NORAD-FAO PROJECT GCP/INT/690/NOR, CRUISE REPORTS "DR. FRIDTJOF NANSEN"

CABO VERDE ECOSYSTEM SURVEY

Survey no: 2021407

20 November - 15 December, 2022

CRUISE REPORTS “DR FRIDTJOF NANSEN”

CABO VERDE ECOSYSTEM SURVEY

Leg 2

Cabo Verde

20 November - 15 December, 2022

by

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Institute of Marine Research

Bergen, 2022

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.

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List of Abbreviations

To be filled in for the final version of the report

EXECUTIVE SUMMARY

The survey plan for 2021 had to be substantially reduced because of the COVID-19 pandemic and only two surveys were conducted by the RV Dr Fridtjof Nansen in 2021. The survey programme for 2021 included a dedicated bottom habitat habitat /environmental monitoring survey outside Mauritania and Senegal and an ecosystem survey of Cabo Verde. The survey in Cabo Verde covered shallow (about 20 m depth) to the upper waters slope (about 1000 m depth). The survey started and ended in Las Palmas, Spain.

This surveys, covering the continental shelf and upper slope from approximatively 20 m to 1000 m depth, had multiple objectives and were hence multidisciplinary. The physical and chemical oceanography, together with plankton and micro plastics, was intensively sampled with a series of fixed stations. 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 food safety of pelagic fish. This report presents the methodology and preliminary results from Leg 2, i.e. off the coast of Cabo Verde from 19 November to 15 December 2021.

The survey tracks and the sampling frequency was based on past demersal and pelagic surveys of the R/V Dr. Fridtjof Nansen in the area. Demersal trawling was carried out during daytime on predetermined positions within predetermined depth strata. They were placed at approximately the same positions as during the survey in 2011, to ensure comparability of catch rates of demersal fish between years (2011 and 2021).

Acoustic trawls for target identification were conducted using pelagic trawls in areas of increased echo backscattering as determined from the echo sounders. The acoustic densities were then allocated to main pelagic species groups. The design for the pelagic fish abundance estimation consisted of transects extending from about 20 to 1 000 m bottom depth. To attempt comparison with the survey in 2011, the Area 1 and 2 of the Cabo Verde islands complex were used. Since a standard zigzag transect pattern around an island would have resulted in an overestimation of acoustic backscatter near the coast, and an underestimation offshore, each of the main strata around each island was split into two, creating 14 strata (strata 0-13). The abundance of pelagic fish in each of the strata has been summed to provide one estimate for Area 1 and one for Area 2.

Altogether 35 trawl hauls (27 demersal and 18 pelagic) were carried out to identify acoustic targets during the survey. A total of 101 CTD casts were made to describe the hydrography of the survey area and 128 plankton stations were sampled (5 phytoplankton nets, 32 Bongo nets, 35 WP 2 nets, 1 Multinet midi, 29 Multinet Mammoth and 26 Manta nets). Samples of commercially important fish species were collected for food nutrition and toxicology tests, while Sargassum spp. were sampled for genetic analysis.

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.

Leg 2 had multiple objectives, of which all were successfully achieved, with all stations conducted, and samples collected according to the sailing order. The weather was calm the first couple of days, then we had some days with strong winds. This caused some problems with the sampling of the manta trawl and we also had to skip one demersal trawl station close to land. Some additional sampling was conducted; - One extra superstation just outside the newly established tuna-farm south of São Vicente, two extra super stations south-west of Santo Antão, believed to be a spawning area, and some extra deep CTD stations in the south western environmental transect. Three extra bottom trawl stations (two south-west of Maio and one on Nola Bank),and two beam trawl stations to get more benthos. 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 acoustic recordings were low for the whole area coveraged, and as in 2011, no clupeids were found. In only once occasion did we deploy the trawl based on strong acoustic signals. This turned out to be a very dense aggregation of mesopelagic fish. However, the abundance of pelagic fish is assessed to be 6 430 thousand tonnes, exclusively belonging to the PEL2 group. This is more than double the roughly 3 000 tons found during the 2011 survey. The geographical distribution of Pel 2 did vary slightly between the two surveys, mainly occuring south of the islands in the north (Area 2), while the opposite occurred in 2011. The recordings of Pel 2 fish south of Boa vista occurred in both of the surveys. The domination of the various species seemed to vary within the survey area. The main pelagic species found in 1981 were Decapterus macarellus, D. punctatus and D. rhonchus. During the survey in 2011 all three species were found but none of them were among the most commonly caught pelagic species. During this survey, we did we only catch a few individuals of Decapterus punctatus and none of the other two species.

The weight of the demersal trawl catches was higher than in 2011, but the composition of the catches is quite different, with few commercially important species and less macroinvertebrates like shrimps, scallops and molluscs, in this survey. Only three of the 8 demersal species monitored by IMar were caught in our catches, of which one of these species were represented by only a couple of juveniles.

The concentration of pelagic fish found during the present survey was low, and as in 2011, no clupeids were found. Also, the catches of Carangids and associated species (PEL 2) were found to be quite small but still the acoustic abundance of pelagic fish was assessed to 6 430 thousand Tonnes, exclusively belonging to the PEL2 group. Of this 4 160 thousand tonnes were found in Area 2. This is about twice as much as the roughly 3 000 tons found during the 2011 survey with the previous *RV Dr. Fridtjof Nansen*.

Only in 5 stations of the 26 were the Manta net was deployed microplastic-like items were found and isolated in 2 mL eppendorfs in freshwater.The 5 samples with microplastics and

the 26 bulk samples of the Manta net have been sent to IMR (Bergen, Norway) for further analyses.

Marine debris was registered at 11 trawl stations, mostly with only one piece of litter per station. One station (station 38) had three pieces of litter. Reference photos of the individual items were taken at three of the stations. Marine debris, remains from fishing tools and other human activities were found in trawl catches as deep as 150 m.

Only two of the pelagic species preselected for nutrition and food safety (microplastics and parasites) analysis, namely Auxis thazard and Selar crumenophthalmus, were caught in the trawls and collected for this purpose. None of these species were caught at more than one station, thus there are no replicates as was requested in the Sailing Order. Additionally, three species with high ecosystem importance were opportunistically sampled at one station each.

High biodiversity of fish was recorded in some of the catches. In the two trawl hauls at 800 m, each of them contained more than 80 distinct species. Most of the species were identified by our skilled fish team, others were preserved in ethanol and were sent to experts on land for verification, further investigation and archived for potential new studies. In total, more than 400 species were identified during the survey and more than 7700 individuals have been measured and weighted in the fish lab.

The topography (on land and underwater) is interesting, with a narrow and steep shelf, going from 30 m to 2000 m within a short distance. Some of the islands are completely flat while others are having mountains as high as 2000 m. There are several previous studies from this area, showing interesting current patterns, eddies, high exchange of water masses, areas with high turbidity while other areas were very calm. Cabo Verde is an area with coastal upwelling, high biodiversity and the area is part of the large-scale oxygen minimum zone band/area. They have two monitoring stations that have been sampling since 2006.

1 INTRODUCTION

The EAF-Nansen Science Plan

The research activities under the EAF-Nansen program are guided by the EAF-Nansen Science Plan. The Science Plan is intended to ensure good scientific use of the wealth of data generated by the RV *Dr. Fridtjof Nansen* and other related data, addressing key research questions in support of tactical and strategic fisheries management. The Science Plan covers 11 research themes, presented in Figure 1.1.

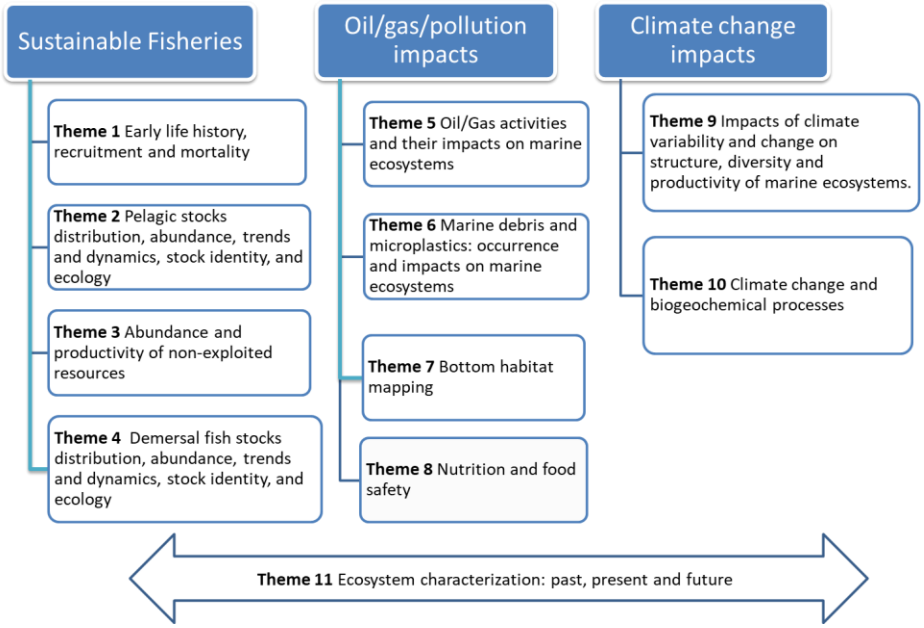


Figure 1.1: Research themes of the EAF-Nansen science plan.

1.1 The survey area

The survey plan for 2021 had to be substantially reduced because of the COVID-19 pandemic and only two surveys were conducted by the RV *Dr. Fridtjof Nansen* in 2021. The survey programme for 2021 included a dedicated bottom habitat habitat /environmental monitoring survey outside Mauritania and Senegal and an ecosystem survey of Cabo Verde. The survey in Cabo Verde covered waters from shallow depths (about 20 m depth) to upper slope (about 1000 m depth) (Figure 1.2). The survey started and ended in Las Palmas, Spain.

The Cabo Verde archipelago is situated on the west African coast about 550 km west of Senegal. It consists of ten islands and several islets. The island group has a surface area of 4 033 km^2 and a coastline of 1 020 km. The continental shelf is small (5 394 km^2) and the country has an EEZ of 734 265 km^2. There is some disagreement on the origins and age of

Macaronesian[1] islands, but the eastern islands Sal and Boavista are older and much of the volcanic topography has been eroded away by wind and time, resulting in more sandy sediments. Depending on what organisms are being considered, Cape Verde may be considered a biodiversity "hotspot" with a high level of endemism (e.g. Merino et al., 2002; Roberts et al., 2002). The wide shelf regions can be found around Boavista and between Boavista and Maio.

The biogeographical unit Macaronesia is widely accepted in ecology, characterised by its relic laurisilva vegetation (Lloris et al., 1991). In Cape Verde, this area is considered a "branch" of the Equato-Guinean province with some connection to the Madeira District (the Canaries and Madeira Islands primarily) (Lloris et al., 1991). As referred above, this is in complete agreement with the expected influence of the Canary Current and equatorial currents (both NEC and NECC) in immigration and colonisation.

Cabo Verde is characterized by low precipitation and a severe shortage of mineral resources. Marine resources are therefore of great significance as fishery has large social and economic effects. It guarantees employment for a large part of the population, contributes to food security, and fish is the major source of animal protein for most of the people on the islands. The fishing industry also contributes to the entry of foreign currency through exports.

[1] Macaronesia:biogeographical province or region commonly accepted in ecology comprising Azores, Cape Verde, Canaries, and Madeira Islands

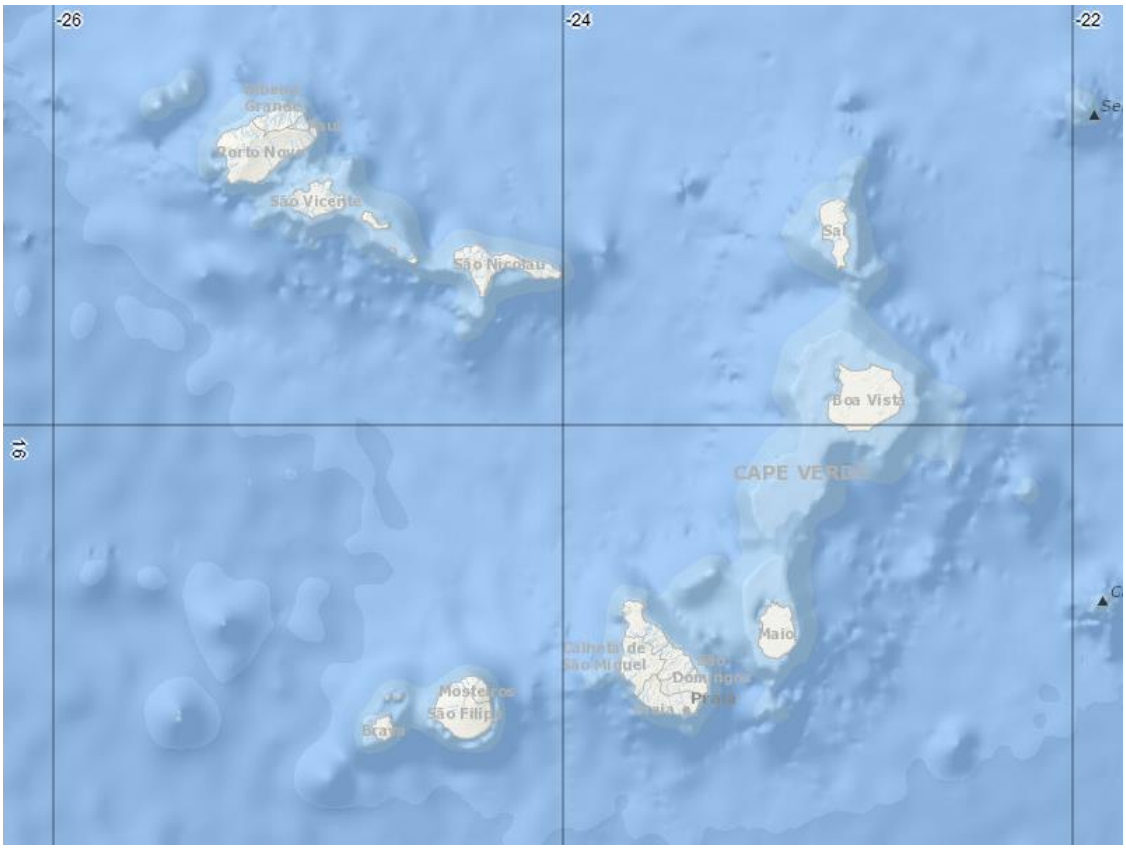


Figure 1.2: Surveyed area with R/V Dr. Fridtjof Nansen during the Cabo Verde 2021 survey.

1.2 Survey objectives

The overall objectives of the survey were to assess the demersal and pelagic resources of the continental shelf and upper slope by determining their distribution and abundance, while also studying the oceanographic conditions, distribution of microplastics and marine debris, and measure nutrient and contaminant levels in commercial fish. All the above will be carried out with a capacity-building and hands-on training in scientific sampling and reporting perspetive.

Based on the above, the following was conducted (in a prioritized order) and conducted in accordance with the sailing orders (Annex I):

- Demersal trawl hauls for assessing the distribution and biological parameters, and provide catch rates of demersal resources.
- Pelagic trawling (alongside acoustic registrations for pelagic resources) for assessing the distribution and biological parameters, and provide biomass estimates of pelagic resources.
- Standard biological sampling of priority species (including length, weight, sex and maturity).

- Sampling for nutrients, contaminants, and presence of microplastics for priority fish species.
- Standard sampling of environmental variables (salinity, temperature, dissolved oxygen, fluorescence, dissolved nutrients, pH, total alkalinity, chlorophyll a).
- Ocean current measurememts.
- Sampling for phytoplankton, zooplankton and ichthyoplankton and microplastics.
- Underway pCO_2 measurements in surface water.
- Standard sampling for meteorological variables (wind direction and speed, air pressure, relative humidity, air temperature and solar radiation).
- Additional sampling at the Cape Verde Ocean Observatory (CVOO) for hydrographic condition and plankton.

1.3 Participation

A total of 26 researchers and technicians from Cabo Verde, Côte d'Ivoire, Spain and Norway participated in the survey. The full list of the participants and their affiliations is provided in Table 1.1.

Table 1.1: *List of participants, roles, affiliations and onboard stay duration*

No	LEG	PARTICIPANT	ROLE	SEX	AFFILIATION	COUNTRY	PERIOD
1	Leg 2	Kathrine Michalsen	Cruise leader	F	IMR	Norway	19.11-15.12
2	Leg 2	Sarah Ann Bruck	Fish Team Leader	F	IMR	Norway	19.11-15.12
3	Leg 2	Diana Zaera-Perez	Fish Team Leader	F	IMR	Norway	19.11-15.12
4	Leg 2	Sara Zamora Terol	Plankton Team Leader	F	IMR	Norway	19.11-15.12
5	Leg 2	David Cervantes	Chemical oceanography	M	IMR	Norway	19.11-15.12
6	Leg 2	Olaf J. Sørås	Chief Instruments Engineer	M	IMR	Norway	19.11-15.12
7	Leg 2	Jori Neteland-Kyte	Instruments Engineer	F	IMR	Norway	19.11-15.12
8	Leg 2	Vito Ramos	Co-Cruise leader	M	IMar	Cabo Verde	19.11-15.12
9	Leg 2	Sandra Correia	Fish Team	F	IMar	Cabo Verde	19.11-15.12

No	LEG	PARTICIPANT	ROLE	SEX	AFFILIATION	COUNTRY	PERIOD
10	Leg 2	Alciany Luz	Fish Team	F	IMar	Cabo Verde	19.11-15.12
11	Leg 2	Carla Santos	Fish Team	F	IMar	Cabo Verde	19.11-15.12
12	Leg 2	Ailton Rocha	Fish Team	M	IMar	Cabo Verde	19.11-15.12
13	Leg 2	Anibal Medina	Fish Team	M	IMar	Cabo Verde	19.11-15.12
14	Leg 2	Katelene Delgado	Fish Team	F	IMar	Cabo Verde	19.11-15.12
15	Leg 2	Rui Freitas	Fish Team	M	UTA	Cabo Verde	19.11-15.12
16	Leg 2	Valéria Lopes	Fish Team	F	UTA	Cabo Verde	19.11-15.12
17	Leg 2	Péricles Silva	Chemical/physical oceanography	M	IMar	Cabo Verde	19.11-15.12
18	Leg 2	Ivanice Silva	Chemical/physical oceanography	F	IMar	Cabo Verde	19.11-15.12
19	Leg 2	Dario Évora	Chemical/physical oceanography	M	IMar	Cabo Verde	19.11-15.12
20	Leg 2	Elizandro Rodrigues	Biological oceanography	M	IMar	Cabo Verde	19.11-15.12
21	Leg 2	Keider Neves	Biological oceanography	M	Biosf	Cabo Verde	19.11-15.12
22	Leg 2	Marcia Costa	Biological oceanography	F	IMar	Cabo Verde	19.11-15.12
23	Leg 2	Chrislainne Alves	Biological oceanography	F	IMar	Cabo Verde	19.11-15.12
24	Leg 2	Francisca A. Salmeron Jimenez	Fish Team; Taxonomist	F	IEO	Spain	19.11-15.12
25	Leg 2	Benjamin N'Guessan	Physcical oceanographer	M	CRO	Ivory Coast	19.11-15.12
26	Leg 2	Maik Tiedemann	Training (Cruise leader)	M	IMR	Norway	19.11-15.12

List of institution abbreviations: IMR - Institute of Marine Research, Norway, IMar - Instituto Do Mar, IEO - Instituto Español de Oceanografía, Spain, CRO - Centre De Recherche Océanologique, Côte d'Ivoire, UTA - Universidade Técnica do Atlãntico, Biosf - Biosfera, Cabo Verde,

1.4 Narrative

The vessel departed from Las Palmas, Spain at 11h00 (UTC) on the 19th of November 2021, and sampling commenced at the first hydrographic station (CVOO) northeast of Cabo Verde on the 22nd at 15h30. After completing sampling at the CVOO station, the vessel proceeded to the eastern tip of the São Nicolau island, where the acoustic coverage initiated on the 23rd of November, heading westwards towards the Nola Seamount. The coverage consisted of an acoustic sampling grid that had a pre-set transect spacing, covering the

shelf (> 20 m) and slope until the 1 000 m bottom depth contour. In parallel with the pelagic coverage, environmental stations, demersal and pelagic trawl stations were also carried out, as described in the sailing orders. When arriving at the Nola Seamount on the 24th of November a process study (see Annex I) was conducted with sampling at predefined stations with the Multinet Mammoth and CTD casts. At sunset of the same day, the acoustic coverage of the Nola Seamount was carried out together with CTD stations (with water sampling, at predefined locations and to the maximum depth) and ADCP recording (around the western Nola Seamount), until sunrise. Afterwards, the Multinet sampling continued until end of daylight on the 25th of November. The vessel headed towards the southern part of the Area 2 (Santo Antão, São Vicente, Santa Luzia and São Nicolau) to continue the acoustic coverage and sampling of the demersal resources. On th 26th of November a first attempt to calibrate the echo sounders was carried out, before resuming the sampling again. Area 2 was finished on the 27th of November.

The vessel then moved east, towards the northeastern island Sal. On the way, three environmental stations were carried out. The acoustic coverage of Sal started on 28th of November and the Area 1 (Sal, Boa Vista, Maio, Santiago, Fogo) was covered. The last environmental transect between Areas 1 and 2 started on the 6th of December and ended on the 7th of December. The vessel then headed towards Nola Bank again, to conduct a Multinet sampling transect from southwest to northeast along the two Nola seamouts during the night. One bottom trawl station and one haul with the beam trawl were also conducted on the top of the Nola Seamount.

On the 9th of December, all sampling was concluded, and the vessel steamed to Las Palmas, were it arrived at 09h00 on the 13th of December. Days spent in the territorial waters of Cabo Verde are shown in Table 1.2. The weather was favourable during the first survey days, but when the vessel headed towards Area 1, the wind increased and the speed had to be reduced. Only one bottom trawl station (east of Sal) could not be conducted due to unfavorable weather conditons. In total, 2 049.2 NM were sailed.

1.5 Survey design and effort

The survey tracks and the sampling frequency followed the agreed survey design described in the sailing orders, and was based on past demersal and pelagic surveys of the R/V *Dr. Fridtjof Nansen* in the area. Demersal trawling was carried out during daytime on predetermined positions within predetermined depth strata Figure 1.4. They were placed at approximately the same positions as during the survey in 2011, to ensure comparability of catch rates of demersal fish between years (2011 and 2021).

Acoustic trawls for target identification were conducted using pelagic trawls in areas of increased echo backscattering as determined from the echo sounders. The acoustic densities were then allocated to main pelagic species groups. The design for the pelagic fish abundance estimation consisted of transects extending from about 20 to 1 000 m bottom depth. To attempt comparison with the survey in 2011, the Areas 1 and 2 of the Cabo Verde islands complex were used. Since a standard zig-zag transect pattern around an island would have resulted in an overestimation of acoustic backscatter near the coast, and an underestimation offshore, each of the main strata around each island was split into two,

creating 14 strata (strata 0-13, see Figure 1.2). The abundance of pelagic fish in each of the strata has been summed to provide one estimate for Area 1 and one for Area 2. The distance between the acoustic transects was defined based on the equal average coverage probability method (Harbitz, 2019) taking into account the desired time to be spent on each stratum, the speed of the vessel and the optimal degree of coverage aimed for. The software StoX (Johnsen et al. 2019, https://www.hi.no/en/hi/forskning/projects/stox) was used for the calculation of the abundance indices of pelagic resources.

Hydrographic variables were measured at every bottom trawl station and at predefined environmental stations (Figure 1.5), called super-stations. At these stations, more elaborate sampling was carried out, including CTD with water samples at standard depths for chemical and nutrient analyses (Figure 1.3). Plankton (phyto-, zoo- and ichthyoplankton) samples were collected using various sampling gear (Phytoplankton net, WP-2 standard net, Bongo net, and Manta trawl), employing vertical, horizontal or oblique tows (depending on the gear). Microplastic samples were also taken by means of the Manta trawl (Figure 1.3). A CTD and a vertical Multinet Midi deployment were carried out at the Cabo Verde monitoring station CVOO.

Plankton sampling was conducted at 30 pre-defined super-stations throughout the survey area (Figure 1.6). Stations were located at similar positions as in 2011, ranging from 30 to 4 000 m bottom depth. South of the San Vincente Island, an extra station was sampled to establish a reference point that could be used to monitor potential changes in the area due to planned industrial activity (tuna farming). Depth stratified sampling of ichthyoplankton was also carried out using the Multinet Mammoth at selected stations of special hydrographic interest around the Nola Bank.

The survey effort in each area considered (Area 1 and 2) is summarised in Table 1.2.

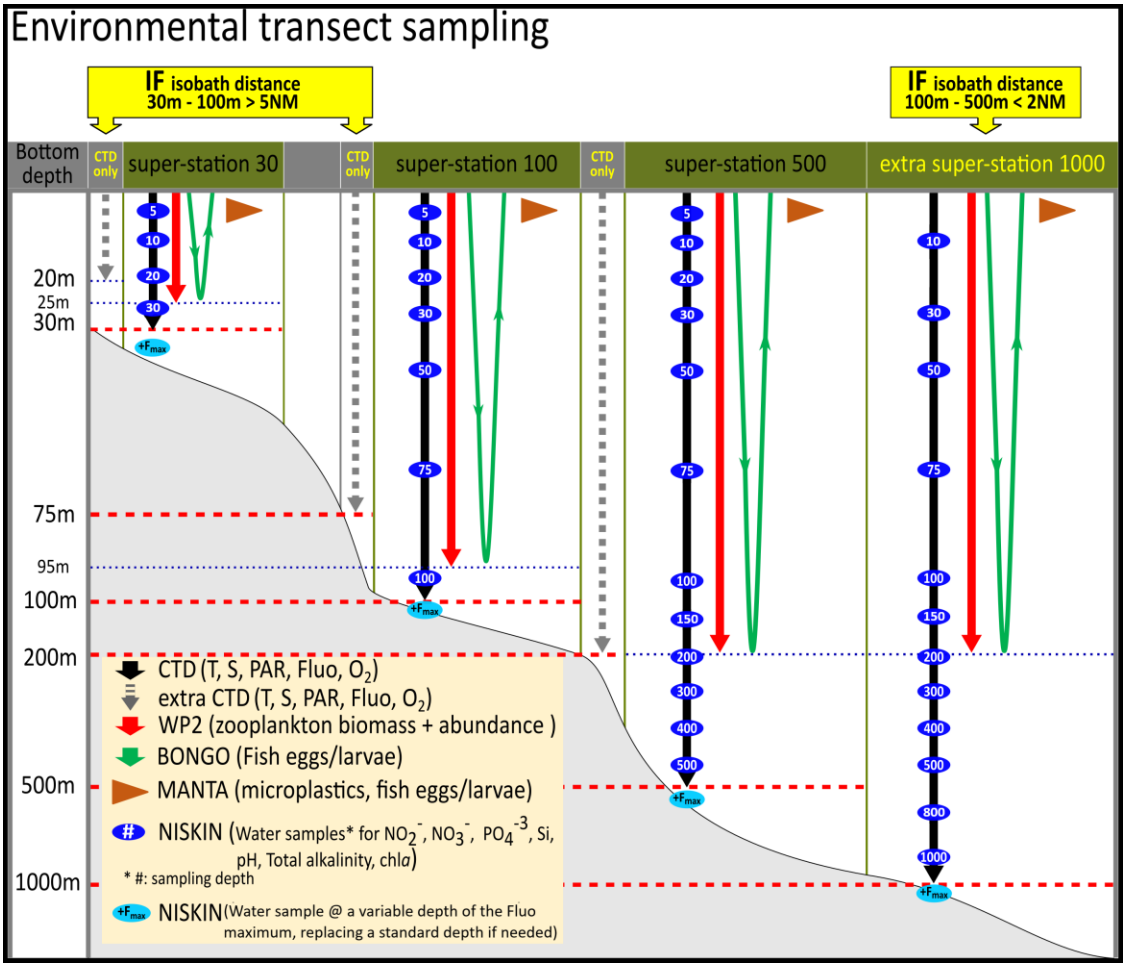


Figure 1.3: Sampling along environmental transects, at predefined stations, called super-stations.

