purpose : 1
LOG : 5151.07 5152.91 1.9 Region : 5010
FDEPTH: 25 45 Gear cond.: 0
BDEPTH: 120 121 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.6 kn
Sorted : 29 Total catch: 28.90 Catch/hour: 56.03

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Engraulis capensis	51.64	1500	92.18	235
Etrumeus whiteheadi	2.21	50	3.94	234
Sardinops sagax	1.18	48	2.11	233
JELLYFISH	0.54	8	0.97	
Sardinella aurita	0.45	2	0.80	
Total	56.03		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 76
DATE :31/10/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 18°14.68
start stop duration Lon E 11°45.01
TIME :10:38:32 10:43:09 4.6 (min) Purpose : 1
LOG : 5236.16 5236.42 0.3 Region : 5010
FDEPTH: 116 115 Gear cond.: 0
BDEPTH: 116 115 Validity : 0
Towing dir: 0° Wire out : 300 m Speed : 3.4 kn
Sorted : 103 Total catch: 648.77 Catch/hour: 8425.58

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	6313.12	337	74.93	236
Thyrsites atun	994.94	325	11.81	
Scomber japonicus	302.73	4260	3.59	237
Merluccius capensis	278.18	3351	3.30	
Chelidonichthys capensis	224.16	1143	2.66	
JELLYFISH	106.36	247	1.26	
Engraulis capensis	98.18	5325	1.17	239
Loligo vulgaris	34.42	247	0.41	
Sardinops sagax	29.48	649	0.35	238
Dentex macrophthalmus	14.68	416	0.17	
Callinectes sp.	13.12	2377	0.16	
Sufflogobius bibarbatus	6.49	1961	0.08	
Synagrops microlepis	6.49	2779	0.08	
Dicologoglossa cuneata	3.25	78	0.04	
Total	8425.58		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 77
DATE :31/10/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 18°22.96
start stop duration Lon E 11°37.89
TIME :15:50:40 15:57:04 6.4 (min) Purpose : 1
LOG : 5280.59 5280.91 0.3 Region : 5010
FDEPTH: 173 175 Gear cond.: 0
BDEPTH: 173 175 Validity : 0
Towing dir: 0° Wire out : 420 m Speed : 3.0 kn
Sorted : 325 Total catch: 325.20 Catch/hour: 3048.75

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	2578.13	57797	84.56	240
Merluccius capensis	120.94	562	3.97	
Chelidonichthys capensis	109.69	234	3.60	
Dentex macrophthalmus	89.06	1453	2.92	
Pontinus accraensis	56.25	938	1.85	
Synagrops microlepis	32.81	6094	1.08	
Pterothrissus belloci	15.94	1078	0.52	
Callinectes sp.	15.94	2578	0.52	
Sea pens	11.25	797	0.37	
Raja miraletus	7.50	9	0.25	
Sufflogobius bibarbatus	3.75	1125	0.12	
Merluccius polli	2.81	516	0.09	
Squilla mantis	1.88	234	0.06	
JELLYFISH	1.88	94	0.06	
Chlorophthalmus atlanticus	0.94	234	0.03	
Total	3048.75		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 78
DATE :31/10/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 18°32.73
start stop duration Lon E 11°59.55
TIME :19:55:55 20:25:16 29.4 (min) Purpose : 1
LOG : 5311.58 5313.14 1.6 Region : 5010
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 71 85 Validity : 0
Towing dir: 0° Wire out : 110 m Speed : 3.2 kn
Sorted : 148 Total catch: 147.72 Catch/hour: 301.98

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
JELLYFISH	291.11	1039	96.40	
Sardinops sagax	10.79	241	3.57	241
Trachurus capensis	0.04	22	0.01	242
Engraulis capensis	0.04	2	0.01	
Fish larvae	0.00	4	0.00	
Total	301.99		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 79
DATE :31/10/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 18°33.72
start stop duration Lon E 11°45.74
TIME :23:15:16 23:23:02 7.8 (min) Purpose : 1
LOG : 5331.89 5332.30 0.4 Region : 5010
FDEPTH: 182 181 Gear cond.: 0
BDEPTH: 182 181 Validity : 0
Towing dir: 0° Wire out : 450 m Speed : 3.1 kn
Sorted : 65 Total catch: 915.04 Catch/hour: 7065.95

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	6670.27	125405	94.40	243
JELLYFISH	302.70	5189	4.28	
PORIFERA (Sponges)	49.73	9297	0.70	
Callinectes sp.	28.11	5838	0.40	
Merluccius capensis	6.49	108	0.09	
Sea pens	4.32	757	0.06	
Squilla mantis	2.16	324	0.03	
Sufflogobius bibarbatus	2.16	541	0.03	
Total	7065.95		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 80
DATE :01/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 18°43.60
start stop duration Lon E 11°49.48
TIME :07:29:05 07:35:50 6.8 (min) Purpose : 1
LOG : 5393.33 5393.66 0.3 Region : 5010
FDEPTH: 212 211 Gear cond.: 0
BDEPTH: 212 211 Validity : 0
Towing dir: 0° Wire out : 540 m Speed : 3.0 kn
Sorted : 378 Total catch: 377.52 Catch/hour: 3355.73

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	2924.80	57440	87.16	244
Merluccius capensis	326.40	5707	9.73	
JELLYFISH	58.67	640	1.75	
C R A B S	20.27	4480	0.60	
G A S T R O P O D S	14.93	2400	0.45	
Synagrops microlepis	4.27	907	0.13	
Sufflogobius bibarbatus	3.20	1493	0.10	
Holothuria scabra	1.07	373	0.03	
Squilla acuelata calmani	1.07	107	0.03	
Pterothrissus belloci	1.07	53	0.03	
Total	3355.73		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 81
DATE :01/11/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 18°42.28
start stop duration Lon E 12°5.54
TIME :10:42:13 11:11:40 29.5 (min) Purpose : 1
LOG : 5417.63 5419.24 1.6 Region : 5010
FDEPTH: 40 75 Gear cond.: 0

BDEPTH: 84 94 Validity : 0
Towing dir: 0° Wire out : 230 m Speed : 3.3 kn
Sorted : 73 Total catch: 299.60 Catch/hour: 610.39

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Sardinops sagax	211.88	5982	34.71	246
JELLYFISH	204.71	15973	33.54	
Etrumeus whiteheadi	139.35	5941	22.83	247
Trachurus capensis	35.86	2746	5.87	245
Thyrsites atun	12.71	4	2.08	
Scomber japonicus	5.38	65	0.88	248
Engraulis capensis	0.49	33	0.08	249
Total	610.39		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 82
DATE :01/11/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 18°50.97
start stop duration Lon E 12°4.00
TIME :15:11:54 16:02:53 51.0 (min) Purpose : 1
LOG : 5452.76 5455.37 2.6 Region : 5010
FDEPTH: 80 85 Gear cond.: 0
BDEPTH: 126 111 Validity : 0
Towing dir: 0° Wire out : 230 m Speed : 3.1 kn
Sorted : 58 Total catch: 292.24 Catch/hour: 343.95

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
JELLYFISH	308.45	11730	89.68	
Trachurus capensis	26.06	1253	7.58	250
Scomber japonicus	4.64	61	1.35	251
Engraulis capensis	4.03	199	1.17	252
Loligo vulgaris	0.49	25	0.14	
Sardinops sagax	0.16	4	0.05	254
Etrumeus whiteheadi	0.12	4	0.03	253
Total	343.95		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 83
DATE :01/11/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 18°51.34
start stop duration Lon E 11°54.35
TIME :17:55:00 18:11:00 16.0 (min) Purpose : 1
LOG : 5468.00 5469.00 1.0 Region : 5010
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 209 189 Validity : 0
Towing dir: 0° Wire out : 110 m Speed : 0.0 kn
Sorted : 994 Total catch: 993.76 Catch/hour: 3726.60

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	3477.60	134220	93.32	255
JELLYFISH	236.40	540	6.34	
Scomber japonicus	7.80	120	0.21	257
Engraulis capensis	4.80	240	0.13	256
Total	3726.60		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 84
DATE :02/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 18°59.70
start stop duration Lon E 12°3.82
TIME :07:40:02 07:49:35 9.6 (min) Purpose : 1
LOG : 5554.86 5555.35 0.5 Region : 5010
FDEPTH: 173 179 Gear cond.: 0
BDEPTH: 173 179 Validity : 0
Towing dir: 0° Wire out : 430 m Speed : 3.1 kn
Sorted : 657 Total catch: 657.32 Catch/hour: 4129.76

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	3525.99	0	85.38	258
Merluccius capensis	338.64	3455	8.20	
JELLYFISH	138.22	5736	3.35	
Sufflogobius bibarbatus	67.35	1030	1.63	
Loligo vulgaris	23.50	276	0.57	
C R A B S	11.06	2350	0.27	
Sea pens	9.68	1106	0.23	
Chelidonichthys capensis	4.52	13	0.11	
Pterothrissus belloci	4.15	138	0.10	
Starfish	2.76	1106	0.07	
Squilla acuelata calmani	1.38	138	0.03	
Synagrops microlepis	1.38	276	0.03	
Dicologoglossa cuneata	1.13	19	0.03	
Total	4129.76		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 85
DATE :02/11/17 GEAR TYPE: BT NO: 1 POSITION:Lat S 19°18.64
start stop duration Lon E 12°17.67
TIME :22:27:12 22:55:21 28.2 (min) Purpose : 1
LOG : 5681.52 5683.00 1.5 Region : 5010
FDEPTH: 110 120 Gear cond.: 0
BDEPTH: 135 140 Validity : 0
Towing dir: 0° Wire out : 300 m Speed : 3.2 kn
Sorted : 109 Total catch: 109.33 Catch/hour: 233.03

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
JELLYFISH	222.95	6175	95.67	
Trachurus capensis	6.52	194	2.80	259
Raja miraletus	2.47	2	1.06	
Chelidonichthys capensis	0.81	4	0.35	
Merluccius capensis	0.17	4	0.07	
Sardinops sagax	0.09	2	0.04	
Sufflogobius bibarbatus	0.02	4	0.01	
Total	233.03		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 86
DATE :03/11/17 GEAR TYPE: BT NO: 4 POSITION:Lat S 19°23.36
start stop duration Lon E 12°40.23
TIME :02:26:35 02:51:27 24.9 (min) Purpose : 1
LOG : 5711.54 5712.82 1.3 Region : 5010
FDEPTH: 5 5 Gear cond.: 0
BDEPTH: 48 44 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.1 kn
Sorted : 36 Total catch: 110.74 Catch/hour: 267.17

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
JELLYFISH	263.45	5283	98.61	
Sardinops sagax	1.79	31	0.67	261
Trachurus capensis	1.50	154	0.56	260
Loligo vulgaris	0.43	43	0.16	
Total	267.17		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 87
DATE :03/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 19°39.47
start stop duration Lon E 12°24.84
TIME :17:57:41 18:07:13 9.5 (min) Purpose : 1
LOG : 5836.24 5836.74 0.5 Region : 5010
FDEPTH: 142 141 Gear cond.: 0
BDEPTH: 142 141 Validity : 0
Towing dir: 0° Wire out : 350 m Speed : 3.1 kn
Sorted :1298 Total catch: 1298.36 Catch/hour: 8174.37

