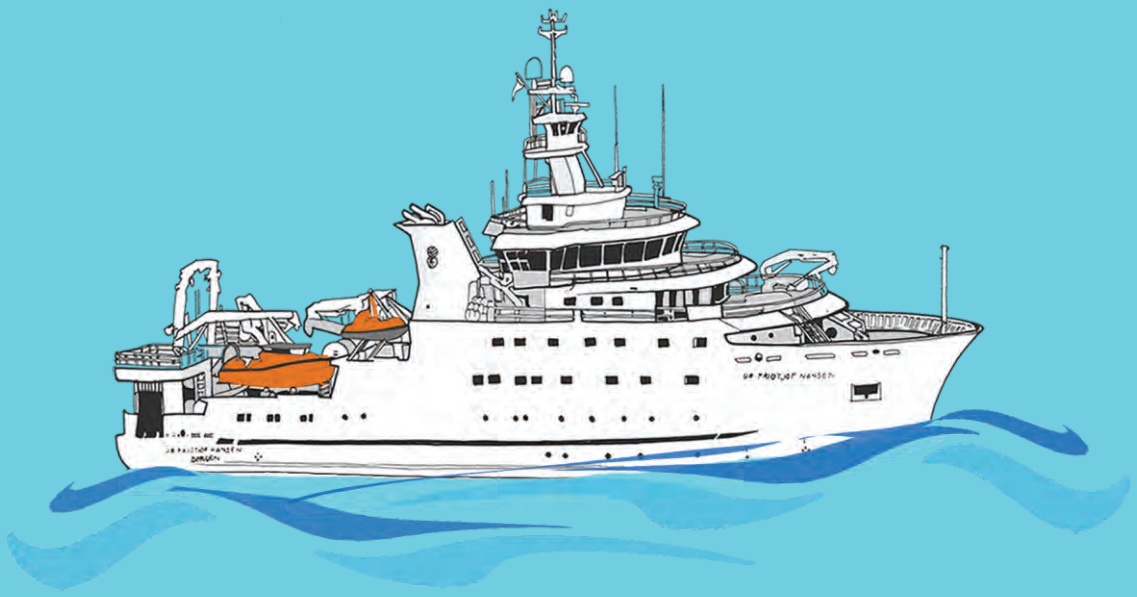
NORAD-FAO PROGRAMME
GCP/GLO/690/NOR

CRUISE REPORTS *DR FRIDTJOF NANSEN*
EAF-Nansen/CR/2017/10



SURVEY OF THE PELAGIC FISH RESOURCES AND ECOSYSTEM OFF WEST AFRICA

South Africa

12 – 17 December 2017

DAFF, South Africa

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.

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CRUISE REPORTS *DR FRIDTJOF NANSEN*

SURVEY OF THE PELAGIC FISH RESOURCES AND ECOSYSTEM OFF WEST AFRICA

South Africa

12 – 17 December 2017

by

Kathrine Michalsen[1], Magne Olsen[1] , Ines D. Bernardes[1], Sarah Ann Bruck[1] and Fannie Shabangu[2]

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Institute of Marine Research
Bergen, 2020

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EXECUTIVE SUMMARY

This survey was part of a regional coverage of the pelagic resources and ecosystems of the southwest coast of Africa, from Gabon to South Africa. These surveys aim at providing synoptic coverages of the main pelagic resources in the region, providing an opportunity to study various aspects of population abundance and biology for the main species. At the same time, these surveys are multidisciplinary 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.

Unfortunately, limited time and poor weather undermined South Africa's part of this regional survey and only a few transects could be performed. Therefore this report provides a short summary of the work done but results are very limited.

CHAPTER 1. INTRODUCTION

1.1 Survey objectives

Hydrography:

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

Phytoplankton, zooplankton and 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 capensis, 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* and *E. whiteheadi;*
- To obtain information on maturity stages, and to collect stomach samples for analysis of contents and otoliths of *Sardinops sagax* and *Trachurus capensis.*

Mesopelagic fish:

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

Marine debris and microplastics:

- To record occurrence of marine debris (surface);
- To map occurrence of microplastics and describe associated neuston communities.

Food safety and nutrition:

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

1.2 Participation

Institute of Marine Research (IMR), Bergen, Norway:

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:

Leikny Fjeldstad

Instituto Nacional de Investigação Pesqueira (INIP), Angola:

Amaro, Aristoteles Patrice da Silva

National Marine Information and Research Centre (NatMIRC), Namibia:

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

Department of Agriculture, Forestry and Fisheries (DAFF), South Africa:

Fannie Shabangu, Nandipha Mhlongo, Onele Mahlathi, Yonela Geja, Mzwamadoda Philips.

Department of Environmental Affairs (DEA), South Africa:

Delphine Thibault, Steven McCue

1.3 Narrative

The survey off South Africa was conducted as part of leg 3.4 that started (in Walvis Bay (Namibia) to Kleinse (South Africa). Namibia's southern region was completed on the evening of 12 December. The vessel then continued the survey in South African waters. The survey was completed on 17 of December, when the vessel arrived in the port of Cape Town.

The design of the survey and the sampling followed the agreed design described in the sailing orders. The west coast of South Africa was surveyed from the border of Namibia (28° S) to 30° S in South Africa, this region was surveyed from 12th to 16th of December 2017.

Because of limited time available the survey only covered the northern portion of South Africa West coast.

1.4 Survey effort

Table 1 summarizes the survey effort by regions and Figure 1 shows the cruise tracks with fishing, plankton and hydrographic stations, respectively, for the west coast of South Africa.

Table 1. Survey effort during the survey. The columns show Distance - distance surveyed (log, NM), and number of samples taken of CTD, Phyto - phytoplankton nets, WP-2 – zooplankton nets, Multi – net for sampling eggs and larvae, Manta – net for sampling plastic particles in the surface, BT-bottom trawl, and PT- Pelagic trawl hauls.

Region name	Region description	Distance nm	CTD no	Phyto no	WP-2 No	Multi no	Manta No	BT no	PT no
South Africa	28-30 ^{o}S	485.58	16	3	5	3	3	1	3

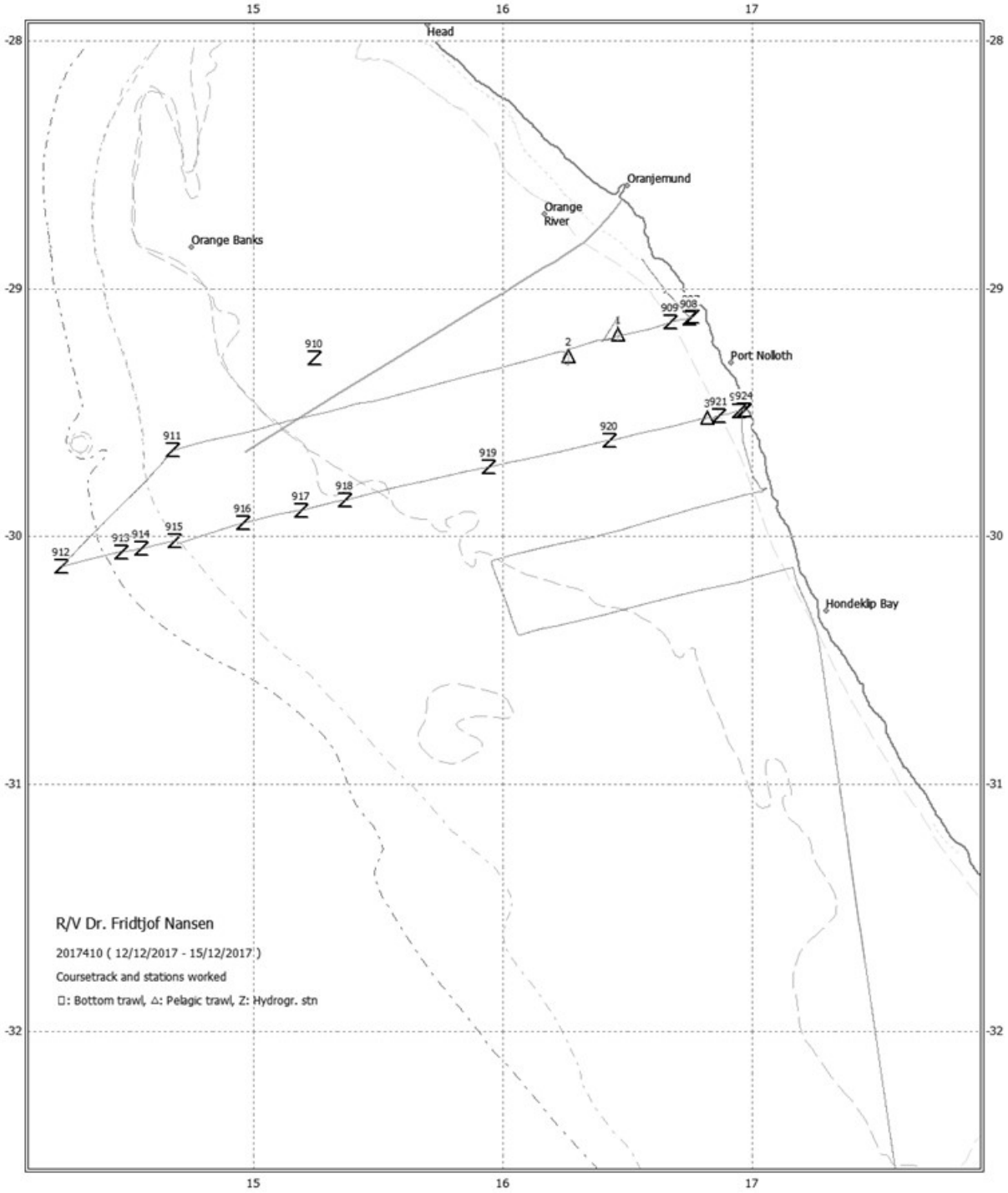

Figure 1. Course track with trawl stations and hydrographical and plankton stations in northwestern part of South-Africa (Orangiemund- Kleinse). Depth contours at 50, 100, 200, and 500 m.

