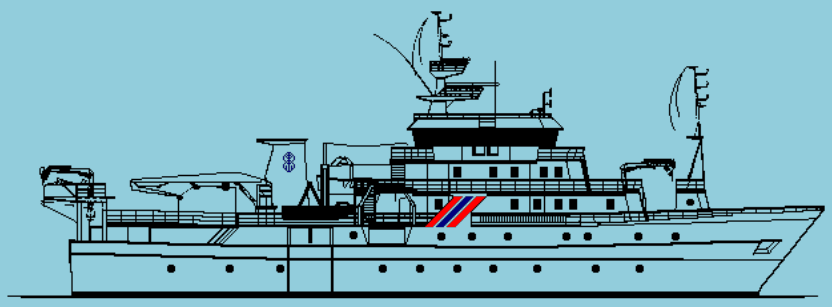

Recruitment studies on anchovy *Engraulis encrasicolus* and sardinella *Sardinella aurita* and *S. maderensis* in the coastal waters of Guinea, Guinea Bissau, Senegal and the Gambia

Cruise Report No 4/2013

1 – 23 May 2013

Centre de Recherches Océanographiques de *Dakar*-Thiaroye, Senegal

Institute of Marine Research, Bergen, Norway

Department of Fisheries Banjul, The Gambia

Instituto Nacional De Desenvolvimento Das Pescas, Cape Verde

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THE EAF-NANSEN PROJECT

FAO started the implementation of the project “Strengthening the Knowledge Base for and Implementing an Ecosystem Approach to Marine Fisheries in Developing Countries (EAF-Nansen GCP/INT/003/NOR)” in December 2006 with funding from the Norwegian Agency for Development Cooperation (Norad). The EAF-Nansen project is a follow-up to earlier projects/programmes in a partnership involving FAO, Norad and the Institute of Marine Research (IMR), Bergen, Norway on assessment and management of marine fishery resources in developing countries. The project works in partnership with governments and also GEF-supported Large Marine Ecosystem (LME) projects and other projects that have the potential to contribute to some components of the EAF-Nansen project.

The EAF-Nansen project offers an opportunity to coastal countries in sub-Saharan Africa, working in partnership with the project, to receive technical support from FAO for the development of national and regional frameworks for the implementation of Ecosystem Approach to Fisheries management and to acquire additional knowledge on their marine ecosystems for their use in planning and monitoring. The project contributes to building the capacity of national fisheries management administrations in ecological risk assessment methods to identify critical management issues and in the preparation, operationalization and tracking the progress of implementation of fisheries management plans consistent with the ecosystem approach to fisheries.

LE PROJET EAF-NANSEN

La FAO a initié la mise en oeuvre du projet "Renforcement de la base des connaissances pour mettre en œuvre une approche écosystémique des pêcheries marines dans les pays en développement (EAF-Nansen GCP/INT/003/NOR)" en décembre 2006. Le projet est financé par de l'Agence norvégienne de coopération pour le développement (Norad). Le projet EAF-Nansen fait suite aux précédents projets/ programmes dans le cadre du partenariat entre la FAO, Norad et l'Institut de recherche marine (IMR) de Bergen en Norvège, sur l'évaluation et l’aménagement des ressources halieutiques dans les pays en développement. Le projet est mis en oeuvre en partenariat avec les gouvernements et en collaboration avec les projets grands écosystèmes marins (GEM) soutenus par le Fonds pour l’Environnement Mondial (FEM) et d'autres projets régionaux qui ont le potentiel de contribuer à certains éléments du projet EAF-Nansen.

Le projet EAF-Nansen offre l’opportunité aux pays côtiers de l'Afrique subsaharienne partenaires de recevoir un appui technique de la FAO pour le développement de cadres nationaux et régionaux visant une approche écosystémique de l’aménagement des pêches et la possibilité d'acquérir des connaissances complémentaires sur leurs écosystèmes marins. Ces éléments seront utilisés pour la planification et le suivi des pêcheries et de leurs écosystèmes. Le projet contribue à renforcer les capacités des administrations nationales responsables de l’aménagement des pêches en introduisant des méthodes d'évaluation des risques écologiques pour identifier les questions d’aménagement d’importance majeure ainsi que la préparation, la mise en œuvre et le suivi des progrès de la mise en œuvre de plans d’aménagement des ressources marines conformes à l'approche écosystémique des pêches.

CRUISE REPORTS "DR. FRIDTJOF NANSEN"

Recruitment studies on anchovy *Engraulis encrasicolus* and sardinella *Sardinella aurita* and *S. maderensis* in the coastal waters of Guinea, Guinea Bissau, Senegal and the Gambia

by

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Bergen, 2014

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CHAPTER 1 INTRODUCTION

General objectives

This aim of the survey was to define the distribution of eggs and larvae of sardinella and anchovy in the region south of Cape Vert. The horizontal and vertical distributions of the eggs and larvae were mapped and related to mapping of water mass circulation and frontal boundaries.

Specific objectives of the survey

1. Identify the distribution area of sardinella (*Sardinella aurita* and *S. maderensis*) and anchovy (*Engraulis encrasicolus*) egg and larvae south of Cape Vert
2. Identify oceanographic features affecting their distribution
3. Explain the retention and distribution mechanisms for eggs and larvae in the survey area

Participation

The scientific members during the cruise were:

From Institute of Marine Research Norway:
Erling Kåre Stenevik (Cruise leader 1/5-7/5), Jens-Otto Krakstad (Cruise leader 8/5-23/5), Tore Mørk, Jan Arne Vågenes (until 7/5), Håkon Langøen (from 8/5), Espen Bagøien, Tor Ensrud, Marek Ostrowski (from 8/5) and Inês Bernardes

From Instituto Nacional De Desenvolvimento Das Pescas, Cape Verde:
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Independent consultants:
Abdoulaye Djiba and Koenraad Van Waerebeck

Narrative

The vessel left Dakar on the 1.5.2013 at 15:10 after a survey meeting onboard together with representatives of the CCLME where the general sampling program was agreed on. It was agreed to cover the main spawning grounds of sardinella between Cape Vert and Guinea and to observe possible changes in egg and larvae distribution between the two coverage's. Between these, a few days were set aside for more in depth process studies to map the oceanographic conditions responsible for the egg and larva distribution.
The sampling started immediately after leaving port with three CTD and WP2 transects across the shelf at 14°N, 13°15'N and at 12°N. The southern limit of the survey region and the start of the first coverage were reached on the 3/5. at 08:45. Sampling stations (10 NM distance) with CTD, WP2 and multinet (one net from bottom to surface) were set out on transects starting from 20 m bottom depth continuing offshore perpendicular to the coast to roughly 1000 m depth. The transects were spaced 15 NM apart. On the 6/5 the vessel had almost surveyed the whole region south of Dakar, when it had to break off for a crew change. It returned to Dakar and docked at 11:00 the same day. After the crew change the vessel departed on the 8/5 at 12:25 and returned to complete the 1st survey coverage. This was determined completed on the 10/5 at 20:00 midway between Cayar and St. Louis, when very few egg and larvae had been seen on two consecutive transects. The vessel then steamed southwards to start the process studies off Cape vert. Three oceanographic transects were completed in different directions to describe the distribution and movement of water masses off Cape Vert. During the first survey coverage, dense concentrations of egg and larvae of anchovy were observed on the last transect south of Cape Vert. This transect was repeated with a more detailed coverage to better determine the horizontal and vertical distribution of egg and larvae. The process study of anchovy was completed on the 13/5 at midnight, and the vessel steamed southwards to prepare for the process study of sardine off Casamance where the concentration of sardinella egg and larvae had been observed to be higher during the first coverage. Only very few sardinella larvae were observed in some initial multinet catches in the southern part of the survey area. It was therefore decided to start the second coverage on the 14/5. The coverage was commenced with a CTD transect to capture the oceanographic features. Once this was completed we came into areas with higher sardinella concentrations. We then increased the sampling station density along two transects and used five vertical nets (standard depths) to enable assessment of vertical distribution. Thereafter the sampling was performed using one net only. On the 17/5 at 09:00 in the morning we broke off the survey in the south of Senegal, on the border to the Gambia to celebrate the Norwegian national day. The survey was resumed on the next day at 08:00. During our first transect in Gambia, large concentrations of sardinella eggs and larvae were observed. It was therefore decided to repeat this transect and with the use of 5 nets to assess vertical distributions, and the inter-station distance was now reduced to only 5 nm to obtain an increased horizontal resolution. After

this, the regular sampling program with one net and 10 nm between stations was resumed, and the second coverage was completed in the evening of the 22/5 before the vessel docked in Dakar in the morning of the 23/5.