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	6837.80	102157	83.65	262
JELLYFISH	1227.56	13398	15.02	
Sufflogobius bibarbatus	72.17	10886	0.88	
Sea pens	20.10	422	0.25	
Merluccius capensis	16.75	170	0.20	
Total	8174.37		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 88
DATE :03/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 19°35.41
start stop duration Lon E 12°46.93
TIME :21:19:15 21:39:02 19.8 (min) Purpose : 1
LOG : 5862.13 5863.18 1.1 Region : 5010
FDEPTH: 43 42 Gear cond.: 0
BDEPTH: 43 42 Validity : 0
Towing dir: 0° Wire out : 125 m Speed : 3.2 kn
Sorted : 657 Total catch: 657.01 Catch/hour: 1992.95

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
JELLYFISH	1205.58	598	60.49	
Trachurus capensis	746.94	52744	37.48	263
Argyrosomus inodorus	11.34	3	0.57	
Holothuria scabra	6.55	601	0.33	
Dicologoglossa cuneata	6.01	164	0.30	
Merluccius capensis	5.46	82	0.27	
Arius latiscutatus **	4.91	27	0.25	
Raja miraletus	3.64	3	0.18	
Chelidonichthys capensis	1.15	3	0.06	
Engraulis capensis	0.55	55	0.03	264
Pterothrissus belloci	0.55	55	0.03	
Sufflogobius bibarbatus	0.27	55	0.01	
Total	1992.95		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 89
DATE :04/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 19°59.16
start stop duration Lon E 12°30.34
TIME :15:34:56 15:42:07 7.2 (min) Purpose : 1
LOG : 5986.95 5987.27 0.3 Region : 5010
FDEPTH: 153 153 Gear cond.: 0
BDEPTH: 153 153 Validity : 0
Towing dir: 0° Wire out : 370 m Speed : 2.7 kn
Sorted : 84 Total catch: 84.18 Catch/hour: 703.45

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	408.30	8624	58.04	265
Merluccius capensis	179.33	2641	25.49	
JELLYFISH	78.05	142	11.10	
Sufflogobius bibarbatus	17.72	2382	2.52	
Chelidonichthys capensis	7.02	25	1.00	
Pterothrissus belloci	6.35	318	0.90	
Scomber japonicus	3.01	25	0.43	
Callinectes sp.	1.67	284	0.24	
Loligo vulgaris	1.00	8	0.14	
Todarodes sp.	0.67	17	0.10	
Dicologoglossa cuneata	0.17	8	0.02	
Synagrops microlepis	0.08	17	0.01	
Squilla mantis	0.08	8	0.01	
Total	703.45		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 90
DATE :04/11/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 20°0.13
start stop duration Lon E 12°56.57
TIME :20:33:29 20:39:48 6.3 (min) Purpose : 1
LOG : 6015.39 6015.73 0.3 Region : 5010
FDEPTH: 30 40 Gear cond.: 0
BDEPTH: 63 62 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.2 kn
Sorted :1030 Total catch: 1029.94 Catch/hour: 9777.91

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	8925.95	877642	91.29	266
JELLYFISH	811.71	1073	8.30	
Thyrsites atun	37.41	9	0.38	
Engraulis capensis	2.85	285	0.03	267
Total	9777.91		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 91
DATE :05/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 20°16.44
start stop duration Lon E 12°37.41
TIME :08:18:54 08:30:14 11.3 (min) Purpose : 1
LOG : 6108.46 6109.00 0.5 Region : 5010
FDEPTH: 157 157 Gear cond.: 0
BDEPTH: 157 157 Validity : 0
Towing dir: 0° Wire out : 370 m Speed : 2.9 kn

Sorted : 542 Total catch: 542.10 Catch/hour: 2870.79

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
JELLYFISH	1500.79	22560	52.28	
Trachurus capensis	1320.21	32515	45.99	268
Merluccius capensis	31.77	212	1.11	
Scomber japonicus	18.01	1059	0.63	269
Total	2870.79		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 92
DATE :05/11/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 20°24.11
start stop duration Lon E 12°43.94
TIME :18:55:53 19:25:34 29.7 (min) Purpose : 1
LOG : 6178.00 6179.44 1.4 Region : 5010
FDEPTH: 20 40 Gear cond.: 0
BDEPTH: 159 147 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 2.9 kn
Sorted : 339 Total catch: 338.63 Catch/hour: 684.56

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
JELLYFISH	549.99	1373	80.34	
Engraulis capensis	62.67	685	9.15	271
Sardinops sagax	58.58	1025	8.56	270
Etrumeus whiteheadi	13.00	354	1.90	272
Scomber japonicus	0.32	2	0.05	273
Total	684.56		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 93
DATE :05/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 20°27.59
start stop duration Lon E 12°29.78
TIME :22:07:32 22:37:09 29.6 (min) Purpose : 1
LOG : 6198.84 6200.44 1.6 Region : 5010
FDEPTH: 290 284 Gear cond.: 0
BDEPTH: 290 284 Validity : 0
Towing dir: 0° Wire out : 700 m Speed : 3.2 kn
Sorted : 87 Total catch: 231.85 Catch/hour: 469.65

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Merluccius capensis	250.55	922	53.35	
Pterothrissus belloci	136.33	711	29.03	
Coelorinchus simorhynchus	30.83	468	6.56	
Lophius vomerinus	15.09	32	3.21	
Sufflogobius bibarbatus	13.90	5635	2.96	274
Galeus polli	10.45	269	2.23	
JELLYFISH	5.17	81	1.10	
Austroglossus pectoralis	3.44	6	0.73	
Chlorophthalmus atlanticus	3.24	140	0.69	
MYCTOPHIDAE	0.32	162	0.07	
Solenocera africana	0.22	59	0.05	
Illex coindetii	0.10	6	0.02	
Total	469.65		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 94
DATE :06/11/17 GEAR TYPE: PT NO: 0 POSITION:Lat S 20°33.90
start stop duration Lon E 12°46.84
TIME :03:53:00 04:17:00 24.8 (min) Purpose : 1
LOG : 6234.02 6235.66 1.7 Region : 5010
FDEPTH: 60 140 Gear cond.: 0
BDEPTH: 182 220 Validity : 0
Towing dir: 0° Wire out : 360 m Speed : 3.2 kn
Sorted : 11 Total catch: 10.56 Catch/hour: 25.58

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
JELLYFISH	22.38	218	87.50	
FISH LARVAE	2.86	2095	11.17	
Pleurobrachia pileus	0.19	228	0.76	
Loligo vulgaris	0.10	7	0.38	
Trachurus capensis	0.02	7	0.09	
MYCTOPHIDAE	0.02	7	0.09	
Total	25.58		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 95
DATE :06/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 20°38.13
start stop duration Lon E 13°14.09
TIME :09:30:40 09:40:03 9.4 (min) Purpose : 1
LOG : 6280.11 6280.60 0.5 Region : 5010
FDEPTH: 83 83 Gear cond.: 0
BDEPTH: 83 83 Validity : 0
Towing dir: 0° Wire out : 215 m Speed : 3.1 kn
Sorted : 71 Total catch: 710.50 Catch/hour: 4544.78

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	3351.81	214861	73.75	275
JELLYFISH	1175.69	8060	25.87	
Merluccius capensis	12.79	704	0.28	
Chlorophthalmus atlanticus	2.56	64	0.06	
Sufflogobius bibarbatus	1.28	384	0.03	
Galeus polli	0.64	64	0.01	
Total	4544.78		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 96
DATE :06/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 20°41.69
start stop duration Lon E 13°4.98
TIME :11:44:12 11:48:38 4.4 (min) Purpose : 1
LOG : 6294.93 6295.16 0.2 Region : 5010
FDEPTH: 123 124 Gear cond.: 0
BDEPTH: 123 124 Validity : 0
Towing dir: 0° Wire out : 320 m Speed : 3.1 kn
Sorted : 74 Total catch: 1523.08 Catch/hour: 20628.62

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	16181.31	62018	78.44	
Aequorea sp.	2985.10	85178	14.47	
Trachurus capensis	1276.39	23323	6.19	276
Merluccius capensis	181.49	3305	0.88	
Sufflogobius bibarbatus	2.17	366	0.01	
Pterothrissus belloci	1.90	27	0.01	
Illex coindetii	0.27	14	0.00	
Total	20628.62		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 97
DATE :06/11/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 20°43.92
start stop duration Lon E 12°50.64
TIME :14:04:36 14:28:06 23.5 (min) Purpose : 1
LOG : 6312.51 6313.69 1.2 Region : 5010
FDEPTH: 0 160 Gear cond.: 0
BDEPTH: 182 189 Validity : 0
Towing dir: 0° Wire out : 370 m Speed : 3.0 kn
Sorted : 4 Total catch: 4.34 Catch/hour: 11.08

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea sp.	4.44	107	40.09	
SIPHONARIIDAE	3.11	2543	28.11	
SALPS	2.96	92	26.73	
Lepidopus caudatus	0.36	3	3.23	
Illex coindetii	0.15	18	1.38	
FISH LARVAE	0.03	5	0.23	
Trachurus capensis	0.03	10	0.23	
Total	11.08		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 98
DATE :07/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 21°9.46
start stop duration Lon E 13°32.68
TIME :18:48:58 18:59:06 10.1 (min) Purpose : 1
LOG : 6520.95 6521.45 0.5 Region : 5020
FDEPTH: 26 27 Gear cond.: 0
BDEPTH: 26 27 Validity : 0
Towing dir: 0° Wire out : 85 m Speed : 2.9 kn
Sorted : 74 Total catch: 355.58 Catch/hour: 2106.10

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	1026.46	85173	48.74	277
Chrysaora fulgida	806.71	3495	38.30	
Chrysaora africana	220.93	474	10.49	
Chrysaora gorilla	22.51	30	1.07	
Callorhinchus capensis	19.31	6	0.92	
Chelidonichthys capensis	4.15	59	0.20	
Chelidonichthys capensis	1.66	6	0.08	0
Trachurus capensis	1.66	6	0.08	279
Arius laticscutatus **	1.54	6	0.07	
Engraulis capensis	1.18	118	0.06	278
Total	2106.10		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017408 STATION: 99
DATE :07/11/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 21°22.14
start stop duration Lon E 13°15.03
TIME :23:01:24 23:31:13 29.8 (min) Purpose : 1
LOG : 6551.55 6553.16 1.6 Region : 5020
FDEPTH: 30 20 Gear cond.: 0
BDEPTH: 134 135 Validity : 0
Towing dir: 0° Wire out : 90 m Speed : 3.3 kn
Sorted : 37 Total catch: 261.84 Catch/hour: 526.84