Table 1.2: *Survey effort in number of sampling stations (total and by sub-area). Number of: BT (demersal), PT (pelagic) and BM (beam) trawl hauls, CTD, WP2, Bongo, Phyto, Multinet and Manta gears used for plankton and microplastics sampling. The distance sailed (in NM) and the time spent in each region is also provided*

region	activity	period	BT	PT	BM	CTD	Manta	Bongo	Multinet Mammoth	Multinet midi	WP2	Phyto	Distance	Days
Cape Verde	steaming	2021-11-21 to 2021-11-22 2021-12-08 to 2021-12-09											392.3	2.1

region	activity	period	BT	PT	BM	CTD	Manta	Bongo	Multinet Mammoth	Multinet midi	WP2	Phyto	Distance	Days
Cape Verde	survey	2021-11-22 to 2021-12-08											2 049.2	15.9
Cape Verde Islands, east	entire survey		21	9	1	63	22	28	12		31	4		
Cape Verde Islands, northwest	entire survey		6	9	1	38	4	4	17	1	4	1		
Total	-	2021-11-21 to 2021-12-08	27	18	2	101	26	32	29	1	35	5	2 441.5	18.0

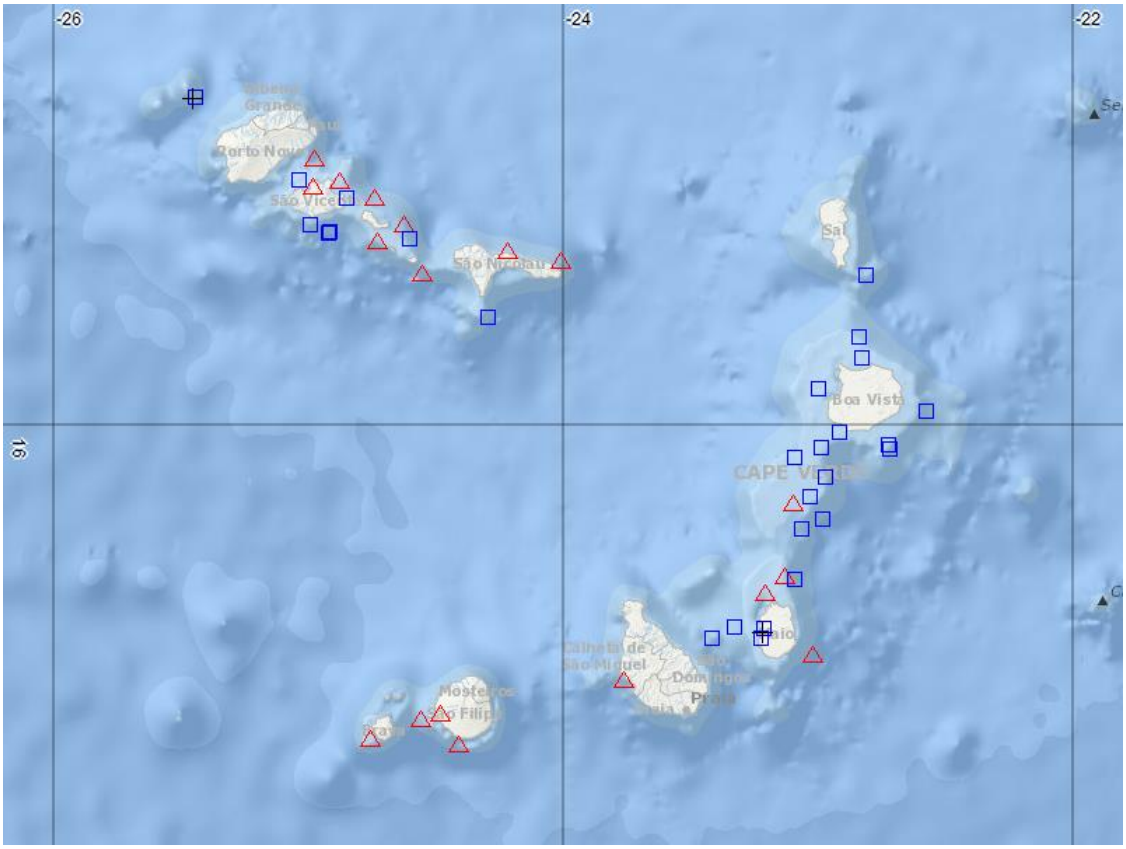


Figure 1.4: Map of trawl station locations. Bottom (squares), pelagic (triangles) and beam (cross) trawls are shown.

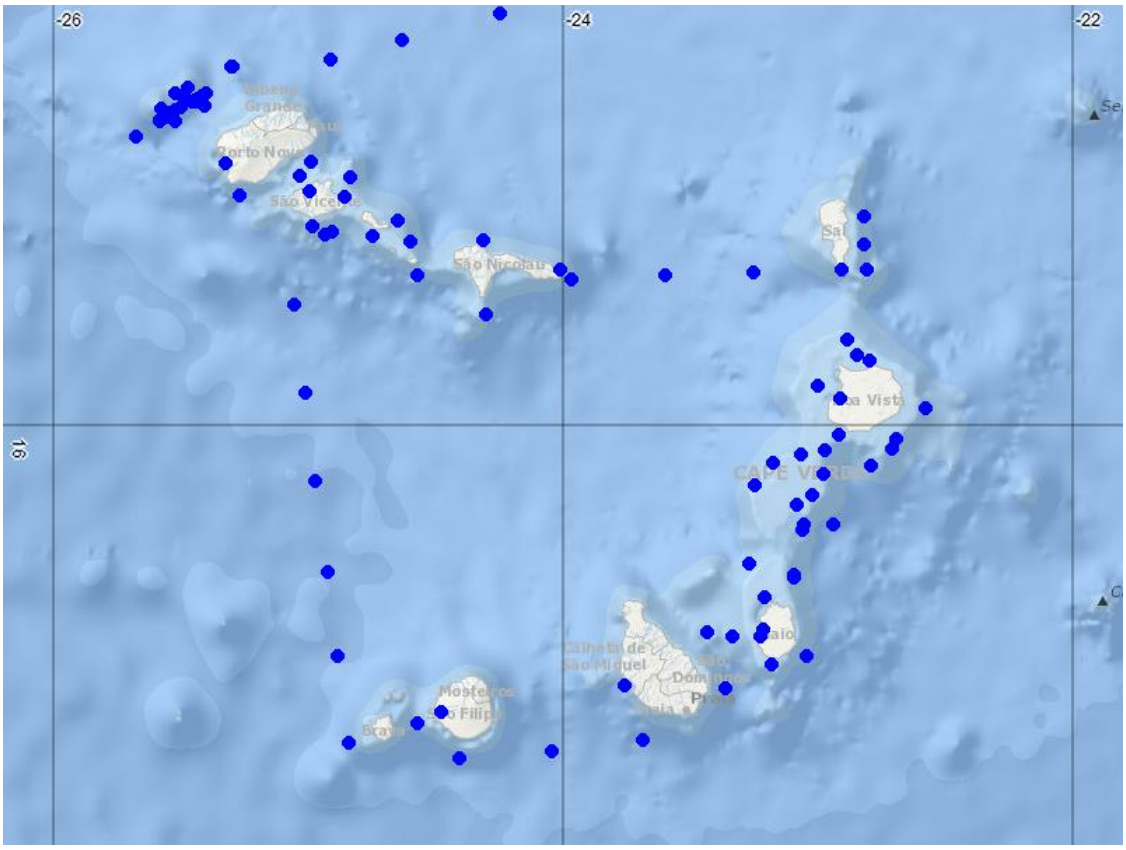


Figure 1.5: Map of trawl station locations. Bottom (squares), pelagic (triangles) and beam (cross) trawls are shown.

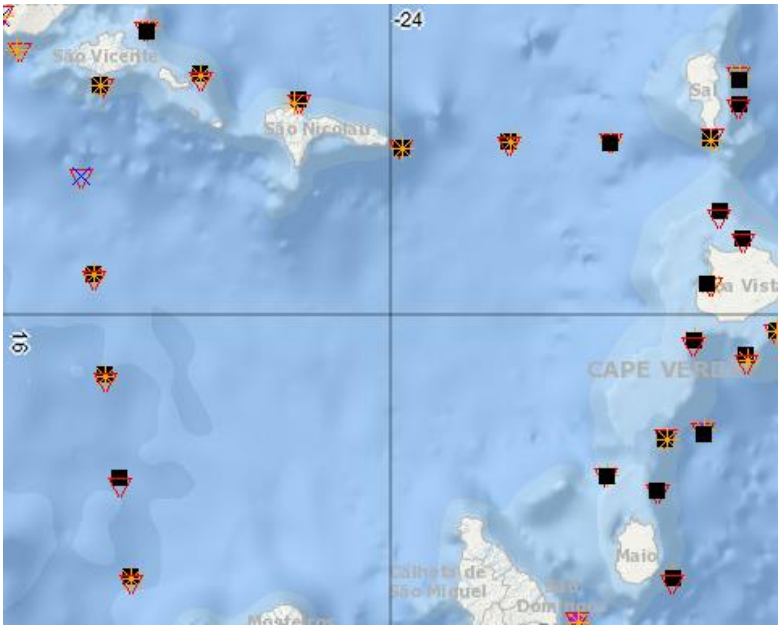


Figure 1.6: Map of plankton station locations. Multinet (cross), WP2 (reversed triangle), Bongo (square), Manta (asterisc) and Phytoplankton (diamond) sampling gir is displayed.

2 METHODS

2.1 Meteorology

Meteorological data were logged continuously from the AANDERAA Smartguard meteorological station and included wind direction and speed, air pressure, relative humidity, air temperature and solar radiation. All data were stored to the vessel's Cruise Logger database.

2.2 Oceanography

2.2.1 Underway hydrographic sampling

2.2.1.1 Ocean currents

Ocean current data were collected with a vessel-mounted Teledyne RDI Ocean Surveyor Acoustic Doppler Profiler operating at 150 kHz. The second vessel mounted ADCP, operating at 75kHz, was undergoing maintenace and was not available for the survey. The ADCP ran 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. Teledyne's VmDAS software was used to collect the raw current data, whereas software created at IMR (QCSYS) was used to process the data.

2.2.1.2 Sea surface temperature, salinity and fluorescence

TSG 4m C3 and 6m WETStar

Both SBE 21 SeaCAT Thermosalinographs (TSG) were needed during the survey due to instrument malfunctions. The survey began with the 4 m intake TSG, but due to issues with the conductivity sensor, the second 6 m drop keel intake TSG was put into operation from 20th of November onwards. The 6 m intake TSG ran continuously during the survey, obtaining samples to measure seawater salinity and temperature every 10 seconds. The 4 m TSG was originally equipped with a Sea-Bird WETStar fluorometer but that was moved to the 6 m TSG on the 3rd of December 2021.

2.2.1.3 pCO_2

Water from the vessel's 4 m intake was pumped through the flow head of a CONTROS HydroC® CO_2 FT sensor. Dissolved gases diffused through a composite membrane into the internal gas circuit leading to a detector chamber, where the partial pressure of CO_2 is then determined via IR absorption spectrometry. Concentration-dependent IR light intensities are converted into the output signal from calibration coefficients stored in firmware and data from additional sensors within the gas circuit.

2.2.2 Fixed hydrographic sampling

2.2.2.1 CTD sensors

A Sea-Bird 911plus CTD containing the sensors identified in Annex II were mounted to a 12-bottle rosette for use at every fixed hydrographic station. Sensor data logging and profiling were performed using Sea-Bird's Seasave software.

For conductivity sensor validation, water was collected from the rosette water sampler at the bottom of each non-shallow CTD deployment when the rosette water bottles were in use. Water was also collected from the entire water column from selected deep CTD stations for conductivity and dissolved oxygen sensor calibration. For this purpose, a Guildline Portasal Salinometer 8410A was used to measure the samples collected for conductivity, whereas the dissolved oxygen water samples were measured using a Metrohm 916 Ti-Touch potentiometric titrator performing automated Winkler titrations (Grasshoff et al., 1983; Langdon, 2010).

2.2.3 Water column ocean currents

The LADCP was not used during the current survey.

2.2.4 Ocean acidification parameters

pH & total alkalinity

Seawater samples for the analysis of pH and total alkalinity were collected at pre-selected hydrographic stations in 250 ml borosilicate glass bottles with silicone tubing. After collection, samples were placed directly into a covered 25°C water bath in preparation for analysis. Samples were measured immediately after reaching 25°C as no preservative was

added to the samples. 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 (or as needed) during the survey to calculate the correction factor appropriate for the measured pH values (Clayton and Byrne, 1993; Chierici et al., 1999). All pH spectrophotometric measurements were performed in triplicate on board. Total alkalinity was determined via an open-cell potentiometric titration using a 0.05 M 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 an integrated Pt1000 temperature sensor was used in combination with Metrohm's tiamo™ software to measure the change in pH for total alkalinity titrations. Certified CO_2 in seawater reference material of known total alkalinity from Scripps Institution of Oceanography was measured every 24 hours (or as needed) during the survey to calculate the correction factor appropriate for the measured total alkalinity values. All total alkalinity titrations were performed in triplicate on board.

2.2.5 Nutrient samples

Seawater samples for the analysis of nitrite, nitrate, silicate and phosphate were collected in 20 ml polyethylene vials at every plankton sampling station and frozen for preservation as requested by our partners from Cabo Verde. When ready for analysis, samples will be thawed in a 50°C water bath for 40 minutes and then allowed to cool to room temperature for 45 minutes (Becker et al., 2019). The nutrient samples are planned to be measured in February 2022 on the vessel with a SEAL QuAAtro39 continuous segmented flow analyser (QuAAtro Methods:Q-070-05 Rev. 7; Q-068-05 Rev. 12; Q-064-05 Rev. 8; Q-038-04 Rev. 4 (multitest MT3B)).

2.3 Plankton

2.3.1 Phytoplankton

Phytoplankton samples were collected using a phytoplankton net with 10 µm mesh size towed at 0-30 m layer at 5 selected super-stations (Annex I) for the analysis of the phytoplankton community. Samples were preserved in 2% acidic Lugol's solution and stored in 100 ml dark glass bottles.

2.3.2 Zooplankton

Zooplankton samples were collected at 35 selected stations, with vertical tows of a WP2 net (180 µm). Sample collection and processing followed the sailing orderss of the survey. Specifically, the net was towed within 5 m from the bottom to the surface, or from 200 m depth to the surface at deep stations. Each sample was halved into parts with a Motoda splitter. One half was size fractionated through 2 000 µm, 1 000 µm and 180 µm mesh sizes, and dried in the oven (60°C) in pre-weighed aluminum trays. The second half was preserved in 4% borax buffered formaldehyde solution.

2.3.3 Ichthyoplankton

Ichthyoplankton was collected with double oblique tows of a Bongo net (405µm). Samples were collected at the 35 environmental stations within 5-10 m from the bottom to the surface, or a maximum depth of 200 m to the surface at deep stations. At station 528 the Bongo net was lost, so in the last 3 stations the Multinet Mammoth (405 µm) was used to replace it in the sampling.

In all cases, once the Bongo was on board the sample from the two nets was treated as follows:

a) One of the nets, the Bongo V, was sieved on a 180 µm sieve and transferred to a 100 ml bottle (or bigger) and preserved immediately in 4 % formaldehyde.

b) From the other net, the Bongo H, was examined under the microscope and ichthyoplankton was sorted. Sorting was made at all of the Bongo stations. The sorted larvae were photographed and preserved in absolut ethanol in small labelled scintillation vials or cryovials indicating clearly the part of the sample used (i.e. 50 %), the preservative, station etc. When sorting was finished, the bulk sample was preserved in absolut ethanol for genetics in small labelled scintillation vials indicating clearly which net was used for sorting, the preservative, station etc. In a few cases of bad weather conditions, an alternative approach was to fix the total sample for ichthyoplankton without separating larvae from the sample onboard.

Samples collected with the Multinet Mammoth were divided in two parts using a Motoda splitter and each half was preserved as mentioned above.

2.3.4 Jellyfish

Not relevant for this survey.

2.4 Fishery resources

2.4.1 Pelagic resources

The area between 20 and 1 000 m bottom depths were surveyed for pelagic fish abundance estimation using the acoustic method.

Acoustic data were recorded using a Simrad EK80 Scientific Split Beam Echo Sounder equipped with keel-mounted transducers at nominal operating frequencies of 18, 38, 70, 120, and 200 kHz. A succsessful calibration of the echo sounders was conducted south of the Maio island on the 2nd of December 2020 and hence the gain was adjusted for recordings throughout the survey. In Annex II, the details of the acoustic settings used during the survey are provided. Acoustic data were processed on board and the backscatter was assigned for biomass estimation to the acoustic categories listed in Table 2.1.

Pelagic trawl hauls were conducted whenever stong acoustic signals showed up on the echosounder or to check if there were any fish close to the surface (and in the blind zone of the echo sounder) during night.

Table 2.1: *Allocation of acoustic densities to species groups. The mean integrator value in each sampling unit (sA-values) was divided between the below listed standard categories/groups of fish. Note that for the groups sardinella, horse mackerel, all encountered species are listed, while only examples are listed for the remaining groups.*

Acoustic category	Group	Taxon	Species
SARD	Sardinella	Sardinella spp.	Sardinella maderensis, Sardinella aurita
HMACK	Horse mackerel	Trachurus spp.	Trachurus trecae, Trachurus picturatus
MACKE	Mackerel	Scomber spp.	Scomber colias
PEL1	Pelagic species 1	Clupeiformes[1]	No records of other Clupeids found in Cabo Verde
PEL2	Pelagic species 2	Carangidae[2]	Caranx crysos
			Decapterus punctatus
			Pseudocaranx dentex
			Selar crumenophthalmus
			Selene dorsalis
			Seriola dumerili
			Seriola fasciata
			Seriola rivoliana
		Scombridae	Auxis thazard
			Sphyraena guachancho
		Sphyraenidae	Lithognathus mormyrus
BOTT	Demersal species	Sparidae[3]	Dentex macrophthalmus
			Galeoides decadactylus
			Antigonia capros
			Dactylopterus volitans
		Other taxa	Glossanodon leioglossus
			Lethrinus atlanticus
PLANK	Plankton	Plankton, Euphausiids, mesopelagic fish	
OTHER	Other pelagic fish	Other taxa	

[1]Except specimens from the Sardinella and Engraulis genera; [2]Except specimens from the Trachurus and Scomber genera; [3]Main taxa group

2.4.1.1 Trawling and biological sampling

Standard biological sampling including length, weight, sex and maturity registrations were carried out for all priority species at all trawling stations. Also, length – weight measurements of up to 30 individuals per station were taken from all other fish species caught. Genetic samples were also taken for selected species (Annex I) based on the standard sampling protocol for genetics (https://nansen-surveys.imr.no/doku.php?id=biological_sampling_procedures).

2.4.1.2 Acoustic abundance estimation

Acoustic data were logged and post-processed on board using the latest acoustic data post-processing software, the Large-Scale Survey System (LSSS) Version 2.7.

In cases where the integrated echo contained more than one category of fish (see Table 2.1), the mean sA-value allocated to each category was in the same ratio as their contribution to the abundance in trawls in that area.

The following target strength (TS) function was applied to convert sA-values (mean integrator value for a given species or group of species in a specified area) to number of fish:

$$TS = 20 * logL - 72dB$$

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

$$C_{F_i} = 1.26 * 10^6 L^{-2}$$

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

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

where

ϱ_i = density of fish in length group i

s_A = mean integrator value

p_i = proportion of fish in length group i

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

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

The integrator outputs were split into the fish groups listed in Table 2.1 using a combination of behaviour pattern as deduced from echo diagrams, the LSSS analysis and catch composition.

The acoustic backscatter was scrutinized daily and allocated to the various acoustic categories. For Pelagic I, Pelagic II and "other species" -50 to -55 dB was used. To identify mesopelagic layers a threshold of -60 dB was used.

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

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

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

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

If the acoustically targeted fish was a mixture of more than one species, a representative distribution of all the species, within the stratum, as shown in the trawl catches, was used. A mean length of 23 cm was used as a proxy for estimating the proportion of the total biomass of this group of species. While it is recognised that catch is a poor indicator of relative abundance, especially for pelagic fish, no other method is easily available from the data available.

The process followed was therefore to:

a) divide the sA-value between groups of fish and/or species,
b) use a mean length of a specific group and/or species for use in the above equation and,
c) calculate the biomass estimates for a region,

using the following procedure:

The length-frequency samples of the species in the category were respectively pooled together with equal importance (normalized).

The mean back scattering strength (ϱ/s_A) of each length frequency distribution of the target group/species was calculated and summed.

The pooled length distribution was used, together with the mean sA-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 by the area. The numbers were then converted to biomass using the estimated weight at length.

2.4.2 Demersal resources

2.4.2.1 Trawling and biological sampling

Demersal trawl stations were carried out on the shelf at approximately the same positions as during the survey in 2011, to ensure comparability between the two surveys.

The possibility to carry out additional bottom trawl stations was explored. Trawls were carried out during daylight hours (06h30 to 18h30 UTC), from 20 to 1 000 m depths.

Trawl duration was standardized to 30 minutes, however, trawls with durations of more than 15 minutes (and more than 0.5 NM) were included in the estimates. The trawling start time is determined by using a "SCANMAR" sensor to detect the landing of the trawl on the bottom, and the stop-time is defined as the time when the wires start to haul the net in. In some cases, the towing was interrupted before 30 minutes due to poor bottom conditions. Hence, some stations were coded as invalid in the database due to flawed sampling. During the demersal sampling, one station was flagged as invalid (Station 257) due to short trawling time, while two other stations (Station 285 and 286) were flagged for species identification only, and as such, excluded from the demersal catch rates. A detailed description of instruments and fishing gear is given in Annex II.

Once the catch was on deck, it was assessed, and, if necessary, subsampling was carried out. At all trawl hauls, the catch was sorted, and length and weight measurements were taken for all fish species using an electronic fish meter and its customized data-acquisition software (Fish2Data). Registrations were then transferred and stored to the Biotic Editor software. In addition, further biological sampling was conducted for pre-agreed priority species.

The sailing orders (Annex I) provided guidelines on the detailed sampling protocols that were used during the survey. As a preparation for the work in the fish lab, a training course was provided on the use of the electronic fish meter, Fish2Data and Biotic Editor software before the survey started.

During this survey trawling was resticted to certain areas. Large parts of the shelf in Cabo Verde consists of hard and rough grounds that prevented trawling. The catch rates are indicative only and reference to biodiversity and catch rates is relevant for only the areas covered.

2.4.2.2 Swept-area abundance estimation

Due to the bottom topography around the islands of Cabo Verde the catches cannot be considered representative for the species and abundance of fish in areas that were not sampled (not accessible for trawling). Therefore swept area abundance estimates has not been provided, but the catch rates were calculated and compared with those from 2011.

2.5 Microplastics

Samples from Manta trawls were collected and processed according to the sailing orderss. All samples were sorted on board for microplastics and ichthyoplankton. Sorted microplastics were photographed and placed in 2 mL eppendorf tubes with freshwater. Remaining fish larvae and eggs were sorted, photographed, preserved in absolut ethanol for genetics in 20 mL scintillation vials. The bulk of neuston samples was preserved in methylated ethanol after sorting.

2.6 Marine debris

Marine debris were registered and classified at each station according to the standard sampling protocol for marine debris (https://nansen-surveys.imr.no/lib/exe/fetch.php?media=nansen-surveys:fishlab_marine_litter_categories.docx). All pieces of litter were weighed and counted, and when possible, photos were taken of the individual pieces for a future reference catalogue. The data and the reference photos were recorded using Fish2Data.

2.7 Bottom habitat mapping

The EM 710 multibeam echo sounder is a high-resolution seabed mapping system. The EM 710 is mounted on the drop keel and the operational depth of the EM 710 is from 3 to 2 000 m. Across track coverage (swath width) is up to 5.5 times the water depth and may be limited by the operator either in angle or in swath width without reducing the number of beams. The operating frequencies are between 70 to 100 kHz. There are 128 beams with dynamic focusing employed in the near field. The transmitting fan is divided into three sectors to maximize range capability and to suppress interference from multiples of strong bottom echoes. The sectors are transmitted sequentially within each ping and use distinct frequencies or waveforms. The along-track beam width is 1 degree. Ping rate is set according to depth. The receiving beam width is 2 degrees. Sound profiles were set manually in the system according to the area of operation. The EM710 was not operational for most of the survey. Data from the EM710 was logged to the on-board Olex plotting system in standard resolution mode.

2.8 Vulnerable Marine Ecosystems

Not relevant for this survey.

2.9 Top predators

Not relevant for this survey.

2.10 Food safety

For nutrition and food safety sampling the protocol in Annex I was followed. Samples of selected species were taken and analysed for nutrient profiles, contaminants and microplastics. Samples were collected at different geographical coordinates. A total of 25

specimens from at least 3 different stations were frozen and will be analyzed for determination of nutrients and food safety parameters at IMR (Bergen, Norway).

2.11 Sediment sampling

Not relevant for this survey.

2.12 Additional sampling

2.12.1 Sampling at Cabo Verde Ocean Observatory and Nola Seamount

Oceanography

The 12-bottle rosette water sampler was used to support the joint monitoring project between Cabo Verde and GEOMAR at the Cabo Verde Ocean Observatory (CVOO) monitoring station. In addition to the proposed sampling plan by Cabo Verde (Table 2.2), the CTD went down to 3 650 m for full sensor coverage and samples were also collected and measured for pH, total alkalinity, chlorophyll a and salinity. Samples were also collected for dissolved nutrients and dissolved inorganic carbon / total alkalinity (DIC/TA). The dissolved nutrient samples will be measured on board in February 2022 and the DIC/TA samples will be sent to GEOMAR for analysis with an estimated completion date of March 2022. The DIC/TA samples will be sent to GEOMAR for analysis. Due to an oversight during the CTD deployment, the first bottle was closed at 3 650 m instead of 450 m. The 10 m depth sample was then removed to make room for the other sampling depths in the sampling plan.