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 averaged every 60 sec.

2.1.2 Thermosalinograph

The SBE 21 Seacat thermosalinograph ran continuously during the survey, obtaining samples of sea surface (at 4 m depth) recording 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 (VMADCP) from RD Instruments is mounted onboard.The system runs in narrow band mode and data are averaged in 16 and 4 m vertical bins at 75 and 150 kHz respectively and stored on files for post survey processing. On this survey, the he 150 kHz was run continuously while the 75 kHz was turned off during the last part of the survey 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 limited in practice to 1000 - 1500 m on the research vessel (R/V) *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 to 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 station sampling

Biological and oceanographic sampling was undertaken on one transect only. Samples were taken at the inshore end of the acoustic transects, at a water depth of between 25 and 30 m, 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 2.

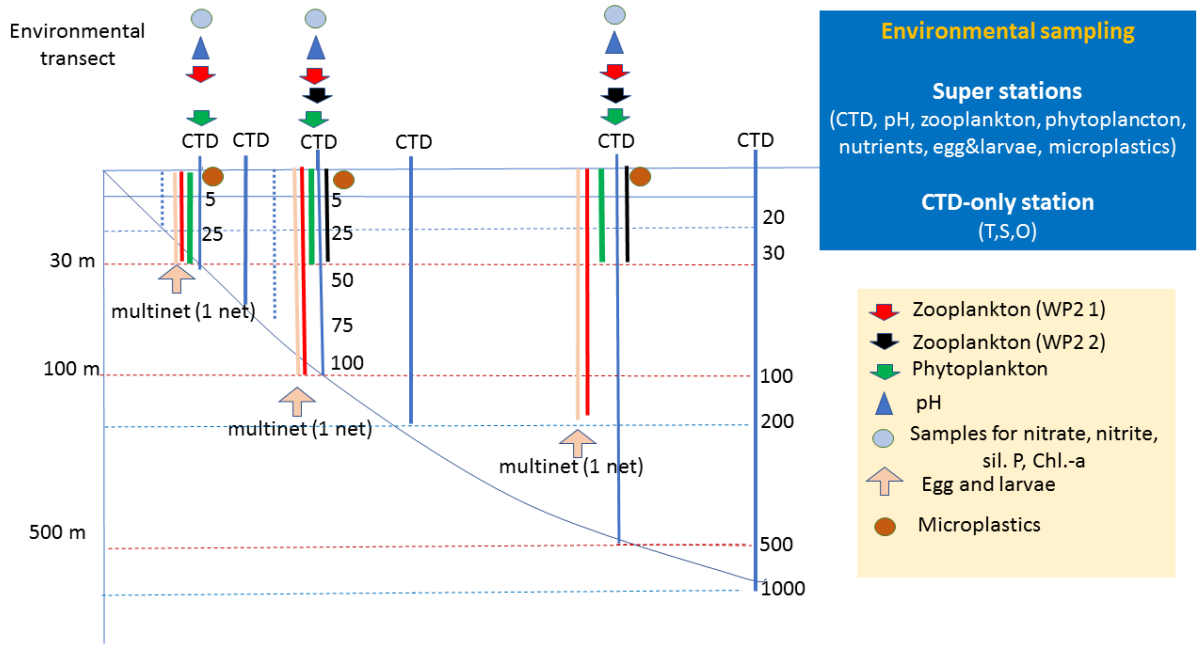

Figure 2. Sampling diagram showing the depth and the equipment used at the super stations transects, from the inshore (left side) towards the deep 500 m stations (right side).

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}).

The South African part of this survey was a short four day survey and only one CTD transect could be sampled. Water samples for sensor validation were not collected in South Africa and the data presented below are from the Namibian part of the survey coverage.

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 3 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 4). Any verified offsets with the sensor data are corrected at the Institute of Marine Research.

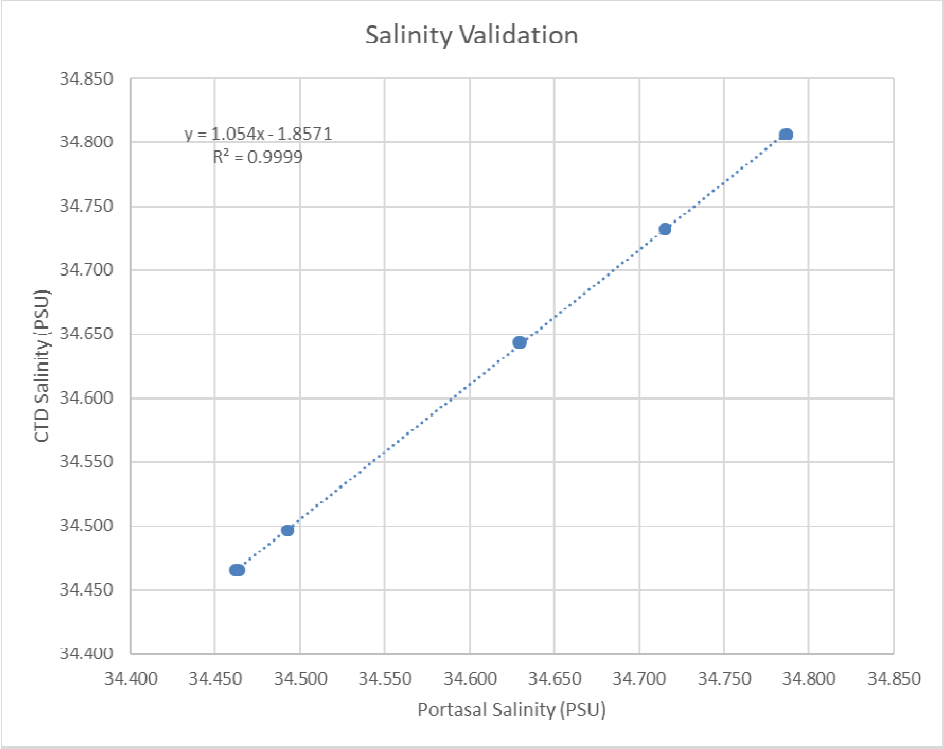

Figure 3. Portasal salinity values compared to CTD salinity values. 6 total samples from stations 878 and 900 (previous leg).

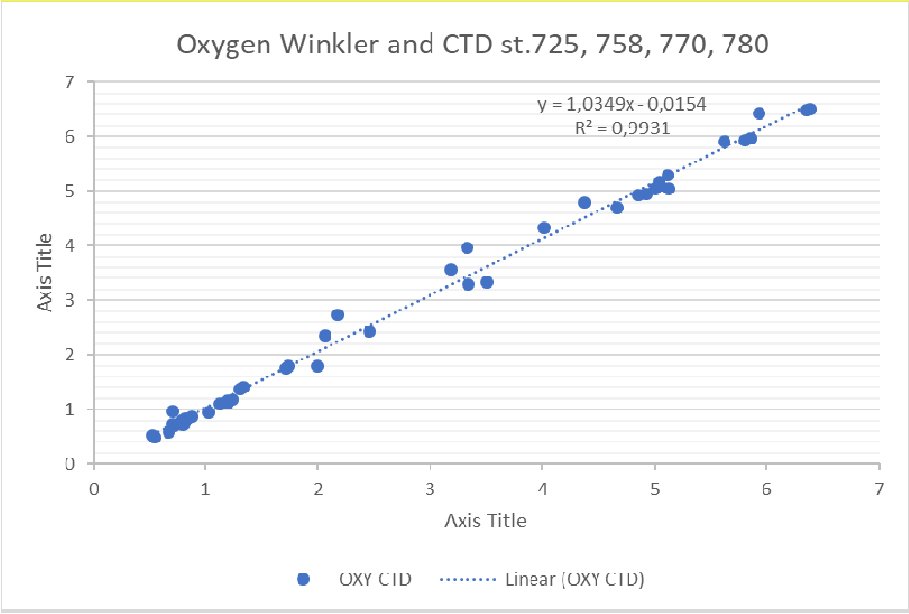

Figure 4. Measured oxygen concentrations plotted against the result from the CTD sensor (47 samples, previous Leg).

2.3.2 Ocean acidification parameters (pH and alkalinity)

The 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' depth. 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 spectrophotometrically using a diode array spectrophotometer and a pH sensitive indicator, m-cresol purple in 2 mM solution, as described by Clayton and Byrne, 1993; 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 on land at IMR and will provide more information on the marine carbonate system and parameters for ocean acidification.

2.3.3 Nutrient samples

Seawater samples (20 mL) for nutrient analysis (nitrate, nitrite, silicate and phosphate) were collected from the Niskin water-bottles. The seawater samples were preserved with 0.2 mL chloroform in 20 mL polyethylene vials, conserved with, and kept cool and in the dark in a refrigerator (Hagebø and Rey, 1984). The analysis will be made on shore by IMR, using a modified Alpkem AutoAnalyzer C (O I Analytical, USA) and following standard procedures (Strickland and Parsons, 1972). Extra standards were added during the analysis to cover the whole measurement range. During the laboratory's quality control of the data, some outliers that were obviously wrong were excluded. The quality control included evaluation of the ratios between the different nutrients.

2.4 Atmospheric soundings

Atmospheric soundings were performed by means of instrumented meteorological balloon launches. The instrumentation consists in 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 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 campaing 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 utlimately drive 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.