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea sp.	439.44	11042	83.41	
Chrysaora fulgida	86.76	70	16.47	
Sardinops sagax	0.48	8	0.09	280
Trachurus capensis	0.08	6	0.02	281
Thyrsites atun	0.04	2	0.01	
Illex coindetii	0.04	4	0.01	
Total	526.84		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 21
DATE :27/11/17 GEAR TYPE: PT NO: 8 POSITION:Lat S 22°43.49
start stop duration Lon E 13°4.48
TIME :07:05:18 07:20:31 15.2 (min) Purpose : 1
LOG : 8231.15 8232.12 1.0 Region : 5020
FDEPTH: 180 210 Gear cond.: 0
BDEPTH: 318 315 Validity : 0
Towing dir: 0° Wire out : 700 m Speed : 3.8 kn
Sorted : 20 Total catch: 50.33 Catch/hour: 198.40

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Krill	82.63	550845	41.65	
Brama brama	54.88	55	27.66	
MYCTOPHIDAE	48.41	60536	24.40	
Thyrsites atun	11.12	16	5.60	58
Aequorea forskalea	0.95	47	0.48	
Molluscs	0.28	706	0.14	
Alloteuthis africana	0.09	95	0.05	
SALPS	0.05	47	0.02	
Total	198.40		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 22
DATE :27/11/17 GEAR TYPE: PT NO: 8 POSITION:Lat S 22°34.72
start stop duration Lon E 13°37.78
TIME :12:14:08 12:33:43 19.6 (min) Purpose : 1
LOG : 8272.68 8273.91 1.2 Region : 5020
FDEPTH: 75 85 Gear cond.: 0
BDEPTH: 138 138 Validity : 0
Towing dir: 0° Wire out : 300 m Speed : 3.8 kn
Sorted : 176 Total catch: 4000.00 Catch/hour: 12257.41

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	11134.63	2994	90.84	59
Aequorea forskalea	1113.46	25263	9.08	60
Todaropsis eblanae	7.66	279	0.06	

Trachipterus sp.	1.74	6	0.01
Total	12257.49		100.00

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 23
DATE :27/11/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 22°21.66
start stop duration Lon E 14°9.55
TIME :18:20:14 18:34:32 14.3 (min) Purpose : 1
LOG : 8321.00 8322.50 1.5 Region : 5020
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 50 59 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 0.0 kn
Sorted : 0 Total catch: 471.19 Catch/hour: 1977.02

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Chrysaora fulgida	1278.88	0	64.69	62
Aequorea forskalea	552.17	0	27.93	61
Chrysaora africana	140.64	0	7.11	63
Todaropsis eblanae	5.18	449	0.26	
Merluccius sp.	0.13	59	0.01	64
Total	1977.00		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 24
DATE :27/11/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 22°35.06
start stop duration Lon E 14°8.00
TIME :21:50:13 22:11:56 21.7 (min) Purpose : 1
LOG : 8346.83 8347.92 1.1 Region : 5020
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 104 107 Validity : 0
Towing dir: 0° Wire out : 123 m Speed : 3.0 kn
Sorted : 63 Total catch: 1074.89 Catch/hour: 2967.94

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Chrysaora fulgida	1703.91	798	57.41	65
Aequorea forskalea	1259.86	27272	42.45	66
Thyrsites atun	3.88	124	0.13	67
Etrumeus whiteheadi	0.30	3	0.01	
Total	2967.95		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 25
DATE :28/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 23°0.48
start stop duration Lon E 13°10.59
TIME :08:41:27 09:11:29 30.0 (min) Purpose : 1
LOG : 8440.37 8441.68 1.3 Region : 5020
FDEPTH: 334 330 Gear cond.: 0
BDEPTH: 334 330 Validity : 0
Towing dir: 0° Wire out : 770 m Speed : 2.6 kn
Sorted : 46 Total catch: 878.51 Catch/hour: 1755.27

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Merluccius capensis	828.33	2088	47.19	68
Helicolenus dactylopterus	373.55	2695	21.28	
Sponges - yellow	258.14	2088	14.71	
Sea urchin	57.55	3568	3.28	
Coelorinchus sp.	41.57	1063	2.37	
Galeus polli	40.01	342	2.28	
Lophius vomerinus	38.87	38	2.21	
Genypterus capensis	33.79	38	1.92	
Coelorinchus polli	20.52	683	1.17	
Epigonus telescopus	20.50	1025	1.17	
Guentherus altivela	13.36	180	0.76	
Chlorophthalmus atlanticus	11.69	266	0.67	
Nezumia micronychodon	3.80	342	0.22	
Plesionika acanthurus	3.34	949	0.19	
Selachophidium guentheri	3.11	76	0.18	
G A S T R O P O D S	2.13	114	0.12	
Sea anemone sp	1.99	38	0.11	
Ommastrephes sp.	1.59	76	0.09	
Bathynectes piperitus	1.29	76	0.07	
MYCTOPHIDAE	0.15	180	0.01	
Total	1755.29		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 26
DATE :28/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 22°55.48
start stop duration Lon E 13°32.33
TIME :13:38:42 14:05:42 27.0 (min) Purpose : 1
LOG : 8472.56 8473.87 1.3 Region : 5020
FDEPTH: 185 189 Gear cond.: 0
BDEPTH: 185 189 Validity : 0
Towing dir: 0° Wire out : 470 m Speed : 2.9 kn
Sorted : 167 Total catch: 3100.00 Catch/hour: 6888.89

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Merluccius capensis	3549.69	27618	51.53	74
Chrysaora fulgida	2113.29	2393	30.68	
Trachurus capensis	828.56	5867	12.03	75
ARCHTOCEPHALUS SP	222.22	2	3.23	
Aequorea forskalea	80.71	1398	1.17	
Bathynectes piperitus	55.96	2076	0.81	
GOBIIDAE	14.38	2036	0.21	
Coelorinchus sp.	8.38	200	0.12	
Lophius vomerinus	8.07	160	0.12	
Thyrsites atun	7.29	2	0.11	
Squilla sp.	0.89	40	0.01	
Total	6889.42		100.01	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 27
DATE :28/11/17 GEAR TYPE: PT NO: 8 POSITION:Lat S 22°53.63
start stop duration Lon E 13°38.74
TIME :16:01:27 16:19:42 18.3 (min) Purpose : 1
LOG : 8484.77 8486.02 1.3 Region : 5020
FDEPTH: 50 57 Gear cond.: 0
BDEPTH: 147 149 Validity : 0
Towing dir: 0° Wire out : 320 m Speed : 4.1 kn
Sorted : 280 Total catch: 978.61 Catch/hour: 3217.34

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Chrysaora fulgida	2814.81	727	87.49	72
Lampanyctodes hectoris	341.52	620956	10.62	73
Aequorea forskalea	59.54	1174	1.85	
Ommastrephes bartrami	1.47	46	0.05	
Total	3217.34		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 28
DATE :28/11/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 22°45.81
start stop duration Lon E 14°10.22
TIME :20:35:43 20:48:53 13.2 (min) Purpose : 1
LOG : 8521.89 8522.54 0.7 Region : 5020
FDEPTH: 55 65 Gear cond.: 0
BDEPTH: 112 113 Validity : 0
Towing dir: 0° Wire out : 165 m Speed : 3.0 kn
Sorted : 126 Total catch: 2600.00 Catch/hour: 11845.10

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Chrysaora fulgida	10239.18	6210	86.44	70
Aequorea forskalea	1433.71	28036	12.10	71
Sufflogobius bibarbatus	170.30	84574	1.44	69
Total	11843.19		99.98	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 29
DATE :29/11/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 22°55.03
start stop duration Lon E 14°15.15
TIME :01:05:14 01:37:20 32.1 (min) Purpose : 1
LOG : 8556.43 8557.81 1.4 Region : 5020
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 103 107 Validity : 0
Towing dir: 0° Wire out : 160 m Speed : 2.6 kn
Sorted : 0 Total catch: 355.26 Catch/hour: 664.04

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Aequorea forskalea	345.91	7060	52.09	76
Chrysaora fulgida	310.69	26	46.79	77
Thyrsites atun	6.28	6	0.95	
Ommastrephes bartrami	1.16	153	0.17	
Total	664.04		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 30
DATE :29/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 23°6.98
start stop duration Lon E 13°31.24
TIME :06:33:48 06:52:13 18.4 (min) Purpose : 1
LOG : 8600.15 8601.12 1.0 Region : 5020
FDEPTH: 220 218 Gear cond.: 0
BDEPTH: 220 218 Validity : 0
Towing dir: 0° Wire out : 600 m Speed : 3.2 kn
Sorted : 183 Total catch: 2801.00 Catch/hour: 9123.78

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Trachurus capensis	6757.92	46397	74.07	78
Chrysaora fulgida	1036.61	349	11.36	80
Merluccius capensis	705.70	7127	7.73	79
Chlorophthalmus atlanticus	446.55	23137	4.89	
Coelorinchus sp.	85.41	1645	0.94	
Macropipus australis	30.39	1495	0.33	
Sufflogobius bibarbatus	20.52	6580	0.22	
Helicolenus dactylopterus	13.06	199	0.14	
Thyrsites atun	11.99	3	0.13	
Todaropsis eblanae	4.59	101	0.05	
Dead shells	3.78	349	0.04	
PORIFERA (Sponges)	2.80	101	0.03	
Pterygosquilla armata capensis	1.89	101	0.02	
E C H I N O D E R M A T A	1.50	199	0.02	
Starfish	0.91	199	0.01	
Unidentified	0.20	49	0.00	
Total	9123.81		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 31
DATE :29/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 23°18.23
start stop duration Lon E 13°28.23
TIME :13:35:26 14:07:53 32.5 (min) Purpose : 1
LOG : 8655.97 8657.77 1.8 Region : 5020
FDEPTH: 247 246 Gear cond.: 0
BDEPTH: 247 246 Validity : 0
Towing dir: 0° Wire out : 620 m Speed : 3.3 kn
Sorted : 95 Total catch: 300.00 Catch/hour: 554.70

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Merluccius capensis	283.60	1161	51.13	82
Helicolenus dactylopterus	90.32	1418	16.28	
Chlorophthalmus atlanticus	85.31	3896	15.38	
PORIFERA (Sponges)	24.85	205	4.48	
Centrolophus niger	14.09	2	2.54	
MYCTOPHIDAE	14.02	3532	2.53	
Trachurus capensis	11.80	41	2.13	83
Sufflogobius bibarbatus	10.37	1594	1.87	
Coelorinchus sp.	8.32	205	1.50	
Todaropsis eblanae	4.90	11	0.88	
Galeus polli	2.74	85	0.49	
Lophius vomerinus	1.94	6	0.35	
Macropipus australis	1.61	80	0.29	
Dead shells	0.57	41	0.10	
Todarodes angolensis	0.35	6	0.06	
Starfish	0.33	153	0.06	
Pterygosquilla armata capensis	0.22	11	0.04	
Solenocera africana	0.11	22	0.02	
Total	555.46		100.14	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 32
DATE :29/11/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 23°6.69
start stop duration Lon E 14°12.04
TIME :19:32:33 19:42:38 10.1 (min) Purpose : 1

LOG : 8705.53 8706.03 0.5 Region : 5020
FDEPTH: 70 70 Gear cond.: 0
BDEPTH: 115 117 Validity : 0
Towing dir: 0° Wire out : 190 m Speed : 3.0 kn
Sorted : 163 Total catch: 2000.00 Catch/hour: 11904.76