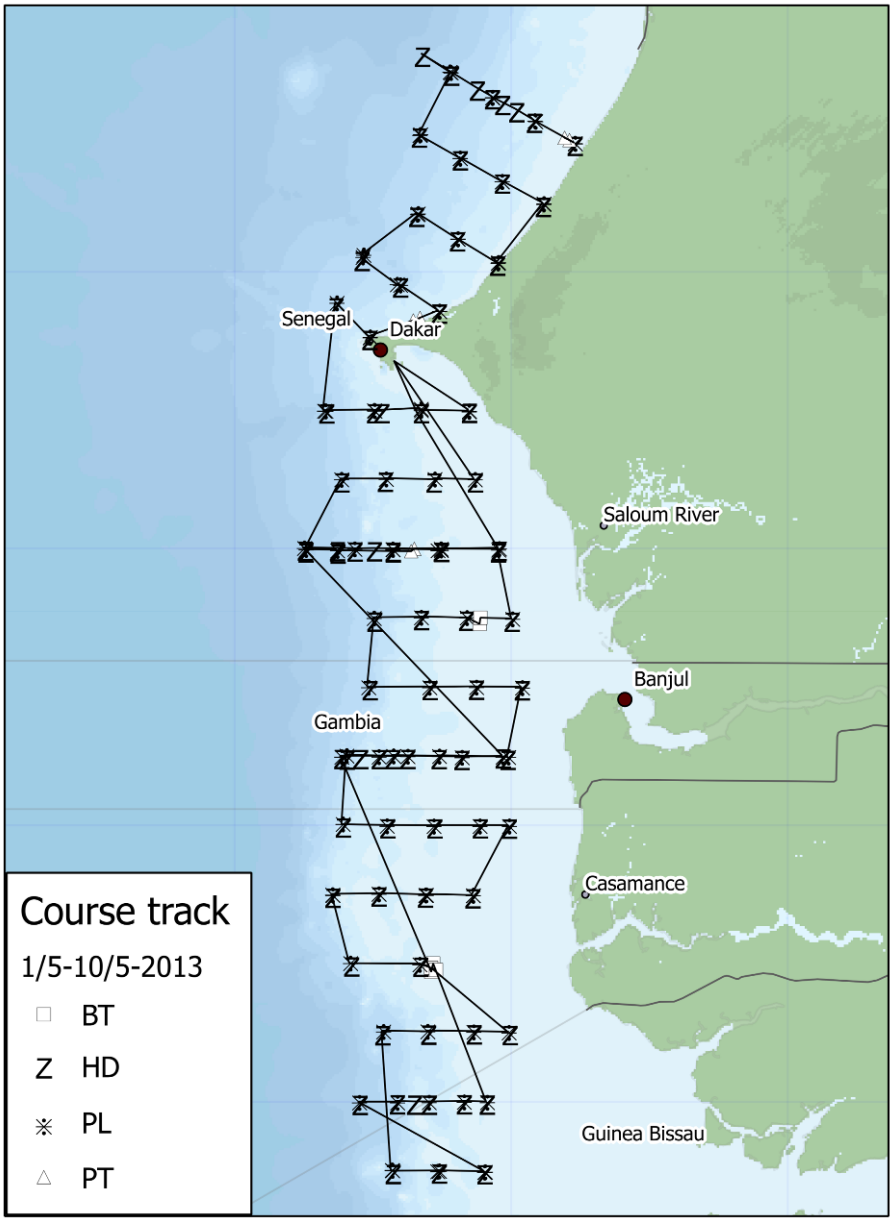

Figure 1.1. Course track Conacry – "Petite Cotê" during the 1st coverage of the survey. Demersal (□) and pelagic (Δ) trawl stations and hydrographic (Z) and plankton (×) stations. Depth contours are indicated.

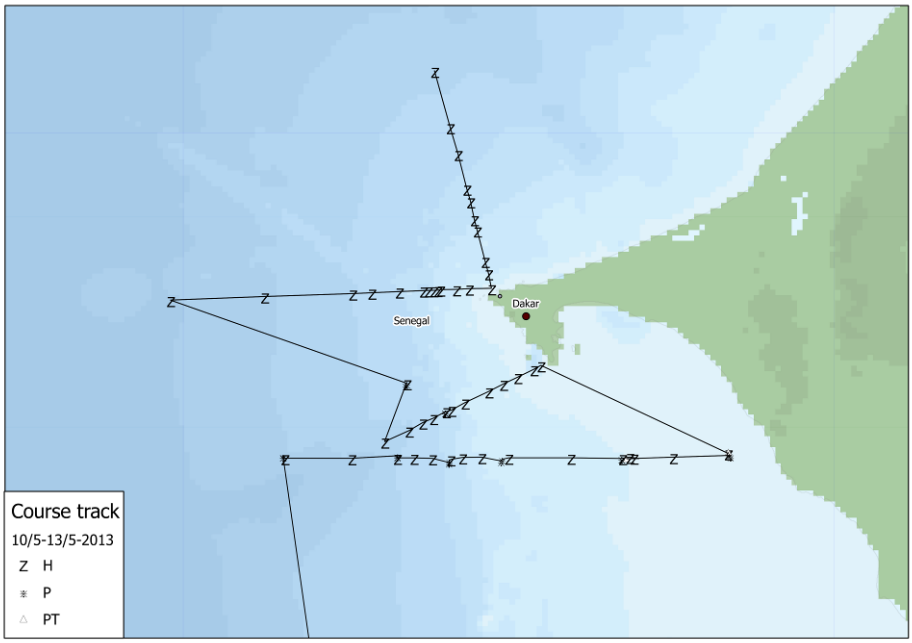

Figure 1.2. Course track Conacry – "Petite Cotê" during the process studies. Demersal (□) and pelagic (Δ) trawl stations and hydrographic (Z) and plankton (×) stations. Depth contours are indicated