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 m). The water was filtered on 0.7µm filters (Munktell glass-fibre filters Grade: MGF) under a 200 mm Hg vacuum). The samples will be transported to IMR, which is an accredited laboratory, for subsequent analysis. The assay is performed by extraction with 90% acetone followed by centrifugation, and analysed with 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.

Net phytoplankton samples (35 cm diameter, 10 µm mesh-size) were also collected at the super-stations, 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 semi-quantitative as no flowmeter was mounted on the net, but used to establish the taxonomic composition of the phytoplankton community.

2.6 Zooplankton sampling

Mesozooplankton was collected with a WP2-net at the super-stations (30 m, 100 m and 500 m bottom depth). The WP2-net (56 cm diameter, 180 µm mesh size) was hauled vertically at a speed of ~0.5 ms^{-1} at each station. At the shallowest and intermediately deep stations (30 m and 100 m bottom-depths , 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 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 transferred onto preweighed and numbered aluminium trays and dried at ~60 ºC for 24 h. After 24h, the samples were frozen until further analysis. These samples will be processed at the IMR, where they will be dried once more and weighed for estimation of biomasses for the different size-groups. The second part of the sample was preserved in a borax buffered seawater/formaldehyde solution (final concentration 4%) 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 at a speed of ~1.5 m s^{-1}, the vessel moving at a speed of ~2 knots.

All fish larvae visible to the naked eye were removed from the total sample, photographed and transferred to vials. The fish larvae were then preserved in a borax buffered seawater/formaldehyde solution. Whilst the rest of the sample was preserved for reference purposes and to check for any overlooked larvae.

The fish eggs will be sorted and the larvae identified at the IMR after the cruise.

2.8 Microplastics and debris

Microplastics are normally defined as small pieces of plastic marine debris smaller than 5 mm. Microplastics were collected along the hydrographic transect at all super-stations At each station, the surface layer was sampled with 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 m s^{-1} for 15 minutes. The counts of 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 under 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 a freezer (-18 °C) 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.

2.9 Food safety

Whole fish, fillet and different organs from various fish that are regularly consumed in South Africa were sampled and preserved during this survey. All the samples will be analysed for a wide variety of nutrients and contaminants (see section 3.7) at the IMR laboratory in Bergen, Norway. Additionally, tissue samples from mackerel will be analysed for the parasite Kudoa, while some of the samples will 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 presence of microplastic particles.

2.10 Top predator observations

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 300 m 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. Following birds were not recorded.

2.11 Biological trawl sampling

Biological sampling of the 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. Species identification was based on the FAO Species Guides. 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 length measured. 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 down, since it seemed less cumbersome and time consuming to do this onland in well equipped labs.

The target groups used for this survey can be found in Table 2, 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.

2.11.1 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 – 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 predifined 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 occurances only presence was noted.

2.12 Acoustic sampling

2.12.1 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 deg operation mode with the bearing of the vertical beams 90 deg, 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 deg. 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.

2.12.2 Echo sounder

Acoustic data were recorded using a Simrad EK80 Scientific Split Beam Echo Sounder equipped with keel-mounted transducers at nominal operating frequencies of 18, 38, 70, 120, 200 and 333 kHz. The sounders were calibrated in Bergen on the 23rd January, 2017. Annex I gives the details of the acoustic settings used during the survey.

2.12.3 Allocation of acoustic energy to species group

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

Scatters were displayed 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 2. 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 2), 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 an 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 consentrations, while -70 dB was used for more

dispersed layers. Biomas estimates can only be estimated for those acoustic groups in which length and weight were recorded (see Table 2).

Table 2. Species groups used for allocation of acoustic densities.

Group	Taxon	Species
Sardinella	*Sardinella* sp.	*S. aurita* *S. maderensis*
Pilchard		*Sardinops ocellatus*
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]	*Decapterus rhonchus* *Seriola carpenteri*
	Other Scombridae	*Auxis thazard* *Sarda sarda*
	Others	*Trichiurus lepturus* *Lepidopus caudatus*
Demersal species	Sparidae	*Dentex macrophthalmus*
	Merlucciidae	*Merluccssius capensis* *M. paradoxus*
Mesopelagic species	Myctophidae[3]	*Diaphus dumerili* *Maurolicus muelleri*
	Other mesopelagic fish	*Trachinocephalus myops*
Plankton	Calanoidae	*Calanus* sp.
	Euphausiidae	*Meganyctiphanes* sp.
	Other plankton	
Jellyfish		*Chrysaora fulgia* *Aequorea forskala*

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

2.12.4 Estimation of biomass

Biomass could not be estimated given the limited duration/geographic range of the survey.

CHAPTER 3. 3. RESULTS - OCEANOGRAPHY

3.1 Underway sampling

To present the environmenatal data we first show the results of the contious sampling aboard the ship and then we present the hydrographic data from the CTD. The weather station was not working properly so we do not present data for atmospheric conditions as incoming solar radiation and wind vectors. The survey off South Africa was conducted as second section of leg 3.4.

3.1.1 Thermosalinograph

In South-Africa, the near surface water is colder and less salt. 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.

3.2 Monitoring line

Hydrographic variables were measured at on of the standard monitoring lines of South-Africa (Figure 5). An overview of the data collected is given in Table 3.

Table 3. Overview of the number of samples collected on water chemistry in South Africa.

Country	No. of sampling stations	No. of nutrients samples	No. of pH/ Alk samples	No. of Chl.A samples	No. of Oxygen samples	No. of salinity samples
South-Africa	15	85	85	73	11	7

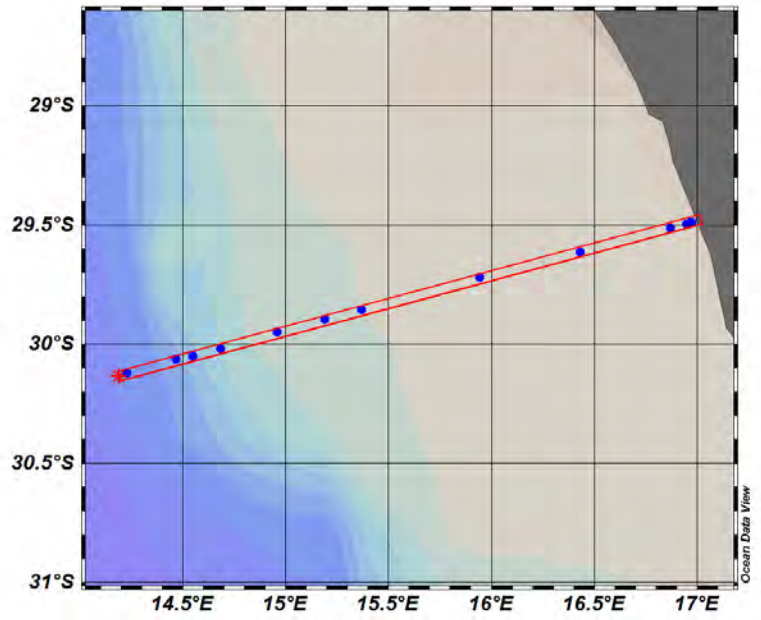

Figure 5. Positions of the CTD stations in waters off South-Africa. Hydrographic transects with superstations used to produced vertical profiles for salinity, temperature, oxygen, PAR and fluorescence. CTD stations no. 588-, in total 86.

3.2.1 Temperature

Warmest water was found in the upper layer across the whole section, with a slight decreasing longitudinal gradient from more than 18 ^{o}C offshore to 12 ^{o}C close to the coast, following the shoaling thermocline (Figure 6). Waters overlying the shelf were typically 8-10 ^{o}C below the thermocline. Deeper waters beyond the shelf break were 5-7 ^{o}C, reaching lowest temperatures at around 1500 m depth offshore.

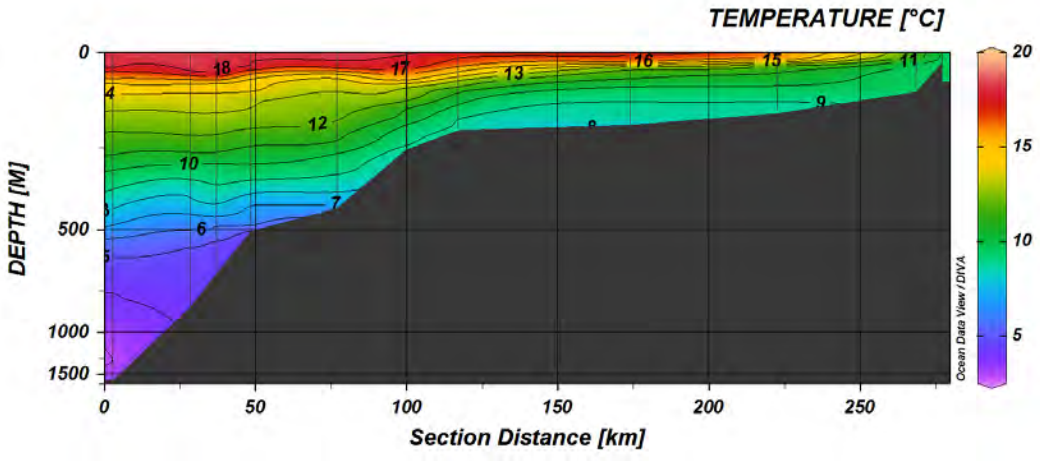

Figure 6. Temperature vertical profile based on the CTD data.

3.2.2 Salinity

A salinity maximum of 35.4 is observed in the upper 100 m towards the offshore end of the section (Figure 7). Beneath a broad layer of salinity ~ 34.8 is found and flowed onto the shelf to 300-500 m depth. A band of relatively fresh water of 34.4 was found offshore between 500-1000 m depth and then salinity slightly incraesed in the deepest layers.