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	7993.51	3810	67.15	84
Aequorea forskalea	3397.14	47738	28.54	85
Sufflogobius bibarbatus	511.01	204417	4.29	86
Total	11901.67		99.97	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 33
DATE :30/11/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 23°14.22
start stop duration Lon E 14°22.80
TIME :00:05:54 00:25:27 19.6 (min) Purpose : 1
LOG : 8731.53 8732.49 1.0 Region : 5020
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 60 67 Validity : 0
Towing dir: 0° Wire out : 150 m Speed : 2.9 kn
Sorted : 0 Total catch: 219.82 Catch/hour: 674.64

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea forskalea	324.64	4383	48.12	87
Chrysaora fulgida	318.14	98	47.16	
Dactylometra africana	26.15	209	3.88	88
Ommastrephes bartrami	5.68	829	0.84	
Merluccius capensis	0.02	15	0.00	
Trachurus capensis	0.01	3	0.00	
Total	674.64		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 34
DATE :30/11/17 GEAR TYPE: PT NO: 8 POSITION:Lat S 23°29.43
start stop duration Lon E 13°18.82
TIME :09:12:39 09:31:42 19.1 (min) Purpose : 1
LOG : 8801.83 8803.02 1.2 Region : 5020
FDEPTH: 90 110 Gear cond.: 0
BDEPTH: 321 309 Validity : 0
Towing dir: 0° Wire out : 450 m Speed : 3.7 kn
Sorted : 0 Total catch: 15.69 Catch/hour: 49.40

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
SALPS	19.65	7861	39.78	
Chrysaora fulgida	18.65	3	37.74	
Aequorea forskalea	8.25	167	16.70	
J E L L Y F I S H	1.64	277	3.32	
Squid unidentified, juvenile	0.69	343	1.40	
Brama brama	0.38	3	0.77	
Molluscs	0.13	113	0.26	
SALPS	0.01	3	0.03	0
Unidentified	0.01	3	0.01	
Total	49.40		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 35
DATE :30/11/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 23°41.85
start stop duration Lon E 13°18.61
TIME :14:39:58 15:10:39 30.7 (min) Purpose : 1
LOG : 8838.45 8840.08 1.6 Region : 5020
FDEPTH: 307 304 Gear cond.: 0
BDEPTH: 307 304 Validity : 0
Towing dir: 0° Wire out : 740 m Speed : 3.2 kn
Sorted : 194 Total catch: 1100.00 Catch/hour: 2151.24

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	1134.80	4379	52.75	89
Merluccius capensis	453.34	1152	21.07	90
Helicolenus dactylopterus	258.67	7083	12.02	
PORIFERA (Sponges)	136.20	698	6.33	
Chlorophthalmus atlanticus	74.97	2435	3.48	
Todarodes angolensis	44.96	55	2.09	
Galeus polli	21.53	354	1.00	
Lophius vomerinus	12.35	10	0.57	
Coelorinchus polli	4.08	145	0.19	
Coelorinchus sp.	3.74	154	0.17	
Macropipus australis	2.44	100	0.11	
Starfish	2.17	886	0.10	
G A S T R O P O D S	0.55	121	0.03	0
MYCTOPHIDAE	0.53	188	0.02	
G A S T R O P O D S	0.42	33	0.02	
S H R I M P S	0.35	100	0.02	
Opistobranch	0.13	22	0.01	
Total	2151.24		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 36
DATE :30/11/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 23°30.02
start stop duration Lon E 14°8.05
TIME :21:28:43 21:48:56 20.2 (min) Purpose : 1
LOG : 8894.14 8895.14 1.0 Region : 5020
FDEPTH: 80 80 Gear cond.: 0
BDEPTH: 142 145 Validity : 0
Towing dir: 0° Wire out : 220 m Speed : 3.0 kn
Sorted : 13 Total catch: 7000.00 Catch/hour: 20771.51

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	15804.15	50326	76.09	93
Aequorea forskalea	3646.88	69199	17.56	92
Sufflogobius bibarbatus	1320.47	330267	6.36	
Total	20771.51		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 37
DATE :01/12/17 GEAR TYPE: PT NO: 8 POSITION:Lat S 23°57.10
start stop duration Lon E 13°40.96
TIME :14:23:12 14:32:39 9.4 (min) Purpose : 1
LOG : 9030.25 9030.92 0.7 Region : 5020
FDEPTH: 90 105 Gear cond.: 0
BDEPTH: 256 259 Validity : 0
Towing dir: 0° Wire out : 550 m Speed : 4.2 kn
Sorted : 0 Total catch: 9.39 Catch/hour: 59.65

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	37.21	13	62.37	94
Aequorea forskalea	8.70	203	14.58	95
DISCOMEDUSA LOBATA	6.98	152	11.71	96
Maurolicus muelleri	5.46	13714	9.15	
Todarodes angolensis	0.76	133	1.28	
Molluscs	0.25	330	0.43	
Leptocephalus, juvenile	0.16	6	0.27	
SALPS	0.13	171	0.21	
Total	59.65		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 38
DATE :01/12/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 23°52.20
start stop duration Lon E 14°10.08
TIME :18:42:43 18:47:45 5.0 (min) Purpose : 1
LOG : 9062.88 9063.14 0.3 Region : 5020
FDEPTH: 55 65 Gear cond.: 0
BDEPTH: 145 146 Validity : 0
Towing dir: 0° Wire out : 165 m Speed : 3.1 kn
Sorted : 237 Total catch: 2500.00 Catch/hour: 29821.07

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	27222.82	14922	91.29	97
Aequorea forskalea	2005.41	33006	6.72	98
Sufflogobius bibarbatus	692.92	255412	2.32	
Merluccius capensis	4.29	1396	0.01	
Thyrsites atun	2.86	131	0.01	
Total	29928.31		100.36	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 39
DATE :02/12/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 23°59.32
start stop duration Lon E 14°21.43
TIME :02:25:53 02:40:53 15.0 (min) Purpose : 1
LOG : 9098.61 9099.34 0.7 Region : 5020
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 85 90 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 2.9 kn
Sorted : 0 Total catch: 4000.00 Catch/hour: 16000.00

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	14308.64	10900	89.43	100
Aequorea forskalea	1667.36	33216	10.42	99
Ommastrephes bartrami	18.05	15272	0.11	
Thyrsites atun	3.50	136	0.02	
Sufflogobius bibarbatus	2.42	1212	0.02	
Total	15999.97		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 40
DATE :02/12/17 GEAR TYPE: PT NO: 8 POSITION:Lat S 24°4.16
start stop duration Lon E 13°58.42
TIME :06:37:58 07:34:42 56.7 (min) Purpose : 1
LOG : 9127.87 9132.87 5.0 Region : 5020
FDEPTH: 20 40 Gear cond.: 0
BDEPTH: 225 221 Validity : 0
Towing dir: 0° Wire out : 300 m Speed : 5.3 kn
Sorted : 261 Total catch: 6000.00 Catch/hour: 6345.85

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	6129.87	3061	96.60	103
Aequorea forskalea	203.59	4470	3.21	104
Seriola lalandi	8.88	4	0.14	
Thyrsites atun	2.12	1	0.03	
Ommastrephes bartrami	1.61	73	0.03	
Total	6346.06		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 41
DATE :02/12/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 24°7.54
start stop duration Lon E 13°51.45
TIME :09:29:51 10:00:40 30.8 (min) Purpose : 1
LOG : 9143.83 9145.32 1.5 Region : 5020
FDEPTH: 259 260 Gear cond.: 0
BDEPTH: 259 260 Validity : 0
Towing dir: 0° Wire out : 635 m Speed : 2.9 kn
Sorted : 87 Total catch: 2709.24 Catch/hour: 5274.33

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	3253.49	1750	61.69	105
Merluccius capensis	1050.10	4043	19.91	106
MYCTOPHIDAE	526.26	126615	9.98	
Sponges - yellow	122.51	1207	2.32	
Todarodes angolensis	108.03	121	2.05	
Coelorinchus sp.	86.90	2173	1.65	
Sufflogobius bibarbatus	45.87	4043	0.87	
Lophius vomerinus	22.93	121	0.43	
Aequorea forskalea	19.31	483	0.37	
Coelorinchus polli	12.37	724	0.23	
G A S T R O P O D S	8.75	543	0.17	
Unidentified invertebrate	7.00	422	0.13	
Galeus polli	3.02	181	0.06	
Pterygosquilla armata capensis	2.72	181	0.05	
Macropipus australis	1.51	60	0.03	
Starfish	1.21	543	0.02	
Chlorophthalmus atlanticus	1.21	121	0.02	
Dead shells	1.21	241	0.02	
Total	5274.38		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 42
DATE :02/12/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 24°15.44
start stop duration Lon E 13°55.87

TIME :18:29:00 18:34:23 5.4 (min) Purpose : 1
LOG : 9220.68 9220.91 0.2 Region : 5020
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 65 96 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 2.8 kn
Sorted : 138 Total catch: 10000.00 Catch/hour: 111524.16

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	108944.05	47710	97.69	107
Aequorea forskalea	2577.66	5665	2.31	
Thyrsites atun	26.32	11	0.02	
Sufflogobius bibarbatus	1.62	814	0.00	
Lampanyctodes hectoris	1.62	2431	0.00	
Maurolicus muelleri	0.81	814	0.00	
Total	111552.07		100.03	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 43
DATE :03/12/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 24°20.91
start stop duration Lon E 14°26.82
TIME :00:26:20 00:34:18 8.0 (min) Purpose : 1
LOG : 9263.54 9263.87 0.3 Region : 5020
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 62 62 Validity : 0
Towing dir: 0° Wire out : 135 m Speed : 2.5 kn
Sorted : 0 Total catch: 237.81 Catch/hour: 1790.26

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	1616.84	753	90.31	108
Aequorea forskalea	69.71	1460	3.89	109
Dactylometra africana	59.32	241	3.31	
Chirodropus gorilla	28.46	8	1.59	
Ommastrephes bartrami	8.13	1694	0.45	
Sufflogobius bibarbatus	3.16	979	0.18	
Thyrsites atun	3.01	113	0.17	110
Engraulis encrasicolus	1.36	113	0.08	111
Merluccius capensis, juvenile	0.15	60	0.01	
Trachurus capensis	0.12	23	0.01	
Total	1790.26		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 44
DATE :03/12/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 24°36.67
start stop duration Lon E 13°56.11
TIME :12:39:21 12:56:16 16.9 (min) Purpose : 1
LOG : 9357.03 9357.85 0.8 Region : 5020
FDEPTH: 217 216 Gear cond.: 0
BDEPTH: 217 216 Validity : 0
Towing dir: 0° Wire out : 580 m Speed : 2.9 kn
Sorted : 1 Total catch: 58.59 Catch/hour: 207.76