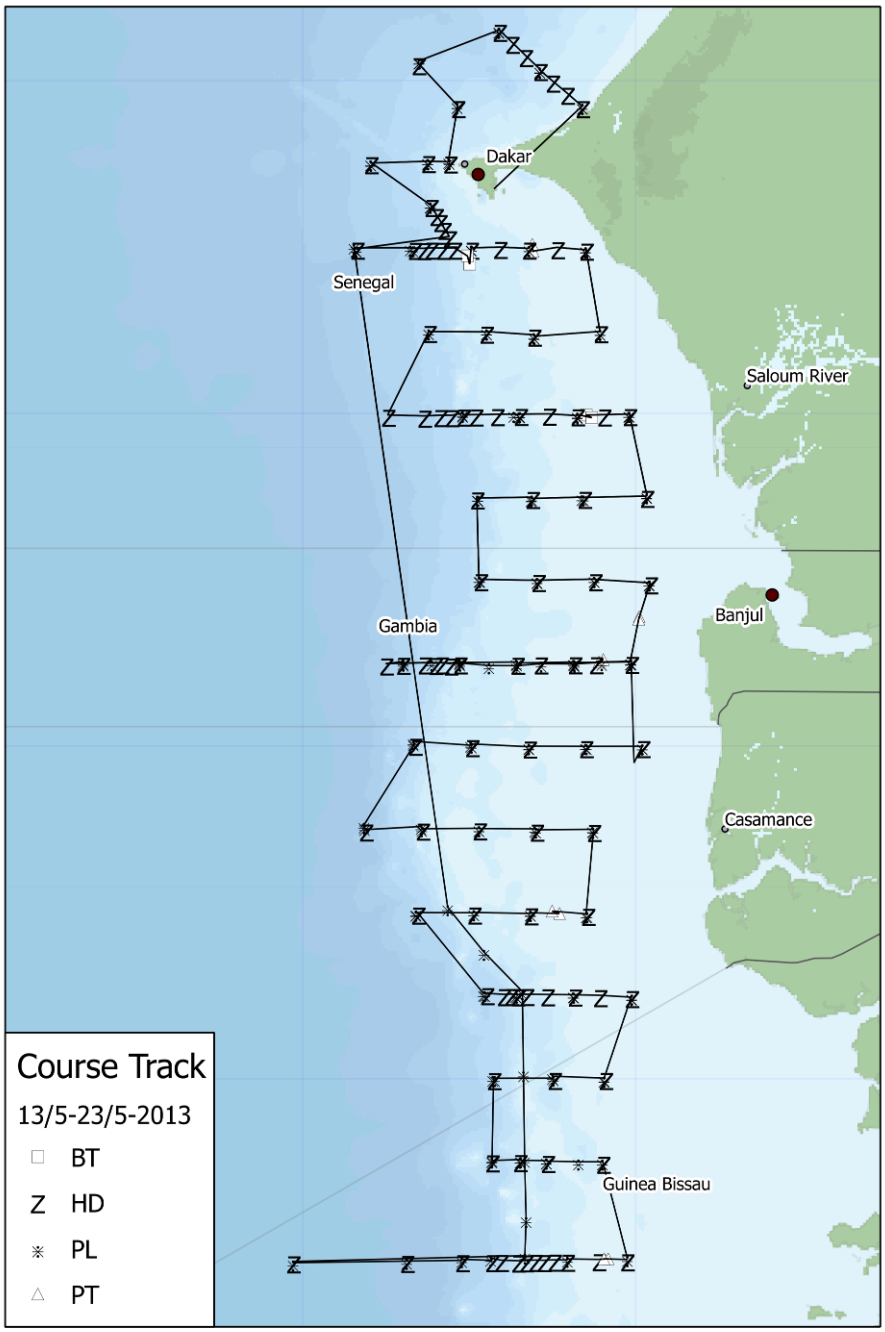

Figure 1.3. Course track Conacry – "Petite Cotê" during the 2nd coverage of the survey. Demersal (□) and pelagic (Δ) trawl stations and hydrographic (Z) and plankton (×) stations. Depth contours are indicated.

CHAPTER 2 METHODS

Meteorological observations

Wind direction and speed, air temperature, air pressure, relative humidity, and sea surface temperature (5 m depth) were logged automatically every 60 sec. with a WIMDA meteorological sensor.

CTD

Vertical temperature and salinity profiles were obtained by a Seabird 911 CTD, while *in situ* concentrations of dissolved oxygen were measured using a CTD-mounted oxygen-sensor. Real time logging and plotting was done using the Seabird Seasave software installed on a PC. Above the shelf and slope, the profiles ranged from the surface to within a few metres above the bottom. Offshore, the maximum sampling depth was 1500 m.

Niskin water-bottles (10 l) attached to a CTD-mounted rosette were used to collect water at predefined depths (see below). For validation of the salinity (conductivity) measurements of the CTD, the salinity of seawater from the Niskin-bottle containing the deepest water-sample from each shallow, intermediately deep, and deep plankton-station was analyzed using a Portasal salinometer (mod. 8410A) onboard the vessel. The salinometer confirmed the CTD sensor data readings.

To validate the oxygen-measurements from the CTD-mounted sensor, concentrations of dissolved oxygen in seawater-samples from the Niskin-bottles were analyzed in the ship laboratory on two occasions during the cruise. Due to time-constraints, a total of only 10 oxygen samples were analyzed. The samples were collected from two stations, and represented various depths within the range of 5-2000m. We analyzed 3 and 7 samples collected from CTD-casts made on the 2nd and 14th of May, respectively. The analyses were made according to the Winkler redox titration method, following the procedures of Hagebø (2008). The oxygen-concentrations calculated from the Winkler method were largely in agreement with the values from the oxygen sensor, although the Winkler levels in all cases were somewhat higher than those from the sensor. The differences between the two methods varied between 0.03-0.3 ml per liter. Whether these differences might reflect an offset of the oxygen-sensor or merely some problem with the Winkler analyses is not clear.

Also attached to the CTD was a Chelsea Mk III Aquatracka fluorometer which measures *in situ* fluorescence on a relative scale. This again, can be related to the absolute chlorophyll concentrations obtained from the analyses of the seawater samples collected from the CTD-attached water-bottles (described below).

Thermosalinograph

The SBE 21 Seacat thermosalinograph was running continuously during the survey, measuring sea surface salinity along with relative temperature (5 m depth) every 10 seconds. An attached in-line Turner Design SCUFA fluorometer measured in situ fluorescence (chlorophyll *a*).

Current speed and direction measurements (ADCP)

A hull-mounted Acoustic Doppler Current Profiler (VMADCP) from RD Instruments was run continuously during the survey. The frequency of the VMADCP is 150 kHz. The system was run in narrow band mode and data were averaged in 8 m vertical bins and stored on files for post survey processing.

Single beam acoustic sampling

Acoustic data were recorded continuously during the survey using a Simrad ER60 scientific echo sounder equipped with keel-mounted transducers at nominal operating frequencies of 18, 38 and 120 kHz. Post processing of acoustic data and separation of backscatters into species groups was done with the software package LSSS.

Chlorophyll

Chlorophyll *a* is a plant pigment, which in oceanography typically is used as an indirect measure for phytoplankton biomass. Seawater samples for analysis of chlorophyll *a* and phaeopigment concentrations were taken at the plankton stations. The samples were collected at predefined depths from rosette-mounted Niskin bottles attached to the CTD. Surface-samples from a manually lowered bucket were also often collected. As a general rule, seawater samples (263 ml) were collected from the standardized depths 0, 5, 10, 25, 50, 75, 100, 150 and 200m, with bottom-depth restricting the number of samples from a given station. In a few cases during the cruise, samples were also taken deeper in the water-column. The seawater samples were filtered on Munktell glass-fiber filters (GF/C, 25 mm diameter) using a custom-made filtration system. During the cruise, the filter-samples were stored at ~ -18°C in the dark for subsequent analysis on shore. After the cruise, the pigment samples were transported to the laboratory in a cooling-box with freezing-elements. The transportation period lasted less than 24h, during which the pigment-samples were held dark. The pigments were then extracted with 90% acetone in darkness over night in the laboratory, and the extracts centrifuged and analysed using a Turner Design fluorometer model 10 AU calibrated with pure chlorophyll *a* (Sigma Inc) (Jeffrey and Humphrey, 1975). Fluorescence was measured before and after acidification by a drop of 5% HCl, and concentrations of chlorophyll *a* and phaeorbides estimated according to Holm-Hansen *et al*. (1965). Note that the sample-temperature must be assumed to have increased during the above-mentioned transportation to the lab, although the samples were still frozen when they arrived at their destination. The possibility of some degradation of chlorophyll can therefore not be rejected.

Hence, we do not discard the possibility of the *in situ* chlorophyll concentrations in the study area actually being higher than here reported.

Biological fish sampling

Trawl hauls were sampled for species composition by weight and number. The deck sampling procedure is described in detail by Strømme (1992). Length measurements were taken for selected target species on most stations. An Electronic Fish Meter (SCANTROL) connected to a customised data acquisition system (Nansis) running on a Windows PC was used for length measurements. The total length of each fish was recorded to the nearest 1 cm, rounding down when this was between sizes. Sex and other biological parameters were collected from the first randomly selected 20-30 individuals of target species.

