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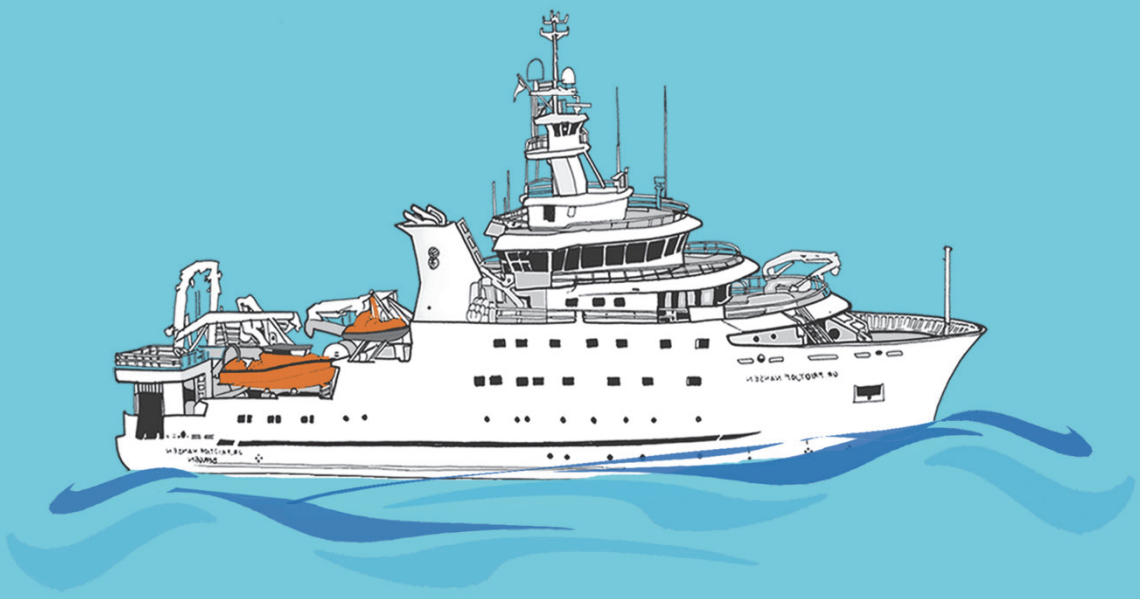
CRUISE REPORTS *DR FRIDTJOF NANSEN*
EAF-Nansen/CR/2019/12



SURVEY OF THE PELAGIC FISH STOCKS AND ECOSYSTEM OFF NORTHWEST AFRICA

Mauritania

9–20 October 2019

Institut Mauritanien de Recherches Océanographiques et des Pêches, Mauritania

Institute of Marine Research
Bergen, Norway

Institut National de Recherche Halieutique, Morocco

Department of Fisheries, The Gambia

University of Western Cape, South Africa

THE EAF-NANSEN PROGRAMME (2017–2021)

The EAF-Nansen Programme "Supporting the Application of the Ecosystem Approach to Fisheries Management considering Climate and Pollution Impacts" supports partner countries and regional organizations in Africa and the Bay of Bengal improving their capacity for the sustainable management of their fisheries and other uses of marine and coastal resources through the implementation of the Ecosystem Approach to Fisheries (EAF), taking into consideration the impacts of the climate and pollution.

The Programme is executed by the Food and Agriculture Organization of the United Nations (FAO) in close collaboration with the Institute of Marine Research (IMR) of Bergen, Norway, and funded by the Norwegian Agency for Development Cooperation (Norad). This Programme is the current phase (2017–2021) of the Nansen Programme which started in 1975.

The aim of the Programme is that sustainable fisheries improve food and nutrition security for people in partner countries. It builds on three pillars, Science, Fisheries Management, and Capacity Development, and supports partner countries to produce relevant and timely evidence-based advice for management, to manage fisheries according to the EAF principles and to further develop their human and organizational capacity to manage fisheries sustainably. In line with the EAF principles, the Programme adopts a broad scope, taking into consideration a wide range of impacts of human activities and natural processes on marine resources and ecosystems including fisheries, pollution, climate variability and change.

A new state of the art research vessel, the *Dr Fridtjof Nansen*, is an integral part of the Programme. A comprehensive science plan, covering a broad selection of research areas, and directed at producing knowledge for informing policy and management decisions, guides the Programme's 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 (2017-2021)

Le programme EAF-Nansen « Soutenir l'application de l'approche écosystémique pour la gestion des pêches compte tenu des impacts du climat et de la pollution » appui les pays partenaires et les organisations régionales en Afrique et dans le golfe du Bengale pour améliorer leur capacité de gestion durable de leurs pêcheries et d'autres usages de la mer ainsi que les ressources côtières, grâce à la mise en œuvre de l'Approche écosystémique des pêches (AEP), en tenant compte des impacts du climat et de la pollution.

Le programme est exécuté par l'Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO) en étroite collaboration avec l'Institut de recherche marine (IMR) de Bergen, en Norvège, et financé par l'Agence norvégienne de coopération au développement (Norad). Ce programme est la phase actuelle (2017-2021) du programme Nansen qui a débuté en 1975.

L'objectif du programme est que la pêche durable améliore la sécurité alimentaire et nutritionnelle des populations des pays partenaires. Il s'appuie sur trois piliers, la science, la gestion des pêches et le développement des capacités, et aide les pays partenaires à produire des avis pertinents et opportuns fondés sur des données factuelles pour la gestion, à gérer les pêcheries conformément aux principes de l'AEP et à développer davantage leur capacité humaine et organisationnelle à gérer durablement les pêches. Conformément aux principes de l'AEP, le programme adopte une large vision, prenant en considération un large éventail d'impacts des activités humaines et des processus naturels sur les ressources et les écosystèmes marins, y compris la pêche, la pollution, la variabilité et le changement climatique.

Un nouveau navire de recherche de pointe, le *Dr Fridtjof Nansen*, fait partie intégrante du programme. Un plan scientifique complet, couvrant un large éventail de domaines de recherche et visant à produire des connaissances pour éclairer les décisions de politique et de gestion, guide les travaux scientifiques du programme.

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

Boyer, D., Ahmed Jeyid, M.A., Majjih, Z., Bruck, S., Kvalsun, M., Mourgues, C., Sanden, J., Sørås, O.J., Otterlei Madsen, F.E., Sleymane, A.K., Wagne, M.M., Niang, A., Samba Bilal, A., Diagne, A., El Vadhel, H., Ba, S., El Abed, J., M'Bengue, B., Mohamed Moctar, S.M., Oubbamoh, H., Fadili, M., Jallow, M.S., Conteh, M.L., Thomas, L.S. 2021. Survey of the pelagic fish stocks and ecosystem off Northwest Africa. Mauritania, 9–20 October 2019. NORAD-FAO PROGRAMME GCP/GLO/690/NOR, CRUISE REPORTS DR FRIDTJOF NANSEN, EAF Nansen/CR/2019/12

CRUISE REPORTS *DR FRIDTJOF NANSEN*

SURVEY OF THE PELAGIC FISH STOCKS AND ECOSYSTEM OFF NORTHWEST AFRICA

Mauritania

9–20 October 2019

by

D. Boyer, M.A. Ahmed Jeyid[2], Z. Majjih[3], S. Bruck, M. Kvalsun, C. Mourgues, J. Sanden, O.J. Sørås, F.E. Otterlei Madsen[1]
A.K. Sleymane, M.M. Wagne, A. Niang, A. Samba Bilal, A. Diagne, H. El Vadhel, S. Ba, J. El Abed, B. M'Bengue, S.M. Mohamed Moctar[2]
H. Oubbamoh, M. Fadili[3]
M.S. Jallow, M.L. Conteh[4]
L.S. Thomas[5]

[1] Institute of Marine Research (IMR), P.O. Box 1870 Nordnes, N-5817 Bergen, Norway
[2] Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), Mauritania
[3] Institut National de Recherche Halieutique (INRH), Morocco
[4] Department of Fisheries (FD), The Gambia
[5] University of Western Cape (UWC), South Africa

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CONTENTS

ABBREVIATIONS

AGC	Automatic gain control
BT	Bottom trawl
CTD	Conductivity, temperature and depth
DO	Dissolved oxygen
FAO	Food and Agriculture Organization of the United Nations
IMR	Institute of Marine Research (Havforskningsinstituttet), Norway
LSSS	Large Scale Survey System
NORAD	Norwegian Agency for Development Cooperation
OMZ	Oxygen minimum zone
PSU	Practical salinity unit
PT	Pelagic trawl
RCG	Reverberation controlled gain
R/V	Research vessel
s_A	Acoustic backscattering area
sV	Acoustic backscattering volume
TA	Total alkalinity
TS	Target strength
VMADCP	Vertical mounted acoustic Doppler current profiler

EXECUTIVE SUMMARY

This survey is part of a synoptic coverage of the pelagic resources and ecosystem off West Africa, from South Africa to Morocco, undertaken by R/V *Dr Fridtjof Nansen* in 2019. These surveys, covering the continental shelf and upper slope from approximatively 20 m to 500 m depth, had multiple objectives and were hence multidisciplinary. The physical and chemical oceanography, together with plankton and micro plastics, was intensively sampled both underway and with a series of fixed stations along transects perpendicular to the coast. Simultaneously, the pelagic stocks were assessed using acoustics complimented by trawling. All surveys used standardised methods to ensure comparability.

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

This report presents the methodology and preliminary results from Leg 4.2, i.e. off the coast of Mauritania from 9 to 20 October 2019.

An east-west acoustic sampling grid, with a transect spacing of 10 NM, covered the Mauritanian continental shelf and upper slope between the 20 m to 500 m bottom depth contours. Identification of echoes and biological sampling of the fish was carried out using pelagic and bottom trawls. Standard hydrographic sections were sampled along the acoustic transects.

Altogether 36 trawl hauls were carried out to identify acoustic targets during the survey. A total of 25 CTD casts were made to describe the hydrography of the survey area and 15 plankton and micro plastic stations were also sampled. Samples of commercially important fish species were collected for food nutrition and toxicology tests, while jellyfish were sampled for genetic analysis. Seabird numbers and cetacean sightings were also recorded.

The information presented below is a brief summary of the results of the data analysed during the survey. Some samples and data have been transported to research institutes in the region, and also farther afield (notably IMR in Bergen, Norway). Samples will be analysed in close cooperation with partner institutions and the results will be reported separately. The resulting datasets will support research as part of the EAF-Nansen Science Plan.

The hydrographic data suggested a well-stratified system with below saturation point dissolved oxygen concentrations in the surface layers and hypoxic waters below 100 m. A hydrographic front was recorded north of the 19°05’N transect where permanent upwelling to the north of Mauritania starts to impact the Mauritanian hydrographic system, creating less stratified waters with more oxygen in the surface and upper layer.

Low phytoplankton activity was recorded throughout the region, with a chlorophyll maximum at around 25 m depth.

Pelagic fish were present throughout large parts of the region, with greater amounts towards the north. The main densities were found inshore of 50 m bottom depth, and were believed to extend inshore of the survey area in some areas. The presence of large numbers of both foreign and local fishing vessels inshore of the 50 m isobath in the large shallow embayment south of Cap Blanc supported this assumption.

Very few dense schools of fish were found. Almost all of the acoustic registrations were in scattered layers of fish composed of mixed pelagic species. These layers often contained small denser patches, which were believed to be sardinella or, in the north, sardine, but this was difficult to confirm through trawling as the catches were invariably highly mixed.

A transboundary acoustic survey was conducted by the R/V *Dr Fridtjof Nansen* in 2017. The overall biomass of all pelagic species was found to be at the same level, while the biomass of sardinella was considerably lower. In contrast, the horse mackerel biomass appears to have more than tripled. The sardine, anchovy and mackerel biomasses have declined.

S. aurita, which comprised the majority of the sardinella biomass, were almost entirely juveniles of less than one-year old.

One significant difference between the surveys is their timing; the 2017 survey was conducted in June/July and the current survey in October 2019. Recruitment of fish and migration may have affected the biomass estimates and this needs to be further investigated.

A longer-term comparison with historical surveys suggests that the biomass of clupeids (the sardinellas and sardine) has decreased markedly since the surveys conducted in the early years of the 21st century. For many years the combined biomass of clupeids exceeded 2 million tonnes, while the surveys of 2017 and 2019 suggest that this abundance has declined ten-fold. In contrast, the biomass of *T. trecae* is at its highest since 2003.

The observed reduction in sardinella biomass is considerable and should be carefully monitored. It should be noted that catch rates of commercial vessels are a poor indicator of the health of the stock and therefre fishery independent information deserves special consideration.

RÉSUMÉ

Cette campagne s'inscrit dans la cadre d'une couverture synoptique des ressources et de l'écosystème pélagiques au large de l'Afrique de l'Ouest, de l'Afrique du Sud au Maroc, entreprise par le N/R *Dr Fridtjof Nansen* en 2019. Cette campagne, qui a couvert le plateau continental et la partie supérieure du talus à une profondeur approximative de 20 m à 500 m, avait des objectifs multiples et était donc multidisciplinaire. L'océanographie physique et chimique, ainsi que le plancton et les microplastiques, ont fait l'objet d'un échantillonnage intensif au moyen d'une série de stations fixes le long de transects perpendiculaires à la côte. Les stocks pélagiques ont été évalués simultanément à l'aide d'études acoustiques et du chalutage. Toutes les analyses ont utilisé des méthodes standardisées pour assurer la comparabilité des données recueillies.

Avec l'élargissement du champ d'application de la recherche menée dans le cadre du Programme EAF-Nansen, les objectifs de la campagne et les stratégies d'échantillonnage connexes ont été étendus pour favoriser la recherche sur les cycles biologiques, l'identité des stocks et les relations trophiques des poissons pélagiques.

Ce rapport présente la méthodologie et les résultats préliminaires obtenus lors du tronçon 4.2 de la campagne, réalisé au large de la Mauritanie du 9 au 20 octobre 2019.

Une grille d'échantillonnage acoustique est-ouest, avec un espacement des transects de 10 nm, a couvert le plateau continental et la partie supérieure du talus mauritanien à des profondeurs allant de 20 m à 500 m. L'écho-identification et l'échantillonnage biologique des poissons ont été réalisés à l'aide de chaluts pélagiques et de chaluts de fond. Des sections hydrographiques standard ont été échantillonnées le long des transects acoustiques.

Au total, 36 traits de chalut ont été effectués pour identifier les cibles acoustiques pendant la campagne. Un total de 25 profils de CTP a été réalisé pour décrire l'hydrographie de la zone d'étude et 15 stations ont également été échantillonnées afin de mesurer le plancton et les microplastiques. Des échantillons d'espèces de poissons à forte valeur commerciale ont été collectés pour la réalisation de tests toxicologiques et analyse de la qualité nutritionnelle, et des méduses ont été échantillonnées pour des analyses génétiques. Le nombre d'oiseaux marins et les observations de cétacés ont également été enregistrés.

Les informations présentées ci-dessous representent un bref résumé des résultats des données analysées au cours de la campagne. Certains échantillons et données ont été envoyés à des instituts de recherche de la région ou plus éloignés (notamment l'IMR à Bergen, en Norvège). Les échantillons seront analysés en étroite collaboration avec les institutions partenaires et les résultats seront communiqués séparément. Les recherches entreprises dans le cadre du plan scientifique EAF-Nansen pourront s'appuyer sur les séries de données collectées.

Les données hydrographiques ont suggéré un système bien stratifié avec des concentrations d'oxygène dissous inférieures au point de saturation dans les couches de surface et des eaux hypoxiques en dessous de 100 m. Un front hydrographique a été enregistré au nord du transect 19° 05' N où l'upwelling permanent au nord de la Mauritanie commence à avoir un

impact sur le système hydrographique mauritanien, créant des eaux moins stratifiées avec plus d'oxygène à la surface et la couche supérieure.

Une faible activité phytoplanctonique a été enregistrée dans toute la région, avec un maximum de chlorophylle à environ 25 m de profondeur.

Les poissons pélagiques étaient présents dans une grande partie de la région, avec des quantités plus importantes vers le nord. Les principales densités ont été trouvées à des profondeurs de 50 m et vers la côte, l'hypothèse étant qu'elles s'étendent vers les zones moins profondes. La présence d'un grand nombre de navires de pêche étrangers et locaux dans l'isobathe de 50 m en correspondance avec la grande baie peu profonde au sud du Cap Blanc a confirmé cette hypothèse.

Très peu de bancs de poissons denses ont été trouvés. Presque tous les enregistrements acoustiques se trouvaient dans des couches éparses de poissons composées d'espèces pélagiques mixtes. Ces couches contenaient souvent de petits bancs plus denses, de sardinelles sans doute, ou, dans le nord, de sardines, mais cela a été difficile à confirmer par le chalutage car les captures étaient invariablement très mélangées.

Une campagne acoustique transfrontalière a été menée par le N/R *Dr Fridtjof Nansen* en 2017. La biomasse globale de toutes les espèces pélagiques s'est avérée être identique, tandis que la biomasse de sardinelle était considérablement plus faible. En revanche, la biomasse du chinchard semble avoir plus que triplé. Les biomasses de sardines, d'anchois et de maquereaux ont diminué.

Les captures de *S. aurita*, qui constituait la majorité de la biomasse de sardinelles, étaient presque entièrement constituées de juvéniles de moins de 1 an.

Une différence significative entre les campagnes est la date à laquelle elles ont été réalisées. En effet, la campagne de 2017 a été menée en juin-juillet et la campagne actuelle en octobre. Le recrutement des poissons et la migration peuvent avoir affecté les estimations de la biomasse et cela doit être étudié de manière plus approfondie.

Une comparaison à plus long terme avec les anciennes campagnes suggère que la biomasse des clupéidés (les sardinelles et la sardine) a nettement diminué depuis les campagnes effectuées dans les premières années du XXIe siècle. Durant de nombreuses années, la biomasse combinée des clupéidés a dépassé 2 millions de tonnes, alors que les campagnes de 2017 et 2019 suggèrent que cette abondance a été divisée par dix. En revanche, la biomasse de *T. trecae* est à son plus haut niveau depuis 2003.

La réduction observée de la biomasse de sardinelles est considérable et doit être suivie de près. Il convient de noter que les taux de capture des navires commerciaux sont un mauvais indicateur de la santé du stock et que les informations obtenues indépendamment du secteur de la pêche méritent une attention particulière.

CHAPTER 1. INTRODUCTION

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

The science plan is a dynamic document that currently covers 11 themes, presented in Figure 1 below.

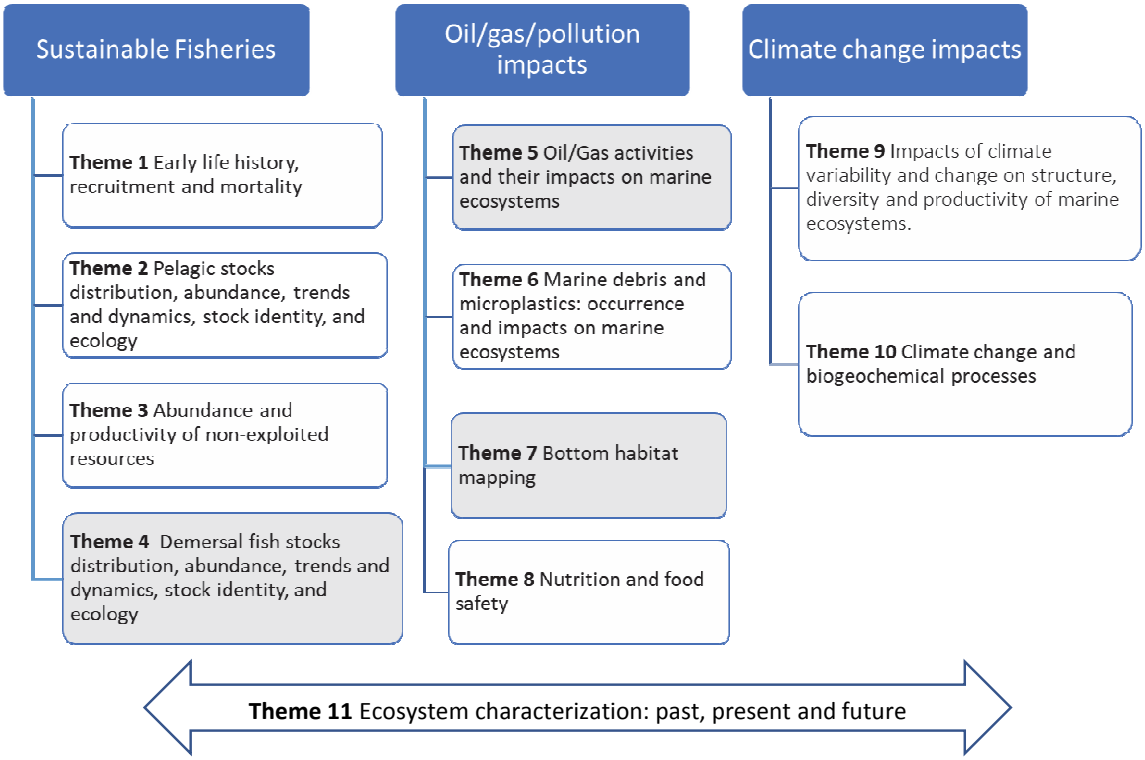


Figure 1. Research themes of the EAF-Nansen science plan

This survey was designed to collect data towards addressing aspects of most of the research themes of the science plan (those with a white background in the figure above).

1.1 Survey objectives

The specific objectives for this survey (Leg 4.2) were:

Hydrography (Themes 9 and 11):

- To map the hydrographic and environmental conditions in the survey area (temperature, salinity, dissolved oxygen, chlorophyll-*a*, nutrients, total alkalinity, pH and ocean currents).
- To obtain information on the dissolved oxygen concentrations, ocean acidification state, and calcium carbonate saturation horizons relevant for calcifying organisms.

Phytoplankton, zooplankton and ichthyoplankton (Themes 1,9 and 11):

- To describe the primary productivity of the region.
- To describe the abundance and biomass patterns of the meso-zooplankton community, as well as its species composition.
- To provide information on the abundance patterns of the ichthyoplankton community (fish eggs and larvae), at the lowest possible taxonomic level.
- To collect samples of jellyfish for a) morphological identification and taxonomic studies, b) genetic studies for the purposes of confirming identity, determining population structure and establishing regional and global connectivity, and c) histological examination of reproductive maturity to determine reproductive synchronicity and semelparity within populations and individuals.

Pelagic stocks (Themes 2, 9 and 11):

- To obtain information on abundance and distribution (including by size) of *Sardinella aurita, Sardinella maderensis, Engraulis encrasicolus, Trachurus trecae*, *Trachurus trachurus, Scomber colias* and *Sardina pilchardus* using acoustic methods and a systematic grid survey strategy.
- To collect samples for morphometric studies and genetic analysis, notably for stock identification of *S. aurita* and *S. maderensis.*
- To obtain information on maturity stages, stomach contents and age of *S. aurita, S. maderensis, S. pilchardus*, *S. colias* and *E. encrasicolus*.

Mesopelagic fish (Themes 3 and 11):

- To trawl for samples of mesopelagic fish in deep waters (if time permits).

Top predators (Themes 9 and 11):

- To record occurrence of top predators.

Marine debris, microplastics and sargassum (Theme 6):

- To record occurrence of marine surface debris, also sargassum weed (if methodology developed and personnel available).
- To map occurrence of microplastics and describe associated neuston communities.

Contaminants and nutrients (Theme 8):

- To collect samples of specific pelagic species for levels of environmental contaminants, nutrients, parasites and microorganisms with regards to food safety and pollution.

1.2 The survey area

The area surveyed in 2019 included the continental shelf and upper slope of the west coast of Africa. Leg 4 covered the northwest African shelf area from the southern border of Senegal to Tangier (Morocco) and was divided into 4 sub-sections: Senegal and Gambia (Leg 4.1), Mauritania (Leg 4.2), Cap Blanc to Cap Cantin (Leg 4.3), and Cap Cantin to Tangier (Leg 4.4), Morocco. An additional survey leg was dedicated to mesopelagic fish investigations (Leg 4.5).

This report describes the activities and preliminary results of Leg 4.2, the survey of Mauritania.

1.3 Participation

Institute of Marine Research (IMR), Norway:

David Boyer (cruise leader), Sarah Bruck, Merete Kvalsun, Jorunn Sanden, Claire Mourgues, Olaf J. Sørås, Fredrik E. Otterlei Madsen.

Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), Mauritania:

Mohamed Ahmed Ahmed Jeyid (co-cruise leader and Mauritanian team leader), Abdel Karim Sleymane, Moulaye Mohamed Wagne, Alioune Niang, Abdallahi Samba Bilal, Ahmed Diagne, Hammoud El Vadhel, Samba Ba, Jemal El Abed, Bouya M'Bengue, Sidi Mohamed Mohamed Moctar.

Institut National de Recherche Halieutique (INRH), Morocco:

Zakaria Majjih (Moroccan team leader), Hassan Oubbamoh, Mohamed Fadili.

Department of Fisheries (FD), The Gambia:

Momodou S. Jallow, Modou Lamin Conteh.

University of Western Cape (UWC), South Africa:

Luanne Samantha Thomas.

1.4 Narrative

The vessel departed from Dakar, Senegal at 16h00 on 9 October 2019 and started the sampling work at the border of Senegal and Mauritania on 10 October at 08h00.

The survey attempted to replicate the methodology previously used for the surveys of acoustic fish stocks in Mauritania (see Krakstad *et al.*, 2017). The survey proceeded along parallel transects perpendicular to the coast with a transect spacing of approximately 10 NM, covering the shelf and slope out to the 500 m bottom depth contour. Figure 2 to Figure 4, respectively show the course track and the oceanographic, plankton and trawl stations worked during the survey.

The Mauritanian border at Cap Blanc was reached at 13h00 on 18 October 2019. Thereafter the vessel sailed to Las Palmas, Spain for a change of staff, arriving at 08h00 on 20 October 2019.

Standard hydrographic sections were sampled along acoustic transects every 60 NM from 500 m bottom depth to 30 m bottom depth close to the coast. Along each hydrographic

section phytoplankton, zooplankton, ichthyoplankton and micro-plastics were also sampled. These multi-disciplinary stations were termed “super-stations”. A single long transect in the north to collect hydrographic data from the coast to 125 NM offshore was planned but there was insufficient time to do this.

The weather was favourable throughout the survey, ranging from flat-calm to short periods of Force 5 winds. At no time did the seas become rough enough to affect the survey. Strong hot, dry offshore sand-laden winds from the desert (this wind was seemingly an adiabatic wind often referred to as Sirocco or Föhn wind) blew for several days, decreasing visibility (which may have had a small impact on the top predator sightings). Large numbers of desert birds and butterflies took refuge on the vessel during this period.

A summary of the survey activities is presented in the Summary Cruise Report (Annex I).

1.5 Survey effort

Altogether 36 trawl hauls were carried out to identify acoustic targets during the survey. 25 CTD casts were made to describe the water properties in the survey area. 15 plankton stations were also sampled, as summarised in Table 1, Table 2 and Table 3.

Table 1. Survey sampling effort during the survey: number of transects

	Acoustic	Plankton & hydrographic
Total	29	5

Table 2. Survey sampling effort during the survey: number of samples

Physical, chemical oceanography & primary productivity	Zooplankton	Eggs & larvae	Microplastics	Acoustic target ID and fish samples	
CTD	WP-2 net	Bongo net	Manta net	Bottom trawl	Pelagic trawl
25	15	15	15	10	26

Table 3. Survey sampling effort during the survey: distance travelled (NM)

Distance on transects	988,8
Distance between transects, trawling and environmental stations	400,7
Total survey effort	1 359,5
Transit from Dakar to Senegal-Mauritania border and Mauritanian border at Cap Blanc to Las Palmas	608,7
Total distance travelled	1 968,3

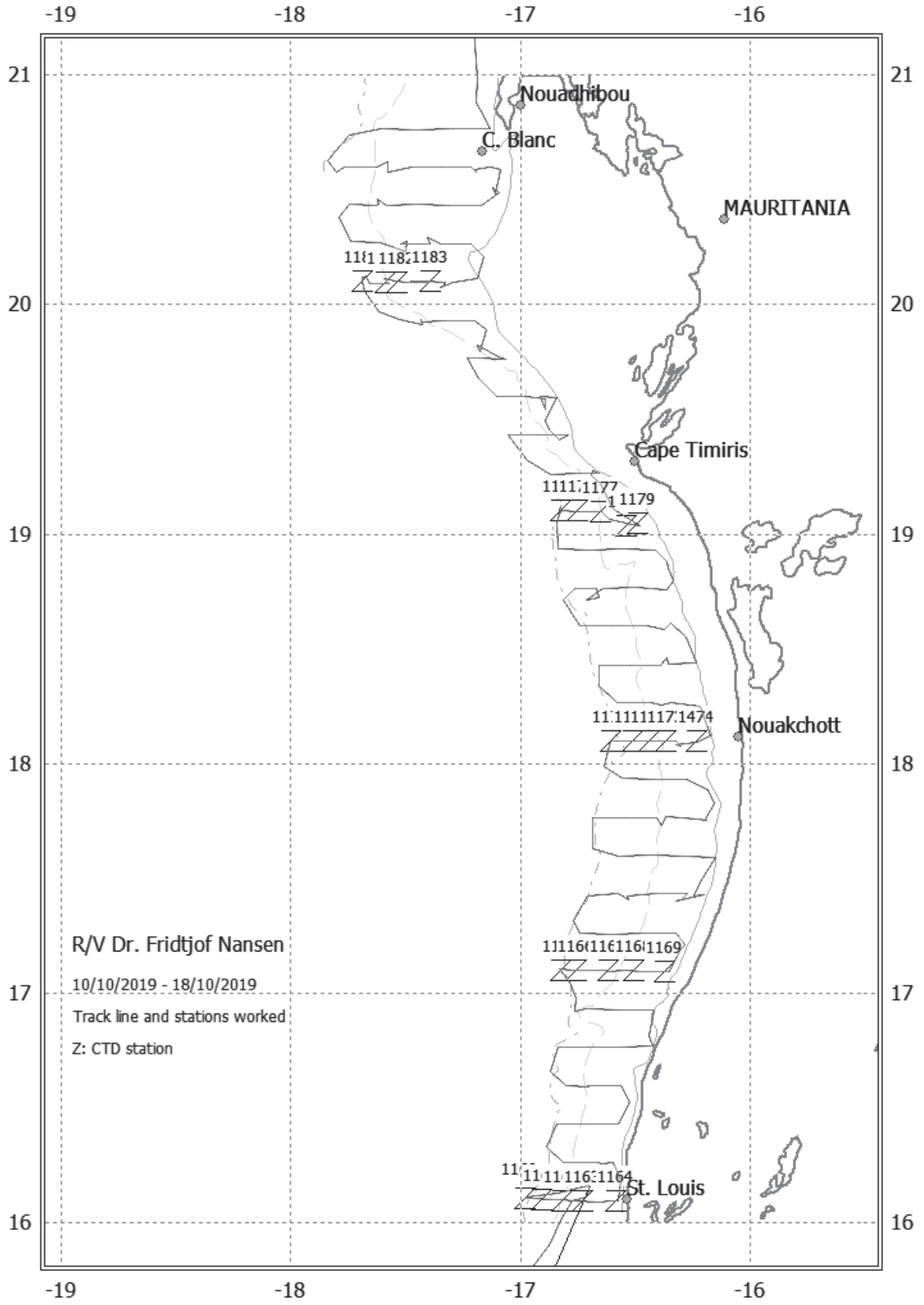


Figure 2. Course track with CTD hydrographic stations. Depth contours at 20 m, 100 m and 500 m are indicated

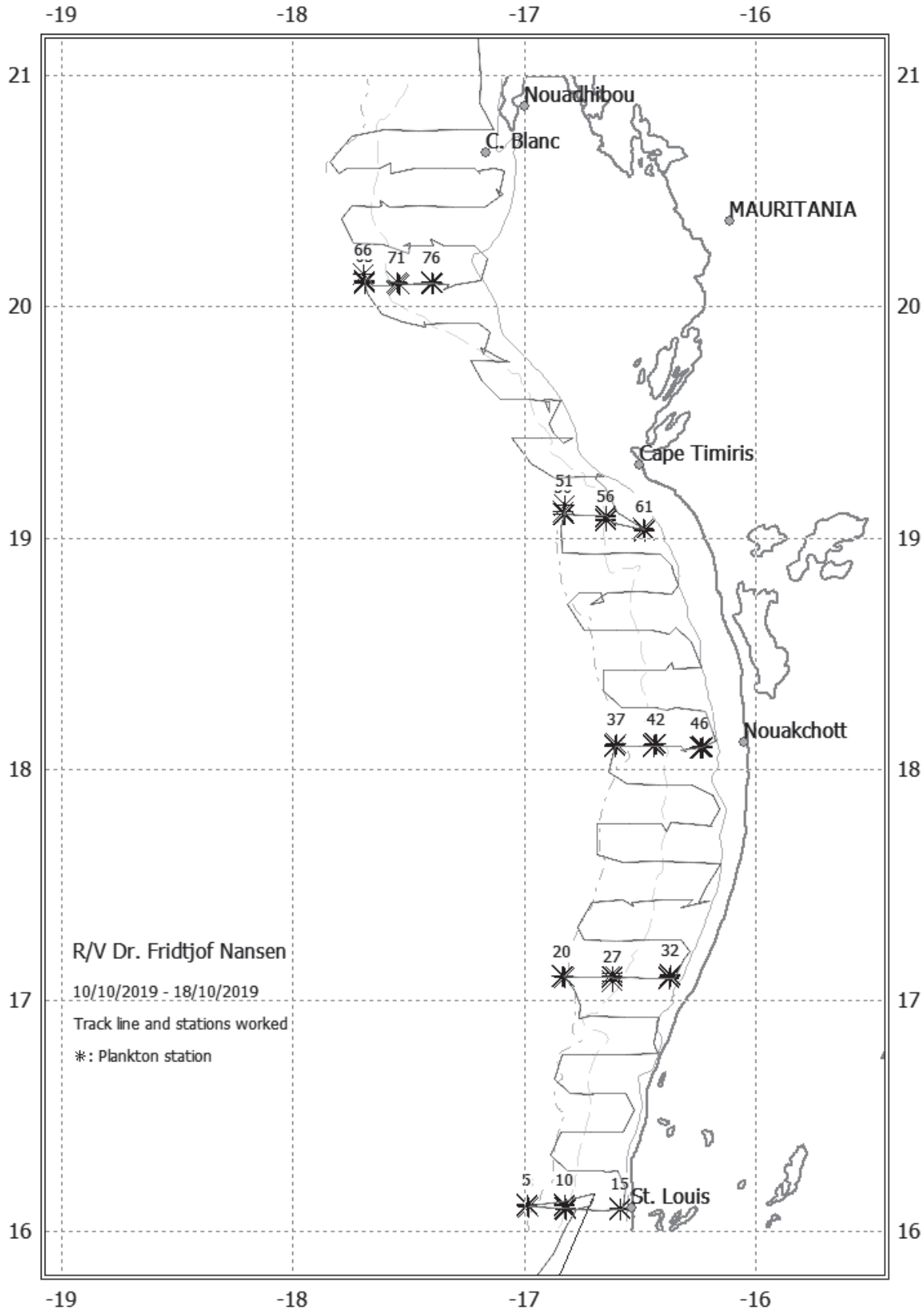


Figure 3. Course track with plankton (super-) stations (depth contours as in Figure 2)

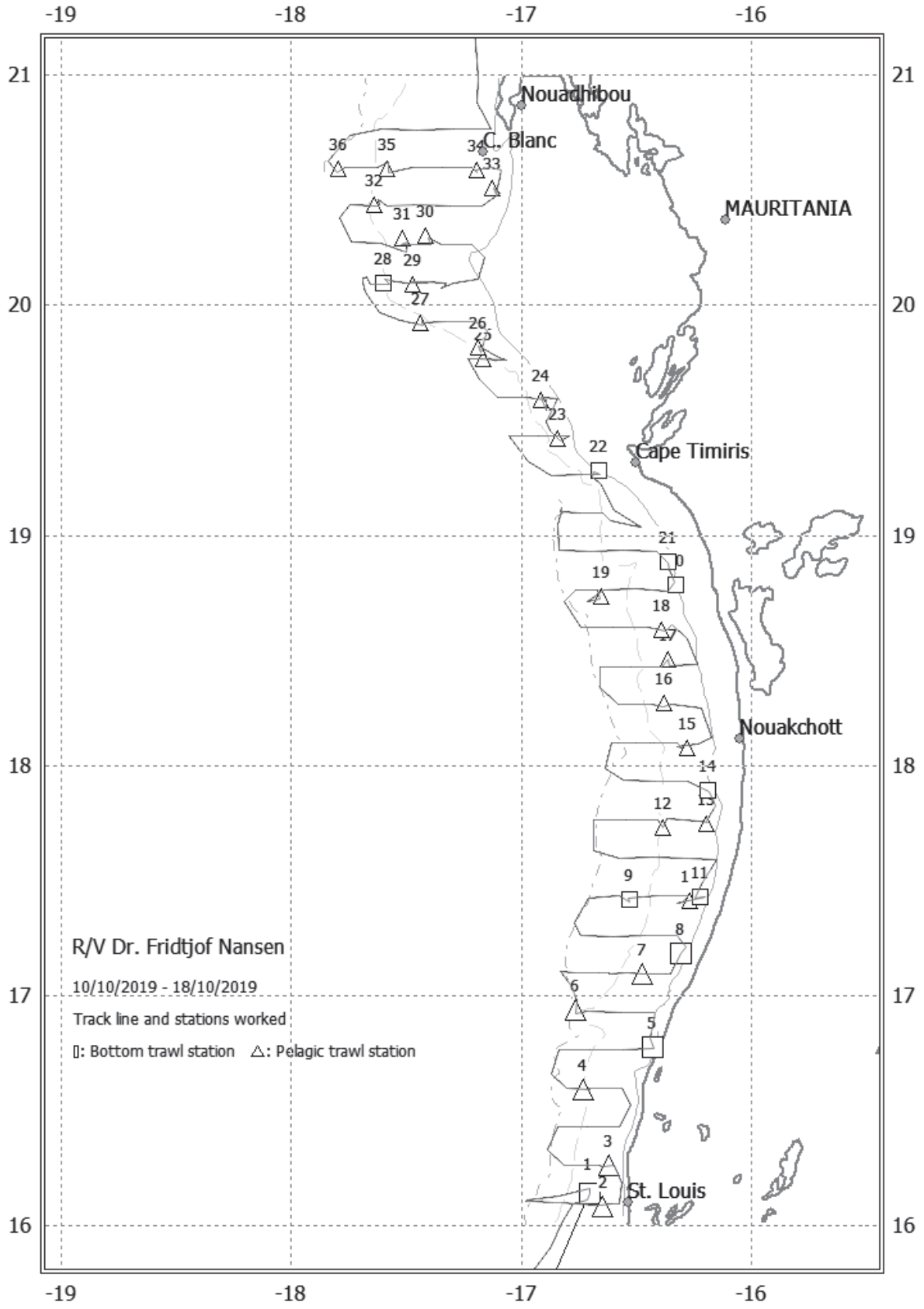


Figure 4. Course track with trawl stations (depth contours as in Figure 2)

CHAPTER 2. METHODS

2.1 Continuous underway meteorological and hydrographic sampling

2.1.1 Meteorological data

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

2.1.2 Thermosalinograph

The SBE 21 Seacat thermosalinograph ran continuously during the survey, obtaining samples from sea surface (at 5.85 m depth) recording salinity and relative temperature every 10 seconds. A Sea-Bird WETStar Fluorometer was also attached in-line to measure sub-surface fluorescence levels. A secondary temperature sensor close to the intake was used to report surface temperature.