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Sufflogobius bibarbatus	87.59	10007	42.16	
Trachurus capensis	48.86	294	23.52	
Chrysaora fulgida	28.56	11479	13.75	112
PORIFERA (Sponges)	27.96	294	13.46	
Aequorea forskalea	11.17	294	5.38	
Merluccius capensis	3.62	6950	1.74	113
Total	207.75		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 45
DATE :04/12/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 25°12.60
start stop duration Lon E 14°23.77
TIME :20:54:59 21:05:39 10.7 (min) Purpose : 1
LOG : 9562.86 9563.41 0.6 Region : 5030
FDEPTH: 65 75 Gear cond.: 6
BDEPTH: 146 147 Validity : 3
Towing dir: 0° Wire out : 220 m Speed : 3.1 kn
Sorted : 0 Total catch: 451.88 Catch/hour: 2541.05

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	2403.94	1074	94.60	115
Aequorea forskalea	134.28	2980	5.28	114
Sufflogobius bibarbatus	1.93	619	0.08	
Ommastrephes bartrami	0.67	6	0.03	
PORIFERA (Sponges)	0.17	6	0.01	
G A S T R O P O D S	0.06	6	0.00	
Total	2541.04		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 46
DATE :05/12/17 GEAR TYPE: PT NO: 2 POSITION:Lat S 25°29.46
start stop duration Lon E 14°45.07
TIME :15:56:59 16:02:32 5.5 (min) Purpose : 1
LOG : 9692.99 9693.30 0.3 Region : 5030
FDEPTH: 76 76 Gear cond.: 0
BDEPTH: 76 76 Validity : 0
Towing dir: 0° Wire out : 220 m Speed : 3.4 kn
Sorted : 164 Total catch: 2800.00 Catch/hour: 30270.27

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	14492.65	0	47.88	
Chelidonichthys capensis	13637.73	47092	45.05	
Merluccius capensis	2085.62	24627	6.89	116
MYCTOPHIDAE	54.16	22314	0.18	117
Total	30270.16		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 47
DATE :05/12/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 25°41.76
start stop duration Lon E 14°44.52
TIME :20:16:59 20:18:42 1.7 (min) Purpose : 1
LOG : 9713.22 9713.30 0.1 Region : 5030
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 87 84 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 2.7 kn
Sorted : 291 Total catch: 290.75 Catch/hour: 10142.34

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	9327.21	1953	91.96	118
Aequorea forskalea	754.88	9593	7.44	119
MYCTOPHIDAE	51.21	33942	0.50	120
Thyrsites atun	5.09	488	0.05	
Loligo vulgaris	3.37	35	0.03	
Lepidopus caudatus	0.56	105	0.01	
Total	10142.32		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 48
DATE :06/12/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 26°0.76
start stop duration Lon E 14°40.26
TIME :03:22:53 03:24:46 1.9 (min) Purpose : 1
LOG : 9748.86 9748.93 0.1 Region : 5030
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 155 156 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 2.3 kn
Sorted : 133 Total catch: 400.00 Catch/hour: 12765.96

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea forskalea	9703.09	160660	76.01	121
Chrysaora fulgida	3058.76	255	23.96	122
Todaropsis eblanae	4.05	255	0.03	
Total	12765.89		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 49
DATE :06/12/17 GEAR TYPE: PT NO: 8 POSITION:Lat S 26°0.27
start stop duration Lon E 14°17.16
TIME :07:02:07 07:10:52 8.8 (min) Purpose : 1
LOG : 9770.83 9771.33 0.5 Region : 5030
FDEPTH: 40 70 Gear cond.: 0
BDEPTH: 221 227 Validity : 0
Towing dir: 0° Wire out : 280 m Speed : 3.4 kn
Sorted : 113 Total catch: 112.87 Catch/hour: 773.98

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	454.90	55	58.77	125
Maurolicus muelleri	158.81	226875	20.52	
Thyrsites atun	82.29	55	10.63	123
Aequorea forskalea	75.65	1097	9.77	124
Todarodes angolensis	2.28	171	0.29	
Lepidopus caudatus	0.05	14	0.01	
Total	773.98		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 50
DATE :06/12/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 26°1.66
start stop duration Lon E 13°50.11
TIME :11:24:16 11:28:34 4.3 (min) Purpose : 1
LOG : 9796.93 9797.10 0.2 Region : 5030
FDEPTH: 290 310 Gear cond.: 0
BDEPTH: 380 379 Validity : 0
Towing dir: 0° Wire out : 550 m Speed : 2.3 kn
Sorted : 10 Total catch: 10.45 Catch/hour: 145.81

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
MYCTOPHIDAE	140.09	84056	96.08	
Todarodes angolensis	4.47	42	3.06	
OMMASTREPHIDAE	0.56	293	0.38	
Nansenia sp.	0.28	42	0.19	
Maurolicus muelleri	0.28	126	0.19	
Phosichthys argenteus	0.14	14	0.10	
Total	145.81		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 51
DATE :06/12/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 26°21.07
start stop duration Lon E 13°48.65
TIME :23:41:45 23:56:05 14.3 (min) Purpose : 1
LOG : 9872.49 9873.15 0.7 Region : 5030
FDEPTH: 85 105 Gear cond.: 0
BDEPTH: 403 402 Validity : 0
Towing dir: 0° Wire out : 240 m Speed : 2.8 kn
Sorted : 0 Total catch: 12.83 Catch/hour: 53.74

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Prionace glauca	27.89	4	51.89	
MYCTOPHIDAE	21.60	8906	40.19	
Maurolicus muelleri	2.48	222	4.61	
Krill	1.42	1474	2.65	
OMMASTREPHIDAE	0.14	88	0.26	
SALPS	0.13	4	0.25	
Lepidopus caudatus	0.07	33	0.12	
Unidentified crustacean larvae	0.01	8	0.02	
Total	53.74		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 52
DATE :07/12/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 26°20.63
start stop duration Lon E 14°24.04
TIME :04:36:25 04:44:27 8.0 (min) Purpose : 1
LOG : 9908.52 9908.93 0.4 Region : 5030
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 293 294 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.0 kn
Sorted : 1 Total catch: 0.70 Catch/hour: 5.23

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
SALPS	3.81	187	72.86	
MYCTOPHIDAE	0.69	471	13.29	
OMMASTREPHIDAE	0.64	306	12.14	
Krill	0.09	456	1.71	
Total	5.23		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 53
DATE :07/12/17 GEAR TYPE: PT NO: 8 POSITION:Lat S 26°18.77
start stop duration Lon E 14°47.98
TIME :07:53:07 08:03:56 10.8 (min) Purpose : 1
LOG : 9931.23 9931.89 0.7 Region : 5030
FDEPTH: 90 110 Gear cond.: 0
BDEPTH: 141 139 Validity : 0
Towing dir: 0° Wire out : 400 m Speed : 3.7 kn
Sorted : 123 Total catch: 994.78 Catch/hour: 5516.35

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Etrumeus whiteheadi	1807.76	8462	32.77	127
Chrysaora fulgida	1447.32	10420	26.24	128
Aequorea forskalea	1164.51	3954	21.11	126
Thyrsites atun	614.53	266	11.14	129
MYCTOPHIDAE	443.62	3194	8.04	
OMMASTREPHIDAE	30.94	1159	0.56	
Todarodes angolensis	4.24	6	0.08	
Sardinops sagax	2.14	44	0.04	130
Lepidopus caudatus	1.28	161	0.02	
Total	5516.35		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 54
DATE :07/12/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 26°40.75
start stop duration Lon E 14°32.48
TIME :18:30:37 18:46:16 15.7 (min) Purpose : 1
LOG : 9992.18 9993.05 0.9 Region : 5030
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 281 275 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.3 kn
Sorted : 197 Total catch: 197.04 Catch/hour: 755.43

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
MYCTOPHIDAE	629.14	164523	83.28	132
Etrumeus whiteheadi	116.47	1691	15.42	131
Aequorea forskalea	6.06	8	0.80	
OMMASTREPHIDAE	2.79	510	0.37	
Sardinops sagax	0.35	4	0.05	
Lepidopus caudatus	0.26	130	0.03	
DISCOMEDUSA LOBATA	0.11	4	0.01	
Krill	0.11	598	0.01	133
NAUTILIDAE	0.06	8	0.01	
Cranchia scabra	0.05	4	0.01	
Unidentified	0.03	4	0.00	
Brama brama	0.01	4	0.00	
Total	755.43		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 55
DATE :08/12/17 GEAR TYPE: PT NO: 8 POSITION:Lat S 26°57.17
start stop duration Lon E 14°42.05
TIME :08:55:47 09:28:39 32.9 (min) Purpose : 1
LOG : 102.89 106.45 3.6 Region : 5030
FDEPTH: 200 100 Gear cond.: 0
BDEPTH: 241 255 Validity : 0
Towing dir: 0° Wire out : 500 m Speed : 6.5 kn
Sorted : 2 Total catch: 13.46 Catch/hour: 24.56

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea forskalea	14.71	78	59.90	
Krill	6.11	5659	24.88	
Maurolicus muelleri	3.74	3961	15.22	
Total	24.56		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 56
DATE :08/12/17 GEAR TYPE: PT NO: 8 POSITION:Lat S 26°57.29
start stop duration Lon E 15°6.01
TIME :13:28:32 14:04:17 35.8 (min) Purpose : 1
LOG : 146.44 152.39 6.0 Region : 5030
FDEPTH: 15 40 Gear cond.: 0
BDEPTH: 108 128 Validity : 0
Towing dir: 0° Wire out : 350 m Speed : 3.0 kn
Sorted : 74 Total catch: 1992.22 Catch/hour: 3343.59

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea forskalea	3329.72	9063	99.59	134
Etrumeus whiteheadi	8.70	2900	0.26	135
OMMASTREPHIDAE	5.17	725	0.15	
Total	3343.59		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 57
DATE :08/12/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 27°15.75
start stop duration Lon E 14°59.46
TIME :22:04:56 22:22:04 17.1 (min) Purpose : 1
LOG : 200.33 201.23 0.9 Region : 5030
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 174 174 Validity : 0
Towing dir: 0° Wire out : 150 m Speed : 3.2 kn
Sorted : 43 Total catch: 42.73 Catch/hour: 149.67

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Etrumeus whiteheadi	126.23	2722	84.34	136
Ommastrephes bartrami	18.91	665	12.64	
Thyrsites atun	4.52	11	3.02	
Total	149.67		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 58
DATE :09/12/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 27°40.30
start stop duration Lon E 15°25.46
TIME :13:47:37 14:17:47 30.2 (min) Purpose : 1
LOG : 321.29 322.68 1.4 Region : 5030
FDEPTH: 100 99 Gear cond.: 0
BDEPTH: 100 99 Validity : 0
Towing dir: 0° Wire out : 280 m Speed : 2.8 kn
Sorted : 44 Total catch: 200.00 Catch/hour: 397.75