Zoo- and ichthyoplankton sampling

Zooplankton, including fish eggs and larvae, were collected from the whole study area by a Hydro-Bios Multinet (Anonymous 1990) as well as a WP2-net (Anonymous 1968).

The Multinet was rigged with 5 nets of mesh-size 405 μm for depth-stratified sampling, a pressure sensor and an electronic flow-meter. The side-panel of each cod-end was fitted with mesh-size 180 μm. The purpose of the smaller mesh-size in the side-panels of the cod-ends was to reduce the stress on the fish larvae and eggs in the samples. The typical towing speed of the net was about 1.6 ± 0.4 m s^{-1} (average ± standard deviation).

For the large-scale survey, only the first net of the Multinet was used, covering the entire water-column in areas with bottom-depths less than 200 m, and ranging from 200 m to the surface in deeper areas.

For process studies in selected target areas, up to 5 nets were used to obtain vertically stratified plankton-samples. The number of nets employed at any given station depended on the bottom depth. The following standardized sampling-depths were used: 200-100 m, 100-75 m, 75-50 m, 50-25 m and 25-0 m (or near-bottom – 0 m when shallower).

Once the Multinet was back onboard after a haul, the depth-stratified samples represented by each net were collected. First, all fish larvae were removed from the total sample, and transferred onto Petri-dishes where they were examined under stereomicroscope. Larvae of the species *Sardinella spp.* and *Engraulis encrasicolus* were identified using the key of Olivar and Fortuño (1991), and their standard lengths measured. In most cases the individuals were also photographed for documentation purposes. The fish larvae of these two species were then preserved in 96 % ethanol and/or 4% borax buffered formaldehyde. Likewise, fish larvae belonging to other species were also preserved with ethanol or formaldehyde.

When all the fish larvae had been removed from the Multinet sample, a known fraction of the remaining sample that permitted the enumeration of eggs was examined under stereomicroscope. The fractionating of the sample was made by use of a Motoda plankton splitter (Motoda 1959). The principle of this procedure is to split a homogenised sample into two “equal” parts, which again can be split further depending on the sample size. Fish eggs were sought identified and counted. Moreover, the egg diameters, their embryos as well as the lipid globules were measured. Fractions of the total Multinet samples - without fish larvae - were then preserved in borax buffered formaldehyde.

At most plankton-stations during the large-scale survey, the WP2 plankton-net (56 cm in diameter, mesh-size 180 µm) was applied to sample zooplankton. The WP2 was hauled vertically from 200m (or near the bottom in shallower areas) to the surface with a velocity of ~ 0.5 m s^{-1}. Once a sample was on deck, it was split into two equal parts by use of the Motoda plankton-splitter (Motoda 1959). One half was preserved with borax-buffered formalin resulting in a 4% final concentration to allow for subsequent taxonomic identification of zooplankton on shore. The other half of the sample – unpreserved - was sequentially sieved through three filters to obtain the zooplankton biomass representing the size-fractions >2000 µm, 2000-1000 µm, and 1000-180 µm. The biomass samples were stored on pre-weighed aluminium dishes, and dried at ~70 °C for periods of 6–24 h. Limited storage capacity in the drying chamber restricted the drying period. The samples were thereafter kept frozen at -18°C for subsequent weighing of biomass dry weight on shore (following a second drying period). Many of these samples contained high abundances of very small bivalves that at times dominated the catches completely. The biomasses of these samples were often very high, in many cases with little else than bivalves represented. For this reason, we do not present these or discuss the WP2 biomass results further in this cruise report.

Cetacean visual observations

During the 2013 recruitment survey, the R/V *Dr Fridtjof Nansen* was simultaneously used by two independent scientists (KVW, AD) as a platform-of-opportunity for visual cetacean observations.
The principal aims consist in the set-up of a significant multiple-year dataset which should lead to an improved understanding of spatial and temporal distribution of cetaceans off western Africa, including timing and paths of migration, as well as the documentation of external morphologic data (e.g. intraspecific variation in colouration patterns) that will contribute to population identification studies. All marine mammal sightings were recorded in 'passing mode', i.e. the vessel's operation did not allow closing in on groups of cetaceans as neither course or vessel speed could be modified. The cruise design, dedicated to fisheries and oceanographic research, required multiple daily stations for trawling, CTDs, plankton-net hauls and other experiments. During these operations vessel speed was much reduced, ranging 0-5km/h. Full stops and occasional back-tracking on a completed transect line also occurred.
Such an operational mode evidently was not compatible with a standard marine mammal line transect sampling protocol considering that several key model assumptions remained unfulfilled. Cruise speed between sampling stations fluctuated around 10 knots, a borderline

velocity as many cetacean species can match or exceed this speed. Overall progress (mean velocity) along the main track line was further reduced due to the many stations; hence the probability for the re-sighting of an earlier encountered cetacean group was significant. To address this, same-day and especially successive sightings of similar groups were critically evaluated both in real time and post-effort. Encounter rates, a commonly used measure of relative abundance, will be comparable between-species and perhaps with rates from similar CCLME cruises by *Dr. Fridtjof Nansen*, however comparability with other, non-CCLME, cruises may be limited.

During transit at cruise speed, observers visually scanned the sea from -90° (port) to +90° (starboard) from the radar deck at 14.3 m eye-height above the sea, alternatingly with compass-equipped 7x50 marine binoculars and by naked eye for spotting cetaceans close to the ship. For sightings at great distance (>2km), which were the majority, high-magnification (18x50) hand-held binoculars with image-stabilizer were used to facilitate species identification. During low-speed or stationary sampling activities the platform was treated as a quasi-fixed vantage point and 360° were scanned, considering that the probability of cetaceans approaching from behind the vessel was significantly increased.

The main documented parameters included (see datasheet for full list): species, time, observer(s), first cue, GPS-position and waypoint number, relative position of animals to ship (estimated angle, initial and closest radial distance), group size estimates (minimum, maximum, best), group composition (adults, juveniles, calves), estimated body size, diagnostic or unusual morphological features, behavioural observations, associated species, basic air/sea conditions, voucher material, besides other miscellaneous information. Notable external features and the movement pattern of the group relative to the vessel were often sketched .

Identification of species was made only after full confirmation of species-diagnostic features. Alternatively sightings were assigned to genus or family level only. When species identification was highly probable (P >0.90) but still could not be confirmed, it was registered as a 'like-species' (cf. IWC usage). Whenever feasible voucher photographs were taken with a reflex camera equipped with a 70-300mm zoom lens. For each sighting a sighting data sheet (hardcopy) was filled out. On a separate form all observer effort data were logged, with indications of sea state, swell and the ship's general activity. Detailed data from the vessel's continuous log are also used in the analysis.

CHAPTER 3 OCEANOGRAPHIC CONDITIONS

The Senegalese coast is located at the southern extremity of the Canary Current upwelling region. Production of small pelagic fish in this region is strongly controlled by environmental conditions, and particular by coastal upwelling. Upwelling supports blooming in the coastal ocean by means of rising cold sub-surface masses to the surface and thus supplying nutrients necessary for primary production. The process of upwelling in the Canary Current System is being generally attributed to the wind-driven divergence near the coast caused by alongshore wind.

However, the coastal region to the south of Cap Vert is a special location because it straddles the northern boundary of the tropical Atlantic. In the low latitude systems, such as this, one has to consider also the remote forcing factors, including the ocean basin-scale tilting of the thermocline or current induced shear as a factor controlling upwelling near the coastal boundaries. The preliminary results from the survey with R/V Dr. Fridtjof Nansen support the view that this is likely to be also the case for the southern Senegalese-Gambia coasts.

