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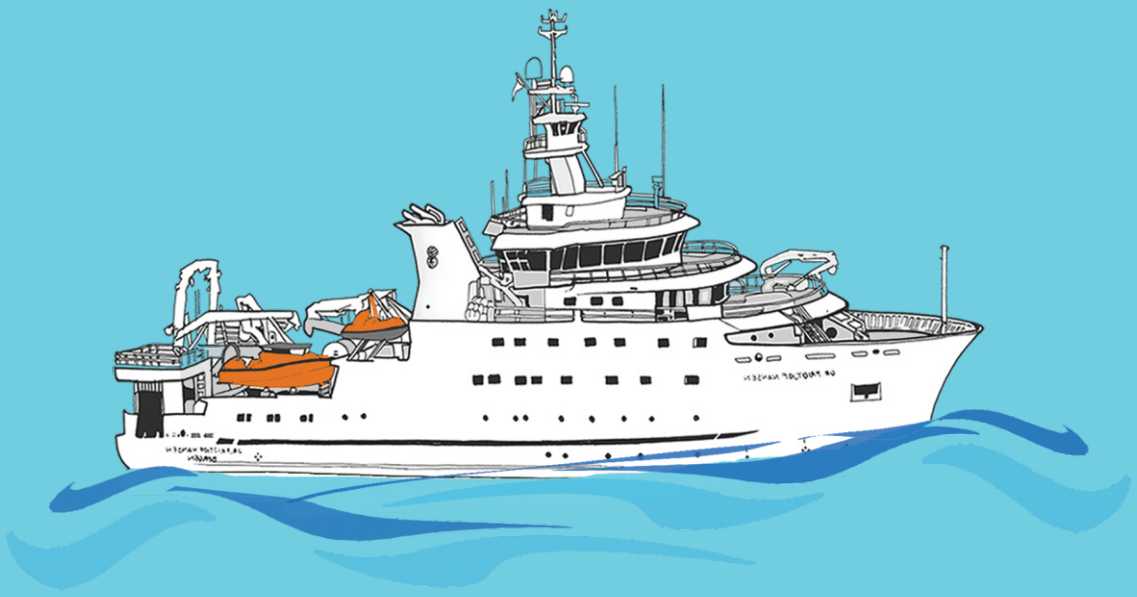
CRUISE REPORTS *DR FRIDTJOF NANSEN*
EAF-Nansen/CR/2017/7



SURVEY OF THE PELAGIC FISH RESOURCES AND ECOSYSTEM OFF WEST AFRICA

Gabon, Republic of Congo, and Democratic Republic of Congo

21 September - 1 October 2017

MAEPA, Gabon
MAEP, Republic of Congo
MPE, Democratic Republic of Congo

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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21 September - 1 October 2017

by

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Institute of Marine Research
Bergen, 2019

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EXECUTIVE SUMMARY

The regional survey on the transboundary pelagic resources and ecosystems off West Africa (Gabon, Congo and Democratic Republic of Congo) had as main objective to estimate the biomass of small pelagic species by the acoustic method as well as the state of the ecosystems within the EEZ of these countries. The specific objectives of the survey were to improve knowledge and understanding of the biology, ecology and population dynamics of major pelagic species as well as the "health status" of the marine ecosystem in the EEZs of these countries. The report describes the varioous sampling operations, the methods used and preliminary results obtained.

During the survey, 68 CTDs, 18 phyto-, 34 WP2, 22 multinet, 22 manta, 12 demersal trawl and 14 pelagic trawl hauls were completed. Catches were sampled by species, weight, height, sex and stage of sexual maturity.

The results showed the presence of small pelagic eggs in the area from the mouth of the Congo River to the south of Cape Lopez and that sardinella stocks were mainly composed of small individuals. Biomass estimates of the main pelagic species were as follows:

- Round Sardinella: 4,819 tonnes
- Flat Sardinella: 37 752 tonnes
- Horse mackerel: 14 817 tonnes
- Mackerel: 28,144 tonnes
- Other clupeoid species: 7 392 tonnes
- Other carangids / scombridae: 78 354 tonnes

Biomass estimates and size composition from the catches indicate that small pelagic stocks may be at very low levels of abundance.

RÉSUMÉ EN FRANCAIS

La campagne régionale sur les ressources pélagiques et les écosystèmes transfrontaliers en Afrique de l Ouest (Gabon, Congo RDC) a eu comme objectif principale à évaluer les petits pélagiques par la méthode acoustique ainsi que l'état des écosystèmes dans les ZEE du Gabon, du Congo et de la RDC. Les objectifs spécifiques de la campagne étaient d'améliorer les connaissances et la compréhension à terme de la biologie, l'écologie et la dynamique des populations des principales espèces pélagiques ainsi que "l'état de santé" de l'écosystème marin dans les ZEE de ces pays. Le rapport décrit les différentes opérations effectuées à bord du navire et donne les résultats préliminaires obtenus lors de cette mission scientifique.

Au cours de la campagne on a pu réaliser 68 CTD, 18 phyto-, 34 WP2, 22 multinet, 22 manta, 12 coups de chalut de démersaux et 14 couts de chaluts de pélagiques. Les captures ont été échantillonnées par espèces, poids, taille, sexe et stade de maturité sexuelle.

Les résultats de la campagne ont montré que beaucoup d'œufs de petits pelagiques ont été prélevés dans la zone de l'embouchure du fleuve Congo jusqu'au sud du Cap Lopez et que les stocks de sardinelle étaient composés essentiellement d'individus de petite taille. Les estimations de biomasse pour les espèces suivantes sont :

- Sardinelle ronde: 4 819 tonnes
- Sardinelle plate: 37 752 tonnes
- Chinchard: 14 817 tonnes
- Maquereau: 28 144 tonnes
- Autres espèces de clupeoidés: 7 392 tonnes
- Autres carangidés/scombridés: 78 354 tonnes

Les estimations de biomasse et la composition en tailles indiquent que les stocks de petits pélagiques sont très faibles.

CHAPTER 1. INTRODUCTION

1.1 Survey objectives

This survey was planned as part of a synoptic coverage of West Africa's pelagic resources and ecosystems conducted from Morocco to South Africa, from May to December 2017 as part of the EAF-Nansen Programme (2017-2021).

In connection with this phase of the Programme, a Science Plan has been developed that addresses 11 different themes within three main lines of research related to resources, impacts of oil/mining activities and pollution on resources and ecosystems and climate change. Therefore, in addition to providing key information on abundance and distribution of main pelagic stocks, the survey programme was designed to also support data collection for priority research questions that will be addresses as part of specific research projects under the science plan.

Overall survey objectives and the sampling plan were agreed with the respective partner institutions and a detailed sailing order was prepared that describes these in detail.

The specific objectives include:

Hydrography:

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

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; to collect samples of jellyfish for identification, biology and ecology.

Pelagic stocks:

- To obtain information on abundance, distribution (also by size) of *Sardinella aurita, Sardinella maderensis, Engraulis encrasicolus, Trachurus trecae*, *Scomber colias, Ethmalosa fimbriata* and *Decapterus rhonchus* using acoustic methods and a systematic grid survey strategy;
- To collect samples for genetic analysis and for morphometric studies, both for stock identification of *S. aurita, S. maderensis, E. encrasicolus, T. trecae, S. colias* and *E. fimbriata*;
- To obtain information on maturity stages, and to collect stomach samples for analysis of contents and otoliths of *S. aurita, S. maderensis, E. encrasicolus, T. trecae*, *S. colias* and *E. fimbriata.*

Marine debris and pollution:

- To record occurrence of marine debris in trawl gear;

- To collect samples for levels of nutrients and contaminants including microplastics;
- To map occurrence of microplastics and describe associated neuston communities.

Contaminants and nutrients in fish:

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

1.2 Participation

Institute of Marine Research, Bergen, Norway:

Kathrine Michalsen, Ines Dias Bernardes, Øystein Skagseth, Ingrid Sværen, Tommy Paulsen, Jan Frode Wilhelmsen, Jan Arne Vågenes

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

Per-Olav Rasmussen, Sofie Myhre Christiansen

Angola:

Filomena Vaz Velho, Miguel André Antonio, Djamila Fernanda Dos S. Pedro C Mauricio, Geraldina De Assuncao Salvador C José, António Buco, William Carlos Joao Augusto, Suzana Joao Da Conceicao S Nicolau, Sonia Cristina Pedro Da Silva, Amaro Jose S Francisco

Gabon:

Mr. Davy Angueko, Ms. Marie Francoise Nzang-Ovono Spouse Eva-ESSANGONE, Mr Jean De Dieu Lewembe, Mr. Jean-Bernard Mougoussi.

Congo:

Mr. Tite Romuald Akenze, Mr. Blaise Richard Ntse, Mr Ahmed Stanislas Belvere Nakavoua, Ms. Rychie Jucelle Léticia Ntelamanou.

Democratic Republic of Congo:

Mr Mulumba Casimir Koffi, Mr. Kambale Mangaya Jean-Marie.

1.3 Narrative

Figures 1 and 2 show the cruise track and the stations worked during the survey. The vessel departed from Point Noire, Congo, at 17h30 UTC on 21st September 2017, starting the sampling work south of Cape Lopez in Gabon on 23rd September at 01h00. The survey proceeded with an acoustic sampling grid with a transect spacing of approximately 10 NM, covering the shelf and slope until the 500-m bottom depth contour. The sampling continued southwards along parallel transects approximately perpendicular to the coast. Due to oil related activity and high density of fishing boats and other vessels some transects had to be adjusted.

The border between Gabon and Congo was reached on the 29th September at 12h00 UTC. In

several areas along the coast of Gabon waters, oil and gas activity occurs. In this area, some transects were shortened to avoid the security perimeter of rigs and vessels. A long environmental transect extending from 20 m to 2000m offshore was conducted on 29th and 30th September from Pointe Noire. Thereafter the vessel continued surveying crossing the Congo River. A north-south hydrographic section was conducted. The border to Angola at Congo River was crossed on the 1st of October. The findings from the northern part of Angola will be presented in survey report for Angola, 2017408.

Table 1 provides an overview of dates/survey days for Gabon and Congo, respectively.

Table 1. Overview of the cruise dates.

	Days in country	Start	Complete
Gabon	8	21 September	29 September
Congo	2,5	29 September	1 October

Standard hydrographical sections were sampled along acoustic transects every 30 NM from 500 m bottom depth to between 20 and 30 m bottom depth close to the coast. Along every second hydrographic section phytoplankton, zooplankton, ichthyoplankton and micro-plastics were also sampled at each super-station.

The weather was generally favourable, and no days were lost due to bad weather or mechanical problems.

1.4 Survey effort

Altogether 26 trawl hauls were carried out to identify acoustic targets during the survey. 68 CTD casts were 68 along 9 hydrographic transects, to describe the water properties in the survey area. Plankton and manta trawl stations sampled were 22, along 6 of the 9 hydrographic transects. Tables 2 and 3 show the survey effort during the survey. Annex II provides the full details of the trawl stations.

Table 2. Sampling effort during the survey. Table shows the number of transects.

	Trawl hauls	Acoustic	Hydrographic	Plankton & hydrographic
Gabon	23	19	7	4
Congo	3	4	2	2
Total	26	23	9	6

Table 3. Number of samples per categories: CTD, Phyto - phytoplankton net, WP-2 – zooplankton net, Multinet - eggs and larvae, Manta trawl net - plastic particles in the surface, BT - bottom trawl, PT-Pelagic trawl.

Region	CTD	Phyto	WP-2	Multinet	Manta	BT	PT	Distance
Gabon	49	12	20	13	13	10	13	1280
Congo	19	6	14	9	9	2	1	31,63
Transit from Point Noire to Cape Lopez								171
TOTAL	68	18	34	22	22	12	14	159,63

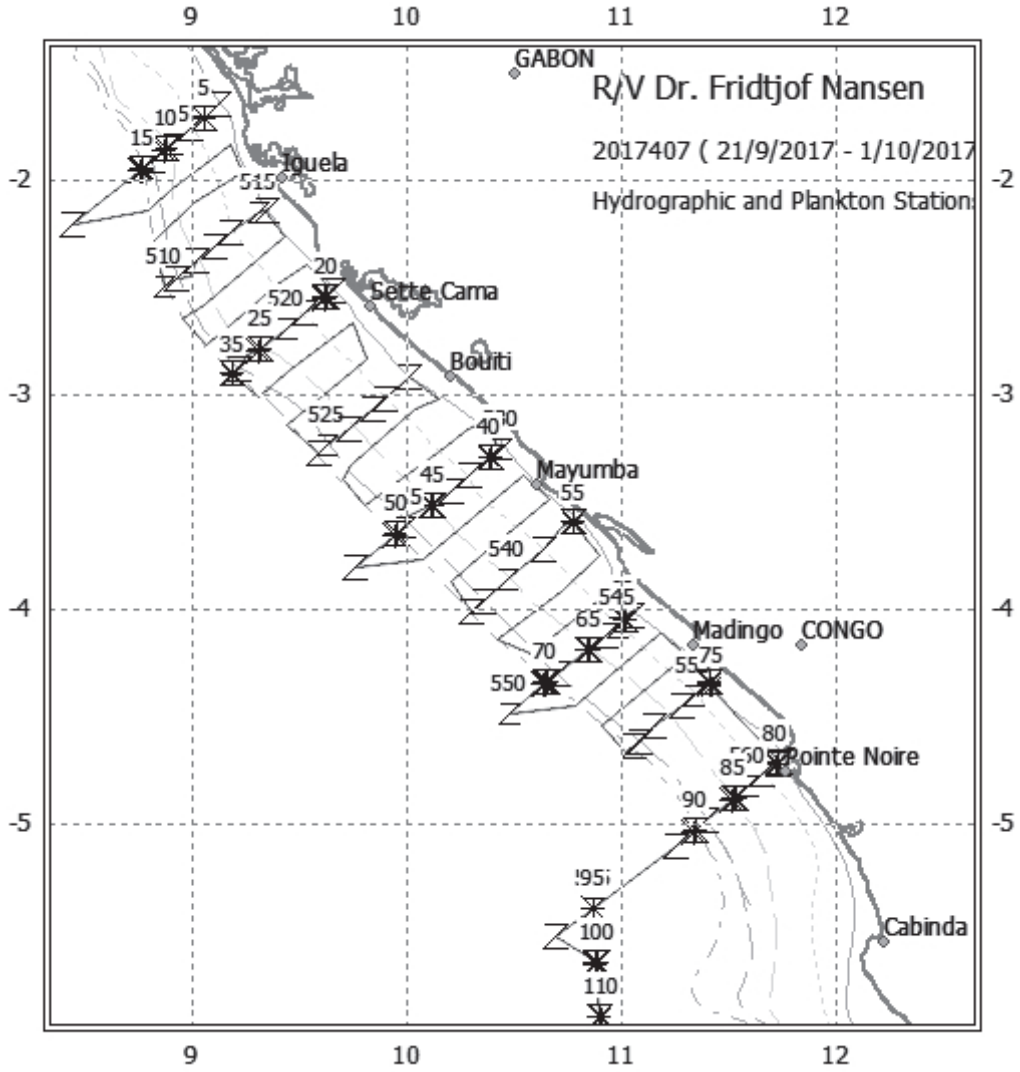


Figure 1. Course track with plankton and hydrographic stations, Gabon and Congo. Depth contours at 20m, 50m, 100m, 200m, 500m and 1000m are shown. Z: CTD; *: super-station.

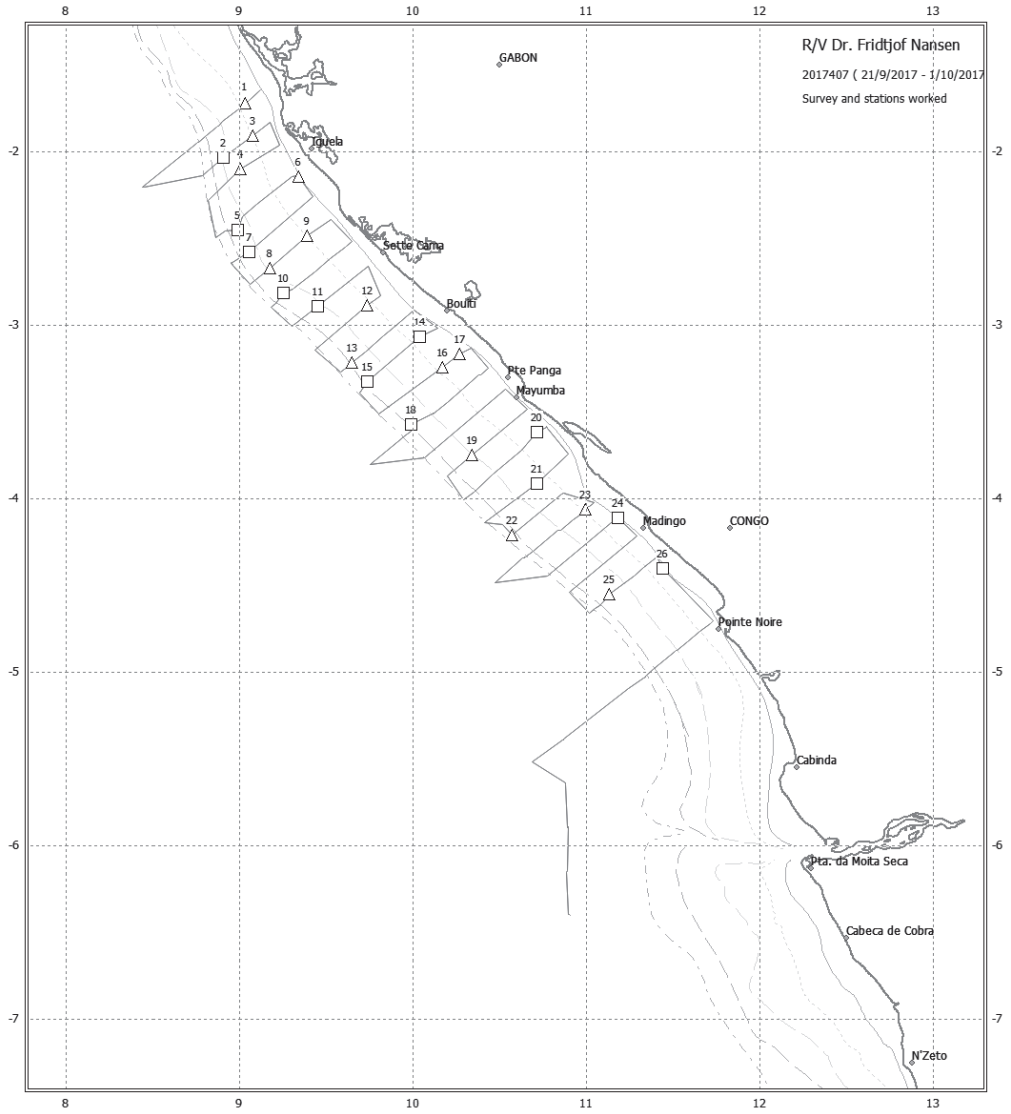


Figure 2. Course track with bottom - and pelagic trawl stations, Gabon and Congo. Depth contours at 20m, 50m, 100m, 200m, 500m and 1000m are indicated.

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 ran during the survey. The frequencis of the VM-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. The 150 kHz data was analysed during the cruise, while the 75kHz data was stored on files for post survey processing. Both the ADCPs were run continuously.

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 “Dr. Fridtjof Nansen”. At greater depths, the EM 302 will be used. 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 station sampling

Standard hydrographical sections were sampled along acoustic transects every 30 NM from 500 m bottom depth to between 20 and 30 m bottom depth close to the coast (500 m, 200 m, 100 m, 75 m, 50 m, 30 m, 20 m). Along every second hydrographic section phytoplankton, zooplankton, ichthyoplankton and micro-plastics were also sampled at the super-station. (CTD with water bottles for samples of nutrients and pH phytoplankton net, WP2, multinet, manta trawl). Samples were taken at the inshore end of the acoustic transects, usually at a water depth of 30 m, 100-m isobath and at at 500 m bottom depth. In addition, CTD stations were added at 20 m, 50 m, 75 m, and 200 m at the same transect. The samples collected on every second hydrographic transects are shown in Figure 3.