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea forskalea	109.26	424	27.47	140
PASIPHAEIDAE	81.21	171719	20.42	
MYCTOPHIDAE	54.96	23720	13.82	
Chelidonichthys capensis	42.40	147	10.66	
Merluccius capensis	41.91	326	10.54	139
Callorhinchus capensis	16.03	24	4.03	
Thyrsites atun	13.28	6	3.34	138
Histioteuthis reversa	8.04	1452	2.02	
Sufflogobius bibarbatus	7.00	1778	1.76	
Trachurus trachurus	5.48	171	1.38	137
Lepidopus caudatus	5.20	799	1.31	
Rajella leopardus	4.53	2	1.14	
Pterygosquilla armata capensis	2.56	171	0.64	
Maurolicus muelleri	1.57	1036	0.39	
Sepia hieronis	0.24	8	0.06	
Cynoglossus capensis	0.23	2	0.06	
Sepia australis	0.22	8	0.06	
Genypterus capensis	0.17	8	0.04	
Zeus capensis	0.13	2	0.03	
Engraulis encrasicolus	0.07	8	0.02	
Total	394.49		99.18	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 59
DATE :09/12/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 27°59.41
start stop duration Lon E 15°35.95
TIME :19:11:02 19:26:44 15.7 (min) Purpose : 1
LOG : 352.64 353.49 0.8 Region : 5030
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 87 84 Validity : 0
Towing dir: 0° Wire out : 140 m Speed : 3.2 kn
Sorted : 156 Total catch: 155.95 Catch/hour: 596.00

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea forskalea	585.63	1051	98.26	141
Sepia australis	4.16	141	0.70	
Ommastrephes bartrami	3.17	340	0.53	
Histioteuthis reversa	1.87	631	0.31	
Sufflogobius bibarbatus	0.63	161	0.11	
Chelidonichthys capensis	0.39	11	0.07	
Trachurus trachurus	0.05	256	0.01	
Engraulis capensis	0.04	8	0.01	
Pterygosquilla armata capensis	0.03	27	0.01	
Etrumeus whiteheadi	0.02	4	0.00	
Total	596.00		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 60
DATE :10/12/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 28°0.40
start stop duration Lon E 15°13.95
TIME :00:13:52 00:32:55 19.1 (min) Purpose : 1
LOG : 378.46 379.32 0.9 Region : 5030
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 152 149 Validity : 0
Towing dir: 0° Wire out : 150 m Speed : 2.7 kn
Sorted : 19 Total catch: 19.16 Catch/hour: 60.34

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea forskalea	37.35	104	61.91	143
LAMINARIA SP.	10.58	3	17.54	
Etrumeus whiteheadi	9.39	202	15.56	142
Sepia australis	1.51	72	2.51	
Ommastrephes bartrami	1.45	164	2.40	
Histioteuthis reversa	0.04	19	0.06	
UNIDENTIFIED FISH	0.02	3	0.03	
Total	60.34		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017409 STATION: 61
DATE :12/12/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 28°58.07
start stop duration Lon E 15°57.38
TIME :01:41:57 02:00:38 18.7 (min) Purpose : 1
LOG : 720.65 721.55 0.9 Region : 5030
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 171 168 Validity : 0
Towing dir: 0° Wire out : 150 m Speed : 2.9 kn
Sorted : 85 Total catch: 84.55 Catch/hour: 271.56

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Etrumeus whiteheadi	258.18	4378	95.07	146
Aequorea forskalea	7.93	22	2.92	145
Sardinops sagax	2.96	3	1.09	
Sepia australis	1.55	662	0.57	
Lepidopus caudatus	0.61	16	0.22	
Ommastrephes bartrami	0.26	55	0.09	
Histioteuthis meleagroteuthis	0.06	22	0.02	
Leptocephalus	0.01	6	0.00	
Total	271.56		100.00	

ANNEX III. BIOLOGY SCALES

Sexual maturity

Stage	State	Description
I	Immature	Ovary and testis about 1/3rd length of body cavity. Ovaries pinkish, translucent, testis whitish. Ova not visible to naked eye.
II	Maturing virgin and recovering spent	Ovary and testis about ½ length of body cavity. Ovary pinkish, translucent, testis whitish, symmetrical. Ova not visible to naked eye.
III	Ripening	Ovary and testis is about 2/3rds length of body cavity. Ovary pinkish yellow colour with granular appearance, testis whitish to creamy. No transparent or translucent ova visible.
IV	Ripe	Ovary and testis from 2/3rds to full length of body cavity. Ovary orange-pink in colour with conspicuous superficial blood vessels. Large transparent, ripe ova visible. Testis whitish-creamy, soft.
V	Spent	Ovary and testis shrunken to about ½ length of body cavity. Walls loose. Ovary may contain remnants of disintegrating opaque and ripe Ova, darkened or translucent. Testis bloodshot and flabby

Stomach content

Scale	Designation	Description
0	Empty	Stomach empty except for water.
1	Very little content	Stomach is almost empty. Only traces of small organisms can be found.
2	Some content	Stomach not completely full and not dilated.
3	Stomach full	Stomach full, but not bloated/dilated.
4	Bloated/dilated	The stomach is visibly expanded and tight. Content can be observed from the outside.

ANNEX IV. PH, ALKALINITY AND ARAGONITE SATURATION STATE

Water samples were collected from the whole water column at the stations on most of the transects. These were analyzed on board for pH and alkalinity, and the nutrients will later be analyzed in on shore laboratories. Preliminary calculations are shown here, final results can only be calculated when nutrient concentrations are known. These variables will be used to characterize the inorganic carbon components of the waters, which also show the status of ocean acidification.

Deep water has low pH because of high content of CO_2, which is produced by degradation of sinking organic material. The upwelling water along the shelf, consequently had low pH values, and pH decreased gradually with depth.

Alkalinity is more related to the salinity of the waters, and a layer was found around 50m depth, consisting of warm high saline water with lower alkalinity than the surrounding waters.

Saturation state of calcium carbonates is an indicator used for monitoring development of ocean acidification in seawater. A saturation state value below one for a calcium carbonate mineral, means the water is under-saturated for the mineral. Under-saturation predicts that over time the mineral will dissolve. Aragonite saturation state was well above one in the waters studied, but in the below 250m depth the values were rather low, as is expected in upwelling waters. For some marine organisms that construct shells of aragonite, saturation state below 2 has been shown to slow down the process of shell formation.

ANNEX V. LIST OF BIOLOGICAL SAMPLES COLLECTED FOR FUTURE ANALYSIS

Country	Area	Survey	Leg	Station	Species	length	Length/ weight	Biology (sex, maturity & stomach fullness)	liver samples frozen	stomach samples frozen	Gonad weight	Stomach weight	fin clips preserved and frozen	otoliths collected
Namibia	North	2017408	2	73	*Engraulis capensis*		100							
Namibia	North	2017408	2	73	*Etrumeus whiteheadi*		13							
Namibia	North	2017408	2	73	*Sardinops sagax*		3	3	3	3	0	3	3	3
Namibia	North	2017408	2	73	*Trachurus capensis*		98	30	30	30	3	30	30	10
Namibia	North	2017408	2	74	*Argyrosomus inodorus*		100	30	30	30	30	30	30	30
Namibia	North	2017408	2	74	*Engraulis capensis*		100							
Namibia	North	2017408	2	74	*Sardinella aurita*		0	1	1	1		1	1	1
Namibia	North	2017408	2	74	*Sardinops sagax*		96	30	30	30	30	30	30	10
Namibia	North	2017408	2	74	*Trachurus capensis*		7	7	7	7	7	7	7	7
Namibia	North	2017408	2	75	*Engraulis capensis*		100							
Namibia	North	2017408	2	75	*Etrumeus whiteheadi*		25							
Namibia	North	2017408	2	75	*Sardinella aurita*		0	1	1	1	1	1	1	1
Namibia	North	2017408	2	75	*Sardinops sagax*		23	24	24	24	24	24	24	10
Namibia	North	2017408	2	76	*Engraulis capensis*		65							
Namibia	North	2017408	2	76	*Sardinops sagax*		8	8	8	8	8	8	8	8
Namibia	North	2017408	2	76	*Scomber colias*		51							
Namibia	North	2017408	2	76	*Trachurus capensis*		100	30	30	30	8	30	30	10
Namibia	North	2017408	2	77	*Trachurus capensis*		104	30	30	30	24	30	30	10
Namibia	North	2017408	2	78	*Sardinops sagax*		117	30	30	30	30	30	30	10
Namibia	North	2017408	2	78	*Trachurus capensis*		11							
Namibia	North	2017408	2	79	*Trachurus capensis*		100	30	30	30	25	30	30	10

Country	Area	Survey	Leg	Station	Species	length	Length/ weight	Biology (sex, maturity & stomach fullness)	liver samples frozen	stomach samples frozen	Gonad weight	Stomach weight	fin clips preserved and frozen	otoliths collected
Namibia	North	2017408	2	80	*Trachurus capensis*		102	30	30	30	30	30	30	10
Namibia	North	2017408	2	81	*Engraulis capensis*		4							
Namibia	North	2017408	2	81	*Etrumeus whiteheadi*		100							
Namibia	North	2017408	2	81	*Sardinops sagax*		100	30	30	30	23	30	30	10
Namibia	North	2017408	2	81	*Scomber colias*		8							
Namibia	North	2017408	2	81	*Trachurus capensis*		100	30	30	30	0	30	30	10
Namibia	North	2017408	2	82	*Engraulis capensis*		102							
Namibia	North	2017408	2	82	*Etrumeus whiteheadi*		3							
Namibia	North	2017408	2	82	*Sardinops sagax*		3	3	3	3	3	3	3	3
Namibia	North	2017408	2	82	*Scomber colias*		54							
Namibia	North	2017408	2	82	*Trachurus capensis*		102	30	30	30	18	30	30	10
Namibia	North	2017408	2	83	*Engraulis capensis*		4							
Namibia	North	2017408	2	83	*Scomber colias*		2							
Namibia	North	2017408	2	83	*Trachurus capensis*		100	30	30	30	17	30	30	10
Namibia	North	2017408	2	84	*Trachurus capensis*		100	30	30	30		30	30	10
Namibia	North	2017408	2	85	*Trachurus capensis*		96	30	30	30	16	30	30	10
Namibia	North	2017408	2	86	*Sardinops sagax*		13	13	13	13	13	13	13	10
Namibia	North	2017408	2	86	*Trachurus capensis*		64	30	30	30	1	30	30	10
Namibia	North	2017408	2	87	*Trachurus capensis*		100	30	30	30	30	30	30	10
Namibia	North	2017408	2	88	*Trachurus capensis*		100	30	30	30	0	30	30	10
Namibia	North	2017408	2	88	*Engraulis capensis*		2							
Namibia	North	2017408	2	89	*Trachurus capensis*		100	30	30	30	25	30	30	10
Namibia	North	2017408	2	90	*Trachurus capensis*		102	30	30	30	0	30	30	10