CTD deployments were performed in conjunction with every plankton sampling station in the Nola Seamount area (Annex I. Appendix 6). Four of these CTD deployments were additionally used to collect water and two extra CTD water samplings were performed on either side of the Nola Seamounts. All water bottle samplings followed the super-station format described in (Figure 1.3). This procedure covered a transect alongareas from southwest and northeast of the seamounts together with samples from the top of and in between the seamounts. Dedicated underway sampling with the 150 kHz ADCP was also performed around each seamount, with the southwest seamount covered near the start of the survey and the northeast seamount covered at the end. All oceanographic measurements performed in the Nola Seamount area followed standard operating procedures described in Section 2.2.

Table 2.2: *Executed water chemistry sampling at the CVOO hydrographic monitoring station. Except for samples taken at 3650 m, 250 m, and 150 m, all depths correspond to the R/V Islândia standard sampling depths.*

Bottle	Depth	Oxygen	DIC TA	Nutrients	Chlorophyll a
1	3650[1]	1	1	1	
2	450	1	2	1	
3	350	2	1	3	

Bottle	Depth	Oxygen	DIC TA	Nutrients	Chlorophyll a
4	250	1	1	1	
5	200	1	1	1	1
6	150	2	1	3	1
7	120	1	1	1	1
8	100	1	1	1	1
9	80	1	1	1	1
10	60	1	1	1	1
11	40	1	1	1	1
12	20	1	2	1	1

[1]Due to an oversight during the CTD deployment, the first bottle was closed at 3650 m instead of 450 m. The 10 m depth sample was then removed to make room for the other sampling depths in the sampling plan.

Plankton

Depth stratified ichthyoplankton sampling was conducted at the CVOO during night (Figure 1.2). Vertical stratified sampling was performed with a Midi Multinet equipped with five 180 µm nets at depths strata of 1 000 – 600 m, 600 – 300 m, 300 – 200 m, 200-100 m, and 100 – 0 m at a speed 0.5 m sec^{-1}. Each sample from each depth stratum was preserved in 4% borax buffered formaldehyde solution and sent to IMar for analyses.

Further stratified sampling was conducted to collect mesozooplankton and ichthyoplankton at selected stations in the area of the Nola Seamounts (Appendix 5 in Annex I) using double oblique tows of a Mammoth Multinet. The first net (N1) had a 180 µm mesh and six additional nets had a 405 µm mesh size (N2-N7). The multinet was deployed with the first net opened at surface to collect mesozooplankton only during the downcast, with a speed of 0.5 m sec^{-1}. During the upcast, the 6 other nets (N2-N7) were opened sequentially at the predefined sampling strata of 200 – 150 m, 150 – 100 m, 100 – 75 m, 75 – 50 m, 50 – 25 m, and 25 – 0 m, with a retrieval speed of 0.5 m sec^{-1}. A total of 17 stations were sampled during day time and 9 stations during night at different dates.

Samples from nets N2-N7 (405 µm) were preserved in absolut ethanol, while the samples from N1 (180 µm) were split with a Motoda splitter in two parts. One half was preserved in 4 % formaldehyde solution and the other half in absolut ethanol.

2.12.2 Sargassum spp. sampling

For *Sargassum* spp. specimens opportunistic samples collected in the trawl and/or manta net were photographed and stored following the protocol in the sailing orders (Annex I).

3 RESULTS

3.1 Meteorology

The spatial distribution shows prevailing northeasterlies over the islands, with speeds ranging between about 0.8 m s^{-1} to 20 m s^{-1}. Three areas of stronger winds were observed:(1) north of 16°N and over Sal and Boa Vista and (2) Santa Luzia to Santo Antão and (3) over the region between Santiago and Brava. Strongest winds occur south of Fogo, north of Santo Antão and east of Sal (Figure 3.1).

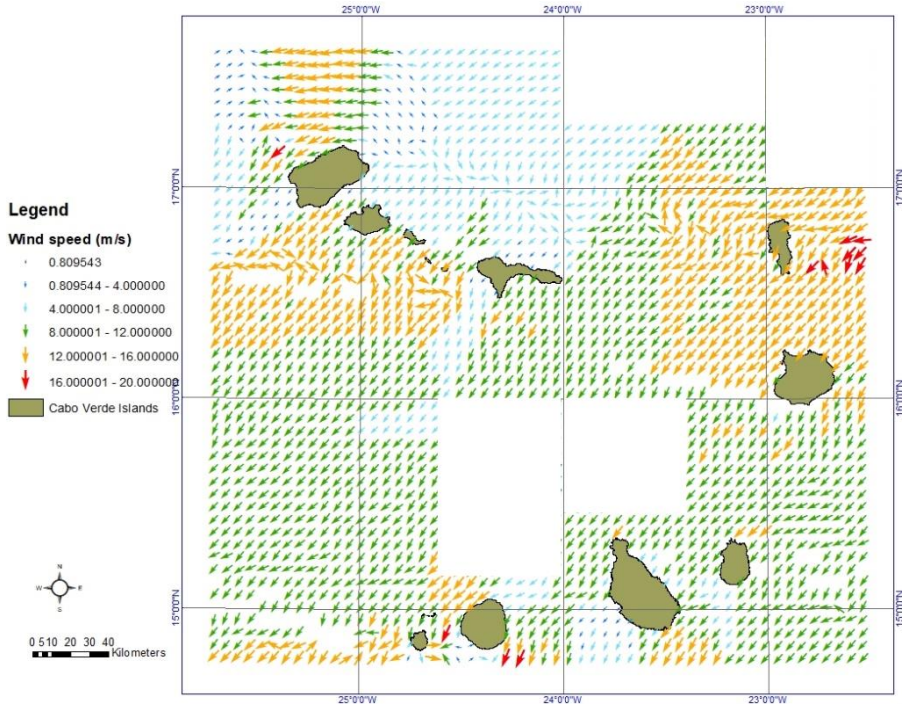


Figure 3.1: 6 km resolution surface winds over the Cabo Verde archipelago from 17 November to 07 December 2021.

Air temperatures primarily ranged between 22-23°C and 27-28°C. The northeastern domain to the south above 15°N including the islands of Sal to Santiago had colder air with temperatures between 22-24°C. The area including the islands of São Nicolau and Santo Antão and below 15°N had temperatures varying between 24-26°C with occurances up to 28°C, particularly south of Santiago and in the northern part between São Nicolau and Santo Antão (Figure 3.2).

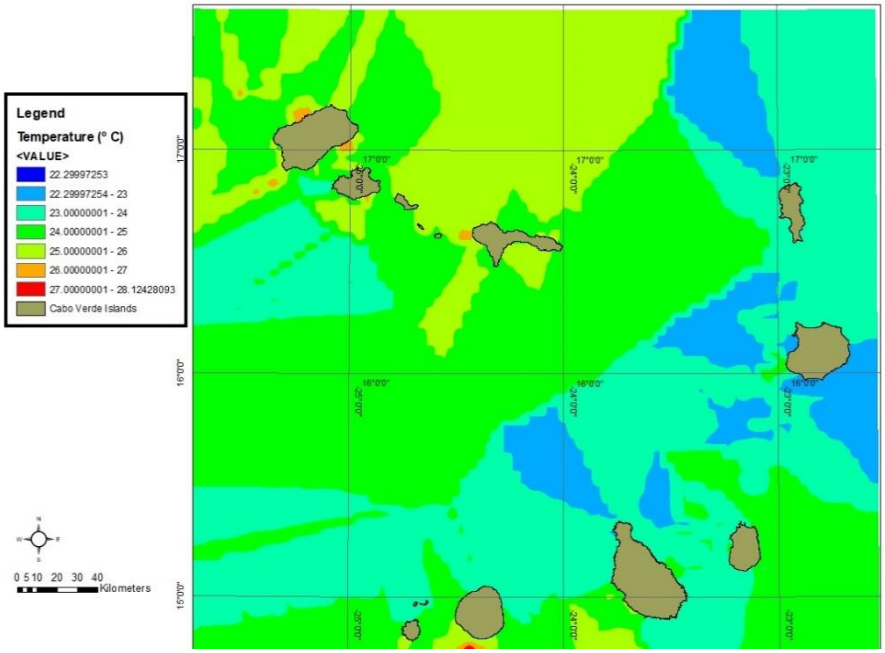


Figure 3.2: 6 km resolution air temperature over the Cabo Verde archipelago from 17 November to 07 December 2021.

3.2 Oceanography

Oceanographic results are presented for ocean currents, sea surface measurements, and CTD deployments around and outside the Cabo Verde archipelago from 22 November 2021 to 09 December 2021.

3.2.1 Underway hydrographic sampling

The 150 kHz ADCP was used throughout the survey to depict ocean current results with a maximum range of 400 m. Because of the malfunctioning salinity and fluorescence sensors on the TSGs, it was decided to use the surface readings from the 101 CTD deployments to depict the sea surface temperature, salinity and fluorescence results (Figure 3.3). Because the CTD was used, sea surface dissolved oxygen results are presented as well.

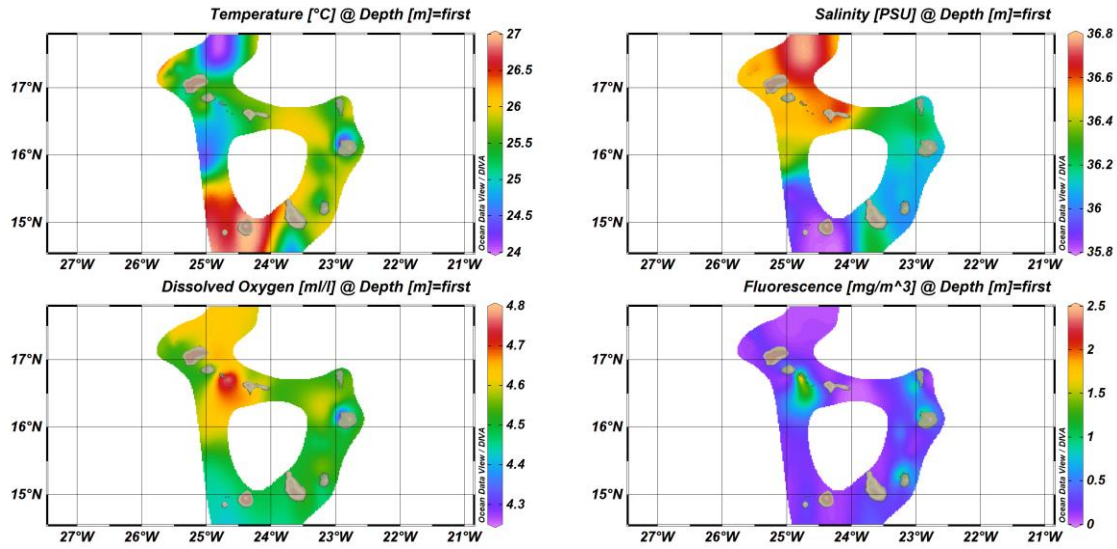


Figure 3.3: Sea surface horizontal distribution of temperature, salinity, dissolved oxygen and fluorescence from the 101 CTD deployments performed during Leg 2 2021.

3.2.1.1 Ocean currents

The Cabo Verde islands are located in the southern vicinity area of the Cabo Verde Frontal Zone delimited by the North Atlantic subtropical gyre and the Atlantic tropical gyre. The area surveyed during the cruise is also a domain of water mass transition mixing the SACW and the NACW which occupy the upper layers of the water column. Over the area, the large-scale surface circulation is modulated by the seasonal variability of the winds and the oscillation of the Intertropical Convergence Zone resulting in seasonality in the flow field with velocities dominated by cyclonic and anticyclonic eddies. Recently, a major current centred at 14ºN with two branches, previously observed, was documented as the Cabo Verde Current (CVC) System (Figure 3.4, Peña-Izquierdo et al., 2015).

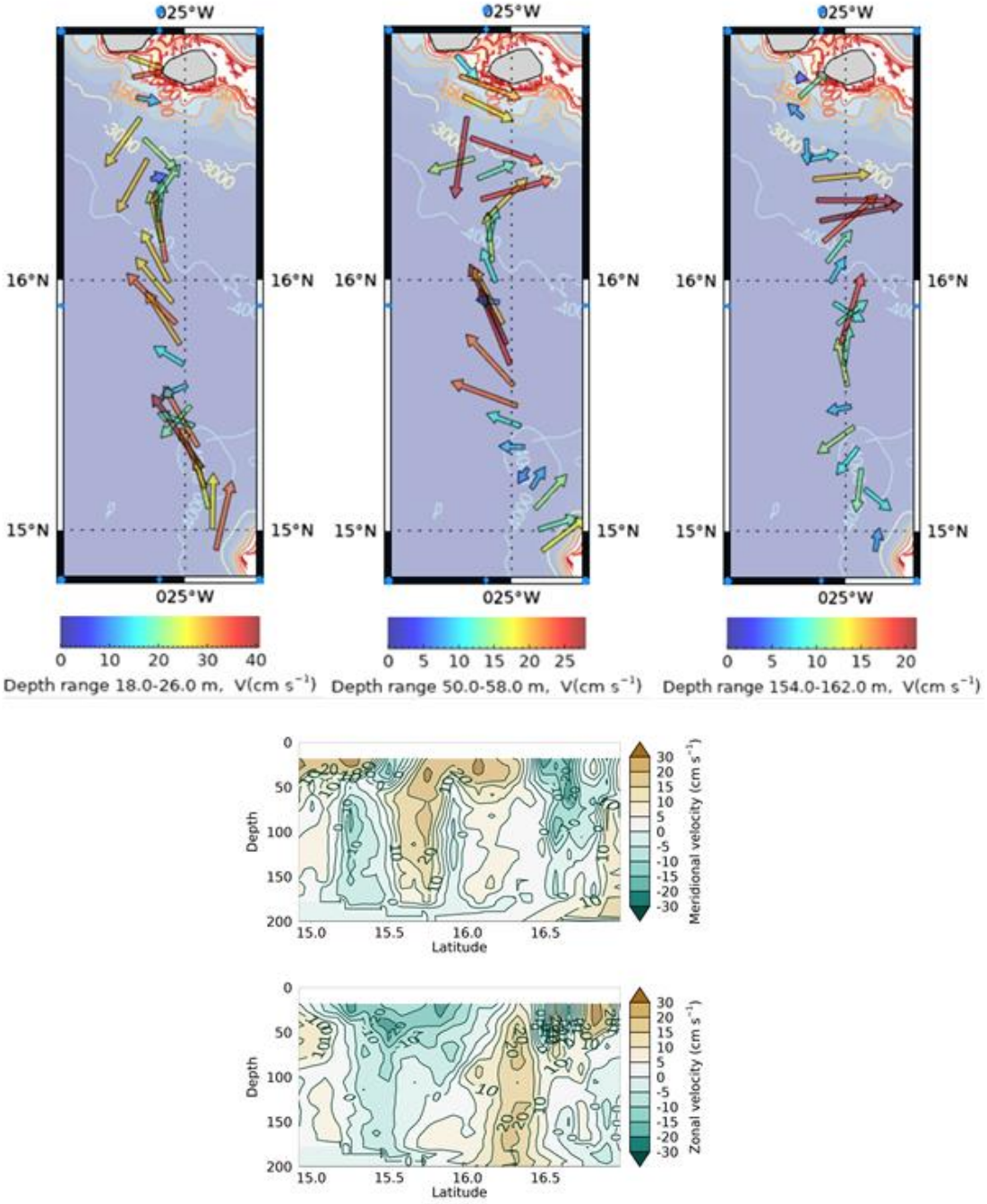


Figure 3.4: Brava to São Vicente ADCP transect averaged at 5 NM.

3.2.1.2 Sea surface temperature, salinity and fluorescence

Temperature varied throughout the archipelago with warmest waters above 26.5°C were observed in the southwestern region surrounding Brava (Figure ocean_02). Colder waters below 25.0°C were depicted between the CVOO monitoring station and the Nola Seamount area in addition to south of São Vicente and north of Sal. The most saline surface waters

(above 36.5 PSU) were depicted in the northern region of the archipelago and in between the CVOO monitoring stations and the Nola Seamount. The strongest dissolved oxygen concentrations, above 4.7 ml l^{-1}, were recorded outside Santa Luzia, which is the same area where the strongest fluorescence signal was recorded which is a marine protected area for Cabo Verde. Sea surface fluorescence signals were relatively higher north of Maio and Boa Vista and southwest of Sal than elsewhere (Figure 3.5).

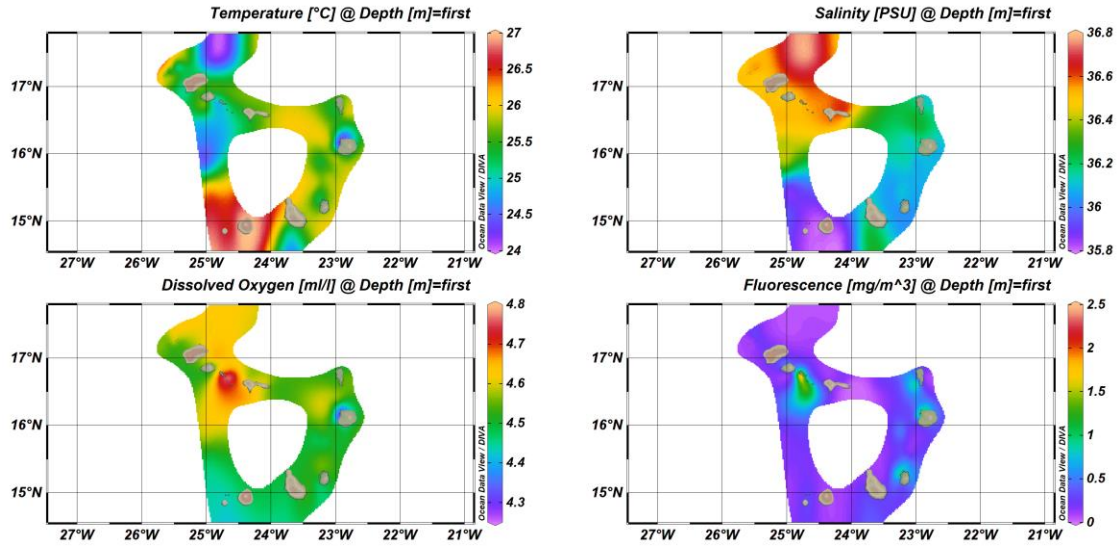


Figure 3.5: Sea surface horizontal distribution of temperature, salinity, dissolved oxygen and fluorescence from the 101 CTD deployments performed during Leg 2 2021.

3.2.1.3 pCO_2

To be included in the final report

3.2.2 Fixed hydrographic sampling

One hundred and one (101) CTD deployments were performed in total at every bottom trawl station, plankton sampling station, and opportunistically at the Nola Seamount and CVOO monitoring station (Figure 1.5). Forty five (45) of those CTD stations collected water samples for nutrients and chlorophyll a. Thirty two (32) of those water sampling CTD stations also collected samples for pH and total alkalinity, some of which were as deep as 1 000 m and ~4 000 m (Figure 1.5).

3.2.2.1 CTD Sensors

Although surface waters cannot be used to identify water masses, they can be used to depict seasonal variability and subsurface mixing as the surface waters of Cabo Verde show potential temperatures between 20-27°C and salinity from 35.58 PSU to 37.08 PSU. Beneath the surface water, however, the Cabo Verde Frontal Zone sitting just north of the Cabo Verde archipelago creates a collision of several water masses in central and intermediate waters (Figure 3.6). Just below the mixed layer down to approximately 500 m, the OMZ dominant South Atlantic Central Water and slightly more saline North Atlantic

Central Water can be found (Pelegrí et al., 2017). At intermediate depths, the colder Antarctic Intermediate Water is found mixing with the slightly more saline Eastern Atlantic Subarctic Intermediate Water (Pelegrí et al., 2017). At the CTD stations deployed beyond 3 000 m between Brava and São Vicente, São Nicolau and Sal, and at the CVOO monitoring station, the relatively warmer North Atlantic Deep Water was found dominating deep waters (Emery, 2019) (Figure 3.6).

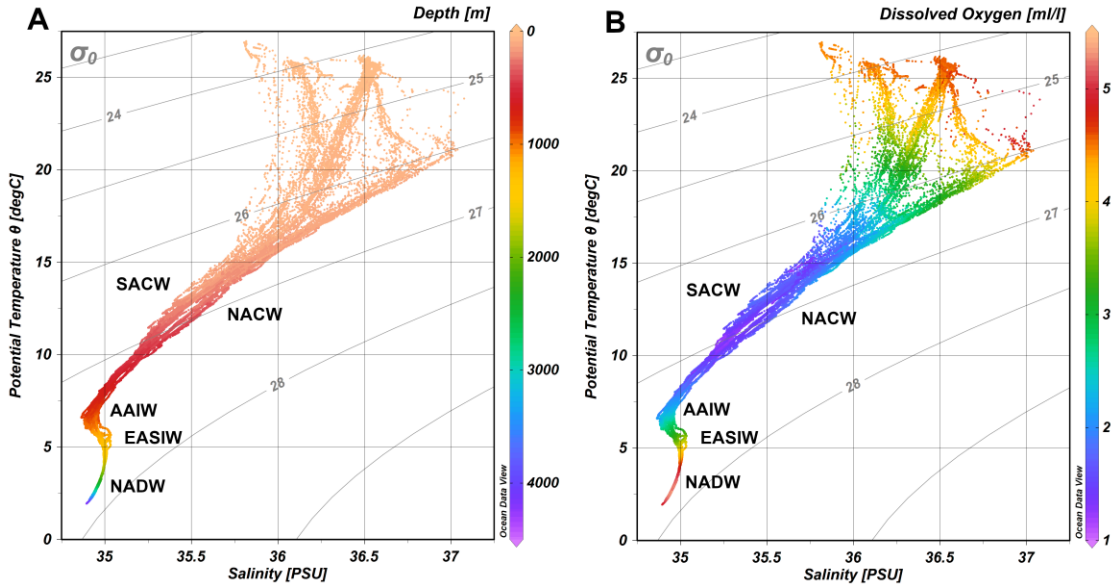


Figure 3.6: TS diagrams with water mass identifications. Figure A has an added depth variable and Figure B has an added dissolved oxygen variable.

Open ocean transect – Brava and São Vicente

To conclude the originally planned sampling, the vessel traversed north from Brava toward São Vicente with CTD deployments ranging from 1 000 to 4 200 m. Figure 3.7 depicts the transect from 1 000 m depth for temperature, salinity, dissolved oxygen and fluorescence. Surface waters were found to be relatively warm, over 25°C, with higher temperatures in the south and a deepening of the thermocline as early as 15.25°N from 50 m in the south to 80 m in the north. Less saline surface water below 36 PSU were observed in the south with a subsurface salinity maximum between 50 to 70 m. The surface waters north of 15.5°N reached over 36.5 PSU and submerged deeper into the water column as far down as 120 m. Dissolved oxygen depicted a similar surface water pattern to temperature as a tightly stratified subsurface oxycline was observed at 50 m in the south with a deepening also beginning at 15.25°N. At depths between 300 and 600 m, the OMZ can be observed most prominently from below 16.25°N, which is less affected by the enclosure of the archipelago. Dissolved oxygen concentrations fell below 1.35 ml l^{-1}, with preliminary data showing a minimum of 1.19 ml l^{-1}. Fluorescence showed maxima between 50 and 70 m until 15.75°N before arising in the water column to ~30 m. Despite a decrease in signal at the deep station 529 before São Vicente, the fluorescence signal was revived at the coast at the shallow station 475 (Figure 3.7).

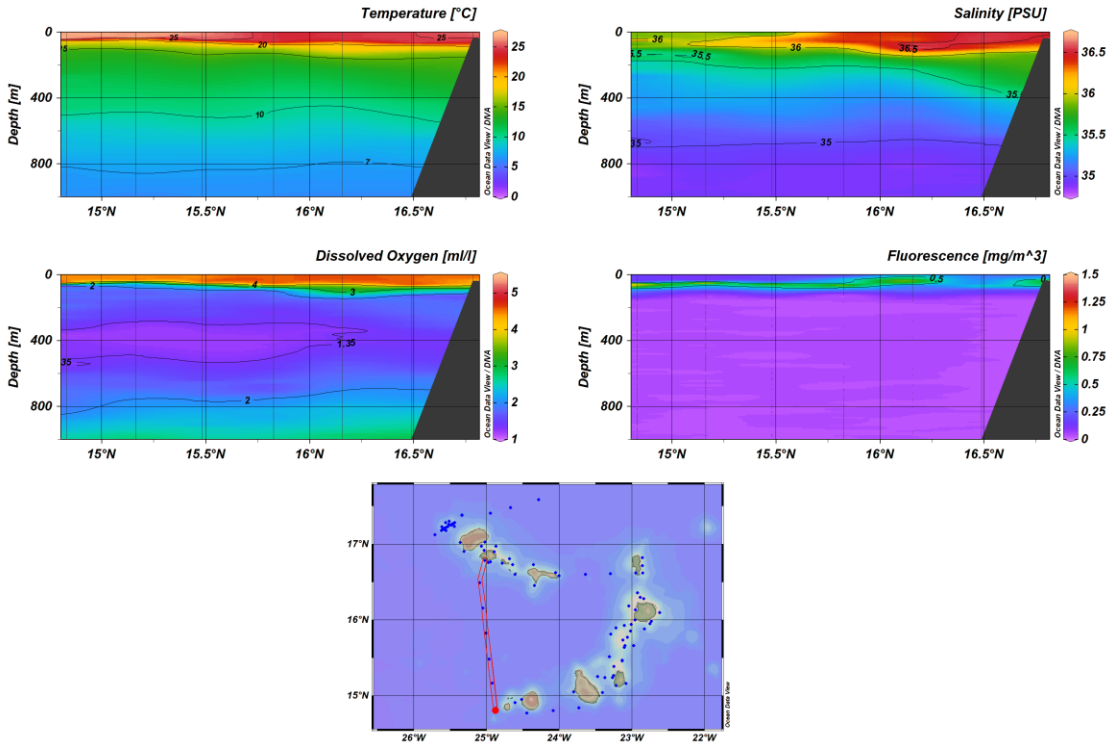


Figure 3.7: CTD transect from Brava toward São Vicente depicting temperature, salinity dissolved oxygen and fluorescence to 1000 m.

3.2.2.2 Water column ocean currents

Not relevant for this survey.

3.3 Plankton

A summary of the number of plankton stations and type of samples collected is presented in 1.2.

3.3.1 Phytoplankton

A total of 5 phytoplankton samples were collected for taxonomic identification. Samples were sent to IMR in (Flødevigen, Norway) to be analyzed.

3.3.2 Zooplankton

A total of 101 aluminum trays for zooplankton dry weight estimation were produced during the survey and transferred to IMR (Bergen, Norwat) for zooplankton biomass estimation. A total of 13 samples (preserved in formaldehyde) belonging to 9 stations were analyzed in the Macro FlowCam. All WP2 samples preserved in formaldehyde (35 in total) have been sent to IMar in Cabo Verde to be analyzed with a ZooSCAN system.