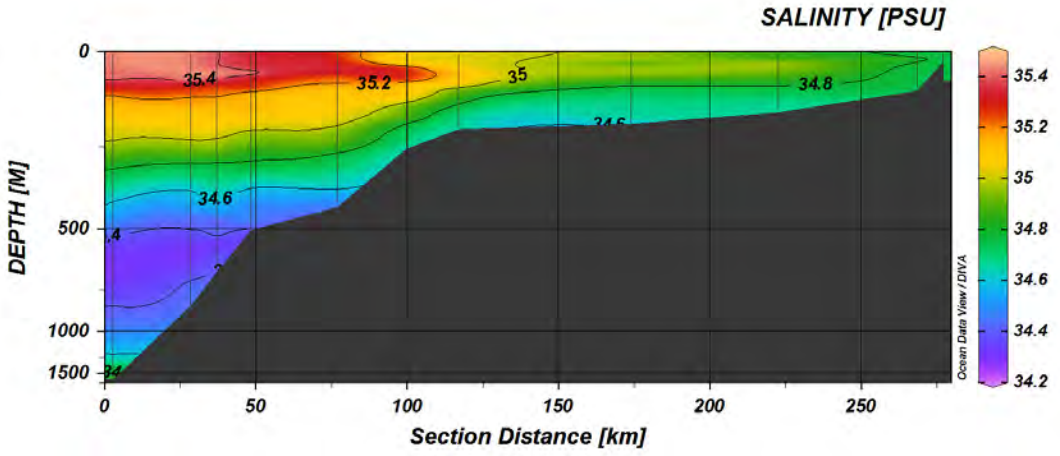

Figure 7. Salinity vertical profile based on the CTD data.

3.2.3 Oxygen

The distribution of dissolved oxgen along the South African transect showed high values around 7 mL L^{-1} in the upper 50 m, and then decreasing to 4-5 mL L^{-1} throughout the rest of the water column (Figure 8). An exception was at the coastal end of the section where oxygen levels reached near depletion over the shelf in the shallow water column.

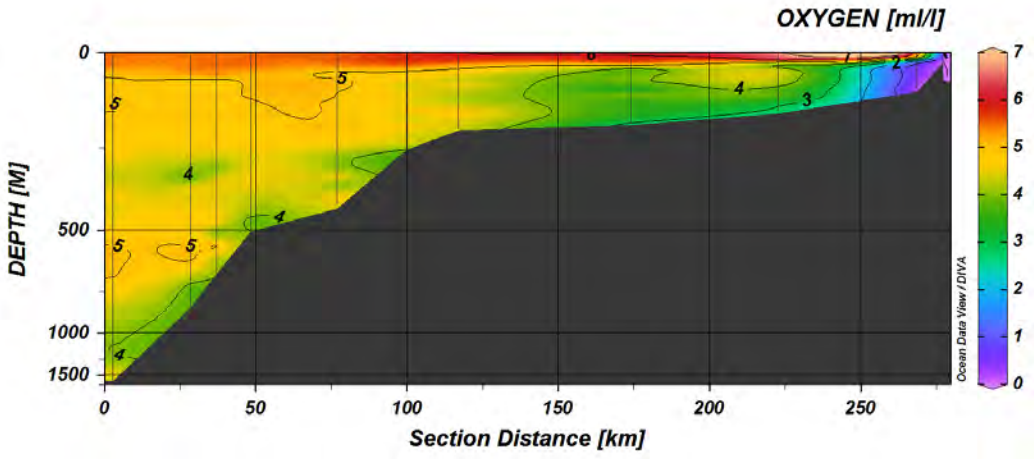

Figure 8. Oxygen vertical profile based on the CTD data.

3.2.4 Fluorescence

The fluorescence along the South African transect showed elevated values in the upper 50 m, with a patch of high fluorescence over the shallow shelf water close to the coast (Figure 9).

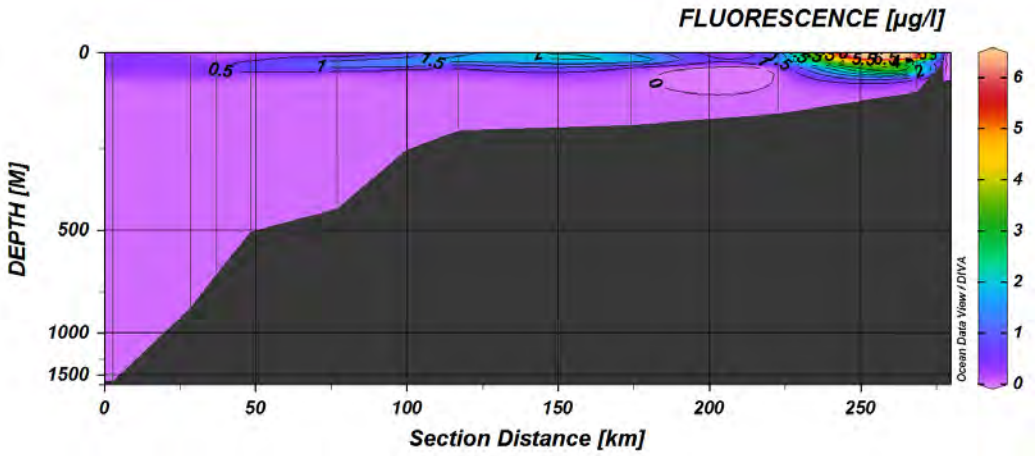

Figure 9. Fluorescence vertical profile based on the CTD data.

3.3 Atmospheric soundings

Figure 10 and the Table 4 give an overview of the atmospheric soundings performed in Southern Namibia and South Africa. Figure 10 shows the location of all at least partially successful soundings, together with their validity time of day. Table 4 indicates 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.

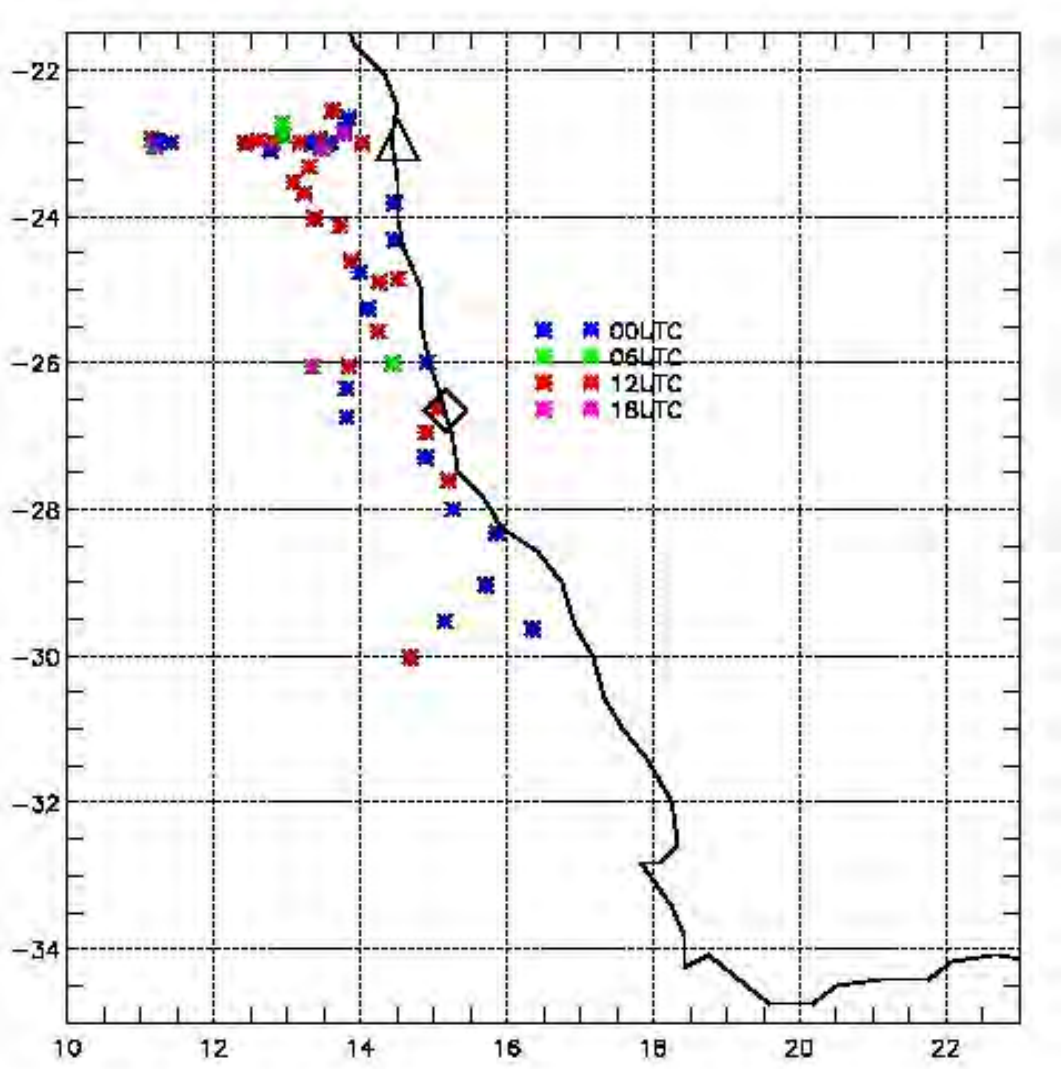

Figure 10. An overview of the atmospheric soundings performed during the cruise. The Figure shows the location of all at least partially successful soundings, together with their validity time of day.

Table 4. Shows the 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 results are shown in Figure 11 (panels (b1)-(b3)) together with the 14UTC sounding (panels (a1)-(a3)). 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.