Country	Area	Survey	Leg	Station	Species	length	Length/ weight	Biology (sex, maturity & stomach fullness)	liver samples frozen	stomach samples frozen	Gonad weight	Stomach weight	fin clips preserved and frozen	otoliths collected
Namibia	North	2017408	2	90	*Engraulis capensis*		2							
Namibia	North	2017408	2	91	*Trachurus capensis*		100	30	30	30	27	30	30	10
Namibia	North	2017408	2	91	*Scomber colias*		4							
Namibia	North	2017408	2	92	*Scomber colias*		1							
Namibia	North	2017408	2	92	*Sardinops sagax*		100	30	30	30	30	30	30	10
Namibia	North	2017408	2	92	*Engraulis capensis*		100							
Namibia	North	2017408	2	92	*Etrumeus whiteheadi*		100							
Namibia	North	2017408	2	93	*Sufflogobius bibarbatus*		30				30			
Namibia	North	2017408	2	95	*Trachurus capensis*		101	30	30	30	0	30	30	10
Namibia	North	2017408	2	96	*Trachurus capensis*		100	30	30	30	30	30	30	10
Namibia	Central	2017408	2	98	*Trachurus capensis*		100	30	30	30	0	30	30	10
Namibia	Central	2017408	2	99	*Trachurus capensis*		4							
Namibia	Central	2017408	2	99	*Sardinops sagax*		4	4	4	4	4	4	4	4
Namibia	Central	2017408	2	100	*Trachurus capensis*		100	30	30	30	30	30	30	10
Namibia	Central	2017408	2	101	*Sardinops sagax*		23	23	23	23	23	23	23	10
Namibia	Central	2017408	2	101	*Trachurus capensis*		100	30	30	30	30	3	30	10
Namibia	Central	2017408	2	101	*Etrumeus whiteheadi*		82							
					TOTAL		**3733**	**867**	**867**	**867**	**570**	**840**	**867**	**337**

ANNEX VI. LIST OF SPECIES COLLECTED FOR FISH IDENTIFICATION COURSE

Species	Number of individuals
Squatina oculata	2
Mustelus mustelus	1
Rhinobatos annulatus	2
Torpedo torpedo	2
Raja miraletus	3
Dasyatis marmorata	3
Callorhinchus capensis	3
Selene dorsalis	3
Chloroscombrus chrysurus	3
Chaetodon hoefleri	3
Prognathodes marcellae	1
Sardinella aurita	3
Engraulis encrasicolus	3
Brachideuterus auritu	3
Pomadasys incisus	3
Pomadasys peroteti	3
Hemiramphus balao	2
Pseudupeneus prayensis	6
Pentanemus quinquarium	3
Galeoides decadactylus	3
Ilisha africana	3
Pteroscion peli	3
Pseudotolithus senegallus	3
Scorpaena normani	3
Pagellus bellottii	2
Lithognathus mormyrus	3
Sphyraena sphyraena	3
Sphyraena guachancho	2
Lagocephalus laevigatus	3
Trichiurus lepturus	3
Zeus faber	2
TOTAL	**85**

ANNEX VII. ABUNDANCE ESTIMATES BY NUMBERS AND BIOMASS

Trachurus capensis

	N (thousands)				Biomass (tonnes)			
Length cm	North	Central	South	TOTAL	North	Central	South	TOTAL
5	16 150	0		16 150	32	0		32
6	24 226	0		24 226	76	0		76
7	17 064	0		17 064	80	0		80
8	198 496	0		198 496	1 315	0		1 315
9	662 364	70 859		733 223	5 975	563		6 538
10	1 404 930	1 629 765		3 034 696	16 729	17 327		34 056
11	3 592 629	3 861 835		7 454 465	55 059	53 528		108 587
12	4 057 797	531 445		4 589 242	78 371	9 393		87 765
13	3 978 508	106 289		4 084 797	95 127	2 351		97 478
14	2 484 992	0		2 484 992	72 443	0		72 443
15	2 940 269	35 430		2 975 698	103 135	1 173		104 307
16	3 044 951	885 742		3 930 694	127 034	35 174		162 208
17	3 312 426	0		3 312 426	162 694	0		162 694
18	1 997 837	0		1 997 837	114 481	0		114 481
19	1 241 097	5 889		1 246 986	82 300	381		82 681
20	1 358 644	58 888		1 417 532	103 502	4 403		107 906
21	940 379	244 387		1 184 766	81 757	20 997		102 754
22	851 688	238 498		1 090 186	83 999	23 395		107 394
23	129 319	38 278		167 597	14 389	4 262		18 652
24	25 659	2 944		28 603	3 205	370		3 575
25	26 685	0		26 685	3 724	0		3 724
26	53 370	0		53 370	8 287	0		8 287
27	0	0		0	0	0		0
28	0	0		0	0	0		0
29	26 685	0		26 685	5 579	0		5 579
30	0	0		0	0	0		0
31	0	0		0	0	0		0
32	0	0		0	0	0		0
33	0	0		0	0	0		0
34	0	0		0	0	0		0
35	0	0		0	0	0		0
TOTAL	32 386 166	7 710 251	0	40 096 417	1 219 294	173 318	0	1 392 612

Engraulis encrasicolus

	N (thousands)				Biomass (tonnes)			
Length cm	North	Central	South	TOTAL	North	Central	South	TOTAL
5								
6								
7								
8								
9	1 360			1 360	12			12
10	534 666			534 666	5 927			5 927
11	1 046 446			1 046 446	14 107			14 107
12	963 251			963 251	15 536			15 536
13	743 669			743 669	14 153			14 153
14	249 566			249 566	5 539			5 539
15	38 480			38 480	986			986
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
TOTAL	3 577 438			3 577 438	56 260			56 260

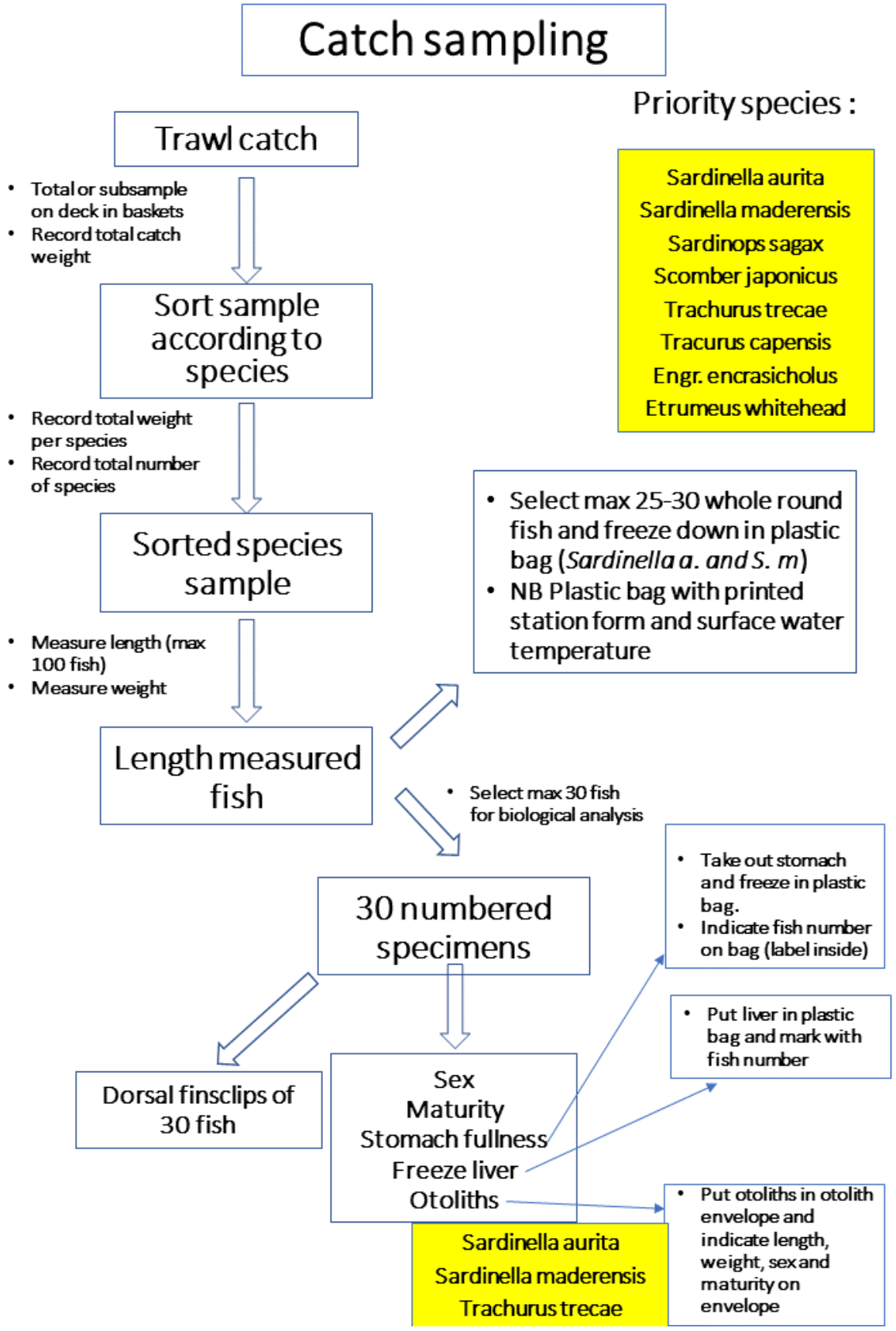
Etrumeus whiteheadi

	N (thousands)				Biomass (tonnes)			
Length cm	North	Central	South	TOTAL	North	Central	South	TOTAL
5								
6								
7								
8								
9								
10								
11								
12								
13	26 036			26036	474			474
14	37 048			37048	848			848
15	92 409			92409	2 620			2620
16	135 809		4 422	140231	4 706		133	4839
17	110 397		94 874	205271	4 621		3 436	8057
18	84 852		379 270	464122	4 245		16 358	20603
19	12 781		347 304	360085	757		17 674	18431
20			169 188	169188			10 075	10075
21			119 289	119289			8 250	8250
22			70 332	70332				0
23			9 728	9728				0
24			4 164	4164				0
25				0				0
TOTAL	499 331		1198570	1697901	18 271		62862	81133

Sardinops sagax

	N (thousands)				Biomass (tonnes)			
Length cm	North	Central	South	TOTAL	North	Central	South	TOTAL
5								
6								
7								
8								
9								
10								
11	35			35	0			0
12	140			140	2			2
13	3 967			3 967	82			82
14	4 519			4 519	116			116
15	174 585			174 585	5 450			5 450
16	336 432	499		336 931	12 649	19		12 668
17	316 998	582		317 580	14 198	27		14 224
18	249 487			249 487	13 182			13 182
19	284 391	1 081		285 472	17 573	70		17 644
20	554 235			554 235	39 740			39 740
21	418 056	166		418 222	34 537	15		34 552
22	47 677	915		48 592	4 509	95		4 604
23		748		748		90		90
24								
25								
TOTAL	2 390 523	3 991		2 394 514	142 038	315		142 4

ANNEX VIII. OVERVIEW OF SAMPLING PROCEDURES IN THE FISH LAB



ANNEX IX. OVERVIEW OF SAMPLES COLLECTED AND SHIPPED

Sample category	Sample sub-category	Preservation	Port of off loading	Transport	Institution address	Contact person	Colli (number, kg, volume)	Quantity (bottles, bags)	Label	Responsible for packing
Nutrients		Chloroform (kept cold, 3 to 5 C)	Cape Town	Air freight to Bergen	IMR	Janne Møgster Linda Fonnes, Espen Bagøien, Tor Ensrud				Sarah
Chlorophyll a		Frozen (-18 to -20 C, best -80)	Cape Town	Boat freight to Bergen (frozen)	IMR	Espen Bagøien				Sarah
phytoplankton		formaldehyde	Cape Town		NatMIRC Leg 3.2 and 3.3, 3.4) DEA, Leg 3.4	Deon Louw (NatMIRC) Hans Verheye (South Africa)				Leevi (Namibia) Delphine (S-A)