3.3.3 Ichthyoplankton

A total of 70 samples were collected for ichthyoplankton taxonomy, including 64 samples collected with a Bongo net and 6 samples collected with a Multinet Mammoth. A total of 6 samples from the Bongo preserved in ethanol were sorted for fish larvae and eggs and kept in 20 mL scintilliation vials. The number of fish larvae sorted were 181 and 261 fish eggs. All samples have been sent to IMR (Bergen, Norway) for further taxonomic and genetic analyses.

3.3.4 Jellyfish

Not relevant for this survey.

3.4 Fishery resources

A total of 47 valid trawl station were carried out, divided into 27 bottom, 18 pelagic and 2 beam trawls (Table 1.2). In the 17 pelagic trawl stations, 85 marine species were identified, of which 965 individuals were measured (length and weight). In the 27 bottom trawl stations, 331 unique species were identified (including fish, epibenthos, crustaceans, marine litter) and 6746 individuals were measured (length and weigth).

3.4.1 Pelagic resources

The hydroacoustic survey covered the shelf and slope from approximately 20 to 1 000 m bottom depth. The very narrow shelf around Cabo Verde was covered by sailing in zig zag patterned transcets within 14 different strata. No clupeid fish (PEL1) aggregations were observed during the acoustic survey or in any of the trawl catches. The PEL2 group (Carangidae, Scombirdae, Sphyraenidae, Sparidae, etc.) was absent from the southern part of the survey area between Bravo and Santiago. Some minor aggregations were found on the west side of Maio, while the main concentrations in Area 1 were found on the southern side of Boa Vista and around Sal. The largest concentrations of pelagic fish were found in shallow waters (<100 m depth) in Area 2 between São Vicente and Ilheu Raso (Figure 3.8). The concentrations corresponded with increased levels of fluorescence in that area. The most common commercially important pelagic species recorded in the trawl catches were *Seriola fasciata*, and *Caranx crysos* (frequency of occurrence), while the highest catches by weight was given by *Selar crumenophthalmus*. However, catches of pelagic species were generally low (less than 5 tonnes per NM^2) and no clupeids were found.

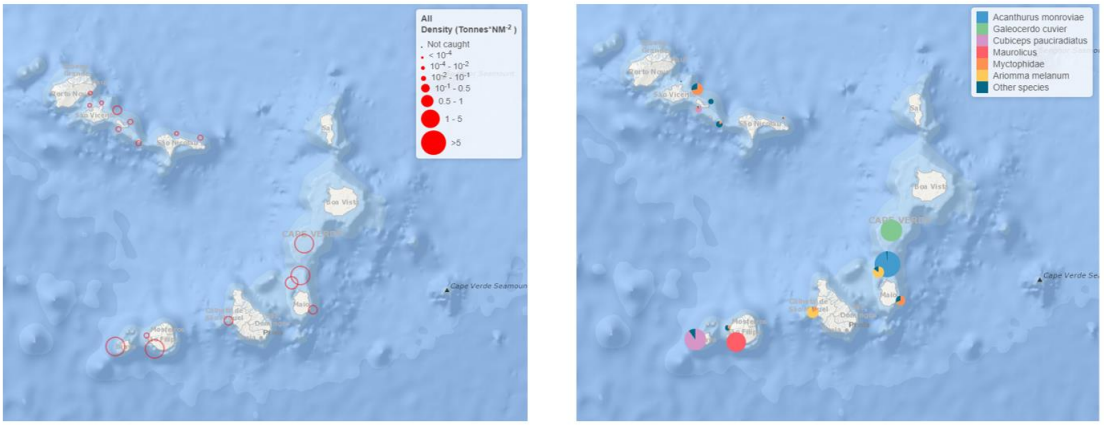


Figure 3.8: Catch rates (density in tonnes per NM2) of the pelagic trawl hauls.

3.4.1.1 Biological characteristics

Length frequencies of pelagic priority species are given in Annex III. The three main species presented here are *Pseudocaranx dentex*, *Selene dorsalis* and *Seriola rivoliana*, with the latter beeing the most numerous and largest species of them. For the two commercially importants species *Seriola fasciata* and *Seriola rivoliana*, the youngest individauls were recorded in northwest, in Area 2, while the older and larger individuals were caught in the eastern part (Figure 3.9). This corresponds to the hypothesis that the main spawning areas for these species is in Area 2 and that the larvae gets transported with the ocean currents to other areas.

Sex as well as stage of maturity was determined for 17 species including mainly sharks, rays and priority species with commercal interest (Annex IV). None of the pelagic species were mature.

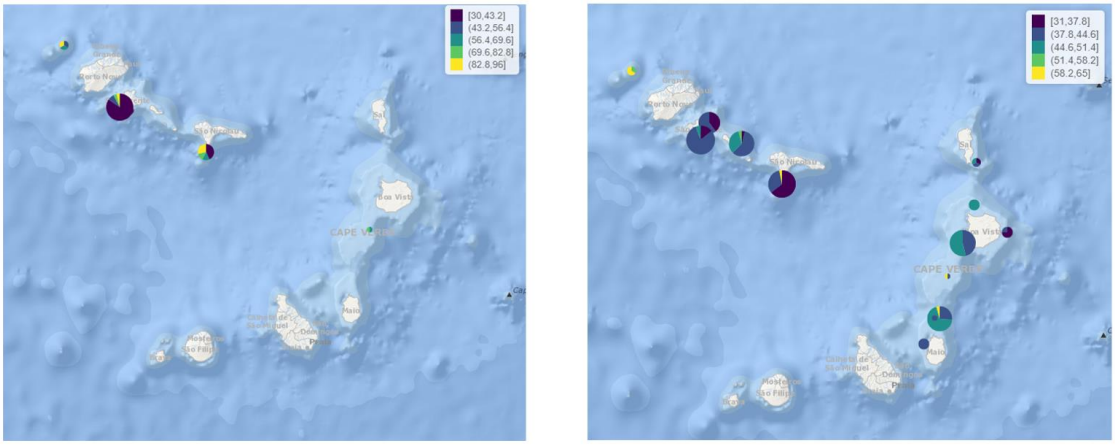


Figure 3.9: Relative abundance of 5 length groups (represented by various colours) of Seriola fasciata (left) and Seriola rivoliana (right). The size of the bubbles represents the species catch rate (in tonnes per NM2) at each station.

3.4.1.2 Distribution and abundance estimates

The abundance of pelagic fish is assessed to 6 430 thousand tonnes, exclusively belonging to the PEL2 group. Of this 4 160 thousand tonnes were found in Area 2. The biomass estimate is based on an average fish length of 23 cm (see section 2.4.1.2). Some of the fish were found in shallow water and smaller concentrations may have been missed inshore of the area surveyed.

The maps of the main acoustic groups of PEL2 (mainly carangids and scombrids), show the distribution as observed with the acoustic integration system Figure 3.10).

In the pelagic trawl hauls, other species such as various mesopelagic species were quite abundant, mainly along the steep slope areas. Especially the species *Ariomma melanurum* was caught frequently and over a large area, in the pelagic trawl catches. Separate biomass estimations were not carried out for this acoustic category. In future surveys, the mesopelagic organisms should be allocated to a specific group and not be included together with plankton and euphausiids, as done in this survey. For the purposes of the current survey, the acoustic category 'OTHER' was also used to assign backscatter of organisms that could not be with certainty categorized as 'PEL2' or 'PLANK' (Table 2.1).

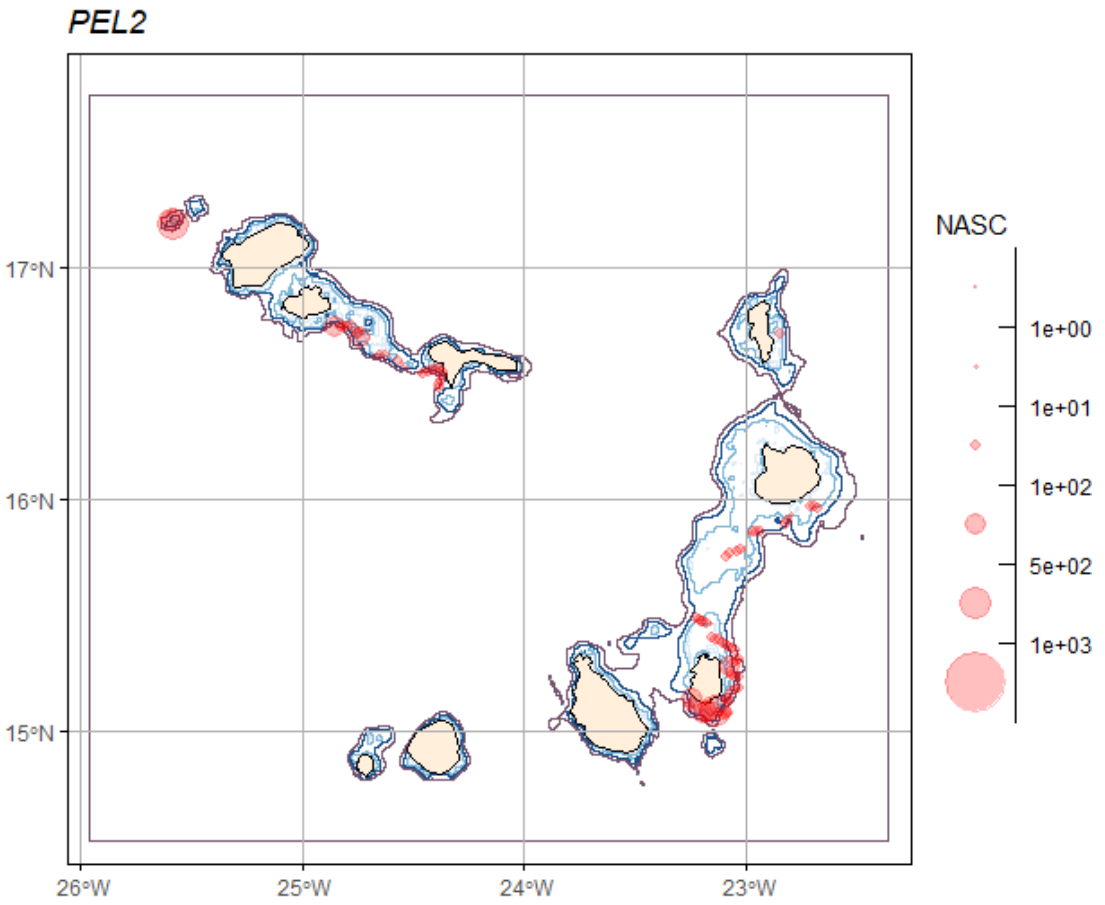
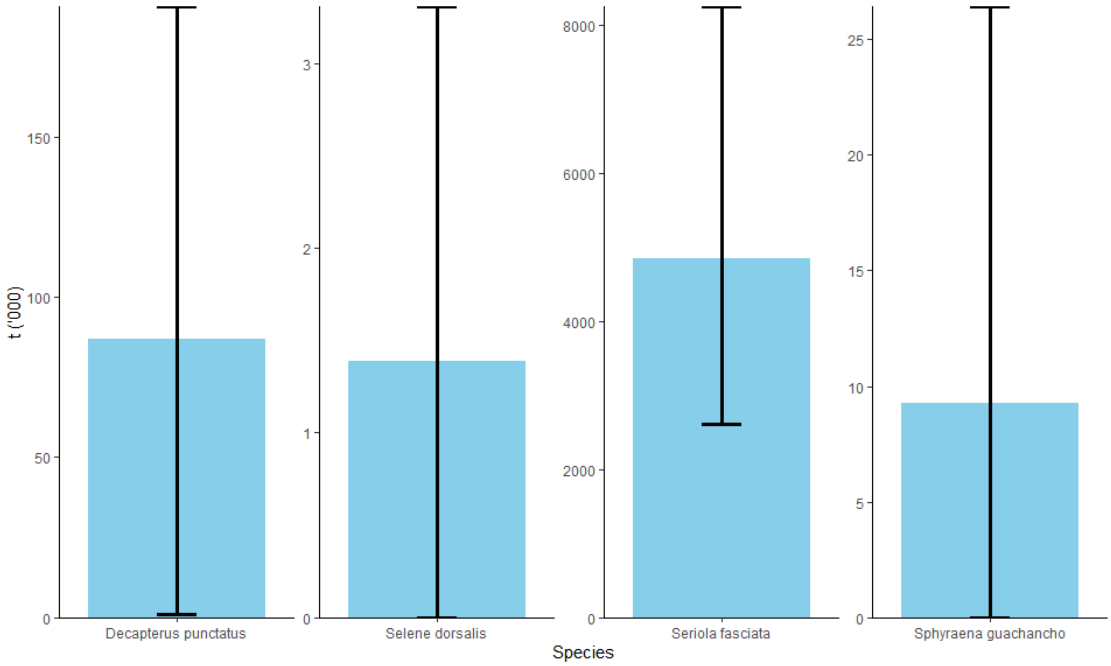


Figure 3.10: Distribution of the PEL2 acoustic category during the survey. 100, 500 and 1000 m isobaths are indicated.



(#fig:stoX_report)Biomass estimates for the main pelagic species, calculated using the StoX software. The error bars represent 5% and 95% confidence intervals

3.4.2 Demersal resources

The topography off the islands of Brava, Fogo and Santiago generally prevents bottom trawling activity. No information on the fish resources around these islands were therefore obtained as part of the trawl survey. As these islands are characterized with a very narrow shelf, the amount of demersal fish is expected to be low compared to the rest of the islands. This assumption is also supported by the acoustic recordings where only minor backscatter stenghts were recorded around the three islands.

Two separate regions were used for the analyses of trawl catch data, namely Area 1 (with a wide shelf area and the João Valente Bank) and Area 2 (where the islands of Santo Antão, São Vicente, Santa Luzia and São Nicolau share a common shelf). Both areas have a relatively shallow shelf, a mixture of hard and sandy substrate on the shelf and a very steep and rough slope to around 3 000 m depth or more. Only “valid” bottom trawls were included in the analyses, and catch rates were calculated for three depth regions; >30 – 50] m, >50 – 100] m and >100 – 500] m. Two trawls at approximately 800 m depth were not included in the catch rate calculations. Total densities from demersal trawls are presented in Figure 3.11.

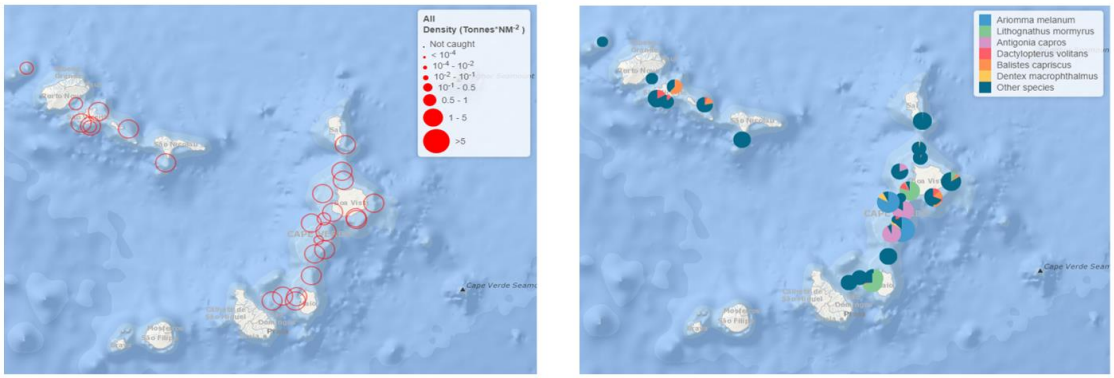


Figure 3.11: Catch rates (density in tonnes per NM2) of the demersal trawl hauls.

3.4.2.1 Biological characteristics

Length frequencies of demersal species are given in Annex III. Most of the species seemed to be relatively young and did not consist of more than one or two yearclasses. The mean length of almost all of the species was around 30 cm. Sex as well as stage of maturity was determined for 17 species including mainly sharks, rays and priority species with commercal interest (Annex IV). Among these, the demersal species *Pseudopeneus prayensis* and *Lithognathus mormyrus*, where the only species were mature and spent individuals could be found.

3.4.2.2 Distribution and catch rates

A total of 21 valid trawl stations were conducted on the shelf between Maio and Sal (Table 3.1). Six (6) of these were between >30 – 50] m, 8 between >50 – 100] m and 5 between >100 – 500] m and 2 between >800 – 1000] m bottom depth. In the northwestern islands, 2 stations were conducted between >30 – 50] m, 3 between >50 – 100] m, 1 between >100 – 500] m. In total 27 bottom trawl stations were conducted.

Around the eastern islands the highest total average catch rate was recorded in the depth intervall between >100 - 500] m, with a value of 341 kg h^{-1}, compared to around 100 kg h^{-1} in the two other depth intervals (Table 3.2). Around the northwestern islands the catch rates were much lower with values around 20 kg h^{-1}, in all the three depth regions (Table 3.2).

Of the total average catch, pelagic species represented 4 % (22.36 kg h^{-1}), 15% (88.911 kg h^{-1}) consisted of demersal species, and 75 % where belonging to the group called “Others” (species not included in any of the other groups, Table 3.2). The species in this group are often considered to be commercially less important. Some of the most abundant species within the group were various mesopelagic species and *Antigonia capros*. In the two deep trawl stations (above 800 m) some big shrimps, especially *Aristaeopsis edwardsiana*, were caught.

The total average catch rate in the depth region between 50<100] m was 298 kg h^{-1} (Table 3.2). Of this commercial demersal species constituted 5.7% (17 kg h^{-1}), pelagic species were caught with an average catch rate of 11 kg h^{-1} (3.8%), sharks with 17 kg h^{-1} (5.7%) and

cephalopods with 0.2 kg h^{-1}. The group of other species was caught with a catch rate of 253 kg h^{-1} representing 84.8% of the overall catch.

The group of commercially important demersal species was subdivided into groupers, seabreams, snappers, and others (Table 3.3). Seabreams were the only group within the depth range >30 - 50] m bottom depth, around the eastern Islands, that indicated some importance in the catches. Average catch rates were 52 kg h^{-1} (44% of the total catch in this depth region). There were very few catches of groupers, snappers and barracudas. In the depth region between >50 - 100] m, in the nortwestern area, some Carangidae were caught, with catch rates of 13.855 kg h^{-1}. In areas with bottom depths of >100 - 500] m the seabream _Dentex macrophthalmus_was caught with a catch rate of 97.8 kg h^{-1}, and from the category "Others" some Zeidae were caught dominated by *Zenopsis conchifer*(catch rate 77.5 kg h^{-1}).

Table 3.1: *Survey effort in number of bottom trawls per depth stratum (>30-50], 50<100] m, >100<500] m and >500-1000m]) by region*

Depth stratum (m)	Cape Verde Islands, east	Cape Verde Islands, northwest	Total
>30-50]	6	2	8
>50-100]	8	3	11
>100-500]	5	1	6
>500-1000]	2		2
Total	21	6	27

Table 3.2: *Catch rates in tonnes per NM^2 (per depth stratum by region) for the main resources groups in the survey area*

Area	depth stratum	Demersal	Pelagic	Cephalopods	Shrimps	Sharks	Rays	Other	Total
Cape Verde Islands, east	30-50m	68.265	2.722	0.094	0.000	2.430	0.717	43.409	117.637
Cape Verde Islands, east	50-100m	0.783	3.698	0.625		11.724	7.116	68.547	92.493
Cape Verde Islands, east	100-500m	16.584	0.059	2.812	0.000	0.342	0.240	321.485	341.522
Cape Verde Islands, northwest	30-50m	0.443	1.981	0.001		1.688	6.609	9.923	20.645
Cape Verde Islands, northwest	50-100m	2.802	13.902	0.350		2.111		6.469	25.634

Area	depth stratum	Demersal	Pelagic	Cephalopods	Shrimps	Sharks	Rays	Other	Total
Cape Verde Islands, northwest	100-500m	0.040		0.285	0.001		0.007	2.622	2.955
Total	-	88.917	22.362	4.167	0.001	18.295	14.689	452.455	600.886

Table 3.3: *Catch rates in tonnes per NM² (per depth stratum by region) for the commercially important demersal resources in the survey area*

Area	depth stratum	Groupers	Seabreams	Snappers	Other	Total
Cape Verde Islands, east	30-50m	0.143	52.061	0.019	65.415	117.638
Cape Verde Islands, east	50-100m	0.548	0.004		91.941	92.493
Cape Verde Islands, east	100-500m		16.572		324.950	341.522
Cape Verde Islands, northwest	30-50m	0.416			20.229	20.645
Cape Verde Islands, northwest	50-100m	0.123	0.050	0.260	25.201	25.634
Cape Verde Islands, northwest	100-500m		0.040		2.915	2.955
Total	-	1.230	68.727	0.279	530.651	600.887

3.4.3 Diversity

From the 23 accepted endemic marine fish species of Cabo Verde, seven were caught during this survey, with_Raja herwigi_ being the most frequent species (7 stations, Table 3.5).

Within the benthos the most abundant group was the Crustacea with 61 species, followed by the Mollusca (22 species), Echinodermata (20 species), Porifera (10 species) and Cnidaria (8 species).

Demersal catches were highly diverse in terms of number of species and, in general, stations deeper than 200 m exhibited highest diversity in the catch with up to 58 different identified fish species and up to 14 different identified benthos species. Overall there were found 194 different identified fish species, with the bony fish being the dominant group, followed by 40 identified benthos species, chondrichthyes with 14 identified species and one turtle.

Pelagic catches were dominated by mesopelagic fish species mainly from the groups Nomeidae, Myctophidae, and Gempylidae. Several Crustacea and Cephalopoda taxa were also found in the catches. In a single pelagic trawl the doctorfish *Acanthurus monroviae* was caught with 480.1 kg.

Table 3.4: *Endemic marine fish species of Cabo Verde, recorded in the surveys with the RV Dr Fridtjof Nansen in 2021 and 2011*

Species	Occurrence	Weight kg	No individuals
	Survey 2011 / Survey 2021	Survey 2011 / Survey 2021	Survey 2011 / Survey 2021
Chromis lubbocki	1 / 1	2.64 / 0.15	41 / 2
Diplodus prayensis	2 / 1	9.38 / 30.75	37 / 126
Diplodus fasciatus	2 / 1	27.18 / 0.75	92 / 1
Parapercis atlantica	2 / 1	0.06 / 0.03	5 / 4
Parapristipoma humile	2 / 2	3.78 / 15.8	14 / 67
Pegusa cadenati	0 / 4	0 / 0.69	0 / 9
Raja herwigi	8 / 7	5.12 / 9.05	14 / 24

3.5 Marine debris

Marine debris was registered at 11 trawl stations, mostly with one piece of litter per station. One station (station 38) had three pieces of litter.

3.6 Bottom habitat mapping

Not relevant for this survey.

3.6.1 Seafloor maps

Not relevant for this survey.

3.6.2 Sediment composition

Not relevant for this survey.

3.6.2.1 Granulometry

Not relevant for this survey.

3.6.2.2 Chemical composition

Not relevant for this survey.

3.6.2.3 Contaminants

Not relevant for this survey.

3.6.3 Benthic fauna

Not relevant for this survey.

3.6.3.1 Epibenthic fauna

Beam trawl and BT- Keiders work- to be updated before the post-survey meeting

3.6.3.2 Benthic infauna

Not relevant for this survey.

3.7 Vulnerable Marine Ecosystems

Not relevant for this survey.

3.8 Top predators

Not relevant for this survey.

3.9 Food safety

Only two of the pelagic species preselected for nutrition and food safety (microplastics and parasites) analysis, namely *Auxis thazard* and *Selar crumenophthalmus*, were caught in the trawls and collected for this purpose. None of these species were caught at more than one station, thus there are no replicates as was requested in the sailing orders. Additionally, three species with high ecosystem importance were oportunistically sampled at one station each. The collected fish species and the station in which they were caught is provided in 3.5.

Table 3.5: *Overview of samples collected for nutrition and food safety analysis (by fish species, station numer and number of individuals preserved)*

Species	Station	No of individuals preserved
Auxis thazard	35	5
Selar crumenophthalmus	24	19
Antigonias capro	26	5
Ariomma melanum	37	15
Maurolicous muelleri	44	150

3.10 Sediment analysis

Not relevant for this survey.

3.11 Additional sampling

3.12.1 Sampling at Cabo Verde Ocean Observatory and the Nola Seamount

3.12 Additional sampling

3.11.1 Sampling at Cabo Verde Ocean Observatory and Nola Seamount

Oceanography

At the CVOO monitoring station, all sampling was performed successfully aside from the first water sample being collected at 3 650 m instead of 450 m. All water sample measurements were performed on board except for dissolved nutrients and DIC/TA. The dissolved nutrient samples will be measured on board in February 2022 and the DIC/TA samples are being sent to GEOMAR for analysis with an estimated completion date of March 2022.

The Nola Seamount region in the northwest area of the survey depicted possible small-scale eddy interactions which gave different water characteristics on each seamount. The southwestern seamount showed a shearing effect that brought a downwelling of warmer more saline waters that were also more oxygenated with a higher fluorescence signal. No downwelling or upwelling was detected in between the seamounts and despite the DOC dropping below 2.0 ml l^{-1}, it was still relatively protected from the ~1 ml l^{-1} OMZ observed east of the northeastern seamount. This northeastern seamount also depicted no indications of downwelling as the southwestern seamount did. (Figures 3.12, 3.13, 3.14).

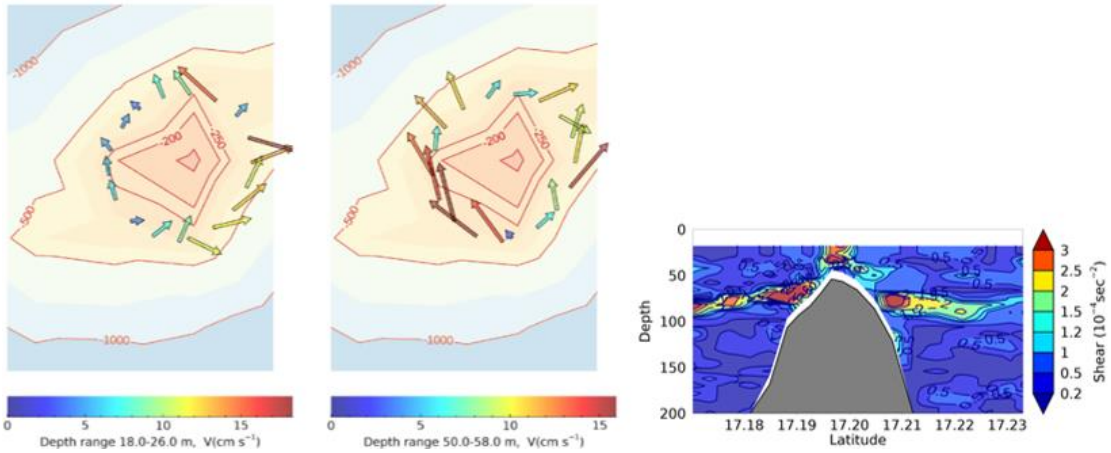


Figure 3.12: Southwestern Nola seamount current depiction at 18-26 m and 50-58 m depths (currents averaged at 0.1 NM) and a cross-sction display of the shearing observed over the southwestern seamount.