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 abouth 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.

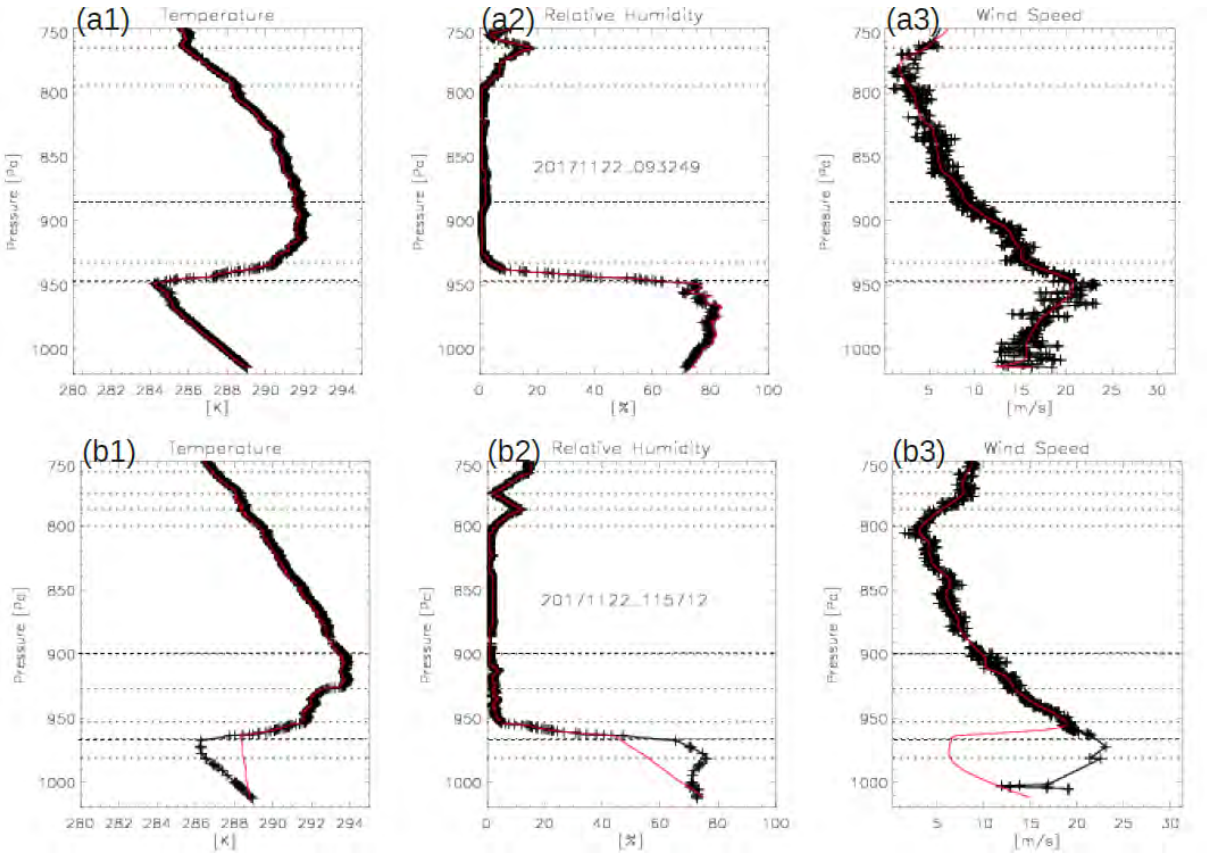

Figure 11. Results from each of the atmospheric soundings taken during the cruise.

3.4 Phyto and zooplankton samples

A total of 11 zooplankton samples for taxonomic analysis were sampled on the South-African shelf alomg the Kleinsee transect (Table 5).

Table 5. Number of samples of phyto- and zooplankton collected.

Country	**Phytoplankton**	**Zooplankton from 200 m**		**Zooplankton from 25 m**	
	Formalin	Formalin	Dried	Formalin	Dried
South-Africa northwest	3	5	7	3	4

3.5 Fish eggs and fish larvae

In South-africa the multinet was deployed only 3 times as 1 transects of super-station was done. None of the stations contained fish larvae.

There was not enough time to fully identify all the fish eggs or fish larvae to species level. The samples were preserved in formalin for further investigation onshore.

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 identities, and trophic relationships of pelagic fish.

For this scope, special effort was to be carried out to collect biological parameters of eight target species: *Trachurus trecae, Trachurus capensis, Sardinella aurita, Sardinella maderensis, Sardinops sagax, Scomber japonicus, Engraulis encrasicolus, Etrumeus whiteheadi.* The biological parameters to be collected were: lengths, weights, otoliths, fin clips, stomachs, livers and gonad maturity stages in the northern northwestern part of South-Africa. However, only three stations were trawled and very few of these species were caught, thus no biological samples were taken. Length and weights were recorded for the target species caught (Table 6).

Table 6. Total number of individuals analyzed for biological parameters in South- Africa.

Species	Length/Weight	Sex	Maturity	Stomach fulness	Liver	Fin clips	Otoliths
Etrumeus whiteheadi	100						
Aequorea forskalea	36						
Engraulis encrasicolus	100						
Trachurus capensis	66						
Sardinops sagax	7						
Total	309						

4.2 Jellyfish sampling

Only *Aequorea forskalea* was found in the trawl along the Kleinsee transect.

4.3 Distribution, size composition and biomass estimates

Given the limited survey coverage, no biomass estimate is available. A few acoustic recordings wre made, mostly from the round herring (*Etrumeus whiteheadi*), from jellyfish and from mesopelagic fish. Round herring was only found at a few stations in very small quantities.

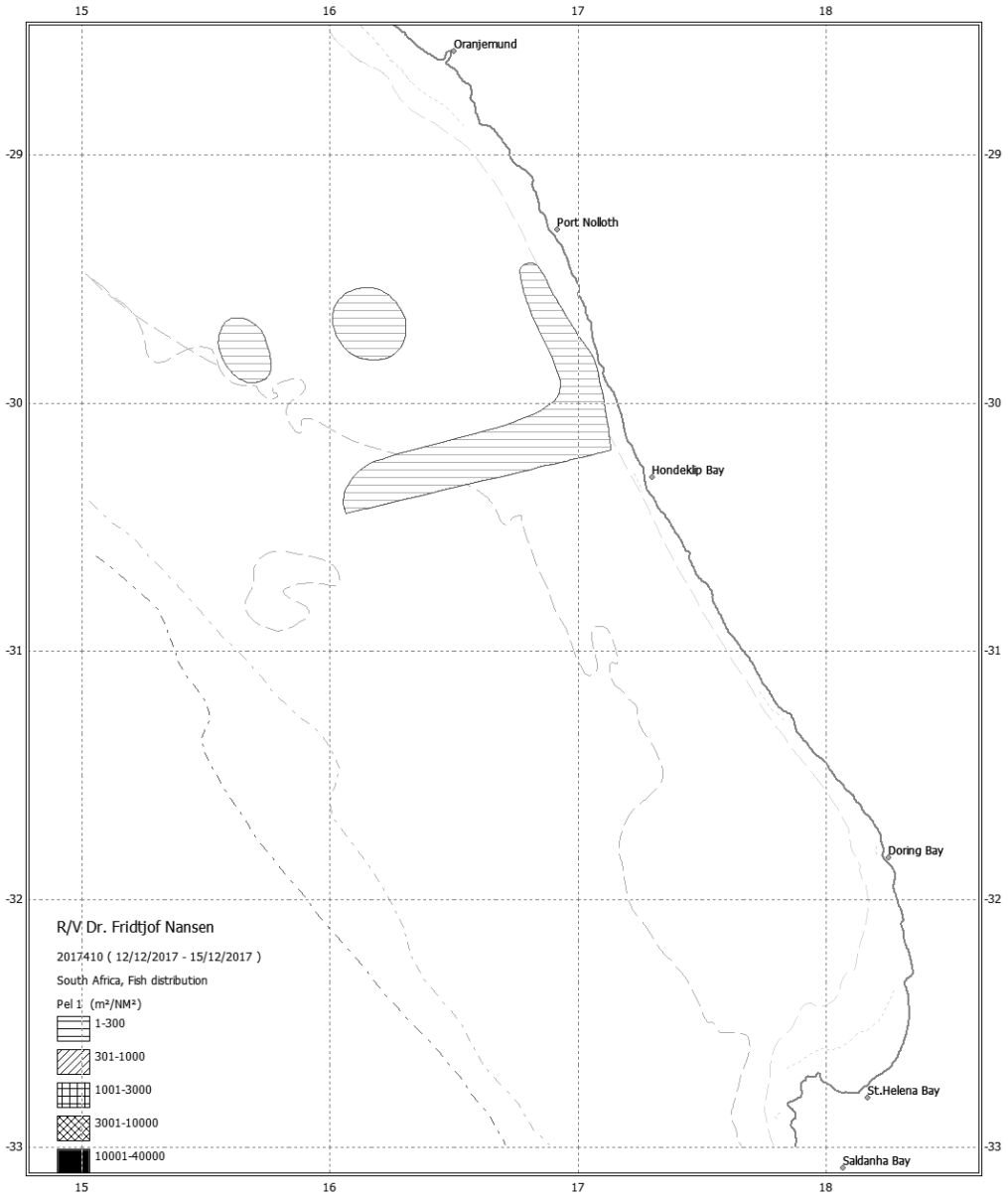

Figure 12. Distribution of P1, (Orange River-Kleinse). Depth contours at 50, 100, 200 and 500m.