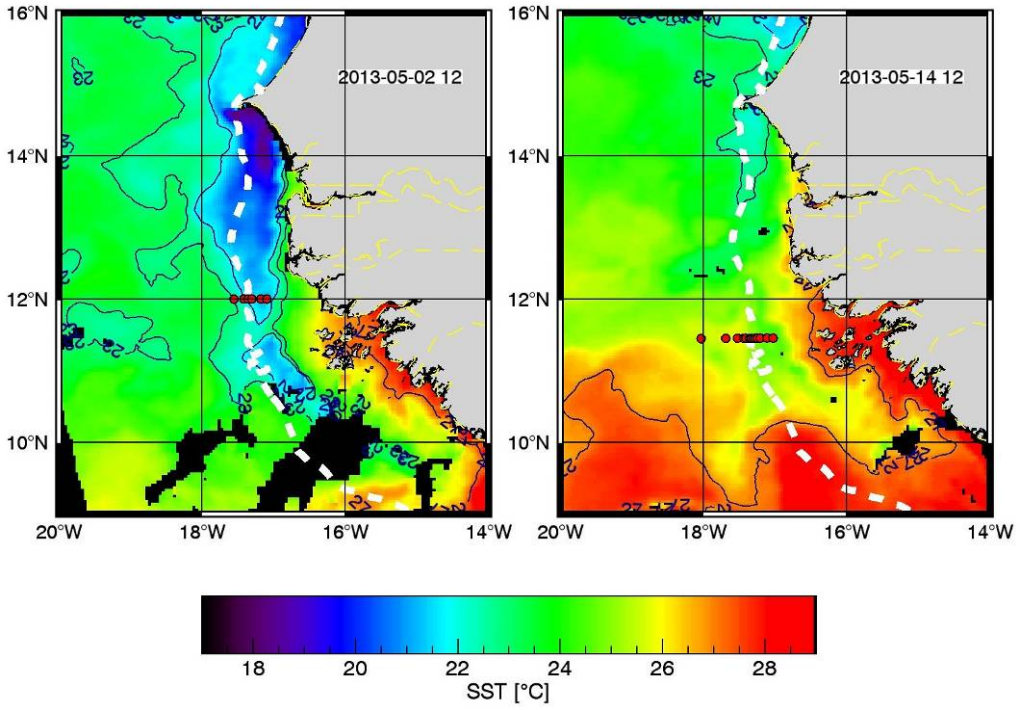

Figure 3. 1 SST The surface temperature expressions of the two type of conditions observed in May 2013. 5-8 May: the cold current flowing southward along the shelf edge; 10-23 May: the northward intrusion of warm water masses along the Guinea coast. Source: daily MODIS Aqua satellite images received onboard. The red dots denote positions of the oceanographic sections depicted in Figure 3. The white broken line follows the 200 m depth contour. The SST is colour coded; the colour scale of the temperature shown below the figure.

In particular, the survey recorded a strong biological response of this section of the coastal ocean to an upwelling event that was caused by a combination of physical forcing factors that included both, a local wind event and remotely controlled large scale tilt of the thermocline

surfacing near the Senegalese coast; the biological response was time-lagged, consisting of an algal bloom followed a week later by spawning event of small pelagic fish.

Figure 1 depicts the sea surface temperature expression of the changing oceanographic conditions during the survey period. During the first week of the survey, between the 2nd and 7th of May, the region experienced a brief spell of a stronger northerly wind. This event resulted in an acceleration of a southward current that flew along the shelf break between the Cap Vert and Guinea for about a week, despite the fact that the current inducing wind-event lasted only for two days. The sea-surface temperature expression of this current, consisting of a pool of water colder than 23°C, continued to manifest itself on the satellite images until May 10. Geostrophic computations based on hydrographic data collected during this period confirmed the existence of this equator-ward flow . After the 10th of May, the equator-ward flow appeared to subside; it signature was no longer detectable from the geostrophic computation, while on the SST-images the only region where sea surface temperature less then 23°C on was observed, was confined to a small sheltered area, located just south of the Cap Vert. This signature appeared to reflect a special case of upwelling; a semi-permanent cell probably maintained specifically downwind of the cape by a combined action of the prevailing northerly winds and of the local topography.

The charts in the top row in Figure 3 demonstrate the results obtained from an oceanographic section that the vessel occupied across the cold water pool seen on the SST image (see Figure 3.1) along the 12°N parallel on May 3. The temperature distribution (top left) exhibits a shallow but a well stratified surface layer on the seaward end of this section. This layer extends down to a depth of 30 m and is terminated by the strong thermocline. The thermal stratification breaks down as one gets closer inshore, in the shelf break region, as the the 20°C isotherm climbs upwards and reveals a presence of a shallow front. Associated with this front is the abovementioned southward flowing coastal jet current; seen in the top center row in Figure 3.2. The concomitant fluorescence distribution (the top right figure) manifests an intense phytoplankton bloom occurring in the well mixed, inshore, portion of the occupied section that is located just shoreward of the core of the southward flow.

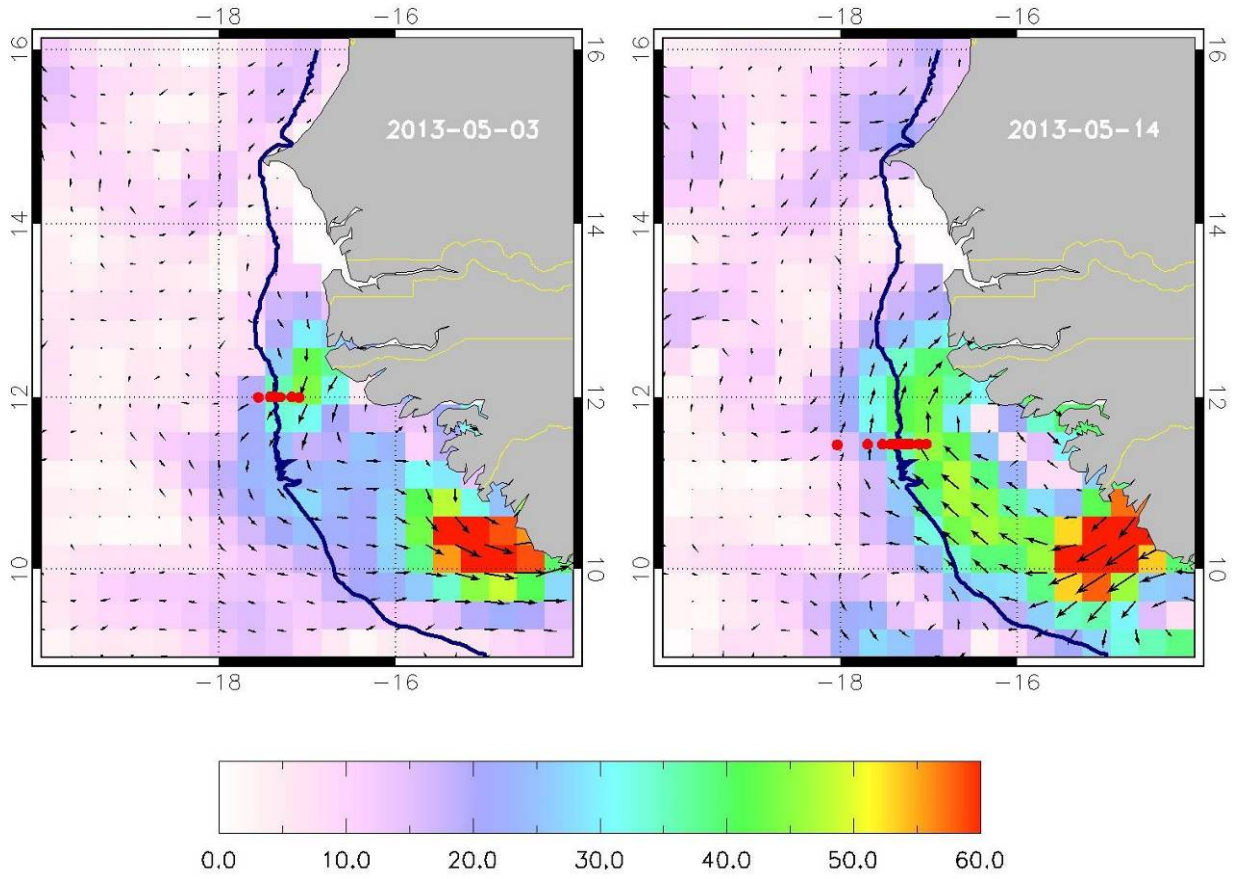

Figure 3. 2 The surface current as derived form satellite altimetry. The current velocities are color-coded; the current direction shown by the arrows. The color scale in cm s^{-1} shown under the figure. The red dots denote positions of the oceanographic sections depicted in Figure 3. The continuous line follows the 200 m depth contour