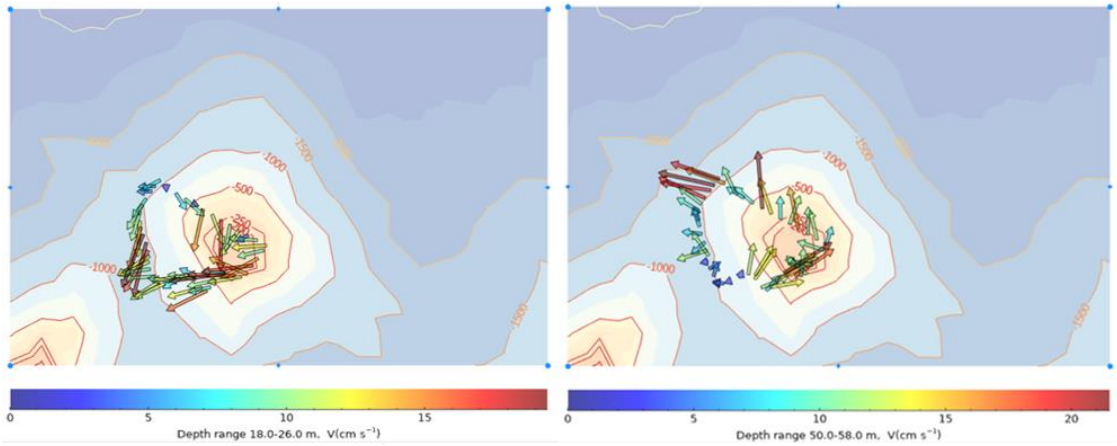


Figure 3.13: Northwestern Nola seamount current depiction at 18-26 m and 50-58 m depths (currents averaged at 0.25 NM).

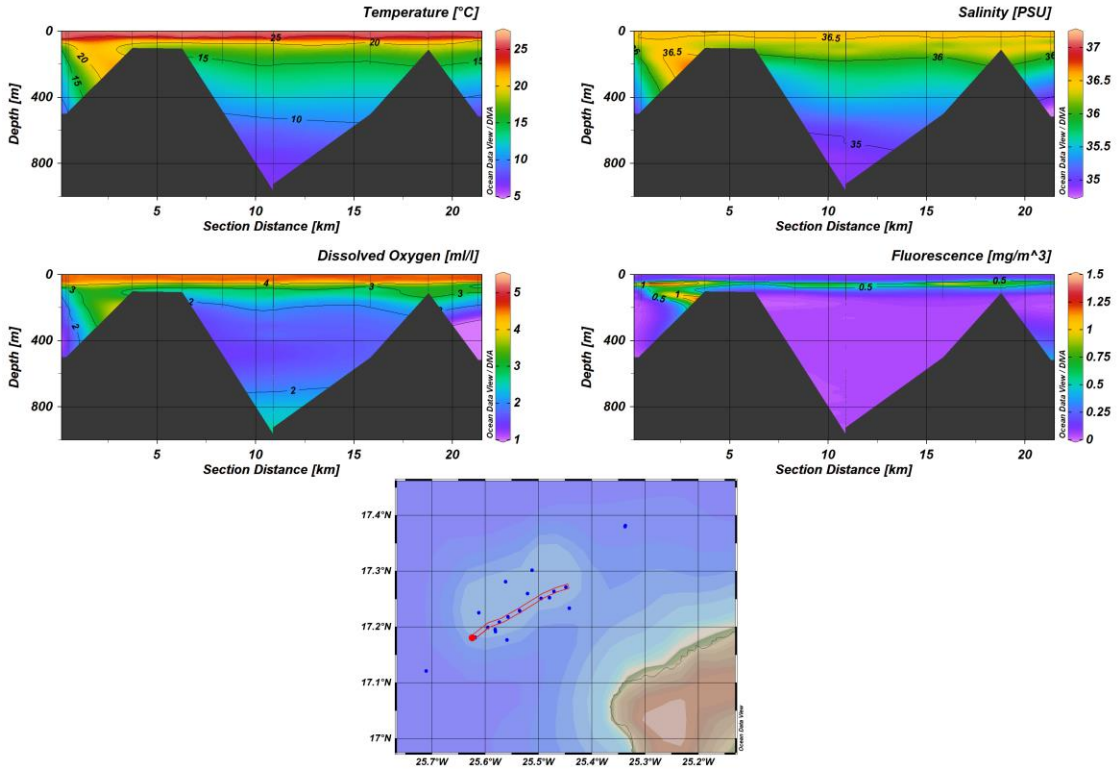


Figure 3.14: CTD transect over the Nola seamount depicting temperature, salinity, dissolved oxygen and fluorescence. The two outer CTD stations were removed from the figure to avoid questionable interpolation.

Plankton

A total of 5 samples were collected with the Multinet Midi (180 µm) at CVOO monitoring.

A total of 161 samples were collected from the 26 stations sampled in Nola Seamount with the Multinet Mammoth.

3.11.2 *Sargassum* spp. sampling

Sargassum spp. was found at three trawl stations and three plankton stations, all in the southern part of the archipelago, around the islands of Fogo and Brava. At each station, an approximate handfull of sargassum was taken aside for close up photography of certain details, and then frozen at -20°C for further analysis on land.

3.12 Capacity building

Capacity building and hands-on training in scientific sampling and reporting were carried out in the fields of survey planning, in procedures and standardised survey methodology, in species identification, usage of state-of-the art scientific equipment, as well as in execution and reporting from the survey. In addition, assistance to the national scientists participation were given during the survey, in the compilation of the data, and in conducting preliminary analyses. Several scientific meetings were arranged during the survey and an overview of these can be found in Annex V.

3.13 Data recorded and collected samples

In line with the Nansen Data Policy the Cruise Leader has ensured that each national institution on-board the vessel have received a copy of the draft report and the basic data pertaining to the particular survey and for their national waters, before leaving the vessel.

The cruise participants have signed the Data policy and agreed to collaborate with scientist from other partner countries and through the EAF-Nansen Science Plan.

An overview of samples collected, people responsible for analysis and status of analysis by the time of the post-survey meeting, can be found in Annex VI.

Persons responsible for samples collected have reported on the status for the analysis at the post-survey meeting. A copy of the analysis/results has to be sent to IMR (Nansen_data@hi.no). The reason for this is to ensure that IMR, as a data custodian, have an overview of the samples for various purposes as;

Data custodian purposes

For use in capacity building and workshops

Collaboration and publication through the EAF-Nansen Science Plan

As reference libraries and DNA barcoding

For more efficient planning of future surveys in the same area

IMR has a responsibility to develop and maintain a functioning and updated system for the storage, management and retrieval of all the data collected during the surveys, or produced from activities performed during the surveys, and make available any part of these data and scientific information as and when required. All requests for data should be sent to FAO (https://www.fao.org/in-action/eaf-nansen/data-access-requests/en/).

Data collected and overview of procedures for data hand-over to partners can be found in Annex VII.

4 CONCLUDING REMARKS

Leg 2 had multiple objectives, of which all were successfully achieved, with all stations conducted, and samples collected according to the sailing orders. The weather was calm the first couple of days, then we had some days with strong winds. This caused some problems with the sampling of the manta trawl and we also had to skip one demersal trawl station close to land. Some additional sampling was conducted; one extra superstation just outside the newly established tuna-farm south of São Vicente, two extra super stations south-west of Santo Antão, considered to be a spawning area, and some extra deep CTD stations in the south western environmental transect. Three extra bottom trawl stations increase benthos samples. 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, to IEO in Spain and to IMR in Bergen, Norway. These samples will be analysed and reported on later.

The acoustic recordings were low for the whole area coveraged, and as in 2011, no clupeids were found (Figure 4.1, Figure 4.2). In only one occasion the trawl was deployed based on strong acoustic signals. This turned out to be a very dense aggregation of mesopelagic fish. However, the abundance of pelagic fish is assessed to be 6 430 thousand tonnes, exclusively belonging to the PEL2 group. This is more than double the roughly 3 000 tons found during the 2011 survey (Figure distrPel2_2011). The geographical distribution of Pel 2 did vary slightly between the two surveys, mainly occuring south of the islands in the north (Area 2), while the opposite occurred in 2011. The recordings of pel 2 fish south of Boa Vista occurred in both of the surveys.

The presence of the various species did vary within the survey area. The main pelagic species found in 1981 were *Decapterus macarellus*, *D. punctatus* (currently *Caranx punctatus*)and *D. rhonchus* (currently *Caranx rhonchus*). During the survey in 2011, all three species were found but none of them were among the most commonly caught pelagic species during this survey.

The weight of the demersal trawl catches was higher than in 2011, and the composition of the catches was quite different, with less commercially important species and less macroinvertebrates like shrimps, scallops and molluscs (Figures 4.3, 4.4). Only three of the 8 demersal species monitored by IMar were caught in our catches, of which one of these species were represented by only a couple of juveniles.

Only in 5 stations of the 26 where the Manta net was deployed microplastic-like items were found indicating low concentrations of microplastics in the surroundings of Cabo Verde.

Marine debris was registered at 11 trawl stations, mostly with one piece of litter per station. One station (station 38) had three pieces of litter. Reference photos of the individual items were taken at three of the stations. Marine debris, remains from fishing tools and other human activities were found in trawl catches as deep as 150 m.

Only two of the pelagic species preselected for nutrition and food safety (microplastics and parasites) analysis, namely *Auxis thazard* and *Selar crumenophthalmus*, were caught in the trawls and collected for this purpose. None of these species were caught at more than one station, thus there are no replicates as was requested in the sailing orders (Annex I). Additionally, three species with high ecosystem importance were opportunistically sampled at one station each.

High biodiversity of fish was recorded in some of the catches. In the two trawl hauls at >800 m bottom depth, each of them contained more than 80 different species. Most of the species were identified, others were preserved in ethanol and were sent to experts on land for verification, further investigation and archived for potential new studies. In total, more than 400 species were identified during the survey and more than 7700 individuals have been measured and weighted.

The topography (on land and underwater) is complex, with a narrow and steep shelf, from 30 m to 2 000 m within a short distance. Some of the islands are flat (age and erosion) while others are mountain-like with heights of >2 000 m. Previous studies from this area, indicate complex current patterns with frequently occurring mesoscale eddies, a high mixing rate of water masses, areas with high turbidity and other areas with stratified conditions. Cabo Verde is an area with coastal upwelling, high biodiversity and being influenced by the eastern Atlantic large-scale oxygen minimum zone. Two monitoring stations have frequently been sampled since 2006. An existent particle distribution model for Cabo Verde can be further developed by means of the collected data from this survey. The model can be used to improve the understanding on dispersal patterns of fish eggs and larvae between the islands. So far, this model lacks currently depth stratified data and information about spawning areas and spawning times for both fish and plankton.

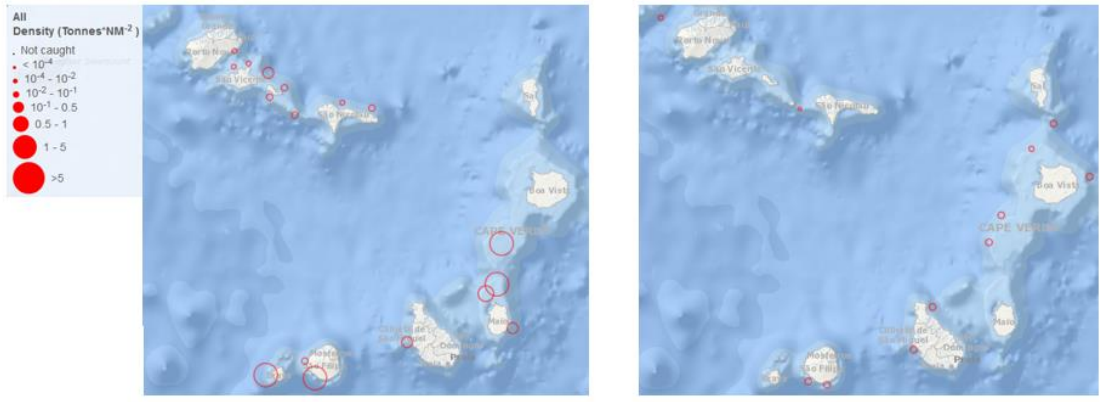


Figure 4.1: Comparison of catch rates (density in tonnes per NM2) of the pelagic trawl hauls in 2021 (left) and 2011(right).

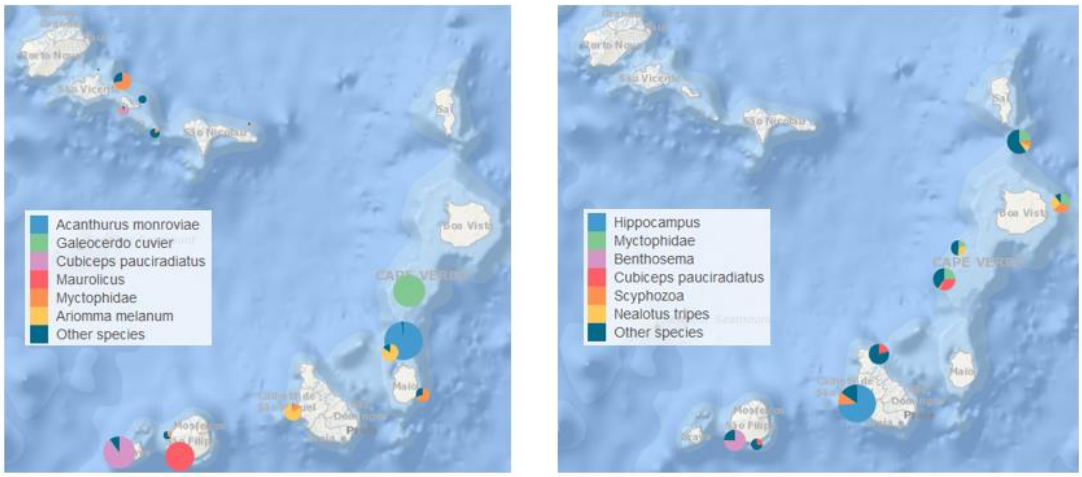


Figure 4.2: Relative species composition of the 7 most abundant species caught in the pelagic trawl in 2021 (left) and in 2011 (right). The size of the bubbles represents the total catch rates (in tonnes per NM2)

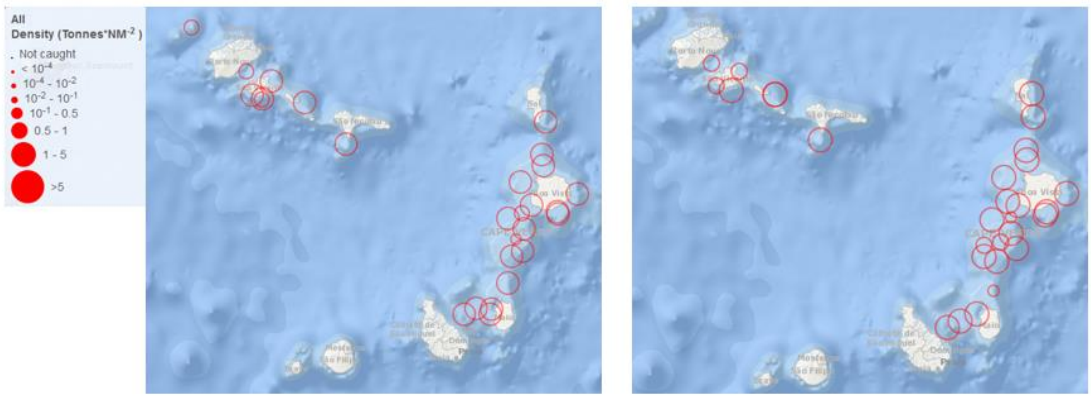


Figure 4.3: Comparison of catch rates (density in tonnes per NM2) of the demersal trawl hauls in 2021 (left) and 2011(right).

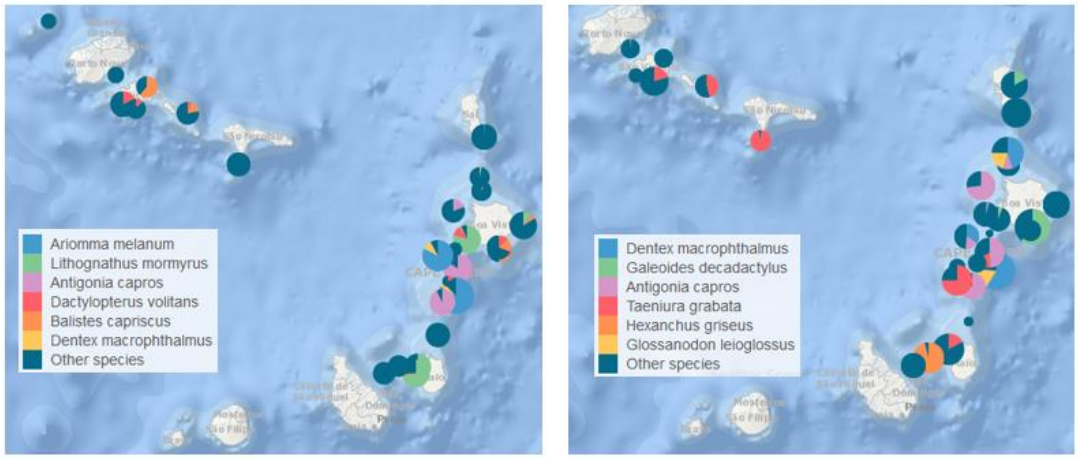


Figure 4.4: Relative species composition of the 7 most abundant species caught in the demersal trawl in 2021 (left) and in 2011 (right). The size of the bubbles represents the total catch rates (in tonnes per NM2)

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ANNEXES

6 ANNEX I SAILING ORDERS

RV Dr Fridtjof Nansen

LEG 2 ECOSYSTEM SURVEY IN CABO VERDE

6.1 ANNUAL SURVEY PLAN

The survey plan for 2021 had to be substantially reduced because of the COVID-19 pandemic and only two surveys will be conducted by the *RV Dr Fridtjof Nansen*. The survey programme for 2021 will include a dedicated bottom habitat habitat /environmental monitoring survey outside Mauritania and Senegal and an ecosystem survey of Cabo Verde.

The survey in Cabo Verde will cover shallow (about 20 m depth) to the upper waters slope (about 1000 m depth). The survey will start and end in Las Palmas, Spain (Table 6.1).

Table 6.1: *Dates, port calls and duration of the survey in Cabo Verde.*

Survey Name	Duration in days	Departure	Arrival	Port of Departure	Port of Arrival
LEG 2 ECOSYSTEM SURVEY IN CABO VERDE	27	19/11/2021	15/12/2021	Las Palmas	Las Palmas

6.2 SURVEY PLAN FOR LEG 2 ECOSYSTEM SURVEY IN CABO VERDE

6.2.1 Survey objectives

The overall objectives of the surveys, as indicated in a message by the Minister of Maritime Economy Paulo Lima Veiga to the Coordinator of the EAF-Nansen Programme Merete Tandstad, dated 31 July 2020 are to obtain an assessment of the demersal and pelagic resources of the continental shelf and upper slope while determining the distribution and abundance of demersal and pelagic species and communities, and collecting biological samples as specified below. Sampling will also be carried out to determine oceanographic conditions (physical, chemical and biological), as well as sampling for microplastics, recording the occurrence of marine debris and mapping of nutrients and contaminants in commercial fish, regarding food safety.

Based on the above, the following is proposed (in a prioritized order):

- A combined demersal and pelagic survey for biomass estimation of resources.
- Standard biological sampling of priority species (including length, weight, sex and maturity)
- Fish samples for nutrients, contaminants, and presence of microplastics in the most common species.
- Standard sampling of environmental variables with CTD and water sampling (salinity, temperature, dissolved oxygen, fluorescence, dissolved nutrients, pH, total alkalinity, chlorophyll a).
- Measuring currents with an ADCP
- Sampling of phytoplankton, zooplankton and ichthyoplankton.
- Sampling with manta trawl for the presence of microplastics in surface waters.
- Underway pCO_2 measurements in surface water.
- CVOO Mooring station hydrographic and plankton sampling.

The objectives were further discussed in connection with a meeting held on 29th June between IMAR, FAO and IMR. This document (sailing order) was also discussed in connection with two pre-survey meetings, held on 25th August and 14th September.

6.2.2 Survey area

The area to be surveyed by the RV *Dr Fridtjof Nansen* in 2021 includes the continental shelf and upper slope of Cabo Verde, from 20 to 1000 m (Figure 6.1).

Standard sampling will be carried out as during most surveys conducted by RV *Dr Fridtjof Nansen* (e.g., oceanographic conditions, including oceans pH and carbonate system, primary productivity, food safety, microplastics, marine debris, biodiversity, pelagic and demersal fish resources). Sampling protocols are standardized to the extent possible to allow comparability across larger geographic scales.

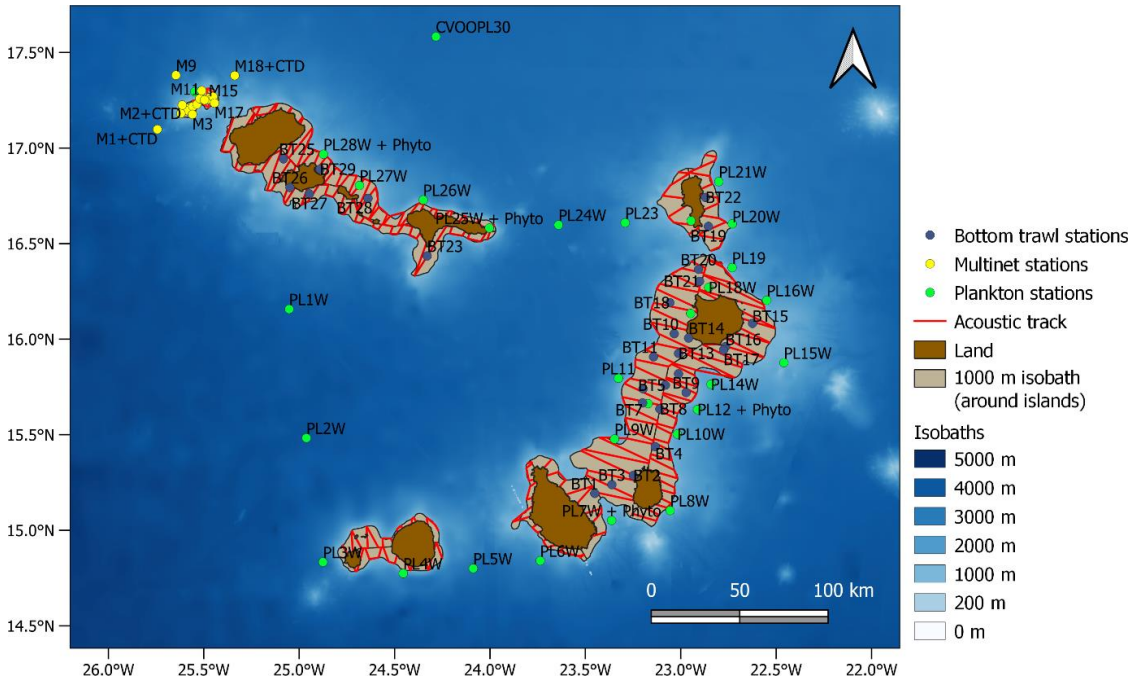

Figure 6.1: Survey area with indication of environmental stations and potential positions for demersal trawling. CVOOPL30 = mooring station, 6 plankton stations include additional phytoplankton sampling (+ Phyto), 5 multinet stations include additional CTD sampling (+ CTD).

6.2.3 Proposed participation in different legs and experience required

Typically, the surveys with the RV *Dr Fridtjof Nansen* include participants from different countries and institutions. With regard to qualifications needed, a mix of experienced scientists/technicians and less experienced ones, will receive on-the-job training in sampling procedures. An overview of the main types of expertise and number of participants required for Leg 2 is provided in Table 6.2 and the list of planned survey participants is shown in Appendix 1.

Table 6.2: *Main types of expertise required and number of participants (scientific team only)*

Leg	Position laboratory	DFN core team	Cabo Verde	External experts
Leg 2	Cruise leader	1		
Leg 2	Co-cruise leader	1	1	
Leg 2	Water chemistry	1	3	
Leg 2	Physical oceanography			1
Leg 2	Plankton biology	1	4	
Leg 2	Fisheries biology / taxonomy	2	8	1
Leg 2	Benthos			
Leg 2	Nutrition and fish safety			
Leg 2	Whale / Seabird observatory			
Leg 2	Local authority			

6.3 SCIENTIFIC RATIONALE

The overall framework and rationale for the surveys carried out by the RV *Dr Fridtjof Nansen* are provided by the EAF-Nansen Programme Science Plan which covers three main pillars (Figure 6.2). Within this framework, the scope and objectives of the surveys in 2021 have been identified with partners, based on national and regional priorities. In addition, data recorded, and samples collected during the survey will be analysed through collaborations initiated through the various Science Plan Themes. An overview of the equipment that is going to be used, data expected to be recorded and samples planned to be collected can be found in Appendix 2a, Appendix 2b, and Appendix 3, respectively.

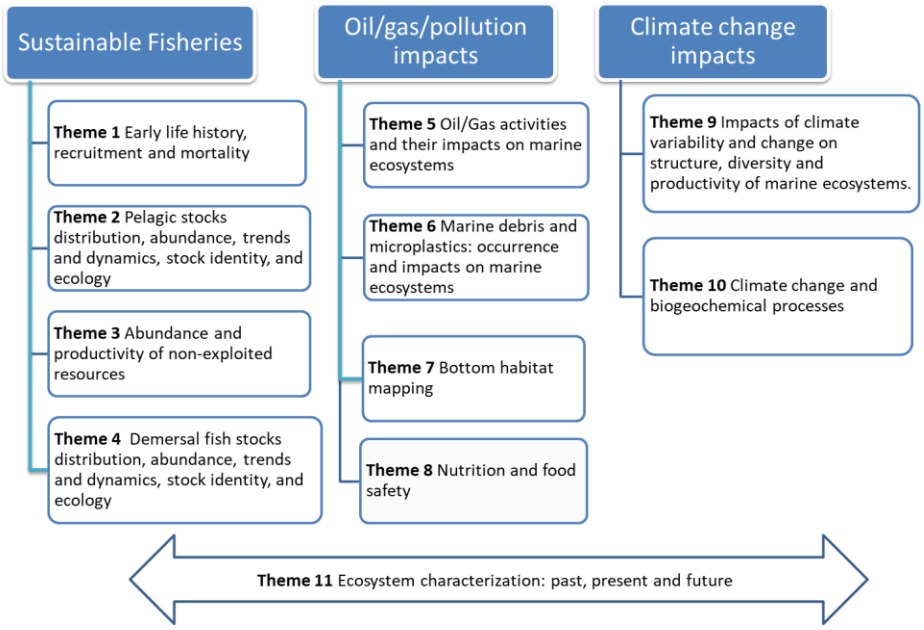

Figure 6.2: Main pillars and research themes of the EAF-Nansen Programme.

6.3.1 Specific objectives and scientific questions for the survey

The specific objectives of the survey are listed below; the emphasis will be based on local needs and scientific importance.