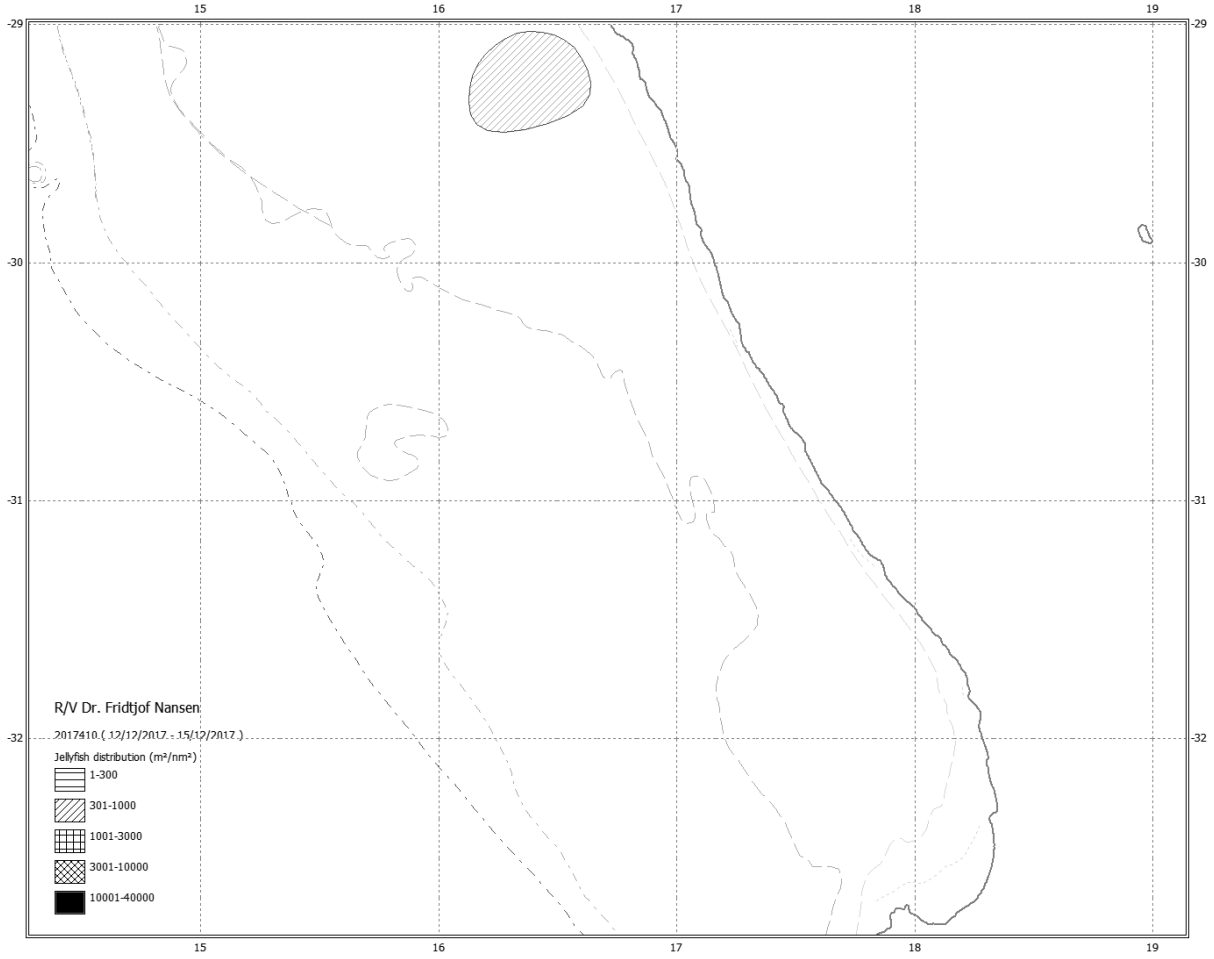

Figure 13. Distribution of jellyfish (between 21°S and 25°S). Depth contours at 50, 100, 200 and 500m.

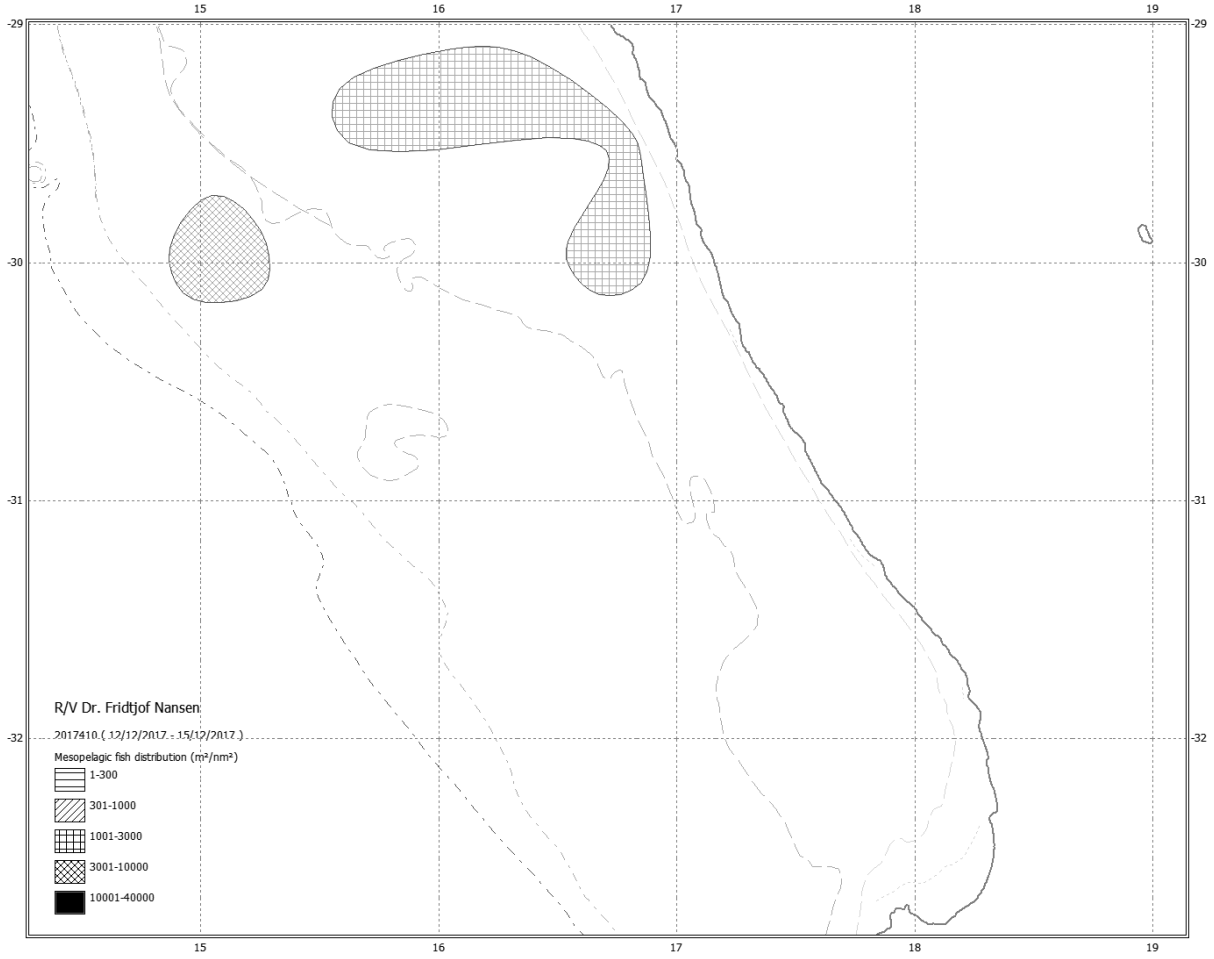

Figure 14. Distribution of mesopelagic fish (between 21°S and 25°S). Depth contours at 50, 100, 200 and 500m.

CHAPTER 5. RESULTS - MICROPLASTICS AND DEBRIS

Microplastics were sampled from the surface with a Manta Trawl Net at the 3 super-stations. The samples were preserved for further investigation onshore.

CHAPTER 6. RESULTS - FOOD SAFETY AND NUTRITION

Table 7 shows the number of samples for the different kind of analysis of fish for food safety. The analysis will be carried out at IMR laboratory. 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 7. The sampling done for analytical work for the species sampled.

					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	25 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	25 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	25 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	25 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

Three species of marine mammals were sighted in South African waters (Table 8), with southern right whales *Eubalaena australis* and Heaviside's dolphins *Cephalorhynchus heavisidii* were the most abundant (Figure 15). Sighted southern right whales displayed a relaxed surface behaviour (Figure 16). Eight seabirds species were sighted in South African waters (Table 9). Off-effort sightings included an unidentified large whale on the evening of 12/12/2017. Cape fur seals were also sighted in great numbers throughout the shelf.

Table 8. Marine mammal species observed in South African waters.

Date	Sighting no.	Latitude (S)	Longitude (E)	Species
12/12/2017	17	28° 51' 30"	16° 25' 08"	Humpback whales
12/12/2017	18	28° 59' 57"	16° 38' 52"	Southern right whales
14/12/2017	19	29° 29' 18"	16° 58' 15"	Heaviside's dolphins

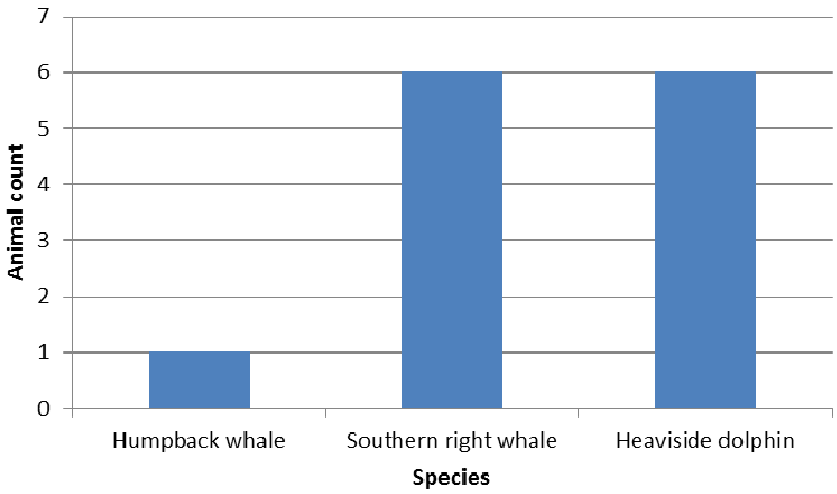

Figure 15. Number of marine mammals sighted in South African waters.