Although the principal oceanographic patterns that were observed before the 14th of May; the southward surface flow and the blooming on the inner shelf were initiated by a wind event, they persisted long after the wind that caused them had relaxed. And apparently, as indicated by our extensive fluorescence observations (not shown), the blooming in the coastal ocean was maintained at the same high levels throughout the entire survey, in spite of the long period of calm weather and strong stratification over the entire shelf. We attribute this to another form of upwelling, perhaps initialed by a local wind event, but maintained for a much longer period by the presence the ocean scale shallow Atlantic thermocline that is surfacing at the southern Senegalese coast. Indeed, all hydrographic casts that were made at about 30 km from the shelf (an approximate length of the internal Rossby radius) indicate that the thermocline depth was, as shown in Figure 3.3, no deeper than 30 m. This depth range appears to be shallow enough for low energetic processes such as large internal waves or oceanic swell to supply nutrients to the primary production during calm seas, as the pool nutrients that is located just below this shallow thermocline does not require much forcing in order to be uplifted into the euphoric zone depth range.

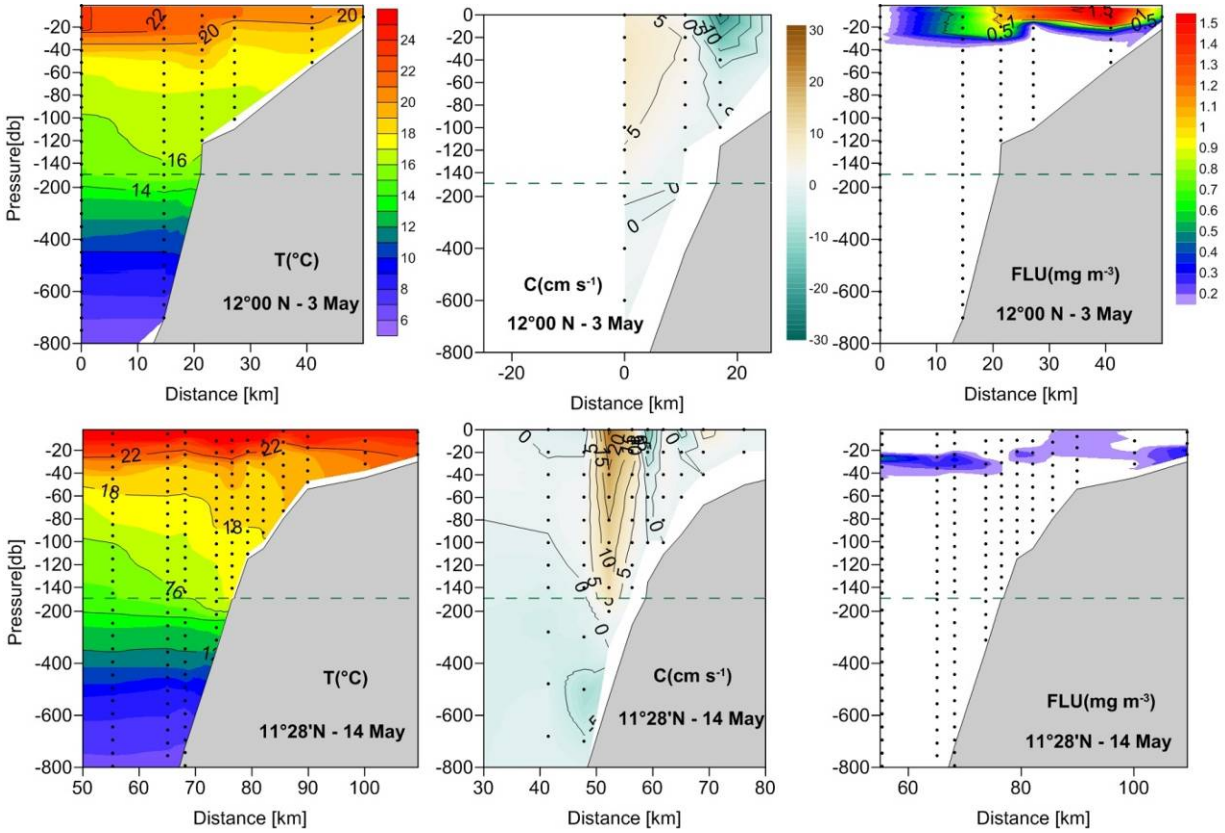

Figure 3.3. Distribution of temperature (left) geostrophic current component across the section and fluorescence along two closely spaced zonal sections at the latitude of 12°N (top) and 11°28'N (bottom), respectively. The parameter values are color coded; the respective color scale is shown to the right of each figure in the top row. The positive current velocities denote the northward flow, the negative ones the southward flow. Note the change in the vertical (pressure) scale at 200 decibars. Note also differing x-axis scales among the figures.

However, one clear case when the productivity on the shelf was inhibited by ocean processes was also observed. On the 14th of May, concomitant with the relaxation of the equatorward flow in the north, a warm front that before the 14th of May 14 stayed confined to the south of 10°N began to advance rapidly towards the north spreading warm waters into the entire Guinea shelf (Figure 3.1, right). Associated with this front was a pole-ward flowing coastal current, along the shelf break. Figure 3.2 depicts the change in the surface flow patterns. After May 14 (Figure 3.2, right), the Guinea region is dominated by the northward flowing current at the shelf break while off Senegal the current is generally weak. On a large spatial scale, the current off Guinea forms a coastally trapped gyral structure with the alongshore radius extending for almost a degree of latitude. The maximum radial velocity within this gyre exceeds 60 cm sec^{-1}. In the region affected by this warm eddy, the conditions for blooming (and hence for pelagic fish reproduction) clearly deteriorate. Figure 3.2, the bottom row, from a section that the vessel occupied along the latitude of 11°28'N, during the period affected by this eddy demonstrates this. The thermocline is depressed shoreward, as the isotherm of 20°C tilts downward in the direction of the coast (left); the northward flowing counter current sets in just off the shelf break (the center bottom figure). Finally, the fluorescence drops by an

order of magnitude with respect to the levels that were observed one week earlier (bottom right).

Towards the end of the survey, this oligotrophic warm-water eddy, first expanded northwards, towards the latitude of 12°N and then retracted southwards along the Guinea coast. To the north of this boundary the high productivity of the shelf seemed to remain unaffected, as all the fluorescence observations that were made in these regions indicate that the blooming event was still ongoing and conditions favourable for pelagic fish feeding and reproduction remained favourable.

Within one week, as the first traces of the algal bloom were captured with the onboard fluorometer, a mass spawning event of sardinella and other small pelagic fishes took place (to be reported separately).