- Hydrography:
  - To map the hydrographic and environmental conditions in the survey area (temperature, salinity, dissolved oxygen, chlorophyll-a, nutrients, pH, total alkalinity and ocean currents).
  - To obtain information on dissolved oxygen concentrations, ocean acidification and the calcium carbonate saturation state relevant for calcifying organisms
  - To capture OMZ and identify vulnerable or high-risk areas
- Primary productivity, zooplankton, ichthyoplankton and microplastics:
  - To describe the abundance and biomass patterns of phytoplankton of the region, as potential food for zooplankton and pelagic fish species.
  - To describe the abundance and biomass patterns of meso-zooplankton community, as well as its species composition.
  - To provide information on the abundance patterns of ichthyoplankton community (fish eggs and larvae), at the lowest possible taxonomic level to identify possible spawning areas for commercial valuable fish species.
  - Map the occurrence of microplastics.
  - Collect samples relevant to the occurrence of phytoplankton relevant to HAB.
  - Carry out combined CTD and plankton sampling at selected stations at the Nola Seamount.
- Demersal resources:

  - Catch rates, distribution and biological parameters (length, weight, sex, maturity staging) of priority demersal resources by means of demersal trawling.
  - Length-weight relationships for all other species not defined above as priority demersal resources.
- Pelagic resources:
  - Distribution, abundance and biological parameters (length, weight, sex, maturity staging) of priority pelagic resources using hydro acoustics and trawling for target identification and biological sampling to provide survey-based biomass indices.
  - Length-weight relationships for all other species not defined above as priority pelagic resources.
  - To collect samples for genetic analysis of selected pelagic species.
- Other trawl-related sampling:
  - Distribution, abundance and biological parameters (length, weight, sex, and maturity staging for males) of priority cartilaginous fish. Vulnerable or red listed species will be released and in those cases maturity staging will only be done by visual inspection of male genitals.
  - Collection of samples for taxonomic courses in the framework of the EAF-Nansen Programme
  - Record the occurrence of seaweed (Sargassum spp.) in fish trawls and the Manta trawl and collect samples for genetic studies
  - Collect samples for levels of nutrients and contaminants in selected commercially important pelagic fish species.
  - Record the occurrence of marine debris collected during demersal trawling by using the draft protocol and take photos for future inclusion in the protocol itself.
  - To identify epibenthos occurring in the bottom trawl
  - Collection of samples for taxonomic identification in the framework of the EAF-Nansen Programme
- Other activities:
  - Hands-on training in the various laboratories
  - Communication through social media

6.4 SAMPLING METHODS

In Leg 2 the area will be surveyed for pelagic fish abundance estimation using the acoustic method, and for demersal species catch rates using bottom trawling. Specific environmental transects will be carried out during the survey. In addition, a CTD station will be carried out at each bottom trawl station.

The design for the pelagic fish abundance estimation will consist of transects extending from about 20 to 1000 m bottom depth (with acoustic recordings from below the echosounder blind zone to a maximum depth of 600 m). To attempt comparison with the

survey in 2011, two main areas have been defined, one comprising the islands in the islands in the eastern part (Area 1= São Tiago, Maio, Boa Vista, Fogo) and the islands of the north-western part (Area 2= Santo Antão, São Vicente, Santa Luzia and São Nicolau) and of the Cabo Verde islands complex. Since a standard zig-zag patterns around an island will give areas close to the coast a higher probability for being sampled than areas longer from the coast, each of the main strata around the island have been split in two (along the horizontal axis), creating 10 new strata (strata 0-9, see Figure 6.1). The abundance of pelagic fish in each of these strata will be summed up to represent one value for Area 1 and one for Area 2. The distance between the acoustic transects has been set using the surveyPLanner (https://rdrr.io/github/Sea2Data/Rstox/man/surveyPlanner.html) of the RstoX package. Here the acoustic transects are created based on the time available, the speed of the vessel and the optimal degree of coverage aimed for. This is an application linked to Stox, which also will be used for calculation of the abundance indices (https://www.hi.no/hi/forskning/prosjekter/stox). Acoustic targets will be identified by pelagic and bottom trawling and acoustic densities will be allocated to main species groups according to the list given in Appendix 4. Bottom trawl stations for the estimation of catch rates of demersal resources will be placed at approximately the same positions as during the survey in 2011, to ensure comparability between the two surveys. The possibility to carry out additional bottom trawl stations will be explored depending on time availability.

CTD deployments with rosette water column sampling will be performed at each demersal trawl station in addition to the environmental stations. Additional environmental station sampling will also take place at the Cabo Verde monitoring station CVOO (see more details below).

Detailed sampling protocols for what is considered as standard sampling on DFN can be found in the Nansen manual site.

Other sampling protocols, area specific information and detailed description of the sampling conducted, will be given below, with reference to the relevant Appendices (5 - 13).

6.4.1 Meteorological and hydrographic sampling in surface water

6.4.1.1 Weather Station

Wind direction, wind speed, air pressure, relative humidity, air temperature and solar radiation data are averaged every 60 seconds and logged continuously from the Aanderaa Automatic Weather Station 2700.

6.4.1.2 Thermosalinograph

A SBE 21 SeaCAT Thermosalinograph (TSG) runs continuously during the survey, obtaining samples at 4 m depth to measure seawater salinity and temperature every 10 seconds. The 4 m engine cooling water intake is also equipped with a Turner Designs C3 Submersible Fluorometer with added turbidity detection capability.

6.4.1.3 Underway pCO_2

Water from the vessel's 4 m intake is pumped through the flow head of a CONTROS HydroC® CO_2 FT sensor for pCO_2 measurements determined via IR absorption spectrometry.

6.4.1.4 Current speed and direction measurements - ADCP

Ocean current data is collected with a vessel-mounted Teledyne RDI Ocean Surveyor Acoustic Doppler Profiler operating at 150 kHz with a depth range of 400 m. The ADCP runs in narrow band mode and averages data in 8 m vertical bins. Heading, pitch, roll and positional data are acquired by a Kongsberg Marine SEAPATH unit. Teledyne's VmDAS software is used to collect the raw current data, whereas the data is processed using software created at IMR.

6.4.2 Hydrographic sampling in the water column

6.4.2.1 CTD

A Sea-Bird 911plus CTD with the following sensors is mounted to a 12-bottle rosette water sampler for use at every hydrographic station. All sensor data logging and real-time profiling is performed using Sea-Bird's Seasave software.

- 2 x SBE 3Plus Temperature ('T') sensors
- 2 x SBE 4C Conductivity sensors for salinity ('S')
- Digiquartz Pressure ('P') sensor
- SBE 43 dissolved oxygen ('DO') sensor
- WET Labs ECO-AFL Fluorometer ('F')
- Satlantic Photosynthetically Active Radiation ('PAR') LOG ICSW sensor

CTD deployments will be carried out at every trawl station as well as at every station where environmental sampling is conducted ('super-station', see below), in accordance with IMRs Standard depth designations shown in Figure 6.3. Additional sampling devices will be deployed for collection of plankton (including ichthyoplankton) and microplastics. Additional CTD deployments will be carried out at each multinet station at Nola Bank (to 200 m) and 6 additional deep stations at Nola Bank. The water samples from the rosette bottles will be used for measurements of pH, total alkalinity, dissolved nutrients (nitrite, nitrate, silicate and phosphate), dissolved oxygen, chlorophyll-a and salinity. Detailed sampling protocols for these parameters can be found in the Nansen manual site (http://nansen-surveys.imr.no/doku.php?id=ctd_lab_information).

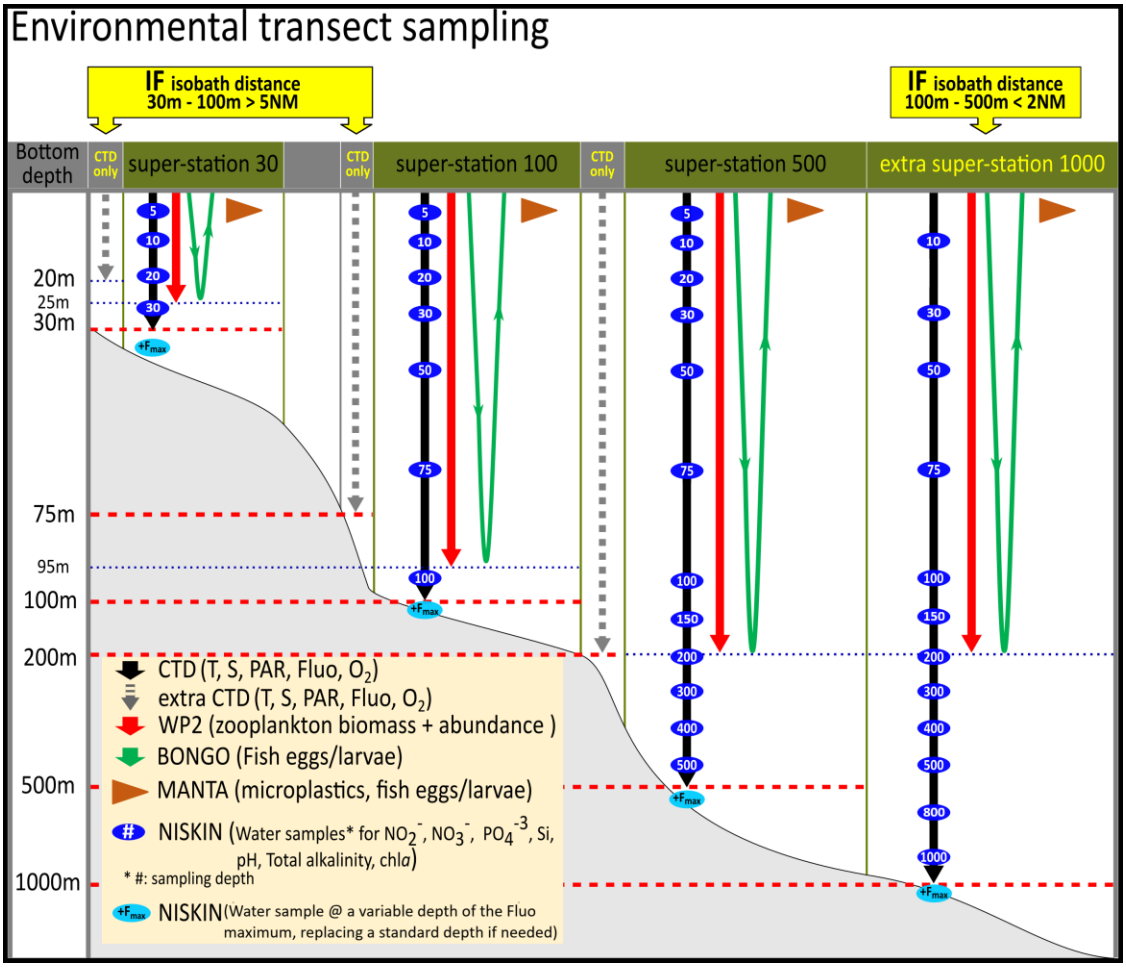

Figure 6.3: Sampling along environmental transects

6.4.2.2 Ocean Acidification parameters - pH and total alkalinity

Seawater samples for the analysis of pH and total alkalinity are collected together in 250 ml borosilicate glass bottles with silicone tubing. Samples are collected from the rosette water sampler in accordance with IMRs Standard Depth designations. If oxygen water samples are not being collecting, these pH/AT samples will be collected first from the rosette bottles due to their gas sensitivity that will alter the pH.

- pH is determined using an Agilent Cary 8454 UV-Vis Diode Array spectrophotometer and a 2-mM m-cresol purple indicator dye solution. See the pH protocol for further details in addition to sampling and analysis procedures.
- Total alkalinity is determined via an open-cell potentiometric titration using a 0.05 M HCl solution with a sodium chloride background as the titrant (Dickson et al. 2007). See the total alkalinity protocol for further details in addition to sampling and analysis procedures.

To assess the ocean acidification state and change in the region, the pH and total alkalinity data will be combined with phosphate, silicate, temperature, salinity and depth to calculate

additional parameters of the carbonate system such as dissolved inorganic carbon, pCO2 and the calcium carbonate saturation states for aragonite and calcite.

6.4.2.3 Dissolved Nutrients

Seawater samples for the analysis of nitrite, nitrate, silicate and phosphate are collected in 20 ml polyethylene vials. Samples are collected from the rosette water sampler in accordance with IMRs Standard Depth designations. Samples are frozen for preservation until analysis in January 2022 with a SEAL QuAAtro39 continuous segmented flow analyser.

6.4.3 Primary productivity

Seawater samples for the analysis of chlorophyll a and phaeopigments are collected in 269 ml high-density polyethylene bottles from depths ranging from 5 to 200 m. Samples are filtered with 25 mm Munktell MG F filters with 0.7 µm particle retention on a 200 mm Hg vacuum pumped filtration system. The filters are stored in a -20°C freezer until ready for extraction for 15-24 hours with 10 ml of 90% acetone at 4°C. Samples are then centrifuged and transferred to cuvettes for analysis on a Turner Designs 10AU Fluorometer (Welshmeyer, 1994; Jeffrey and Humphrey, 1975). Samples are first measured without acid for chlorophyll a determination and then a second time with two drops of 5% HCl for phaeopigment determination. The 10AU is calibrated approximately once a year with standards created from a chlorophyll a solid. See the chlorophyll a protocol for further details in addition to sampling and analysis procedures.

Qualitative phytoplankton samples are collected at selected stations in the studied area (Appendix 5). A phytoplankton net (35 cm in diameter and mesh-size of 10 µm), is hauled vertically at a speed <0.1 m $s^{-1}$from the depth of 30 m to the surface (5 m above bottom at the 30 m stations). Samples will be preserved in the 100 ml dark glass bottles with the addition of 2 ml of neutral Lugol solution.

6.4.4 Zooplankton

Zooplankton samples are collected at 29 selected stations (Appendix 5). Samples will be collected by vertical hauls of a WP2 net (56 cm diameter, mesh size 180 µm) at a speed of 0.5 m sec^{-1}. The net will be towed within 5 m from the bottom to the surface, or from 200 m depth to the surface at deep stations. The plankton leader should ensure that this procedure is followed accurately on deck, write the actual depth of the tow (displayed in the monitor), and take flowmeter counts before and after the tow.

In summary, the WP2 samples will be processed as follows:

- The sample will be halved into parts with a Motoda splitter.
- One half will be used for biomass estimation (size fractionation through 2000 µm, 1000 µm and 180 µm mesh sizes)
- The second half will be preserved in 4% borax buffered formaldehyde solution and will be processed onboard through the FlowCam-Macro.

The exact procedure to be followed is described in detail in the Nansen Plankton Guidelines (see https://nansen-surveys.imr.no/doku.php?id=plankton_lab_information).

6.4.5 Ichthyoplankton

Ichthyoplankton is collected at all zooplankton stations (Appendix 5), with double oblique tows of a Bongo net equipped with 405 µm nets. The Bongo will be towed obliquely within 5 m from the bottom or a maximum depth of 200 m to the surface at deep stations. Wire speed and the vessel speed should strictly follow the Nansen Plankton Guidelines (see https://nansen-surveys.imr.no/doku.php?id=plankton_lab_information).

Once the Bongo net is on board, the samples will be transferred in the lab and will be processed as follows:

- The sample of the left net (V) will be preserved directly in 4% borax buffered formaldehyde solution (especially made for ichthyoplankton).
- The sample of the right net (H) will be used for estimation of the Zooplankton Displacement Volume (details in the Nansen Plankton Guidelines). Afterwards, the sample will be examined under the microscope and all fish larvae (and eggs if possible) will be sorted out. Plankton examination should be done thoroughly and in small amounts; during this process the rest of the sample should be kept cool (by the use of ice packs, fridge etc.). When sorting has finished, the bulk sample should be preserved in 96% ethanol (in bottles labelled bottles as "sorted"). The sorted ichthyoplankton will be photographed and preserved in 96% ethanol for genetics in small labelled scintillation vials indicating clearly which net was used for sorting, the preservative, station etc. In case of lack of time or bad weather conditions, an alternative approach is to fix the total sample for ichthyoplankton without separating larvae from the sample onboard. However, to the extent possible this method should be avoided. More details on the sample processing can be found in the Nansen Plankton Guidelines (see https://nansen-surveys.imr.no/doku.php?id=plankton_lab_information).

If Bongo deployment is not possible due to net malfunction etc., ichthyoplankton will be sampled by Multinet (midi or mammoth) according to the instructions in the Nansen Plankton Guidelines (see https://nansen-surveys.imr.no/doku.php?id=plankton_lab_information).

6.4.6 Sampling at Cabo Verde Ocean Observatory and Nola Seamount

6.4.6.1 CVOO

The Cabo Verde Ocean Observatory is located at 17N 36.40' - 24W 14.98. The following sampling is to be carried out:

Plankton

Stratified zooplankton sampling will be conducted at night by the use of a midi multinet equipped with fine nets (180 µm mesh size). The net will be towed vertically at a speed 0.5

m sec-1 and five depth strata (0-100 m, 100-200 m, 200-300 m, 300-600 m, 600-1000 m) will be sampled. The entire samples will preserve in 4% borax buffered formaldehyde solution (no biomass estimation will be done).

Hydrography

A CTD rosette water sampler will be deployed to approximately 3630 m to obtain the full sensor profile of the water column. Beginning at 450 m, water samples will be collected according to Table 3. Dissolved oxygen and chlorophyll a will be analysed on board during the survey. Nutrients will be analysed on board in January 2022. And dissolved inorganic carbon / total alkalinity samples will be sent to GEOMAR after the survey for later analysis.

Table 6.3: *Except for samples taken at 250 m and 150 m, all depths correspond to the R/V Islândia standard sampling depths.*

Bottle	Depth	Oxygen	DIC TA	Nutrients	Chlorophyll a
1[1]	450	1	2	1	
2	350	2	1	3	
3	250	1	1	1	
4	200	1	1	1	1
5	150	2	1	3	1
6	120	1	2	1	1
7	100	1	1	1	1
8	80	1	1	1	1
9	60	1	1	1	1
10	40	1	1	1	1
11	20	1	1	1	1
12	10	1	1	1	1

[1]CTD to go down to 3650 m but water bottle sampling will begin at 450 m.

6.4.6.2 Nola Seamounts

Ichthyoplankton stratified sampling will be conducted at selected stations in the area of Nola Seamounts (Appendix 6) using oblique tows of a Mammoth Multinet equipped with nets of 405 µm mesh size (downward speed 30 m min^{-1}, retrieval:30 m min^{-1}). The exact sampling strata will be defined based on station depth and it can be maximum six (i.e, 0-25 m, 25-50 m, 50-75 m, 75-100 m, 100-150 m, 150-200 m). Nets with mesh size of 405 µm will be mounted from the second to seventh position in the Mammoth frame (N2-N7). <U+039F>ne additional net of 180 µm will be mounted at the first position (N1) and will be towed opened during the downcast for the collection of mesozooplankton.

Samples from nets N2-N7 (405 µm) will be preserved in 96% ethanol, while the samples from N1 (180 µm) will be split with a Motoda splitter. One half will be preserved in 4% formaldehyde solution and the other half in 96% ethanol.

6.4.7 Microplastics

6.4.8 Biological sampling for fisheries resources

Once the catch is on deck, it is assessed, and, if necessary, subsamples are taken. At all trawl hauls, the catch is sorted according to species, and length and weight measurements will be taken for all fish species using an electronic fish meter connected to a customized data acquisition system (Fish2Data and Biotic Editor) running on the server of the vessel. In addition, further biological sampling will be done for pre-agreed priority species.

Appendix 7 and Appendix 8 provides guidelines on the detailed sampling protocols. As a preparation for the work in the fish lab, a training course will be provided on the use of the electronic fish meter, Fish2Data and Biotic Editor software.

6.4.8.1 Demersal fish

Conduct length-weight measurements, length frequencies and standard biological sampling for all priority species at all stations that they are caught (Appendix 9). Also, length – weight measurements of 30 individuals from all other fish species found in the catches.

6.4.8.2 Pelagic fish

Length–weight measurements, length frequencies and standard biological sampling for priority species at all stations that they are caught will be carried out (Appendix 9). Length – weight measurements will also be taken from 30 individuals from for all other species found in the catches. Genetic samples will be taken from selected species (REF _Ref85360616 * MERGEFORMAT Appendix 9) based on the standard sampling protocol for genetics (https://nansen-surveys.imr.no/doku.php?id=biological_sampling_procedures).

6.4.8.3 Other trawl-related sampling

The protocol that will be followed for cartilaginous will be the same as for demersal / pelagic resources described in Appendix 9. Specimens for taxonomic courses will be collected following the protocol in Appendix 10. Species that cannot be identified should be preserved in formalin or frozen and sent to taxonomic experts for identification following the protocol given in Appendix 13.

IMar are interested in individuals of Crustaceans and molluscs (except for Cephalopods), for curation a long-term storage (see Appendix 13). With respect to fish, Cephalopods and sponges, the samples should be sent to IEO. However, in some cases IMar would also like to have samples of specific fish taxa, listed in Appendix 13 (preserved in formalin or ethanol). These samples will be off-loaded in Las Palmas, taken care of by IEO and then sent to Cabo Verde. The frozen samples will have to be sent together with other frozen samples (sea freight from Las Palmas to Bergen and then reshipped and sent to Cabo Verde).

In addition, IEO are interested in samples of all individuals of fish and crustacean that the people in the fish lab find difficult to identify. The protocol for preservation and labelling can be found in Appendix 13. IEO will be responsible for taking care of the samples when the vessel arrives in Las Palmas.

In cases where more than two partners are interested in the same individual, then IMar should have the samples.

For Sargassum sp. specimens the protocol in Appendix 11 is to be followed.

For nutrition and food safety sampling the protocol in Appendix 12 is to be followed.

Samples of selected commercially important pelagic species will be taken and analysed for nutrients profiles, contaminants and microplastics. Samples will be taken at different geographical coordinates.

A total of 25 specimens at 3 different stations will be frozen and later analyzed for determination of nutrients and food safety parameters.

Marine debris will be registered and classified at each station according to the categories listed in the sampling protocol for marine litter (https://nansen-surveys.imr.no/doku.php?id=biological_sampling_procedures. All pieces of litter should be weighed and counted, and when possible, photos should be taken of the individual pieces for a reference catalogue. The data and the reference photos should be recorded using Fish2Data and imported into the Biotic Editor. One person from each shift will be responsible for recording this data.

For epibenthos sampling, specimens in the trawl catches will be identified and pictures of all epibenthos (one picture per trawl, all species included, see Figure 6.4) should be taken.

Figure 6.4: Example of photograph with epibenthos to be taken at each demersal trawl station.

6.4.8.4 Demersal fish catch rates

Due to the limited number of stations available for demersal trawling only catch rates will be provided, as the sampling cannot be considered representative for the whole surveyed area.

6.4.8.5 Pelagic fish biomass estimation - acoustics

The biomass of pelagic fish will be estimated using the acoustic method as in previous surveys (https://nansen-surveys.imr.no/doku.php?id=biomass_calculations), using the 38KHz frequency transducer of the EK80 scientific split beam echosounders. The StoX [StoX (stoxproject.github.io)] software will be used for the biomass indices calculations.

Training of regional scientists in the processing of the collected acoustic data will be carried out during the survey. Appendix 4 show the species listed within acoustic categories that will be used when scrutinizing the echograms.

6.5 DATA COLLECTED AND STANDARD PROCEDURE FOR HANDING OVER SAMPLES TO PARTNERS

In line with the Nansen Data Policy, the Cruise Leader is to ensure that each national institution represented in the survey receives a copy of the draft report and the basic data (e.g. catch data) pertaining to the particular survey and for their national waters before leaving the vessel and document what data and samples has been shared and with whom (Appendix 2b, Appendix 3).

The cruise participants are expected to sign and conform the Data policy of the EAF-Nansen Programme

Persons responsible for samples need to inform about the status of analysis, and report about this at the post-survey meeting as well as send a copy of the analysis/results to IMR (nansen_data@hi.no). IMR, as a data custodian for the EAF-Nansen Programme, is required to have an overview of the samples/analysis at any point in time to;

- ensure that data life-cycle management is carried out in the expected way
- be used for capacity building purposes (e.g. workshops, training courses, etc.)
- Advance collaboration and publishing through the EAF-Nansen Science Plan
- Maintain reference libraries (e.g., for taxonomic purposes) and DNA barcoding
- Plan efficiently future surveys in the same area

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APPENDICES

6.6.1 Appendix 1. Planned list of participants for Leg 2

Table 6.4: *List of planned participants, role, e-mail address, gender, affilitaion and country of origin.*

No	LEG	PARTICIPANT	ROLE	E MAIL	SEX	AFFILIATION	COUNTRY
1	Leg 2	Kathrine Michalsen	Cruise leader	kathrine@hi.no	F	IMR	Norway
2	Leg 2	Sarah Ann Bruck	Fish Team Leader	sarah.ann.bruck@hi.no	F	IMR	Norway
3	Leg 2	Diana Zaera-Perez	Fish Team Leader	diana.zaera-perez@hi.no	F	IMR	Norway
4	Leg 2	Sara Zamora Terol	Plankton Team Leader	sara.zamora.terol@hi.no	F	IMR	Norway
5	Leg 2	David Cervantes	Chemical oceanography	david.cervantes@hi.no	M	IMR	Norway
6	Leg 2	Olaf J. Sørås	Chief Instruments Engineer	Olaf.soeraas.hi.no	M	IMR	Norway
7	Leg 2	Jori Neteland-Kyte	Instruments Engineer		F	IMR	Norway
8	Leg 2	Vito Ramos	Co-Cruise leader	vito.melo@imar.gov.cv	M	IMar	Cabo Verde
9	Leg 2	Sandra Correia	Fish Team	sandra.correia@imar.gov.cv	F	IMar	Cabo Verde
10	Leg 2	Alciany Luz	Fish Team	alciany.luz@imar.gov.cv	F	IMar	Cabo Verde
11	Leg 2	Carla Santos	Fish Team	limacarla92@gmail.com	F	IMar	Cabo Verde
12	Leg 2	Ailton Rocha	Fish Team	ailton.rocha@imar.gov.cv	M	IMar	Cabo Verde
13	Leg 2	Anibal Medina	Fish Team	anibal.medina@yahoo.com	M	IMar	Cabo Verde
14	Leg 2	Katelene Delgado	Fish Team	katecruz06@gmail.com	F	IMar	Cabo Verde
15	Leg 2	Rui Freitas	Fish Team	rfreitas@uta.cv	M	UTA	Cabo Verde
16	Leg 2	Valéria Lopes	Fish Team	vhfortes@uta.cv	F	UTA	Cabo Verde
17	Leg 2	Péricles Silva	Chemical/physical oceanography	pericles.silva@oscm.cv	M	IMar	Cabo Verde
18	Leg 2	Ivanice Silva	Chemical/physical oceanography	ivanice.monteiro@oscm.cv	F	IMar	Cabo Verde
19	Leg 2	Dario Évora	Chemical/physical oceanography	dario.evora@imar.gov.cv	M	IMar	Cabo Verde
20	Leg 2	Elizandro Rodrigues	Biological oceanography	elizandro.rodrigues@oscm.cv	M	IMar	Cabo Verde

No	LEG	PARTICIPANT	ROLE	E MAIL	SEX	AFFILIATION	COUNTRY
21	Leg 2	Keider Neves	Biological oceanography	biokeider2012@hotmail.com	M	Biosfera I	Cabo Verde
22	Leg 2	Marcia Costa	Biological oceanography	marcia.costa@imar.gov.cv	F	IMar	Cabo Verde
23	Leg 2	Chrislainne Alves	Biological oceanography	chrislainne.alves@outlook.com	F	IMar	Cabo Verde
24	Leg 2	Francisca A. Salmeron Jimenez	Fish Team; Taxonomist	paqui.salmeron@ieo.es	F	FAO expert	Spain
25	Leg 2	Benjamin N'Guessan	Physcical oceanographer	nguessan.k.benjamin@gmail.com	M	CRO	Ivory Coast
26	Leg 2	Maik Tiedemann	Training (Cruise leader)	maik.tiedemann@hi.no	M	IMR	Norway

6.6.2 Appendix 2a. Overview of sampled components and equipment to be used

Overview of the gear codes to be used in the Toktlogger system, detailed information about the rigging of the equipment as well as technical drawings and other specifications of the various equipment can be found in the Nansen wiki site (https://nansen-surveys.imr.no/doku.php).