2.1.3 Current speed and direction measurements (ADCP)

The ocean current data were collected with Teledyne RDI Ocean Surveyor ADCP OS150, operating at the frequency of 150 kHz. The 75 kHz ADCP, which is also fitted onboard was not operational during this survey. RDI's VmDAS data logging software was run in narrow band mode and averaged data in 8 m vertical bins. Heading, pitch, roll and positional data were acquired by a Kongsberg Marine SEAPATH unit. The VmDAS software used these data to convert the ADCP's along beam velocities into earth coordinates.

2.2 Fixed hydrographic and plankton sampling

A series of biological and oceanographic sampling stations were undertaken every 60 NM, i.e. along every sixth acoustic transect (Transects 1, 7, 13, 19 and 25). Samples were collected near the inshore end of the acoustic transects, usually at a water depth of approximately 30 m, at the 100 m isobath and at the outer end of the transects, i.e. at 500 m bottom depth (Figure 3 and Figure 5). These stations were referred to as "super-stations". On the final sampling line numerous fishing vessels and a seismic vessel were operational in the vicinity of the inner 30 m super-station, so this station was sampled at 35 m depth, several NM west of the intended sampling site. Samples of zooplankton, fish eggs and larvae, as well as microplastics, were collected at these "super-stations".

CTD casts were deployed at all super-stations, and at intermediate stations at approximately 75 m and 200 m bottom depth. These stations were referred to as "dry stations".

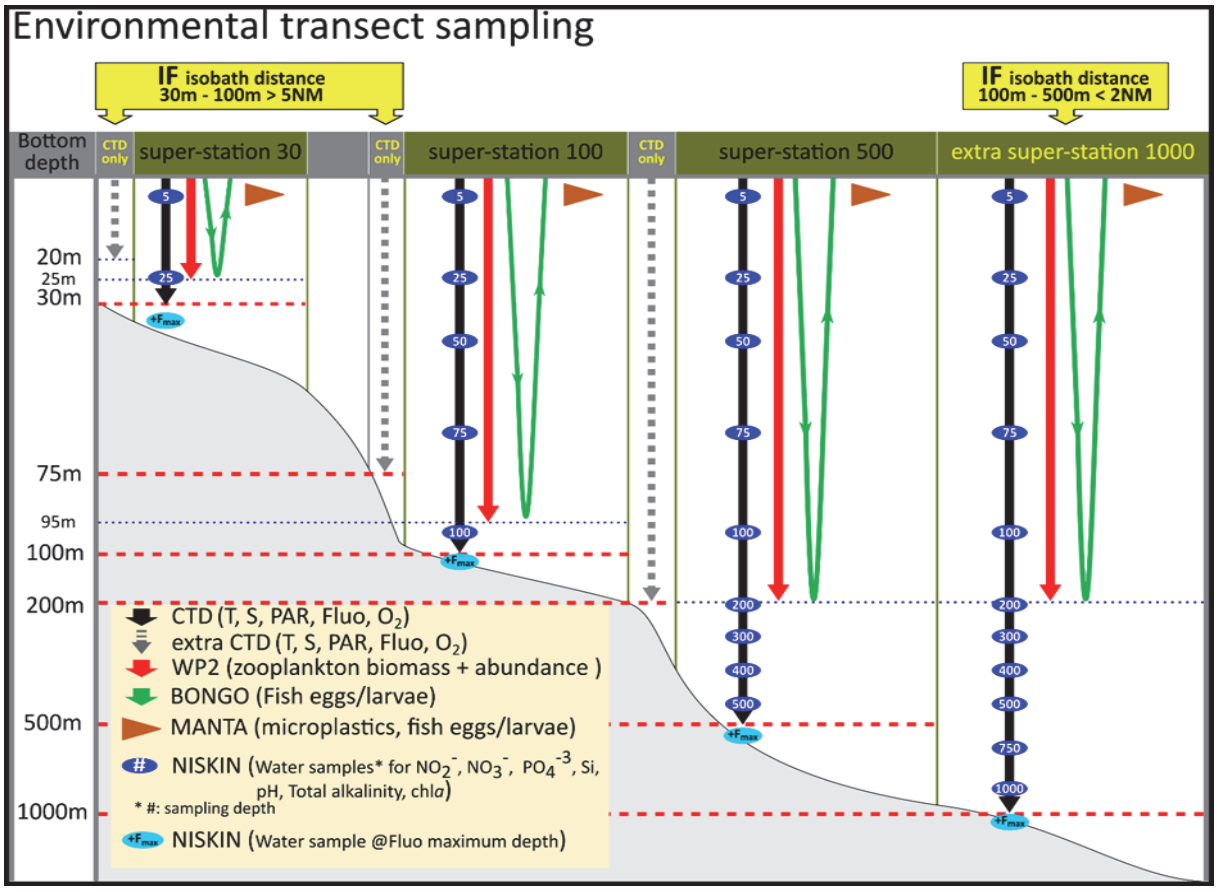


Figure 5. A diagrammatic scheme of the fixed-station sampling regime: three super-stations sampled along each transect (at the 30 m, 100 m and 500 m isobaths) and two dry CTD stations at the 75 m and 150 m isobaths. The position of the stations was occasionally changed under certain conditions (see text)

Water samples for pH, total alkalinity, nutrients, and pigments were collected along these transects in order to determine the state of ocean acidification and the nutrient availability for primary production. Once analyses are complete, phosphate and silicate concentrations combined with the on-board measurements of pH and total alkalinity can be used to calculate the area's inorganic carbon components. This, together with the aragonite saturation state can be used to update the ocean acidification status of the region. For all the rosette deployments (super-stations and dry stations), the CTD sensors recorded temperature, salinity, dissolved oxygen and fluorescence. The data from the CTD were processed using Surfer software to produce surface maps and ODV software to obtain vertical profiles.

At each super-station CTD deployment, Niskin bottles mounted on the rosette collected water at predefined depths during the upcast to obtain environmental profile data. The CTD was halted at each predefined depth for at least 20 seconds to allow the bottles to rinse with the surrounding water as it reached equilibrium to best represent the water composition at that depth. pH, total alkalinity (A_T), nutrients and pigments (chlorophyll-*a* and phaeopigment) were sampled at each super-station, pH, A_T and nutrients being taken for all depths while pigments were sampled between the surface and 200 m.

Data collected at the dry CTD stations were restricted to physical oceanographic parameters, namely temperature, salinity, PAR (Photosynthetically Active Radiation), fluorescence and

oxygen, which were recorded at 1 m intervals throughout the water column. Vertical temperature and salinity profiles were obtained by a Seabird 911 CTD, while *in situ* concentrations of dissolved oxygen (DO) were measured using a CTD-mounted SBE 43 oxygen sensor. Real time logging and plotting was performed using the Seabird Seasave software installed. Attached to the CTD was an uncalibrated Chelsea Mk III Aquatracka fluorometer, which measured *in situ* relative fluorescence.

2.2.1 Water sampling methodology

2.2.1.1 Dissolved Oxygen

As noted above, DO was measured using a CTD-mounted SBE 43 dissolved oxygen sensor. In order to validate the sensor measurements, water samples were collected below 200 m and measured via Winkler titrations (Langdon, 2010). Figure 6 shows the relation between DO as determined by the sensor and by the Winkler method. A drift value of 1.6% was recorded between the sensor and the chemical method. The sensor was determined to be operating within the normal tolerance limits and no correction to the DO values was applied.

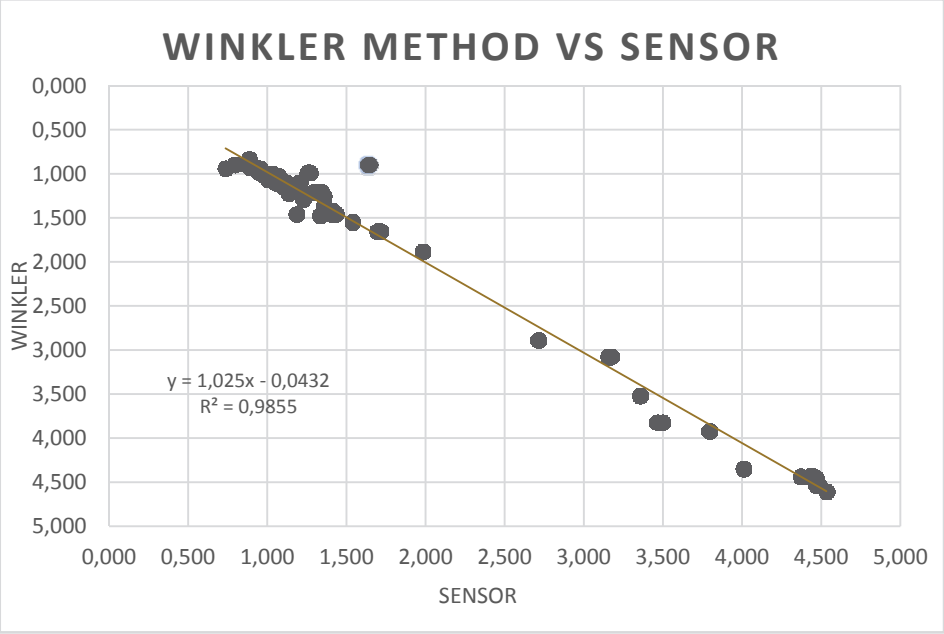


Figure 6. Measured oxygen concentrations (74 samples) plotted against oxygen sensor data

2.2.1.2 Salinity

Unfortunately, it was not possible to validate the salinity sensor values as the salinometer was out of order.

2.2.1.3 Ocean acidification parameters - pH and alkalinity

Water samples for pH and total alkalinity analysis were collected in the same 250 ml borosilicate glass bottle using silicone tubing. Since no preservative was used, it was necessary to keep the samples in the dark while waiting to stabilise at 25°C (with a water bath) for analysis. pH was determined using an Agilent Cary 8454 UV-Vis Diode Array spectrophotometer and a 2-mM m-cresol purple indicator dye solution. The indicator dye was

measured every 24 hours during analyses to determine the correction factor appropriate for sample measurements (Clayton and Byrne, 1993; Chierici *et al*., 1999). All pH spectrophotometric measurements were performed in triplicates on board.

Total alkalinity was measured via an open-cell potentiometric titration using a 0.05M HCl solution with a sodium chloride background as the titrant (Dickson *et al.*, 2007). A Metrohm 888 Titrando equipped with an Aquatrode plus pH electrode with Pt1000 temperature sensor was used in combination with the Metrohm Tiamo software to measure the change in pH and perform the total alkalinity titrations. Certified Reference Material of known total alkalinity from Scripps Institution of Oceanography was measured every 24 hours during analyses to determine the correction factor appropriate for sample measurements. All total alkalinity titrations were performed in triplicates on board.

2.2.1.4 Nutrients

Seawater samples for nutrient analyses (nitrite, nitrate, silicate and phosphate) were collected at standard depths (one sample at each depth) at each super-station in 20 ml polyethylene vials. Samples were preserved with 0.2 ml chloroform and kept refrigerated and dark (Hagebø and Rey, 1984) until being sent to the Institute of Marine Research for analysis. Analysis was performed using a Skalar San++ Continuous Flow Analyser while following standard procedures (Grasshoff *et al*., 1999). Storage and transport may result in loss of accuracy of the results.

2.2.2 Plankton: primary productivity, zoo- and ichthyoplankton

2.2.2.1 Chlorophyll-*a* and phaeopigments: Primary productivity

Chlorophyll-*a* was sampled as an indicator of phytoplankton biomass. Seawater was collected from the CTD at the standard depths (not below 200 m) for chlorophyll-*a* and phaeopigment measurements. The water was filtered using a 0.7 µm filtration system (Munktell glass-fibre filters Grade: MGF, vacuum 200 mm Hg). After filtration, the assay was performed by extraction with 90% acetone followed by centrifugation, and analysed with a fluorometer (model 10 AU, Turner Designs Inc., Sunnyvale, Ca., USA), according to Welshmeyer (1994) and Jeffrey and Humphrey (1975).

2.2.2.2 Zooplankton

Zooplankton samples were collected with a WP2-net (56 cm diameter, mesh size 180 µm) (Fraser 1966, Anonymous, 1968) which was hauled vertically at a speed of ~0.5 ms^{-1} at each station. At the shallow and intermediate 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 m and 90 m, respectively). At the stations with bottom depth of 500 m, the sampling stratum was from 200 m to the surface.

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 of decreasing mesh sizes (2 000 µm, 1 000 µm and 180 µm). The zooplankton retained on each sieve were dried on pre-weighted aluminium trays at ~ 60 ºC for 24 h. Samples were

transferred to IMR (Bergen) for analysis and biomass estimation of the different size groups of zooplankton. The second part of the sample was preserved in 4% formaldehyde buffered with borax for subsequent species identification and quantification, also at IMR.

2.2.2.3 Fish eggs and larvae

Sampling for fish eggs and larvae was done at the super stations with a Bongo net equipped with 405 µm mesh. The net was towed obliquely from ~20 m above the bottom, or from a maximum depth of 200 m, to the surface with a speed of ~1.5 m s^{-1}. Once the Bongo net was on board, the samples were transferred to the lab for processing.

The sample from the left net (V) was sieved through a 180 µm mesh, transferred to a 100 ml flask (or bigger) and preserved in 4% borax buffered formaldehyde solution.

The sample of the right net (H) was examined under the microscope and all fish larvae (and eggs when possible) were sorted. After sorting, the bulk sample was used for estimation of the Zooplankton Displacement Volume (details in the Nansen Plankton Guidelines). The sorted ichthyoplankton were photographed and preserved in 96% ethanol for genetic analysis in small labelled scintillation vials or Eppendorf tubes. The biggest fish larvae were removed from the sample, photographed, transferred to vials, and preserved in 4% formaldehyde buffered with borax. The rest of the sample was preserved in 96% ethanol for further laboratory analysis. After the cruise, fish eggs will be sorted, and the sorted larvae will be taxonomically analysed at the IMR.

2.2.2.4 Microplastics

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

The samples collected were washed in filtered seawater through a sieve with a mesh-size of 180 µm. Microplastic particles were sorted from the sample under a stereomicroscope, and the sorted sample was then checked once more to identify the smallest plastic particles. All potential plastic items were then placed on a gridded petri dish for examination under the stereomicroscope, photographed and, if possible, measured and described (e.g. length, shape, type and colour). The sorted microplastics were washed with distilled water and dried in pre-weighed aluminium trays in a drying cabinet at 30ºC. The trays were packed in aluminium foil and stored at room temperature for transport to IMR, where they will be studied in more detail. After removing the plastics, the remaining part of the samples - mainly biological material - was preserved in 96% ethanol for studies of neuston at UWC after the cruise.

2.3 Top predator observations

The observation platform, at 24.6 m above sea level, was used throughout the survey. A single observer scanned for cetaceans and seabirds during most of the daylight hours every day. Leica 10 x 42 binoculars were used.

All cetaceans sighted were counted and, when possible, identified. The time of sighting was recorded; this was later matched with the vessel's course track to provide position.

A maximum amount of effort was concentrated on and near the track-line so as not to miss any sightings there. During low-speed or stationary sampling activities the platform was treated as a quasi-fixed vantage point and 360° were scanned, considering that the probability that cetaceans may approach from behind the vessel was significantly increased.

Species were identified in a strictly conservative way, i.e. only when diagnostic features were confirmed, otherwise the sighting was assigned to the family or genus level.

As a high priority, but depending on distance, it was attempted to take photographs with a Canon reflex camera with a 70-300 mm zoom lens.

Seabirds were identified, where possible, and counted in 'passing mode', counting being restricted to a 180 ° line from port and to starboard. It was recognised that detection rates decline significantly with distance and therefore counting was limited to birds passing within about 300 m of the vessel, i.e. a swathe of 600 m within which it was assume that all birds were detected. Counts were made periodically throughout the day, each count taking several minutes to complete. Counting ceased during stations for trawling, CTDs and plankton-net hauls.

2.4 Food safety

Whole fish, fillets and various organs from fish that are regularly consumed, namely *S. maderensis, S. aurita, S. pilchardus* and *E. encrasicolus,* were sampled during this survey and preserved. All the samples will be analysed for a wide variety of nutrients and contaminants at the IMR, Bergen.

The Mauritanian region was divided into five 1° latitudinal regions for sampling purposes: from 16°N to 21°N.

Small fish (<25 cm total length) were prepared in three parallel samples consisting of not more than 50 fish per sample per region. The mean weight and length of each fish for each sample was measured. While it was intended that these samples should be collected from around 3-8 closely positioned stations, in reality the numbers of fish caught were sometimes rather low and so fish were collected throughout each region as available. These samples were pooled (50 fish per sample), blended (macerated or liquidized) in a food mixer and then frozen in the - 20°C freezer.

Large fish (>25 cm total length) were collected as available, with up to 25 fish per sample per region. The length, weight, sex and maturity of each individual fish was measured. The fish

were then divided into five groups with five fish in each sample. Fillet samples, including skin, were collected from each fish, blended and frozen at -20°C such that five fish were included in each sample. Livers were similarly removed from the same five groups of five fish, blended and frozen.

2.5 Biological sampling of fish

Biological sampling of fish was carried out using pelagic and bottom trawls. A complete record of fishing stations and catches is shown in Annex II. Annex III gives a summary of the catches. In shallow water (<30 m) or at night when pelagic fish was close to the surface, the small pelagic Åkratrawl with floats or the bottom trawl with floats was used for sampling. In deeper waters, the MultPelt 642-M, a much larger trawl, was used. This gear has a much larger opening and can be trawled at faster speeds (up to 5 knots) and therefore is much more successful at catching fast-swimming pelagic species, especially adult sardinella, sardines and horse mackerel. See Annex IV for a description of the fishing gear used during this survey.

All catches were sampled for composition by weight and numbers. The entire catch was sampled if less than about 100 kg. For larger catches (the majority) the catch was first well mixed using shovels and then divided into quarters or eighths and opposite sectors were collected such that either half or a quarter of the catch was sampled. If catches were very large (greater than ~1 tonne) then the catch was spread evenly on the deck and about four random sectors were sectioned off and all of the organisms within each sector were collected. As the crane-mounted scale was not functioning the total catch size was estimated, usually by the fishing master.
Species identification was based on the FAO Species Guides. Length frequency distributions of the target species (see Table 4), by total fish length to the nearest cm below, were measured from all stations where they were present. These length measurements are normally used to estimate the length-weight relationship used in the biomass calculations. Neither of the small fish-meter scales were working during this survey (one had been returned to Bergen for repair and the second gave either erroneous or highly imprecise weights) and therefore it was not possible to weigh individual fish with sufficient precision. Length-weight relationships were therefore obtained from the subsequent survey from fish sampled just to the north of Cap Blanc. Individual biological information on sex and maturity was recorded for 40 fish per trawl (when present) of all target species. These descriptors are recorded in Annex V.

In addition, up to 40 samples per degree of whole specimens of *S. pilchardus, S. aurita* and *S. colias* were frozen for subsequent biological, morphometric and genetic analysis on land.

A full list of biological samples per species and trawl station is given in Annex VI.

2.6 Jellyfish sampling

Jellyfish were sampled from the trawl hauls. When the total catch was considered too big, the catch (fish, jellyfish, etc.) was sub-sampled. Thereafter, all jellyfish specimens caught, or representative random samples thereof, were identified to the lowest possible taxon and, if not damaged, measured across the upper surface of the bell and weighed.

Up to five (undamaged) jellyfish per species per degree latitude were preserved for further analysis. A small section of the oral arm tissue was removed and preserved in 96% ethanol (EtOH) and stored at -20°C. The rest of the specimen was stored in formalin. It was intended to collect representative samples of *Pelagia*, *Atolla* and *Periphylla*, but none were encountered.

2.7 Acoustic sampling

2.7.1 Bottom mapping echo sounder

The EM302 multibeam echo sounder was used as a high-resolution seabed mapping system. Data acquisition started approximately 10 m below the transducers, while the maximum acquisition depth was limited in practice to between 2 000–2 500 m. Across-track coverage (swathe width) is up to 5.5 times water depth and may be limited by the operator either in angle or in swathe width without reducing the number of beams. The operating frequency is 30 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°. Ping rate is set according to depth. The receiving beam width is 2°. Sound profiles were set manually in the system according to the area of operation. The data were logged to the on-board Olex plotting system.

2.7.2 Sonor data

A Simrad SH90 Sonar recorded data continuously 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° operation mode with the bearing of the vertical beams 90°, 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°. 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, were kept the same during all the surveying except during trawling operations where the sonar was at times used actively to focus in on targets. Observations of fish aggregations were noted in an Excel file to assist interpretation and analysis of the sonar data.

No other sonars were used during the survey.

2.7.3 Echo sounder

Echosounder 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. A successful calibration of the echo sounders was conducted in Walvis Bay on 11–12 May 2019, and confirmed during a subsequent calibration off Dakar, Senegal

immediately prior to this survey; the echo sounder gains from the Walvis Bay calibration were used (Annex VII).

Three stations were sampled for food safety and nutrition. *Sardinella aurita*, *Sardinella maderensis* and *Engraulis encrasicolus* were sampled individually (n=25) and in composite form. Only one of each species was captured at each individual station. Established protocols were followed. Samples were shipped to Bergen for further analysis.

2.7.3.1 Scrutinisation

Acoustic data were logged and post-processed on board using the latest acoustic data post-processing software, the Large-Scale Survey System (LSSS) Version 2.6.

The acoustic backscatter from the 38 kHz frequency of the EK80 was scrutinized daily and allocated to the various target groups. The integrator outputs (backscatter) were split into the fish groups listed below (Table 4) by a small group of "experienced scientists" using a combination of behaviour pattern as deduced from echo diagrams, the LSSS analysis and catch composition.

When sardinellas occurred an s_V threshold of -45 dB used to filter out other species and plankton. For other target species, and Pelagic-I and Pelagic-II species -47 dB or -50dB was generally used.

Table 4 lists the target groups used. These are based on groupings used during previous *Nansen* surveys, but recently undated such that all groups are standardised throughout western Africa. Note that the group "plankton" includes a range of dispersed weak scatterers including jellyfish, mesopelagic fish and, of course, zooplankton (and was colloquially referred to as "*Nansen plankton*").

The catch composition was adjusted to account for the difference in the catch of some of the trawls compared to the acoustically insonified targets being identified. This was done particularly for bottom trawls, and several pelagic trawls towed very close to the seabed, where large amounts of benthic and demersal fish were caught, mixed with the targeted pelagic fish. The bottom fish were removed from the calculations of catch composition.

Length distributions of each species, for each catch, was calculated and normalized to a unit number (usually 100). These were then averaged without weighting. Very small catches (less than about 20 fish) were not included. In some surveys different size-classes (of e.g. young fish and older fish or different cohorts of certain species) occur in distinct areas and so can be separated by allocating each to different strata. The size classes in this survey were well mixed and so the various length distributions were pooled together, the length frequency sampled in each trawl being weighted equally.

Determining the species composition of the acoustic backscatter when congeneric species, notably the two sardinella species and the two horse mackerel species, occurred in a stratum was not attempted during scrutinising. Rather the total backscatter was allocated to each species based on the length frequency distribution of each species as sampled from the trawls

in a stratum. As an alternative, to test the sensitivity of using different methods, total catch of all trawls in a stratum was also used as a proxy for estimating the proportion of congeneric species that could not be separated during scrutinising (this is described, and the results reported, in Annex VIII).

Table 4. Species groupings used to allocate acoustic backscatter

Group	**Taxon**	**Species**
Sardinella Sardine	Clupeidae	*Sardinella aurita* *S. maderensis* *Sardina pilchardus*
Horse mackerel	Carangidae	*Trachurus trecae* *T. trachurus*
Mackerel	Scombridae	*Scomber colias*
Anchovy	Engraulidae	*Engraulis encrasicolus*
Pelagic species 1 (other clupeiforme species)	Clupeidae	*Ilisha africana*
Pelagic species 2 (other pelagic species of potential commercial importance)	Carangidae	*Campogramma glaycos* *Caranx rhonchus* *Chloroscombrus chrysurus* *Selene dorsalis* *Trachinotus ovatus*
	Scombridae	*Auxis* sp. *Sarda sarda*
	Sphyraenidae	*Sphyraena guachancho*
	Trichiuridae	*Trichiurus lepturus*
Demersal species (listed are the species that were most commonly caught)		*Loligo vulgaris* *Lagocephalus laevigatus* *Pagellus bellottii* *Carlarius parkii* *Pomadasys incisus* *Pseudupeneus prayensis* *Lagocephalus lagocephalus* *Belone belone gracilis* *Galeoides decadactylus* *Boops boops* *Sepia bertheloti*
Other	Haemulidae	*Brachydeuterus auritus*
Plankton - weak scattering layers including mesopelagic fish, jellyfish and zooplankton		

2.7.3.2 Biomass estimation

Distributions are provided and biomass estimates were attempted for species identified as priority species by local scientists; *Sardinella aurita*, *S. maderensis*, *Trachurus trecae, T. trachrus, Sardina pilchardus*, *Engraulis encrasicolus* and *Scomber colias* (see Survey Objectives).

Distribution maps are also provided for Pelagic-I (*Ilisha africana*, which is commercially fished in some west African countries, although not in Mauritania) and Pelagic-II (a mixture of pelagic fish, non clupeoids, which are either fished commercially in other west African countries or have potential commercial value). The biomasses of these two groups were not estimated. *I. africana* is rarely encountered in Mauritania and therefore has no commercial value. The Pelagic-II group of fish, which includes *Caranx rhonchus*, is a diverse group with many different forms. This includes the bullet-shaped *Sarda sarda*, the ribbon shaped *Trichiurus lepturus*, the flat butterfly-shaped fish *Selene dorsalis*, etc. To assume that these fish have similar target strengths, and hence their biomass can be estimated as a group, is likely to lead to a highly inaccurate and misleading estimate.

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:

$$TS = 20 \log L - 72 \text{ dB}$$

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

$$C_{Fi} = 1.26\ 10^{6}\ L^{-2}$$

where L is total length in 1 cm length group *i* and C_{Fi} (m^{-2}) is the reciprocal back scattering strength, or so-called fish conversion function. In order to split and convert the allocated s_A-values (m^2/NM^2) to fish densities (numbers per length group per NM^2), the following formula was used:

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

where

ρ_i = density of fish in length group *i*
s_A = mean integrator value
p_i = proportion of fish in length group *i*
$\sum_{i=1}^{n} \frac{p_i}{C_{Fi}}$ = the relative back scattering cross section (m^2) of the length frequency sample of the target species, and
C_{fi} = reciprocal back scattering cross-section (σ_{bs}^{-1}) of a fish in length group *i.*

The above equations show that the conversion from s_A-values to number of fish is dependent on the length composition of the fish. It was therefore important to get representative length distributions for the key species groups throughout the whole distribution range.

The length-weight relationship, which is used to convert numbers to biomass, is normally calculated for each species or group, based on all fish sampled within each stratum or country. As noted earlier, the small scale in the fish lab was not working during this survey, nor the

previous (Senegal and Gambia) or subsequent (Morocco) surveys, and the accuracy of the larger scale was questionable for smaller fish. The length-weight relationships from a previous Mauritanian survey that was conducted at the same time of year were used; the Nansen survey of the pelagic stocks conducted in November 2002 (Table 5, *Toresen et al*., 2002). Using the length-weight relationships of the pelagic survey of June/July 2017 (Kragstad *et al.*, 2017), but as this was at a different time of year, when the condition of the fish is likely to be different, it was decided rather to use the 2002 survey.

During the 2002 survey individual weight measurements were used to estimate the condition factor in the length-weight relationship:

$$w = \text{cond. } L^3\ 100$$

The specific condition factors used are listed in Table 5.

Table 5. Condition factors used for conversion of fish numbers to biomass (from the 2002 Nansen survey of Mauritania, Toresen *et al.*, 2002)

Species	**CF**
S. aurita	0.96
S. maderensis	0.96
S. pilchardus	0.82
E. encrasicolus	0.54
S. colias	0.96*
T. trecae	0.96
T. trachurus	0.96

* *S. colias* was not measured during the 2002 survey and therefore the CF has been assumed to be the same as sardinella

The biomass estimation process used the following procedure:

- Divide the s_A-value between groups of fish and/or species through scrutinisation of the acoustic data and information from the trawl catches.
- Define strata based on the occurrence of a species, or group of species, in an area based on the distribution of s_A-values.
- Calculate the average s_A-value (per nm) of each species/group in each stratum.
- The length-frequency samples of the species for the stratum were pooled together with equal weighting (as described above).
- The mean back scattering strength (ρ/s_A) of each length class of the target group/species was calculated. The total backscattering for all length classes was then summed. This was automatically done in the Excel spreadsheet made available for acoustic abundance estimation on board R/V *Dr Fridtjof Nanse*n.
- The pooled length distribution was used, together with the mean s_A-value, to calculate the density (numbers per NM^2) by length groups and species, using the above formula. The total number by length group in the area was obtained by multiplying each number/NM^2 by the area (as generated by Nansis Maptool).
- The numbers were then converted to biomass using the estimated weight at length.

CHAPTER 3. RESULTS

3.1 Water sampling

3.1.1 Cross shelf (surface) hydrographic profiles

Figure 7 shows the surface maps (-5 m) of temperature, salinity and DO. Between 16°05'N and 19°05'N the near-surface temperature was between 30°C and 26°C, while further north, between 19°05' and 20,05'N, the temperature drops between 25°C to 21°C. The salinity surface map shows relatively high salinity levels throughout the region, apart from the southeastern area between 16°05' and 17°05'N. The near-surface concentration of dissolved oxygen was connsistently below 4.8 ml/l throughout the region apart from the northern area between 19°05' and 20°05'N where it was between 4.7 ml/l and 5.2 ml/l, and the central-eastern and south-eastern areas, where it was between 4.7 ml/l and 5.0 ml/l.

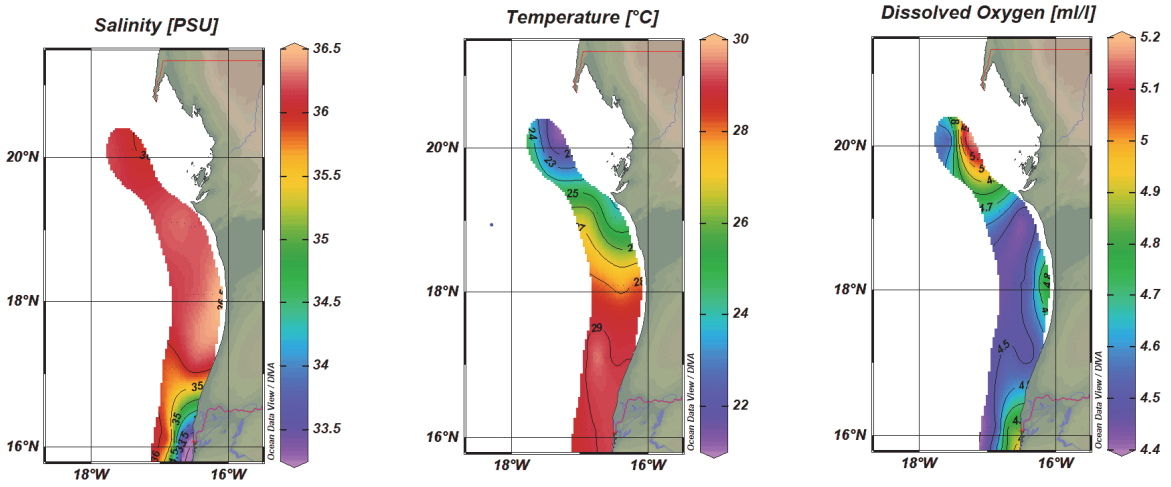


Figure 7. Sea surface salinity, temperature and dissolved oxygen of the Mauritania area

3.1.2 Vertical hydrographic transect profiles

Profiles of water samples were analysed along all five transects on the continental shelf area of Mauritania (Figure 2). Three transects are presented below to illustrate the key physical characteristics of the survey area (Figure 8, Figure 9 and Figure 10). The remaining two transects (for the 17°05' and 18°05'N transects) are presented in Annex IX. The 19°05'N transect is essentially representative of the entire Mauritanian shelf and shelf-break zone, with the exception of the southernmost and northernmost areas, which are represented by the 16°05'N and 20°05'N transects respectively.

Transect 16°05’N

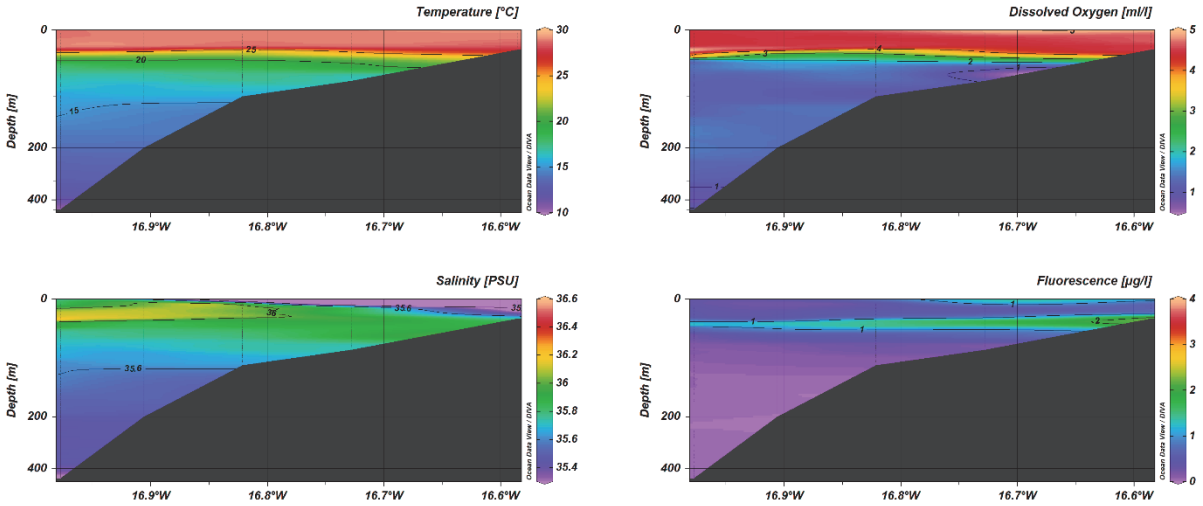


Figure 8. Hydrographic profile at 16°05'N of the temperature, salinity, dissolved oxygen and fluorescence

The temperature profile on the southernmost transect shows a broad thermocline in the upper 100 m with the temperature declining from nearly 30°C to 17°C. The salinity profile indicates a surface slick of low salinity water, near 35.2 PSU, near the shore, increasing to above 36 PSU farther offshore. Below 200 m the salinity stabilised near 35.5 PSU until it declined again below 35.4 PSU near the ocean floor. The DO profile shows surface values just about 5.0 ml/l, but by 100 m depth this had declined to less than 2 ml/l, with the OMZ in near-bottom waters from 100 m and below essentially being anoxic. The fluorescence profile shows a maximum of approximately 2 µg/l in the layer between 40 and 60 m with values approaching 0 µg/l below 100 m.