Chlorophyll

The chlorophyll *a* concentrations measured by fluorescence analyses in the laboratory after the cruise was generally higher in near-surface water during the first regional coverage than during the second coverage. This is reflected in Figure 3.4, showing horizontally interpolated levels for depths of ~ 5 m. In this report we use the 5 m levels as an indicator for the phytoplankton situation near the surface. Both coverage's started in the southern part of the study area and progressed northwards. During the first coverage (3. - 10. May) the average chl. *a* concentration at ~ 5 m for all stations in the entire study area was 5.3 mg m^{-3} (standard deviation of 3.9, 50 observations). The range was 0.3 – 19 mg chl. *a* m^{-3}. Shortly after, during the second coverage (14. - 22. May), the average concentration had decreased to 1.9 mg m^{-3} (standard deviation of 2.3, 57 observations). The range was now between 0.1- 9.1 mg chl.*a* m^{-1}. Boxplots for the 5 m concentrations during each coverage are presented in Figure 3.5. For the entire area, when considering all depths during both coverages, the range of the chlorophyll concentrations in our study was between near zero and ~ 19 mg m^{-3}.

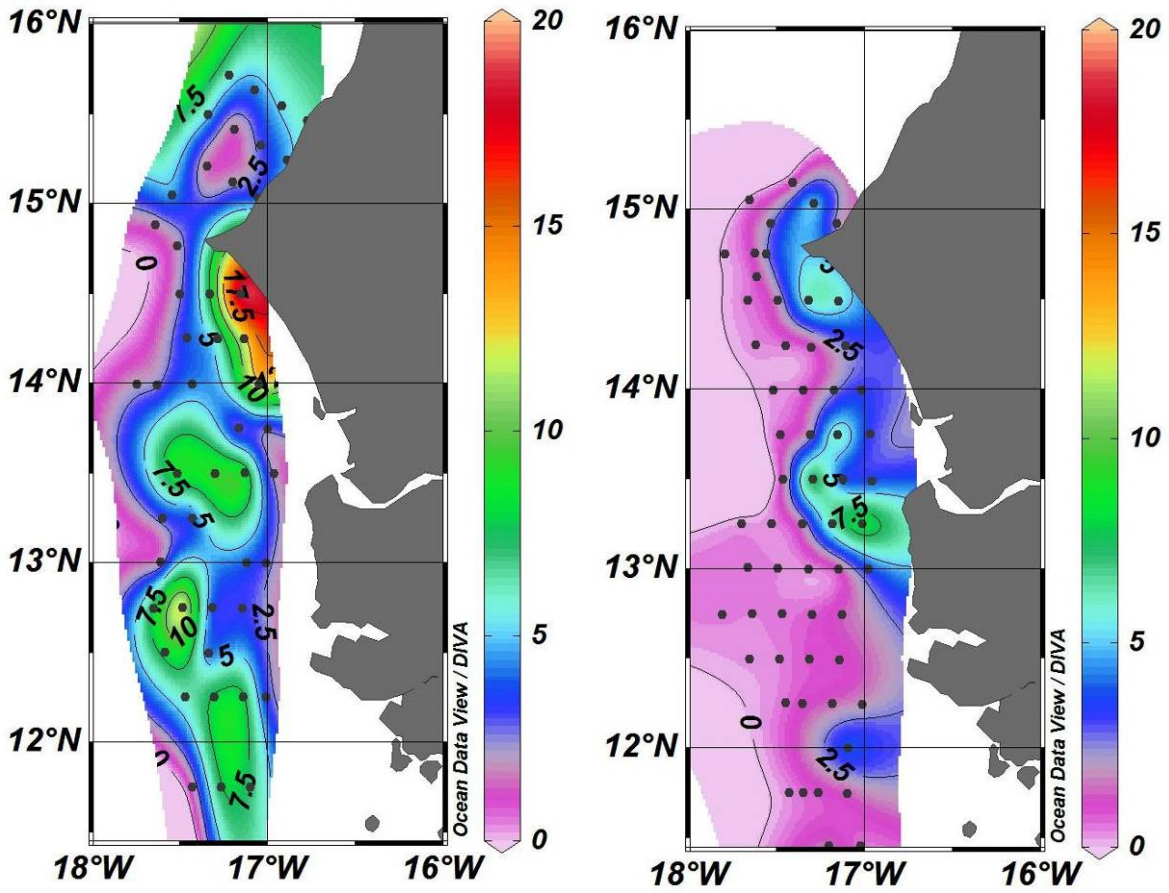

Figure 3.4. Horizontally interpolated concentrations of chlorophyll *a* (mg m^{-3}) at the depth of ~ 5m during the first (left panel) and second (right panel) regional coverages, 3.-10. and 14.-22. May 2013, respectively. Station positions are indicated by black dots. Note that both coverage's started in the southern part of the study area and progressed northwards. Figures produced by the free software "Ocean Data View" (Schlitzer, R., Ocean Data View, http://odv.awi.de, 2013), using the interpolation method "Diva gridding".

A strong phytoplankton bloom took place near the coast off Dakar during the first coverage (see Fig. 3.4). The average chl. *a* concentration at ~ 5 m depth for 5 stations in the area between 14.0 and 15.0 ºN, and -17.0 and - 17.5 ºW), was 9.3 mg m^{-3} (standard deviation of 6.1, and range of 3.9 - 19.2 mg m^{-3}). High chlorophyll levels at 5 m depth also occurred in other areas during this period, particularly further south (Figure 3.4)

During the second coverage (14. - 22. May), the chlorophyll concentrations had decreased in most of the study area (Figures 3.4 and 3.5). Note, however, that some high chlorophyll levels still occurred during this coverage, mainly between 13 - 14° N. In the previously defined local area just off Dakar, the previously very high concentrations had now decreased strongly (average of 2.1 mg m^{-3}, standard deviation of 2.2, range 0.5 - 6.4, 6 observations).

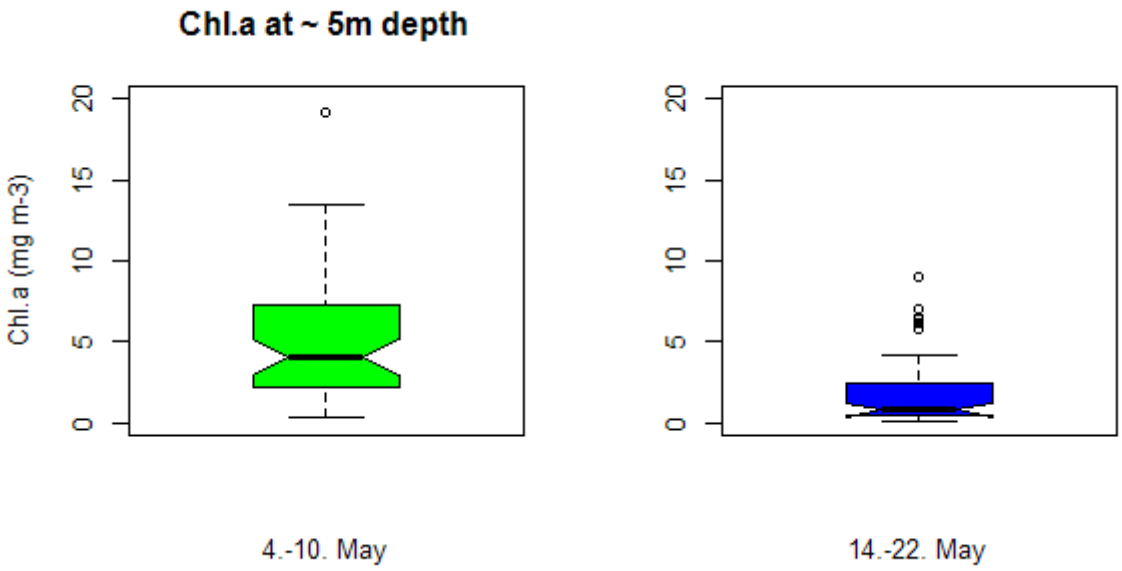

Figure 3.5. Chlorophyll (mg m^{-3}) at depth of ~ 5m for the whole study area depth during the first (left panel, 52 observations) and second (right panel, 57 observations) survey coverages shown as boxplots. The horizontal lines in the boxes represent the medians, and the upper and lower limits of the boxes represent the 25 and 75 percentiles respectively.