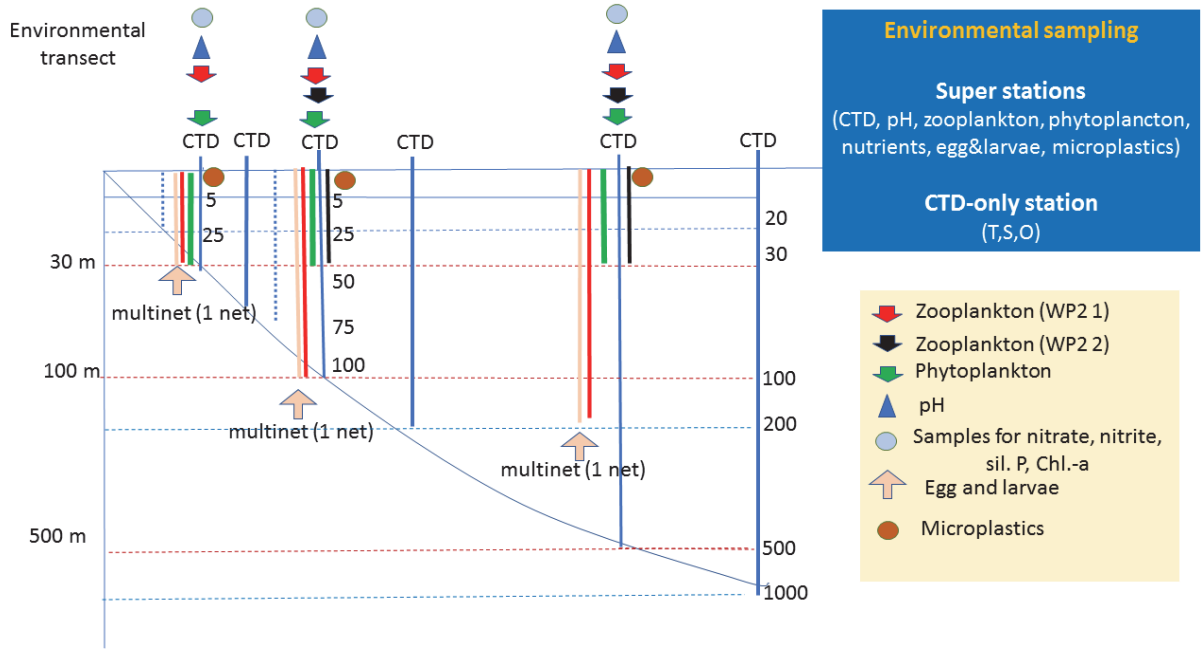


Figure 3. Overview of sampling conducted at environmental transects.

2.3.1 CTD sensors – temperature, salinity, oxygen, light 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 installed on a PC. Attached to the CTD was also an uncalibrated Chelsea Mk III Aquatracka fluorimeter, which measures *in situ* fluorescence on relative scale and a Photosyntetic Active radiation (PAR) sensor, measuring downwelling irradiance (in micromole photons m^2).

The salinity sensor was valitated with analyses of water samples using a Portasal salinometer (mod. 8410A) onboard the vessel (Table 4). The oxygen sensor was validated with analyses of water samples using the method of Winkler titration (Grasshoff *et al.* 1983) and the results are presented in Table 5. When comparing the sensor values from the CTD, with the standard watersamples (salinity) and the Winkler titration measurements, it can be concluded that the

sensors are preforming well and the measured sensor values can be trusted and used in further analysis.

Table 4. Comparison between the measured salinity from the CTD and the salinity obtained from water samples using the Portasal salinometer.

Station nr.	**Date (dd/mm/yyyy)**	**P CTD**	**temp. CTD**	**S CTD**	**S water sample**	**ΔS**
502	23/09/2017	15,300	25,7980	34,5910	34,588	-0,003
503	23/09/2017	25,900	25,6680	34,7650	34,764	-0,006
504	23/09/2017	44,500	25,2030	34,9530	34,913	-0,037
505	23/09/2017	90,600	17,1950	35,8010	35,763	-0,037
507	23/09/2017	193,400	15,3780	35,6390	35,650	0,011
508	23/09/2017	499,300	7,4400	34,6830	34,688	0,005
509	23/09/2017	2001,700	3,4400	34,9650	34,963	-0,002
509	23/09/2017	2001,700	3,4400	34,9650	34,962	-0,003

Table 5. Comparison between the measured oxygen from the CTD and the oxygen measured based on the Winkler titration.

Station #	Bottle #	Depth (m)	Oxygen (CTD)	Oxygen (Titration)	Difference
536	1	480,98	2,112	2,012	-0,1
536	2	400,3	1,767	1,78	0,013
536	3	300	1,368	1,242	-0,126
536	4	199,7	2,266	2,16	-0,106
536	5	99,4	1,825	1,827	0,002
536	6	75,2	3,362	3,195	-0,167
536	7	50,4	4,839	4,676	-0,163
536	8	25,3	4,743	4,708	-0,035
536	9	5,2	4,793	4,688	-0,105
537	1	1665	5,329	5,304	-0,025
537	2	999,8	3,504	3,507	0,003
537	3	749,2	2,832	2,805	-0,027
537	7	73,3	2,462	2,284	-0,178
537	8	47	4,328	3,997	-0,331
537	9	24,2	4,751	4,646	-0,105
537	10	4,8	4,806	4,778	-0,028

2.3.2 Ocean acidification parameters (pH and alkalinity)

Seawater samples collected at standard depths were used to determine chlorophyll, pH, alkalinity and for nutrient analyses (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 analyses (nitrate, nitrite, silicate and phosphate) were taken from the Niskin water-bottles. Samples were collected from the standardized depths 5, 25, 50, 75, 100, 200, 300, 400, 500, 600, 800 and 1000 m, with bottom-depth restricting the number of samples collected from a given station. The seawater samples were stored in 20 mL polyethylene vials, conserved with 0.2 mL chloroform (1% chloroform solution), and kept cool and dark in a refrigerator (Hagebø and Rey, 1984). The analysis was made at the Institute of Marine Research (Bergen, Norway), 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 outlying values that were obviously wrong were excluded. The quality control included evaluation of the ratios between the different nutrients.

2.4 Phytoplankton sampling

Chlorophyll *a* is a plant pigment, which in oceanography typically is used as an indirect measure for phytoplankton biomass. Seawater samples for analysis of chlorophyll *a* and phaeopigment concentrations were collected at predefined depths with rosette-mounted Niskin bottles attached to the CTD at the plankton stations. Seawater samples (250 mL) were collected from the standardized depths 5, 25, 50, 75, 100, 200, 300, 400, 500, 600, 800 and 1000 m, with bottom-depth restricting the number of samples collected from a given station.

The seawater samples were filtered on Munktell glass-fibre filters (GF/C, 25 mm diameter) using a custom-made filtration system. During the cruise, the filter-samples were stored at ~ -18°C in the dark for subsequent analysis on shore in the IMR laboratory in Norway. The pigments were extracted with 90% acetone in darkness over-night, and the extracts centrifuged and analysed using a Turner Design fluorometer model 10 AU calibrated with pure chlorophyll *a* (Sigma Inc). Interference from phaeopigments was corrected for by measuring the amount of pigments once again, after having added a weak acid (10% HCl). The method of determining the amount of chlorophyll *a* and phaeopigments extracted in 90% acetone was launched in the early nineteen-sixties (Yentsch & Menzel 1963), but the method

itself and the calibration-factors have later been changed several times (e.g. Holm-Hansen et al. 1965, Jeffrey & Humphrey 1975, Welschmeyer 1994, Humphrey & Jeffrey 1997, Jeffrey & Welshmeyer 1997). The measurement of chlorophyll *a* and phaeopigments by the fluorometer was performed according to the guidelines of the producer (Turner Designs 1992), and the present version of the method was first described by Holm-Hansen & Riemann (1978).

Qualitative phytoplankton samples were collected at "super-stations" (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). The samples were preserved with a solution of 2% formaldehyde in dark glass bottles. These samples are used to establish the taxonomic composition of the phytoplankton community.

2.5 Zooplankton sampling

Mesozooplankton was collected with a WP2-net along the hydrographic transects at the super-stations. 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, the net was equipped with a flowmeter to measure the sampling distance. At the shallowest 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 pre-weighed and numbered aluminium trays at ~60ºC for 24 h nd then frozen. These samples will be dried once more and weighed on shore at the IMR after the cruise 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 for subsequent species identification and quantification, in partner countries (INIP, Angola).

2.6 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}. 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.

From most of the samples fish larvae visible with "the naked eye" were removed from the total sample, photographed and transferred to sample bottles. The fish larvae were then preserved in 4% formaldehyde buffered with borax. When all visible fish larvae had been removed from the Multinet sample, the rest of the sample was splitted into a suitable part, and eggs were removed from that part and then preserved in 4% formaldehyde buffered with borax. A part equal to that which eggs were removed from was preserved for reference purposes.

2.7 Microplastics

Microplastics are normally defined as small pieces of plastic marine 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 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 ms^{-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, microplastic particles were sorted from the sample under a stereo-microscope, and the sorted sample was then checked once more 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 dried in pre-weighed aluminium-trays in room-temperature. The trays with dried microplastic were packed in aluminium foil and stored at -20^0C 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 4% for studying the neuston at UWC, Cape Town, after the cruise.

2.8 Food safety

Whole fish, fillet and different organs from various fish that are regularly consumed in the four countries surveyed were sampled and preserved. All the samples will be analysed for a wide variety of nutrients and contaminants at IMR, Bergen, as listed below. Tissue samples from mackerel will 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.

2.9 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 Åkra trawl. In several instances, especially when the acoustic target was 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 Annex III), gonad weight, and stomach fullness (according Annex III) were recorded. 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 specific fish species were taken: otoliths (in paper envelopes), 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, as it seemed less cumbersome and time consuming to do this on land in well equipped labs.

The target groups used for this survey were *Sardinella aurita and S. maderensis*, *Scomber japonicus, Trachurus trecae and T. capensis, and Engraulis encrasicolus*. 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.

2.10 Acoustic sampling

2.10.1 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.

2.10.2 Echo sounder

Acoustic equipment

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 survey was started without an *a priori* calibration, although the sounders were calibrated in Bergen on the 23rd January 2017. Annex I gives the details of the acoustic settings used during the survey.

2.10.3 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 6. 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 6), the mean s_A-value allocated to each category was more or less in the same ratio as their contribution to the abundance in trawls in that area. Note that due to low abundance, biomass estimates could not be calculated for all the listed fish groups/species. Even though *Decapterus punctatus* was not listed as a priority species in the objectives, it often occurs with its congener *D. rhonchus* and hence the two species cannot be separated acoustically. *D. punctatus* was therefore included in the Pelagic 2 fish group.

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 1, Pelagic 2 and “other pelagic species” -50 dB was used. To identify mesopelagic layers a threshold of -60 dB was used.

Table 6. Allocation of acoustic densities to species groups. Note that for the groups sardinella, horse mackerel, big-eye grunt and pilchard all encountered species are listed, while only examples are listed for the remaining groups

Group	**Taxon**	**Species**	**Sampling**
Sardinella	*Sardinella* sp.	*S. aurita* *S. maderensis*	*Full biological*
Horse mackerel	*Trachurus* sp.	*T. trecae*	*Full biological*
Mackerel	Scombridae	*Scomber colias*	*Full biological* *not otoliths*
Other		*Brachydeuterus auritus*	*Length &* *Weight*
Pelagic species 1	Clupeiformes[1]	*Ilisha africana* *Engraulis encrasicolus*	*Full biological* *not otoliths*
Pelagic species 2	Carangidae[2]	*Selene dorsalis* *Chloroscombrus chrysurus* *Decapterus rhonchus* *Seriola carpenteri*	
	Scombridae	*Auxis thazard* *Sarda sarda*	*Length & Weight*
	Sphyraenidae	*Sphyraena guachancho*	
	Others	*Trichiurus lepturus* *Lepidopus caudatus*	
Demersal species	Sparidae[3]	*Dentex angolensis* *D. macrophthalmus* *D. congoensis* *D. canariensis* *D. barnardi* *Pagellus bellottii* *Sparus caeruleostictus* *S. pagrus africanus*	*Length & Weight*
	Other taxa	*Saurida brasiliensis* *Arioma bondi* *Pomadasys incisus* *Galeoides decadactylus*	
Mesopelagic species	$Myctophidae_3$ Other mesopelagic fish	*Diaphus dumerili*	*Total mass*
Plankton	Calanoidae Euphausiidae Other plankton	*Calanus* sp. *Meganyctiphanes* sp.	

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

2.10.4 Estimation of biomass

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.

In cases where the integrated echo contained more than one category of fish (see Table 6), 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 following target strength (TS) function was applied to convert s_A-values (mean integrator value for a given species or group of species in a specified area) to number of fish:

$$TS = 20 \log L - 72 \text{ dB} \quad (1)$$

which can be converted (see Toresen *et al*. 1998 for details) to the area form (scattering cross sections of acoustic targets):

$$CF = \frac{10^{7.2}}{4\pi} \cdot \overline{L}^{-2} \quad (2)$$

where *CF* is the conversion factor from acoustic density to fish biomass and $\overline{L^2}$ 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 presently are available for the species at hand, and equation (2) has therefore been applied consequently 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 different regions, 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 digitised using Nansis Maptool Version 2.01.4. 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 (from 1 to 4 single NM observations). This is a source of bias, but this 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 20 m). 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. Target species of the same genus, i.e. *S. aurita* / *S. maderensis* and *T. trecae* / *T. capensis*, are not acoustically distinguishable, and the s_A values were therefore split according to the relative distributions of the two species in each length group. The total number of fishes in each length group was estimated as:

$$\rho_i = \frac{< s_A > t_{i,j} \cdot u_i}{\sum_i \frac{u_i}{C_{Fi}}} \cdot A_s = \frac{10^{7.2} \cdot t_{i,j} \cdot u_i \cdot < s_A > \cdot A_s}{4\pi \sum_i u_i \cdot (L_i + 0.5)^2} \qquad (3)$$

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 integrator outputs were split into the fish groups listed below using a combination of behaviour pattern as deduced from echo diagrams, the LSSS analysis and catch composition.

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 the Excel spread-sheet made available for acoustic abundance estimation on board RV "*Dr. Fridtjof Nansen*".
- 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.

CHAPTER 3. RESULTS - OCEANOGRAPHY

3.1 Underway sampling

3.1.1 Atmospheric conditions

As expected, the incoming solar radiation show the diurnal cycle, but also pronounced inter-diurnal differences with values of maximum solar radiation varying from about 400W.m^{-2} to 1000 W.m^{-2} (Figure 4 a). During the first few days the winds were consistently strong from the south (i.e. blowing toward north). The subsequent period from about 23rd Sept. – 29th Sept. was characterized by weaker and more shifting winds during the day, from upwelling winds from the south to downwelling favorable winds from the north. On the 30th Sept. and the 1st Oct., the wind was relatively strong and consistent from the north, before turning more easterly during 2nd-3rd Oct. (Figure 4 b).

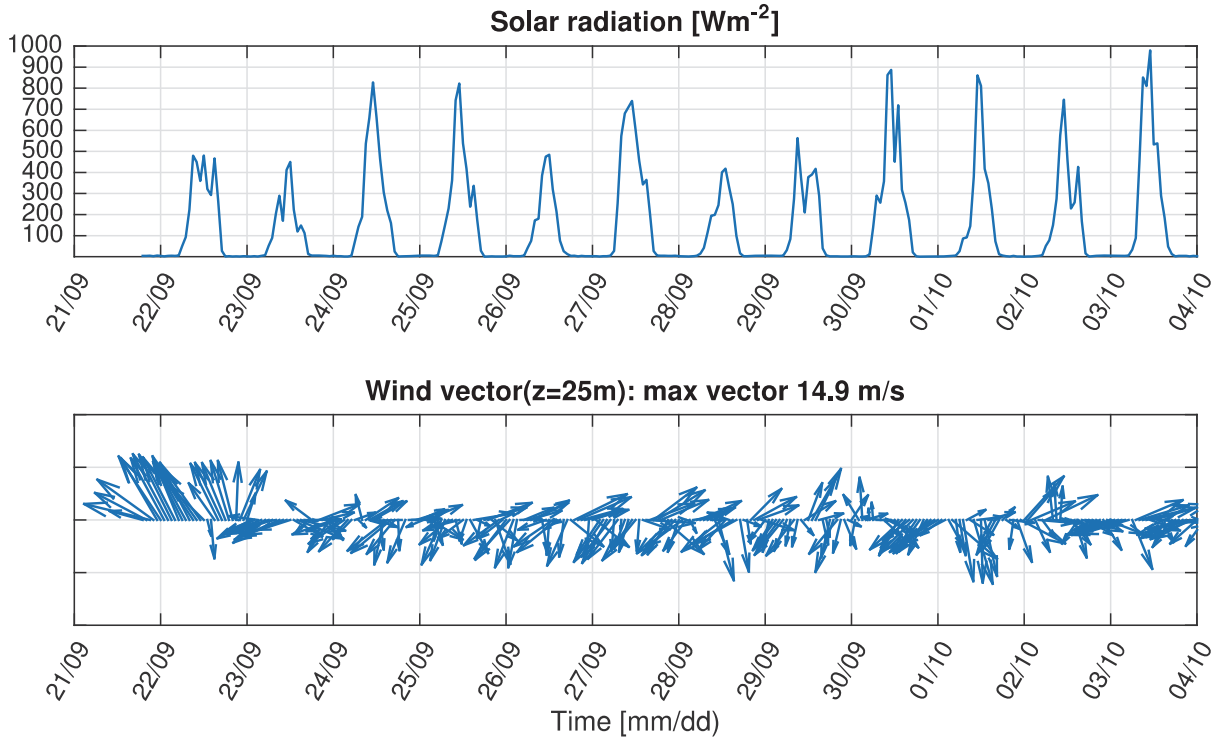


Figure 4. The measured a) solar radiation and b) wind obtained from the meteorological instruments mounted at 25 m above sea level aboard the RV Dr. Fritjof Nansen. Note that the wind vector points in the direction that the wind is blowing. An approximate scaling factor of the order (ln10)/ln(25) = .7 is required to reference wind to the normal 10 m height.

3.1.2 Thermosalinograph

The thermosalinograph data of near surface conditions (4m depth) show relatively saline and cold conditions in the north, off Gabon (Figure 5). Also, there is a gradient from the coast with colder and less saline water due to coastal upwelling. This is also reflected in elevated levels of fluorescence. Further south, towards the Congo River, there is a gradually increasing influence of the warm and less saline Congo River water. Corresponding to this the fluorescence and turbidity show increased values. Just south of the Congo River, the conditions are again relatively saline and cold. The transect going north to south at about 6°S indicates that the Congo River plume is slanted toward northwest.

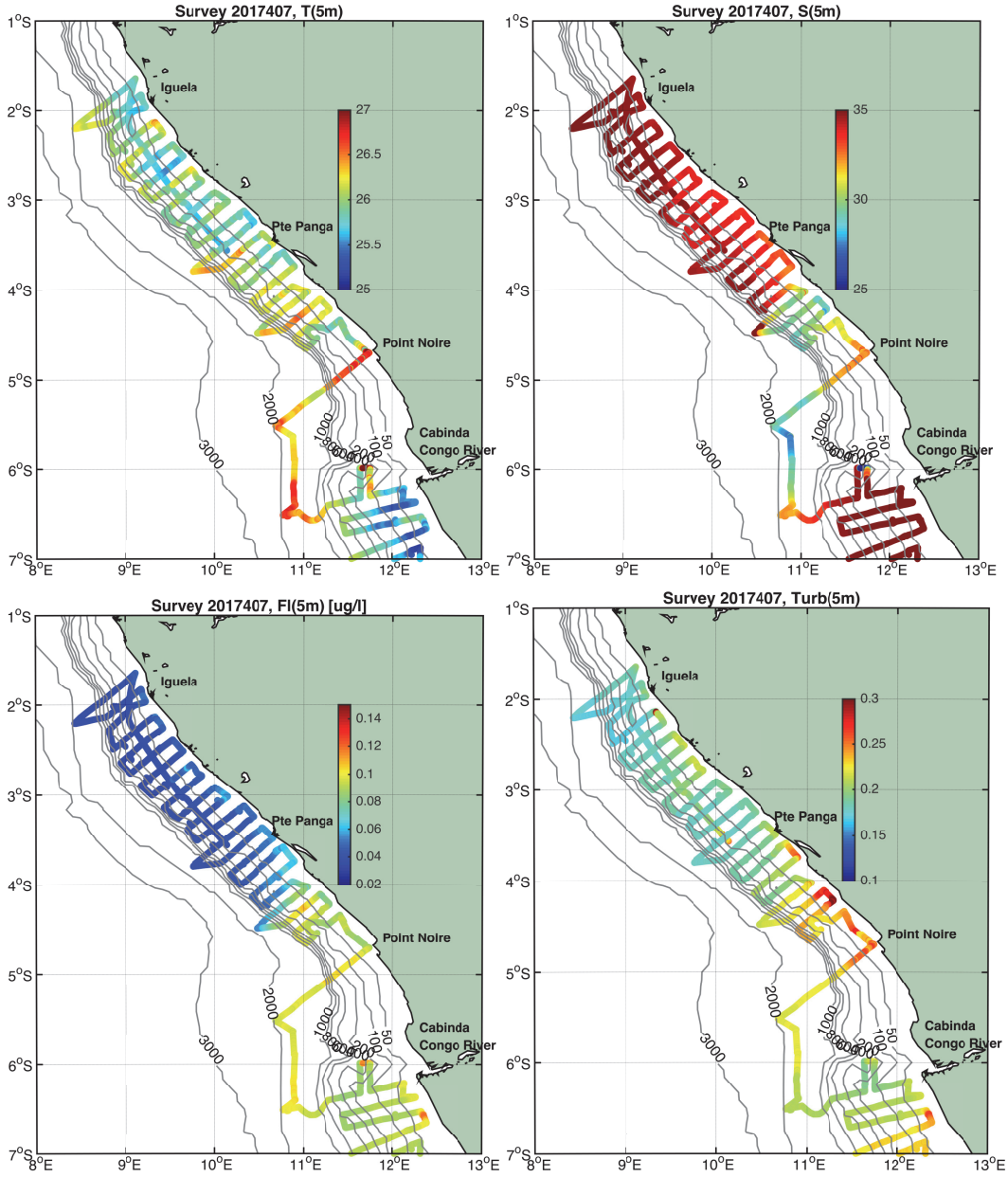


Figure 5. Termosalinograph data at 4 m depth from the RV DR. Fritjof Nansen during the period 22 Sept. – 3 Oct. 2017 showing temperature (upper left), salinity (upper right), fluorescence (lower left) and turbidity (lower right).