Transect 19°05’N

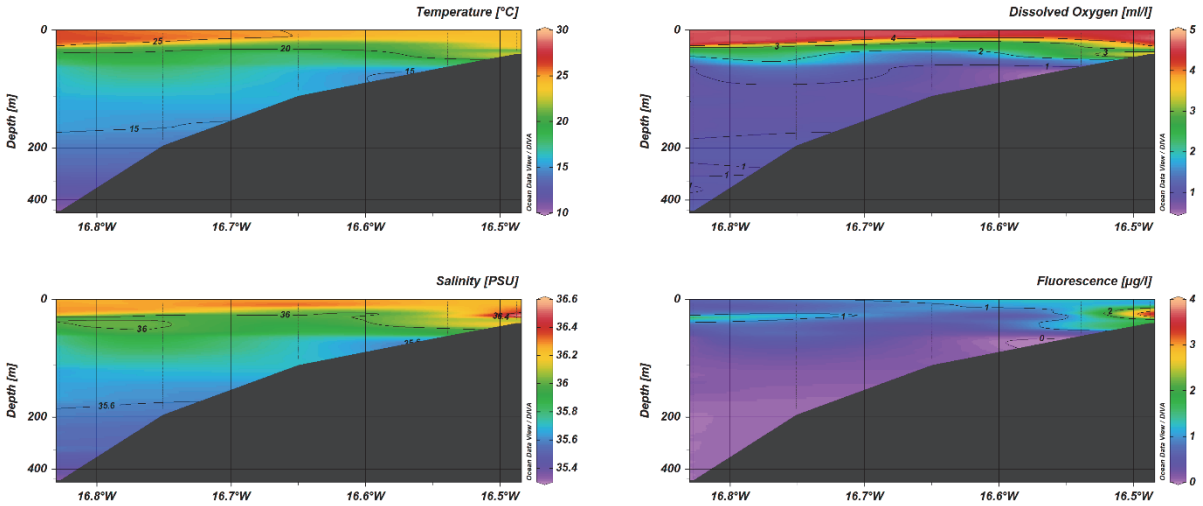


Figure 9. Hydrographic profile at 19°05'N of the temperature, salinity, dissolved oxygen and fluorescence

The 19°05’N transect has a coastal temperature profile that declines from 25°C to 17.5°C from the surface to 50 m and then more gradually from 27.5°C down to 11°C at 500 m. The salinity profile has a high salinity near 36.2 PSU at the surface to below 35.4 PSU in the deeper layers. But does have a maximum above 36.4 PSU near the coast at 30 m. The DO profile shows a relatively high value in the near-surface layer (4.5 m/l), with the OMZ below 1 ml/l occurring from about 75 m downwards. The fluorescence profile shows a high value in the near-shore surface waters (>3 µg/l) at 25 m. The fluorescence maximum remained at this depth in the outer stations with values around 1 µg/l. The fluorescence signal was non-detectable below 100 m.

Transect 20°05’N

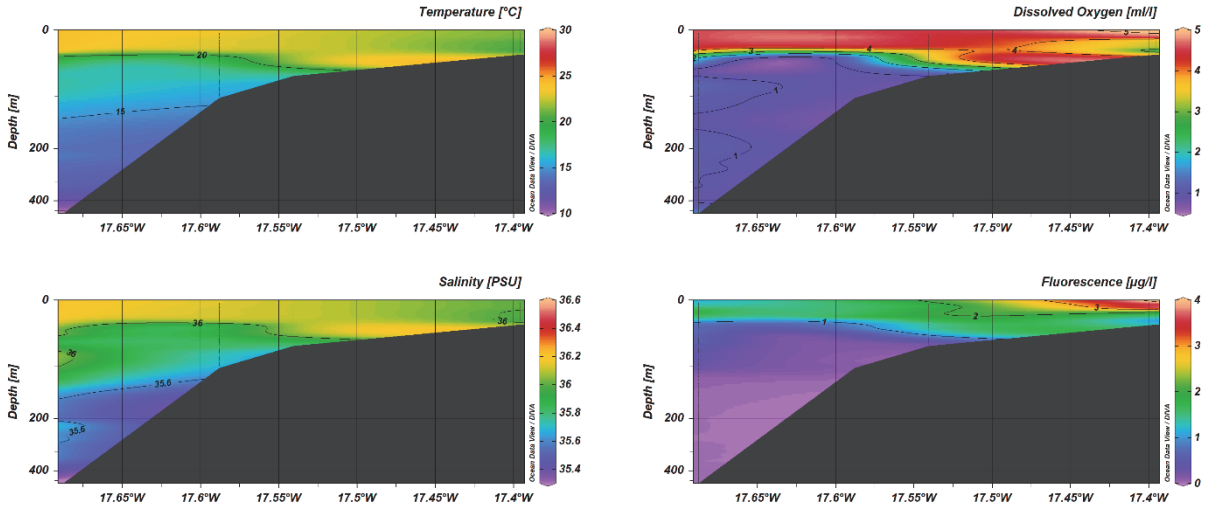


Figure 10. Hydrographic profile at 20°05'N of the temperature, salinity, dissolved oxygen and fluorescence

The northernmost transect is less stratified than farther south, as indicated by the temperature profile, which shows a weak thermocline of 24°C to 20°C from the surface to 100 m. This is also reflected in the salinity profile except that the salinity doesn’t reach 35.6 PSU until approximately 175 m. The DO and fluorescence profiles show relatively high values at the surface (near 5 ml/l and 5 µg/l respectively), particularly near the shore for fluorescence. However, a large zone of anoxic water lies near the seabed from 100 m and below. It is interesting to point out the pocket of water between 50 and 100 m on the shelf as temperature, salinity, DO and fluorescence (slightly) levels begin to increase to near surface offshore levels on the shelf floor.

3.1.3 pH and Dissolved Oxygen Relationship

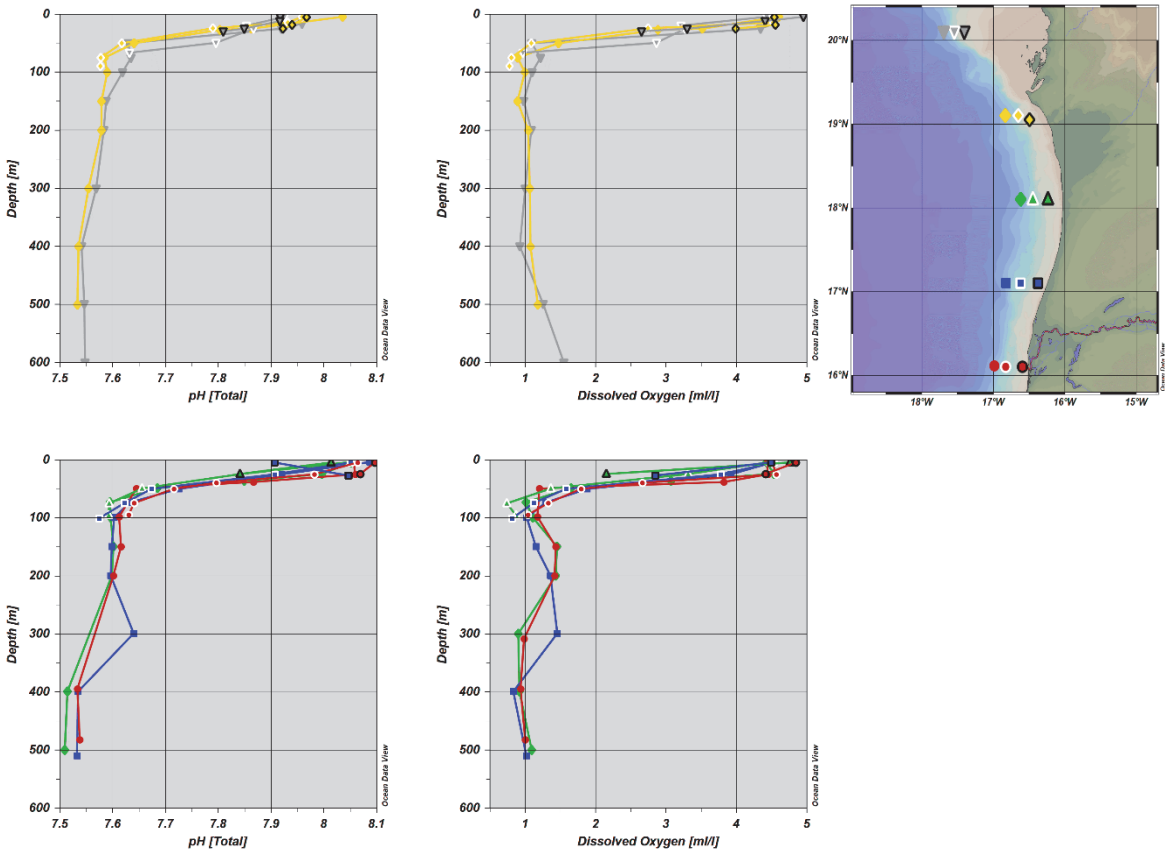


Figure 11. pH and dissolved oxygen relationship for the five hydrographic transects along Mauritania. Profile colours and station outlines correspond to the provided station map

The central and southern transects of Mauritania show higher subsurface pH levels with most lying between 8 and 8.1. In comparison, the northern transects, situated near 20°N and 19°N respectively, only had one value (offshore) above a pH of 8 (confirmed with triplicate measurements). As does dissolved oxygen, pH decreases sharply to 100 m, at which point it stabilizes near 7.6 before decreasing again, slowly, to levels between 7.5 and 7.55 at 400 m and below. Dissolved oxygen drops to an average of 1 ml/l at 100 m before remaining relatively stable in the northern region before increasing again above 1 ml/l near 400 m with water at 600 m reaching 1.5 ml/l. Although there is an extremely small DO increase near 200 m in the northern region, this increase is more detectable in the central and southern regions as values reach 1.5 ml/l at 150 m for the 16°N and 18°N transects. The 17°N transect however reaches 1.5 ml/l at 300 m, where pH also increases from 7.6 to 7.65 at 300 m (both values for pH and dissolved oxygen at 300 m were confirmed by either a triplicate measurement or Winkler titration validation). Despite small increases farther down in the water column, the Mauritanian coast shows consistently low pH and DO levels below 100 m.

3.1.4 Chlorophyll a

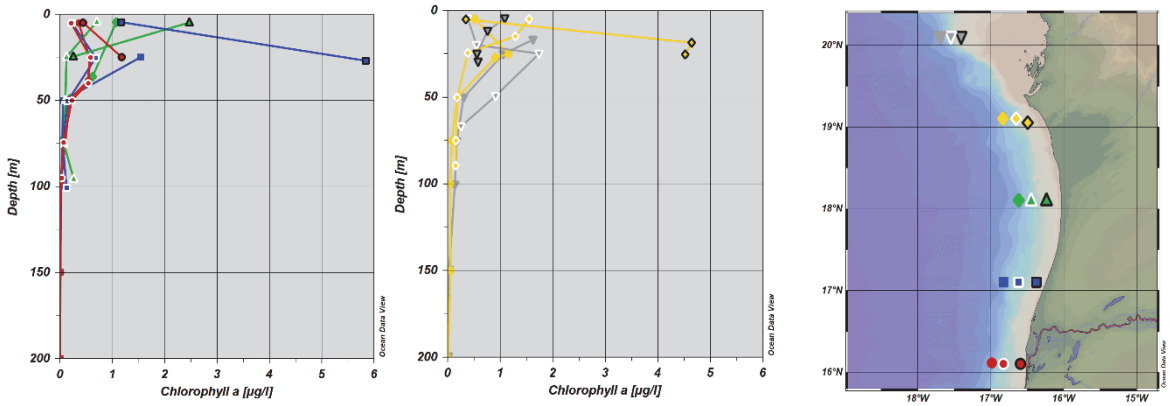


Figure 12. Chlorophyll a concentration as measured by fluorometric analysis for the five hydrographic transects along Mauritania. Profile colours and station outlines correspond to the provided station map

Chlorophyll a concentrations depict maxima near 20-25 m on the 17°N and 19°N transects, with levels approaching 6 µg/l inshore at 17°N and reaching 4.5 µg/l inshore at 19°N. These maxima agree with the fluorescence sensor measurements in Figure 9 and Annex IX. Figure 10 for the 20°N transect also shows subsurface fluorescence sensor levels approaching 4 µg/l inshore but the collected chlorophyll a samples (measured in triplicates or duplicates for confirmation) do not share the same trend. Decreasing coastal water temperature can support signs of upwelling, however coastal water temperature does not decrease at 17°N but does decrease at 19°N and 20°N (Figure 9 and Figure 10). Despite most chlorophyll a concentrations remaining below 2 µg/l, further investigation into the nutrient data can help in the detection of upwelling along the Mauritanian coast, especially at 17°N and 19°N.

3.2 Plankton and microplastics

3.2.1 Zooplankton

A total of 35 aluminum trays for zooplankton dry weight estimation were produced during the survey and transferred to IMR for zooplankton biomass estimation. Based on these measurements the horizontal distribution pattern of mesozooplankton biomass (g m^{-2}) is presented in Figure 13. Total zooplankton biomass ranged between 1.0-6.7 g m^{-2}, with the highest values in the northern stations, followed by the coastal stations. Size fractionation of samples revealed that organisms smaller than 1 mm in size comprised most of the zooplankton biomass, although for certain stations, particularly in the northern area of the survey, the contribution of organisms larger than 2 mm was also important (Figure 14).

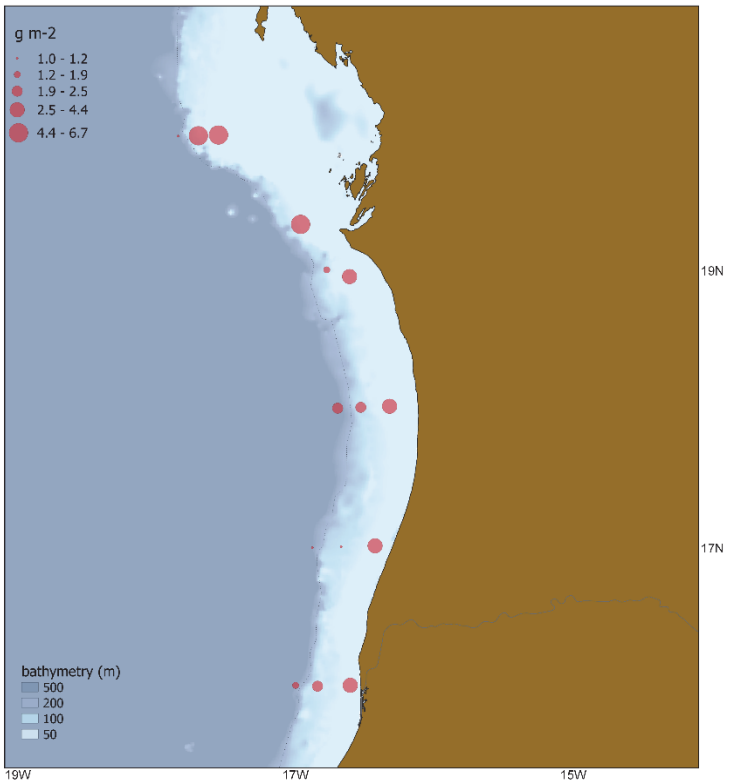


Figure 13. Total zooplankton biomass (g m-2)

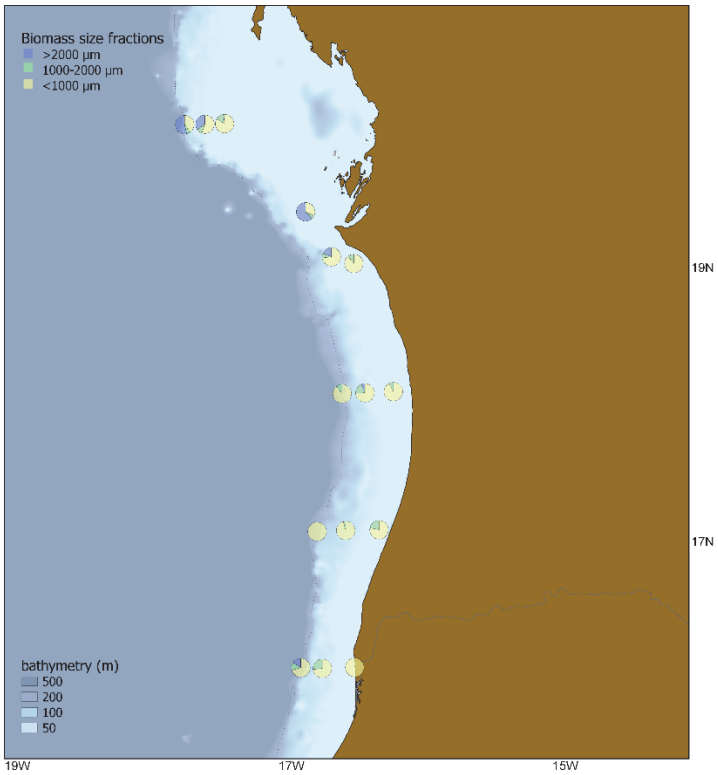


Figure 14. Contribution of different size fractions (< 2 000 µm, 1 000–2 000 µm, and > 1 000 µm) to the total zooplankton biomass

3.2.2 Fish eggs and larvae

A total of 15 pairs of Bongo net samples were collected. Two of the bongo samples may have been somewhat compromised when the gear touched the bottom and, especially in one, a large amount of sediment was collected. Many eggs and larvae were also collected in the Manta trawl, of which 15 samples were also taken at the same stations (Table 6, Figure 15 and Figure 16).

Table 6. Number of samples taken at super stations

Station depth	WP2	Manta	Bongo V	Bongo H	Total
30 m	5	5	5	5	20
100 m	5	5	5	5	20
500 m	5	5	5	5	20
Total	15	15	15	15	60

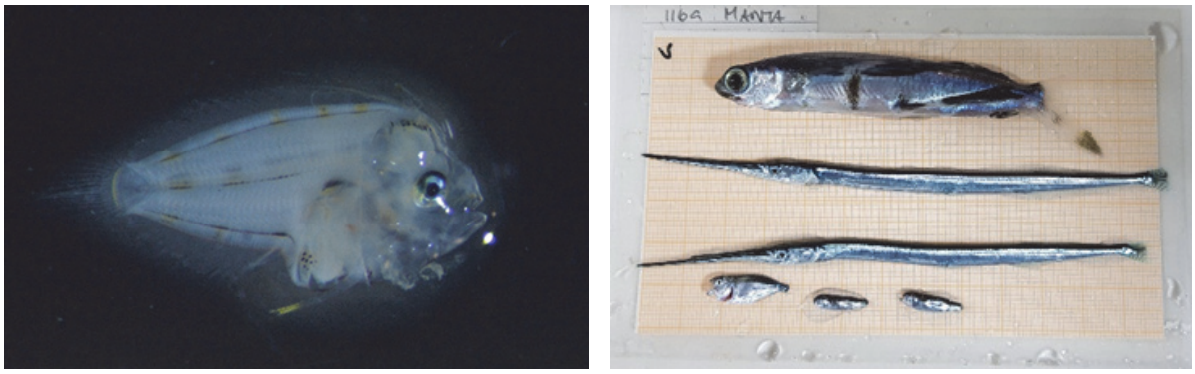


Figure 15. Fish larvae and juveniles found in the Bongo and Manta trawl net samples

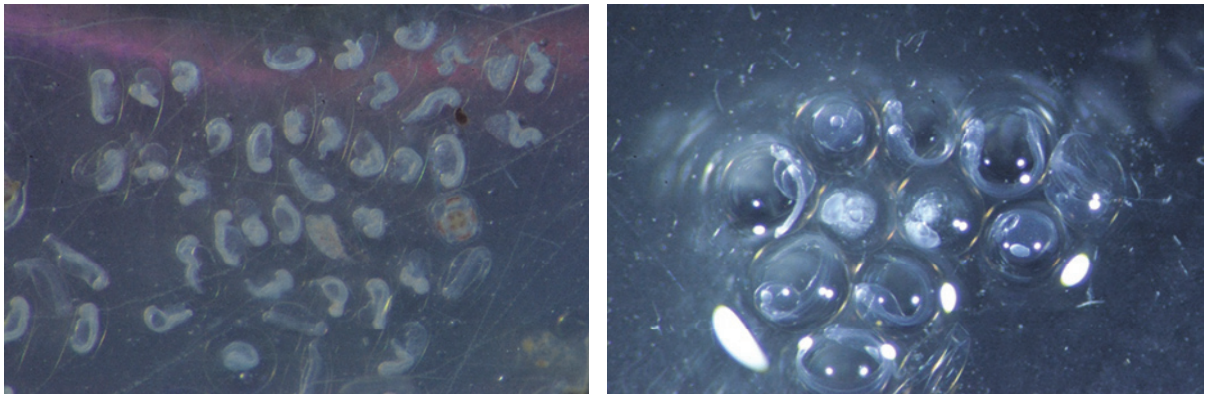


Figure 16. Fish eggs and larvae hatching from eggs found in the Manta trawl net samples

3.2.3 Microplastics

A total of 15 Manta trawl net hauls were successfully taken (Table 6). The results will be reported separately. An example of some of the microplastics sampled is shown in Figure 17.

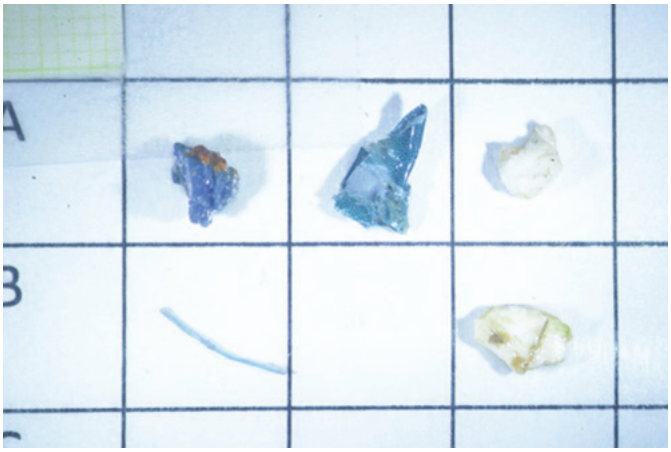


Figure 17. Microplastics and marine debris from a Manta trawl net

3.3 Top predator observations

Nine full days of effort were expended searching for cetaceans and seabird, averaging around 8.5 hours per day. Note that no accurate record of time spent on observations (=effort) was kept.

Table 7 summarises the sightings of cetaceans. Table 8 summarises the seabird counts per day.

In addition to the seabirds listed below, numerous terrestrial-based birds from the desert were also alighted on the vessel during the Scirocco winds, many remaining on board for several days. These included at least two kestrels (one was a *Falco tinnunculus*, the other may have been a *Falco naumanni*), several redstarts (*Phoenicurus phoenicurus*), several wheatears (*Oenanthe oenanthe*), several turtle doves (*Streptopelia turtur*), a Pharaoh eagle-owl (*Bubo ascalaphus*), several spotted flycatchers (*Muscicapa striata*), a white wagtail (*Motacilla alba*), a yellow wagtail (*Motacilla flava*), several Spanish sparrows (*Passer hispaniolensis*). Also a single osprey (*Pandion haliaetus*) was seen flying past the vessel.

Table 7. Summary of daily sightings of cetaceans and turtles

Scientific name	English name	French name	10.10	11.10	12.10	13.10	14.10	15.10	16.10	17.10	18.10	Total
Delphinus delphis	Common dolphin	Dauphin commun							2 415	700		3 115
Dolphin	Unidentified dolphin	Dauphin	30									30
Physeter macrocephalus	Sperm whale	Cachalot							11	2		13
Caretta caretta	Loggerhead turtle	Tortue carette	1									1
Chelonia mydas	Green turtle	Tortue verte				1						1

Table 8. Summary of daily sightings of seabirds

Scientific name	English name	French name	10.10	11.10	12.10	13.10	14.10	15.10	16.10	17.10	18.10	Total
No. of counts/day			6	9	7	9	9	10	5	4	3	62
Ardenna grisea	Sooty shearwater	Puffin fuligineux				2	3					5
Calonectris diomedea borealis	Cory's shearwater	Puffin cendré (atlantique)		1		20	32	7		26	17	103
Chlidonias niger	Black tern	Guifette noir	3	47	22	7	7	490				576
Hydrobates pelagicus	European storm-petrel	Oceanite tempete					2					2
Hydroprogne caspia	Caspian tern	Sterne caspienne						1				1
Larus fuscus	Lesser black-backed gull	Goéland brun	3	8	1	2	0	25	2	0	0	41
Morus bassanus	Northern gannet	Fou de bassan	1		2	1	4	5		21	115	149
Oceanites oceanicus	Wilson's storm-petrel	Oceanite de wilson				7	50					57
Pelecanus onocrotalus	White pelican	Pélican blanc						3				3
Stercorarius lomgicaudus	Long-tailed skua	Labbe a long queue	1									1
Stercorarius skua	Great skua	Grand labbe	6	3	0	13	2	1	4	2	15	46
Stercorarius pomarinus	Pomarine skua	Labbe pomarin	4	14	19	50	15	18	13	8		141
Sterna hirundo	Common tern	Sterne pierregarin	15	164	13		28	48				268
Thalasseus maximus	Royal tern	Sterne royale		4		1	5	8				18
Thalasseus sandvicensis	Sandwich tern	Sterne caugek	47	3	0	19	0	60	6	0	0	135
Xema sabini	Sabine's gull	Mouette de sabine	3	31	1	8		3		6		52

3.4 Food safety

Table 9 shows the number of samples collected for the various types of analyses of fish for the assessment of food safety. The analysis will be carried out at IMR, Bergen, Norway.

Table 9. The sampling done for analytical work for each species

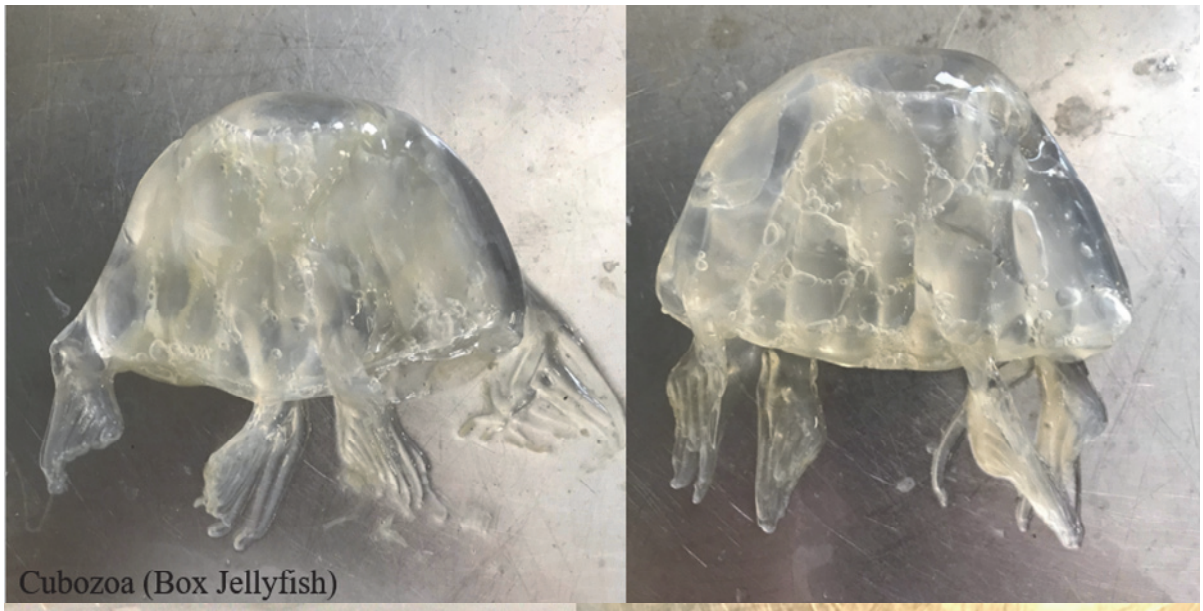
Species	Station No.	Liver	Fillet
Sardinella maderensis	10	N = 15	N = 25
	22	N = 15	N = 25
Sardinella aurita	10	N = 15	N = 25
Engraulis encrasicolus	5	Whole N = 3	N = 3
	22	Whole N = 3	N = 3
	24	Whole N = 3	N = 3
	32	Whole N = 3	N = 3

3.5 Jellyfish

Overall, nine species of jellyfish were caught in the fish trawls, occurring at 14 out of the 36 stations (Table 10). In a single catch, it was estimated that 16 000 individuals of *Aequora* sp. were caught, however, all individuals were damaged and could not be sampled. Some examples of the jellyfish sampled are shown in Figure 18.

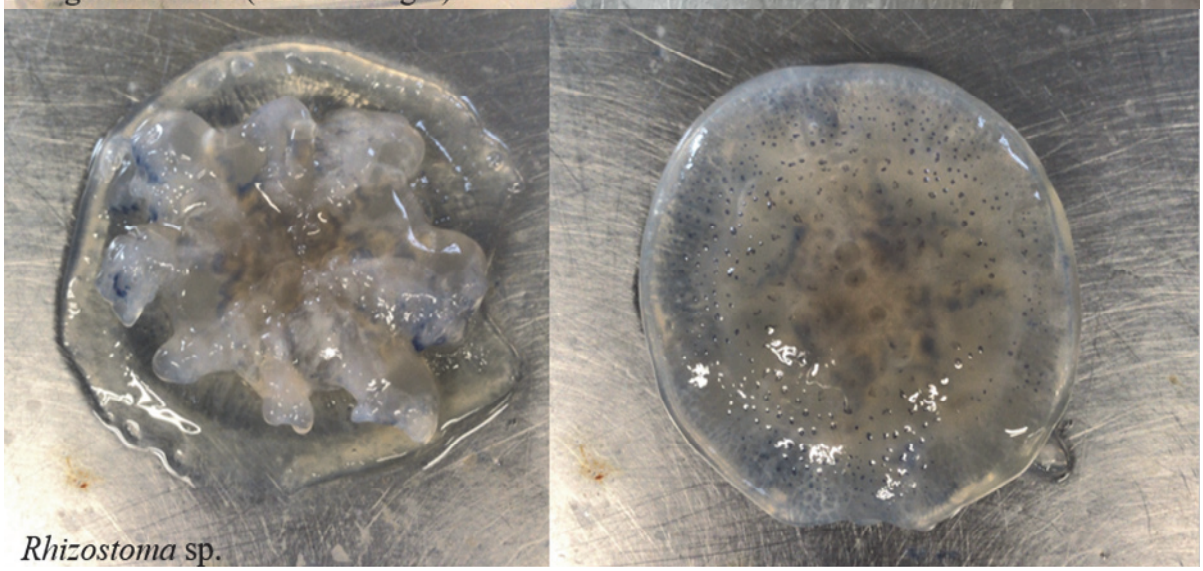
Table 10. Jellyfish sampled in Mauritania survey

Species	No. stations	Total no. caught	No. Sampled	Av. diameter of bell (cm)
Catostylus tagi	2	211	7	24
Chrysaora sp.	1	5	5	7
Cubozoa (sp.1)	1	180	5	17
Rhizostoma sp.	2	5	3	10
Rhizostomeae (sp.1)	4	43	26	21
Cyanea capilata	1	1	1	34
Unknown Jellyfish	1	3	3	31
Pelagia noctiluca	1	6	6	5



Cubozoa (Box Jellyfish)

Pelagia noctiluca (Mauve stinger)



Rhizostoma sp.

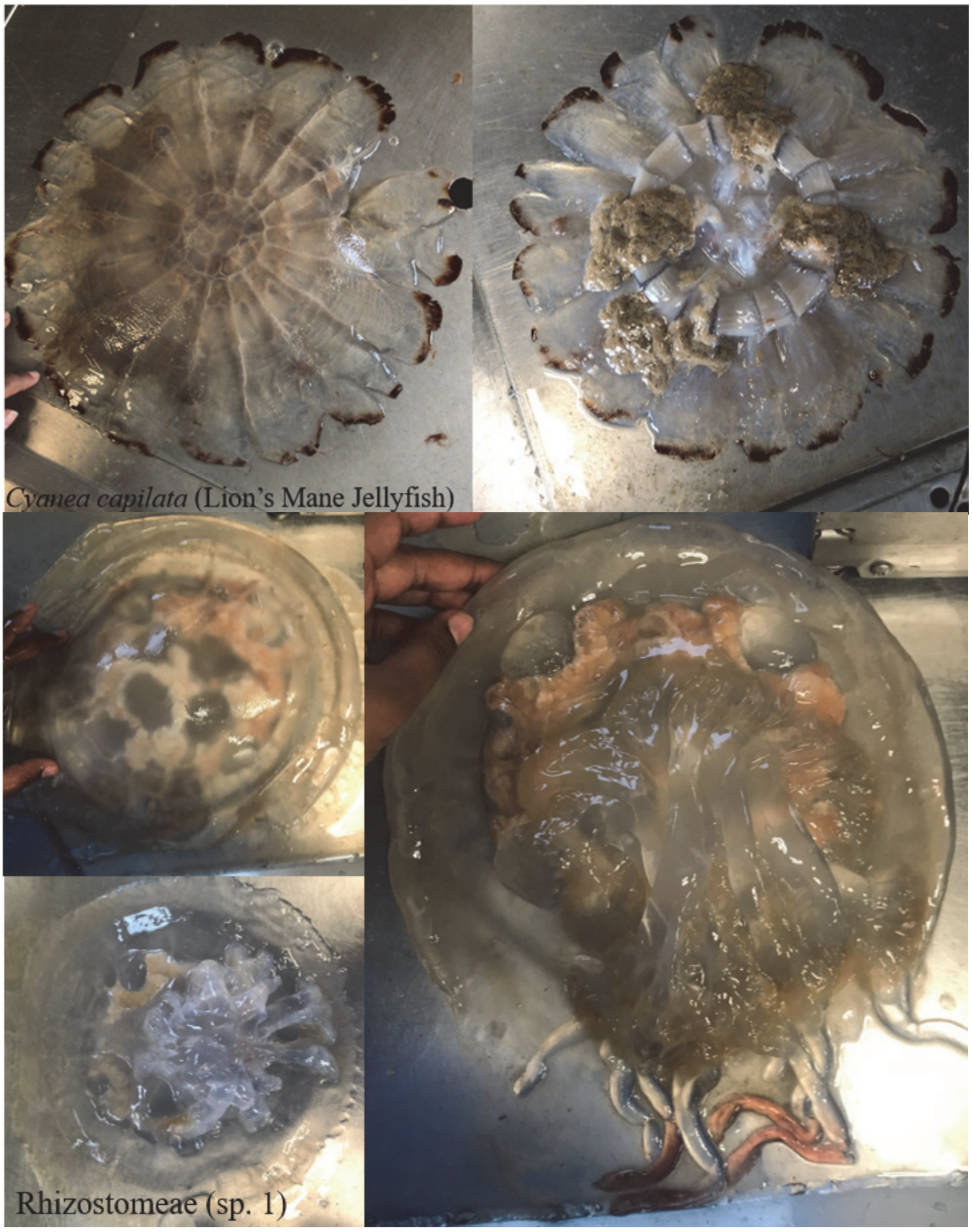


Figure 18. Examples of jellyfish caught during the survey

3.6 Biology of target pelagic fish species

In the following are the provisional results of key biological parameters notably sex, maturity, size, distribution and biomass of the key species. Samples taken for post-survey age and growth, stock structure, population biology and trophic interaction studies have been transported to various research institutes for analysis (see Annex X) and will be reported separately. Annex VI reports the numbers of samples collected.

3.6.1 Sex-ration

In the northern part of Mauritania males and females of *S. maderensis*, *S. pilchardus* and *E. encrasicolus* were essentially equally represented in the samples, while *S. aurita*, *S. pilchardus* and both *Trachurus* species were mostly juveniles (Figure 19). Note that too few *S. colias* were sampled in the north to warrant any biological analysis.

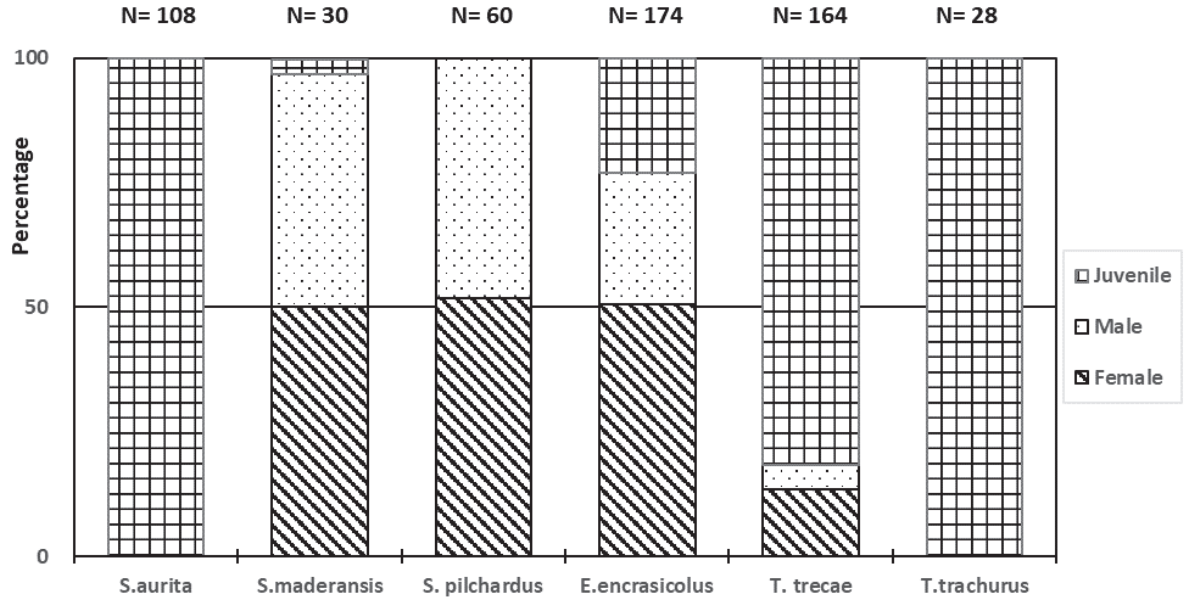


Figure 19. Sex-ratio of target species: Cap Timiris to Cap Blanc

To the south, between St Louis and Cap Timiris, the general trends were similar, with the exception that a small proportion of *S. aurita* were adults (with an equal proportion of each sex), while the anchovy were all juveniles, as were the few *T. trachurus* sampled in this region (Figure 20).