Figure 16. Two southern right whales (a) sighted off Kleinsee, South Africa, and one animal had scars from a boat propeller on the left fluke (b). Photos by Steven McCue.

Table 9. Seabird species observed in South African waters.

Species	**Animal count**
Yellow nose albatross	6
Unidentified albatross	1
Cape gannet	1
Subantarctic skua	4
White chin petrel	13
Wilson’s storm petrel	1
Kelp gull	40
Unidentified cormorant	18

CHAPTER 8. SUMMARY OF SURVEY RESULTS

Given the limited geographic scope of thi survey, biomass estimates were not attempted.

All results from this part of the survey will be meaningful when associated with a regional overview based on the data collected further north.

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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 I.1, 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.

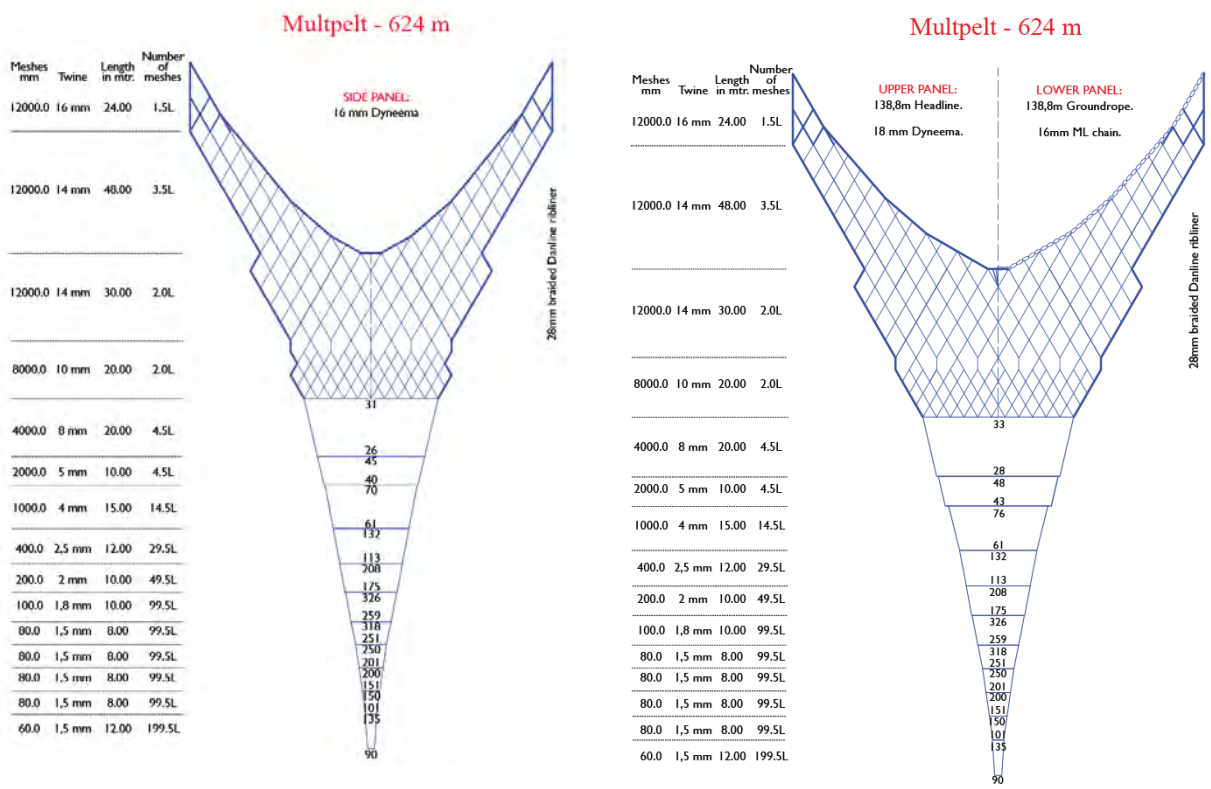
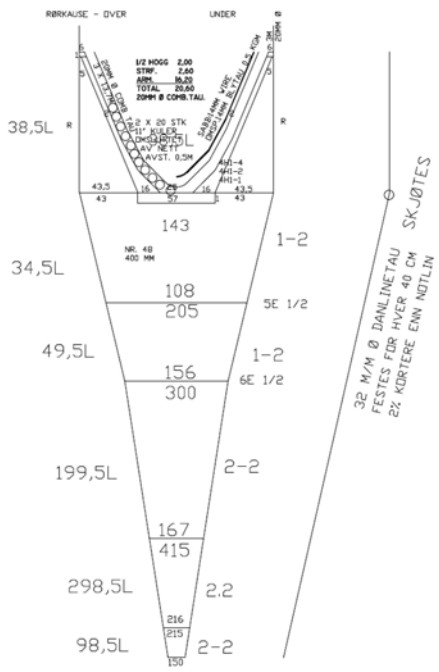


Figure I.1. Schematic drawing of the MultPelt 624.

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



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levert nov.1995
TRÅLBASER: A.AASEN OG H.O. DAHL

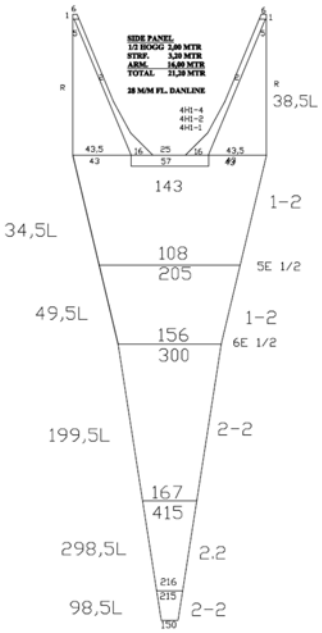


Figure I.2. Schematic drawing of the small pelagic Åkratrawl.

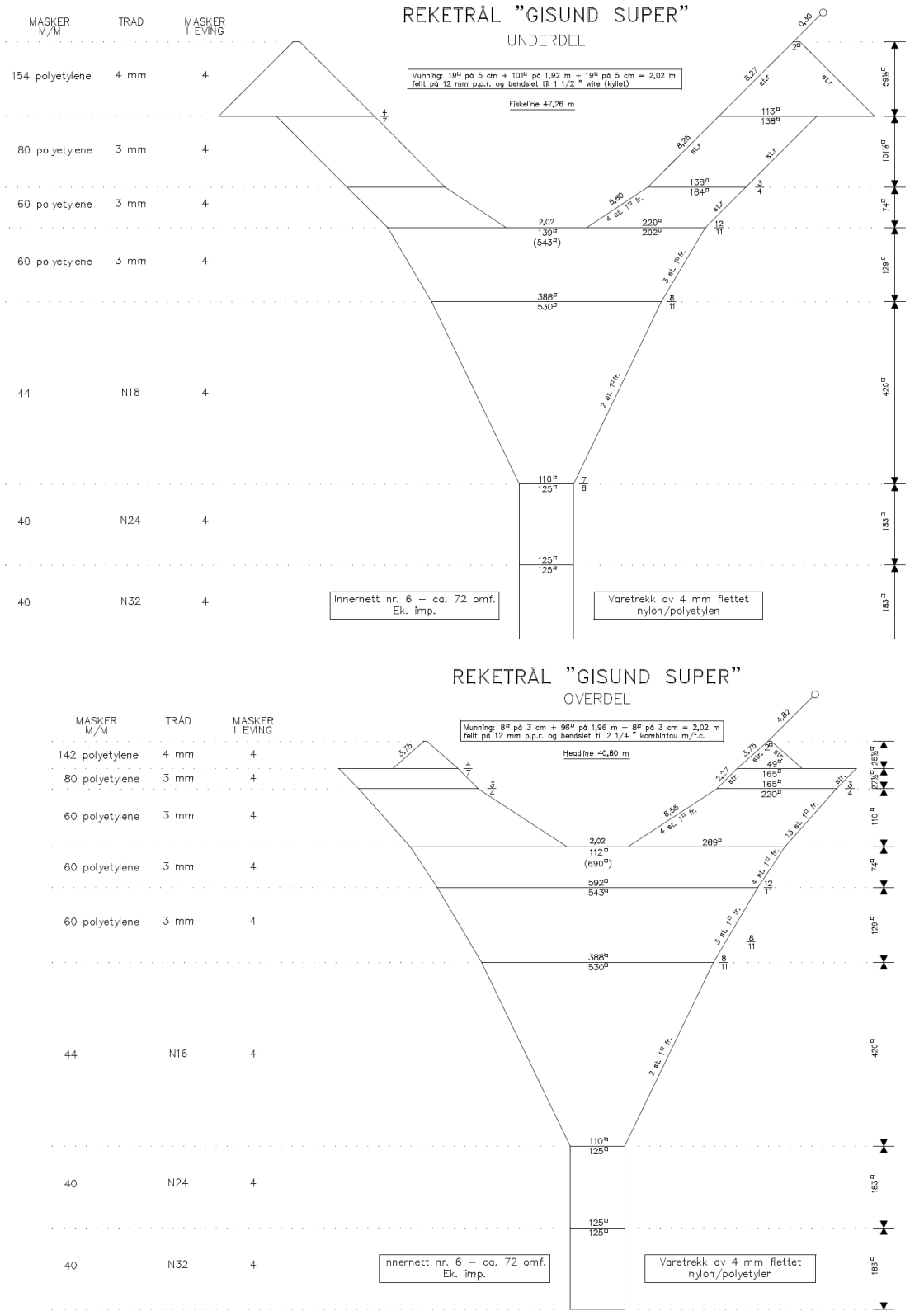


Figure I.3. Schematic drawing of the Super Gisund bottom trawl.