3.1.3 ADCP current velocity

The continuous vertical profiles of currents measured by the ADCP 150KHz show that off Gabon, in the upper depth bin observed with the instrument (starting from 18m below surface), the flow is generally northwards of about 0.2-0.5 m.s-1 on the shelf (Figure 6). Interestingly this current decreases rapidly with increasing depth (50 m) and there is even a tendency of this flow to reverse direction toward south.

No measurements are made shallower than 18 m depth thus we cannot conclude whether there is a southward flow shallower than 18 m very close to the coast.

Southward of 4°S, on the shelf off Congo, the currents are weak and northward near the coast. Downstream of the Congo River the currents are strong toward southeast. This could in part be in accordance with entrained water into the Congo River water flowing in the opposite, i.e offshore, and direction. At 50 m, the currents are weak whereas at 214 m there is a tendency for a northward flow.

Along the entire survey along Gabon and Congo, and similarly for the subsequent survey along Angola, there is a continuous northward slope current of about 0.2 ms^{-1} with the core over the 400-800 m isobaths that are prominent in the 214 m depth layer. Further analysis should be performed to investigate the structure of this current at larger depth using the 75 KHz ADCP which extends deeper, with further sampling also in 14 m depth bins.

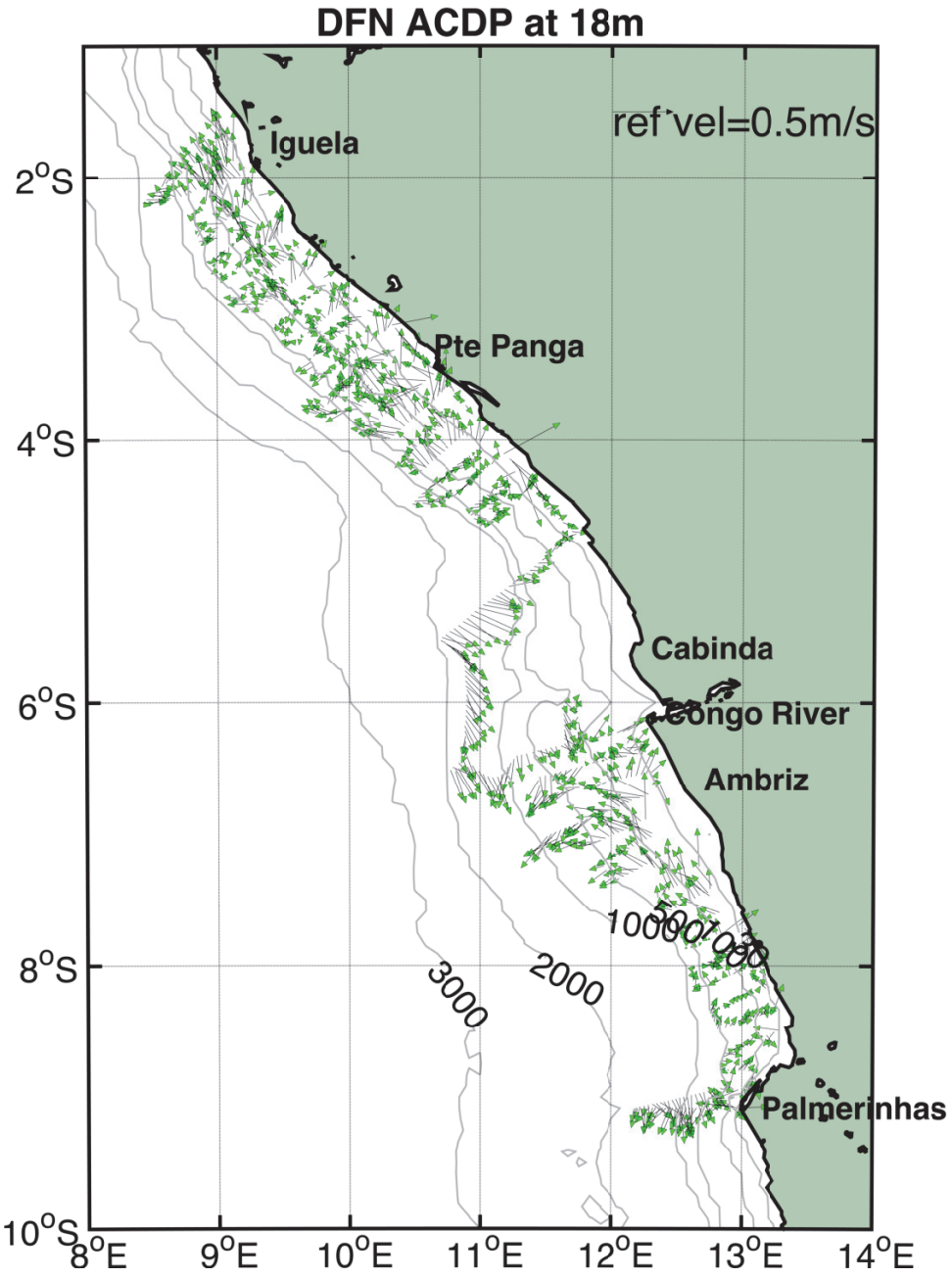


Figure 6a. Stick plots of VM-ADCP current velocities from a) 18m, b) 50 m, and c) 214 m depth obtained during the period 22 Sept. – 10 Oct. 2017. The arrows represent 4 m depth mean values over 5-minute sampling time. For comparison, we here also include the currents from the Angola shelf to the south. A reference arrow of 0.5 m/s is included in the plot.

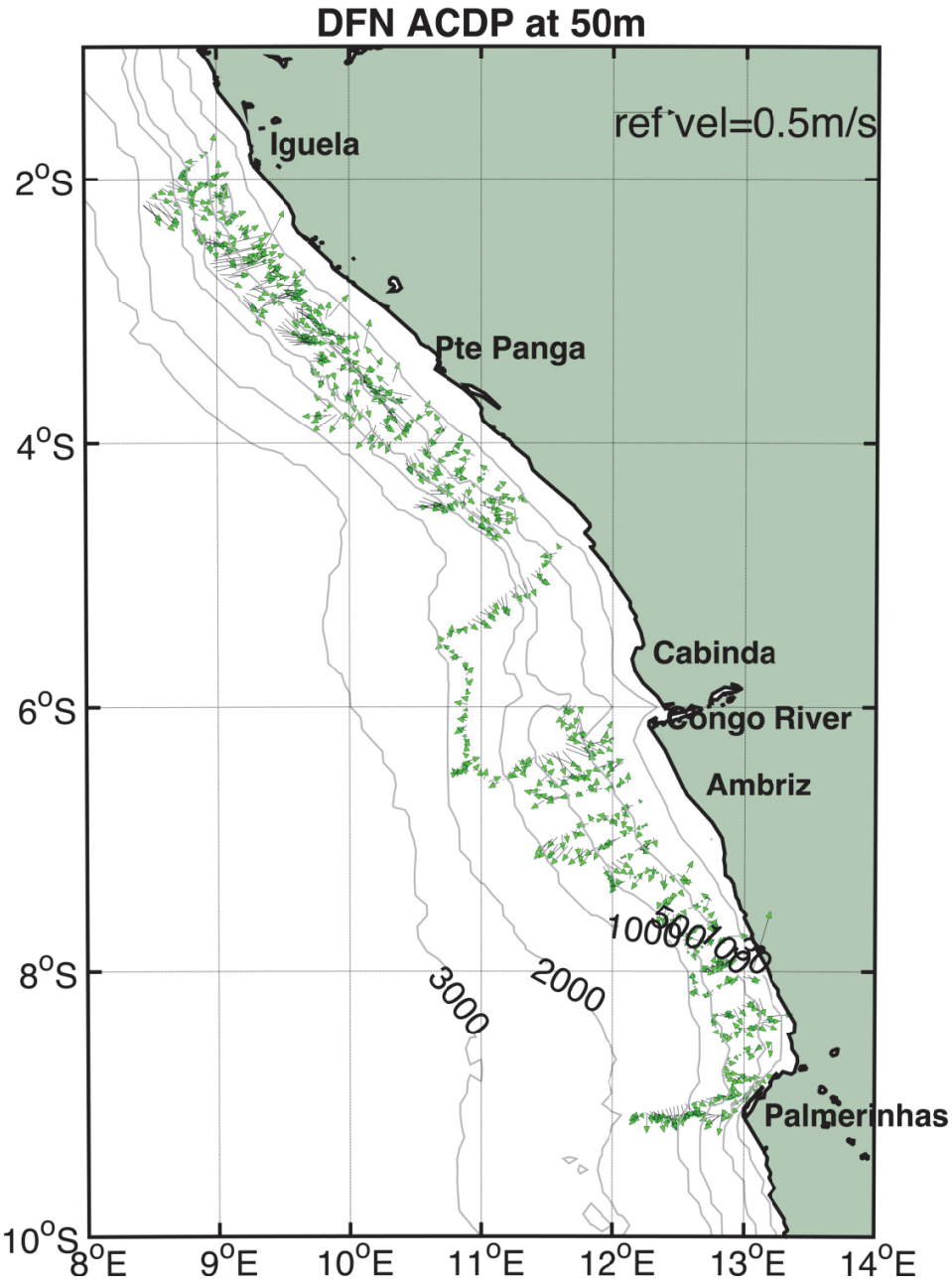


Figure 6b. (cont.).

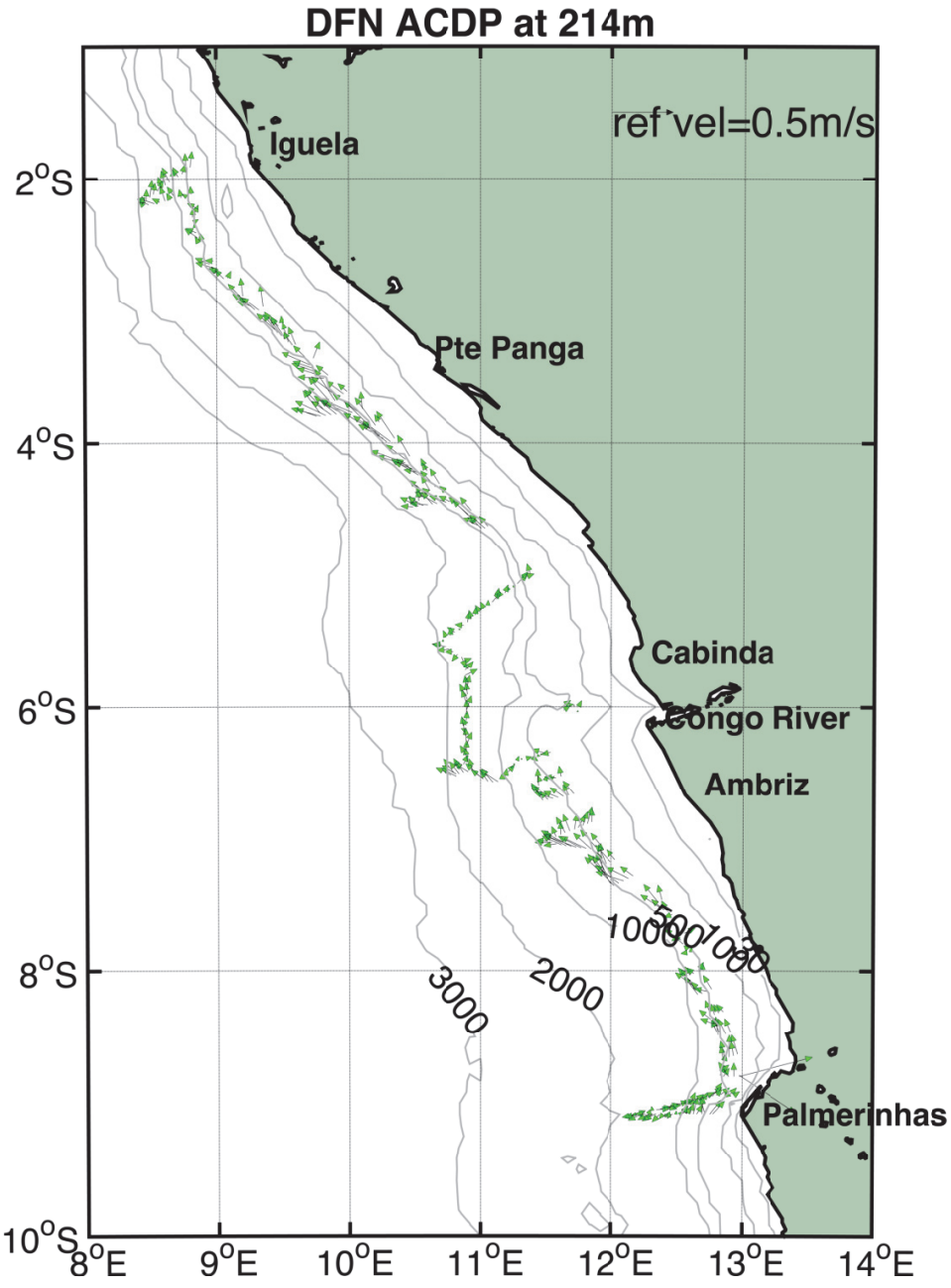


Figure 6c. (cont.).

3.2 Hydrography

The continental shelf off Gabon and Congo 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, downstream of the Congo River there is a deep valley with depths between 500-1000 m cutting through the continental shelf. Hydrographic variables were measured in sections normal to the coastline about every 30 nm (Figure 7). The CTD sampled continuous profiles of pressure, temperature, salinity, oxygen, fluorescence, oxygen and Photosyntetic

Active Radiaation (PAR). In addition, water samples for analysis of nutrients, chlorophyll, salinity and oxygen were collected from surface to bottom at selected depths.

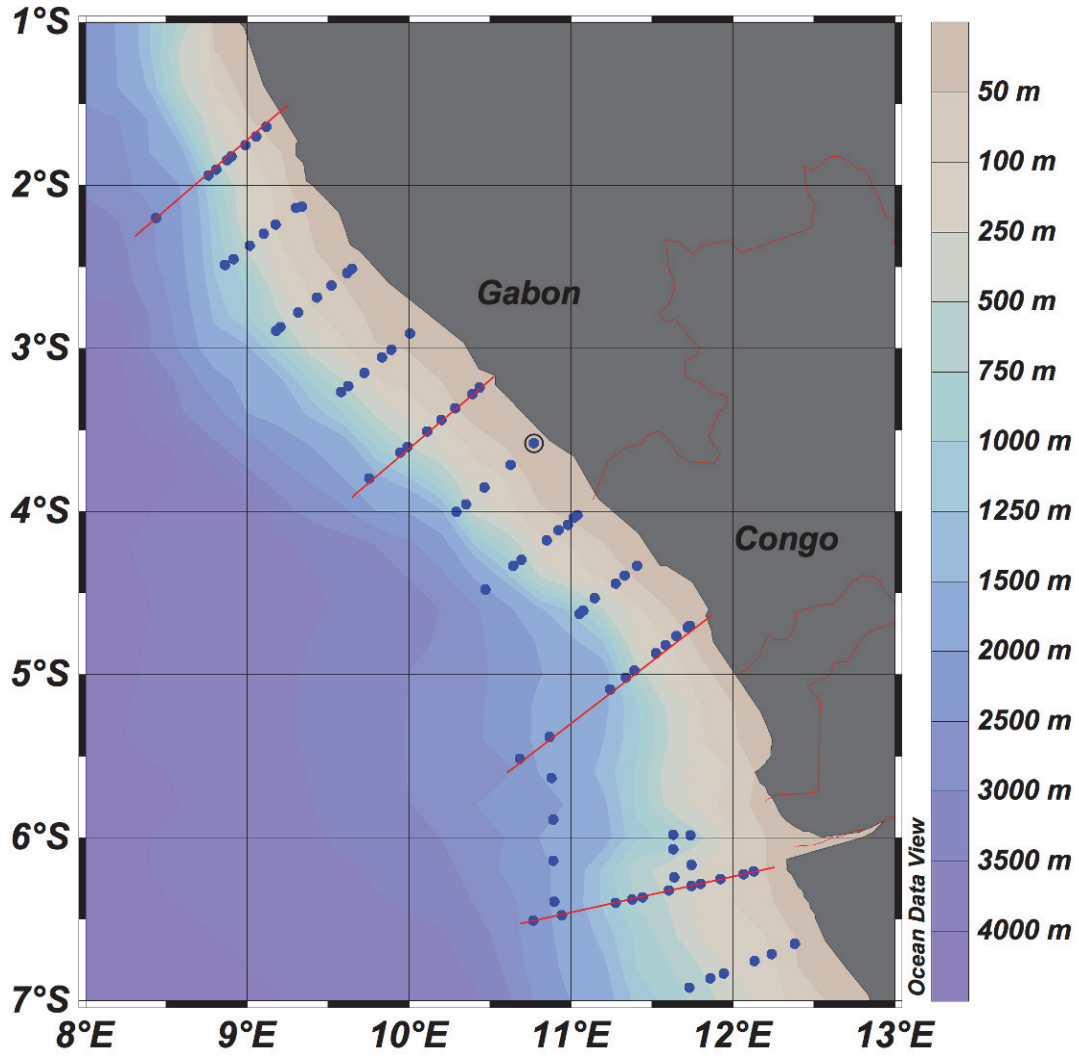


Figure 7. Positions of the CTD stations in waters off Gabon, Congo and Congo River. Red lines indicate hydrographic transects used to produce vertical profiles for salinity, temperature, oxygen, PAR and fluorescence. CTD stations no. 502-587, in total 86.

3.2.1 Temperature

In the upper layer covering the inner part of the shelf the temperature typically exceeds 24 ^{o}C (Figure 8). The only exception is in the Congo River section where colder water of about 20 ^{o}C intrudes the shelf. In all the sections the temperature decreases to 10 ^{o}C at depths between 300 to 400 m.

3.2.2 Salinity

The general salinity distribution constitutes a relatively fresh surface layer, then a layer between 50 m to some hundred meters with a salinity maximum, and further down a gradual decrease in salinity toward abyssal conditions. However, there are some noteworthy details on the shelf connected to the fresh surface layer. The most pronounced near coast fresh layer is in the section at 4^{o}S off Gabon (Figure 9), whereas in the two sections closest to the Congo River low salinity layers are found, with value ranging around of the order 10.0-15.0 offshore (Figure 9). The most saline shelf water is found in the section just to the south of the Congo River.

3.2.3 Oxygen

The distribution of dissolved oxgen was generally high in the upper 50 m, and then decreasing with depth to 1-1,5 mL/L in a pronounced oxygen minimum zone (OMZ) at 250 to 400 m depth. The upper high oxygen layer is most homogenous in the northernmost section, whereas in the three sections to the south there are clear indications of onslope intrusion of lower oxygen water near the bottom.

3.2.4 Fluorescence

It is only in the upper 100m that there is a clear difference in fluorescence between the sections. In the two northernmost sections, there are relatively high values at the shelf that becomes gradually deeper offshore, typically reaching a maximum at 20-40 m. In the section to the north of Congo River relatively high fluorescence values are found in the upper 15 m, with a marked maximum about 100 km from the coast. Similar conditions, but with generally lower values are found to the south of the Congo River.