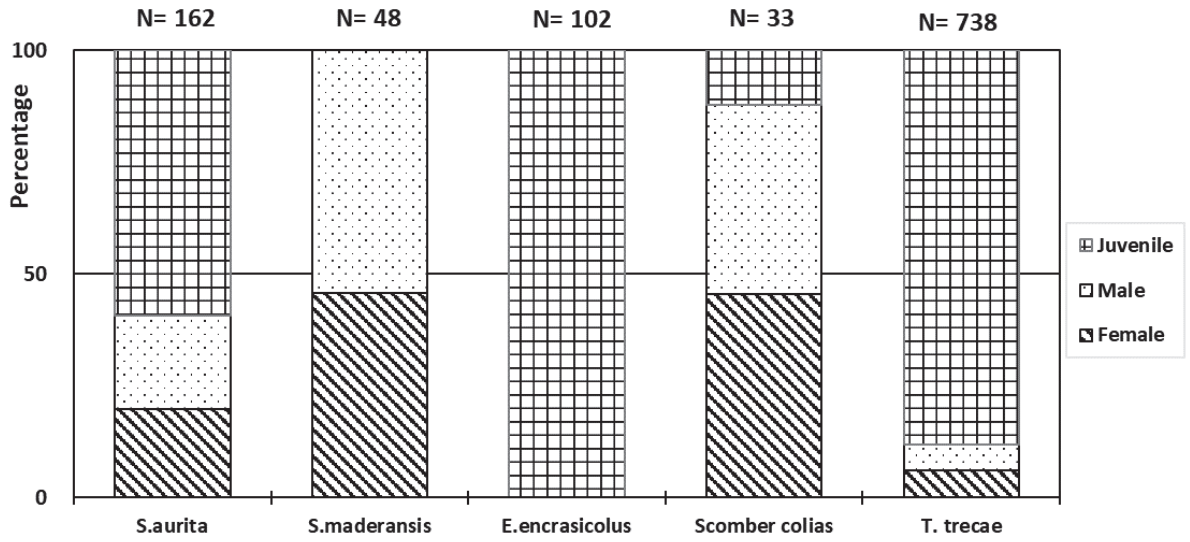


Figure 20. Sex-ratio of target species: St Louis to Cap Timiris

3.6.2 Sexual maturity

The sexual maturity of the various species in the northern part of Mauritania showed that, as with the sex-ratio data, *S. aurita*, and both *Trachurus* species were mostly juveniles. *S. maderensis* and *E. encrasicolus* were in a range of maturity states, while the few *S. pilchardus* sampled were mostly ripe (Figure 21). To the south, the few *S. maderensis* sampled were maturing to spent, while most fish of the other species sampled were juveniles or immature (Figure 22).

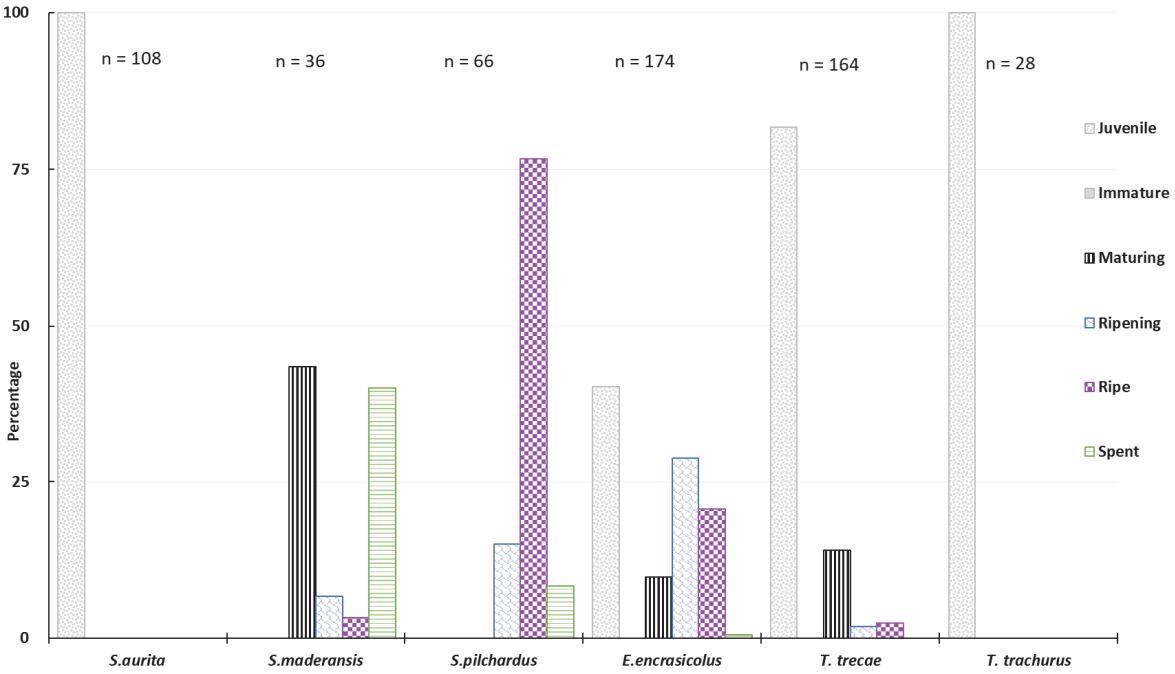


Figure 21. Sexual maturity of target species: Cap Timiris to Cap Blanc

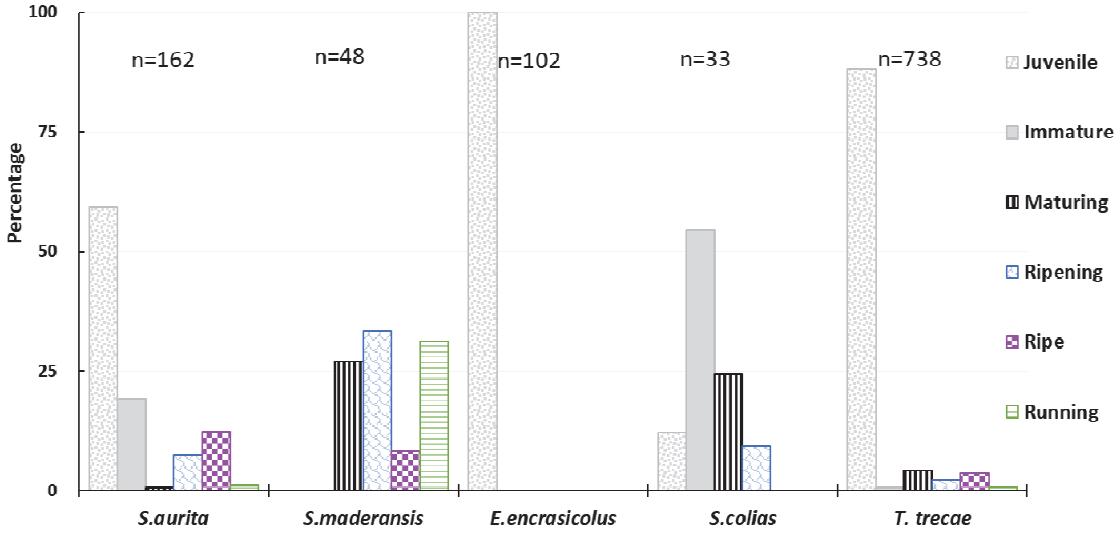


Figure 22. Sexual maturity of target species: St Louis to Cap Timiris

3.6.3 Length-frequency and distribution

This section contains details of the distribution of the various target species and some brief comments on the size of the fish.

S. aurita were mostly juvenile fish, with a modal length of 11 cm to 17 cm. A small proportion (by number) of the stock were adults ranging from 21 cm to over 30 cm, probably comprising of several cohorts (Figure 23). *S. aurita* were widely distributed throughout the region, mostly inshore of the 40 m isobath, but occasionally out to 80 m bottom depth (Figure 30). All catches were well-mixed with horse mackerel and other pelagic species (Annex III). Compared to *S. aurita* relatively few *S. maderensis* were found. These were mainly in the south (Figure 30) and were large adult fish mostly from 23 cm to 31 cm (Figure 24).

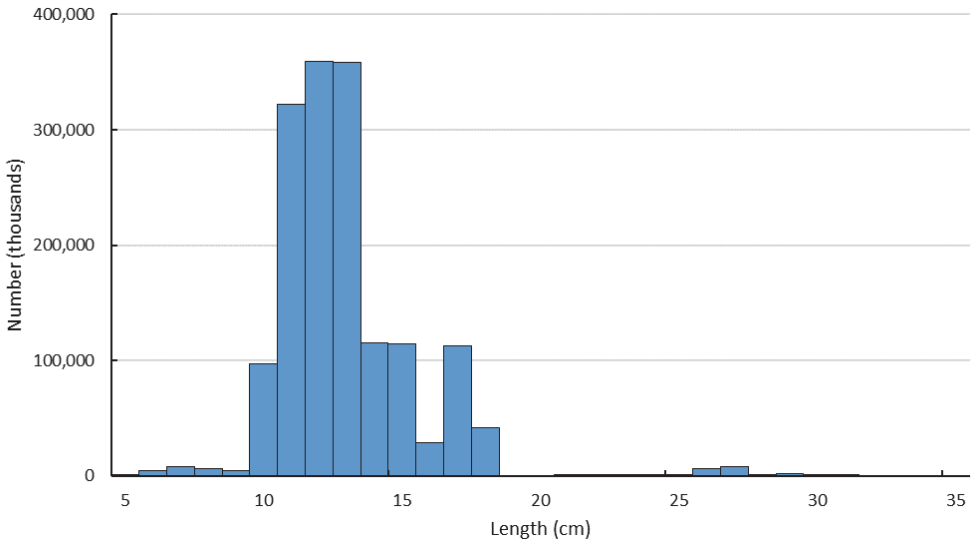


Figure 23. Length frequency distribution of *Sardinella aurita*, total population

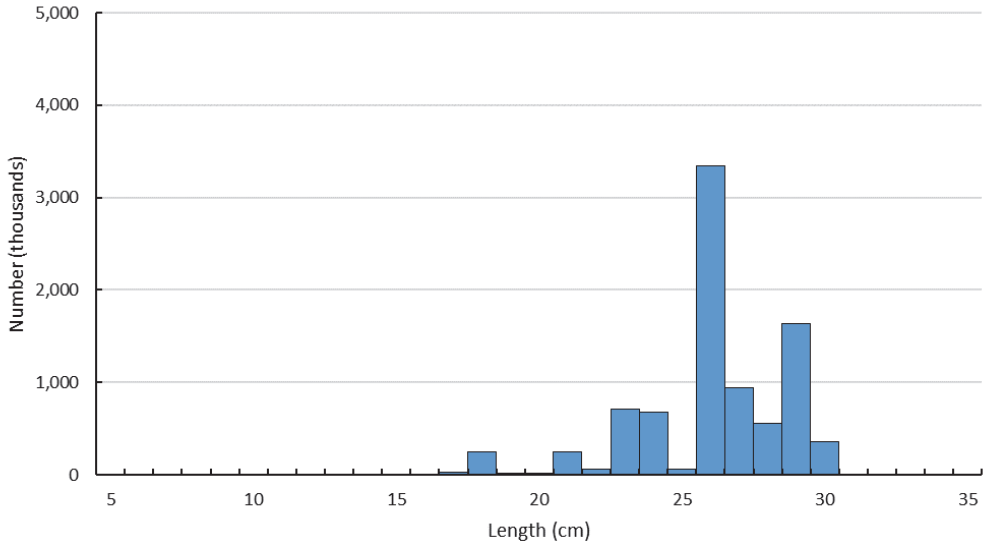


Figure 24. Length frequency distribution of *Sardinella maderensis*, total population

Few *S. pilchardus* were found and these were close to the northern border (Figure 31) and, as with most pelagic fish, occurred in well-mixed shoals, usually with sardinellas, anchovy and horse mackerel. One catch of mostly sardines was taken in the north, although the acoustic record suggested that these fish were widely distributed in small schools, rather than in large dense single-species schools with which sardine are usually found (Annex III). A cohort of 22-24 cm dominated but with a significant number of larger fish from 26 cm to 31 cm (Figure 25).

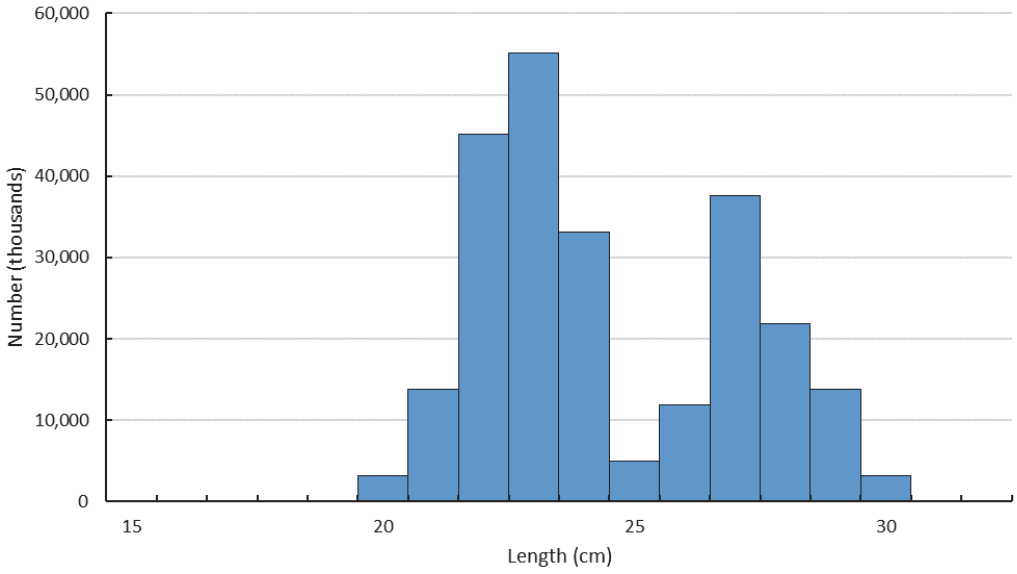


Figure 25. Length frequency distribution of *Sardina pilchardus*, total population

E. encrasicolus were widely distributed throughout the region (Figure 32), mostly in well-mixed shoals of sardinella and horse mackerel. A few dense mono-specific schools were found in relatively deep waters in the north. The fish were mostly small, with a modal peak from 8 cm to 10 cm (Figure 26).

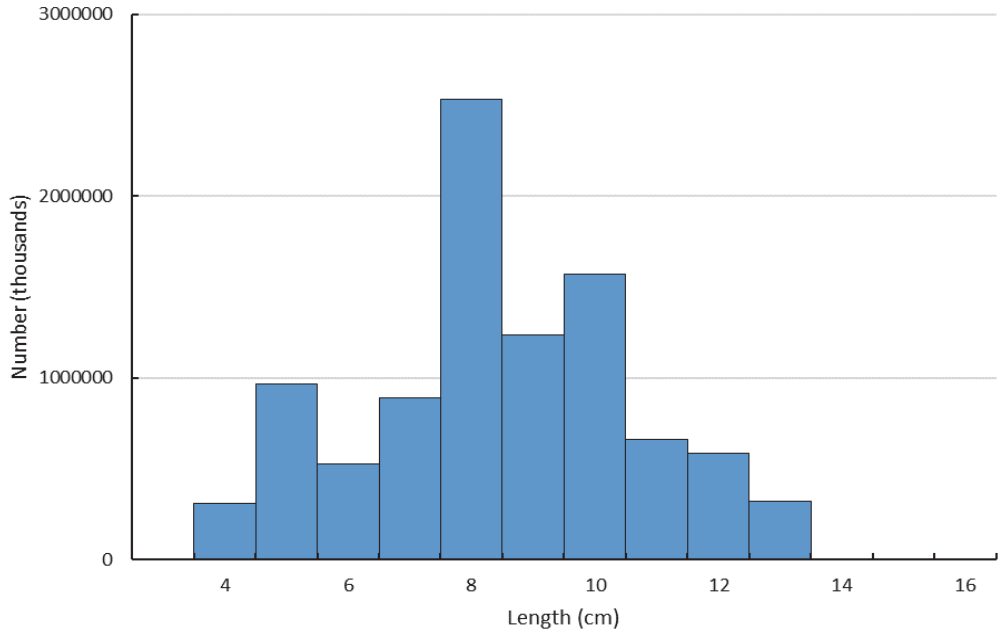


Figure 26. Length frequency distribution of *Engraulis encrasicolus*, total population

Few *Scomber* were found. These were widely distributed throughout the area (Figure 33) and, in the trawls in which they occurred, always formed a small portion of the catches, mixed with other pelagic species, but notably horse mackerel (Annex III). The few fish sampled were large, with lengths ranging from 29 cm to 34 cm (Figure 27).

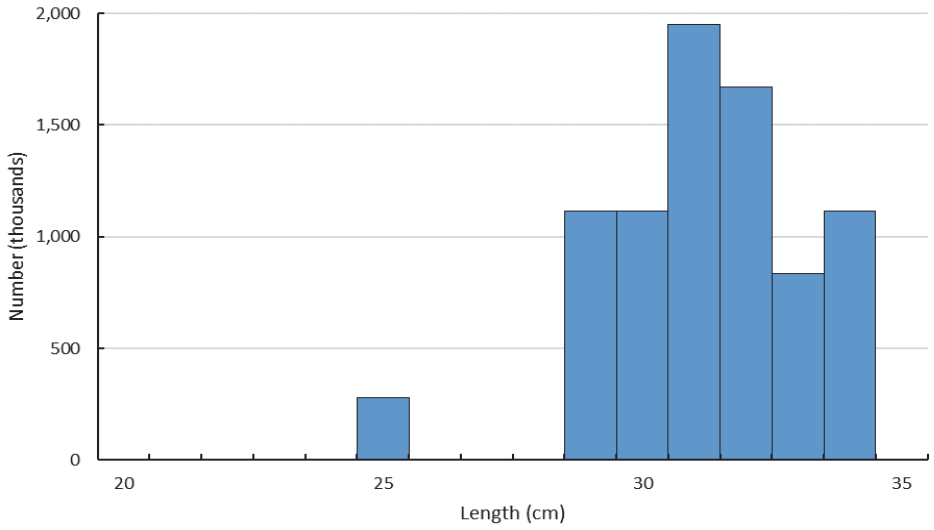


Figure 27. Length frequency distribution of *Scomber colias*, total population

Trachurus trecae dominated the pelagic catches throughout the region (Annex III), being found from shallow waters to beyond the 80 m isobath (Figure 34). Most catches were mixed with other pelagic species. The majority were from a juvenile cohort, from 9 cm to 13 cm, but some adult fish of 24 cm and larger were also found (Figure 28).

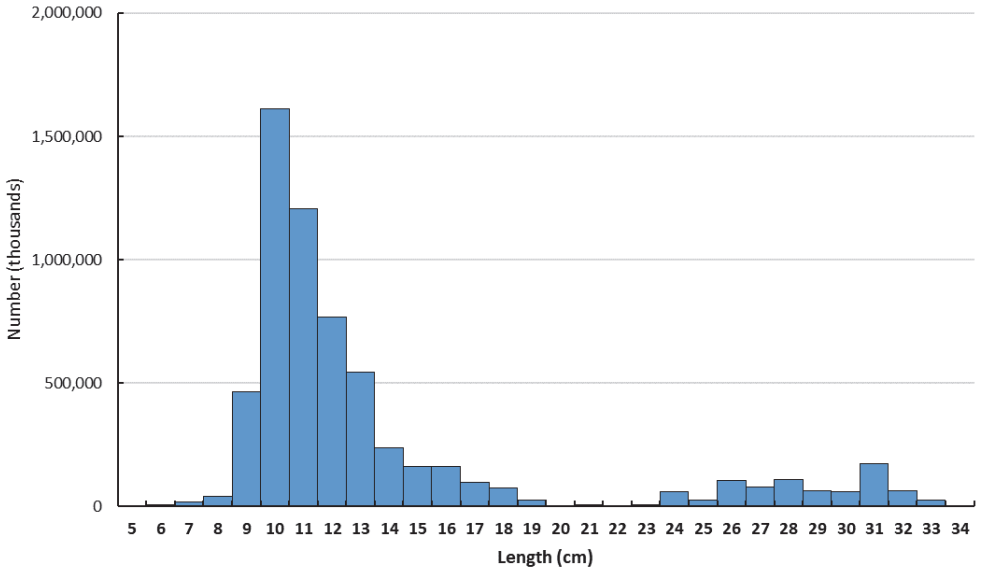


Figure 28. Length frequency distribution of *Trachurus trecae*, total population

T. trachurus were only found close to the northern border, and then only in small amounts (Figure 34). These were all from a juvenile cohort of 9 cm to 12 cm (Figure 29).

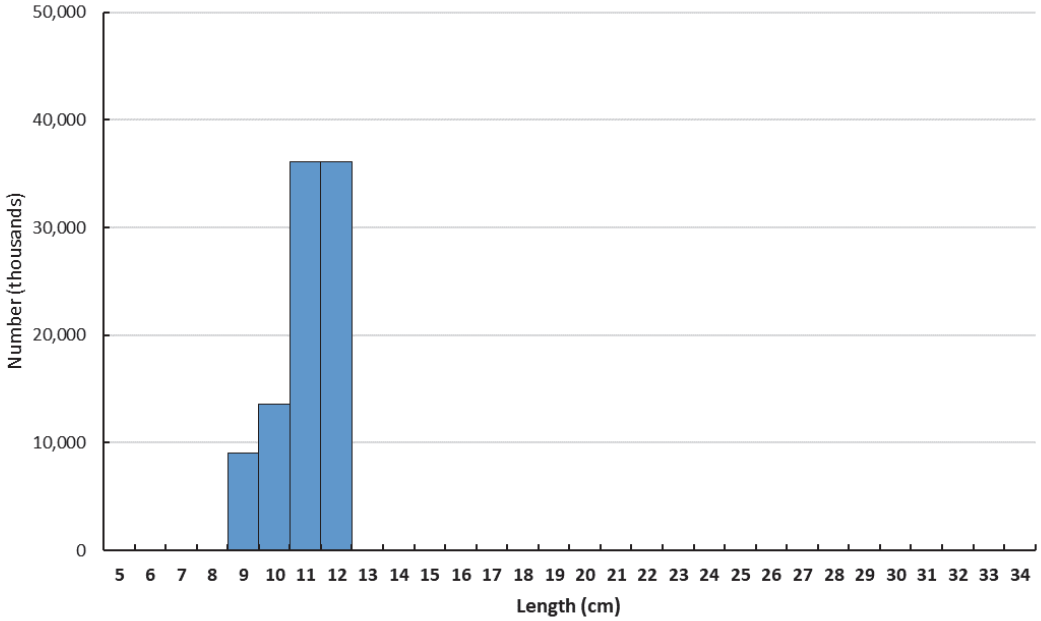


Figure 29. Length frequency distribution of *Trachurus trachurus*, total population

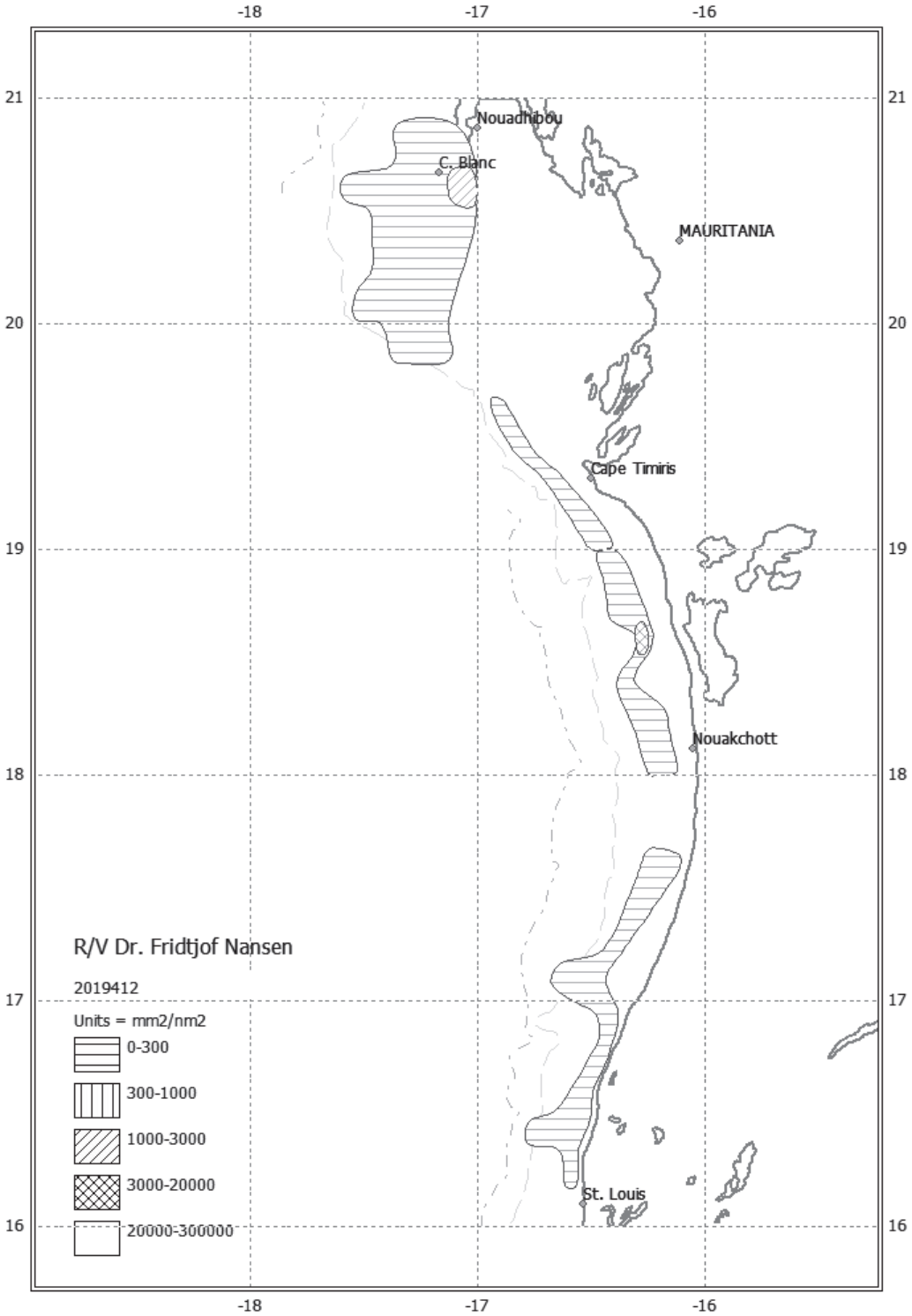


Figure 30. Distribution (density= m^2/NM^2) of both species of sardinellas (depth contours as in Figure 2)

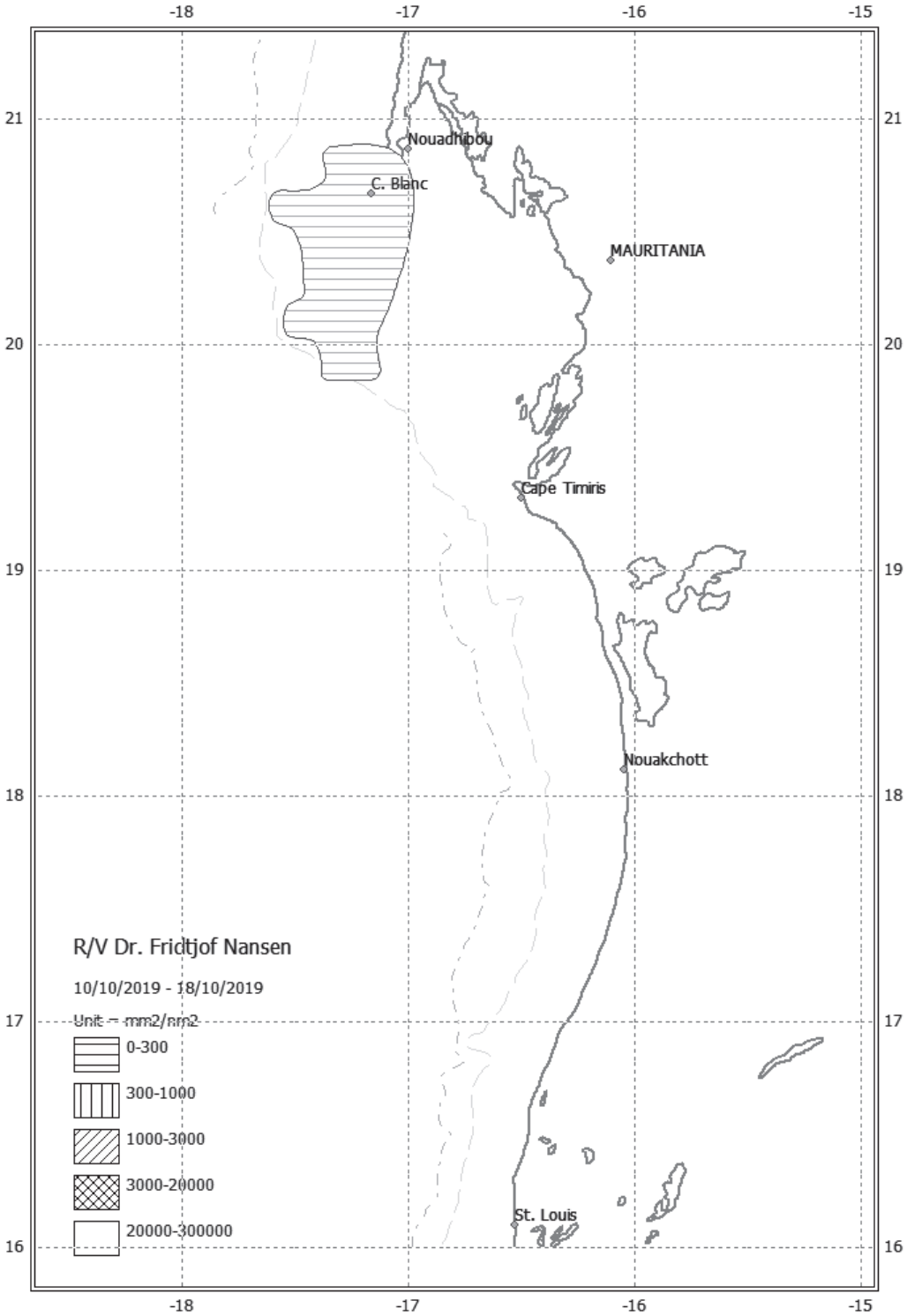


Figure 31. Distribution (density= m^2/NM^2) of sardine (depth contours as in Figure 2)

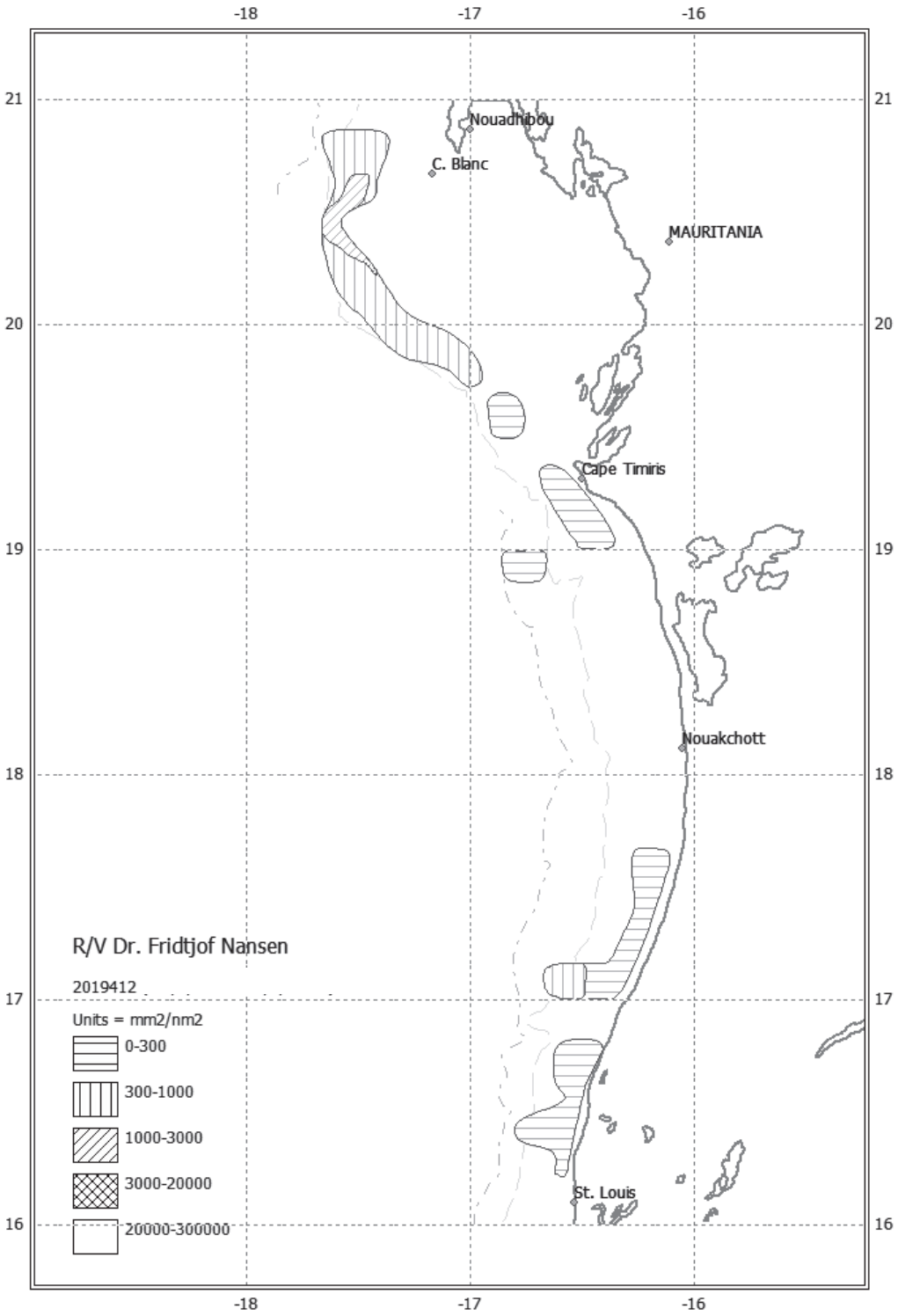


Figure 32. Distribution (density= m^2/NM^2) of anchovy (depth contours as in Figure 2)

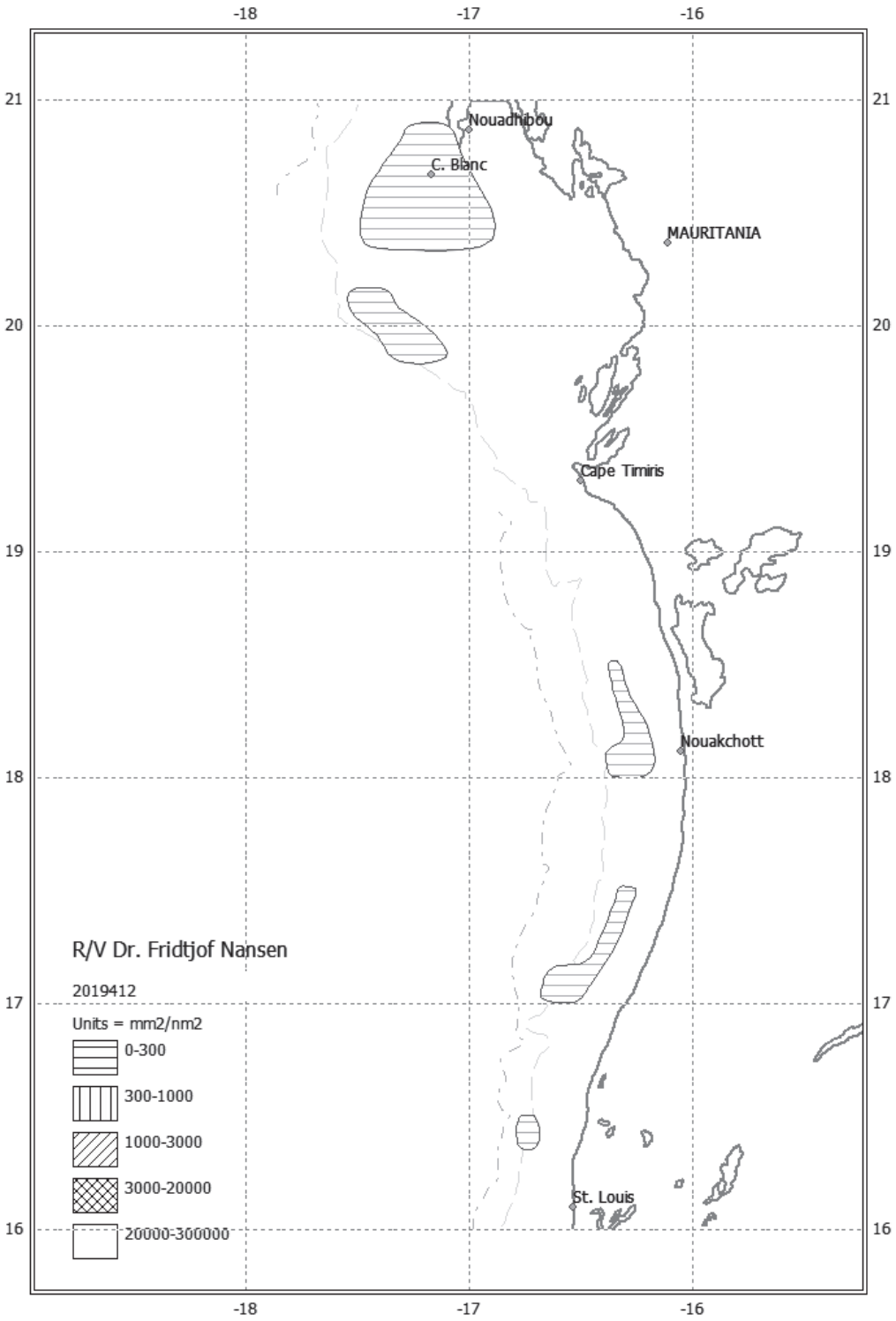


Figure 33. Distribution (density= m^2/NM^2) of *Scomber colias* (depth contours as in Figure 2)