Table 6.5: *Overview of sampled components and equipment to be used.*

Component sampled	Equipment
Physical-air	Weather station (wind speed, direction, temperature, light sensor)
Physical-water	CTDO, Fluorescence sensor, PAR sensor; 150kHz ADCP; thermosalinograph (T,S,Fl); turbidity sensor
Chemical-water	Water samples and chemical analysis, pH, AT, pCO2, nutrient analyzer; fluorometer instrument, salinity, oxygen
Phytoplankton	Phytoplankton-net (non-quantitative), Water samples (quantitative), Chlorophyll analysis from fluorometer instrument
Zooplankton	WP2 (180 µm), Bongo net (180 µm), Multinet midi (180 µm), Echo sounders (EK 80), flow cam,
Ichthyoplankton and jellyfish	Multinet midi (180 µm), Multinet mammoth (180 µm and 405 µm), Bongo net (180 µm), CUFES (continuous underwater fish egg sampler)
Fish (incl. mesopelagic fish)	Pelagic (Åkra trawl, MultPelt trawl) and Demersal trawls (Gisund Super), Echo sounders (EK 80), Omni-directional Fisheries sonar (SH 90)
Benthos	Demersal trawl (Gisund)
Plastic	Manta trawl (180 mµ), demersal and pelagic trawl
Mammals and seabirds	
Bathymetry	Olex (with input from EM 710)

6.6.3 Appendix 2b. Data collected and overview of procedures for data hand-over to partners

See Annex VII.

6.6.4 Appendix 3. Samples to be collected, preservation and follow-up work

See Annex VI.

6.6.5 Appendix 4. Allocation of acoustic densities to species groups

The updated table is presented in Section 2.4.1 (Table 2.1).

6.6.6 Appendix 5. Plankton sampling locations for WP2, Bongo, Manta and phytoplankton sampling

Table 6.6: *Plankton sampling locations for WP2, Bongo, Manta and phytoplankton sampling.*

Station	Longitude	Latitude	WP2	Bongo	Manta	Phytoplankton	Bottom depth m
PL1W	-25.053	16.157	x	x	x		3900
PL2W	-24.962	15.483	x	x	x		4120
PL3W	-24.875	14.833	x	x	x		3480
PL4W	-24.455	14.774	x	x	x		2140
PL5W	-24.088	14.800	x	x	x		3360
PL6W	-23.737	14.840	x	x	x		2580
PL7W + Phyto	-23.362	15.051	x	x	x	x	1700
PL8W	-23.056	15.103	x	x	x		1340
PL9W	-23.347	15.477	x	x	x		1380
PL10W	-23.018	15.503	x	x	x		1620
PL11	-23.326	15.796	x	x	x		2060
PL12 + Phyto	-22.912	15.632	x	x	x	x	1900
PL13W	-23.171	15.662	x	x	x		80
PL14W	-22.841	15.763	x	x	x		1740
PL15W	-22.459	15.876	x	x	x		1300
PL16W	-22.549	16.203	x	x	x		1580
PL17	-22.948	16.134	x	x	x		28
PL18W	-22.854	16.270	x	x	x		43
PL19	-22.730	16.374	x	x	x		1420
PL20W	-22.730	16.604	x	x	x		1360
PL21W	-22.800	16.824	x	x	x		1660
PL22W + Phyto	-22.946	16.619	x	x	x	x	20
PL23	-23.291	16.609	x	x	x		2600
PL24W	-23.641	16.598	x	x	x		3460
PL25W + Phyto	-24.003	16.581	x	x	x	x	1060
PL26W	-24.350	16.729	x	x	x		1720
PL27W	-24.684	16.804	x	x	x		20

Station	Longitude	Latitude	WP2	Bongo	Manta	Phytoplankton	Bottom depth m
PL28W + Phyto	-24.873	16.968	x	x	x	x	960
PL29W	-25.547	17.295	x	x	x		1380
PL30W	-25.051	16.786	x	x	x		20

6.6.7 Appendix 6. Multinet stations over the Nola Seamounts

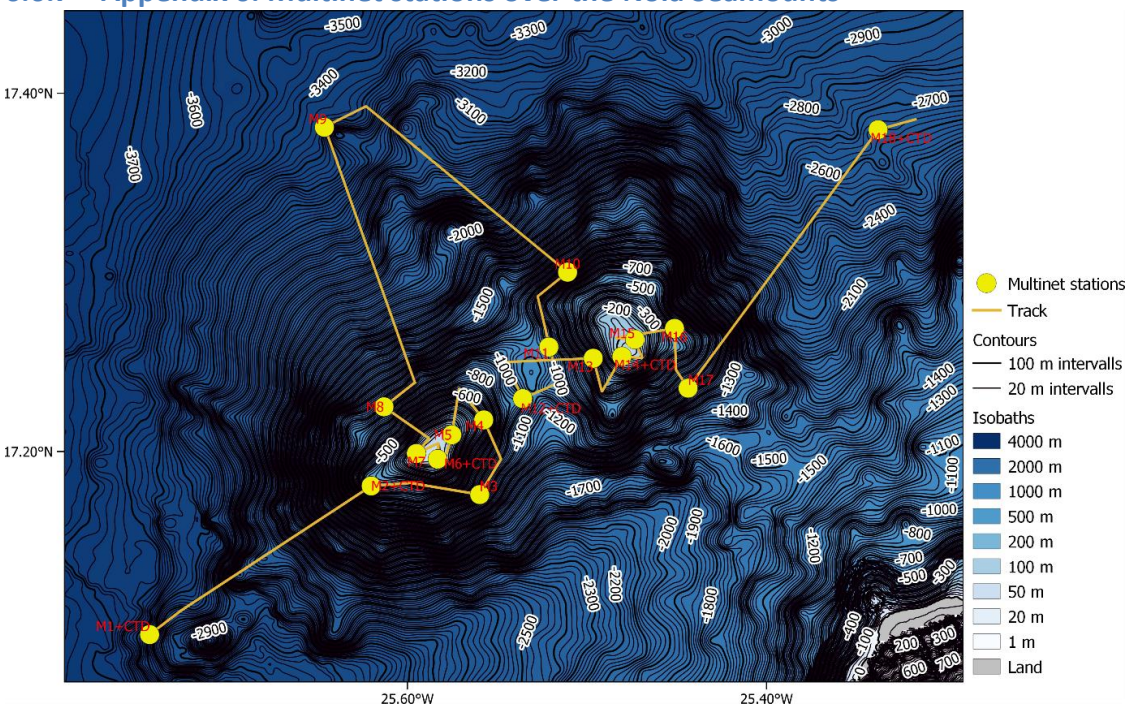


Figure 6.5: Map of selected Multinet stations over the Nola Seamounts

Table 6.7: *Multinet stations over Nola Seamounts.*

Station	Latitude	Longitude	bottom depth m
M1 + CTD	17.098	-25.744	3300
M2 + CTD	17.181	-25.620	500
M3	17.176	-25.560	1000
M4	17.218	-25.558	500
M5	17.209	-25.575	100
M6 + CTD	17.196	-25.583	60
M7	17.199	-25.595	100
M8	17.225	-25.613	1000
M9	17.352	-25.693	3300
M10	17.300	-25.511	1000
M11	17.258	-25.521	1000
M12 + CTD	17.230	-25.536	1000
M13	17.252	-25.497	500
M14 + CTD	17.253	-25.481	100

Station	Latitude	Longitude	bottom depth m
M15	17.263	-25.473	100
M16	17.269	-25.451	500
M17	17.235	-25.444	1000
M18 + CTD	17.380	-5.338	2640

6.6.8 Appendix 7. Overview of sampling procedures in the fish laboratory. The priority species are listed in Appendix 9

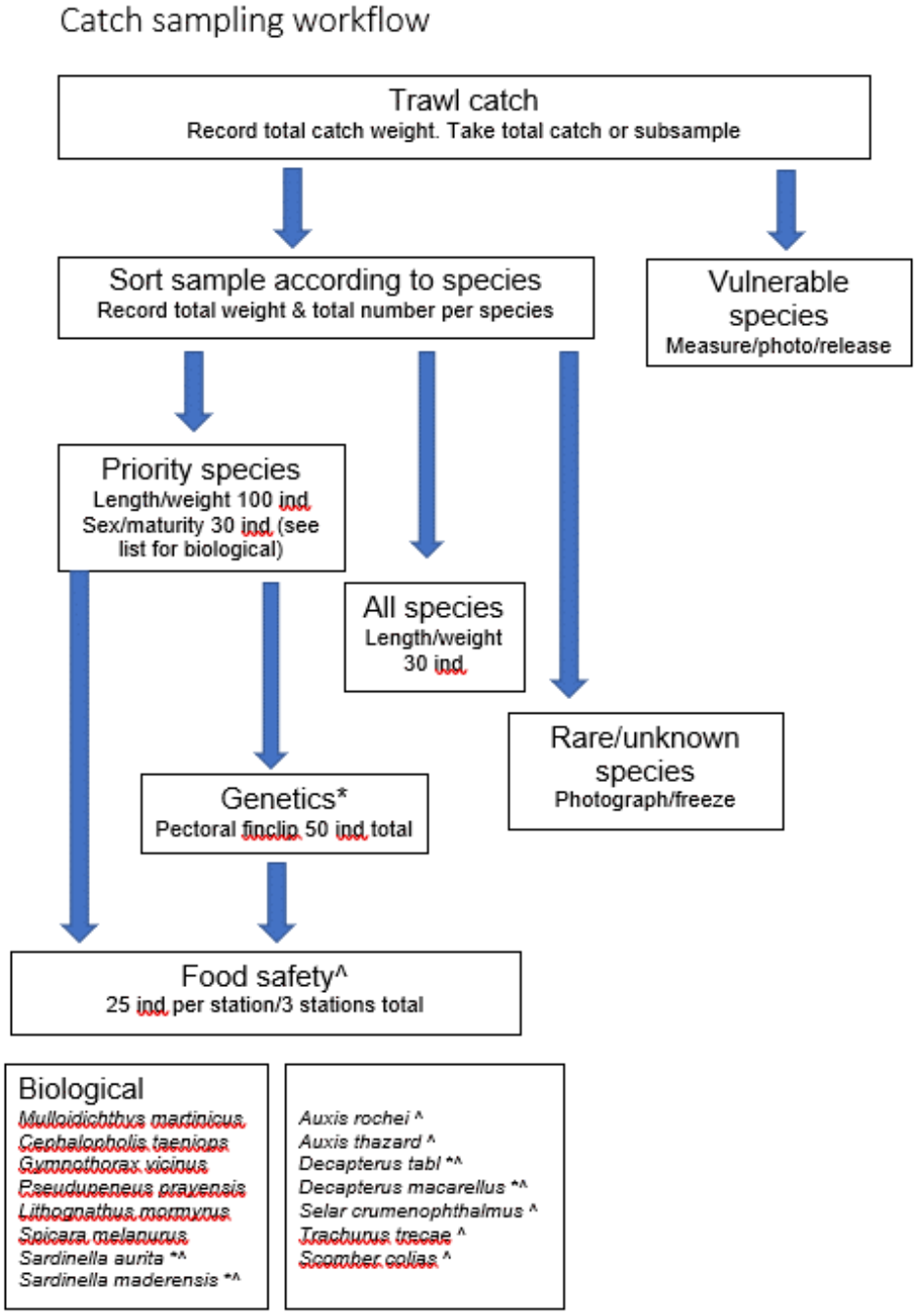


Figure 6.6: Please insert the right caption

6.6.9 Appendix 8. Biological scales used for maturity stage

Table 6.8: *Biological scales used for maturity stages.*

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

Table 6.8: *Biological scales used for maturity stages.*

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

6.6.10 Appendix 9. Biological sampling protocol for priority fish species

Table 6.9: *Biological sampling protocol for priority fish species.*

Species	Catch weight number	Measured specimen Lengths weights	Sex maturity	Genetic FINCLIPS	Whole specimens	Photograph	Nutrition and Food safety sampling
All species	Every station	Length/weight of all abundant species			Species that are difficult to ID	Species that are difficult to ID	
PRIORITYSPECIES							
Demersal							
Mulloidichthys martinicus	Every station	Max 100/station	Max 30/station				
Cephalopholis taeniops	Every station	Max 100/station	Max 30/station				
Gymnothorax vicinus	Every station	Max 100/station	Max 30/station				
Pseudupeneus prayensis	Every station	Max 100/station	Max 30/station				
Lithognathus mormyrus	Every station	Max 100/station	Max 30/station				
Spicara melanurus	Every station	Max 100/station	Max 30/station				
Pelagic							
Sardinella aurita	Every station	Max 100/station	Max 30/station	50 inds in total			Max 25 per station/3 stations
Sardinella maderensis	Every station	Max 100/station	Max 30/station	50 inds in total			Max 25 per station/3 stations
Auxis rochei		Max 100/station	Max 30/station				Max 25 per station/3 stations
Auxis thazard		Max 100/station	Max 30/station				Max 25 per station/3 stations
Decapterus tabl		Max 100/station	Max 30/station	50 inds in total			Max 25 per station/3 stations
Decapterus macarellus		Max 100/station	Max 30/station	50 inds in total			Max 25 per station/3 stations

Species	Catch weight number	Measured specimen Lengths weights	Sex maturity	Genetic FINCLIPS	Whole specimens	Photograph	Nutrition and Food safety sampling
Selar crumenophthalmus		Max 100/station	Max 30/station				Max 25 per station/3 stations
Trachurus spp		Max 100/station					Max 25 per station/3 stations
Trachurus trecae		Max 100/station	Max 30/station	50 inds in total			Max 25 per station/3 stations
Scomber colias		Max 100/station	Max 30/station				Max 25 per station/3 stations
Trachurus picturatus		Max 100/station					
Decapterus punctatus		Max 100/station					
Caranx crysos		Max 100/station					
Caranx hippos		Max 100/station					
Caranx latus		Max 100/station					
Caranx lugubris		Max 100/station					
Elagatis bipinnulata		Max 100/station					
Trachinotus ovatus		Max 100/station					
Trachinotus goreensis		Max 100/station					
Trichionotus teraia		Max 100/station					
Selene dorsalis		Max 100/station					
Seriola carpenteri		Max 100/station					
Seriola dumerili		Max 100/station					
Seriola rivoliana		Max 100/station					
Katsuwonus pelamis		Max 100/station					

Species	Catch weight number	Measured specimen Lengths weights	Sex maturity	Genetic FINCLIPS	Whole specimens	Photograph	Nutrition and Food safety sampling
Euthynnus alletteratus		Max 100/station					
Apsilus fuscus		Max 100/station					
Acanthocybium solandri		Max 100/station					
Orcynopsis unicolor		Max 100/station					
Sarda sarda		Max 100/station					
Scomberomorus tritor		Max 100/station					
Thunnus alalunga		Max 100/station					
Thunnus albacares		Max 100/station					
Thunnus obesus		Max 100/station					
Sphyraena barracuda		Max 100/station					
Sphyraena guachancho		Max 100/station					
Sphyraena viridensis		Max 100/station					
Elasmobranchs		Max 100/station	Max 30/station (sex only)				
Vulnerable species	Every station	All	All/no				
Benthic epifauna	Every station				Unidentified species in formalin or ethanol	One picture per station – all species included	
Plastic/rubbish/fishing gear	Every station						

Table 6.9: *Biological sampling protocol for priority fish species.*

Species	Catch weight number	Measured specimen Lengths weights	Sex maturity	Genetic FINCLIPS	Whole specimens	Photograph	Nutrition and Food safety sampling

Species	Catch weight number	Measured specimen Lengths weights	Sex maturity	Genetic FINCLIPS	Whole specimens	Photograph	Nutrition and Food safety sampling
All species	Every station	Length/weight of all abundant species			Species that are difficult to ID	Species that are difficult to ID	
PRIORITYSPECIES							
Demersal							
Mulloidichthys martinicus	Every station	Max 100/station	Max 30/station				
Cephalopholis taeniops	Every station	Max 100/station	Max 30/station				
Gymnothorax vicinus	Every station	Max 100/station	Max 30/station				
Pseudupeneus prayensis	Every station	Max 100/station	Max 30/station				
Lithognathus mormyrus	Every station	Max 100/station	Max 30/station				
Spicara melanurus	Every station	Max 100/station	Max 30/station				
Pelagic							
Sardinella aurita	Every station	Max 100/station	Max 30/station	50 inds in total			Max 25 per station/3 stations
Sardinella maderensis	Every station	Max 100/station	Max 30/station	50 inds in total			Max 25 per station/3 stations
Auxis rochei		Max 100/station	Max 30/station				Max 25 per station/3 stations
Auxis thazard		Max 100/station	Max 30/station				Max 25 per station/3 stations
Decapterus tabl		Max 100/station	Max 30/station	50 inds in total			Max 25 per station/3 stations
Decapterus macarellus		Max 100/station	Max 30/station	50 inds in total			Max 25 per station/3 stations
Selar crumenophthalmus		Max 100/station	Max 30/station				Max 25 per station/3 stations

Species	Catch weight number	Measured specimen Lengths weights	Sex maturity	Genetic FINCLIPS	Whole specimens	Photograph	Nutrition and Food safety sampling
Trachurus spp		Max 100/station					Max 25 per station/3 stations
Trachurus trecae		Max 100/station	Max 30/station	50 inds in total			Max 25 per station/3 stations
Scomber colias		Max 100/station	Max 30/station				Max 25 per station/3 stations
Trachurus picturatus		Max 100/station					
Decapterus punctatus		Max 100/station					
Caranx crysos		Max 100/station					
Caranx hippos		Max 100/station					
Caranx latus		Max 100/station					
Caranx lugubris		Max 100/station					
Elagatis bipinnulata		Max 100/station					
Trachinotus ovatus		Max 100/station					
Trachinotus goreensis		Max 100/station					
Trichionotus teraia		Max 100/station					
Selene dorsalis		Max 100/station					
Seriola carpenteri		Max 100/station					
Seriola dumerili		Max 100/station					
Seriola rivoliana		Max 100/station					
Katsuwonus pelamis		Max 100/station					
Euthynnus alletteratus		Max 100/station					
Apsilus fuscus		Max 100/station					

Species	Catch weight number	Measured specimen Lengths weights	Sex maturity	Genetic FINCLIPS	Whole specimens	Photograph	Nutrition and Food safety sampling
Acanthocybium solandri		Max 100/station					
Orcynopsis unicolor		Max 100/station					
Sarda sarda		Max 100/station					
Scomberomorus tritor		Max 100/station					
Thunnus alalunga		Max 100/station					
Thunnus albacares		Max 100/station					
Thunnus obesus		Max 100/station					
Sphyraena barracuda		Max 100/station					
Sphyraena guachancho		Max 100/station					
Sphyraena viridensis		Max 100/station					
Elasmobranchs		Max 100/station	Max 30/station (sex only)				
Vulnerable species	Every station	All	All/no				
Benthic epifauna	Every station				Unidentified species in formalin or ethanol	One picture per station – all species included	
Plastic/rubbish/fishing gear	Every station						

6.6.11 Appendix 10. Protocol for sampling for taxonomic collections/courses

I.Fish and macroinvertebrates samples for regional taxonomy course (date and venue to be defined)

Representatives of selected families will be retained from the trawl catches to be used for the practical sessions of the taxonomy training course. The list is intended to provide collectors with a broad selection of taxa that might be available in the catches with the goal of having enough variety of species/families as well as sufficient specimens.

For the purpose of the training course, 2-3 selected specimens in good condition should be:

a) Placed in clearly labelled plastic bags,

b) Preserved in frozen condition making sure the individuals are separated from each other at least until they freeze (consider separate bags for delicate taxa)

c) Stored in clearly marked Styrofoam boxes in the large walk in freezer

A log sheet is to be kept with an overview of the collected specimens. The log should contain the following information:

- Species name
- Station number
- Number of individuals preserved

The log is to be sent to peter.psomadakis@gmail.com at the end of the survey, together with trawl station information data.

Representative specimens from selected families/genera will be collected from the list provided (species_capeverde_species for collection IMR.xlsx) -

II.Fish samples for IMR internal courses and training

Representative specimens from selected families/genera will be frozen in clearly labelled zip lock bags.

One or two specimens of each species, from the list provided (species_capeverde_species for collection IMR.xlsx) are to be preserved. Specimens in good conditions should be chosen. These samples are to be sent to IMR and preserved for training purposes.

If deep-water hauls are carried out, specimens are also to be preserved for training purposes and included to the list for IMR. A log sheet is to be kept (with survey number, station number and a comment with picture name if a picture is taken).

6.6.12 Appendix 11. Protocol for seaweed sampling

Opportunistic samples collected in the trawl and/or manta net will be photographed and stored following the protocol below:

- Collect sample (bulk)
- Take photo of sample collected (bulk)
- Clean /rinse thalli of Sargassum with clean sea water to remove attached organisms and adherent debris such as shells, sand, mud; and remove epiphytes by scraping gently with tissue paper. This is for molecular /DNA barcoding.
- Take close-up photo of single thallus of Sargassum to show characteristic features:(i) branching pattern, of main axis (ii) leaf-like appendage form/shape, (iii) margin of leaf-like appendage (iv) air bladder (with or without spine) (v) look for spines on main axis (stem)
- FOR MOLECULAR [DNA barcoding] Preserve a small quantity (a small branch of Sargassum sample, with leaf-like structures, which should cover an adult palm) from each collection (of the cleaned thalli in bullet 4)
- Preserve the above at -20^{o}C in a plastic bag with appropriate labelling (same information as for the samples from the sampling gear used).

Place remaining bulk sample (bullet 2) in plastic bag and store at -20^{o}C; label appropriately.

6.6.13 Appendix 12. Protocol for nutrition and food safety sampling

Sample selected pelagic species listed in Appendix 8 for analysis of nutrients and contaminants. N=25 of each species from 3 stations. If small catches, a minimum of 5 fish from each station. The fish should be stored whole in the freezer pending shipment to IMR. IMR will be responsible for analyzing the samples (Reksten et al, 2020). The fish will be stored in plastic bags marked with species, station, and date. The trawl form with station information should follow the samples. An electronical copy should be sent to marian.kjellevold@hi.no.

6.6.14 Appendix 13. Protocol for nutrition and food safety sampling

Fish and macroinvertebrates samples for post-survey taxonomic studies

Specimens included in a list of relevant/problematic taxa (Cabo Verde survey fish taxa to be collected post taxonomy studies.xlsx) will be retained for post-survey taxonomy studies.

For this activity, the collectors will follow a standard step-by step sampling procedure (Sampling procedures onboard the R.V. Dr. F. Nansen.docx)

Specimens, will be:

- Measured and weighed,
- photographed in fresh condition if the species is unknown,
- tissue sampled if the species is unknown,
- individually labelled/tagged
- preserved either in frozen condition (large specimens) or fixed in formalin (small, medium-size specimens)

Benthic invertebrates samples

Benthic specimens of special interest or that are difficult to identified will be sampled according to a given protocol (Methods for sampling, processing, photographing, fixing and preserving benthic invertebrates' samples).

Specimens will be:

- Photographed in fresh condition (label with station information and field collection number visible in photographs)
- Fixed and preserved according to taxa specific methodology described in above mentioned document
- Stored in clearly labelled containers

For both fish/macroinvertebrates and benthos, a log sheet is to be kept with an overview of the collected specimens.

ANNEX II - DESCRIPTION OF INSTRUMENTS AND FISHING GEAR

Acoustic instruments

The Simrad EK80/18, 38, 70,120 and 200 kHz scientific sounder was run during the survey. Scrutinizing was done in LSSS using the data from the 38-kHz transducer. The standard sphere calibrations were checked on the 26.11.2021 in Flamenco Bay, Sao Vincente, Cabo Verde, using Cu64 for the 18 kHz. Due to some technical problems and increasing amount of plankton in the water as daylight decreased, another calibration took place on the 02.12.2021, southwest of Maio for the Cu60 for the 38 kHz, WC38.1 for the 70, 120 and 200 kHz. The details of the settings for the 38-kHz echo sounder were as follows:

Table 6.10: *Echosounder settings used during the survey.*

Transceiver2 menu 38kHz			
Transducer depth	6.84 m	SA correction	-0.09 dB
Absorption coeff.	9.7 dB/km	Angle sensitivity	18
Pulse duration	medium (1.024ms)	3 dB beamwidth	6.22º along ship
Bandwidth	34-38kHz		6.29 athwart ship
Max power	2000 Watt	Alongship offset	-0.05º
2way beam angle	0	Athwardship offset	-0.06º
gain	26.98 dB	Bottom detection menu	Minimum level -50dB

Fishing gear

The vessel has one small four-panel Åkrahamn pelagic trawl, one MultPelt 624 trawl (Figure 1, new in 2017) and one 'Gisund super bottom trawl'. All trawls were used during the survey. The smallest pelagic trawl has 8 to 12 m vertical opening under normal operation, whereas the MultPelt 624 trawl has 25 to 35 m opening.

The bottom trawl has a 31-m headline and a 47-m footrope fitted with a 12" rubber bobbins gear. The codend has 24 mm meshes. The vertical opening is about 5.5 m. The distance between the wing tips is about 18 m during towing. The sweeps are 40 m long. The trawl doors are 'Thyborøen' combi, 8 m2 and weigh 2000 kg. The door spreading is about 45 m when using restraining rope. Trawling was conducted for species identification only and no restraining rope was therefore used during the survey.