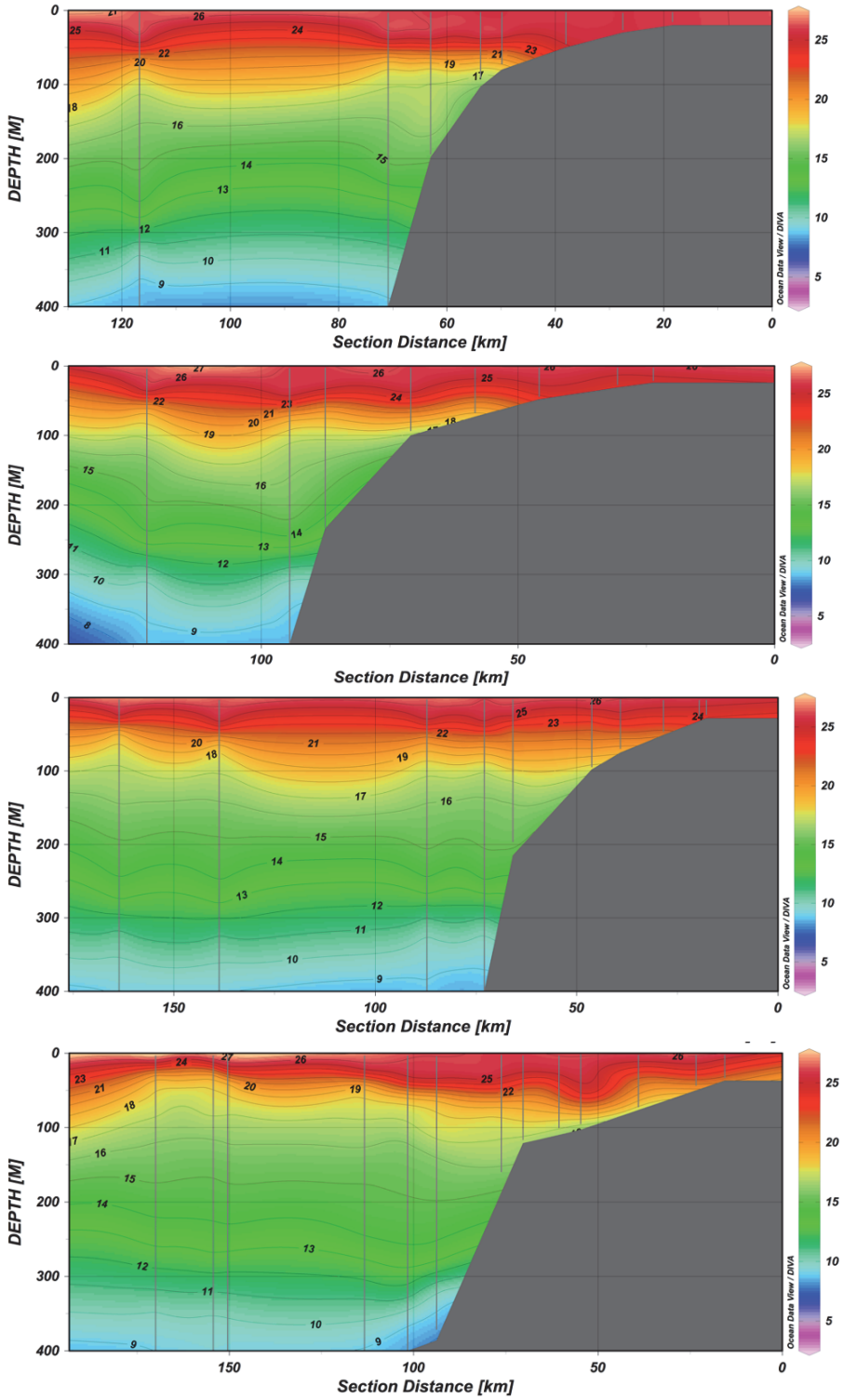


Figure 8. Cross section of temperature (^{o} C) from north to south based on the CTD data. See Figure 1 for positions of the sections.

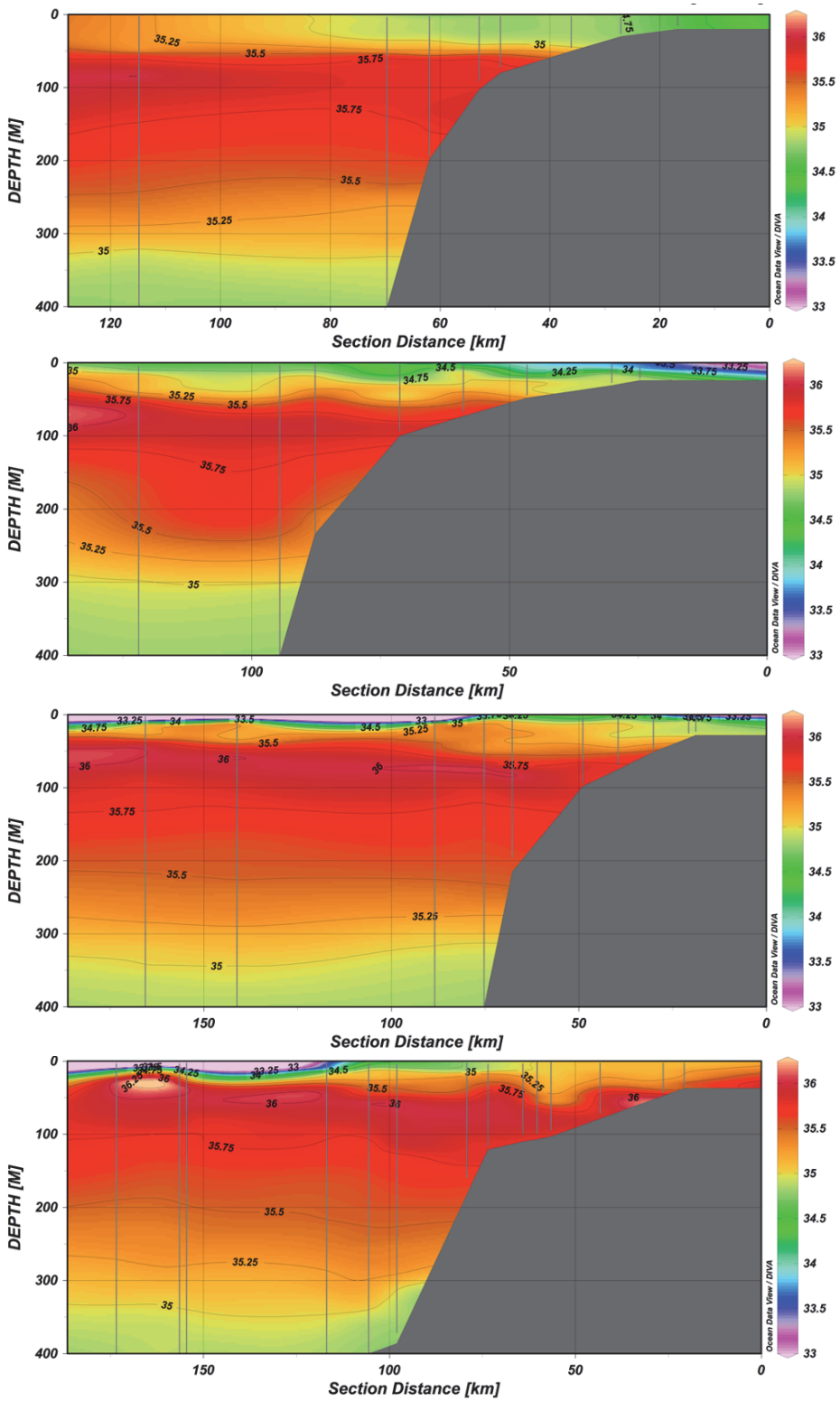


Figure 9. Cross section of salinity from north to south based on the CTD data. See Figure 1 for positions of the sections.

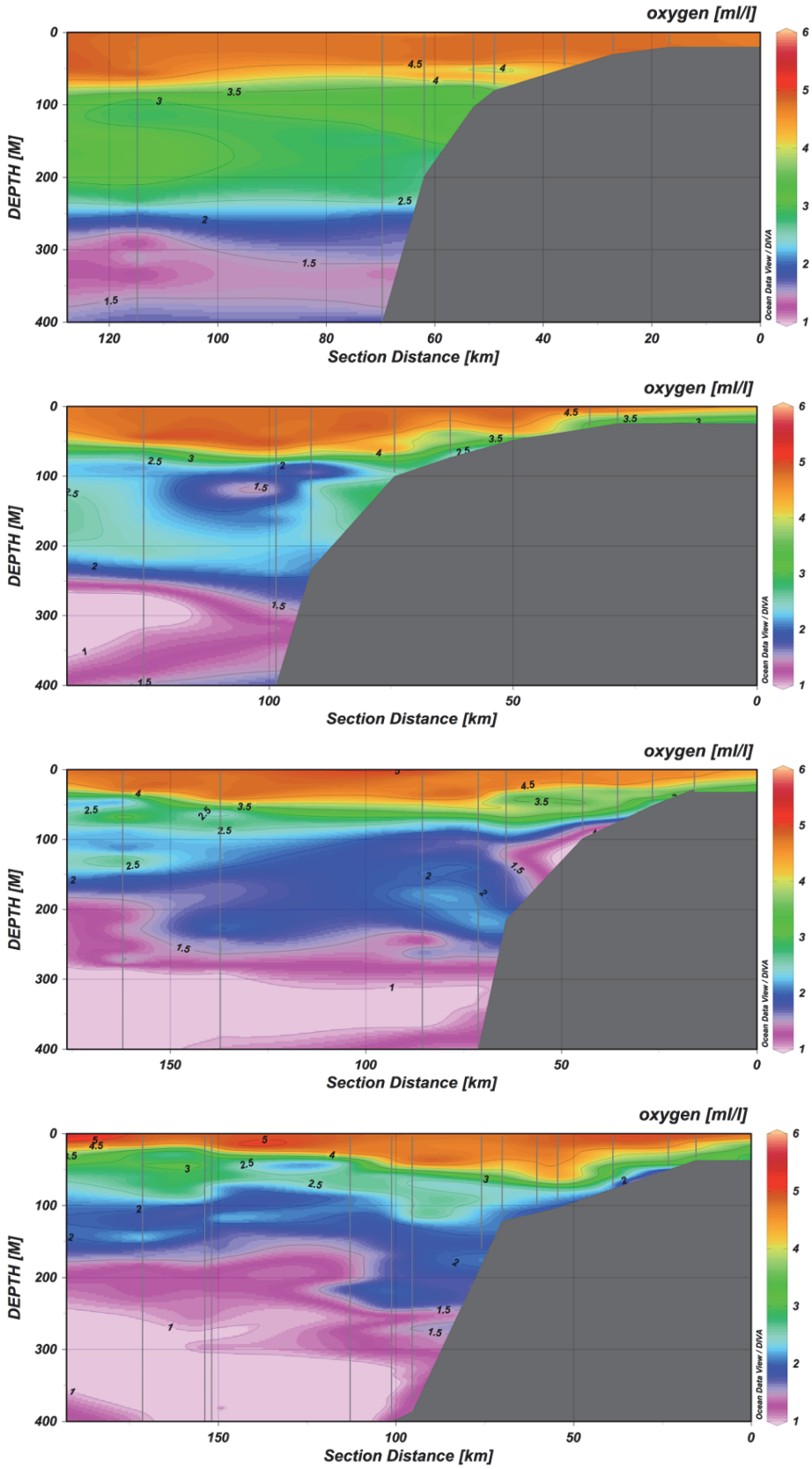


Figure 10. Cross section of oxygen from north to south based on the CTD data. See Figure 1 for positions of the sections.

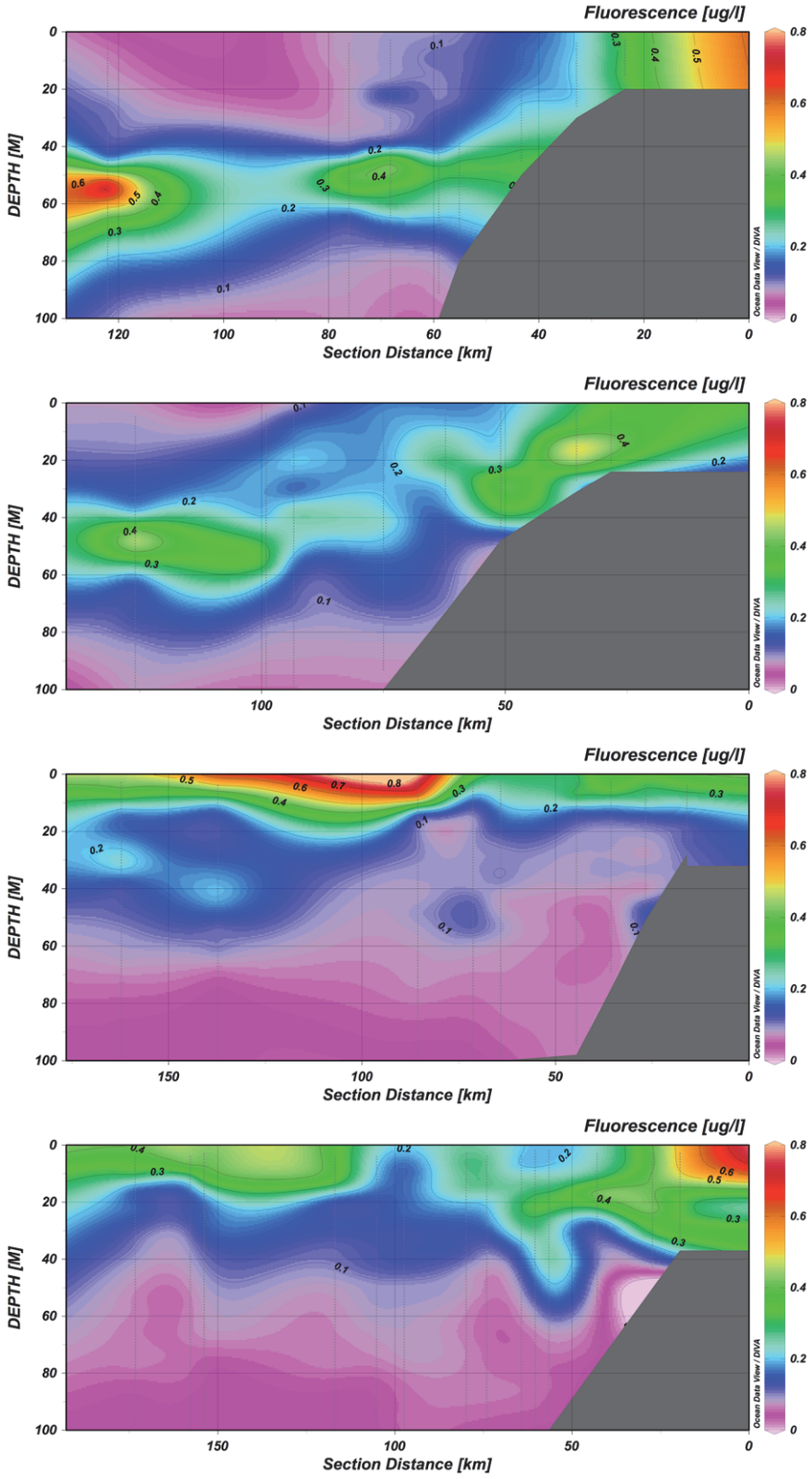


Figure 11. Cross section of fluorescence, from north to south based on the CTD data. See Figure 1 for positions of the sections, note different vertical scale.

3.2.5 Horizonal distribution of fluorescence PAR

Fluorescence distributions at 5 and 50 m essentially show opposite patterns (Figure 12). At 5 m there are elevated values along-stream the Congo River water, as well as over the shelf of Congo and the coast of Gabon. In the deep water, values are low. Contrarily, at 50 m depth the values are low beneath the Congo River water, and over the shelves of Congo and Gabon, whilst outside the shelf break there are elevated values that exceeded even the maximum values at 5m. These different distributions can at least in part be explained by the changes in the measured PAR (Figure 13). In the area directly in the stream of the Congo River (st no 578 and 569, and along the coast of the Congo (st no 529) the water is dark, with high absorbance of light, and production and use of nutrient does hence only occur in the upper 10-20 m. However, for the stations offshelf along Congo and Gabon (st no 509, 523 and 537) the light penetrates much deeper and can therefore utilize the deeper nutrients, and thereby explain the high fluorescence values at 50 m.

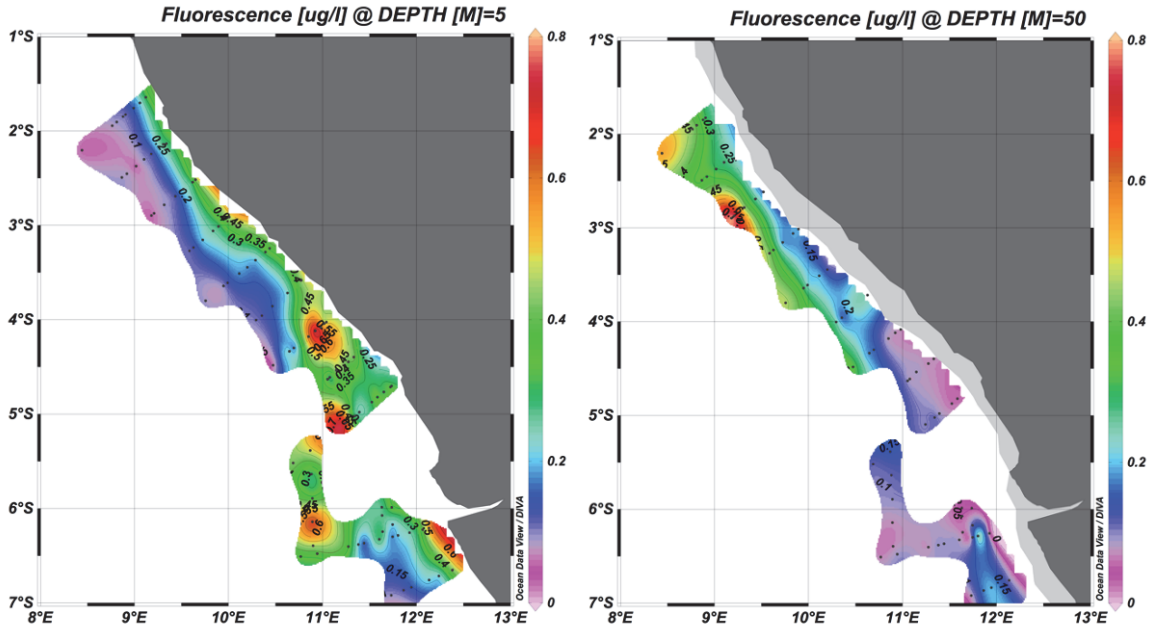


Figure 12. The horizontal distribution of fluorescence off Gabon and Congo at left) 5 m depth and right) 50 m depth.

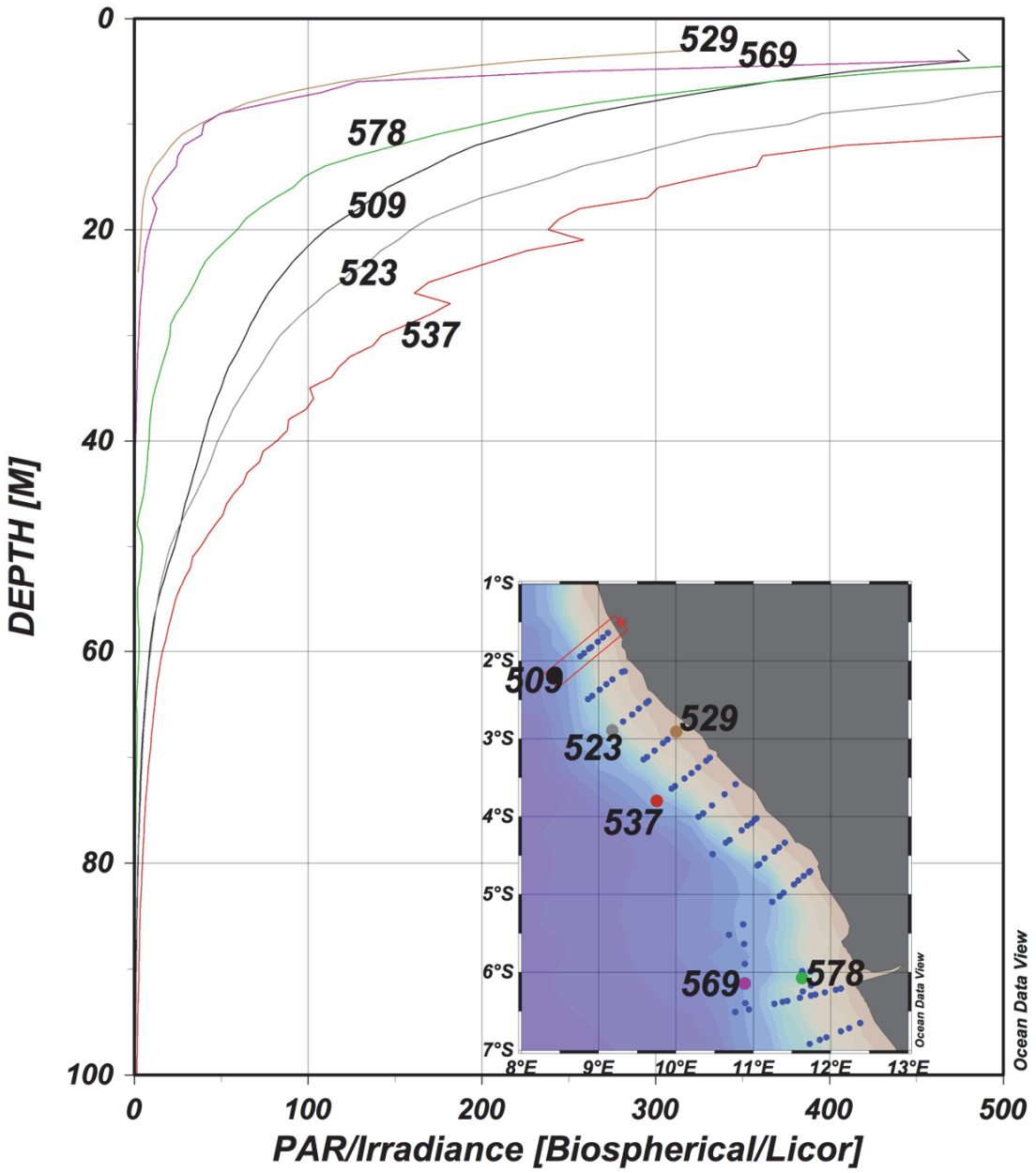


Figure 13. Vertical profiles from the PAR sensor mounted on the CTD for selected station during day time. Locations of the profiles are shown on the map.