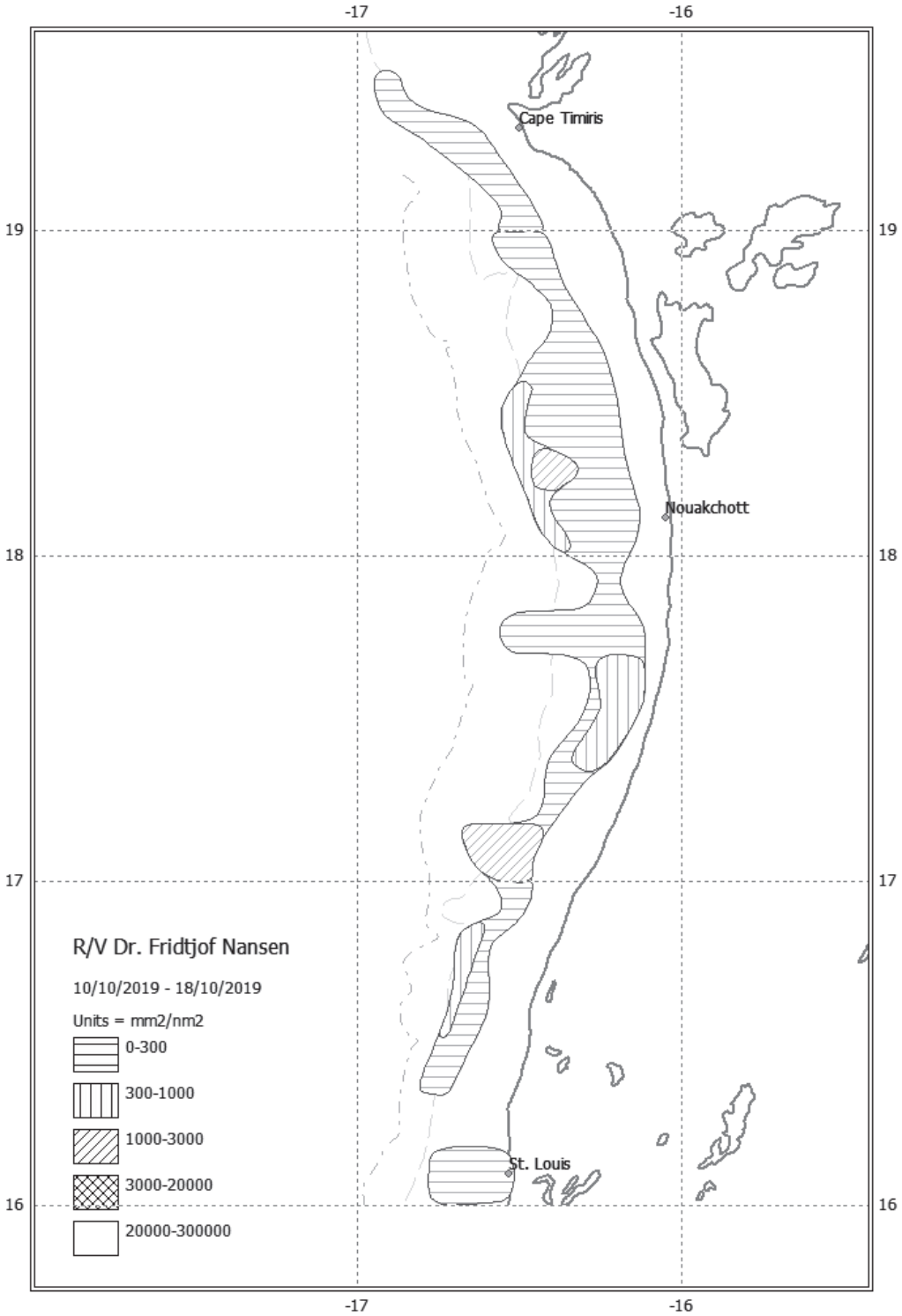


Figure 34. Distribution (density= m^2/NM^2) of both species of horse mackerel (depth contours as in Figure 2)

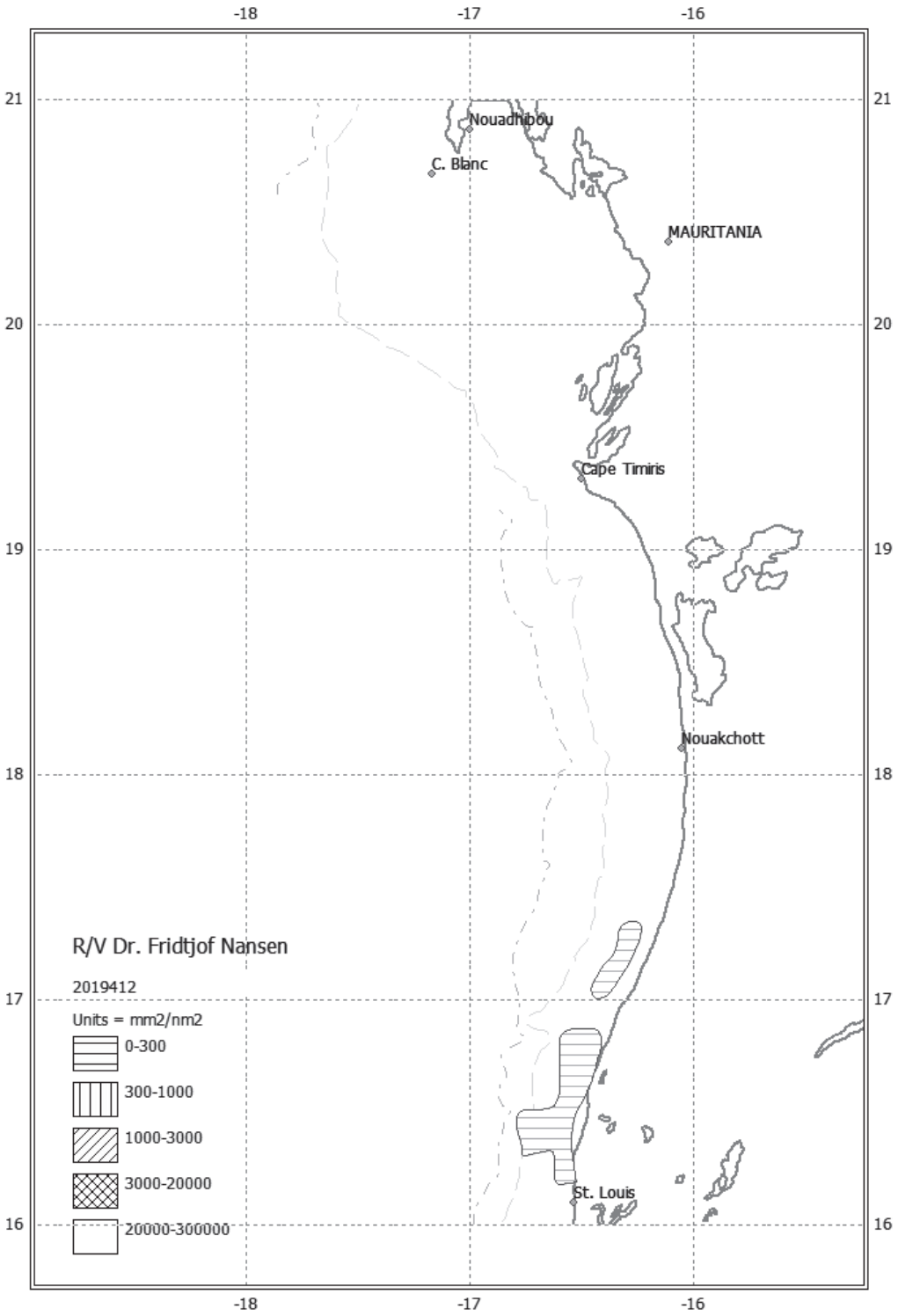


Figure 35. Distribution (density= m^2/NM^2) of Pelagic-I fish (*Ilisha africana*) (depth contours as in Figure 2)

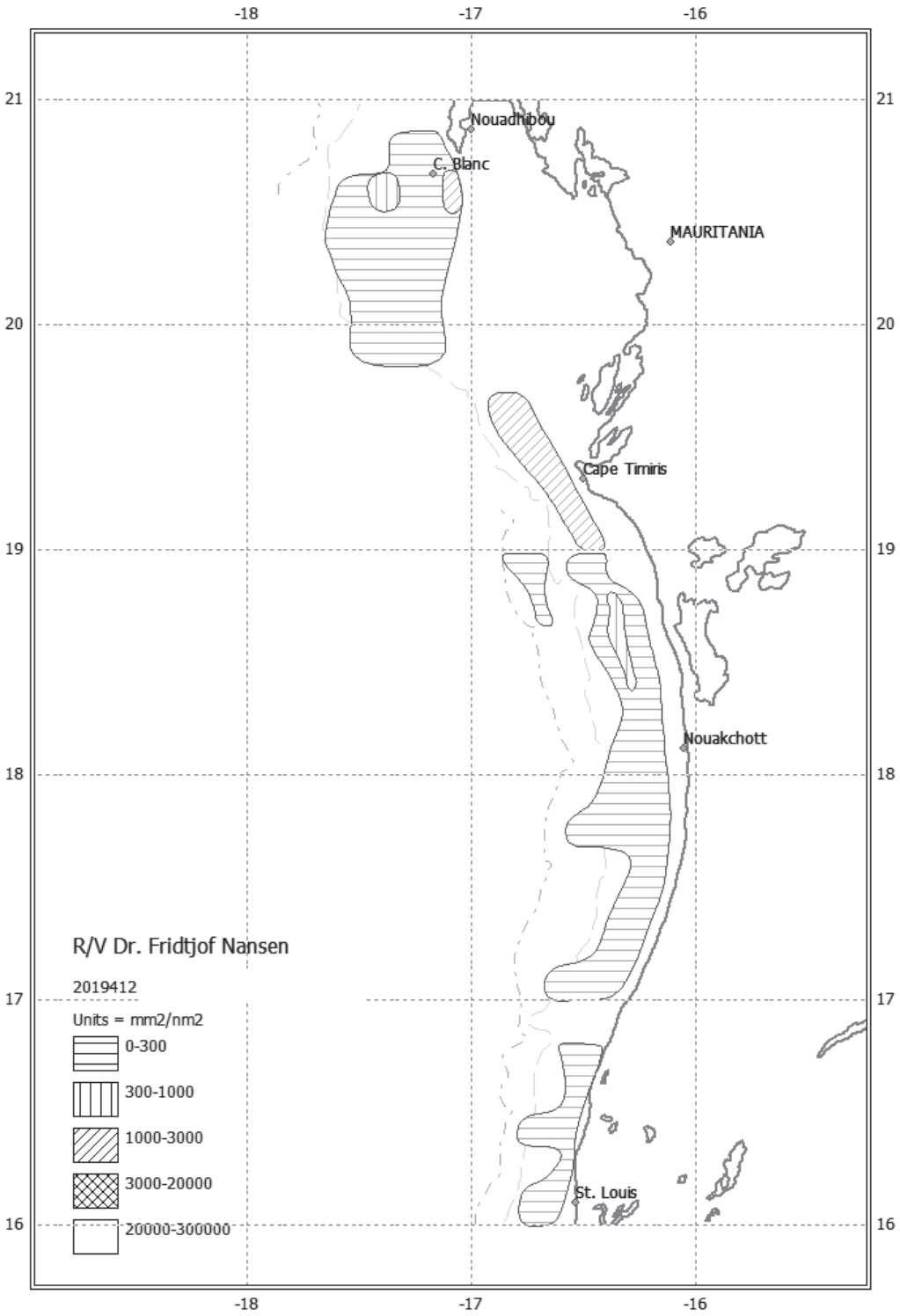


Figure 36. Distribution (density= m^2/NM^2) of Pelagic-II fish (other carangids, etc.) (depth contours as in Figure 2)

Ilisha africana (called Pelagic-I fish in the LSSS database) occurred in the south of Mauritania (Figure 35), and then only in small quantities. As this species has very limited commercial value in Mauritania further analysis and biomass estimates have not been done.

Other pelagic fish (referred to as Pelagic-II) were widely distributed (Figure 36). The most common ones in this group were largehead hairtail *Trichiurus lepturus* (caught in 19 trawls), African lookdown *Selene dorsalis* (17), false scad *Caranx rhonchus* (13), vadigo *Campogramma glaycos* (10), pompano *Trachinotus ovatus* (9), *Auxis sp*., Atlantic bonito *Sarda sarda* (9) Atlantic bumper *Chloroscombrus chrysurus* (6), and Guananche barracuda *Sphyraena guachancho* (6). Few have any commercial value in Mauritania, although C. rhonchus, which was found in small amounts, is apparently targeted along with the *Trachurus* species, from which it is virtually indistinguishable to all but trained persons.

A range of demersal species were caught, the most frequent being the European squid *Loligo vulgaris* (caught in 28 trawls), smooth puffer *Lagocephalus laevigatus* (21), red pandora *Pagellus bellottii* (17), Guinean sea catfish *Carlarius parkii* (9), bigeye grunt *Brachydeuterus auratus* (9), bastard grunt *Pomadasys incisus* (8), West African goatfish *Pseudupeneus prayensis* (8), oceanic puffer *Lagocephalus lagocephalus* (8), garfish *Belone belone gracilis* (7), lesser African threadfin *Galeoides decadactylus* (7), bogue *Boops boops* (7) and African cuttlefish *Sepia bertheloti* (7).

3.6.4 Biomass estimates

The mean s_A and size of each stratum are presented in Annex XI. The biomass of each of the target species by area (south of 19°N and north of 19°N) is presented in Table 11. A strata-by-strata list of biomass estimates by length-class, and also numbers of fish, are presented in Annex XII.

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

	South of 19° St Louis – Cap Timiris	North of 19° Cap Timiris – Cap Blanc	Total
S. aurita	17 956	24 543	44 155
S. maderensis	1 520	136	
S. pilchardus	0	19 730	19 730
E. encrasicolus	16 105	29 691	45 796
S colias	984	1,554	2 537
T. trecae	217 489	69 194	287 608
T. trachurus	0	925	
Total	254 054	145 772	399 826

CHAPTER 4. CONCLUDING REMARKS ON LEG 4.2

Leg 4.2 had multiple objectives, almost all of which were successfully achieved. The physical and chemical oceanography, together with plankton and microplastics, was intensively sampled while the pelagic stocks were assessed using acoustics complimented by trawling. Samples of commercially important fish species were collected for food nutrition and toxicology tests, while jellyfish were sampled for genetic analysis. Seabird numbers and cetacean sightings were also recorded.

One of the objectives that was not attempted, due to the lack of personnel and agreed methodology, was to collect information on the abundance and distribution of macro-plastics and the distribution of sargassum weed. Macro-plastics were seen throughout the region, especially close to shore, but a purely subjective assessment suggests that the amount was less than off more heavily populated countries to the south. No sargassum weed was seen.

The second objective that was not attempted was to sample two long oceanographic transects extending some 150 NM eastwards from the Mauritanian coast. There was insufficient time to sample either of these transects, although the northernmost transect, which was on the Mauritanian border off Cap Blanc, was subsequently sampled using a towed undulating CTD sampler at the start of survey Leg 4.3.

The information presented in this report summarises the results of the data analysed during the survey. Some samples and data have been transported to research institutes in the region, and also farther afield (notably IMR in Bergen, Norway). These samples will be analysed and reported on later.

The hydrographic data suggested a well-stratified system throughout the Mauritanian system, generally with below saturation point dissolved oxygen concentrations in the surface layers and hypoxic waters below 100 m. A hydrographic front was recorded on the 20°05'N transect where permanent upwelling to the north of Mauritania starts to impact the Mauritanian hydrographic system, creating less stratified waters with more oxygen in the surface and upper layer.

Pelagic fish were present throughout large parts of the Mauritanian region, with greater amounts towards the north. The main densities were found inshore of 50 m bottom depth, and were believed to extend inshore of the survey area in some areas. The presence of large numbers of both foreign and local fishing vessels inshore of the 50 m isobath in the large shallow embayment south of Cap Blanc supported this assumption.

Very few dense schools of fish were found. Almost all of the acoustic registrations were in scattered layers composed of mixed pelagic species. These layers often contained small denser patches, which were believed to be sardinella, or in the north sardine, but this was difficult to confirm through trawling as the catches were invariably highly mixed. However, during the scrutinising process, these dense marks were allocated to sardinella (or sardine) based on the knowledge and previous experience of the scrutinising panel. There remains however a degree of uncertainty in the species allocation of the acoustic backscatter.

The overall biomass of all pelagic species is similar to what found in 2017, however these results suggest that the biomass of sardinella is considerably less in 2019. In contrast the horse mackerel biomass appears to have more than tripled. The sardine, anchovy and mackerel biomasses have declined.

S. aurita, which comprised the majority of the sardinella biomass, were almost entirely juveniles of less than one year old.

One significant difference between the surveys is their timing; the 2017 survey was conducted in June/July and the current survey in October 2019. Recruitment of fish and migration may have affected the biomass estimates and this needs to be further investigated and the results assessed at the regional level.

Acoustic surveys have inherent inaccuracies and biases, as there are with any survey technique, which means that the biomass estimates have a degree of uncertainty. The methodology used in the 2017 and 2019 surveys, and indeed previous Nansen surveys, has been as faithfully replicated as possible such that the biomass estimates should be comparable. The abundance of some species has increased while others have declined, which could be accounted for by either the trawling being different (the catchability of the species had changed) or the acoustic backscatter being wrongly allocated between species. However, there is no reason to suspect either of these; the survey was conducted by the same vessel using the identical trawl gear, while the scrutinising panel on both surveys consisted of the same scientists from both Mauritania and Morocco, both having a large amount of experience in acoustics. It is therefore likely that these changes in biomass are real.

A longer-term comparison with historical surveys suggests that the biomass of clupeids has decreased markedly since the surveys conducted in the early part of the 21st century (Table 12).

As noted above, these estimates should not be viewed in isolation but need to be put into the perspective of the regional estimates for the Canary Current ecosystem as at least some of these changes may be due to migration.

Table 12. Summary of Nansen biomass estimates of Mauritania since 1996 (thousands of tonnes, the relevant survey reports should be consulted for more details)

	S. maderensis	*S. aurita*	*S. pilchardus*	*E. encrasicolus*	*S. colias*	*T. trecae*	*T. trachurus*	Other carangids, etc.
Nov 1996	860	545				0	0	400
Nov 1997	653	547		0		152	12	496
Nov 1998				Data not available				
Nov 1999	182	558				150		410
Nov 2000	576	344	726	0		725		315
Jun 2001	103	465	1 104	1		256	22	392
Nov 2001	144	82				4		362
Jun 2002	77	851	844	163	33	800		330
Nov 2002	237	85				179	67	194
Jun 2003	301	585	808	19	0	461	22	137
Nov 2003	1 077	210	254		0	255	3	142
Nov 2004	1 335	213	404			74	9	148
Nov 2005	527	74	2 178	98		149		114
Nov 2006	1 013	206	33	34		85		122
Nov 2017	116	34	61	78	25	90	2	40
Nov 2019	2	42	20	46	3	287	1	*

* Biomass not estimated (see Section 2.7.2.2)

Small pelagics are short-lived, highly fecund fish. They live in an unstable part of the marine system, the near-surface environment varying more than any other habitat in the ocean. The biomass of small pelagics can therefore change dramatically in a short period of time, hence the changes in abundance of the various species may simply be part of natural changes that would have occurred without any harvesting.

However, the apparent reduction in sardinella biomass is considerable and should be carefully monitored. It should be noted that catch rates of small pelagics by commercial vessels are a poor indicator of the health of the stock. Due to the schooling nature of sardinella, and the targeting nature of fishing, catch rates can remain high until the stock has been reduced to a very low level.

CHAPTER 5. REGIONAL OVERVIEW

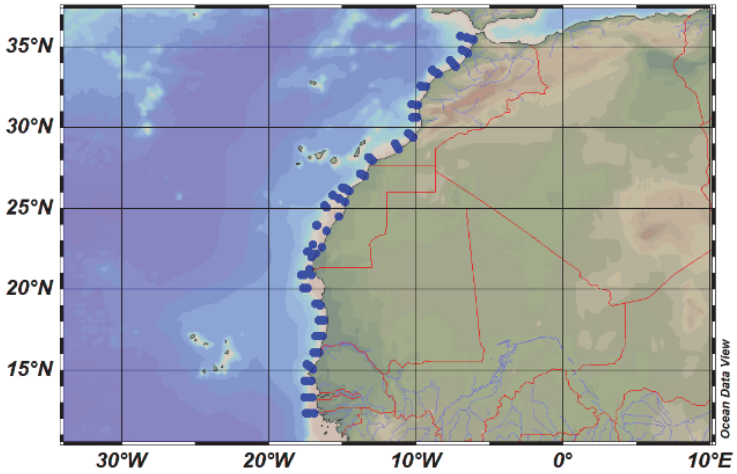
The R/V *Dr Fridtjof Nansen* series of surveys of the pelagic resources in Northwest Africa (Leg 4 of the western Africa coverage for 2019) encompassed Morocco to Senegal. These surveys commenced in the south and progressed northwards and were conducted during September to November. Note that the previous Nansen surveys in 2017 progressed from northern Morocco southwards and took place in a different season; May–July.

The first leg (4.1) was from the southern border of Senegal to the north, including The Gambia, and took place from 26 September to 7 October 2019. The second leg (4.2) was off the coast of Mauritania from 9 to 20 October 2019. After completing the survey in Mauritania, the vessel steamed to Las Palmas for some routine maintenance, returning for legs 4.3 and 4.4, starting at Cap Blanc on 1 November 2019 and arriving off Tanger on 29 November 2019.

A common survey design was adopted throughout the entire region with parallel transects perpendicular to the coastline, 10 nm apart, and acoustic measurements of pelagic fish obtained on the shelf from 20 m to 500 m bottom depth. At each degree of latitude, a hydrographical transect was carried out, often to a depth of 1 000 m. Meteorological and hydrographic measurements were recorded routinely on these transects in addition to samples on ocean acidification parameters (pH and total alkalinity), nutrients, chlorophyll a, zooplankton, fish eggs and larvae and microplastics. Weather conditions were generally good for surveying apart in northern Morocco, where strong winds made surveying more challenging.

5.1 Oceanographic conditions

Northwest Africa is characterised by four water masses: Eastern North Atlantic Central Water (ENACW), South Atlantic Central Water (SACW), Mediterranean Intermediate Water (MIW) and Eastern Atlantic Subarctic Intermediate Water (EASIW). Per normal protocol, most CTD deployments are conducted in waters down to 500 m.



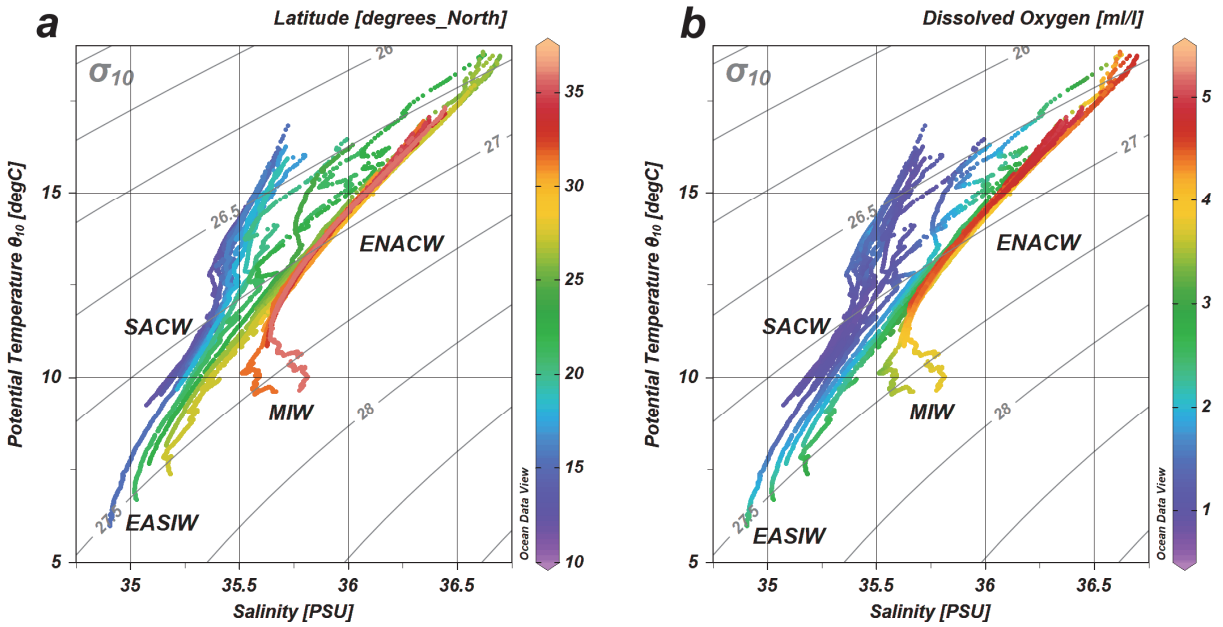


Figure 37. R/V *Dr Fridtjof Nansen* 2019 Northwest Africa CTD distribution map (83 total CTD stations) followed by two T-S diagrams with a dissolved oxygen overlay (a) and a latitudinal overlay (b) for data point region identification

Approximately 80% of the data points collected during Leg 4 are from 100 to 500 m depths with the other 20% going down just below 1000 m. In the upper waters off the Gambia and Senegal, the less-saline, oxygen-deficient SACW with DO values near 0.8 ml/l is observed until it begins mixing with the more oxygenated and saline NACW (~35.5 – 36.7 PSU and ~5 ml/l respectively) in Mauritania near 20°N (Emery 2001). As we go into intermediate waters, the less-saline EASIW (< 35.3 PSU) can be observed throughout the Gambia, Senegal, Mauritania and northwards into Morocco. However, in northern Morocco at approximately 32°N, the more saline (35.0 – 35.8 PSU) and slightly more oxygenated MIW from the Strait of Gibraltar can be observed dominating that region (Figure 37).

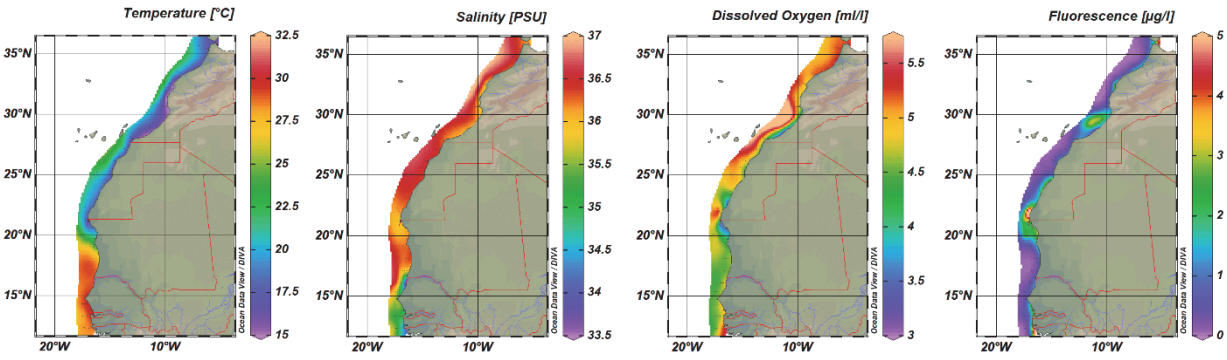


Figure 38. R/V *Dr Fridtjof Nansen* 2019 Northwest Africa horizontal distribution of temperature, salinity, dissolved oxygen and fluorescence at 5 m depth as recorded by the CTD

During this autumn season, the southern region of the survey from the Gambia to Senegal and Mauritania exhibited the warmest subsurface waters reaching 30°C. From northern Mauritania and norhwards, subsurface waters cool to 23°C offshore and 17.5° inshore with a

minimum at approximately 16°C near 29°N. From northern Morocco to southern Mauritania, subsurface salinity remains relatively high from 36 – 36.75 PSU. This high salinity is also observed offshore of Senegal but decreases down to 35 – 34.5 PSU inshore along the coasts of the Gambia and Senegal, especially near the Casamance River outlet. The region's subsurface water is relatively well ventilated with dissolved oxygen levels ranging from 4 – 6 ml/l with most of Morocco and southern Senegal falling into that higher-level category. Most of Mauritania, northern Senegal and the Gambia averaged approximately 4.5 ml/l. Oxygen levels do drop below 4 ml/l in the tight coastal areas of northern Mauritania, and again near 29°N. However, just offshore at 29°N, oxygen levels are the highest recorded in the region. The qualitative fluorescence data depicts three areas of increased fluorescence: just below the Casamance River in Senegal, near 22°N and near 29°N. Again, 29°N is also the same latitude of lowest subsurface temperature and oxygen maxima (Figure 38).

5.2 Fish distribution and abundance

This series of surveys was carried out in the same way as the previous R/V *Dr Fridtjof Nansen* (1994–2017) regarding both survey design, acoustic scrutinizing and biomass estimation methodology. However, possible limitations in the standardization of specific methodologies and parameters used have been identified and require further detailed investigation. Direct comparison of biomass estimates from the present survey (Table 13) with historic surveys (Table 14) should therefore be done with utmost caution.

A re-evaluation of the biomass estimates over time and across regions to establish a consistent time-series (see Table 14) is recognised as important and is planned within Theme 2 of the EAF-Nansen Programme. Within this project a number of aspects are of direct relevance to the current survey.

As during all the historic surveys, the same target strength was used for all species. For species with low target strength, such as Atlantic chub mackerel (*Scomber colias*), the biomass will be underestimated due to this.

A further bias recognized as potentially important for some regions, both within the northwest African region and elsewhere, is that large embayments and shallow waters of less than 20 m depth are known to contain significant amounts of some of the target species such as sardinellas, as these areas are often favoured by artisanal fishers. This may bias biomass indices, as changes in stock biomass become indistinguishable from distribution shifts when coverage of the distribution is incomplete.

For the present surveys, the length-weight ratio applied in the estimate is based on data collected in the respective areas of the survey. Historically this has to some extent varied between surveys. A study to identify the effect of this in the assessments may be undertaken in the future, also within the framework of Theme 2. This project will also be investigating the effect of using different vessels for the time-series.

Sardine (*Sardina pilchardus*)

The biomass estimate of sardine was similar to the estimates from previous surveys (Table 13) with, apart from some 20 000 t found in northern Mauritania, the entire stock being distributed mainly between Cap Blanc and Cape Bojador (Figure 39).

Sardinella (*Sardinella aurita* and *S. maderensis*)

There are indications that sardinella stocks have declined throughout the Canary Current LME during the past 5 to 10 years. Around 400 000 t were estimated during this series of surveys which is close to the average biomass estimated in surveys since 2015 (see Table 14). However, during the period from 1994 to 2005 the average sardinella biomass estimate was close to 3 million tonnes, and the large difference together with anecdotal information suggests a significant decline.

No sardinella from the CCLME stocks were recorded in Moroccan waters during the survey (Figure 40), the sardinella stock having disappeared completely in Morocco from around 2 million tonnes estimated a decade ago.

Some *Sardinella* spp were found in the northern part of the survey area, close to Tanger. These are believed to be part of the Mediterranean stock.

Less than 50 000 t of sardinella were recorded in Mauritanian waters. This contrasts with the fishery statistics that recorded catches of sardinella as 300 000 t in 2019, and 500 000 t in 2018. This anomaly between the catches and survey estimates requires further investigation, and a project within framework of Theme 2 of the EAF-Nansen Programme has been proposed. In particular, the seasonality of catches should be compared to the survey estimates in that region.

An environmental anomaly was noted in 2019; this being the coldest year in Mauritania on record. This may suggest that the sardinella had migrated out of Mauritanian waters, but this is not supported by increases in the abundance of sardinella in other parts of the CC system.

A significant proportion of the total sardinella biomass was found in Senegalese and The Gambian waters; around 350 000 t. While catch statistics for sardinella are not available for this region, the availability of sardinella in local markets has been reduced as reflected by indications of increasing prices. This suggests that the sardinella stock in this region may have also declined, as elsewhere in Northwest Africa.

It is currently assumed that each of the sardinella species form a single stock in the Northwest African region. An analysis of genetic and morphometric characteristics is currently being conducted within Theme 2 of the EAF-Nansen Programme to reassess the stock status.

Anchovies (*Engraulis encrasicolus*)

The anchovy biomass estimate was the highest recorded in the 25-year time-series of surveys. However, anchovy remains a relatively minor part of the pelagic fish community. Anchovy

were found throughout Mauritania and Morocco, the main part of the stock between Cape Cantin and Cape Bojador (Figure 39).

Horse mackerels (*Trachurus trachurus* and *T. trecae*)

The combined horse mackerel biomass was one of the highest estimates in the 25-year time-series (Table 14).

T. trecae were found throughout Senegal, The Gambia and Mauritania, while *T. trachurus* was restricted to waters north of Cap Blanc (Figure 40). Very high densities of *T. trecae* were registered in Northern Senegal, suggesting a possible increase in stock size in this region.

Atlantic chub mackerel (*S. colias*)

The overall biomass estimate of chub mackerel was similar to the past 5-year mean, but this represents around double the long-term biomass estimated earlier this century (Table 14). While *S. colias* was found throughout the region, by far the largest part of the biomass was in Moroccan waters, mainly between Cap Blanc and Cape Bojador (Figure 41).

As with several other small pelagic species in this region, it is assumed that chub mackerel constitute a single stock. Along with the sardinellas, the *S. colias* stock status is being assessed within Theme 2 of the EAF-Nansen Programme through an analysis of genetic and morphometric characteristics.

Other species

More than one million tonnes of snipe fish (*Macroramphosus* sp) were found off northern Morocco.

Other pelagic species were widespread throughout the region (Figure 42).