ANNEX II. RECORDS OF FISHING STATIONS

R/V Dr. Fridtjof Nansen SURVEY:2017410 STATION: 1
DATE :12/12/17 GEAR TYPE: PT NO: 8 POSITION:Lat S 29°11.10
start stop duration Lon E 16°27.75
TIME :12:23:13 13:09:09 45.9 (min) Purpose : 1
LOG : 800.51 803.36 2.9 Region : 6000
FDEPTH: 80 50 Gear cond.: 0
BDEPTH: 138 133 Validity : 0
Towing dir: 0° Wire out : 340 m Speed : 3.7 kn
Sorted : 44 Total catch: 400.32 Catch/hour: 522.95

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea forskalea	522.25	917	99.87	1
Todarodes angolensis	0.67	12	0.13	
Sepia australis	0.04	1	0.01	
Total	522.95		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017410 STATION: 2
DATE :12/12/17 GEAR TYPE: PT NO: 8 POSITION:Lat S 29°16.36
start stop duration Lon E 16°15.75
TIME :16:00:30 16:31:03 30.6 (min) Purpose : 1
LOG : 821.19 822.93 1.8 Region : 6000
FDEPTH: 68 70 Gear cond.: 0
BDEPTH: 158 158 Validity : 0
Towing dir: 0° Wire out : 300 m Speed : 3.4 kn
Sorted : 68 Total catch: 68.25 Catch/hour: 134.05

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea forskalea	93.15	189	69.49	2
Maurolicus muelleri	35.94	39641	26.81	3
Todarodes angolensis	4.40	10	3.28	
Ommastrephes bartrami	0.55	12	0.41	
Leptocephalus	0.00	2	0.00	
Total	134.05		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017410 STATION: 3
DATE :14/12/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 29°31.22
start stop duration Lon E 16°49.37
TIME :03:11:52 03:42:02 30.2 (min) Purpose : 1
LOG : 1091.85 1093.30 1.4 Region : 6000
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 116 109 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.4 kn
Sorted : 86 Total catch: 204.99 Catch/hour: 407.68

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea forskalea	388.00	646	95.17	4
Engraulis encrasicolus	8.40	1903	2.06	8
Pterygosquilla armata capensis	4.86	6080	1.19	
Etrumeus whiteheadi	3.21	867	0.79	6
Sepia hieronis	1.13	457	0.28	
Ommastrephes bartrami	1.09	278	0.27	
Trachurus capensis	0.70	278	0.17	7
Sardinops sagax	0.28	34	0.07	5
Total	407.68		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 50 m 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 250 m 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.

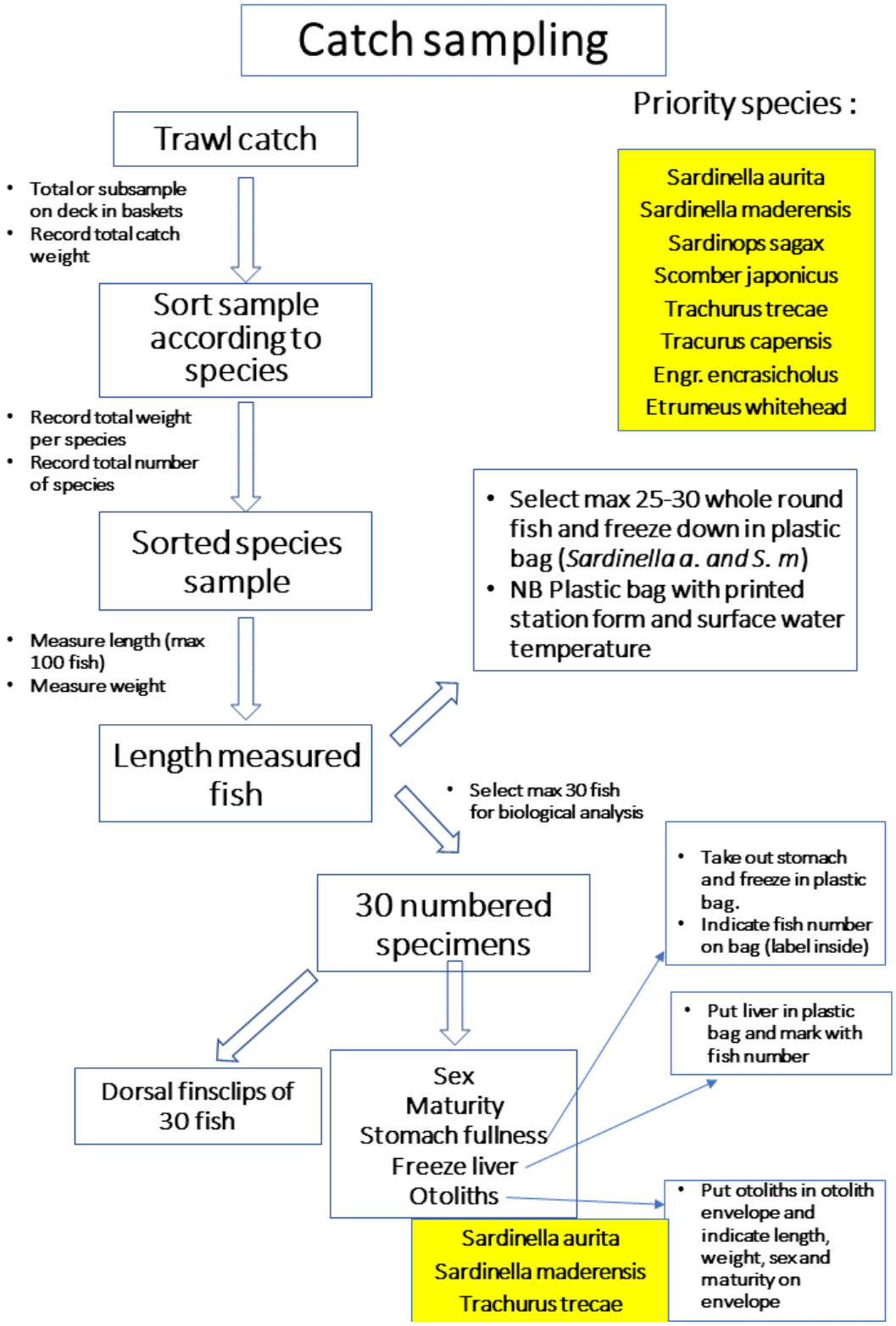
ANNEX V. LIST OF BIOLOGICAL SAMPLES COLLECTED FOR FUTURE ANALYSIS

Sample category	Sample sub-category	Preservation	Port of off loading	Transport	Institution address	Contact person	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)
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	Leevi (Namibia) Delphine (S-A)

Sample category	**Sample sub-category**	**Preservation**	**Port of off loading**	**Transport**	**Institution address**	**Contact person**	**Responsible for packing**
						Huggett (South Africa)	
Jellyfish	arm	ethanol + frozen	Cape Town		UWC	Mark Gibbons	Delphine (S-A)
	remaining	formalin	Cape Town		UWC	Mark Gibbons	Delphine (S-A)
	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 Gibbons	Delphine (S-A)
	contaminants and nutrients	homogenized and freeze dried	Cape Town	shipment	IMR/NIFES	Leikny Fjellstad	Leikny

Sample category	Sample sub-category	Preservation	Port of off loading	Transport	Institution address	Contact person	Responsible for packing
	diversity	frozen	Cape Town	shipment	IMR	Rupert Wienerot er	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/NatMi rc		Nandipha
	otoliths	dry	Walvis Bay and Cape Town	All samples from the region to NatMIR C	To NatMIRC with local participants	La-toya Shivute (chair BCC WG)	?
	whole specimens for morphometr ic analysis	frozen	Cape Town (species found in Namibia/Sou th Africa)	Walvis Bay and Cape Town	NatMIRC DAFF	Nandipha Mhlongo	Nandipha
Liver		frozen	Cape Town		?		Nandipha
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 VI. OVERVIEW OF SAMPLING PROCEDURES IN THE FISH LAB



ANNEX VII. OVERVIEW OF HYDROGRAPHICAL STATIONS

Superstations: every 6 transect, 3 stations at 30m, 100m, 500m.

1. CTD to bottom
2. Phytoplankton net to 30 m (or 25 m at inner station) - maks haul speed 0,1 m^s
3. WP2 to 25 m (inner station), 100 m or 200 m – maks haul speed 0,5 m^s
4. Also a second WP2 to 30 m at 100 m or 200 m – maks haul speed 0,5 m^s
5. Manta trawl at surface for 15 minutes - maks speed 1-1,5 m^s
6. Multinet (usually simultaneous with Manta trawl) to bottom (inner and middle stations) or 100 m (outer station) – maks speed 1,5 m^s

CTD: every 3 transect, at bottom depths (20m, 50m, 75m, 100m, 200m, 500m). In some special cases, we go deeper.