3.3 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 reported separately. Overview of the phyto- and zooplankton collected is presented in Table 7.

Table 7. Number of samples of phyto- and zooplankton collected.

Country	Phytoplankton	Zooplankton from 100m and 200 m		Zooplankton from 25 m	
	Formalin	Formalin	Dried and freezed	Formalin	Dried and freezed
Gabon	12	8	16	12	37
Congo	6	7	23	8	23
Total	18	15	39	20	60

3.4 Fish-eggs and larvae

Fish-eggs and -larvae were were sampled with Multinet; 405µm mesh. The diameter of the fish egg, oil globule and the yolk were measured using the micrometer. It is important to emphasise that the fish eggs and fish larvae abundance was significantly lower using the Multinet than with the Manta trawl. All samples were preserved for further examination on land. An overview of the ichthyoplankton samples collected is presented in Table 8.

Table 8. Summary of Multinet sampling stations.

Country	No. of sampling stations	No. of stations with fish larvae	Total no. of fish larvae	Total no. of samples preserved
Gabon	13	7*	95	27
Congo	9	3*	22	13
Total	22	10	117	40

*6 samples were not examined for fish larvae.

3.5 Microplastics

The contents from the Manta trawl was examined onboard using a stereomicroscope before being preserved for analysis onshore. All samples analysed contained microplastics. Red and yellow paint particles, most likely originating from the sampling gear, are included in the data. All suspected plastic items were placed on a gridded petri dish and pictures were taken and saved as reference. An overview of the sampling stations is presented in Table 9.

Table 9. 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
Gabon	13	11*	101	13	11
Congo	9	9	59	9	9
Total	22	20*	160	22	20

*2 samples were not examined for microplastics.

3.6 Food safety

Table 10 shows the number of samples for the different kind of analysis of fish for food safety. The analysis will be carried out at NIFES, Bergen, Norway.

Table 10. The sampling done for analytical work for each species.

Species	No. of samples	Tissue	Nutr.[1]	Cont.[2]	Other
Trachurus trecae (small)	3 x 25 3 x 25	Fillet w/skin + bone Whole fish	X	X	TBARS
Sardinella maderensis	25	Fillet, Feces, Liver	X	X	TBARS
Engraulis encrasicolus	3 x 25 3 x 25	Fillet w/skin + bone Whole fish	X	X	TBARS
Scomber colias(small)	3 x 25 3 x 25	Fillet w/skin + bone Whole fish	X	X	TBARS
Lutjanus fulgens	25	Fillet, liver, gut content	X	X	TBARS
Sphyraena guachancho	25	Fillet, liver, gut content	X	X	TBARS

CHAPTER 4. RESULTS - 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 support research on life cycles, stock identities, and trophic relationships of pelagic fish. For these facets, special effort was carried out to collect several biological parameters (otoliths, fin clips, stomachs, liver, gonad weight) and stage gonad maturity for post-survey age and growth, stock structure, population biology and trophic interaction studies. Annex V reports the numbers of samples collected. These samples will be analysed later, and the results reported separately.

The on-board analysis of several key biological parameters, notably length-weight, sex, maturity and stomach fullness are presented in the results section. Samples of fish were also collected for subsequent onshore analysis (see AnnexV).

Mesopelagics were sampled at 1 station, with 27 frozen individuals. At one station, 5 samples of jellyfish (for Mark Gibbons at UWC, Cape Town, South Africa) were also collected.

4.2 Sex-ratio and gonad development

Very few fish of the main target groups (sardinellas, horse mackerels, and mackerel) were caught in Gabon and Congo, and hence the sample sizes are small. Most biological data and samples (including otoliths, sex, gonad maturity, stomachs, and liver) were collected for *Sardinella aurita* (60 samples) and for *Sardinella maderensis* (43 samples). Since in several instances, especially for *Trachurus trecae,* the measured fish were small, it was decided to freeze these, such that otoliths and stomachs could be obtained on land. Sex ratios and proportions of gonad maturity stages (females only) by length were not possible to calculate for *T. trecae* as we almost exclusively caught immature individuals.

4.3 Distribution, size composition and biomass estimates

Overall, few distinct and well-defined acoustic recordings reminiscent of schooling pelagic fish were observed off Gabon, and when they did occur, the extent of the recordings was usually limited to a narrow depth range and short distance. Off Congo no schools of fish or distinct acoustic recordings were observed. Most of the acoustic backscatters were attributed to four groups; Sardinella, horse mackerel, mackerel and *Brachydeuterus*. These were recorded in waters shallower than 80m, except for the acoustic echos assigned to horse mackerel, which were observed at depths up to 150 m.

Of the main target species, only Pelagic 2 and *Trachurus trecae* was found over an extended area. Sardinella and Pelagic 1 (*Engraulis encrasicolus* and *Illisha africana*) were caught in very low numbers. Species more frequently caught belonged to the ‘Pelagic 2’ group and

'Other pelagics', and included *Sphyraena guachancho*, *Selene dorsalis, Trichurus lepturus,* and *Brachydeuterus auritus*, respectively.

4.3.1 Horse mackerel (Trachurus trecae)

The size distribution of horse mackerel varied between trawl catches. Shallow pelagic tows generally contained juvenile (4-6 cm) fish, whereas deeper pelagic and demersal trawls caught larger (> 10 cm) individuals. Consequently, the overall length distribution consisted of mainly one age cohort, with modes at 7 and 9 cm (Figure 14).

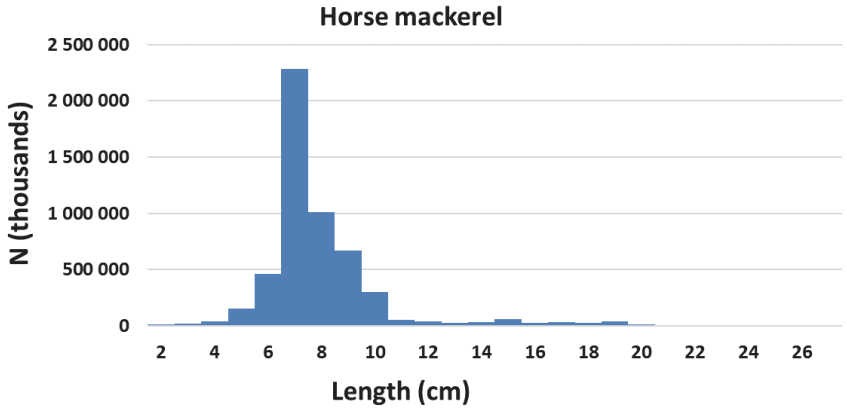


Figure 14. Length distribution of *Trachurus trecae* off Gabon and Congo.

The acoustic recordings showed that the horse mackerel were distributed over large areas of the Gabonese and Congolese shelf between 30-200 m (Figure 15). The fish density was however generally low in the trawl catches (average 2 $kg.h^{-1}$), except for in 4 catches, in which two were above 100 $kg.h^{-1}$ and two above 200 $kg.h^{-1}$. During daytime, the horse mackerel was mainly observed close to the bottom at 50-80 m depths.

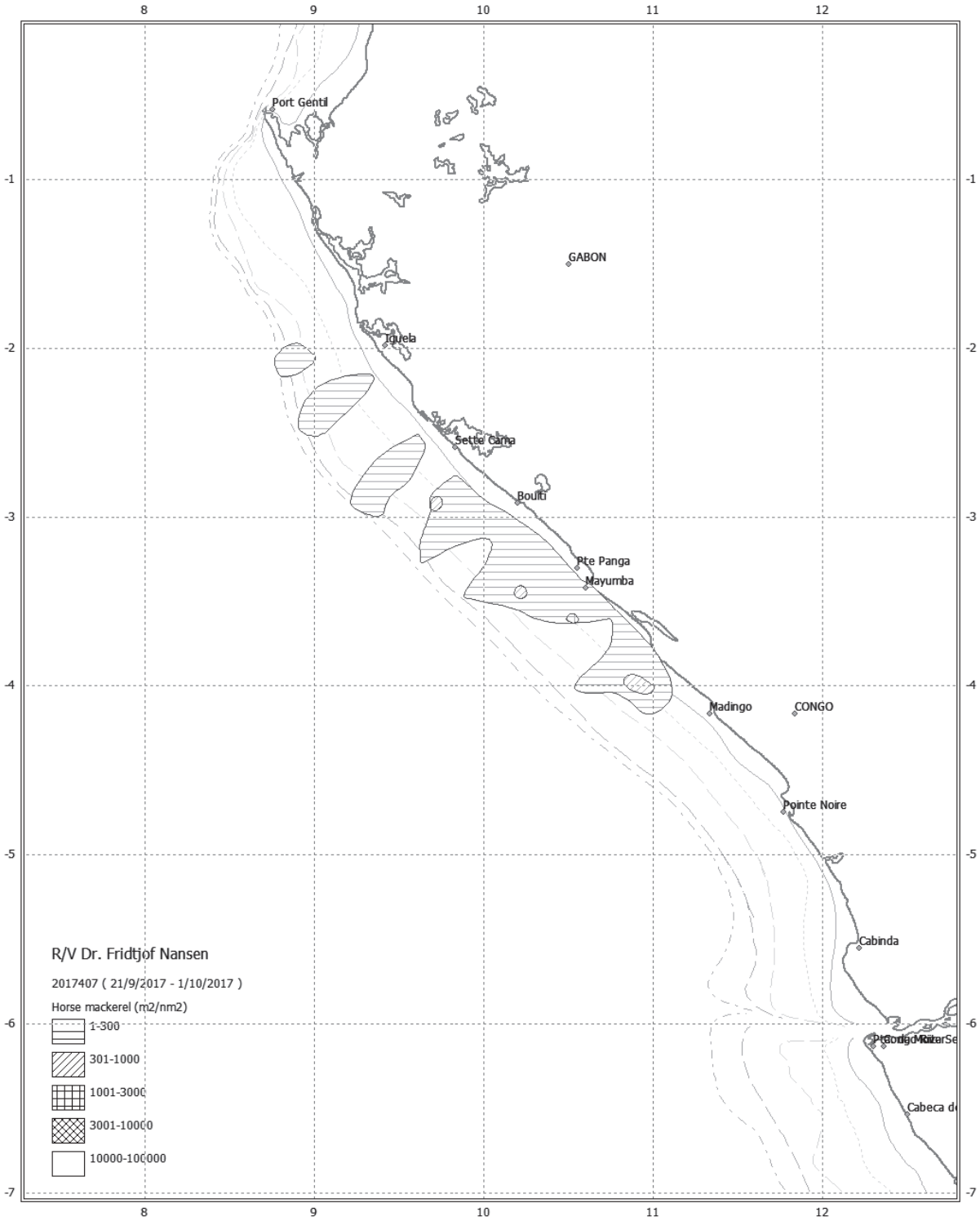


Figure 15. Distribution of *Trachurus trecae* off Gabon and Congo. Depth contours as in Figure 2.

4.3.2 Mackerel (*Scomber colias*)

Scomber colias was caught in more than half of the fishing stations, with highly variable catch rates. Its depeth distribution was also broad, caught from 36 to 298 m depth. The mean size of the individuals is larger when compared with the horse mackerel (Figure 16).

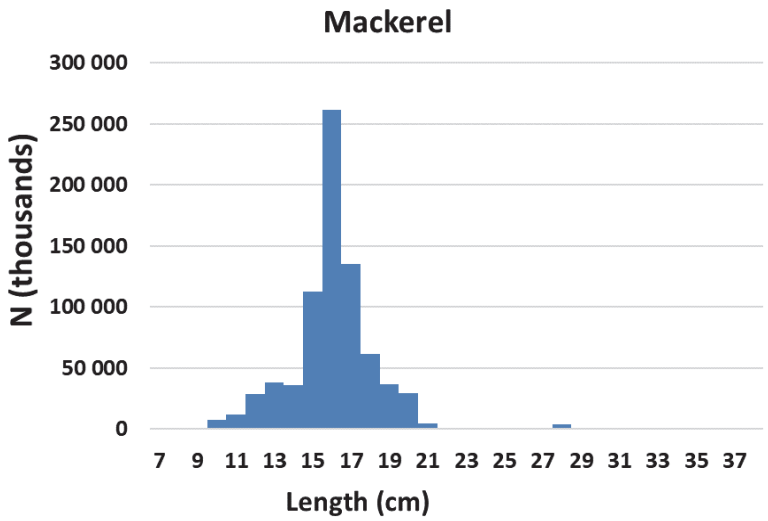


Figure 16. Length distribution of *Scomber colias* off Gabon and Congo (catches raised according to acoustid registrations).

Both mackerel and horse mackerel showed an overlapping of their distribution area (Figure 17).

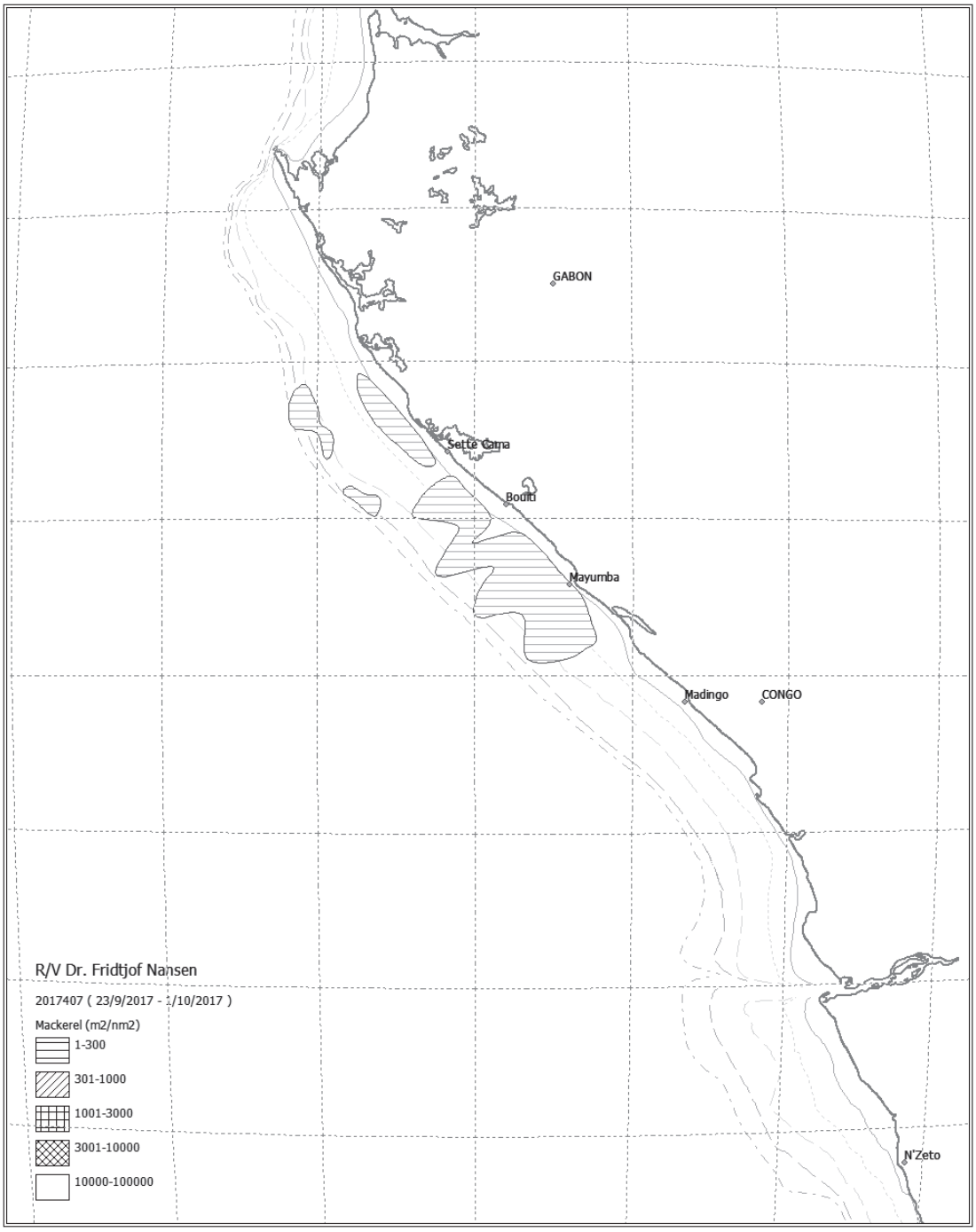
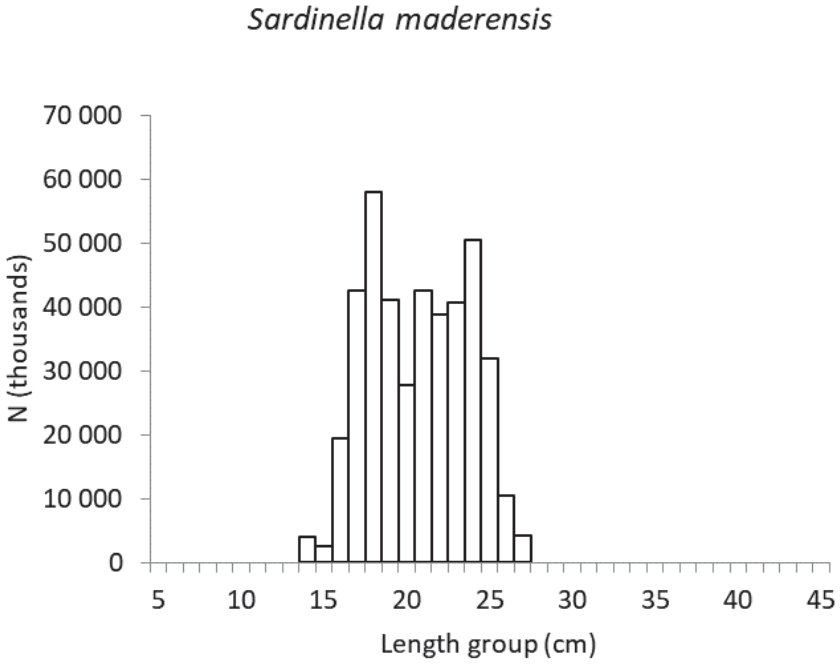
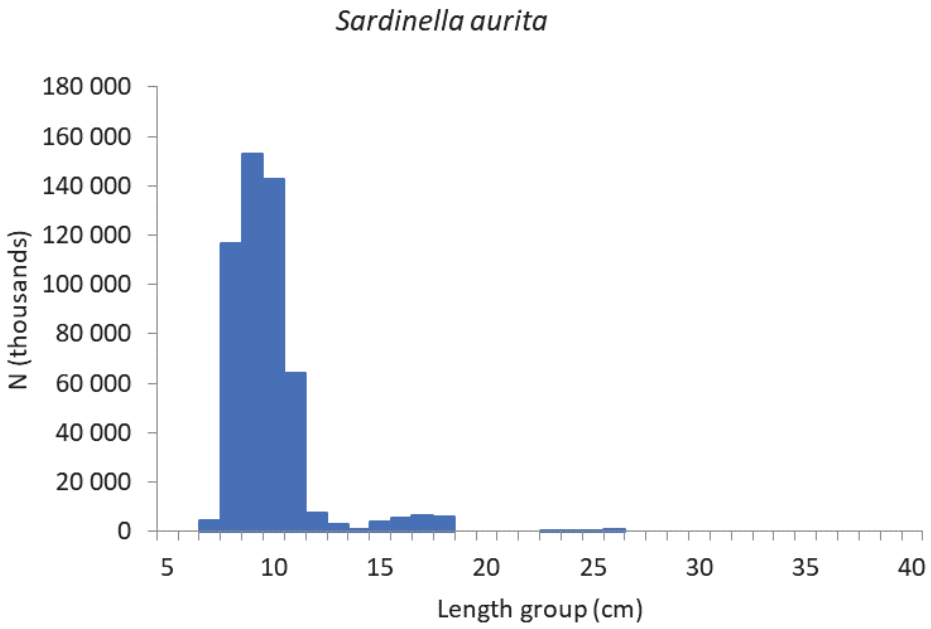


Figure 17. Distribution of *Scomber colias* off Gabon and Congo. Depth contours as in Figure 2.

4.3.3 Sardinellas

S. aurita was found in 14 out of 26 trawl hauls. The catch rates suggest that overall *S. aurita* was 55% of sardinella (in numbers). Mean length of *S. aurita* was lower than than for *S. maderensis*. In terms of biomass, *S. aurita* was 11% of the total biomass of sardinella. *S. maderensis* showed two peaks in the length distribution, indicating the presence of two age classes whereas for *S. aurita* only one peak was seen in the length distribution (Figure 18).