Table 13. Regional biomass estimates from 2019 R/V *Dr Fridtjof Nansen* surveys (‘000 tonnes)

	Cap Cantin to Tanger	Cape Cantin to Cape Bojador	Cape Bojador to Cap Blanc	Cap Blanc to Cap Timiris	Cap Timiris to St Louis	Northern Senegal	Petite Côte	The Gambia	Casamance	**TOTAL**
Sardina pilchardus	235	567	3 452	20						**4 274**
Sardinella aurita				25	18	3	25	36	83	**190**
S. maderensis				0	2	5	34	49	113	**202**
E. encrasicolus	5	215	3	30	16					**269**
Trachurus trecae			4	69	217	134	36	4	14	**479**
T. trachurus	26	196	380	1						**603**
Scomber colias	110	106	512	2	1	2	16	17	0	**766**
	376	**1 084**	**4 351**	**146**	**254**	**145**	**112**	**105**	**210**	**6 783**

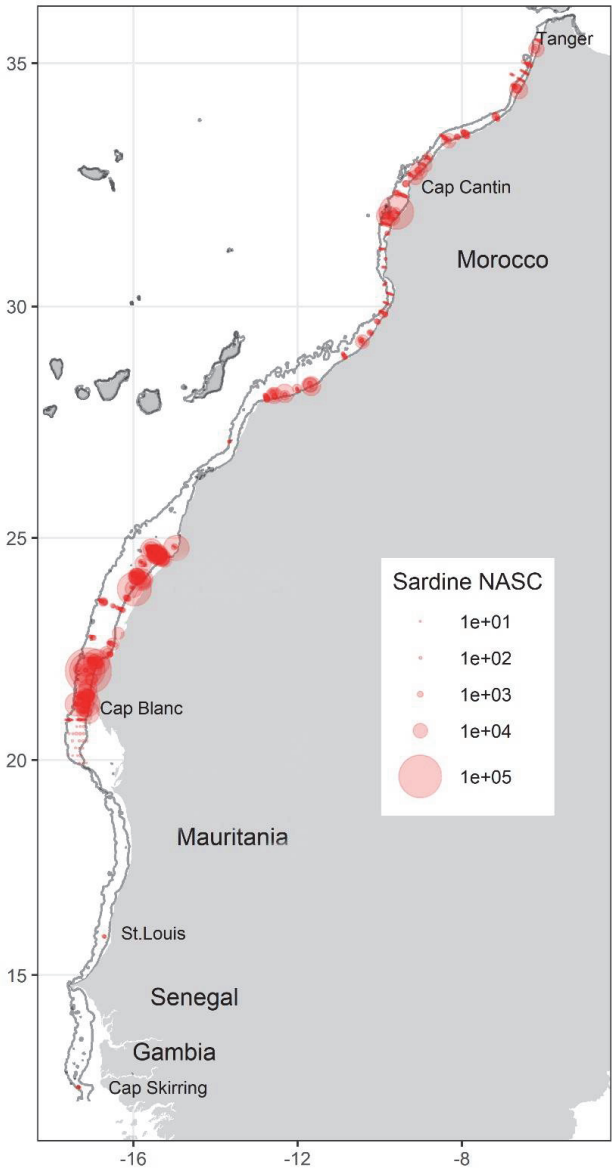


Figure 39. Distribution of sardine (*Sardina pilchardus*), (NASC = nautical area scattering coefficient). 20 m and 100 m depth contours are indicated with grey lines. The countries involved in the surveys and start/end points of each survey segment are named

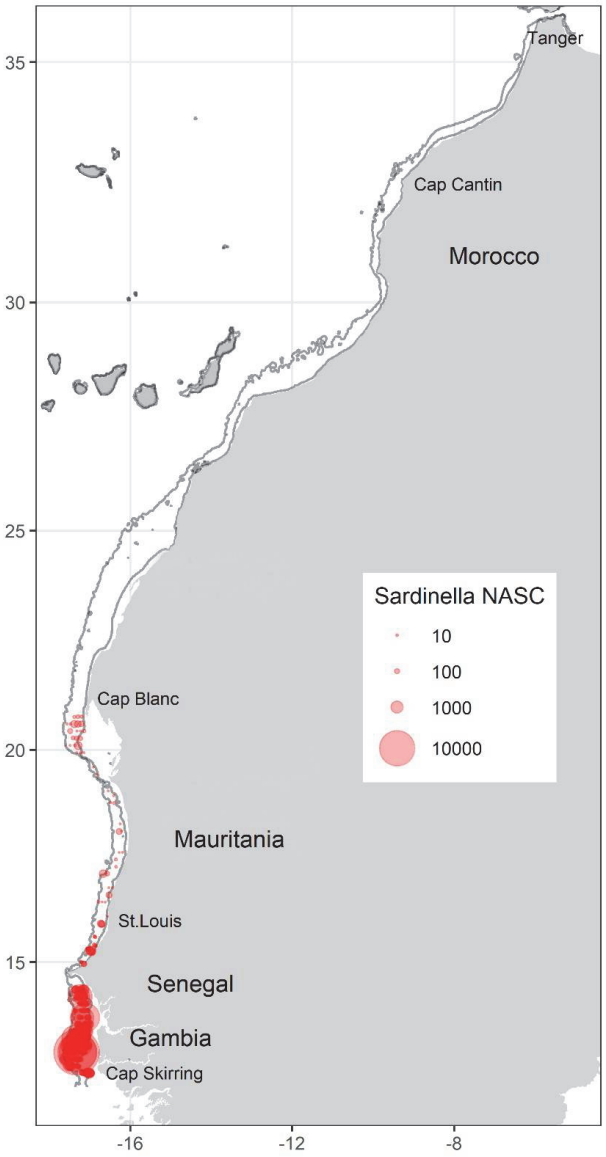


Figure 40. Distribution of sardinella (*Sardinella aurita* and *S. maderensis* combined), (NASC = nautical area scattering coefficient). 20 m and 100 m depth contours are indicated with grey lines. The countries involved in the surveys and start/end points of each survey segment are named

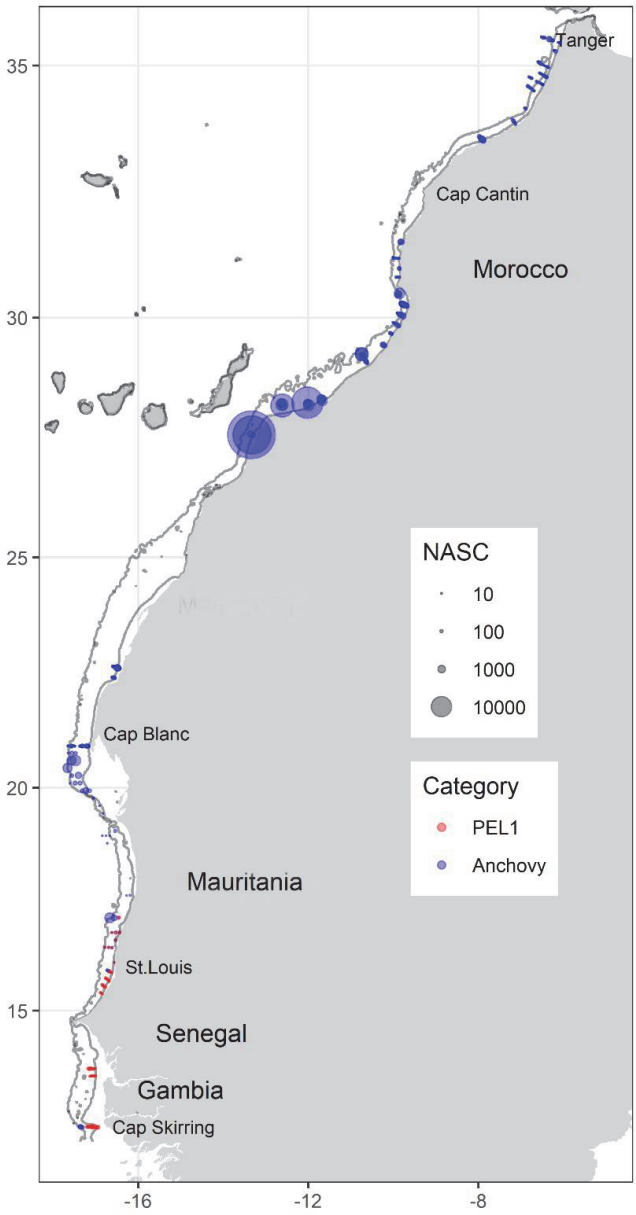


Figure 41. Distribution of anchovy (*Engraulis encrasicolus*, blue) and other clupeids (Pel 1, mainly *Ilisha africana*, red) (NASC = nautical area scattering coefficient). 20 m and 100 m depth contours are indicated with grey lines. The countries involved in the surveys and start/end points of each survey segment are named

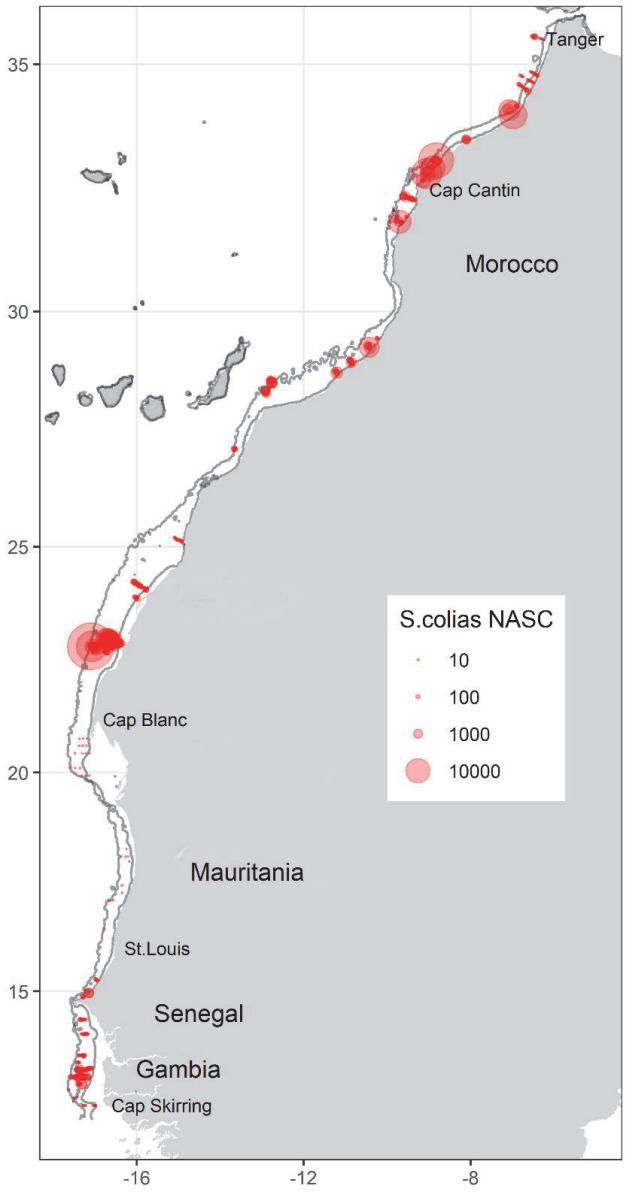


Figure 42. Distribution of Atlantic chub mackerel (*Scomber colias*) (NASC = nautical area scattering coefficient). 20 m and 100 m depth contours are indicated with grey lines. The countries involved in the surveys and start/end points of each survey segment are named

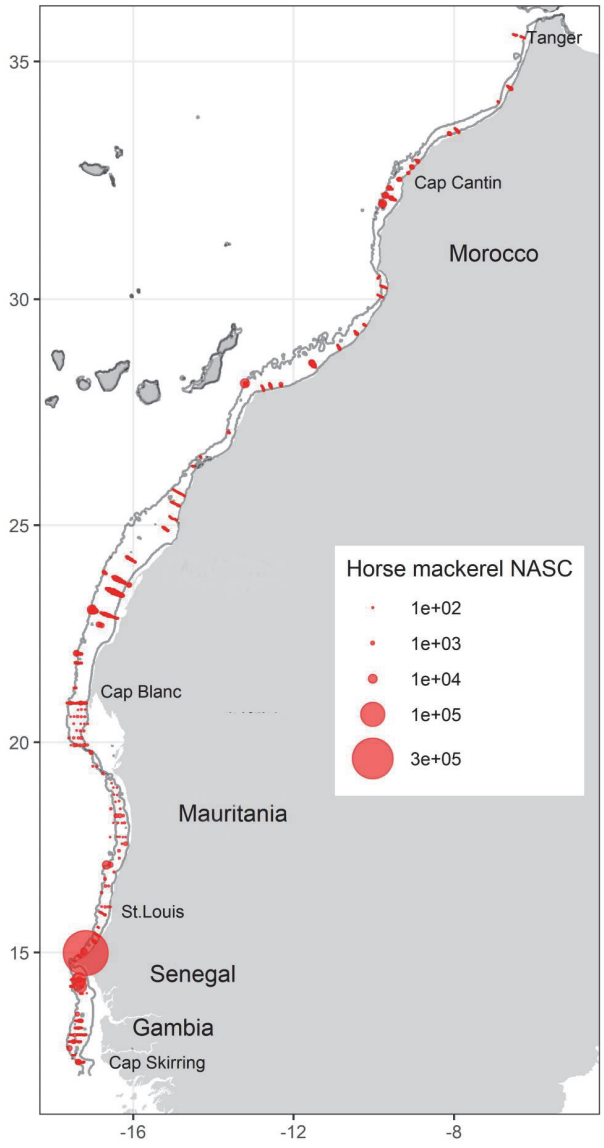


Figure 43. Distribution of horse mackerels (*Trachurus trachurus* and *T. trecae* combined) (NASC = nautical area scattering coefficient). 20 m and 100 m depth contours are indicated with grey lines. The countries involved in the surveys and start/end points of each survey segment are named

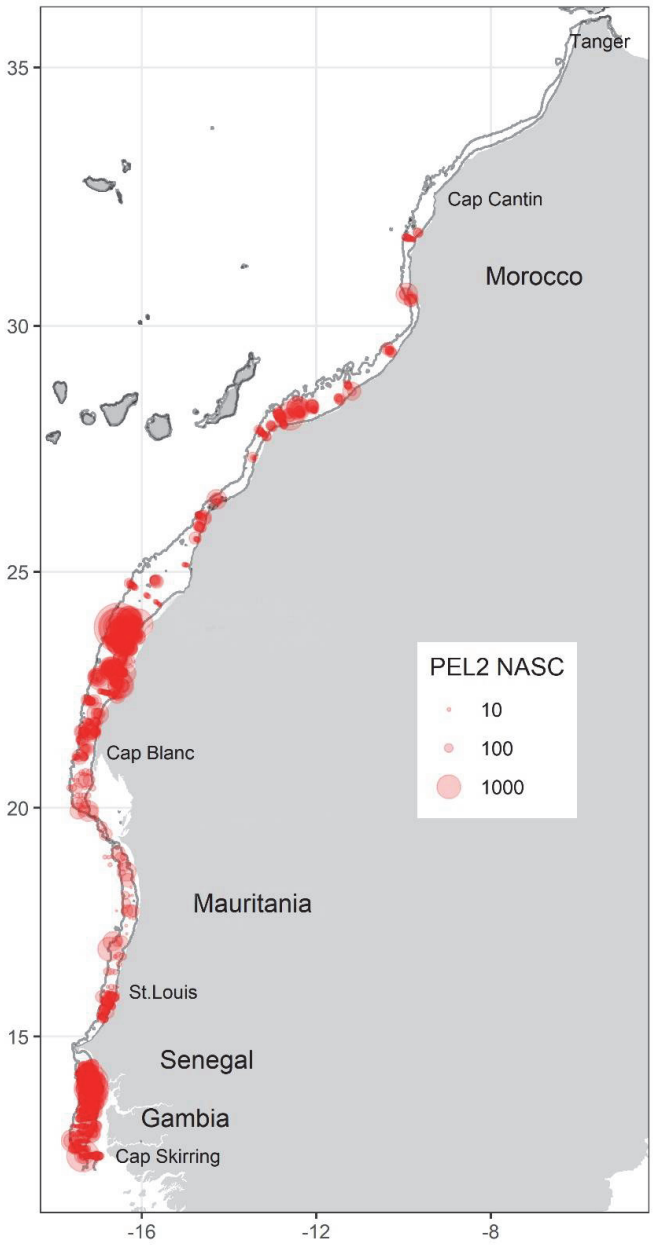


Figure 44. Distribution for Pel 2 (Carangidae, Scombridae, Sphyraenidae and Trichiuridae) (NASC = nautical area scattering coefficient). 20 m and 100 m depth contours are indicated with grey lines. The countries involved in the surveys and start/end points of each survey segment are named

Table 14. Acoustic biomass data (million tonnes) from the R/V *Dr Fridtjof Nansen* (in bold) and other vessels for the main species.
Values are not directly comparable among years

YEAR	*S. pilchardus*	*S. aurita*	*S. maderensis*	*T. trachurus*	*T. trecae*	*S. colias*	*E. encrasicolus*	*Total (excl. sardine)*	Total
1995	**3.75**	**1.62**	**1.88**	**0.26**	**0.18**			**3.94**	**7.69**
1996	**5.56**	**1.63**	**1.53**	**0.45**	**0.66**			**4.27**	**9.83**
1997	**1.13**	**0.82**	**1.00**	**0.54**	**0.66**			**3.02**	**4.15**
1998	**1.63**	**0.82**	**1.00**	**0.18**	**0.80**			**2.80**	**4.43**
1999	**2.67**	**2.13**	**1.48**	**0.10**	**0.65**	**0.27**		**4.64**	**7.30**
2000	**3.65**	**1.91**	**0.79**	**0.28**	**1.76**	**0.10**	**0.24**	**5.08**	**8.73**
2001	**4.75**	**1.80**	**1.43**	**0.12**	**0.36**	**0.31**	**0.02**	**4.04**	**8.79**
2002	**6.30**	**1.43**	**0.99**	**0.28**	**0.58**	**0.29**	**0.04**	**3.61**	**9.91**
2003	**5.70**	**1.26**	**1.77**	**0.32**	**0.39**	**0.55**	**0.03**	**4.31**	**10.01**
2004	**7.41**	**1.59**	**2.45**	**0.18**	**0.73**	**0.51**	**0.08**	**5.54**	**12.95**
2005	**8.01**	**0.81**	**1.33**	**0.14**	**1.21**	**0.24**	**0.11**	**3.85**	**11.86**
2006	3.62	1.13	2.05	0.04	0.40	0.44	0.08	4.14	7.76
2007	5.88	0.99	1.19	0.45	0.99	0.61	0.19	4.41	10.29
2008	4.42	2.00	0.55	0.33	0.70	0.63	0.12	4.32	8.74
2009	5.04	2.86	1.67	0.13	0.87	0.76	0.05	6.35	11.39
2010	2.60					0.28			
2011	1.95					0.38			
2012	2.07					0.45			
2013	3.77					0.65			
2014	4.10					1.08			
2015	**4.50**	**0.62**	**0.87**	**0.41**	**0.54**	**0.72**	**0.16**	**3.31**	**7.81**
2016	2.96	0.04	0.05	0.23	0.05	1.06	0.08		
2017	**5.05**	**0.26**	**0.21**	**0.10**	**0.13**	**0.44**	**0.14**	**2.12**	
2019	**4.22**	**0.19**	**0.20**	**1.00**		**0.83**	**0.27**	**2.58**	**6.80**
Av 1995-2004	4.60	1.44	1.42	0.98		0.32	0.09	4.10	8.70
Av 2015-2019	4.18	0.28	0.33	0.63		0.76	0.16	2.67	7.31

Years 1995-2006, 2015, 2017 and 2019: Data from the R/V *Dr Fridtjof Nansen.*

Years 2007-2008: Data are *Nansen* equivalents of local vessels using agreed conversion factors.

Year 2009: All data from the Mauritanian R/V *Al Awan* and the Moroccan R/V *Al Amir*, and data for Senegal and The Gambia were estimated by the Working Group.

Year 2010: No estimates for the Mauritanian R/V *Al Awan*, the Moroccan R/V *Al Amir*, Senegal, and The Gambia.

Year 2011: Some estimates for the CCLME (from the R/V *Dr Fridtjof Nansen*) were presented by the CCLME project coordinator.

Year 2012: Data from Mauritanian R/V *Al Amir* were presented to the Working Group for North of Cape Blanc, and results from a survey by the Russian R/V *Atlantida* in Mauritania and Senegal.

Years 2013 and 2014: Survey data from Morocco, Mauritania, and the Russian R/V *Atlantida*.

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ANNEX I. CRUISE SUMMARY REPORT

SHIP
Name: Dr Fridtjof Nansen **Call Sign: LDLG**

Type of ship: Research ship

CRUISE NO. / NAME **2019411.** PELAGIC STOCKS AND ECOSYSTEMS SENEGAL-MOROCCO,
Leg 4.2. Mauritania

CRUISE PERIOD start 07/10/2019 to 20.10.2019

PORT OF DEPARTURE: Dakar, Senegal

PORT OF RETURN: Las Palmas, Spain

RESPONSIBLE LABORATORY

Name: Institute of Marine Research

Address: P.O. Box 1870 Nordnes, N-5817 Bergen

Country: Norway

CHIEF SCIENTIST(S)
David Boyer

OBJECTIVES AND BRIEF NARRATIVE OF CRUISE

Survey objectives

Hydrography:

To map the hydrographic and environmental conditions in the survey area (temperature, salinity, dissolved oxygen, chlorophyll-a, nutrients, total alkalinity, pH and ocean currents).

To obtain information on the dissolved oxygen concentrations, ocean acidification state, and calcium carbonate saturation horizons relevant for calcifying organisms.

Phytoplankton, zooplankton and ichthyoplankton:

To describe the primary productivity of the region.

To describe the abundance and biomass patterns of the meso-zooplankton community, as well as its species composition.

To provide information on the abundance patterns of the ichthyoplankton community (fish eggs and larvae), at the lowest possible taxonomic level.

To collect samples of jellyfish for a) morphological identification and taxonomic studies, b) genetic studies for the purposes of confirming identity, determining population structure and establishing regional and global connectivity, and c) histological examination of reproductive maturity to determine reproductive synchronicity and semelparity within populations and individuals.

Pelagic stocks:

To obtain information on abundance, distribution (also by size) of *Sardinella aurita, Sardinella maderensis, Engraulis encrasicolus, Trachurus trecae*, *Trachurus Trachurus, Scomber colias* and *Sardina pilchardus* using acoustic methods and a systematic grid survey strategy.

To collect samples for genetic analysis and for morphometric studies and genetic analysis (for stock identification of *S. aurita* and *S. maderensis).*

To obtain information on maturity stages, and to collect stomach samples for analysis of contents and otoliths of *S. aurita, S. maderensis, S. pilchardus*, *S. colias* and *E. encrasicolus.*

Mesopelagic fish:

To trawl for samples of mesopelagic fish in deep waters (as time permits).

Top predators:

To record occurrence of top predators.

Marine debris and microplastics:

To record occurrence of marine debris and sargassum weed (surface).

To map occurrence of microplastics and describe associated neuston communities.

Contaminants:

To collect samples of specific pelagic species for levels of environmental contaminants, nutrients, parasites and microorganisms with regards to food safety and pollution.

PROJECT (IF APPLICABLE)

Project name: Strengthening the Knowledge Base for and Implementing an Ecosystem Approach to Marine Fisheries in Developing Countries (EAF-Nansen GCP/INT/003/NOR)

Coordinating body: Centre for Development Cooperation in Fisheries, Institute of Marine Research, Bergen, Norway.

PRINCIPAL INVESTIGATORS:

A. David Boyer
B. Sarah Bruck
C. Olaf Søras
D. Merete Kvalsun
E. Jorunn Sanden
F. Claire Mourgues
G. Fredrik E. Otterlei Madsen

Summary of measurements and samples taken

PI	NO	UNITS	DATA TYPE	DESCRIPTION See separate instructions for explanation of codes and data types.
B	24	Stations	H10, H17, H21, B02	Seabird 911+ CTD probe with pressure, conductivity, temperature, oxygen, PAR irradiance and fluorescence sensors
B	70	Samples	H22, H24, H25, H26, B02	Water samples taken during CTD upcasts. Samples taken for measurement of Nitrite, Nitrate, Silicate, Phosphates, phytoplankton pigments at standard depths
B	70	Samples	H21, H27, H28	Water samples taken during CTD upcasts. Samples taken for measurement of alkalinity, oxygen and pH at standard depths
C	8	Days	H71	SBE 21 SeaCAT Thermosalinograph sampling at 4 m depth salinity and relative temperature every 10 seconds. An attached in-line C3 Turner Design Submersible Fluorometer measured turbidity and chlorophyll-a levels. Period 26.11-12.12

C	8	Days	M90	Meteorological data logged from the AANDERAA meteorological station included wind direction and speed, air pressure, humidity, air temperature and sea surface temperature (SST). All data were averaged by unit distance sailed (1 NM).
C	8	Days	D71	150 kHz vessel mounted Ocean Surveyor ADCP operating at narrow band mode and data were averaged in 16 and 4 m vertical bins Period 26.11-12.12
A	8	Days	B28	Acoustic data collected with Simrad SH90 fishery sonar
A	8	Days	B28	Continuous recording of acoustic data with EK80 operating at six frequencies (18, 38, 70, 120, 200 and 333 kHz)
D	12	Hauls	B09	Zooplankton sampling with WP2 vertical net tows from bottom to surface with 180 µm mesh.
D	12	Hauls	B09	Egg and larvae sampling with MIDI Hydrobios Bongo. Sampling performed at 3 standard depths with oblique tows from bottom to surface with 180 µm mesh. Samples collected for biomass calculations as for preservation/identification.
A	12	Hauls	B10, P01	Sampling of microplastic (<0.5mm) and larger plastic debris is done using a Manta trawl (0.333 mm mesh)
A	12	Stations	B19	Demersal trawl stations for species identification and biological sampling
A	18	Stations	B14	Pelagic trawl stations for species identification and biological sampling
E	3	Stations	P13, B72	Fish samples for food safety and nutrition
E	78	Samples	P02	Water samples taken during CTD upcasts. Samples taken for measurements of methylmercury.

GENERAL OCEAN AREA(S):
Central Atlantic Ocean, W Africa

SPECIFIC AREAS:

Samples collected between the 20m and 500m isobaths in the country of Mauritania

ANNEX II. RECORDS OF FISHING STATIONS

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 1
DATE :10/10/19 GEAR TYPE: BT NO: 2 POSITION:Lat N 16°8.52
start stop duration Lon W 16°42.02
TIME :07:33:34 08:04:06 30.5 (min) Purpose : 1
LOG : 8474.11 8475.89 1.8 Region : 1200
FDEPTH: 70 69 Gear cond.: 0
BDEPTH: 70 69 Validity : 0
Towing dir: 0° Wire out : 230 m Speed : 3.5 kn
Sorted : 113 Total catch: 228.38 Catch/hour: 448.84

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Catostylus sp	294.01	409	65.50	
Trachurus trecae	98.26	3636	21.89	1
Boops boops	21.07	1336	4.69	
Loligo vulgaris	9.75	130	2.17	
Merluccius senegalensis	3.30	24	0.74	
Zeus faber	2.36	16	0.53	
Lepidotrigla cadmani	2.28	39	0.51	
Raja miraletus	2.16	2	0.48	
Citharus linguatula	2.12	59	0.47	
Pentheroscion mbizi	1.89	8	0.42	
Pagellus bellottii	1.65	16	0.37	
Caranx rhonchus	1.42	637	0.32	
Octopus vulgaris	1.26	2	0.28	
Parapenaeus longirostris	0.94	515	0.21	
Unidentified crab	0.79	680	0.18	
Torpedo torpedo	0.71	2	0.16	
Trichiurus lepturus	0.71	4	0.16	
Octopus defilippi	0.71	6	0.16	
Alloteuthis africana	0.55	314	0.12	
Priacanthus arenatus	0.55	2	0.12	
G A S T R O P O D S	0.47	51	0.11	
Venus sp.	0.31	12	0.07	
Lagocephalus laevigatus	0.28	2	0.06	
Saurida brasiliensis	0.24	63	0.05	
Sphoeroides spengleri	0.24	28	0.05	
Sepia bertheloti	0.24	20	0.05	
Unidentified	0.24	8	0.05	
Dentex angolensis	0.16	4	0.04	
Nudibranch sp	0.08	12	0.02	
GOBIIDAE	0.08	47	0.02	
G A S T R O P O D S	0.04	12	0.01	0
Dentex maroccanus	0.00	4	0.00	
Selene dorsalis	0.00	16	0.00	
Total	448.84		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 2
DATE :10/10/19 GEAR TYPE: PT NO: 8 POSITION:Lat N 16°5.16
start stop duration Lon W 16°38.66
TIME :15:38:59 16:01:11 22.2 (min) Purpose : 1
LOG : 8519.72 8521.40 1.7 Region : 1200
FDEPTH: 20 50 Gear cond.: 0
BDEPTH: 47 55 Validity : 0
Towing dir: 0° Wire out : 250 m Speed : 4.5 kn
Sorted : 117 Total catch: 483.30 Catch/hour: 1306.22

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	661.62	2368	50.65	2
Brachydeuterus auritus	266.59	1968	20.41	
Stromateus fiatola	197.41	324	15.11	
Trichiurus lepturus	59.68	519	4.57	
Selene dorsalis	46.92	216	3.59	
Caranx rhonchus	22.05	81	1.69	3
Pagellus bellottii	13.19	65	1.01	
Alectis alexandrinus	11.62	11	0.89	
Loligo vulgaris	10.81	86	0.83	
Trachinotus ovatus	5.84	22	0.45	
Sphyraena barracuda	4.43	5	0.34	
Sardinella maderensis	4.16	19	0.32	
Pomadasys jubelini	1.14	3	0.09	
Fistularia petimba	0.49	3	0.04	
Ilisha africana	0.27	3	0.02	
Total	1306.22		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 3
DATE :10/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 16°15.83
start stop duration Lon W 16°37.15
TIME :19:31:47 19:57:19 25.5 (min) Purpose : 1
LOG : 8544.86 8546.32 1.5 Region : 1200
FDEPTH: 10 22 Gear cond.: 0
BDEPTH: 42 52 Validity : 0
Towing dir: 0° Wire out : 110 m Speed : 3.4 kn
Sorted : 81 Total catch: 502.92 Catch/hour: 1181.49

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Brachydeuterus auritus	664.75	8345	56.26	
Selene dorsalis	182.96	4313	15.49	
Chloroscombrus chrysurus	92.18	775	7.80	
Stromateus fiatola	49.62	70	4.20	
Ilisha africana	43.98	1466	3.72	
Caranx crysos	30.45	155	2.58	
Trichiurus lepturus	22.27	423	1.88	
Sardinella maderensis	21.38	99	1.81	6
Sphyraena guachancho	15.51	310	1.31	
Trachinotus ovatus	11.84	56	1.00	
Trachurus trecae	10.15	141	0.86	7
Alectis alexandrinus	7.80	7	0.66	
Arius parkii **	6.48	9	0.55	
Pomadasys rogeri	5.45	14	0.46	
Sardinella aurita	5.36	40	0.45	5
Engraulis encrasicolus	5.07	1551	0.43	4
Euthynnus alletteratus	3.43	5	0.29	
Loligo vulgaris	2.26	28	0.19	
Galeoides decadactylus	0.56	14	0.05	
Total	1181.49		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 4
DATE :11/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 16°35.71
start stop duration Lon W 16°43.63
TIME :03:55:16 04:20:14 25.0 (min) Purpose : 1
LOG : 8618.24 8619.54 1.3 Region : 1200
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 63 54 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.1 kn
Sorted : 46 Total catch: 45.62 Catch/hour: 109.58

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	31.95	1878	29.15	8
Dasyatis sp.	27.43	2	25.03	
Auxis rochei	25.75	137	23.50	
Loligo vulgaris	10.62	122	9.69	
Carlarius heudelotii	5.33	2	4.87	
Scomber colias	2.07	10	1.89	
Lagocephalus laevigatus	1.35	10	1.23	
Chloroscombrus chrysurus	1.30	12	1.18	
Ilisha africana	1.06	12	0.96	
Boops boops	0.82	70	0.75	
Brachydeuterus auritus	0.72	10	0.66	
Alloteuthis africana	0.38	223	0.35	
MYCTOPHIDAE	0.29	74	0.26	
Selene dorsalis	0.24	77	0.22	
Saurida brasiliensis	0.19	36	0.18	
Priacanthus arenatus	0.05	17	0.04	
Synagrops microlepis	0.05	10	0.04	
Total	109.58		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 5
DATE :11/10/19 GEAR TYPE: BT NO: 2 POSITION:Lat N 16°46.54
start stop duration Lon W 16°25.68
TIME :09:27:35 09:59:09 31.6 (min) Purpose : 1
LOG : 8666.29 8668.20 1.9 Region : 1200
FDEPTH: 20 21 Gear cond.: 0
BDEPTH: 20 21 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.6 kn
Sorted : 150 Total catch: 1203.59 Catch/hour: 2288.19

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Pomadasys jubelini	545.70	2890	23.85	
Synagrops microlepis	323.35	4030	14.13	
Stromateus fiatola	238.78	380	10.44	
Engraulis encrasicolus	202.89	5338	8.87	9
Ilisha africana	188.59	5612	8.24	
Galeoides decadactylus	167.30	1414	7.31	
Caranx crysos	88.21	350	3.86	
Pseudotolithus senegallus	85.48	304	3.74	
Carlarius heudelotii	69.35	198	3.03	
Chloroscombrus chrysurus	61.14	411	2.67	
Trichiurus lepturus	57.79	578	2.53	
Brachydeuterus auritus	55.97	2312	2.45	
Sphyraena guachancho	29.81	274	1.30	
Pseudotolithus typus	20.99	76	0.92	
Pagrus caeruleostictus	20.91	129	0.91	
Pomadasys incisus	18.86	228	0.82	
Caranx rhonchus	15.82	46	0.69	
Pseudupeneus prayensis	10.65	91	0.47	
Lagocephalus laevigatus	10.65	46	0.47	
Eucinostomus melanopterus	10.04	106	0.44	
Dasyatis marmorata	9.24	10	0.40	
Selene dorsalis	9.13	913	0.40	
Drepane africana	8.82	46	0.39	
Pagellus bellottii	8.52	46	0.37	
Alectis alexandrinus	5.48	122	0.24	
Umbrina canariensis	4.41	91	0.19	
Portunus validus	4.26	15	0.19	
Polydactylus quadrifilis	3.73	46	0.16	
Penaeus notialis	2.74	76	0.12	
Cubozoa sp	2.30	342	0.10	
Rhinobatos rhinobatos	2.21	2	0.10	
Pomatomus saltatrix	1.52	15	0.07	
Zanobatus shoenleinii	1.06	2	0.05	
Sardinella maderensis	0.91	15	0.04	
CYNOGLOSSIDAE	0.76	46	0.03	
Sardinella aurita	0.68	163	0.03	10
Diplodus sargus	0.15	15	0.01	
Total	2288.19		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 6
DATE :11/10/19 GEAR TYPE: PT NO: 8 POSITION:Lat N 16°56.51
start stop duration Lon W 16°45.77
TIME :13:50:28 14:38:30 48.0 (min) Purpose : 1
LOG : 8702.14 8705.49 3.4 Region : 1200
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 234 135 Validity : 0
Towing dir: 0° Wire out : 220 m Speed : 4.2 kn
Sorted : 0 Total catch: 0.00 Catch/hour: 0.00

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
N O C A T C H	0.00	0	0.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 7
DATE :11/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 17°5.77
start stop duration Lon W 16°28.05
TIME :21:59:09 22:28:22 30.2 (min) Purpose : 1
LOG : 8740.32 8741.89 1.6 Region : 1200
FDEPTH: 10 24 Gear cond.: 0
BDEPTH: 67 69 Validity : 0
Towing dir: 0° Wire out : 110 m Speed : 3.5 kn
Sorted : 47 Total catch: 47.29 Catch/hour: 93.96

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	55.67	3614	59.25	13
Loligo vulgaris	14.19	290	15.10	
Engraulis encrasicolus	11.92	3137	12.69	11
Lagocephalus laevigatus	5.56	30	5.92	
Sardinella aurita	1.91	44	2.03	12
Trichiurus lepturus	1.39	28	1.48	
Sarda sarda	1.19	4	1.27	
Sphyraena guachancho	1.15	8	1.23	
JELLYFISH	0.32	2	0.34	
Boops boops	0.24	18	0.25	
Scomber colias	0.20	2	0.21	
Saurida brasiliensis	0.20	52	0.21	
NOMEIDAE	0.02	2	0.02	
Selene dorsalis, juvenile	0.00	4	0.00	
Bregmaceros sp.	0.00	64	0.00	
Total	93.96		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 8
DATE :12/10/19 GEAR TYPE: BT NO: 2 POSITION:Lat N 17°10.95
start stop duration Lon W 16°18.34
TIME :01:14:48 01:34:47 20.0 (min) Purpose : 1
LOG : 8758.98 8760.13 1.1 Region : 1200
FDEPTH: 26 25 Gear cond.: 0
BDEPTH: 26 25 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.5 kn
Sorted : 138 Total catch: 555.36 Catch/hour: 1666.91

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Pomadasys incisus	645.44	4442	38.72	
Galeoides decadactylus	511.46	6279	30.68	
Pagellus bellottii	118.14	708	7.09	
Brachydeuterus auritus	91.73	720	5.50	
Pomadasys jubelini	85.96	372	5.16	

Pteroscion peli	49.46	144	2.97
Carlarius parkii	35.06	108	2.10
Plectorhinchus mediterraneus	20.89	180	1.25
Trichiurus lepturus	18.49	72	1.11
Cymbium cymbium	13.45	24	0.81
Ilisha africana	12.49	144	0.75
Pseudupeneus prayensis	9.36	84	0.56
Chilomycterus reticulatus	9.12	6	0.55
Umbrina canariensis	8.88	36	0.53
Chloroscombrus chrysurus	4.56	24	0.27
Pseudotolithus senegalensis	4.08	12	0.24
Chilomycterus spinosus mauretanicus	4.08	6	0.24
Raja miraletus	3.78	12	0.23
Penaeus notialis	3.36	120	0.20
Sphyraena guachancho	3.24	6	0.19
Leptocharias smithii	3.06	3	0.18
Scomberomorus tritor	2.58	3	0.15
Alectis alexandrinus	2.28	3	0.14
Solea senegalensis	2.16	12	0.13
Engraulis encrasicolus	0.96	144	0.06
Syacium micrurum	0.72	12	0.04
Sepia bertheloti	0.60	3	0.04
Boops boops	0.48	60	0.03
Fistularia petimba	0.42	6	0.03
Eucinostomus melanopterus	0.30	3	0.02
Selene dorsalis	0.24	12	0.01
Dentex canariensis	0.06	3	0.00
Total	1666.91		100.00

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 9
DATE :12/10/19 GEAR TYPE: BT NO: 2 POSITION:Lat N 17°25.25
start stop duration Lon W 16°31.59
TIME :08:29:44 09:00:54 31.2 (min) Purpose : 1
LOG : 8819.29 8821.08 1.8 Region : 1200
FDEPTH: 130 130 Gear cond.: 0
BDEPTH: 130 130 Validity : 0
Towing dir: 0° Wire out : 360 m Speed : 3.4 kn
Sorted : 83 Total catch: 369.94 Catch/hour: 712.11

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Merluccius senegalensis	555.15	5128	77.96	
Zenopsis conchifer	41.50	17	5.83	
Pterothrissus belloci	26.03	393	3.65	
Raja straeleni	22.91	10	3.22	
Pontinus kuhlii	22.64	139	3.18	
Scorpaena normani	10.01	146	1.41	
Loligo vulgaris	7.55	69	1.06	
Lagocephalus laevigatus	5.70	8	0.80	
Brotula barbata	5.08	8	0.71	
Pomadasys incisus	3.85	23	0.54	
Zeus faber	3.70	31	0.52	
Dentex angolensis	3.23	15	0.45	
Citharus linguatula	1.54	31	0.22	
Chilomycterus sp.	1.39	31	0.19	
Arnoglossus imperialis	1.08	23	0.15	
Dentex macrophthalmus	0.77	15	0.11	
Total	712.11		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 10
DATE :12/10/19 GEAR TYPE: PT NO: 8 POSITION:Lat N 17°24.64
start stop duration Lon W 16°16.02
TIME :11:41:54 12:19:20 37.4 (min) Purpose : 1
LOG : 8841.52 8844.70 3.2 Region : 1200
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 42 57 Validity : 0
Towing dir: 0° Wire out : 230 m Speed : 5.1 kn
Sorted : 159 Total catch: 673.92 Catch/hour: 1080.58

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	596.15	2642	55.17	15
Caranx rhonchus	244.04	1103	22.58	14
Lagocephalus laevigatus	54.90	199	5.08	
Alectis alexandrinus	38.35	13	3.55	
Stromateus fiatola	24.37	38	2.26	
Brachydeuterus auritus	22.96	141	2.12	
Sardinella aurita	20.88	104	1.93	16
Pagellus bellottii	17.96	83	1.66	
Scomber colias	15.84	48	1.47	17
Carlarius parkii	12.70	19	1.18	
Dasyatis sp.	9.52	2	0.88	
Loligo vulgaris	6.96	35	0.64	
Sardinella maderensis	5.74	29	0.53	18
Trichiurus lepturus	4.36	19	0.40	
Auxis rochei	3.05	11	0.28	
Pomadasys jubelini	1.67	6	0.15	
Sarda sarda	1.12	2	0.10	
Total	1080.58		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 11
DATE :12/10/19 GEAR TYPE: BT NO: 2 POSITION:Lat N 17°25.76
start stop duration Lon W 16°13.42
TIME :14:14:12 14:39:14 25.0 (min) Purpose : 1
LOG : 8857.78 8859.28 1.5 Region : 1200
FDEPTH: 31 38 Gear cond.: 0
BDEPTH: 31 38 Validity : 0
Towing dir: 0° Wire out : 150 m Speed : 3.6 kn
Sorted : 35 Total catch: 231.42 Catch/hour: 554.74