Sample category	**Sample sub-category**	**Preservation**	**Port of off loading**	**Transport**	**Institution address**	**Contact person**	**Colli** (number, kg, volume)	**Quantity** (bottles, bags)	**Label**	**Responsible for packing**
zooplankton	biomass	dried	Cape Town	Air freight to Bergen	IMR	Bjørn Kraft, Espen Bagøien				Sarah
zooplankton	identification	formaldehyde	Cape Town		NatMIRC Leg 3.2 and 3.3, 3.4) DEA, Leg 3.4	Ruby (INIP) Richard Horaeb (NatMIRC) Catarina (INIP) Hans Verheye, Jenny Huggett (South Africa)				Leevi (Namibia) Delphine (S-A)
Jellyfish	arm	ethanol + frozen	Cape Town		UWC	Mark Gibbons				Delphine (S-A)
	remaining	formalin	Cape Town		UWC	Mark Gibbons				Delphine (S-A)

Sample category	**Sample sub-category**	**Preservation**	**Port of off loading**	**Transport**	**Institution address**	**Contact person**	**Colli** (number, kg, volume)	**Quantity** (bottles, bags)	**Label**	**Responsible for packing**
	Whole individuals	dried + frozen	Cape Town		UWC	Mark Gibbons				Delphine (S-A)
fish larvae		*formaldehyde*	*Cape Town*		NatMIRC Leg 3.2 and 3.3, 3.4) DEA, Leg 3.4	Josephine Edwards (Namibia) Yonela Geja (South Africa)				Leevi (Namibia) Delphine (S-A)
fish eggs		*formaldehyde*	*Cape Town*							Leevi (Namibia) Delphine (S-A)
Microplastics		*dry*		*Air freight*	*IMR*	*Bjørn Einar Grøsvik*				Sarah
Neuston (from manta trawl)		*formalin and ethanol*	*Cape Town*	*car*		*Mark Gibbons*				
mesopelagic fish	species id., stable isotope, fatty acid, genetics	formaldehyde	Cape Town	car	UWC	Mark Gibbons				Yonela Geja(S-A)
	diet, genetics, growth	alcohol	Cape Town	Car	UWC	Mark Gibbons				Delphine (S-A)
	reproduction	formaldehyde	Cape Town	Car	UWC	Mark				Delphine (S-A)

Sample category	**Sample sub-category**	**Preservation**	**Port of off loading**	**Transport**	**Institution address**	**Contact person**	**Colli** (number, kg, volume)	**Quantity** (bottles, bags)	**Label**	**Responsible for packing**
						Gibbons				
	contaminants and nutrients	homogenized and freeze dried	Cape Town	shipment	IMR/NIFES	Leikny Fjellstad				Leikny
	diversity	frozen	Cape Town	shipment	IMR	Rupert Wieneroter				Sarah
Pelagic fish	Finclips for genetic analysis	ethanol	Cape Town	Air freight	IMR	Geir Dahle				Sarah
	stomachs	frozen	Cape Town Leg 3.4	Car	DAF/NatMirc					Nandipha
	otoliths	dry	Walvis Bay and Cape Town	All samples from the region to NatMIRC	To NatMIRC with local participants	La-toya Shivute (chair BCC WG)				?
	whole specimens for morphometric analysis	frozen	Cape Town (species found in Namibia/South Africa)	Walvis Bay and Cape Town	NatMIRC DAFF	Nandipha Mhlongo				Nandipha
Liver		frozen	Cape Town		?					Nandipha

Sample category	**Sample sub-category**	**Preservation**	**Port of off loading**	**Transport**	**Institution address**	**Contact person**	**Colli** (number, kg, volume)	**Quantity** (bottles, bags)	**Label**	**Responsible for packing**
Various fish for species course		frozen	Walvis Bay	ship	IMR, Norway	Rupert W.				Sarah
Empty helium bottles			Cape Town	Ship/car	Supplier in Namibia	Thomas Toniazzo				Thomas

ANNEX X. DAY-TO-DAY OPERATIONS OF THE ATMPSPHERIC SOUNDINGS

Ground check and data processing set

The Vaisala sounding system was obtained complete with a GC25 sonde initialisation and conditioning unit and with a digital data processing PC running the DIGICora III software. The conditioning unit determines sounding coefficients, connection information including UHF frequencies, sonde initialisation, and a reference ground measurement to check sonde performance against. Operation of this system was consistently within expected parameters. The only point of attention regards the drying silica beads that need to be exchanged periodically to ensure a reliable ground check.

Data processing with DIGICora was generally reliable, except for two program crashes that initially appeared to imply complete data loss. Fortunately however the sounding data could be recovered with the assistance of the Vaisala support team. The system appeared to become unreliable if left running long after the sounding had finished, so the measure was taken to monitor progress and stop the program as soon as data acquisition automatically terminated; or else to force a manual stop once a sufficient balloon altitude was reached. The cause(s) of these isolated crashes could not be understood; unsupervised human interference with the system during operation cannot be excluded.

Telemetry and telecommunication

The sounding system relies on both UHF and GPS data links to maintain communications between the ground station and the sonde; additionally both GPS links between ground station and satelite, and between sonde and satellite must be maintained with a minimum of four overlapping satellites on a well-defined geome (i.e. they must be non-aligned).

Both data links proved vulnerable to fouling through dust, sea-salt, and condensation of the antennas and their cable connections. The initial set-up suggested by Vaisala and by FFI (the original owner of the system) proved totally inadequate in this respect. All connections had to be reinforced, secured, and robustly insulated against the weather, and they had to be periodically checked, cleaned and refitted. This point was learned by experience when the signal strength was seen to weaken or fail. The GPS link proved the most fragile, and unfortunately signal loss resulted in the complete lack of wind data in two soundings. In addition to regular inspection of the GPS antenna and cables, the measure was taken of expressly testing each sonde for GPS signal before release., by “walking” it around the open deck of ship while monitoring the data acquisition system. This was somewhat difficult to do by a single operator, especially in bad weather conditions.

UHF antenna gain and exposure also proved a critical aspect of the telecommunication rigging. The RM21 adirectional azimuthal antenna relies on the RAA20 pre-amplifier to produce sufficient signal strength for the Sounding Processing Station (SPS). Corrosion inside the RAA20 was identified as a problem, upon removal of which signal strength improved. However, large metallic elements of the ship structure, such as the forecastle and the housing

of the ship's radar system, proved insurmountable obstacles to reception on the ~75cm wavelength band of the sonde's UHF communication system. Again through trial and error, it was found that the only well-exposed, accessible situation for the RM21 antenna and the RAA20 unit is the railing to the side of the crow's nest. The latter proves no obstacle to line-of-sight reception, and only occasionally is the shielding of the upper radar system in the way. The cabling was re-rigged and connected to an external electronic box where the SPS was placed; the latter was connected to the data processing PC via the vessel's ethernet link.

Balloon release and ascents

The smallest available balloon size (200g) was chosen in order to minimize steric encumbrance on ship areas and the amount of Helium required. This choice proved to be critical in order to be able to execute balloon inflation and release from the R/V *Dr Fridtjof Nansen*, due to the lack of suitable spaces anywhere on the ship. Standard balloon sizes (320g) as normally shipped by vendors would result in complete inoperability on-board this vessel.

Inflation volume between 200-250PSI resulted in balloon ascent rates between 2-4 m/s and bursting altitudes between 20-27km. Higher volumes provide more lift and result in higher ascent rates and lower bursting altitudes; they were required under strong winds in order to overcome air turbulence in the initial phase of the flight after release.

The absence on the R/V *Dr Fridtjof Nansen* of a clear area open to the sky from which to execute the launch (e.g. typically the fan-tail on oceanographic research vessels) meant both limits on available trajectories and unusually strong ship-induced turbulence (especially in case of high wind) whose consequences on initial balloon trajectory had to be learned by experience. This unfortunately cost three sondes in failed launches as the balloon either failed to clear the ship structure, or the atmospheric boundary layer, or was subject to such violent accelerations while emerging from the ship's wake that the sonde was damaged. Close liason with the bridge ahead of launch to adjust the vessels speed and attitude with respect to the wind proved absolutely crucial in order to be able to execute safe launches. This also was learned in a trial-and-error process, including the necessity to firmly require cooperation from and patiently await coordination with the bridge before release. In particular during high-wind conditions, the only way to achieve a safe release is for the ship to slow down to 3 knots and execute a 360-dgreee loop to starboard. The meteorologist must stand ready with the ballon and the sonde attached (stopper on) on the starboard side of the second deck to the stern of the forecastle, and monitor the wind on deck during the manoevre. The best release is achieved at the point when ship-wake turbulence from the forecastle subsides and the wind starts blowing directly from port to starboard across the deck.

Operational planning

The ability to satisfy all of the requirements and aspirations set for the atmospheric sounding campaign was hampered by a limited provision of sondes, determined by limited funding at the time of purchase. A total of 56 sondes was procured, to be used over a total of 30 days at sea. This fell short of the desirable amount necessary for regular temporal sampling at

synoptic times plus opportunity-driven ascents. The meteorologist therefore had to decide in advance on a flexible sounding schedule based on present and future ship location, and present and forecast weather conditions, to maximise the information likely gained. This was no easy task, and was further complicated by the evolving sailing schedule of the vessel.

The sounding were carried out over two legs of the cruise, which were rather different in planning and execution. The first leg was essentially a repeat transect along the 23 degree line of latitude off Walvis Bay, Namibia; the second leg was a continuous coastal survey between Walvis Bay and HondeklipBaai, South Africa. Both were primarily aimed at the characterisation and stock-taking of fisheries. The first leg was mainly carried out according to a planned schedule, with adaptations as required by circumsances; the second leg was strongly affected by trawling opportunities based on ecosounding data. This made the future location of the vessel unpredictable even on a 12-hour horizont.

Communication between the cruise leader and the meteorologist regarding the cruising plan, its alterations, and the atmospheric sounding requirements was also markedly better during the first leg, with in particular the cruise leader proactively informing the meteorologist of sailing plan alterations or prospective difficulties such as activities on the ship during launch time that could affect launching operations.

By contrast, meteorological obervations were in no way integrated or even taken into consideration for the contingent sailing plans during the second leg. As a result, the meteorologist faced continuous uncertainty with regard to the opportunity and possibility of performing a sounding at a given time even just 12 or 6 hours ahead. It resulted in a need to be almost continuously on alert to changing ship prospective location and operations, and in having to “ask around” in order to try and obtain the required information. This was exhausting and of limited effectiveness.

Clearly meteorological observations are more easily integrated in oceanographic cruises compared with fisheries surveys, or in cruises that focus on a given geographical location. However, in every case it remains essential that any balloon operations be integrated in the day-to-day operational planning of the ship, and not left as an afterthought to be dealt with as a secondary issue as was done during leg 3.4 of the 2017 survey with the R/V *Dr Fridtjof Nansen*.