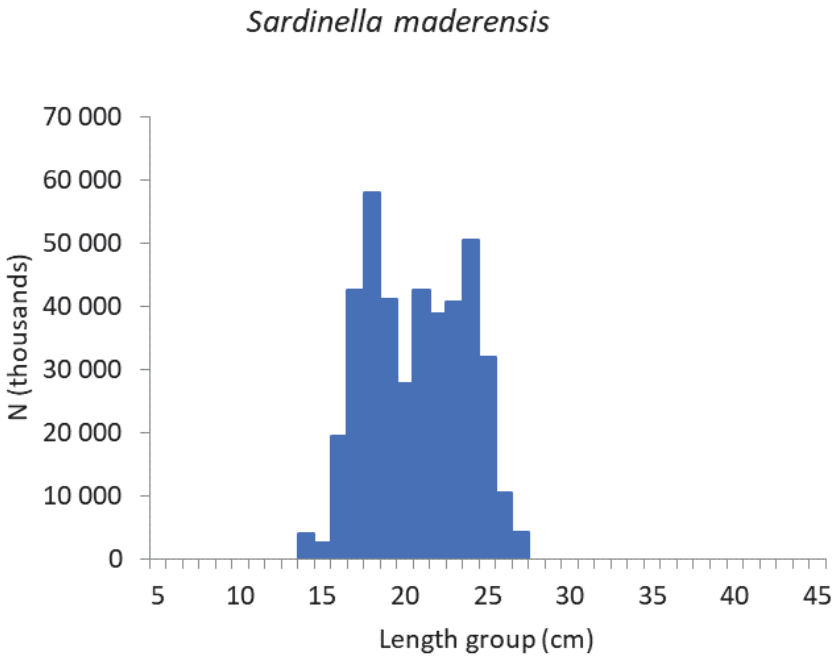


Figure 18. Length distribution of Sardinellas off Gabon and Congo – *Sardinella aurita* (N=517871), *Sardinella maderensis* (N=418038). The length distributions are weighted by acoustic densities.

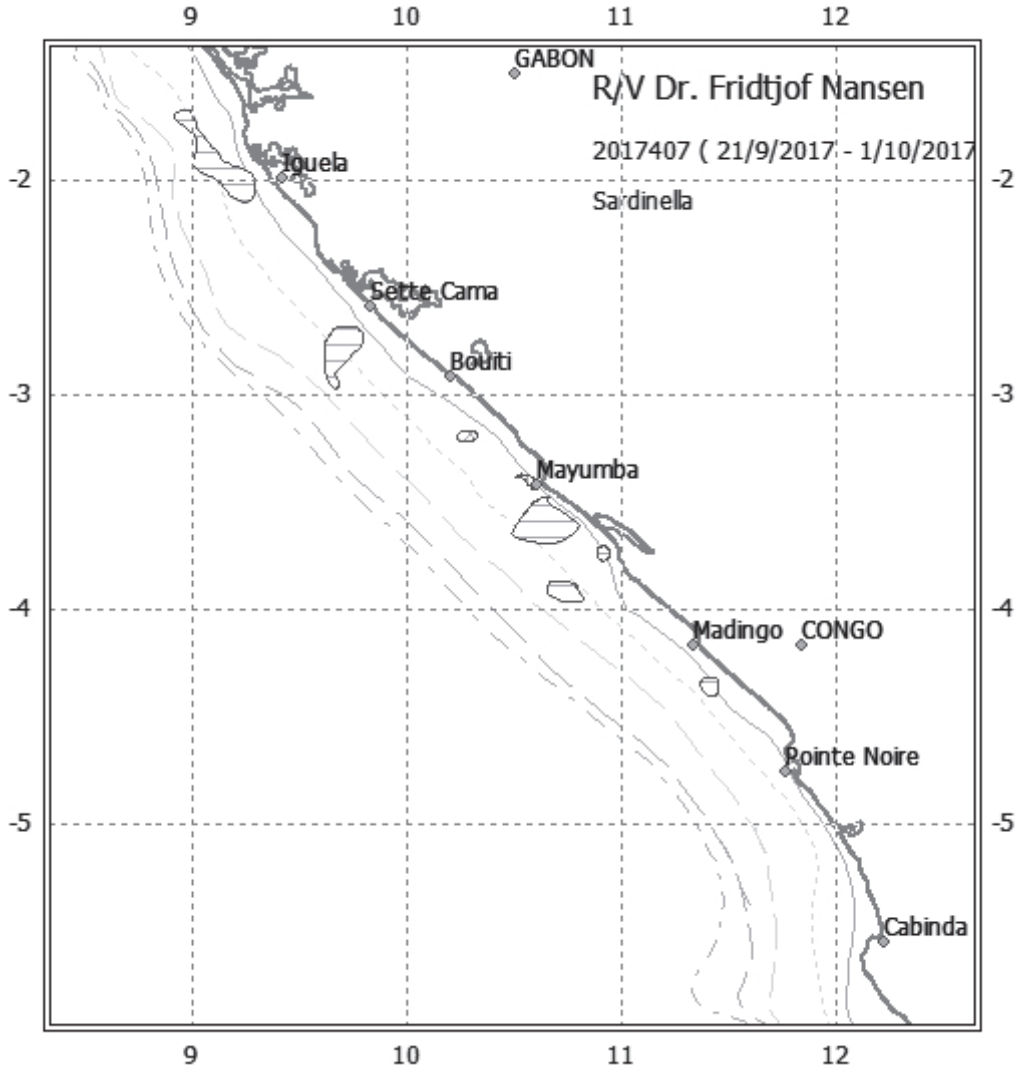


Figure 19. Distribution of sardinella off Gabon and Congo. Depth contours as in Figure 1.

4.3.4 Pelagic I fish

Ilisha africana and *Engraulis encrasicolus,* belonging to the acoustic category 'Pelagic I', were caught both in pelagic and bottom trawls at 23-115 m depth. Average catch rates for these species were 41,2 and 2,4 kg h^{-1}, respectively, with an average of 17 kg h^{-1}. However, the number of fishes in the catches were too low to establish a reliable length frequence for biomass estimation. A pooled length distribution for the species were established and the length-weight relationship coefficients *a* and *b* were estimated to 0,0022 and 3,43, respectively and used for biomass estimate purposes. A length average of 16 cm for the pelagic 1 species was used for biomass calculations.

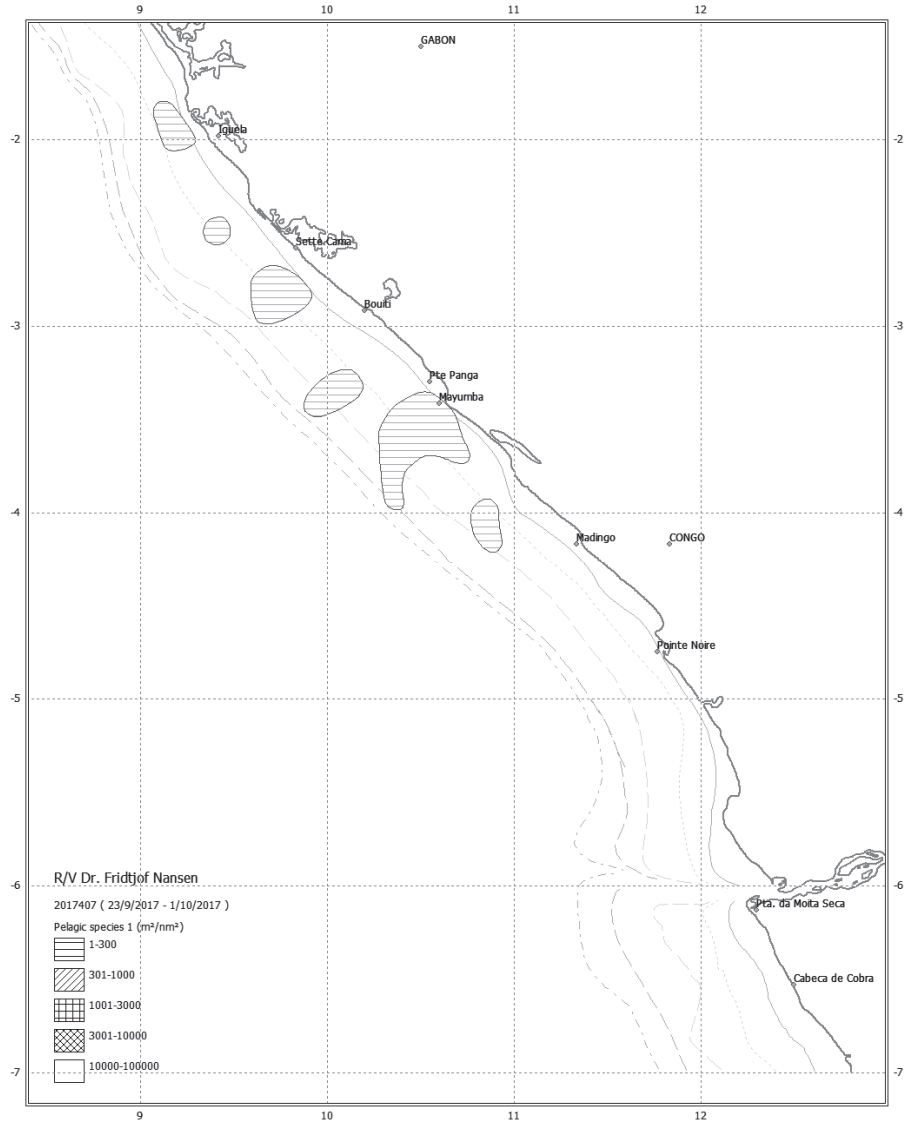


Figure 20. Distribution of Pelagic species I off Gabon and Congo. Depth contours as in Figure 1.

4.3.5 Pelagic 2 fish

Chloroscombrus chrysurus, Selene dorsalis, Sphyraena guachancho and *Trichiurus lepturus* were the most frequently caught species in the acoustic category 'Pelagic 2'. *Decapterus rhonchus, Auxis thazard* and *Sarda sarda* were also caught, although less frequently.

Chloroscombrus chrysurus, Selene dorsalis, Decapterus rhonchus and *Auxis thazard* were distributed from 24 m to 102 m depth whilst the remaining species extended their distribution from 24 m down to 296 m depth (Figure 21). Pelagic 2 species were caught in 16 trawls with an average catch rate of 6.9 kg h^{-1} for all the species in the group. The average catch rates for each individual species belonging to the Pelagic 2 group varied between 0.9 kg h^{-1} for *Sarda sarda* to 14.7 kg h^{-1} for *Trichiurus lepturus.*

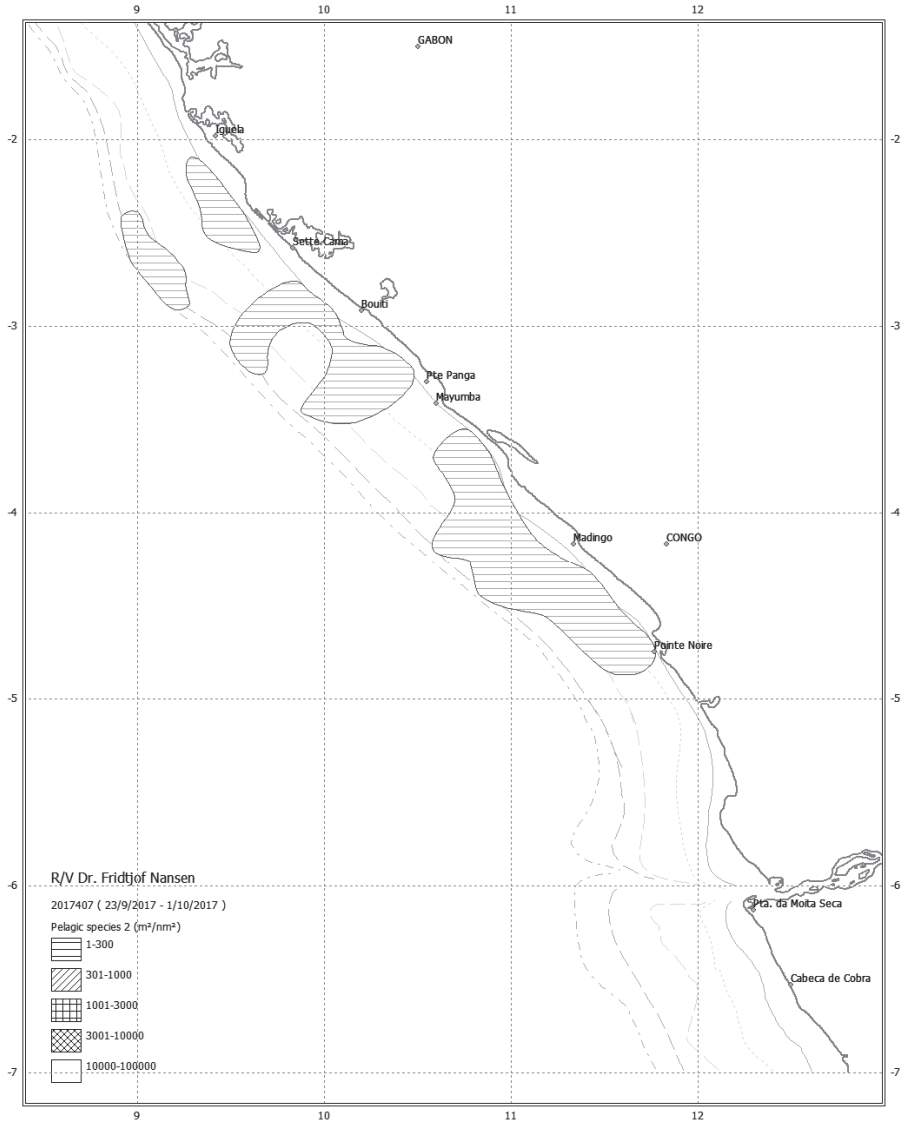


Figure 21. Distribution of Pelagic 2 species off Gabon and Congo. Depth contours as in Figure 1.

A pooled length distribution for the species included in pelagic 2 group was established and the length-weight relationship coefficients *a* and *b* were estimated to 0,00243 and 2,6691, respectively and used for biomass estimate purposes. *a* and *b* were calculated based mostly in data from *Chloroscombrus chrysurus* and *Selene dorsalis* which dominated the catches. An average length of 30 cm was used for biomass calculation purposes.

4.4 Biomass estimates

A summary of the biomass estimates is given in Table 11. Biomasses per strata and length-weight relationships obtained from the biological samples and used in the biomass estimation are provided in Annex VIII.

Table 11. Summary of biomass estimates of pelagic fish (tonnes).

Country	Sardinellas	Horse mackerel	Mackerel	Pelagic fish 1	Pelagic fish 2
Gabon-Congo	42 570	14 817	28 144	7 392	78 354

Table 12. Biomass estimates of the two sardinella species, based on catches (tonnes).

	S. aurita	*S. maderensis*
Gabon-Congo	4 819	37 752

The main species of the pelagic community in the three countries assessed were horse mackerel (*Trachurus trecae)* and Pelagic 2*,* with a biomass close to 15 000 t and 71 000 t, respectively. The biomass of sardinellas was low, just over 40 000 t. *S. maderensis* had a total biomass close to 38 000 t, whilst *S. aurita* consisted of less than 5 000 t.

CHAPTER 5. CONCLUDING REMARKS

Pelagic fish were mostly present in the northern area of the survey coverage, primarily in Gabon and northern parts of Congo. Off Congo no schools of fish or distinct acoustic recordings were observed. Most of the acoustic backscatters were attributed to the four groups: aardinella, horse mackerel, mackerel and big-eye grunt. These were recorded in waters shallower than 80 m, except for the acoustic echos assigned to horse mackerel, which could be observed at depths up to 150 m.

Very few fish of the main target groups (sardinellas, horse mackerels, and mackerel) were recorded and caught in Gabon and Congo, and hence the sample sizes are small. Most biological data and samples (including otoliths, sex, gonad maturity, stomachs, and liver) were collected for *Sardinella aurita* (60 samples) and for *Sardinella maderensis* (43 samples).

The main stocks of the two pelagic species of sardinella (*S. maderensis* and *S. aurita*) are shared between Gabon, Congo and Angola, and investigations previously carried out by the EAF-Nansen project indicate that for both stocks, more than 25% of the total abundance within this region (especially juveniles and large adults) can be found off Congo-Gabon during certain periods of the year. The main part of the commercial sardinella fishery takes place in Angola, but the two species are important for the artisanal fleet in all three countries. Previous studies strongly indicate that one of the most important spawning and nursery areas for the *S. aurita* is located off Congo and Gabon south of Cape Lopez. However, the detailed distribution of larvae and retention mechanisms involved are not well known. This information is critical to avoid negative impacts on these critical habitats, as well as for understanding the possible impacts of climate change on stock abundance. In this context, it is important to be aware that this region has very high oil related industrial activities. A large-scale oil spill or accidental release of other chemicals during the recruitment/nursery period is assumed to have potentially strong detrimental impacts on these species.

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ANNEX I. DESCRIPTION OF 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 1, new in 2017) and one 'Gisund super bottom trawl'. All trawls were used during the survey. 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.

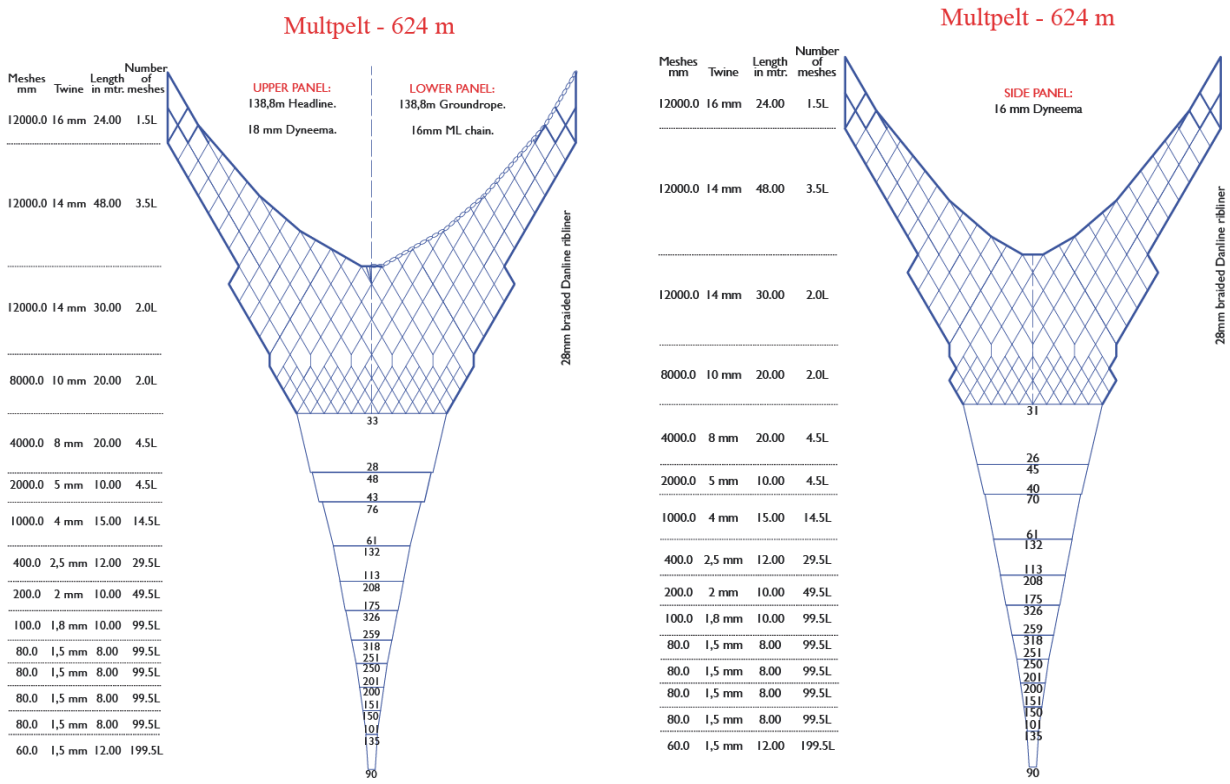
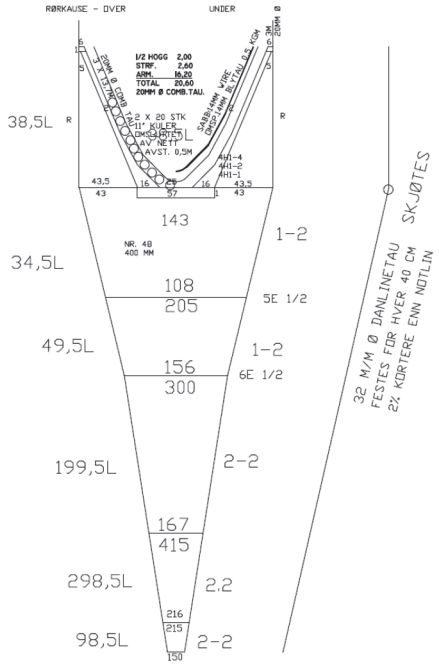


Figure 1. Schematic drawing of the MultPelt 624.

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



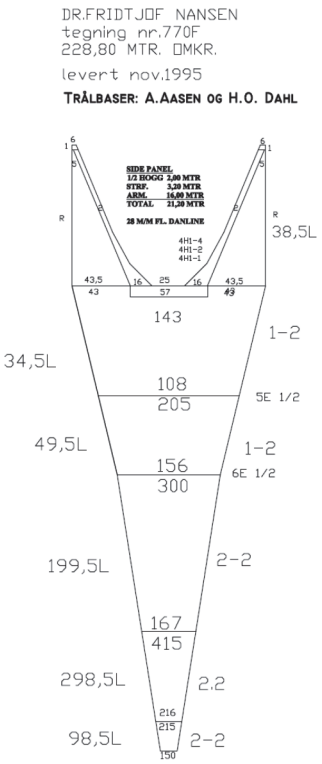


Figure 2. Schematic drawing of the small pelagic Åkratrawl.