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	151.50	12014	27.31	19
Boops boops	122.35	12235	22.06	
Pagrus caeruleostictus	89.80	218	16.19	
Pomadasys incisus	59.45	278	10.72	
Dentex canariensis	32.41	158	5.84	
Pagellus bellottii	28.77	225	5.19	
Plectorhinchus mediterraneus	22.01	50	3.97	
Pseudupeneus prayensis	18.84	129	3.40	
Loligo vulgaris	3.21	26	0.58	
Fistularia petimba	2.73	29	0.49	
Brachydeuterus auritus	2.73	41	0.49	
Raja miraletus	2.68	5	0.48	
Carlarius parkii	2.30	10	0.41	
Parapristipoma octolineatum	2.16	10	0.39	
Torpedo torpedo	2.01	5	0.36	
Trichiurus lepturus	2.01	10	0.36	
Dentex gibbosus	1.53	5	0.28	
Sardinella aurita	1.39	161	0.25	20
Selene dorsalis	1.34	29	0.24	
Scorpaena elongata	1.25	2	0.22	
Chaetodon robustus	0.96	5	0.17	
Syacium micrurum	0.58	2	0.10	
Serranus scriba	0.53	5	0.10	
Lagocephalus laevigatus	0.48	2	0.09	
Pontinus kuhlii	0.38	2	0.07	
Penaeus notialis	0.38	10	0.07	
Engraulis encrasicolus	0.34	29	0.06	21
Dicologoglossa hexophthalma	0.24	2	0.04	
Dicologoglossa cuneata	0.24	0	0.04	
Citharus linguatula	0.10	2	0.02	
Galeoides decadactylus	0.05	2	0.01	
Fishing gears	0.00	0	0.00	
Total	554.74		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 12
DATE :12/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 17°43.89
start stop duration Lon W 16°22.99
TIME :22:54:14 23:24:52 30.6 (min) Purpose : 1
LOG : 8935.26 8936.85 1.6 Region : 1200
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 96 97 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.1 kn
Sorted : 6 Total catch: 6.32 Catch/hour: 12.38

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachinotus ovatus	6.46	12	52.22	
Pyrosoma	4.90	12243	39.56	
Lagocephalus lagocephalus	0.74	2	6.01	
Lagocephalus laevigatus	0.20	2	1.58	
Selene dorsalis	0.04	43	0.32	
Trachurus trecae	0.04	2	0.32	
Total	12.38		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 13
DATE :13/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 17°44.72
start stop duration Lon W 16°11.60
TIME :01:11:22 01:40:21 29.0 (min) Purpose : 1
LOG : 8949.85 8951.27 1.4 Region : 1200
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 37 36 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 2.9 kn
Sorted : 27 Total catch: 27.15 Catch/hour: 56.21

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachinotus ovatus	29.03	126	51.64	
Loligo vulgaris	15.07	130	26.81	
Stromateus fiatola	9.69	14	17.24	
Auxis rochei	0.70	2	1.25	
Sphyraena guachancho	0.66	6	1.18	
Alloteuthis africana	0.54	306	0.96	
Trichiurus lepturus	0.33	2	0.59	
Trachurus trecae	0.12	8	0.22	
Lagocephalus laevigatus	0.04	2	0.07	
Bregmaceros sp.	0.02	21	0.03	
Total	56.21		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 14
DATE :13/10/19 GEAR TYPE: BT NO: 2 POSITION:Lat N 17°53.57
start stop duration Lon W 16°11.17
TIME :03:54:11 04:17:52 23.7 (min) Purpose : 1
LOG : 8968.40 8969.83 1.4 Region : 1200
FDEPTH: 27 29 Gear cond.: 0
BDEPTH: 27 29 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.6 kn
Sorted : 115 Total catch: 378.68 Catch/hour: 959.09

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Pagellus bellottii	280.37	4194	29.23	
Pomadasys incisus	115.49	737	12.04	
Caranx rhonchus	76.29	623	7.95	22
Brachydeuterus auritus	64.74	707	6.75	
Galeoides decadactylus	59.57	448	6.21	
Pteroscion peli	53.04	350	5.53	
Pagrus caeruleostictus	48.02	129	5.01	
Pseudotolithus senegalensis	31.30	68	3.26	
Halobatrachus didactylus	25.99	684	2.71	
Dentex canariensis	24.31	539	2.54	
Cymbium marmoratum	23.35	5	2.43	
Plectorhinchus mediterraneus	20.21	91	2.11	
Gymnura altavela	19.20	3	2.00	
Leptocharias smithii	14.79	20	1.54	
Raja miraletus	12.11	28	1.26	
Loligo vulgaris	11.40	106	1.19	
Cynoglossus senegalensis	8.81	8	0.92	
Penaeus notialis	8.21	243	0.86	
Trachinotus ovatus	8.21	30	0.86	
Scorpaena angolensis	7.29	76	0.76	
Trichiurus lepturus	6.53	30	0.68	
Dicologoglossa hexophthalma	5.62	53	0.59	
Citharus linguatula	5.47	46	0.57	
Selene dorsalis	4.25	61	0.44	
Torpedo torpedo	3.90	48	0.41	
Alloteuthis africana	3.50	1801	0.36	
Zeus faber	3.24	3	0.34	
Solea senegalensis	3.19	8	0.33	0
Pseudupeneus prayensis	2.74	23	0.29	
Chelidonichthys gabonensis	1.82	8	0.19	
Carlarius parkii	1.82	8	0.19	
Dicologoglossa cuneata	1.52	38	0.16	
Boops boops	1.37	106	0.14	
Bothus podas	0.61	30	0.06	
Fistularia petimba	0.51	3	0.05	
Cymbium sp.	0.30	61	0.03	
Fishing gears	0.00	3	0.00	
Total	959.09		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 15
DATE :13/10/19 GEAR TYPE: PT NO: 8 POSITION:Lat N 18°4.75
start stop duration Lon W 16°16.82
TIME :14:34:09 15:05:50 31.7 (min) Purpose : 1
LOG : 9036.36 9039.08 2.7 Region : 1200
FDEPTH: 20 40 Gear cond.: 0
BDEPTH: 38 44 Validity : 0
Towing dir: 0° Wire out : 250 m Speed : 5.2 kn
Sorted : 117 Total catch: 245.52 Catch/hour: 465.15

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Caranx rhonchus	310.89	1228	66.84	23
Pagellus bellottii	120.87	1008	25.99	
Sphyrna zygaena	15.69	2	3.37	
Loligo vulgaris	4.21	21	0.90	
Acanthurus monroviae	3.86	4	0.83	
Trachurus trecae	2.80	11	0.60	
Auxis sp.	2.20	8	0.47	
Chelidonichthys gabonensis	2.12	15	0.46	
Alloteuthis africana	1.52	936	0.33	
Lagocephalus laevigatus	0.57	2	0.12	
Scomber colias	0.42	2	0.09	
Total	465.15		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 16
DATE :13/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 18°16.31
start stop duration Lon W 16°22.72
TIME :19:23:59 19:47:49 23.8 (min) Purpose : 3
LOG : 9072.95 9074.30 1.4 Region : 1200
FDEPTH: 10 12 Gear cond.: 0
BDEPTH: 70 72 Validity : 0
Towing dir: 0° Wire out : 110 m Speed : 3.4 kn
Sorted : 87 Total catch: 87.43 Catch/hour: 220.13

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	175.42	11391	79.69	24
Trachinotus ovatus	36.91	123	16.77	
Loligo vulgaris	4.58	43	2.08	
Scomber colias	0.91	10	0.41	26
Bregmaceros sp.	0.86	1604	0.39	
Sardinella aurita	0.60	8	0.27	25
Caranx rhonchus	0.55	3	0.25	
Saurida brasiliensis	0.20	40	0.09	
Alloteuthis africana, juvenile	0.10	106	0.05	
Total	220.13		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 17
DATE :14/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 18°27.68
start stop duration Lon W 16°21.68
TIME :01:37:26 01:59:36 22.1 (min) Purpose : 3
LOG : 9122.52 9123.47 0.9 Region : 1200
FDEPTH: 20 35 Gear cond.: 0
BDEPTH: 45 44 Validity : 0
Towing dir: 0° Wire out : 110 m Speed : 3.2 kn
Sorted : 16 Total catch: 16.21 Catch/hour: 44.01

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Loligo vulgaris	36.92	271	83.90	
Lagocephalus laevigatus	6.73	35	15.30	
JELLYFISH	0.35	14	0.80	
Total	44.01		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 18
DATE :14/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 18°35.38
start stop duration Lon W 16°23.39
TIME :05:30:36 06:00:41 30.1 (min) Purpose : 3
LOG : 9153.96 9155.76 1.8 Region : 1200
FDEPTH: 10 24 Gear cond.: 0
BDEPTH: 55 49 Validity : 0
Towing dir: 0° Wire out : 110 m Speed : 3.6 kn
Sorted : 22 Total catch: 22.01 Catch/hour: 43.87

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Coryphaena hippurus	20.25	2	46.16	
Trachinotus ovatus	8.97	34	20.45	
Sphyrna zygaena	5.64	2	12.86	27
Loligo vulgaris	4.98	150	11.36	
Lagocephalus lagocephalus	2.43	12	5.54	
Trachurus trecae	0.92	52	2.09	28
Sarda sarda	0.52	2	1.18	
Rhizostoma sp	0.16	18	0.36	
Total	43.87		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 19
DATE :14/10/19 GEAR TYPE: PT NO: 8 POSITION:Lat N 18°44.08
start stop duration Lon W 16°39.26
TIME :11:34:26 12:30:48 56.4 (min) Purpose : 3
LOG : 9200.16 9204.09 3.9 Region : 1200
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 196 355 Validity : 0
Towing dir: 0° Wire out : 360 m Speed : 4.2 kn
Sorted : 25 Total catch: 24.92 Catch/hour: 26.52

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Aequorea sp.	17.90	17903	67.50	
Krill	5.51	0	20.79	
Illex coindetii	1.50	434	5.66	
Lagocephalus laevigatus	0.94	19	3.54	
Selene dorsalis	0.53	335	1.99	
Sphoeroides cf. pachygaster	0.08	94	0.30	
Branchiostegus semifasciatus	0.02	16	0.09	
Engraulis encrasicolus	0.02	2	0.06	
Unidentified	0.01	4	0.03	
Synagrops microlepis	0.01	2	0.02	
Ariomma bondi	0.01	2	0.02	
Total	26.52		100.01	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 20
DATE :14/10/19 GEAR TYPE: BT NO: 2 POSITION:Lat N 18°47.29
start stop duration Lon W 16°19.82
TIME :15:42:22 16:21:58 39.6 (min) Purpose : 3
LOG : 9230.70 9232.98 2.3 Region : 1200
FDEPTH: 19 20 Gear cond.: 0
BDEPTH: 19 20 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.5 kn
Sorted : 111 Total catch: 278.86 Catch/hour: 422.52

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Pomadasys incisus	92.73	633	21.95	
Dentex canariensis	75.33	1027	17.83	
Lagocephalus laevigatus	52.09	45	12.33	
Fishing gears	42.82	32	10.13	
Dasyatis pastinaca	22.91	8	5.42	
Diplodus bellottii	16.06	103	3.80	
Caranx rhonchus	15.76	121	3.73	29
Fistularia tabacaria	13.82	18	3.27	
Plectorhinchus mediterraneus	12.55	73	2.97	
Octopus vulgaris	8.79	8	2.08	
Chilomycterus reticulatus	8.12	3	1.92	
Spondyliosoma cantharus	7.03	48	1.66	
Loligo vulgaris	6.85	6	1.62	
Leptocharias smithii	6.67	9	1.58	
Pagrus caeruleostictus	5.88	21	1.39	
Pseudupeneus prayensis	4.06	30	0.96	
Fistularia petimba	3.64	39	0.86	
Pagellus bellottii	3.03	109	0.72	
Sepia officinalis	2.91	6	0.69	
Campogramma glaycos	2.61	6	0.62	
Holothuria sp.	2.48	5	0.59	
Carlarius parkii	2.42	3	0.57	
Pomadasys rogeri	2.30	3	0.55	
Halobatrachus didactylus	2.24	6	0.53	
Zeus faber	1.82	2	0.43	
Serranus scriba	1.79	12	0.42	
Pomatomus saltatrix	1.64	3	0.39	
Stephanolepis hispidus	1.45	6	0.34	
Scorpaena angolensis	1.21	12	0.29	
Nicholsina usta	0.79	3	0.19	
Sepia bertheloti	0.42	3	0.10	
Rypticus saponaceus	0.30	3	0.07	
Total	422.52		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 21
DATE :14/10/19 GEAR TYPE: BT NO: 2 POSITION:Lat N 18°53.27
start stop duration Lon W 16°21.74
TIME :17:24:24 17:36:29 12.1 (min) Purpose : 3
LOG : 9238.63 9239.36 0.7 Region : 1200
FDEPTH: 24 23 Gear cond.: 0
BDEPTH: 24 23 Validity : 0
Towing dir: 0° Wire out : 130 m Speed : 3.6 kn
Sorted : 134 Total catch: 2371.04 Catch/hour: 11776.70

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Caranx rhonchus	4504.17	164593	38.25	30
Boops boops	2860.93	99328	24.29	
Plectorhinchus mediterraneus	2632.95	16540	22.36	
Pomadasys incisus	599.01	4291	5.09	
Sardinella aurita	375.50	8270	3.19	31
Epinephelus aeneus	146.87	25	1.25	
Trachurus trecae	118.01	2593	1.00	
Campogramma glaycos	57.22	179	0.49	
Pagellus bellottii	53.64	1073	0.46	
Dentex canariensis	53.64	1520	0.46	
Pseudupeneus prayensis	51.85	268	0.44	
Leptocharias smithii	50.07	89	0.43	
Fishing gears	46.79	35	0.40	
Pagrus caeruleostictus	44.70	179	0.38	
Loligo vulgaris	42.91	179	0.36	
Diplodus bellottii	28.61	179	0.24	
Galeoides decadactylus	26.82	179	0.23	
Spondyliosoma cantharus	23.25	179	0.20	
Epinephelus costae	13.21	5	0.11	
Pseudupeneus prayensis	12.52	89	0.11	0
Citharus linguatula	12.52	89	0.11	
Dasyatis marmorata	10.73	89	0.09	
Serranus scriba	10.73	89	0.09	
Coris julis	0.06	5	0.00	
Total	11776.70		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 22
DATE :15/10/19 GEAR TYPE: BT NO: 2 POSITION:Lat N 19°16.81
start stop duration Lon W 16°39.89
TIME :07:28:38 08:00:02 31.4 (min) Purpose : 3
LOG : 9333.61 9336.24 2.6 Region : 1200
FDEPTH: 17 31 Gear cond.: 0
BDEPTH: 17 31 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.4 kn
Sorted : 127 Total catch: 2500.00 Catch/hour: 4777.07

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chloroscombrus chrysurus	1325.29	15604	27.74	
Sardinella maderensis	571.19	4391	11.96	34
Galeoides decadactylus	557.40	18581	11.67	
Engraulis encrasicolus	327.33	96239	6.85	35
Pomatomus saltatrix	326.60	6170	6.84	
Carlarius parkii	259.11	762	5.42	
Pagellus bellottii	226.44	3592	4.74	
Diplodus bellottii	176.37	2285	3.69	
Caranx rhonchus	153.14	5117	3.21	32
Gymnura altavela	152.87	17	3.20	
Selene dorsalis	147.33	7076	3.08	
Penaeus notialis	129.19	10777	2.70	
Brachydeuterus auritus	127.74	5444	2.67	
Mustelus mustelus	72.58	182	1.52	
Stromateus fiatola	55.16	109	1.15	
Sphyraena guachancho	29.03	254	0.61	
Pomadasys incisus	27.58	1670	0.58	
Trachurus trecae	22.50	5952	0.47	33
Campogramma glaycos	19.60	73	0.41	
Trichiurus lepturus	15.24	182	0.32	
Scomberomorus tritor	14.52	73	0.30	
Fishing gears	8.52	0	0.18	
Pteroscion peli	7.26	73	0.15	
Loligo vulgaris	6.89	36	0.14	
Sardinella aurita	6.53	109	0.14	
Pseudupeneus prayensis	6.17	36	0.13	
Panulirus regius	5.35	2	0.11	
Penaeus kerathurus	0.11	73	0.00	
JELLYFISH	0.02	2	0.00	
Plastic	0.00	2	0.00	
Total	4777.07		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 23
DATE :15/10/19 GEAR TYPE: PT NO: 8 POSITION:Lat N 19°25.30
start stop duration Lon W 16°50.45
TIME :14:40:06 15:38:37 58.5 (min) Purpose : 3
LOG : 9387.64 9392.34 4.7 Region : 1200
FDEPTH: 40 60 Gear cond.: 0
BDEPTH: 61 85 Validity : 0
Towing dir: 0° Wire out : 290 m Speed : 4.8 kn
Sorted : 135 Total catch: 1509.00 Catch/hour: 1546.90

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Campogramma glaycos	1328.55	2565	85.88	
Auxis rochei	208.04	775	13.45	
Sarda sarda	5.47	9	0.35	
Lagocephalus laevigatus	3.65	29	0.24	
Pagellus bellottii	0.53	1	0.03	
Loligo vulgaris	0.25	1	0.02	
Chelidonichthys gabonensis	0.23	2	0.01	
Sepia orbignyana	0.17	48	0.01	
Selene dorsalis	0.01	7	0.00	
Total	1546.90		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 24
DATE :15/10/19 GEAR TYPE: PT NO: 2 POSITION:Lat N 19°35.51
start stop duration Lon W 16°54.77
TIME :17:59:13 18:26:55 27.7 (min) Purpose : 3
LOG : 9407.96 9410.14 2.2 Region : 1200
FDEPTH: 15 42 Gear cond.: 0
BDEPTH: 57 57 Validity : 0
Towing dir: 0° Wire out : 240 m Speed : 4.7 kn
Sorted : 115 Total catch: 114.64 Catch/hour: 248.22

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Campogramma glaycos	79.64	165	32.08	
Sphyrna zygaena	66.60	30	26.83	
Auxis sp.	37.55	102	15.13	
Trachinotus ovatus	29.75	91	11.99	
Sarda sarda	15.03	28	6.05	
Lagocephalus laevigatus	7.19	37	2.90	
Trichiurus lepturus	4.98	26	2.01	
Rhizostoma sp	3.98	13	1.61	
Engraulis encrasicolus	2.86	650	1.15	36
Sardinella aurita	0.39	2	0.16	
Loligo vulgaris, juvenile	0.17	230	0.07	
Sepia sp, juvenile	0.04	89	0.02	
Trichiurus lepturus, juvenile	0.03	247	0.01	
Total	248.22		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 25
DATE :15/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 19°46.03
start stop duration Lon W 17°9.78
TIME :23:39:30 00:10:06 30.6 (min) Purpose : 3
LOG : 9448.66 9450.37 1.7 Region : 1200
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 107 256 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.4 kn
Sorted : 8 Total catch: 209.22 Catch/hour: 410.10

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Diaphus sp.	396.22	141503	96.62	
Lestrolepis intermedia	7.45	851	1.82	
Synagrops microlepis	3.20	639	0.78	
Trachipterus trachypterus	1.80	4	0.44	
Trichiurus lepturus	1.06	265	0.26	
Lagocephalus laevigatus	0.31	6	0.08	
Illex coindetii	0.05	159	0.01	
Total	410.10		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 26
DATE :16/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 19°49.04
start stop duration Lon W 17°11.37
TIME :03:26:23 03:46:17 19.9 (min) Purpose : 3
LOG : 9473.67 9474.77 1.1 Region : 1200
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 62 87 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.3 kn
Sorted : 13 Total catch: 13.29 Catch/hour: 40.07

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	22.37	1167	55.83	37
JELLYFISH	12.30	21	30.70	
Synagrops microlepis	3.59	684	8.95	
Trichiurus lepturus	0.84	223	2.11	
Engraulis encrasicolus	0.45	72	1.13	38
Lagocephalus laevigatus	0.30	18	0.75	
Illex coindetii	0.18	42	0.45	
Selene dorsalis	0.03	33	0.08	
Total	40.07		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 27
DATE :16/10/19 GEAR TYPE: PT NO: 8 POSITION:Lat N 19°55.41
start stop duration Lon W 17°26.26
TIME :08:16:39 08:22:59 6.3 (min) Purpose : 3
LOG : 9508.93 9509.27 0.3 Region : 1200
FDEPTH: 80 100 Gear cond.: 0
BDEPTH: 258 216 Validity : 0
Towing dir: 0° Wire out : 320 m Speed : 3.2 kn
Sorted : 23 Total catch: 2495.90 Catch/hour: 23657.82

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Capros aper	23501.42	747583	99.34	
Auxis rochei	111.09	256	0.47	
Trachurus trachurus	15.92	66	0.07	39
Carlarius parkii	12.70	9	0.05	
Trachinotus ovatus	9.67	28	0.04	
Lagocephalus lagocephalus	4.74	19	0.02	
Dentex macrophthalmus	2.27	9	0.01	
Total	23657.82		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 28
DATE :16/10/19 GEAR TYPE: BT NO: 2 POSITION:Lat N 20°5.81
start stop duration Lon W 17°36.04
TIME :16:48:35 17:04:20 15.8 (min) Purpose : 3
LOG : 9555.11 9555.88 0.8 Region : 1200
FDEPTH: 112 112 Gear cond.: 0
BDEPTH: 112 112 Validity : 0
Towing dir: 0° Wire out : 270 m Speed : 3.0 kn
Sorted : 96 Total catch: 381.99 Catch/hour: 1455.20

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	875.28	18773	60.15	
Merluccius senegalensis	310.55	1478	21.34	
Pterothrissus belloci	194.44	1524	13.36	
Umbrina canariensis	19.50	30	1.34	
Trachurus trachurus	17.68	488	1.21	
Dentex angolensis	16.30	107	1.12	
Zeus faber	8.23	15	0.57	
'Spider crab'	7.31	396	0.50	
Scorpaena stephanica	4.57	30	0.31	
Citharus linguatula	0.76	30	0.05	
Arnoglossus imperialis	0.30	107	0.02	
Unidentified crab	0.20	15	0.01	
GOBIIDAE	0.03	107	0.00	
Plastic	0.02	4	0.00	
Loligo vulgaris	0.02	30	0.00	
Total	1455.20		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 29
DATE :16/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 20°5.55
start stop duration Lon W 17°28.27
TIME :21:13:01 21:32:37 19.6 (min) Purpose : 3
LOG : 9575.58 9576.75 1.2 Region : 1200
FDEPTH: 10 22 Gear cond.: 0
BDEPTH: 46 45 Validity : 0
Towing dir: 0° Wire out : 110 m Speed : 3.6 kn
Sorted : 121 Total catch: 120.55 Catch/hour: 368.84

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Campogramma glaycos	130.04	211	35.26	
Trachurus trecae	121.90	8582	33.05	42
Engraulis encrasicolus	92.83	9874	25.17	44
Chrysaora sp.	14.87	37	4.03	
Sarda sarda	4.47	9	1.21	
Lagocephalus lagocephalus	1.10	3	0.30	
Sardinella aurita	0.92	64	0.25	43
Loligo vulgaris	0.67	37	0.18	
Belone belone gracilis	0.61	6	0.17	
Scomber colias	0.49	3	0.13	
Lagocephalus laevigatus	0.37	9	0.10	
Pagellus bellottii	0.31	3	0.08	
Sardina pilchardus	0.24	3	0.07	
Saurida brasiliensis	0.01	6	0.00	
Sepia officinalis, juvenile	0.01	3	0.00	
GOBIIDAE	0.00	3	0.00	
Arnoglossus imperialis	0.00	3	0.00	
Schedophilus pemarco, juvenile	0.00	3	0.00	
Total	368.84		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 30
DATE :17/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 20°18.35
start stop duration Lon W 17°24.85
TIME :05:05:57 05:31:23 26.2 (min) Purpose : 3
LOG : 9625.34 9627.35 2.0 Region : 1200
FDEPTH: 30 34 Gear cond.: 0
BDEPTH: 39 43 Validity : 0
Towing dir: 0° Wire out : 200 m Speed : 3.3 kn
Sorted : 0 Total catch: 86.09 Catch/hour: 197.16

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	76.12	7319	38.61	45
Sardinella aurita	56.02	4058	28.41	
Rhizostoma sp	25.01	39	12.68	
Sardina pilchardus	12.32	682	6.25	46
Sarda sarda	10.26	9	5.20	
Campogramma glaycos	4.08	7	2.07	
Arius parkii **	3.89	7	1.97	
Trichiurus lepturus	3.34	7	1.70	
Loligo vulgaris	1.47	5	0.74	
Lagocephalus lagocephalus	1.31	21	0.66	
Belone belone gracilis	1.01	14	0.51	
Sepia bertheloti, juvenile	0.82	27	0.42	
Loligo vulgaris, juvenile	0.64	156	0.33	
Pagellus bellottii, juvenile	0.50	169	0.26	
Schedophilus pemarco, juvenile	0.16	2	0.08	
Paraconger notialis	0.09	2	0.05	
Ophichthus sp.	0.07	2	0.03	
Sphoeroides spengleri	0.05	2	0.02	
GOBIIDAE	0.00	9	0.00	
Total	197.16		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 31
DATE :17/10/19 GEAR TYPE: PT NO: 8 POSITION:Lat N 20°17.41
start stop duration Lon W 17°31.01
TIME :07:56:41 08:46:48 50.1 (min) Purpose : 3
LOG : 9640.39 9644.54 4.2 Region : 1200
FDEPTH: 20 40 Gear cond.: 0
BDEPTH: 55 50 Validity : 0
Towing dir: 0° Wire out : 280 m Speed : 5.0 kn
Sorted : 0 Total catch: 157.31 Catch/hour: 188.32

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Campogramma glaycos	129.65	227	68.85	
Sarda sarda	37.29	81	19.80	
Lagocephalus laevigatus	7.90	198	4.20	
Pteroplatytrygon violacea	6.82	2	3.62	
Trichiurus lepturus	3.14	1	1.67	
Lagocephalus lagocephalus	1.51	5	0.80	
Loligo vulgaris	0.98	1	0.52	
Scomber colias	0.55	1	0.29	7
Pagellus bellottii	0.36	1	0.19	
Sepia officinalis	0.07	2	0.04	
CONGRIDAE	0.05	1	0.03	
Total	188.32		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 32
DATE :17/10/19 GEAR TYPE: PT NO: 8 POSITION:Lat N 20°26.19
start stop duration Lon W 17°38.31
TIME :14:28:26 15:17:04 48.6 (min) Purpose : 3
LOG : 9687.98 9691.28 3.3 Region : 1200
FDEPTH: 50 80 Gear cond.: 0
BDEPTH: 95 90 Validity : 0
Towing dir: 0° Wire out : 350 m Speed : 4.1 kn
Sorted : 500 Total catch: 5000.00 Catch/hour: 6169.03

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Engraulis encrasicolus	6022.70	752838	97.63	48
Auxis rochei	133.99	173	2.17	
Arius parkii **	12.34	25	0.20	
Total	6169.03		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 32
DATE :17/10/19 GEAR TYPE: PT NO: 8 POSITION:Lat N 20°26.19
start stop duration Lon W 17°38.31
TIME :14:28:26 15:17:04 48.6 (min) Purpose : 3
LOG : 9687.98 9691.28 3.3 Region : 1200
FDEPTH: 50 80 Gear cond.: 0
BDEPTH: 95 90 Validity : 0
Towing dir: 0° Wire out : 350 m Speed : 4.1 kn
Sorted : 500 Total catch: 5000.00 Catch/hour: 6169.03

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Engraulis encrasicolus	6022.70	752838	97.63	48
Auxis rochei	133.99	173	2.17	
Carlarius parkii	12.34	25	0.20	
Total	6169.03		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 33
DATE :17/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 20°30.74
start stop duration Lon W 17°7.44
TIME :19:55:20 20:25:12 30.1 (min) Purpose : 3
LOG : 9730.07 9731.64 1.6 Region : 1200
FDEPTH: 15 23 Gear cond.: 0
BDEPTH: 28 28 Validity : 0
Towing dir: 0° Wire out : 110 m Speed : 3.5 kn
Sorted : 77 Total catch: 76.95 Catch/hour: 153.39

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Sardina pilchardus	93.53	819	60.97	49
Rhizostoma sp	15.51	18	10.11	
Pagellus bellottii	10.41	132	6.78	
Spondyliosoma cantharus	7.57	44	4.94	
Loligo vulgaris, juvenile	6.82	740	4.44	
Sarda sarda	6.42	6	4.18	
Auxis thazard	2.79	4	1.82	
Belone belone gracilis	1.95	24	1.27	
Sepia bertheloti	1.71	54	1.12	
Caranx rhonchus	1.67	8	1.09	50
Carlarius heudelotii	1.24	2	0.81	
Campogramma glaycos	1.04	2	0.68	
Loligo vulgaris	0.80	2	0.52	
Scomber colias	0.48	2	0.31	
Lagocephalus laevigatus, juvenile	0.36	8	0.23	
Trachurus trecae	0.36	2	0.23	
Penaeus notialis	0.28	6	0.18	
Chrysaora sp.	0.16	12	0.10	
Sphoeroides spengleri	0.12	2	0.08	
Sardinella aurita, juvenile	0.12	6	0.08	
Jellyfish	0.06	12	0.04	
Zeus faber, juvenile	0.00	2	0.00	
Selene dorsalis, juvenile	0.00	20	0.00	
Total	153.39		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 34
DATE :17/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 20°35.39
start stop duration Lon W 17°11.48
TIME :23:10:33 23:41:05 30.5 (min) Purpose : 3
LOG : 9749.54 9751.25 1.7 Region : 1200
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 36 38 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.4 kn
Sorted : 37 Total catch: 36.53 Catch/hour: 71.77

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Auxis thazard	12.22	24	17.03	
Sardinella aurita	11.55	550	16.10	52
Sepia bertheloti	10.22	228	14.23	
Belone belone gracilis	8.84	75	12.32	
Trachurus trecae	7.86	92	10.95	53
Sardina pilchardus	6.33	77	8.81	51
JELLYFISH	3.97	31	5.53	
Loligo vulgaris	2.91	397	4.05	
Campogramma glaycos	2.16	4	3.01	
Trichiurus lepturus	1.53	6	2.14	
Caranx rhonchus	0.86	4	1.20	
Lagocephalus lagocephalus	0.83	2	1.15	
Hirundichthys speculiger	0.75	2	1.04	
Sepia officinalis	0.67	8	0.93	
Trachurus trachurus	0.31	6	0.44	
Scomber colias	0.28	2	0.38	
Microchirus theophila	0.20	2	0.27	
Selene dorsalis, juvenile	0.12	112	0.16	
Belone belone gracilis, juvenile	0.04	22	0.05	
Chloroscombrus chrysurus, juvenile	0.04	6	0.05	
Lagocephalus laevigatus, juvenile	0.04	6	0.05	
Schedophilus pemarco	0.02	8	0.03	
CARANGIDAE, juvenile	0.02	14	0.03	
Plastic	0.02	2	0.03	
Total	71.77		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 35
DATE :18/10/19 GEAR TYPE: PT NO: 1 POSITION:Lat N 20°35.79
start stop duration Lon W 17°34.92
TIME :03:56:35 04:29:32 32.9 (min) Purpose : 3
LOG : 9783.84 9785.75 1.9 Region : 1200
FDEPTH: 0 0 Gear cond.: 0
BDEPTH: 80 80 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.5 kn
Sorted : 0 Total catch: 250.00 Catch/hour: 455.37

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Engraulis encrasicolus	439.80	33313	96.58	57
Sardina pilchardus, juvenile	4.70	211	1.03	
Trachurus trecae	4.04	268	0.89	55
Octopus vulgaris	2.73	2	0.60	
Sardinella aurita	1.35	71	0.30	56
Trachurus trachurus	0.58	38	0.13	54
Belone belone gracilis	0.55	5	0.12	
Trichiurus lepturus	0.51	2	0.11	
Caranx rhonchus	0.51	2	0.11	
Pagellus bellottii	0.27	2	0.06	
Loligo vulgaris, juvenile	0.20	24	0.04	
CONGRIDAE	0.07	2	0.02	
Sepia bertheloti, juvenile	0.05	5	0.01	
Total	455.37		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2019412 STATION: 36
DATE :18/10/19 GEAR TYPE: PT NO: 4 POSITION:Lat N 20°35.79
start stop duration Lon W 17°47.67
TIME :06:28:16 06:43:43 15.4 (min) Purpose : 3
LOG : 9801.58 9802.56 1.0 Region : 1200
FDEPTH: 10 22 Gear cond.: 0
BDEPTH: 387 384 Validity : 0
Towing dir: 0° Wire out : 120 m Speed : 3.8 kn
Sorted : 0 Total catch: 20.70 Catch/hour: 80.39

SPECIES	CATCH/HOUR weight	CATCH/HOUR numbers	% OF TOT. C	SAMP
Brama brama	49.32	62	61.35	
Lagocephalus lagocephalus	23.15	50	28.79	
MYCTOPHIDAE	7.53	5336	9.37	
Belone belone gracilis, juvenile	0.39	12	0.48	
Selene dorsalis, juvenile	0.00	16	0.00	
Total	80.39		100.00	

ANNEX III. SUMMARY OF TRAWLS

No.	Date	Time start	Trans No.	Trawl type	Net depth start	Bottom depth start	Target	Success	Sard	Pilch	Mack	Anch	HM	Other pel	Pel-I	Pel-II	Dem
									% composition								
1	10.10.	07:33		BT	70	70	Test	Yes					97.8			2.2	Excl.
2	10.10.	15:38	1	PT8	20	47	Small shoals	Yes	0.3				50.7	20.4		0.5	28.1
3	10.10.	19:31	2	PT4	10	42	Dense marks in layer	Yes	2.3			0.4	0.9	56.3	3.7	21.3	15.2
4	11.10.	03:44	4	PT4	0	63	V.small marks	Yes			1.9		29.2	0.7	8.3	1.4	58.6
5	11.10.	09:27	5	BT	20	20	Small shoals	Yes	0.3			28.6		8.0	26.7	37.0	Excl.
6	11.10.	13:50	6	PT8	0	234	Dense marks near surface	No			No catch						
7	11.10.	21:59	7	PT4	10	67	Scratches in dense layer	Yes	2.0		0.2	12.7	59.3			4.0	21.8
8	12.10.	01:14	8	BT	26	26	Scratches in dense layer	Yes				0.8		68.8	10.0	21.3	Excl.
9	12.10.	08:29	9	BT	130	130	Marks on bottom	Yes									100
10	12.10.	11:41	9	PT1	0	42	Scratches in midwater	Yes	2.5		1.5		55.2	2.1		23.4	15.4
11	12.10.	14:14	9	BT	31	38	Small marks near bottom	Yes	0.8			0.2	93.6	1.6		3.6	Excl.
12	12.10.	22:54	11	PT4	0	97	Dense layer	Yes					0.5			87.0	12.5
13	13.10.	01:11	11	PT4	0	37	Dense layer	Yes					0.2			54.7	45.1
14	13.10.	03:54	12	BT	27	27	Many dense marks	Yes						40.0		60.0	Excl.
15	13.10.	14:34	13	PT8	20	38	Dispersed marks	Yes			0.1		0.6			67.3	32.0
16	13.10.	19:23	14	PT4	10	72	Dense layer	Yes	0.3		0.4		79.7			17.0	2.6
17	14.10.	01:37	15	PT4	20	45	Dense schools near surface	No									100
18	14.10.	05:30	16	PT4	10	55	Dense layer	Yes					2.1			21.6	76.3
19	14.10.	11:34	17	PT1	0	196	Dense layer near surface	Yes				0.1				2.0	98.0

No.	Date	Time start	Trans No.	Trawl type	Net depth start	Bottom depth start	Target	Success	Sard	Pilch	Mack	Anch	HM	Other pel	Pel-I	Pel-II	Dem
									% composition								
20	14.10.	15:42	17	BT	19	19	Small schools in midwater	no								100	Excl.
21	14.10.	17:24	18	BT	24	24	Small schools near bottom	Yes	7.5				2.3			90.2	Excl.
22	15.10.	07:28	20	BT	17	17	Small dense schools	Yes	0.6			15.4	1.2	6.0		75.7	Excl.
23	15.10.	14:40	21	PT8	40	61	Dense layer with scratches	Yes								99.7	0.3
24	15.10.	17:59	22	PT4	15	57	Dispersed layer	Yes	0.2			1.2				67.3	31.4
25	15.10.	23:39	23	PT4	0	107	Dispersed layer	Yes								0.7	99.3
26	16.10.	03:26	23	PT4	0	62	Dense layer	Yes				1.1	55.8			2.2	40.9
27	16.10.	08:16	24	PT8	80	258	Dense shoal near bottom	Yes					0.1			0.5	99.4
28	16.10.	16:48	25	BT	112	112	Scattered fish near bottom	Yes					61.4				38.6
29	16.10.	21:13	25	PT4	10	46	Dense marks near bottom	Yes	0.3	0.1	0.1	25.2	33.1			36.5	4.9
30	17.10.	05:05	26	PT4	39	43	Dense layer	Yes	28.4	6.3			38.6			11.0	15.7
31	17.10.	07:56	26	PT8	20	55	Small marks near bottom	Yes			0.3					90.3	9.4
32	17.10.	14:28	26	PT8	50	95	Dense marks on bottom	Yes				97.6				2.4	0.0
33	17.10.	19:55	27	PT4	15	28	Scratches near bottom		0.1	61.0	0.3		0.2			7.8	30.6
34	17.10.	23:10	28	PT4	0	36	Layer in midwater		16.1	8.8	0.4		11.4			23.6	39.7
35	18.10.	03:56	28	PT1	0	80	Layer near surface		0.3	1.0		95.6	1.0			0.2	1.9
36	18.10.	06:28	28	PT4	10	387	Dense layer near surface	Yes									100

PT1 = small pelagic Åkratrawl

PT4 = MultPelt 624 trawl

PT8 = small pelagic Åkratrawl

BT = Super Gisund bottom trawl

ANNEX IV. DESCRIPTION OF FISHING GEAR

Fishing gear

The vessel has one small four-panel 'Åkrahamn' pelagic trawl, one MultPelt 624 trawl (Figure IV.1, new in 2017) and one 'Gisund super bottom trawl'. All trawls were used during the survey.