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

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

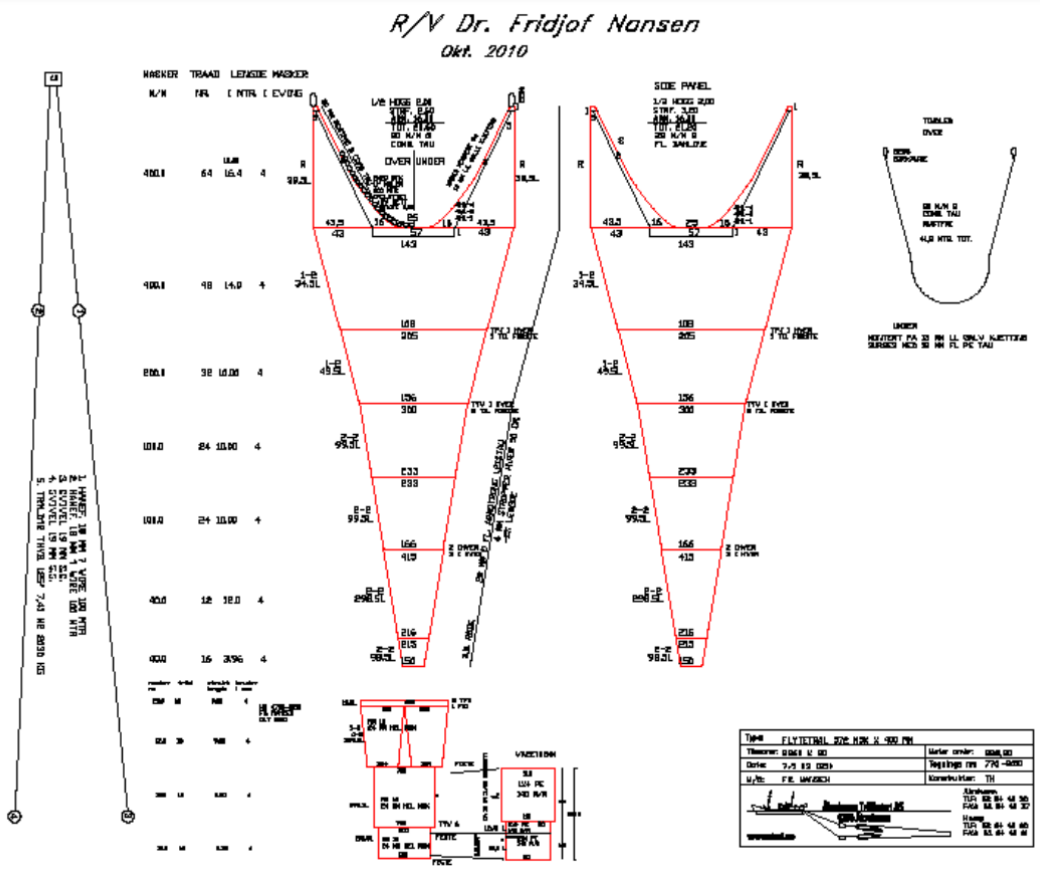


Figure 6.7: Technical drawing of the small pelagic Åkratrawl.

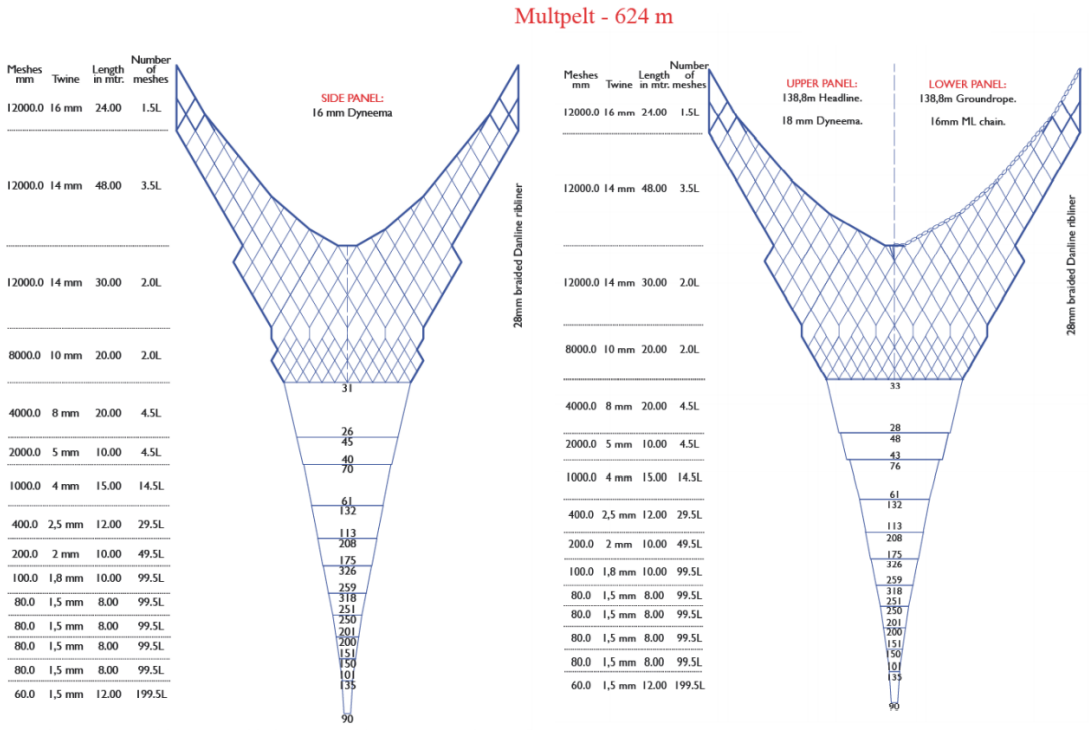


Figure 6.8: Technical drawing of the MultPelt 624 trawl.

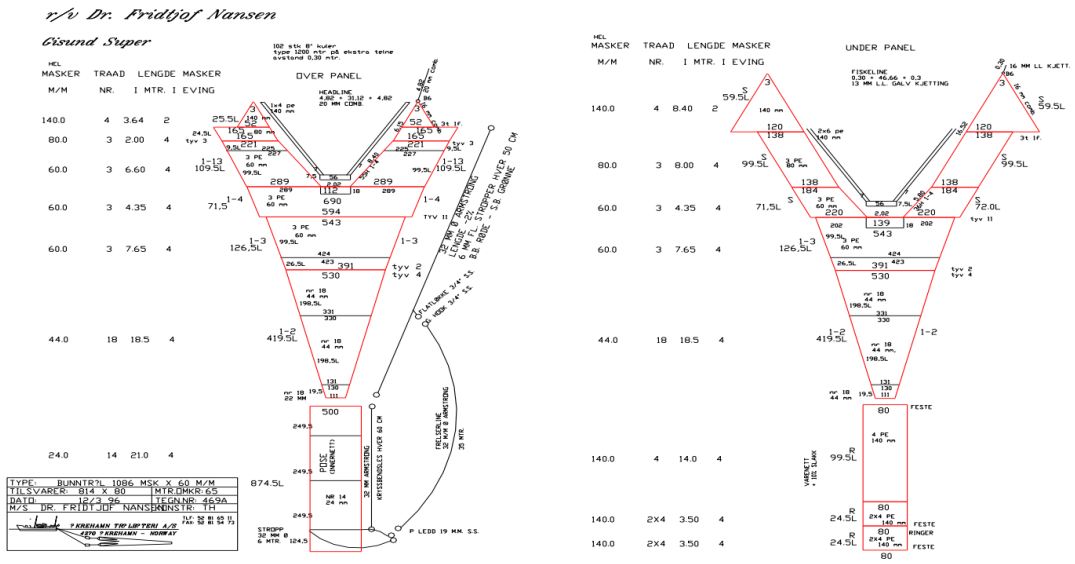


Figure 6.9: Technical drawing of the Gisund Super trawl.

CTD Sensors

Table 6.11: *Quality assurances of the CTD sensors showing the serial number, model, calibration date and station number in which it has been used.*

Type	Serial Number	Model	Calibration Date	Stations
Deck unit	11-1082	SBE 11plus		0443-0543
Pressure sensor	127957	DigiQuartz	21.09.2013	0443-0543
Underwater unit	1160	SBE 9plus 6800m	20.10.2018	0443-0543
Water sampler	32-0972	SBE 32 6800m		0443-0543
Conductivity sensor	3848	SBE 4C 6800m	08.07.2021	0443-0543
Conductivity sensor	2798	SBE 4C 6800m	22.04.2021	0443-0543
Oxygen sensor	3527	SBE 43 7000m	18.06.21	0443-0479
Oxygen sensor	3115	SBE 43 7000m	18.06.21	0480-0543
Submersible pump	52147	SBE 5T	2014	0443-0543
Submersible pump	54196	SBE 5T		0443-0543
Temperature sensor	1527	SBE 3plus 6800m	07.05.2021	0443-0543
Temperature sensor	1166	SBE 3plus 6800m	13.07.2021	0443-0543
Fluorometer	4892	FLRTD G4 0-125 µg	08.11.2017	0443-0543
Sonar Altimeter	71815	Benthos PSA-916	01.04.2018	0443-0483
Altimeter	76741	Valeport VA500	06.04.2021	0484-0543
PAR sensor	1123	PAR-LOG ICSW	12.10.2017	0443-0543

Thermosalinograph Sensors – 4 m water intake

Table 6.12: *Quality assurances of the Thermosalinograph Sensors (4 m water intake) showing the serial number, model, calibration date and dates it has been used.*

Type	Serial Number	Model	Calibration Date	Usage Dates
Thermosalinograph	3418	SBE21	07.07.2020	19.11.21-09.12.21[1]
Conductivity sensor	3418	SBE21	07.07.2020	19.11.21-09.12.21[2]
Temperature sensor (Int)	3418	SBE21	07.07.2020	19.11.21-09.12.21[3]
Temperature sensor (Ext)	903	SBE38	05.02.2020	19.11.21-09.12.21[4]
Fluorometer	WS1S-257S	Wet Labs	20.04.2015	19.11.21-03.12.2021
Turbidity sensor	2300402	Turner	2019	Didn't work

[1]TSG 3418 needed maintenance on 04.12.2021. No data were recorded on these days; [2]TSG 3418 needed maintenance on 04.12.2021. No data were recorded on these days; [3]TSG 3418 needed maintenance on 04.12.2021. No data were recorded on these days; [4]TSG 3418 needed maintenance on 04.12.2021. No data were recorded on these days

Thermosalinograph Sensors – 6 m drop keel water intake

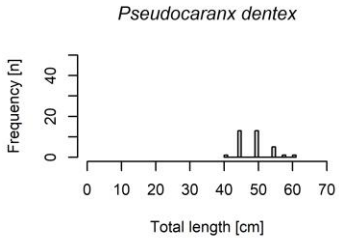
Table 6.13: *Quality assurances of the Thermosalinograph Sensors (6 m water intake) showing the serial number, model, calibration date and dates it has been used.*

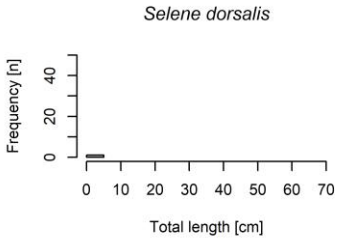
Type	Serial Number	Model	Calibration Date	Usage Dates
Thermosalinograph	3419	SBE21	09.03.2021	20.11.21-09.12.21[1]
Conductivity sensor	3419	SBE21	09.03.2021	20.11.21-09.12.21[2]
Temperature sensor (Int)	3419	SBE21	09.03.2021	20.11.21-09.12.21[3]
Temperature sensor (Ext)	880	SBE38	26.11.2020	20.11.21-09.12.21
Fluorometer	WS1S-257S	Wet Labs	20.04.2015	03.12.21-09.12.21
Turbidity sensor	2300402	Turner	2019	Didn't work

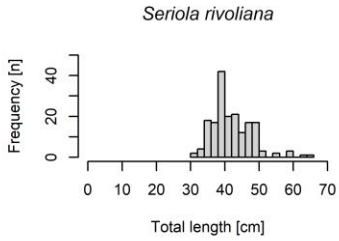
[1]TSG 3419 needed repair from 23.11.21 to 26.11.21. No data were recorded on these days; [2]TSG 3419 needed repair from 23.11.21 to 26.11.21. No data were recorded on these days; [3]TSG 3419 needed repair from 23.11.21 to 26.11.21. No data were recorded on these days

ANNEX III - LENGTH DISTRIBUTION OF MAIN SPECIES

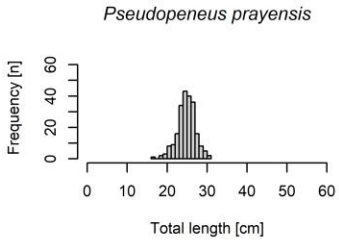
Pelagic species

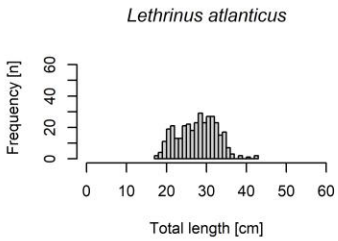


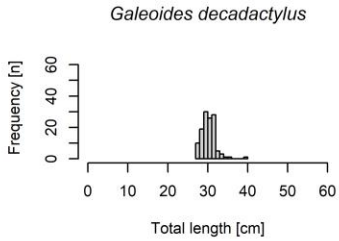


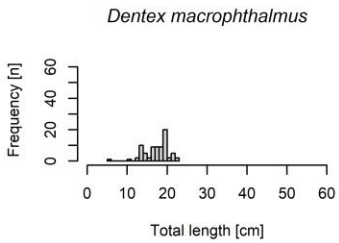


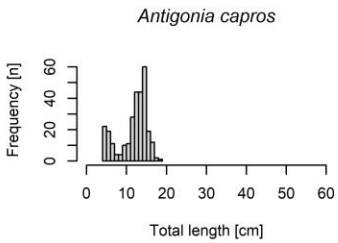
Demersal species

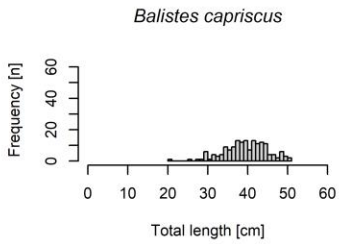


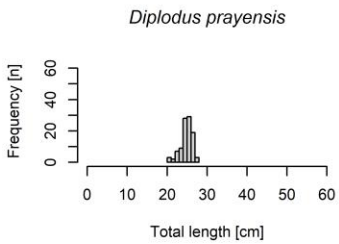


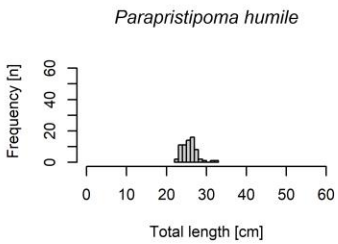


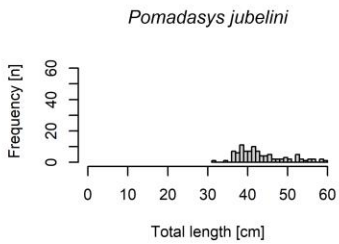


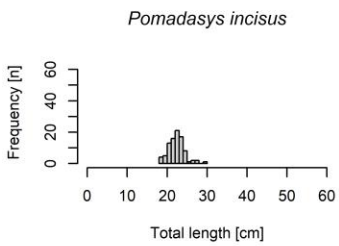


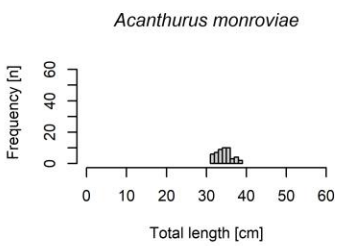


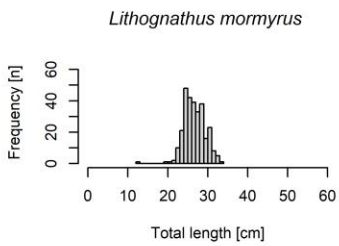












ANNEX IV - MATURITY AND SEX

Table 6.14: *Sex and maturity information for priority taxa*

Sex	**Female**	**3**	**4**	**5**	**6**	**7**	**Male**	**9**	**10**	**11**	**12**	**13**
Maturity	1	2	3	4	5	Total	1	2	3	4	5	Total
Apristurus laurussonii	n.d.						2	2				4
Auxis thazard	3	8				11						
Centrophorus uyato			3			3		4				4
Centroscymnus crepidater	n.d.						1					1
Centroscymnus owstonii	2					2						
Dasyatis sp.	n.d.							2				2
Leptocharias smithii		2				2		10				10
Lithognathus mormyrus	3	30	60	144		237	2	6	21	120	5	154
Mulloidichthys martinicus	n.d.							8	3	4		15
Mustelus mustelus	n.d.						14	66				80
Paragaleus pectoralis	n.d.						4	6	3			13
Pseudopeneus prayensis	5	30	57	176	5	273	10	28	75	52		165
Raja herwigi	n.d.						2	8				10
Rhizoprionodon acutus	n.d.						3	4			5	12
Selar crumenophthalmus	1					1	1					1
Taeniura grabata	n.d.							4				4
Torpedo sp.	n.d.						1					1

n.d. = not determined

ANNEX V - CAPACITY BUILDING

Table 6.15: *Overview of the presentations given during the survey*

Date	Title	Name
19.11	Safety briefing and daily life on board	Kathrine Michalsen
20.11	Presentation of the sailing order	Kathrine Michalsen
21.11	Briefing and preparations for the work in the various lab's	Team leaders
22.11	Briefing and preparations for the work in the various lab's continues	Team leaders
23.11	Summing up of the benthos results from 2011	Keider Neves
23.11	Presentation about Cabo Verde (history, daily life, economy, culture)	Anibal Medina and Rui Freitas
27.11	«Ex-post evaluation of fishery policy interventions on Decepaterus macarellus stock recovery in northern Cabo Verde»	Katelene Delgado
1.1200000000000001	Biodiversity in Cabo Verde	Rui Freitas
4.12	Ocean circulation and hydrodynamic connectivity between the Cabo Verde Islands	Anibal Medina
6.12	Guided tour on the bridge – Captain	Aron Håpoldøy
7.12	Presentation of IMar and the institute's statistics	Vito Ramos
8.1199999999999992	Guided tour in the engine	Jostein Møvik
9.1199999999999992	Presentation of IEO	Francisca A. Salmeron Jimenez
10.119999999999999	Presentation of otolith work for Spicara melanurus	Alciany Luz
11.12	Guided tour in the acoustic lab – Olaf	Olaf Sørås
12.12	Presentation of the CVOO	Péricles Silva
13.12	Summing-up meeting with presentations of work on board; Plankton lab, CTD lab, Physical oceanography, Fish lab, Acoustics, Comparison with the survey results from 2011	Various Teams
14.12	Survey report	All

ANNEX VI - SAMPLE OVERVIEW

Table 6.16: *Samples collected, preservation and follow-up work*

Sample number	Sample Type	Analysis	Preservation	Quantity of samples	Port of offloading	Transport method	Receiving country	Receiving institution	Responsible at Receiving Institution
20214407-001	Water samples	Dissolved Inorganic Carbon / Total alkalinity	None	14	Las Palmas	Private to IEO, further arrangements by FAO	Cabo Verde	Imar	Pericles Silva " <pericles.silva@oscm.cv>
									"Björn Fiedler"
									bfiedler@geomar.de
20214407-002	Phytoplankton	Phytoplankton community composition	Lugol solution	5 x 100 mL amber glass bottles	Las Palmas	Air freight	Norway	IMR,	Lars Naustvoll
								Institute of Marine Research	Larsjn@hi.no
								Algae Laboratory v / Lars Naustvoll	
								New Flødevigsveien 20	
								4817 His	
20214407-003	Zooplankton - WP2	Biomass estimation	Dried and then frozen	101 x aluminum trays	Las Palmas	Sea freight	Norway	IMR, Bergen	Stamatina Isari
20214407-004	Zooplankton - WP2	Community identification	4% for maldehyde	35 x 100 mL bottles	Las Palmas	Private to IEO, further arrangements by FAO	Spain/Cabo Verde	Taken care of by IEO, then reshipped to Imar	Elizandro
20214407-005	Zooplankton - Midi	Community identification	4% for maldehyde	5 x 100 mL bottles	Las Palmas	Private to IEO, further arrangements by FAO	Spain/Cabo Verde	Taken care of by IEO, then reshipped to Imar	Elizandro

Sample number	Sample Type	Analysis	Preservation	Quantity of samples	Port of offloading	Transport method	Receiving country	Receiving institution	Responsible at Receiving Institution
2021407-006	Zooplankton - Mammoth 180 µm (Nola)	Genetics	absolut ethanol	26 (14 x 100 mL + 12 x 250 mL bottles)	Las Palmas	Air freight	Norway	IMR, Bergen	Stamatina Isari
2021407-007	Zooplankton - Mammoth 180 µm (Nola)	Community identification	4% for maldehyde	26 (19 x 100 mL + 7 x 250 mL)	Las Palmas	Air freight	Norway	IMR, Bergen	Stamatina Isari
2021407-008	Ichtyoplankton - Mammoth 405 µm (Nola)	Ichthyoplankton identification, genetics	absolut ethanol	161 (152 x 100 mL + 9 x 250 mL)	Las Palmas	Air freight	Norway	IMR, Bergen	Stamatina Isari
2021407-009	Ichtyoplankton - Mammoth 405 µm (replacement Bongo)	Community identification	absolut ethanol	3 (3 x 250 mL)	Las Palmas	Air freight	Norway	IMR, Bergen	Stamatina Isari
2021407-010	Ichtyoplankton - Mammoth 405 µm (replacement Bongo)	Community identification	4% for maldehyde	3 (2 x 250 mL + 1 x 500 mL)	Las Palmas	Air freight	Norway	IMR, Bergen	Stamatina Isari
2021407-011	Ichtyoplankton - Bongo V	Community identification	4% for maldehyde	32 (8 x 100 mL + 21 x 250 mL + 3 x 500 mL)	Las Palmas	Air freight	Norway	IMR, Bergen	Stamatina Isari
2021407-012	Ichtyoplankton - Bongo H	Community identification	absolut ethanol	32 (8 x 100 mL + 22 x 250 mL + 2 x 500 mL	Las Palmas	Air freight	Norway	IMR, Bergen	Stamatina Isari
2021407-013	Ichtyoplankton - Bongo H	Species identification, Genetics	absolut ethanol	6 x 20 mL scintillation vials	Las Palmas	Air freight	Norway	IMR, Bergen	Stamatina Isari

Sample number	Sample Type	Analysis	Preservation	Quantity of samples	Port of offloading	Transport method	Receiving country	Receiving institution	Responsible at Receiving Institution
20214407-0144	Ichtyoplankton - Manta	Species identification, Genetics	absolut ethanol	26 x 20 mL scintillation vials	Las Palmas	Air freight	Norway	IMR, Bergen	Stamatina Isari
20214407-0155	Neuston	Community identification	absolut ethanol	26 (17 x 100 mL + 8 x 250 mL + 1 x 500 mL)	Las Palmas	Air freight	Norway	IMR, Bergen	Stamatina Isari
20214407-0166	Microplastics	Abundance and chemical composition	In fresh water	5 x 2 mL eppendorf	Las Palmas	Air freight	Norway	IMR, Bergen	Bjørn Einar Grøsvik
20214407-0177	Microplastics	Detection of microplastics in filtered seawater in plankton lab	Seawater	2 x 500 mL	Las Palmas	Air freight	Norway	IMR, Bergen	Bjørn Einar Grøsvik
20214407-0188	Water samples	Nutrients in seawater- to be analysed on board end-February 2022	Frozen		Samples remain on board	Samples remain on board	Samples remain on board	Samples remain on board	David Cervantes
20214407-0199	Whole fish	Taxonomic identification - problematic sp according to list	Frozen	11 zip lock bags	Las Palmas	Road/private to IEO, further arrangements by FAO	Spain	IEO	Pepe/Peter
20214407-0200	Whole fish	Taxonomic identification - unknown/problematic sp	Frozen /10 % formalin	67 zip lock bags	Las Palmas	Private to IEO, further arrangements by FAO	Spain	IEO	Pepe
20214407-0211	Whole fish	Taxonomic identification – Post survey training course	Frozen	84 zip lock bags	Las Palmas	Private to IEO, further arrangements by FAO	Spain	IEO	Pepe

Sample number	Sample Type	Analysis	Preservation	Quantity of samples	Port of offloading	Transport method	Receiving country	Receiving institution	Responsible at Receiving Institution
2021407-022	Whole fish	Taxonomic identification-IMR Training course	Frozen	43 zip lock bags	Las Palmas	Sea freight	Norway	IMR, Bergen	Sarah/Ines/ Diana
2021407-023	Whole fish	Nutrition and Food Safety	Frozen	5 zip lock bags	Las Palmas	Sea freight	Norway	IMR, Bergen	Mariann Kjellevold
2021407-024	Whole fish	Museum collection	20% formalin	50 zip lock bags	Las Palmas	Private to IEO, further arrangements by FAO	Spain/Cabo Verde	Taken care of by IEO, then reshipped to Imar	Alciany Luz
2021407-025	Invertebrates	Taxonomic identification/museum collection	4% buffered formalin		Las Palmas	Private to IEO, further arrangements by FAO	Spain/Cabo Verde	Taken care of by IEO, then reshipped to Imar	Keider Neves
2021407-025	Sargassum	Genetics/Morphometrics	Frozen	3 zip lock bags + 2 x 20 mL scintillation vials (ethanol)(from plankton sampling)	Las Palmas	Sea freight	Norway	IMR, then reshipped to Fisheries Commission	Stamatina Isari/ Maame Esi Bordah Quayson
								Min of Fisheries and Aquaculture Development	

ANNEX VII - DATA COLLECTED AND OVERVIEW OF PROCEDURES FOR DATA HAND-OVER TO PARTNERS

Table 6.17: *Data collected and overview of procedures for data hand-over to partners (all collected data will be stored at the IMR server)*

Survey no 2021402	Data	after the survey	at the post survey meeting	upon request	not collected stored	analyzed by partner country	analyzed through the Science Plan
Data types							

Survey no 2021402	Data	after the survey	at the post survey meeting	upon request	not collected stored	analyzed by partner country	analyzed through the Science Plan
Acoustic data	EK80 narrowband (CW)		x				
Acoustic data	EK80			x			
Acoustic data	MS70				x		
Acoustic data	ME70				x		
Acoustic data	SU90			x			
Acoustic data	SH90				x		
Acoustic data	SBP300				x		
Acoustic data	EM302				x		
Acoustic data	EM710				x		
Physics	CTD probe	x					
Physics	CTD Underway				x		
Physics	ADCP 75kHz				x		
Physics	ADCP 150kHz	x					
Physics	LADCP				x		
Physics	Thermosalinograph	x					
Physics	Nutrients		x				
Physics	pH	x					
Physics	Total alkalinity	x					
Physics	PCO2	x					
Physics	Chlorophyll	x					
Biology	Trawl catch data	x	x				
Biology	Zooplankton biomass		x				
Biology	Phytoplankton		x				
Pollution	Microplastics						x
Observation platforms	VAMS				x		
Observation platforms	WBAT				x		

Survey no 2021402	Data	after the survey	at the post survey meeting	upon request	not collected stored	analyzed by partner country	analyzed through the Science Plan
Observation platforms	Deep vision				x		
Observation platforms	Scanmar			x			
Observation platforms	Activity diary (cruise logger)	x					
Observation platforms	Nansis survey backup			x			