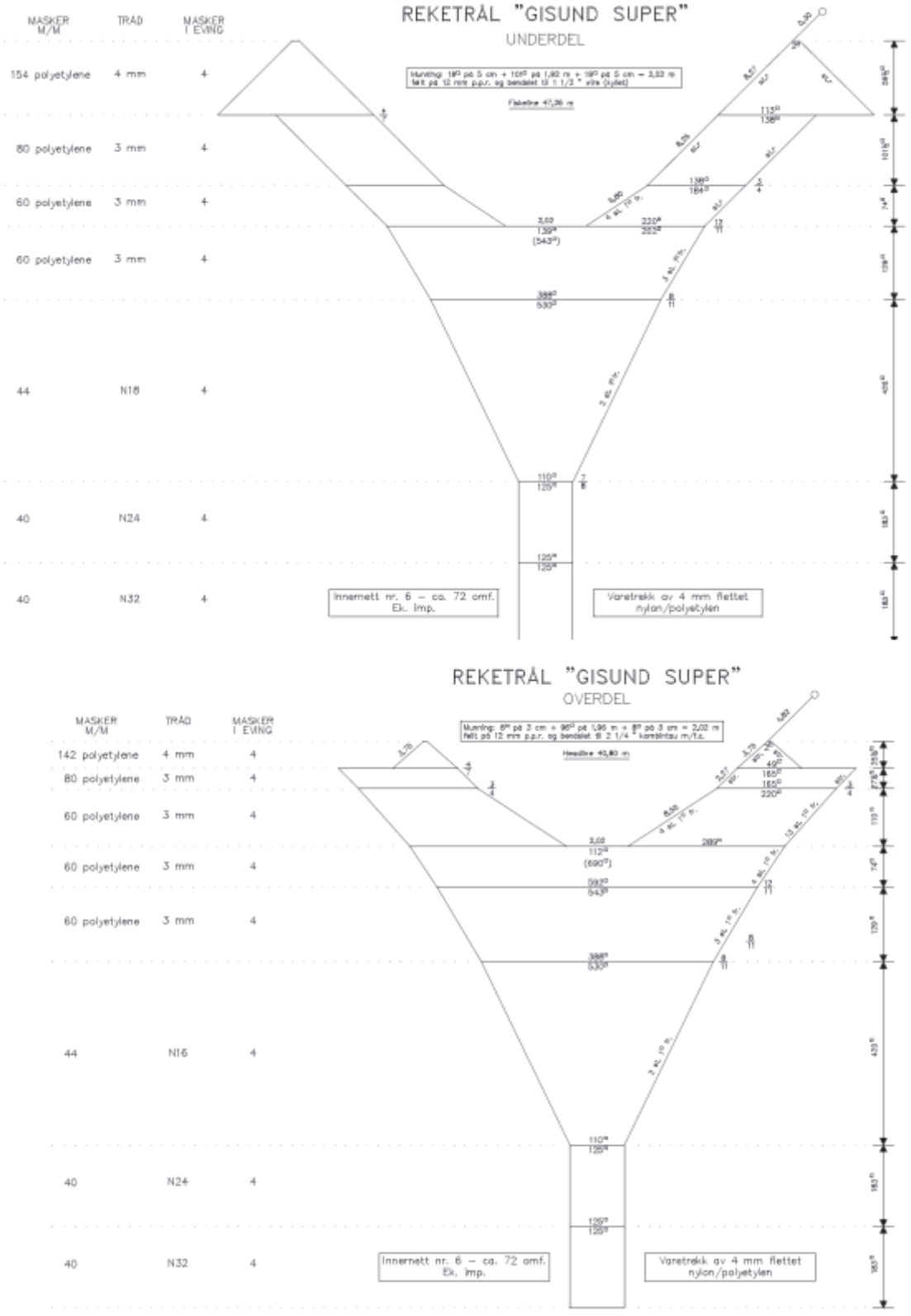


Figure 3. Schematic drawing of the Super Gisund bottom trawl.

ANNEX II. RECORDS OF FISHING STATIONS

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 1
DATE :23/09/17 GEAR TYPE: PT NO: 0 POSITION:Lat S 1°43.14
start stop duration Lon E 9°2.00
TIME :02:05:31 02:36:31 31.0 (min) Purpose : 1
LOG : 350.73 352.33 1.6 Region : 3300
FDEPTH: 46 44 Gear cond.: 0
BDEPTH: 46 44 Validity : 0
Towing dir: 0° Wire out : 160 m Speed : 2.5 kn
Sorted : 3 Total catch: 3.07 Catch/hour: 5.93

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Sardinella maderensis	2.40	56	40.46	11
Decapterus punctatus	1.53	45	25.77	10
Decapterus punctatus	0.87	155	14.68	
Caranx rhonchus	0.62	12	10.44	12
Alloteuthis africana	0.39	217	6.53	
Sardinella aurita	0.12	8	1.96	13
Engraulis encrasicolus	0.01	2	0.16	
Total	5.93		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 2
DATE :23/09/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 2°1.78
start stop duration Lon E 8°54.49
TIME :16:21:16 16:40:42 19.4 (min) Purpose : 1
LOG : 493.34 494.34 1.0 Region : 3300
FDEPTH: 102 95 Gear cond.: 0
BDEPTH: 102 95 Validity : 5
Towing dir: 0° Wire out : 260 m Speed : 3.0 kn
Sorted : 26 Total catch: 141.75 Catch/hour: 437.71

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	250.68	14369	57.27	15
Ariomma bondi	77.79	3363	17.77	
Sepia orbignyana	20.04	52	4.58	
Pagellus bellottii	14.95	8504	3.42	16
Dentex congoensis	13.93	766	3.18	14
Saurida brasiliensis	11.55	1683	2.64	
Squatina oculata	9.20	3	2.10	
Chelidonichthys gabonensis	8.15	374	1.86	
Lagocephalus laevigatus	7.81	34	1.78	
Illex coindetii	5.10	154	1.16	
Priacanthus arenatus	4.08	408	0.93	
Scomber japonicus	4.08	154	0.93	17
Fistularia petimba	3.74	19	0.85	
Sardinella aurita	2.38	120	0.54	18
Citharus linguatula	1.53	19	0.35	
Dactylopterus volitans	1.36	19	0.31	
Boops boops	0.68	34	0.16	
Grammoplites gruveli	0.68	34	0.16	
Total	437.72		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 3
DATE :23/09/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 1°54.36
start stop duration Lon E 9°4.87
TIME :20:36:22 21:06:36 30.2 (min) Purpose : 1
LOG : 535.85 536.87 1.5 Region : 3300
FDEPTH: 15 15 Gear cond.: 0
BDEPTH: 48 44 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.0 kn
Sorted : 33 Total catch: 33.00 Catch/hour: 65.50

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Sardinella maderensis	51.72	437	78.97	20
Sardinella aurita	3.53	34	5.39	19
Sphyraena guachancho	3.49	12	5.33	
Decapterus punctatus	1.79	155	2.73	
Lagocephalus laevigatus	1.75	6	2.67	
Scomberomorus tritor	1.71	2	2.61	
Selene dorsalis	0.64	6	0.97	
Alloteuthis africana	0.48	278	0.73	
Chloroscombrus chrysurus	0.16	2	0.24	
Ilisha africana ***	0.16	4	0.24	
Saurida brasiliensis	0.08	28	0.12	
Plastic	0.00	6	0.00	
Total	65.50		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 4
DATE :24/09/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 2°5.91
start stop duration Lon E 9°0.32
TIME :01:05:59 01:39:08 33.2 (min) Purpose : 1
LOG : 580.79 582.44 1.7 Region : 3300
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 146 80 Validity : 0
Towing dir: 0° Wire out : 150 m Speed : 3.0 kn
Sorted : 10 Total catch: 9.89 Catch/hour: 17.90

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Decapterus punctatus	7.57	148	42.26	21
Sardinella aurita	6.91	300	38.62	22
Scomber japonicus	1.88	54	10.52	23
Sphyraena guachancho	0.40	2	2.22	
Saurida brasiliensis	0.29	45	1.62	
Ariomma bondi	0.25	62	1.42	
Trachurus trecae	0.25	62	1.42	
Alloteuthis africana	0.22	110	1.21	
J E L L Y F I S H	0.07	2	0.40	
Unidentified	0.05	49	0.30	
Total	17.90		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 5
DATE :24/09/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 2°27.00
start stop duration Lon E 8°59.49
TIME :07:25:42 08:00:51 35.2 (min) Purpose : 1
LOG : 644.07 645.62 1.6 Region : 3300
FDEPTH: 124 136 Gear cond.: 0
BDEPTH: 124 136 Validity : 0
Towing dir: 0° Wire out : 320 m Speed : 3.0 kn
Sorted : 60 Total catch: 1005.24 Catch/hour: 1715.91

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Boops boops	674.97	52291	39.34	
Spicara alta	273.87	50376	15.96	
Dentex congoensis	224.60	221469	13.09	25
Scomber japonicus	193.84	25652	11.30	24
Ariomma bondi	192.68	75477	11.23	
CAPROIDAE	118.40	66104	6.90	
Priacanthus arenatus	12.19	522	0.71	
Sepia sp.	9.29	116	0.54	
Squatina oculata	4.40	2	0.26	
Trachurus trecae	3.48	58	0.20	26
Sarda sarda	2.25	5	0.13	27
Torpedo torpedo	1.84	3	0.11	
Chelidonichthys gabonensis	1.74	189	0.10	
Fistularia petimba	0.92	3	0.05	
Raja miraletus	0.85	2	0.05	
Illex coindetii	0.58	29	0.03	
Total	1715.91		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 6
DATE :24/09/17 GEAR TYPE: PT NO: 7 POSITION:Lat S 2°8.54
start stop duration Lon E 9°20.46
TIME :12:29:57 13:02:52 32.9 (min) Purpose : 1
LOG : 694.77 696.37 1.6 Region : 3300
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 21 19 Validity : 0
Towing dir: 0° Wire out : 160 m Speed : 3.0 kn
Sorted : 4 Total catch: 4.38 Catch/hour: 7.98

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Scomberomorus tritor	7.33	7	91.78	28
Jellyfish	0.62	2	7.76	
Sepiella ornata	0.04	18	0.46	
Total	7.98		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 7
DATE :24/09/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 2°34.49
start stop duration Lon E 9°3.49
TIME :17:33:17 18:06:12 32.9 (min) Purpose : 1
LOG : 745.31 746.69 1.4 Region : 3300
FDEPTH: 118 119 Gear cond.: 0
BDEPTH: 118 119 Validity : 0
Towing dir: 0° Wire out : 340 m Speed : 2.8 kn
Sorted : 37 Total catch: 81.24 Catch/hour: 148.07

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Spicara alta	50.81	605	34.32	
Chelidonichthys gabonensis	25.08	157	16.94	
Sepia orbignyana	14.07	281	9.50	
Dentex congoensis	12.69	26	8.57	29
Illex coindetii	6.12	55	4.14	
Umbrina canariensis	5.91	16	3.99	
Ariomma bondi	5.03	11	3.40	
Boops boops	4.08	222	2.76	
Scomber japonicus	4.08	11	2.76	33
Small shrimps	4.08	146	2.76	
Raja straeleni	2.99	2	2.02	
Dentex angolensis	2.41	18	1.62	31
Pagellus bellottii	1.97	26	1.33	30
Raja miraletus	1.90	7	1.28	
Zeus faber	1.75	4	1.18	
Priacanthus arenatus	1.39	7	0.94	
Scomberomorus tritor	1.17	2	0.79	
Fistularia petimba	0.62	2	0.42	
Scorpaena sp.	0.58	4	0.39	
Trachurus trecae	0.44	11	0.30	32
Sepia sp.	0.36	4	0.25	
Citharus linguatula	0.15	11	0.10	
Erythrocles monodi	0.15	4	0.10	
Trachinus sp.	0.15	7	0.10	
Saurida brasiliensis	0.07	11	0.05	
Arnoglossus imperialis	0.04	11	0.02	
Plastic	0.00	4	0.00	
Total	148.07		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 8
DATE :24/09/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 2°40.00
start stop duration Lon E 9°10.63
TIME :21:48:28 22:18:41 30.2 (min) Purpose : 1
LOG : 787.84 789.26 1.4 Region : 3300
FDEPTH: 15 15 Gear cond.: 0
BDEPTH: 94 87 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 2.8 kn
Sorted : 10 Total catch: 9.84 Catch/hour: 19.54

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Scomber japonicus	11.08	522	56.71	34
Engraulis encrasicolus	3.38	441	17.28	36
Cypselurus melanurus	2.10	10	10.77	
Lagocephalus laevigatus	1.85	6	9.45	
Trachurus trecae	0.71	115	3.66	35
Ariomma bondi	0.28	10	1.42	
Cypselurus cyanopterus ***	0.08	4	0.41	
Saurida brasiliensis	0.04	12	0.20	
Sardinella aurita	0.02	2	0.10	
Total	19.54		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 9
DATE :25/09/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 2°29.01
start stop duration Lon E 9°23.48
TIME :00:27:20 01:00:26 33.1 (min) Purpose : 1
LOG : 814.30 815.96 1.6 Region : 3300
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 46 53 Validity : 0
Towing dir: 0° Wire out : 150 m Speed : 3.1 kn
Sorted : 2 Total catch: 22.60 Catch/hour: 40.97

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Decapterus punctatus	18.31	2144	44.69	
Sphyraena guachancho	6.16	22	15.04	
Euthynnus alletteratus	5.00	4	12.21	
Decapterus rhonchus**	4.97	24	12.12	37
Jellyfish	2.25	13	5.49	
Trachinotus ovatus	0.91	2	2.21	
Alloteuthis africana	0.73	321	1.77	
Scomber japonicus	0.62	2	1.50	
Apogon sp.	0.62	42	1.50	
Engraulis encrasicolus	0.54	228	1.33	
Selene dorsalis	0.47	2	1.15	
Boops boops	0.40	100	0.97	
Total	40.97		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 10
DATE :25/09/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 2°48.81
start stop duration Lon E 9°15.15
TIME :09:53:44 10:15:22 21.6 (min) Purpose : 1
LOG : 881.34 882.64 1.3 Region : 3300
FDEPTH: 111 113 Gear cond.: 0
BDEPTH: 111 113 Validity : 0
Towing dir: 0° Wire out : 310 m Speed : 2.4 kn
Sorted : 147 Total catch: 639.00 Catch/hour: 1772.54

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Scomber japonicus	1143.86	39495	64.53	38
Trachurus trecae	281.00	38139	15.85	40
Spicara alta	167.27	12696	9.44	
Dentex congoensis	71.84	4677	4.05	39
Ariomma bondi	57.17	4011	3.23	
Saurida brasiliensis	18.59	2571	1.05	
Rhinobatos albomaculatus	7.99	3	0.45	
Lagocephalus laevigatus	4.66	6	0.26	
Torpedo torpedo	4.58	8	0.26	
Trigla lyra	4.52	191	0.26	
Boops boops	4.30	252	0.24	
Illex coindetii	2.86	166	0.16	
Fistularia petimba	1.66	6	0.09	
Sepia orbignyana	1.44	11	0.08	
Antigonia capros	0.72	58	0.04	
Raja miraletus	0.33	6	0.02	
Total	1772.79		100.01	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 11
DATE :25/09/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 2°53.22
start stop duration Lon E 9°27.00
TIME :16:29:10 16:55:54 26.7 (min) Purpose : 1
LOG : 916.83 918.32 1.5 Region : 3300
FDEPTH: 104 106 Gear cond.: 0
BDEPTH: 104 106 Validity : 0
Towing dir: 0° Wire out : 290 m Speed : 2.9 kn
Sorted : 28 Total catch: 119.03 Catch/hour: 267.19

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	101.40	22310	37.95	42
Scomber japonicus	56.68	2889	21.21	41
Lagocephalus laevigatus	43.77	105	16.38	
Fistularia petimba	19.66	49	7.36	
Ariomma bondi	16.05	483	6.01	
Pagellus bellottii	5.98	117	2.24	44
Dentex congoensis	5.11	227	1.91	45
Chelidonichthys gabonensis	4.67	153	1.75	
Priacanthus arenatus	3.21	22	1.20	
Engraulis encrasicolus	3.06	460	1.15	46
Saurida brasiliensis	2.33	438	0.87	
Boops boops	1.90	132	0.71	
Sepia sp.	1.75	16	0.66	
Illex coindetii	1.31	74	0.49	
Sardinella aurita	0.15	7	0.05	
Zeus faber	0.15	7	0.05	
Total	267.18		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 12
DATE :25/09/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 2°52.95
start stop duration Lon E 9°44.42
TIME :22:37:15 23:07:22 30.1 (min) Purpose : 1
LOG : 1029.77 1031.55 1.8 Region : 3300
FDEPTH: 15 15 Gear cond.: 0
BDEPTH: 53 58 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.5 kn
Sorted : 0 Total catch: 5.76 Catch/hour: 11.47

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
JELLYFISH	4.62	22	40.28	
Trachurus trecae	2.15	673	18.75	
Sphyraena guachancho	1.39	6	12.15	
Decapterus punctatus	1.00	120	8.68	
Engraulis encrasicolus	1.00	271	8.68	
Alloteuthis africana	0.56	291	4.86	
Saurida brasiliensis	0.40	155	3.47	
Sardinella aurita	0.20	38	1.74	
Scomber japonicus	0.16	6	1.39	
Total	11.47		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 13
DATE :26/09/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 3°12.69
start stop duration Lon E 9°39.04
TIME :04:44:52 05:14:57 30.1 (min) Purpose : 1
LOG : 1072.19 1074.01 1.8 Region : 3300
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 119 114 Validity : 0
Towing dir: 0° Wire out : 145 m Speed : 3.6 kn
Sorted : 0 Total catch: 0.00 Catch/hour: 0.00

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
NOCATCH	0.00	0	0.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 14
DATE :26/09/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 3°3.99
start stop duration Lon E 10°2.31
TIME :11:34:05 11:57:04 23.0 (min) Purpose : 1
LOG : 1120.79 1122.03 1.2 Region : 3300
FDEPTH: 41 43 Gear cond.: 0
BDEPTH: 41 43 Validity : 0
Towing dir: 0° Wire out : 200 m Speed : 3.2 kn
Sorted : 141 Total catch: 140.91 Catch/hour: 367.91

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Decapterus punctatus	61.57	10616	16.73	48
Lutjanus fulgens	61.04	112	16.59	
Dentex gibbosus	44.80	133	12.18	
J E L L Y F I S H	36.19	157	9.84	
Pomadasys incisus	36.03	154	9.79	
Lutjanus goreensis	23.50	3	6.39	
J E L L Y F I S H	20.78	91	5.65	0
Sardinella aurita	19.84	1070	5.39	47
Boops boops	16.66	144	4.53	
Drepane africana	8.62	13	2.34	
Pseudotolithus senegalensis	7.26	3	1.97	
Selene dorsalis	6.63	29	1.80	
Alloteuthis africana	4.49	1441	1.22	
Sphyraena guachancho	3.55	5	0.97	
Galeoides decadactylus	3.39	8	0.92	
Fistularia petimba	2.92	5	0.79	
Pomadasys jubelini	2.14	3	0.58	
Chloroscombrus chrysurus	1.80	47	0.49	
Elops senegalensis	1.67	3	0.45	
Dentex canariensis	1.46	3	0.40	
Trachurus trecae	1.25	131	0.34	49
Pagellus bellottii	0.94	8	0.26	
Alectis alexandrinus	0.89	3	0.24	
Brachydeuterus auritus	0.47	5	0.13	
Total	367.91		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 15
DATE :26/09/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 3°19.36
start stop duration Lon E 9°44.27
TIME :15:33:07 15:59:33 26.4 (min) Purpose : 1
LOG : 1150.62 1151.97 1.4 Region : 3300
FDEPTH: 132 128 Gear cond.: 0
BDEPTH: 132 128 Validity : 0
Towing dir: 0° Wire out : 370 m Speed : 3.1 kn
Sorted : 64 Total catch: 4010.86 Catch/hour: 9105.24

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Scomber japonicus	5250.26	175008	57.66	50
Spicara alta	2421.68	18640	26.60	
Umbrina canariensis	480.91	570	5.28	
Zenopsis conchifer	273.19	284	3.00	
Zeus faber	239.05	427	2.63	
Boops boops	145.13	2134	1.59	
Dentex congoensis	91.06	854	1.00	51
Ariomma bondi	71.15	2134	0.78	
Antigonia capros	37.00	1137	0.41	
Invertebrate	31.31	143	0.34	
Sphoeroides pachygaster	28.47	143	0.31	
Mustelus mustelus	18.71	7	0.21	
Trachurus trecae	11.37	143	0.12	
Heptranchias perlo	5.99	2	0.07	
Total	9105.27		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 16
DATE :26/09/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 3°14.56
start stop duration Lon E 10°10.36
TIME :20:59:19 21:29:44 30.4 (min) Purpose : 1
LOG : 1195.12 1196.80 1.7 Region : 3300
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 47 44 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.3 kn
Sorted : 29 Total catch: 29.29 Catch/hour: 57.77