The smallest pelagic trawl has an 8 to 12 m vertical opening under normal operation, whereas the MultPelt 624 trawl has a 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, plus 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 8 m^2 'Thyborøen' combi and weigh 2 000 kg. Trawling was conducted for species identification only and no restraining rope was 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. All trawls are equipped with a trawl eye that provides information about the trawl opening and the distance from the footrope to the bottom. A pressure sensor is used to show the depth on the headline.

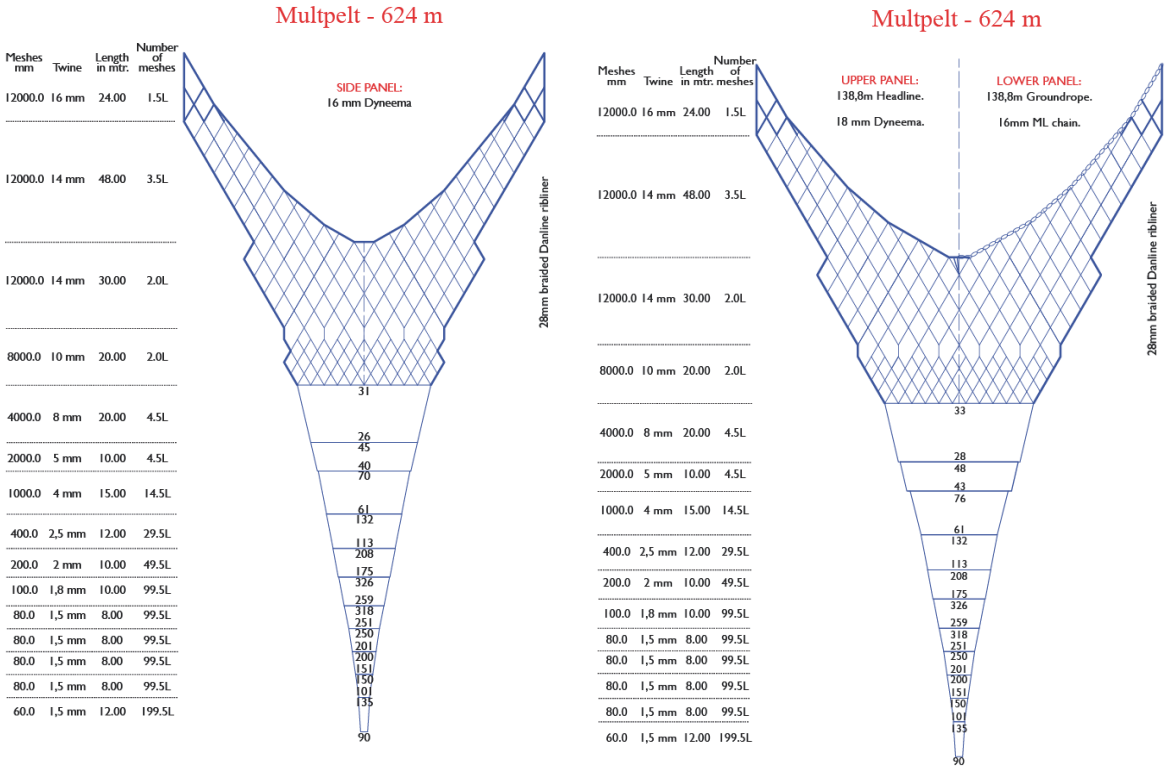


Figure IV.1. Schematic drawing of the MultPelt 624 trawl

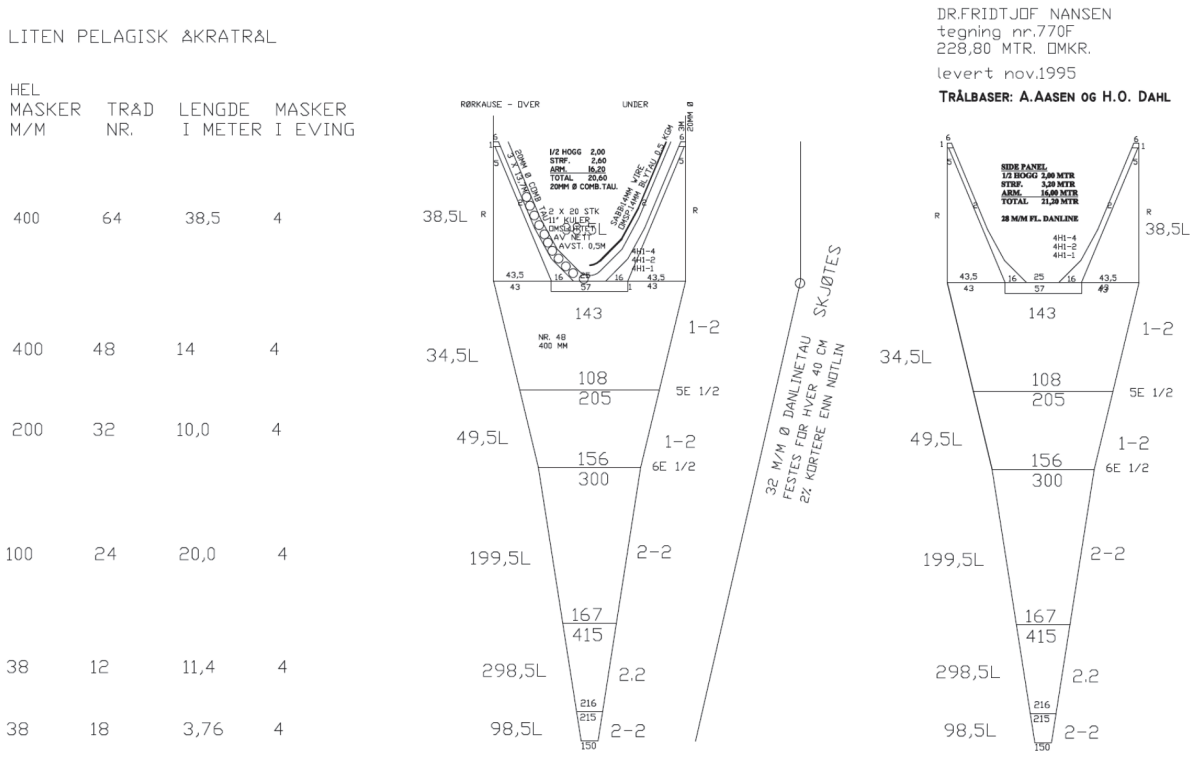


Figure IV.2. Schematic drawing of the small pelagic Åkratrawl trawl

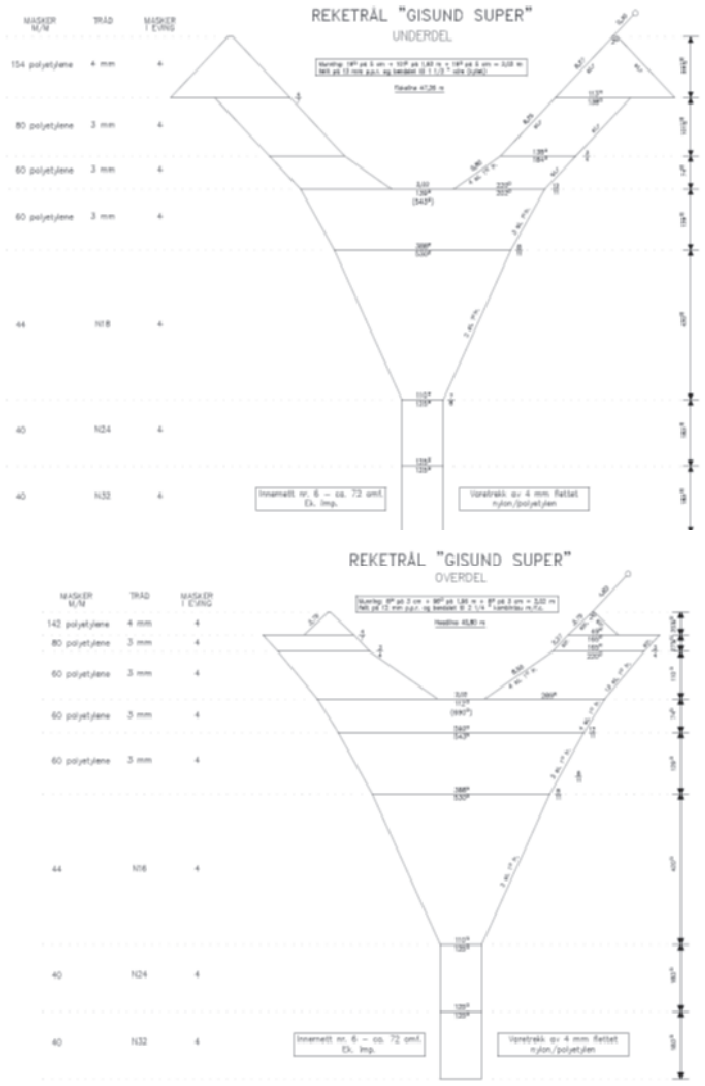


Figure IV.3. Schematic drawing of the Super Gisund bottom trawl

ANNEX V. SEXUAL MATURITY (STAGES) AND STOMACH CONTENTS (SCALES)

Sexual maturity

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

Stomach content

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

ANNEX VI. BIOLOGICAL SAMPLES COLLECTED FOR FUTURE ANALYSIS

Gear Equipment	Sample Type	Analysis	Preservation	No. of samples	Receiving institution
Niskin bottles on CTD Rosette	Seawater	Nutrients	0.2 ml chloroform (4°C)	93	IMR
WP2 (180 µm) from max 200 m 1/2 Split	Aluminium trays	Zooplankton biomass estimation	Dried and then frozen	36	IMR
WP2 (180 µm) from max 200 m 1/2 Split	Bottles with ½ of bulk WP2 sample	Zooplankton community identification	4% formaldehyde	15	IMR
Bongo V (left net, 405 µm), double oblique tow from max 200 m	Bottles with the bulk of the sample	Ichthyoplankton community identification	4% formaldehyde	15	IMR
Bongo H (right net 405 µm), double oblique tow from max 200 m	Bottles with the bulk of the sample after sorting ichthyoplankton	Ichthyoplankton community identification	4% formaldehyde	18	IMR
Bongo H (right net 405 µm), double oblique tow from max 200 m	Bottles with the bulk sample after sorting ichthyoplankton (if not done on live sample)	Ichthyoplankton community identification	96% ethanol	14	IMR
Manta trawl (335 µm): surface tow for 15 mins	Neuston community identification	Neuston community identification	96% ethanol	16	IMR
Manta trawl (335 µm): surface tow for 15 mins	Scintillation vials with sorted larval fish and eggs from the bulk manta sample	Species identification, Genetics	96% ethanol (unmethylated)	16	IMR
Manta trawl (335 µm): surface tow for 15 mins	Aluminium trays with sorted microplastics form the bulk manta sample	Abundance and chemical composition of microplastics	Photographed, dried and frozen	11	IMR
Trawl samples	Jellyfish arm	Genetics	96% Ethanol + frozen	57	UWC
Trawl samples	jellyfish whole	Identification/Morphometrics|	5% Formalin	51	UWC

Gear Equipment	Sample Type	Analysis	Preservation	No. of samples	Receiving institution
Trawl samples	Finclips of priority species (*S.aurita* & *S.colias*)	Genetics (stock identity)	96% Ethanol	98	IMR
Trawl samples	Whole individuals (priority species)	Genetics/Morphometrics	Frozen	117	INRH
Trawl samples	Processed fish samples	Contaminants/nutrition	Frozen		IMR
Trawl samples	Food safety samples	Chemical composition	Freezed dried / vacuum packed		IMR
Trawl samples	Fish liver - food safety	Chemical composition	Frozen -80		INRH

ANNEX VII. DESCRIPTION OF ACOUSTIC INSTRUMENT SETTINGS

The Simrad EK80/18, 38, 70, 120, 200 and 333 kHz scientific sounder was run throughout the survey. Scrutinizing was done in LSSS using data from the 38-kHz transducer. The last standard sphere calibrations were checked on 23.01.2017 in Sandviksflaket, Bergen, Norway using a Cu64 sphere 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 used during the survey for the 38-kHz echo sounder were as follows:

Transceiver 2 menu (38 kHz)

Transducer depth	5.8 m
Absorption coeff.	-8.4 dB/km
Pulse duration	Medium (1,024 ms)
Max power	2000 Watt
Equivalent beam angle	-20,7 dB
Gain	26,62 dB
$_{S}$A correction	0.03 dB
3 dB beamwidth:	
alongship	6.25°
athwartship	6.38°
Alongship offset	0.01º
Athwartship offset	0.06º
Bottom detection menu	Minimum level 50 Db
Angle sensitivity:	
alongship	18.0°
athwartship	18.0°

ANNEX VIII. SCRUTINISATION – SEPARATING CONGENERIC SPECIES

Two sets of congeners, the sardinellas *S. aurita* and *S. maderensis* and the horse mackerels *T. trecae* and *T. trachurus*, could not be separating during the securitization process. This therefore had to be done purely based on the trawl catches, but the method used to combine the results of several trawls can affect the species proportions to which the acoustic backscatter is allocated, and hence the biomasses calculated. The method used in this report was to combine trawls by length-frequency and weighted by the total number of each species caught. An alternative method, which has been used in some previous Nansen surveys (e.g. the pelagic surveys of Guinea, Sierra Leone, Liberia, Ivory Coast and Ghana of 2017) estimates the abundance of individual congeneric species from mixed catches using the total catch (kg/hour) of each species from all the trawls in a stratum as a proxy.

In order to test the importance of using one method over the other, the outputs of each method is compared below.

The two species of sardinella occurred together in just one stratum, Stratum 1. Based on the total amount of each species caught in all of the trawls conducted in that stratum *S. aurita* was estimated to account for 52% of the backscatter and *S. maderensis* for the remaining 48%.

Similarly, only *T. trecae* was found throughout most of the region, but small amounts of *T. trachurus* occurred together with *T. trecae* in the northernmost stratum (Stratum 9). Once again, based on the catches in this stratum, 97% of the backscatter can be attributed to *T. trecae* and 3% to *T. trachurus*.

	S. aurita	***S. maderensis***
Proportion of sardinella in Stratum 1	52%	48%
	T. trecae	***T. trachurus***
Proportion of horse mackerel in each Stratum 9	97%	3%

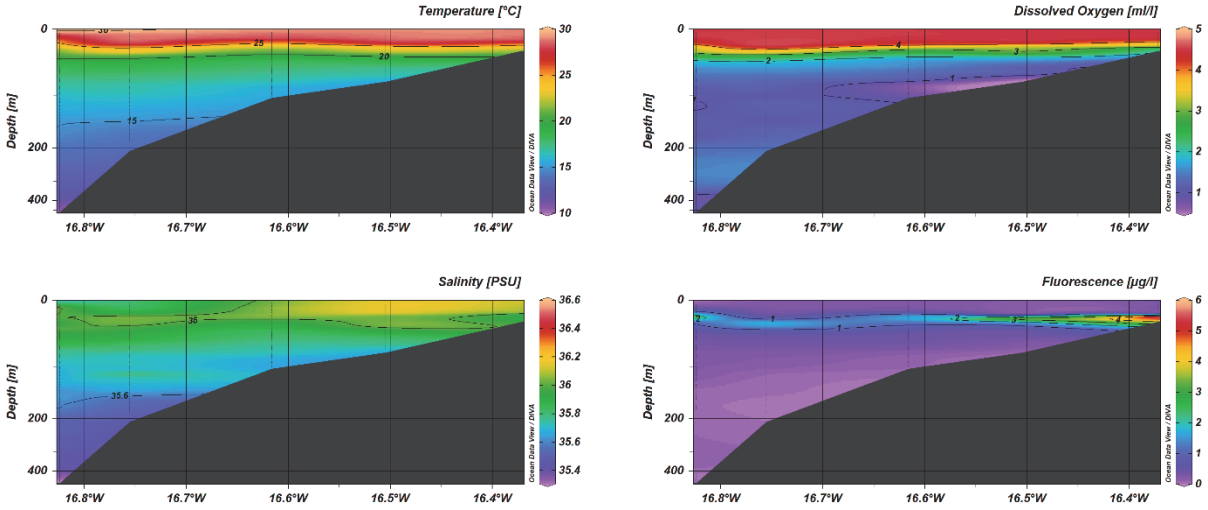
These proportions were then used to allocate the backscatter, and then calculate biomasses, which has then been compared to the method based on the different length-frequencies.

	S. aurita	***S. maderensis***
Trawl method	3,462 t	3,861 t
LF method	5,347 t	1,659 t
	T. trecae	***T. trachurus***
Trawl method	67,624 t	1,494 t
LF method	68,590 t	844

Clearly the two methods yield very different results for sardinella, but the difference is modest for the horse mackerels. The reason for this is that the length frequencies for the two sardinella species were completely different; *S. aurita* having a strong modal peak of 11 cm to 13 cm, while *S. maderensis* were 26 cm to 29 cm. With the horse mackerels the size difference was less.

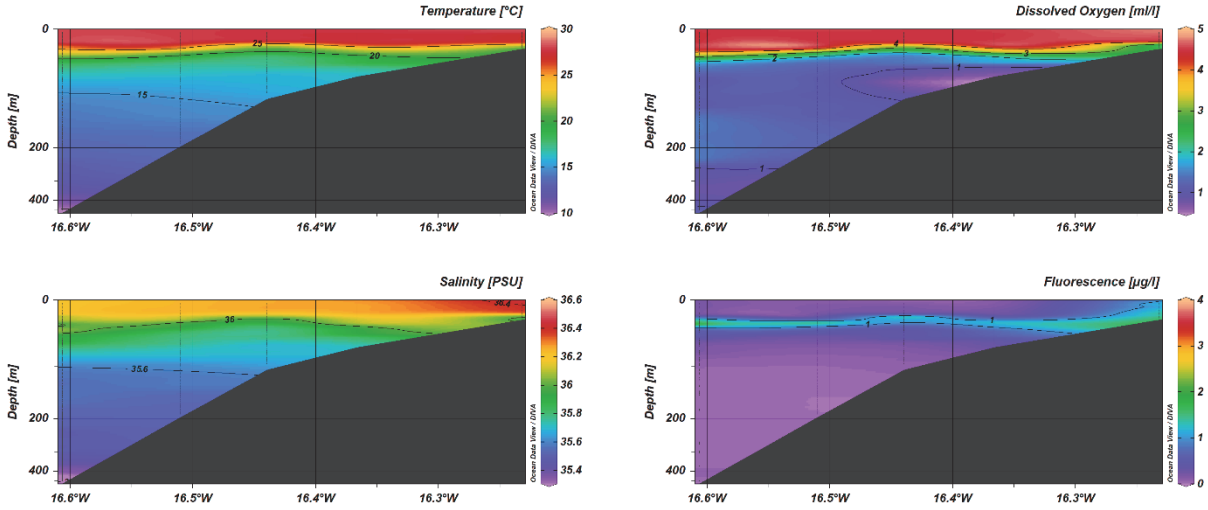
ANNEX IX. CTD PROFILES FOR THE 17°06'N AND 18°06'N TRANSECTS

Transect 17°05'N*



* Transect 17°05'N is the only transect in which the fluorescence scale was increased to 6 µg/l to capture the whole range

Transect 18°05'N



ANNEX X. OVERVIEW OF SAMPLES AND DATA TO BE ANALYSED FROM LEG 2

	Analyses	Samples	Preservation	Port of offloading	Institution address	Contact person
Niskin bottles on CTD	Sea water nutrients	20 ml scintillation vials	0.2 ml chloroform (keep cool)	Dakar	IMR	David Cervantes
WP2 (180 µm) from max 200 m ½ Split	Zooplankton biomass estimation	Aluminium trays	Dried and then frozen	Las Palmas	IMR	Stamatina Isari
WP2 (180 µm) from max 200 m ½ Split	Zooplankton community identification	Bottles with ½ of bulk WP2 sample	4% formaldehyde	Las Palmas	IMR INRH	Stamatina Isari/Omar Ettahiri
Bongo V (left net, 405 µm), double oblique tow from max 200 m	Ichthyoplankton community identification	Bottles with the bulk of the sample after sorting ichthyoplankton	4% formaldehyde	Las Palmas	IMR INRH	Stamatina Isari/Omar Ettahiri
Bongo H (right net 405 µm), double oblique tow from max 200 m	Ichthyoplankton community identification	Bottles with the bulk of the sample after sorting ichthyoplankton	4% formaldehyde	Las Palmas	IMR INRH	Stamatina Isari/Omar Ettahiri
	Ichthyoplankton community identification	Scintillation vials with sorted larval fish and eggs from one of right bongo net (H)	96% ethanol	Las Palmas	IMR INRH	Stamatina Isari/Omar Ettahiri
Manta trawl (335 µm): surface tow for 15 mins	Neuston community identification	Neuston community identification	96 % ethanol	Las Palmas	UWC	Mark Gibbons
	Species identification, Genetics	Scintillation vials with sorted ichthyoplankton from the bulk manta sample	96% ethanol	Las Palmas	IMR	Stamatina Isari
	Abundance and chemical composition of microplastics	Aluminium trays with sorted microplastics from the bulk manta sample	Photographed, dried and frozen		IMR	Bjørn Einar Grøsvik,

	Analyses	Samples	Preservation	Port of offloading	Institution address	Contact person
Trawl samples	Species identification	Jellyfish whole individual	Dried + frozen	Las Palmas	UWC	Mark Gibbons
Trawl samples	Genetic analyses?	Jellyfish arm	96% Ethanol + frozen	Las Palmas	UWC	Mark Gibbons
Trawl samples	??	Jellyfish the rest	4% formaldehyde	Las Palmas	UWC	Mark Gibbons
Trawl samples	Taxonomy	Whole fish, for species that cannot be identified	Frozen	Las Palmas	IMR	
Trawl samples	Sardina pilchardus	Otoliths	dried	Casablanca	INRH	
Trawl samples	Frozen samples (morphometrics) S. aurita and S.colias	Whole fish to be used for morphometrics, genetics and otoliths		Casablanca	INRH	Malika Chlaida
Trawl samples	Mesopelagic fish	Whole fish for identification, genetics	Frozen	Casablanca	INRH	El Ayoubi
Trawl samples	Chemical composition	Food safety samples	Frozen dried / vacuum packed	La Palmas	IMR	Marian Kjellevold
Trawl samples	Chemical composition	Fish liver - food safety	Frozen -80			

ANNEX XI. AREA, SA AND TRAWLS USED IN CALCULATION OF BIOMASS

Species	Region	Stratum	Area	Mean SA	Trawls
Sardinella	South of 19°	1	700.66	33.84	3 5 7 8 11
	South of 19°	2	426.51	140.79	19
	North of 19°	5	222.78	2.11	22 24
	North of 19°	7	1 469.34	103.34	29 30 33 34 35
Sardine (pilchard)	North of 19°	1	1 479.71	58.3	29 30 33 34 35
Anchovy	South of 19°	1	328.88	30.09	3 5
	South of 19°	2	403	205.59	7 8 11
	South of 19°	4	86.61	2091	19
	North of 19°	5	191.03	56.33	22
	North of 19°	6	97.71	15.2	24
	North of 19°	7	793.71	452.04	26 29 32, 35
Scomber (mackerel)	South of 19°	1	47.11	10	4
	South of 19°	2	219.01	8.429	7 10
	South of 19°	3	204.38	0.913	15 16
	North of 19°	5	835.92	4.36	29 31
	North of 19°	4	263.26	1.18	31 33 34
H.mackerel	South of 19°	1	146.87	220.7	1 2
	South of 19°	2	1 757.54	431.06	4, 5, 7, 10, 11, 12, 13, 15, 16, 18, 21
	North of 19°	8	236.97	154.87	22
	North of 19°	9	1 823.45	184.59	26, 27, 28 29, 30, 33, 34, 35
Pelagic -I	South of 19°	1	387.82	34.286	3 4 5
	South of 19°	2	110.17	85.75	7
Pelagic-II	South of 19°	4	439.46	50.5	1 2 3 4 5
	South of 19°	1	1 672.93	138.73	8 10 11 12 13 14 15 16 18 20 21
	South of 19°	3	120.24	7.86	None
	North of 19°	8	389.76	1 066.56	22 23 24
	North of 19°	9	1731.8	175.17	26 27 29 30 31 32 33 34 35

ANNEX XII. ABUNDANCE ESTIMATE BY NUMBER AND BIOMASS BY LENGTH CLASS

Sardinella estimates of numbers by length

	N by strata (thousands)				N by strata (thousands)			N total (thousands)
Length cm	*S.aurita* Stratum 1	*S.aurita* Stratum 2	*S.aurita* Stratum 7	TOTAL	*S.maderensis* Stratum 1	*S.maderensis* Stratum 5	TOTAL	Sardinella All strata
4								
5	983			983				983
6	4 917			4 917				4 917
7	8 091			8 091				8 091
8	6 482			6 482				6 482
9	5 029			5 029				5 029
10	13 075		84 320	97 395				97 395
11	3 174		318 922	322 096				322 096
12	246	2 753	355 795	358 794				358 794
13	5 878	2 753	349 821	358 452				358 452
14	5 632	2 753	106 892	115 277				115 277
15	1 877	88 096	24 811	114 784				114 784
16	939	27 530		28 469		11	11	28 480
17	2 816	110 119		112 936		34	34	112 970
18	939	41 295		42 234	181	68	250	42 483
19						23	23	23
20						23	23	23
21	375			375		251	251	626
22	751			751		57	57	808
23	1 502			1 502	363	354	717	2 219
24	751			751	544	137	681	1 432
25	375			375		57	57	433
26	6 383			6 383	3 267	80	3 347	9 730
27	7 885			7 885	907	34	942	8 827
28	1 502			1 502	544	11	556	2 058
29	1 877			1 877	1 633		1 633	3 511
30	375			375	363		363	738
31	751			751				751

	N by strata (thousands)				N by strata (thousands)			N total (thousands)
Length cm	***S.aurita* Stratum 1**	***S.aurita* Stratum 2**	***S.aurita* Stratum 7**	**TOTAL**	***S.maderensis* Stratum 1**	***S.maderensis* Stratum 5**	**TOTAL**	**Sardinella All strata**
32								
33								
34								
35								
Sum	82 609	275 299	1 240 561	1 598 468	7 804	1 141	8 944	1 607 413

Sardinella estimates weight by length

Using Condition factor from November 2002 survey

	Biomass by strata (tonnes)				Biomass by strata (tonnes)			Biomass (tonnes)
Length cm	*S.aurita* Stratum 1	*S.aurita* Stratum 2	*S.aurita* Stratum 7	TOTAL	*S.maderensis* Stratum 1	*S.maderensis* *Stratum 5*	TOTAL	Sardinella All strata
4								
5	2							
6	13			13				13
7	33			33				33
8	38			38				38
9	41			41				41
10	145		937	1 082				1 082
11	46		4 656	4 703				4 703
12	5	52	6 671	6 727				6 727
13	139	65	8 263	8 466				8 466
14	165	81	3 128	3 374				3 374
15	67	3 149	887	4 103				4 103
16	40	1 187		1 228		0	0	1 228
17	145	5 666		5 811		2	2	5 812
18	57	2 510		2 567	11	4	17	2 582
19						2	2	2
20						2	2	2
21	36			36		24	24	60
22	82			82		6	6	88
23	187			187	45	44	95	276
24	106			106	77	19	105	202
25	60			60		9	9	69
26	1 140			1 140	584	14	655	1 738
27	1 574			1 574	181	7	204	1 762
28	334			334	121	3	134	457
29	463			463	403		434	865
30	102			102	99		106	201
31	225			225				225
32								
Sum	5 246	12 709	24 543	42 497	1 520	136	1 795	44 153

Sardine (pilchard) estimates of numbers and weight by length

Using Condition factor from November 2002 survey

	N (thousands)	Biomass (tonnes)
Length cm	TOTAL	TOTAL
15		
16	3 197	118
17	14 074	618
18	46 176	2 397
19	56 393	3 429
20	33 915	2 396
21	5 142	419
22	12 195	1 139
23	38 496	4 097
24	22 445	2 707
25	14 139	1 923
26	3 197	488
27		
28		
Sum	249 369	19 730

Anchovy estimates of numbers and weight by length

Using Condition factor from November 2002 survey

	N (thousands)						
Length cm	**Stratum 1 South**	**Stratum 2 South**	**Stratum 4 South**	**Stratum 5 North**	**Stratum 6 North**	**Stratum 7 North**	**TOTAL**
4	1 010		308 597	18 336			327 942
5			969 875	57 628	256		1 027 759
6	3 029		529 023	31 434	256		563 742
7	90 440	15 578	793 534	47 150	2 820		949 522
8	98 925	1 215 107	1 234 386	73 345	9 997	59 137	2 690 898
9	2 084	15 578	573 108	34 053	9 741	671 461	1 306 024
10	6 445	186 940			1 538	1 452 216	1 647 139
11					256	691 978	692 234
12						614 061	614 061
13						334 548	334 548
14							
Sum	200 923	1 433 203	4 099 926	243 610	24 864	3 823 401	9 825 927

	Biomass (tonnes)						
Length cm	**Stratum 1 South**	**Stratum 2 South**	**Stratum 4 South**	**Stratum 5 North**	**Stratum 6 North**	**Stratum 7 North**	**TOTAL**
4	0		152	9			161
5			871	52	0		923
6	4		785	47	0		836
7	206	35	1 808	107	6		2 163
8	328	4 030	4 094	243	33	196	8 924
9	10	72	2 653	158	45	3 109	6 047
10	40	1 169			10	9 078	10 297
11					2	5 683	5 685
12						6 476	6 476
13						4 445	4 445
14							
	589	5 306	10 211	607	97	28 987	45 796

Scomber estimates of numbers and weight by length

Using same Condition factor as clupeids

	N (thousands)					
Length cm	**Stratum 1 South**	**Stratum 2 South**	**Stratum 3 South**	**Stratum 4 North**	**Stratum 5 North**	**TOTAL**
24						
25	21	81	8	160	14	283
26						
27						
28						
29	83	323	33	638	54	1 131
30	83	323	33	638	54	1 131
31	144	566	57	1 117	95	1 980
32	124	485	49	957	82	1 697
33	62	242	25	479	41	848
34	83	323	33	638	54	1 131
35						
Sum	598	2 344	237	4 628	394	8 201

	Biomass (tonnes)					
Length Cm	**Stratum 1 South**	**Stratum 2 South**	**Stratum 3 South**	**Stratum 4 North**	**Stratum 5 North**	**TOTAL**
24						
25	3	13	1	25	2	45
26						
27						
28						
29	20	80	8	157	13	279
30	22	88	9	174	15	308
31	43	170	17	335	29	594
32	41	160	16	316	27	559
33	22	88	9	173	15	306
34	33	127	13	252	21	446
35						
	185	725	73	1 432	122	2 537

Horse mackerel estimates of numbers by length

	T.trecae						*T.trachurus*		All horse mackerel
	N (thousands)								
Length cm	Stratum 1 South	Stratum 2 South	Stratum 8 North	Stratum 9 North	TOTAL		Stratum 9 North		All strata
4									
5									
6				4 939	4 939				4 939
7				19 757	19 757				19 757
8	864	6 427		39 513	46 804				46 804
9	432	297 818		202 556	500 806		5 842		506 647
10	30 228	1 020 562	2 425	683 652	1 736 866		8 762		1 745 628
11	432	888 886		397 529	1 286 847		23 366		1 310 213
12	1 295	660 873	19 399	123 779	805 347		23 366		828 713
13		198 632	111 546	281 683	591 860				591 860
14		32 136	72 747	155 612	260 496				260 496
15	1 714	63 283	26 674	76 642	168 314				168 314
16	432	6 427	9 700	123 876	140 434				140 434
17		12 854		66 934	79 788				79 788
18		12 854		52 059	64 914				64 914
19	3 455	12 854		7 437	23 746				23 746
20	864				864				864
21	432	6 558			6 990				6 990
22	432				432				432
23		6 558			6 558				6 558
24	1 675	59 025			60 701				60 701
25		26 234			26 234				26 234
26		78 701		22 311	101 012				101 012
27	3 390	59 025		14 874	77 289				77 289
28	419	45 909		52 059	98 387				98 387
29	4 608	59 025			63 633				63 633
30	419	59 025			59 444				59 444
31		177 076			177 076				
32	24 726	39 350			64 076				

	T.trecae					*T.trachurus*	All horse mackerel
	N (thousands)						
Length cm	**Stratum 1 South**	**Stratum 2 South**	**Stratum 8 North**	**Stratum 9 North**	**TOTAL**	**Stratum 9 North**	**All strata**
33	838	26 234			27 071		
34							
35							
Sum	76 653	3 856 329	242 491	2 325 212	6 500 685	61 336	6 562 021

Horse mackerel estimates of weight by length

Using Condition factor from November 2002 survey

	T.trecae						*T.trachurus*		All horse mackerel
	Biomass (tonnes)								
Length cm	Stratum 1 South	Stratum 2 South	Stratum 8 North	Stratum 9 North	TOTAL		Stratum 9 North		All strata
4									
5									
6				13	13				13
7				80	80				80
8	5	38		233	276				276
9	4	2 451		1 667	4 122		48		4 170
10	336	11 342	27	7 598	19 302		97		19 400
11	6	12 978		5 804	18 788		341		19 130
12	24	12 391	364	2 321	15 100		438		15 538
13		4 692	2 635	6 653	13 980				13 980
14		941	2 129	4 554	7 624				7 624
15	61	2 262	954	2 740	6 017				6 017
16	19	277	418	5 342	6 056				6 056
17		661		3 444	4 105				4 105
18		781		3 164	3 946				3 946
19	246	915		529	1 690				1 690
20	71				71				71
21	41	626			667				667
22	47				47				47
23		817			817				817
24	237	8 333			8 570				8 570
25		4 176			4 176				4 176
26		14 060		3 986	18 046				18 046
27	677	11 784		2 970	15 431				15 431
28	93	10 202		11 569	21 865				21 865
29	1 136	14 547			15 683				15 683
30	114	16 077			16 191				16 191
		53 133			53 133				53 133

	T.trecae						*T.trachurus*		All horse mackerel
	Biomass (tonnes)								
Length cm	Stratum 1 South	Stratum 2 South	Stratum 8 North	Stratum 9 North	TOTAL		Stratum 9 North		All strata
	8 149	12 968			21 116				21 116
	302	9 468			9 770				9 770
35									
Sum	11 568	205 922	6 526	62 667	286 683		925		287 608

ANNEX XIII. HYDROGRAPHY SENSORS AND WATER CHEMISTRY QUALITY ASSURANCE

CTD Sensors

Type	Serial Number	Model	Calibration Date
Deck unit	11-1082	SBE 11plus	
Pressure sensor	127957	DigiQuartz	22.07.2013
Underwater unit	09P75372-1160	SBE 9plus 6800m	20.10.2018
Water sampler	32-0972	SBE 32 6800m	
Conductivity sensor	42037	SBE 4C 6800m	04.12.2018
Conductivity sensor	43080	SBE 4C 6800m	04.12.2018
Oxygen sensor	43-3525	SBE 43 7000m	02.02.2019
Submersible pump	52147	SBE 5T	2014
Submersible pump	054196	SBE 5T	
Temperature sensor	31602	SBE 3plus 6800m	18.12.2018
Temperature sensor	03P4537	SBE 3plus 6800m	18.12.2018
Fluorometer	4892	WET Labs ECO-AFL fluorometer	08.11.2017
Sonar Altimeter	1186	Benthos PSA-916	2005
Par sensor	1123	PAR-LOG ICSW	12.10.2017

Thermosalinograph – 6 m water intake

Type	Serial Number	Model	Calibration Date	Usage Start Date
Thermosalinograph	21-3418	SBE21	06.04.2016	15.04.2017
Conductivity sensor	3418	SBE21	06.04.2016	15.04.2017
Temperature sensor (Int)	3418	SBE21	06.04.2016	15.04.2017
Temperature sensor (Ext)	0880	SBE38	23.03.2016	15.04.2017
Fluorometer	257S	9702011 WETStar	20.04.2015	02.01.2019

Water Chemistry Quality Assurance

pH and total alkalinity samples were measured in triplicates.

Parameter	**Sample count***	**Average Triplicate*** **Standard Deviation**
pH	93	0.005
Total alkalinity	91	211

*Erroneous values removed

Fluorometric standard measurements were performed to quality control chlorophyll a and phaeopigment measurements:

Parameter	**Sample Count**	
Chlorophyll a	72*	
	Low Standard	**High Standard**
Standard Measurement Count	8	2
Standard Average	480	4207
Standard Standard Deviation	12	73
Standard Average Drift	-12	-29

*Erroneous values removed

CTD dissolved oxygen and salinity value validity statistics

Parameter	**Sample Count**	**Offset from factory calibration**
Dissolved Oxygen	72	-0.7%
Salinity	0	N/A

The Portasal salinometer was being repaired during Leg 4.2. Therefore, it was not possible to perform validation measurements for the salinity values derived from the CTD.