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Decapterus punctatus	16.80	5383	29.09	
Sardinella aurita	11.52	1181	19.94	
J E L L Y F I S H	7.81	18	13.52	
Unid. juvenile fishes	4.64	4475	8.02	
Engraulis encrasicolus	3.93	892	6.79	
Ilisha africana ***	3.83	79	6.62	55
Trachurus trecae	2.13	704	3.69	
Sphyraena guachancho	2.01	8	3.48	
Alloteuthis africana	1.60	606	2.77	
Brachydeuterus auritus	1.22	37	2.12	
Scomberomorus tritor	0.95	2	1.64	
Scomber japonicus	0.59	3	1.02	52
Sardinella maderensis	0.43	2	0.75	
Sepia orbignyana	0.32	2	0.55	
Total	57.77		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 17
DATE :26/09/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 3°9.75
start stop duration Lon E 10°16.35
TIME :22:52:32 23:11:05 18.6 (min) Purpose : 1
LOG : 1205.10 1206.13 1.0 Region : 3300
FDEPTH: 5 5 Gear cond.: 0
BDEPTH: 30 31 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.3 kn
Sorted : 9 Total catch: 1000.00 Catch/hour: 3234.50

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Sardinella maderensis	2995.34	42097	92.61	57
Sardinella aurita	143.81	3564	4.45	56
Chloroscombrus chrysurus	94.64	1168	2.93	
Loligo vulgaris	0.71	61	0.02	
Total	3234.50		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 18
DATE :27/09/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 3°34.10
start stop duration Lon E 9°59.53
TIME :08:06:13 08:37:09 30.9 (min) Purpose : 1
LOG : 1260.61 1262.16 1.6 Region : 3300
FDEPTH: 121 120 Gear cond.: 0
BDEPTH: 121 120 Validity : 0
Towing dir: 0° Wire out : 300 m Speed : 3.0 kn
Sorted : 0 Total catch: 104.44 Catch/hour: 202.60

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
PORIFERA (Sponges)	66.77	239	32.96	
Scomber japonicus	55.83	2099	27.56	60
Dentex congoensis	34.49	904	17.02	59
Spicara alta	15.83	846	7.81	
Ariomma bondi	13.42	500	6.63	
Zeus faber	4.50	0	2.22	
Mustelus mustelus	3.06	2	1.51	
Squalus cf. mistukurii	2.83	2	1.40	
Illex coindetii	2.21	114	1.09	
Sepia orbignyana	1.59	14	0.79	
Dentex angolensis	1.24	4	0.61	
Trachurus trecae	0.47	8	0.23	61
Chelidonichthys gabonensis	0.27	10	0.13	
Citharus linguatula	0.08	6	0.04	
Total	202.60		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 19
DATE :27/09/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 3°44.83
start stop duration Lon E 10°20.50
TIME :23:31:10 23:59:55 28.8 (min) Purpose : 1
LOG : 1373.59 1375.03 1.4 Region : 3300
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 100 104 Validity : 0
Towing dir: 0° Wire out : 150 m Speed : 3.0 kn
Sorted : 1 Total catch: 16.93 Catch/hour: 35.32

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Saurida brasiliensis	8.60	3101	24.34	
Engraulis encrasicolus	7.30	929	20.68	63
Invertebrate	5.43	58	15.36	
Trachurus trecae	3.80	584	10.75	62
Scomber japonicus	2.75	104	7.80	64
Trichiurus lepturus	2.63	8	7.44	
Echeneis naucrates	2.50	4	7.09	
Lagocephalus laevigatus	1.13	2	3.19	
Cypselurus melanurus	0.88	2	2.48	
Priacanthus arenatus	0.17	6	0.47	
Ariomma bondi	0.08	17	0.24	
Sardinella aurita	0.04	2	0.12	
Selene dorsalis	0.01	6	0.04	
Total	35.32		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 20
DATE :28/09/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 3°37.02
start stop duration Lon E 10°43.08
TIME :08:15:11 08:44:47 29.6 (min) Purpose : 1
LOG : 1432.89 1434.57 1.7 Region : 3300
FDEPTH: 35 38 Gear cond.: 0
BDEPTH: 35 38 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.4 kn
Sorted : 180 Total catch: 180.42 Catch/hour: 365.71

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
J E L L Y F I S H	209.59	142	57.31	
Brachydeuterus auritus	56.51	8507	15.45	
Chloroscombrus chrysurus	23.15	278	6.33	72
Ilisha africana ***	16.42	414	4.49	67
Sphyraena sphyraena	7.42	85	2.03	
Galeoides decadactylus	7.18	97	1.96	
Pomadasys incisus	6.36	30	1.74	
Sphoeroides marmoratus	4.38	2	1.20	
Selene dorsalis	4.34	296	1.19	69
Sardinella maderensis	3.81	26	1.04	66
Elops lacerta	3.41	10	0.93	
Pseudupeneus prayensis	3.28	30	0.90	
Sepia sp.	2.80	2	0.76	
Carlarius parkii	2.59	6	0.71	
Pseudotolithus senegalensis	2.59	4	0.71	
Auxis sp.	2.19	2	0.60	
Chloroscombrus chrysurus, juvenile	1.70	0	0.47	
Panulirus regius	1.07	2	0.29	
Pagellus bellottii	1.05	93	0.29	
Trachurus trecae	0.97	371	0.27	68
Balistes punctatus	0.89	2	0.24	
Trichiurus lepturus	0.77	10	0.21	
Pteroscion peli	0.73	14	0.20	
Lagocephalus laevigatus	0.73	4	0.20	
Sardinella aurita	0.53	63	0.14	65
Drepane africana	0.41	2	0.11	
Stromateus fiatola	0.24	2	0.07	
Epinephelus aeneus	0.20	2	0.06	
Decapterus rhonchus**	0.16	57	0.04	73
Trachinocephalus myops	0.12	2	0.03	
Scomber japonicus	0.08	2	0.02	
Engraulis encrasicolus	0.01	6	0.00	
Total	365.71		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 21
DATE :28/09/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 3°54.78
start stop duration Lon E 10°42.89
TIME :13:30:54 13:52:54 22.0 (min) Purpose : 1
LOG : 1470.51 1471.71 1.2 Region : 3300
FDEPTH: 70 70 Gear cond.: 0
BDEPTH: 70 70 Validity : 0
Towing dir: 0° Wire out : 195 m Speed : 3.3 kn
Sorted : 144 Total catch: 144.49 Catch/hour: 394.06

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	138.11	19410	35.05	74
Dasyatis centroura	109.09	3	27.68	
Engraulis encrasicolus	38.29	7129	9.72	94
Dentex angolensis	30.65	147	7.78	
Pagellus bellottii	19.31	194	4.90	
J E L L Y F I S H	18.11	11	4.60	
Selene dorsalis	12.87	46	3.27	
Sardinella aurita	5.95	55	1.51	75
Brachydeuterus auritus	5.35	387	1.36	
Saurida brasiliensis	5.29	1083	1.34	
Sepia orbignyana	2.62	3	0.66	
Brotula barbata	2.40	3	0.61	
Pseudupeneus prayensis	1.91	22	0.48	
Lagocephalus laevigatus	1.91	5	0.48	
Carlarius parkii	0.82	3	0.21	
Alloteuthis africana	0.60	0	0.15	
Trigla lyra	0.27	3	0.07	
Illex coindetii	0.22	11	0.06	
Boops boops	0.16	11	0.04	
Bembrops heterurus	0.11	8	0.03	
Hemicaranx bicolor	0.05	3	0.01	
Scorpaena sp.	0.01	3	0.00	
Total	394.10		100.01	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 22
DATE :28/09/17 GEAR TYPE: PT NO: 1 POSITION:Lat S 4°12.40
start stop duration Lon E 10°34.39
TIME :18:32:20 19:02:59 30.7 (min) Purpose : 1
LOG : 1509.91 1511.66 1.7 Region : 3300
FDEPTH: 95 100 Gear cond.: 0
BDEPTH: 292 299 Validity : 0
Towing dir: 0° Wire out : 280 m Speed : 3.4 kn
Sorted : 21 Total catch: 27.72 Catch/hour: 54.26

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Unid. juvenile fishes	33.85	201283	62.37	
Invertebrate	8.38	57	15.44	
Small shrimps	3.18	5744	5.86	
Synagrops microlepis	2.58	123	4.76	
Trichiurus lepturus	2.39	795	4.40	
Unidentified	2.27	110	4.18	
Small squids	1.24	354	2.28	
Merluccius polli	0.23	2	0.43	
Scomber japonicus	0.12	2	0.22	
Parexocoetus hillianus	0.03	2	0.06	
Total	54.27		100.01	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 23
DATE :29/09/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 4°3.47
start stop duration Lon E 10°59.95
TIME :00:42:50 01:13:03 30.2 (min) Purpose : 1
LOG : 1551.27 1552.73 1.5 Region : 3300
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 42 51 Validity : 0
Towing dir: 0° Wire out : 145 m Speed : 2.9 kn
Sorted : 7 Total catch: 103.99 Catch/hour: 206.47

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Mobula sp.	49.64	2	24.04	
Brachydeuterus auritus	36.21	993	17.54	
Ilisha africana ***	30.14	608	14.60	80
Sphyraena sphyraena	22.67	42	10.98	
Scomberomorus tritor	17.39	12	8.42	81
Trichiurus lepturus	17.15	91	8.31	
JELLYFISH	9.61	6	4.65	
Sardinella maderensis	7.03	48	3.40	77
Selene dorsalis	3.10	91	1.50	
Chloroscombrus chrysurus	2.90	28	1.40	
JELLYFISH	2.62	2	1.27	0
Lagocephalus laevigatus	2.03	6	0.98	
Elops lacerta	1.63	4	0.79	
Trachinotus ovatus	1.55	6	0.75	
Stromateus fiatola	0.91	6	0.44	
Sarda sarda	0.79	2	0.38	
Pteroscion peli	0.40	10	0.19	
Sepia hieredda**	0.24	22	0.12	
Trachurus trecae	0.16	2	0.08	
Sardinella aurita	0.16	4	0.08	
Remora australis	0.05	2	0.03	
Remora remora	0.05	4	0.03	
Decapterus punctatus	0.04	10	0.02	
Total	206.47		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 24
DATE :29/09/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 4°6.67
start stop duration Lon E 11°11.09
TIME :15:59:40 16:30:03 30.4 (min) Purpose : 1
LOG : 1642.64 1644.27 1.6 Region : 3400
FDEPTH: 23 24 Gear cond.: 0
BDEPTH: 23 24 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.2 kn
Sorted : 56 Total catch: 463.00 Catch/hour: 914.42

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Brachydeuterus auritus	400.94	31331	43.85	
Ilisha africana ***	220.35	8970	24.10	82
Selene dorsalis	50.22	1685	5.49	83
Trichiurus lepturus	46.75	480	5.11	
Sphyraena guachancho	29.35	91	3.21	
Parapenaeus longirostris	25.83	3223	2.83	
Chloroscombrus chrysurus	18.58	290	2.03	84
Alectis alexandrinus	14.42	4	1.58	
Callinectes pallidus	11.18	34	1.22	
Sphyrna lewini	10.74	16	1.17	
Pseudotolithus typus	10.59	51	1.16	
Stromateus fiatola	10.45	160	1.14	
Lagocephalus laevigatus	9.58	43	1.05	
Pentanemus quinquarius	7.54	203	0.83	
Galeoides decadactylus	7.27	20	0.79	
Sepia hieredda**	7.27	334	0.79	
Scomberomorus tritor	6.91	8	0.76	
Pisodonophis semicinctus	6.24	30	0.68	
Cynoglossus senegalensis	5.53	24	0.60	
Sepia hieredda**	3.87	2	0.42	0
Rhinobatos rhinobatos	3.12	2	0.34	
Pteroscion peli	2.90	203	0.32	
Sardinella maderensis	2.03	14	0.22	
Panulirus regius	1.03	6	0.11	
Stromateus fiatola	0.75	2	0.08	0
Selar crumenophthalmus	0.67	2	0.07	
Carcharhinus sp.	0.59	2	0.06	
Total	914.71		100.03	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 25
DATE :30/09/17 GEAR TYPE: PT NO: 4 POSITION:Lat S 4°32.81
start stop duration Lon E 11°8.13
TIME :00:45:23 01:15:12 29.8 (min) Purpose : 1
LOG : 1705.27 1706.93 1.7 Region : 3400
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 114 115 Validity : 0
Towing dir: 0° Wire out : 150 m Speed : 3.4 kn
Sorted : 1 Total catch: 65.09 Catch/hour: 130.97

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Invertebrate	79.94	0	61.04	
Trichiurus lepturus	28.05	72	21.42	
Lagocephalus laevigatus	10.38	26	7.93	
Saurida brasiliensis	8.69	477	6.64	
Echeneis naucrates	2.29	4	1.75	
Engraulis encrasicolus	1.53	189	1.17	87
Trachurus trecae	0.08	18	0.06	86
Total	130.97		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2017407 STATION: 26
DATE :30/09/17 GEAR TYPE: BT NO: 2 POSITION:Lat S 4°24.09
start stop duration Lon E 11°26.63
TIME :07:33:06 08:03:13 30.1 (min) Purpose : 1
LOG : 1749.79 1751.56 1.8 Region : 3400
FDEPTH: 26 24 Gear cond.: 0
BDEPTH: 26 24 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.5 kn
Sorted : 116 Total catch: 476.40 Catch/hour: 949.00

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Brachydeuterus auritus	314.60	12386	33.15	0
Ilisha africana ***	220.32	12365	23.22	90
Trichiurus lepturus	107.57	1116	11.34	
Lagocephalus laevigatus	93.92	223	9.90	
Chloroscombrus chrysurus	32.85	618	3.46	88
Argyrosomus hololepidotus	26.73	2	2.82	
Sphyraena sphyraena	25.50	68	2.69	
Carlarius parkii	20.80	44	2.19	
Galeoides decadactylus	19.16	104	2.02	
Selene dorsalis	19.16	261	2.02	89
Pteroscion peli	17.09	528	1.80	
Pseudotolithus senegallus	10.04	30	1.06	
J E L L Y F I S H	9.40	4	0.99	
Sphyrna lewini	5.78	8	0.61	
Rhizoprionodon acutus	5.18	2	0.55	
Cynoglossus senegalensis	4.31	8	0.45	
Chaetodipterus lippei	3.57	8	0.38	
Sardinella maderensis	2.93	22	0.31	91
Callinectes pallidus	2.91	10	0.31	
Parapenaeus longirostris	2.23	207	0.23	
Drepane africana	1.64	8	0.17	
Panulirus regius	1.08	4	0.11	
Pentanemus quinquarius	0.74	22	0.08	
Stromateus fiatola	0.59	8	0.06	
Pisodonophis semicinctus	0.40	2	0.04	
Penaeus notialis	0.36	4	0.04	
Trachurus trecae	0.15	14	0.02	92
Total	949.00		100.	

ANNEX III. BIOLOGY SCALES

Stages for classification of 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

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

List of biological samples collected

Station	Species	Length/Weight	Biology (sex, maturity & stomach fullness)	Liver samples frozen	Stomach samples frozen	Gonad weight	Stomach weight	Otoliths collected	Fin clips preserved and frozen	Frozen individuals	Jellyfish genetics	Jellyfish formalin
1	Sardinella maderensis	29	29	29	29			4	15			
2	Trachurus trecae	30										
2	Sardinella aurita	7								7		
2	Scomber japonicus	9								9		
3	Sardinella aurita	17	17	17	17	17	17	2	17			
3	Sardinella maderensis	100	30	30	30	20	30	5	15			
3	Trachurus trecae									10		
4	Scomber japonicus	30	30	30	30	30	30		15			
4	Sardinella aurita	30	30	30	30	30	30	5	15	10		
4	Decapterus punctatus	82										
4	Mesopelagic sp. A									27		
5	Scomber japonicus	52	30	30	30	30	30		30	25		
5	Trachurus trecae	2										
5	Sarda sarda	3										
5	Dentex congolensis	58										
6	Scomberomeus tritor	4										
6	Trachurus trecae	3										
7	Dentex congolensis	50										
7	Dentex angolensis	5										
7	Pagellus belotti	7										
8	Trachurus trecae	59										
8	Engraulis encrasicolus	100								10		
8	Scomber japonicus	100	30	30	30	30	30		15			

Station	Species	Length/Weight	Biology (sex, maturity & stomach fullness)	Liver samples frozen	Stomach samples frozen	Gonad weight	Stomach weight	Otoliths collected	Fin clips preserved and frozen	Frozen individuals	Jellyfish genetics	Jellyfish formalin
9	Decapterus rhonchus	12										
10	Scomber japonicus	168								25		
10	Trachurus trecae	193								25		
11	Scomber japonicus	100										
11	Engraulis encrasicolus	34										
11	Trachurus trecae	45										
14	Trachurus trecae	50							30	25		
14	Sardinella aurita	100							30	25		
14	Jellyfish sp. A										5	5
14	Jellyfish sp. B										5	5
14	Decapterus punctatus	100										
15	Scomber japonicus	98										
16	Scomber japonicus	13										
16	Ilisha africana	39										
17	Sardinella aurita	100	30	30	30	30	30	5	15			
17	Sardinella maderensis	100	30	30	30	30	30	5	15			
18	Scomber japonicus	100							30	25		
19	Trachurus trecae	60										
19	Engraulis encrasicolus	90										
19	Scomber japonicus	50										
20	Sardinella aurita	31							30	20		
20	Trachurus trecae	84							30	25		
20	Sardinella maderensis	13	13	13	13	13	13	5	13			

ANNEX VI. SCRUTINISATION OF ACOUSTIC BACKSCATTER FROM SARDINELLA

Scrutinisation of the acoustic backscatter is especially challenging in tropical waters, largely due to the high diversity of pelagic organisms, including plankton, masking the fish scatters. As described in the main body of this report, while not a perfect method, the s_V threshold was adjusted to filter out plankton.

Few trawl hauls taken during the day successfully sampled the targeted fish, primarily because densely shoaling pelagic fish are particularly adept at avoiding the trawl net. This was further complicated when one of the trawl winches failed, meaning that from the 2nd August it was not possible to use the large pelagic trawl (Multpelt) on this leg. This was the only net that was somewhat successful at catching these fish, eventhough it could only be used in waters deeper than about 50 m due to its size. The mix of pelagic species in the night trawl hauls made scrutinisation even more difficult.

In most night-time situations, the backscatter was identified based on the trawl catch of the nearest trawl or a trawl from a similar depth on an adjacent or nearby transect. The following criteria were used during scrutinisation:

Day

As became obvious during this survey, and which seems to be the trend for sardinella surveys elsewhere, few sardinella were caught during the day. From night-time trawls in the same vicinity, combined with the experience of the on-board scientists, all dense schools encountered during the day were confidently identified as sardinella.

Night

Several trawls targeting dispersed shoals in areas where sardinella-like schools had been recorded during the day, caught a mixture of sardinella and other pelagic species.

ANNEX VII. CRITICAL PARAMETERS USED TO ESTIMATE ABUNDANCE

Sardinellas

Sardinellas: strata area and mean SA

Stratum	Area	Mean SA
1	172.4344	205.833
2	106.9836	192
3	14.6657	6057
4	150.6452	154.438
5	12.1013	1257
6	11.7471	109
7	43.9337	132
8	20.9357	281

Sardinellas: parameters Length-Weight relationship

	S. aurita	*S. madeirensis*
L-W factor a	0.0046	0.0047
L-W factor b	3.1855	3.2095
r^2	0.9761	0.9767

Horse mackerel

Horse mackerel: strata area and mean SA

Stratum	Area	Mean SA
1	2230.73	89.16
2	119.1994	108.50
3	331.8879	51.25
4	376.5212	64.00
5	15.9168	651.00
6	15.2111	489.67
7	10.2505	845.5
8	49.3372	808.33

Horse mackerel: parameters Length-Weight relationship

	Trachurus trecae
L-W factor a	0.0075
L-W factor b	3.1316
r^2	0.88

Mackerel

Mackerel: strata area and mean SA

Stratum	Area	Mean SA
1	349.6226	84
2	1938.689	64.204
3	215.5307	66.4
4	79.6095	15

Mackerel: parameters Length-Weight relationship

	Scomber colias
L-W factor a	0.0066
L-W factor b	3.03
r^2	0.7586

Pelagic I fish

Pelagic I: strata area and mean SA

Stratum	Area	Mean SA
1	137.8916	40
2	61.6121	17.5
3	272.7764	17.864
4	189.3597	57.35
5	597.3117	25.031
6	128.5497	86.267

Pelagic I: parameters Length-Weight relationship

	Pelagic I
L-W factor a	0.0022
L-W factor b	3.4316
r^2	0.9038

Pelagic II fish

Pelagic II: strata area and mean SA

Stratum	Area	Mean SA
1	329.4294	62.727
2	348.0428	92.571
3	1158.117	87.113
4	2005.733	52.828

Pelagic II: parameters Length-Weight relationship

	Pelagic II
L-W factor a	0.0243
L-W factor b	2.6691
r^2	0.9513