Considering vertical distributions during the cruise, the chlorophyll concentrations were highest in the upper part of the water column, and decreasing with depth. While many stations displayed the highest concentrations near the surface, a preliminary evaluation of the data indicates that several stations showed slightly deeper maximum concentrations, for instance at ~ 25m. This will be studied in more detail in the follow-up analyses.

CHAPTER 4 ICHTHYOPLANKTON SAMPLING

Horizontal Distribution of eggs and larvae of sardinella and anchovy

First coverage

Acoustic recordings of pelagic fish was collected during the entire survey. These recordings were used to describe the distribution of adult fish. Trawl samples of these were taken at regular intervals to verify the species composition and to collect biological information. *Sardinella* was the most widely distributed species group observed acoustically on the shelf. During the first survey coverage the fish was found at depths >20 m and the distribution generally ended before the end of the transects. Figure 4.1 illustrates the distribution within the region surveyed. The species was probably distributed both south and north of the surveyed area.

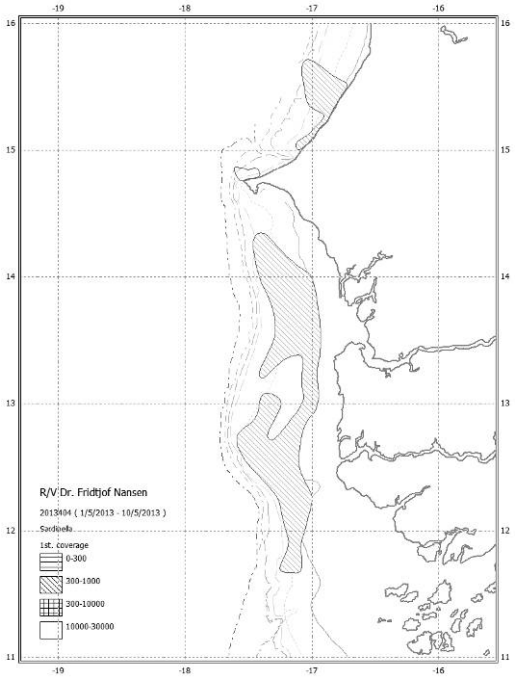

Figure 4.1. Distribution of acoustic recordings of sardinella during the first coverage of the survey area

Very little anchovy was observed acoustically, and all of it was observed in a small area south of Dakar. The schools of anchovy can be found mixed with sardinella of similar size and species separation is difficult to make with confidence. No distribution map was produced from the observations.

The distribution of egg and larvae of anchovy and sardinella during the first coverage of the survey area is described in Figure 4.2. The figure shows that the distribution of sardinella larvae was mainly in the southern part of the survey area while the anchovy eggs were found immediately south of Dakar, while with some larvae also were found further north and south. Looking at the overlaid map of satellite derived SST one observe the relatively cold water masses present in most of the survey area during this coverage.

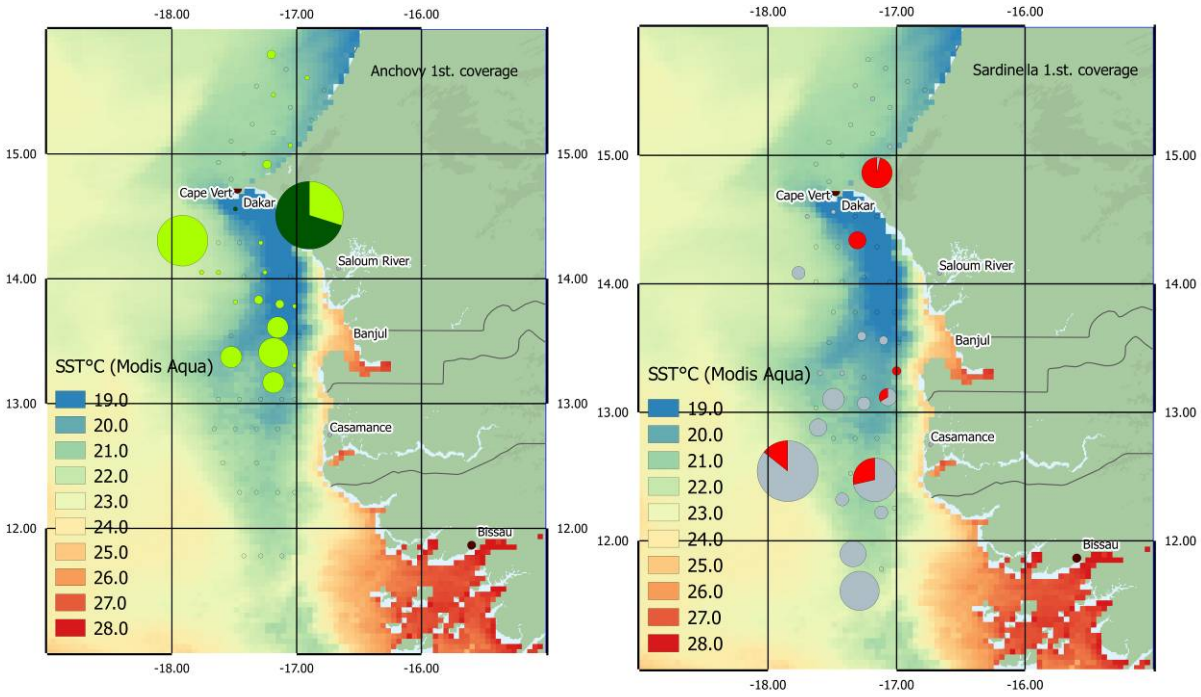

Figure 4.2. Horizontal distribution of anchovy eggs (dark green) and larvae (light green) and sardinella egg (red) and larvae (grey) per station during the first coverage. Open circles indicate stations without observations. The map is overplayed a map of satellite derived SST (Modis Aqua).

Second coverage

Sardinella was the most widely distributed species group observed acoustically on the shelf also during the second coverage. Figure 4.3 illustrates the distribution within the region surveyed. No adult anchovy was observed. This is probably related to the much warmer water conditions observed during this coverage. The distribution of sardinella is similar to the first coverage with the exception that during the first coverage very little sardinella was found inshore, immediately south of Dakar in the area with the coldest water masses.

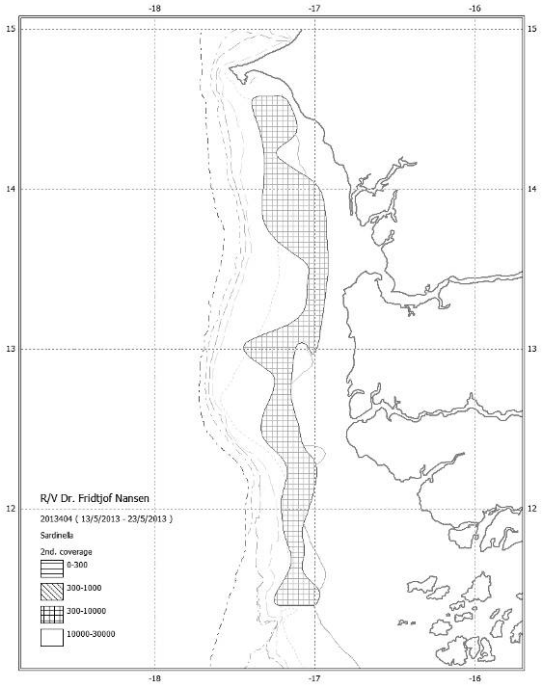

Figure 4.3. Distribution of acoustic recordings of sardinella during the second coverage of the survey area

Looking at the overlaid map of satellite derived SST in Figure 4.4 one observes the relatively warm water masses (compared to the first coverage, Figure 4.2) present in most of the survey area during this coverage. The distribution of anchovy larva (No eggs were found) was mainly concentrated offshore on both sides of Cape Vert in the cooler, northwards moving, water masses. The distribution was more concentrated than during the first coverage. Sardinella eggs and larvae were found throughout the shelf and especially in the regions with warmer waters, Figure 4.4.

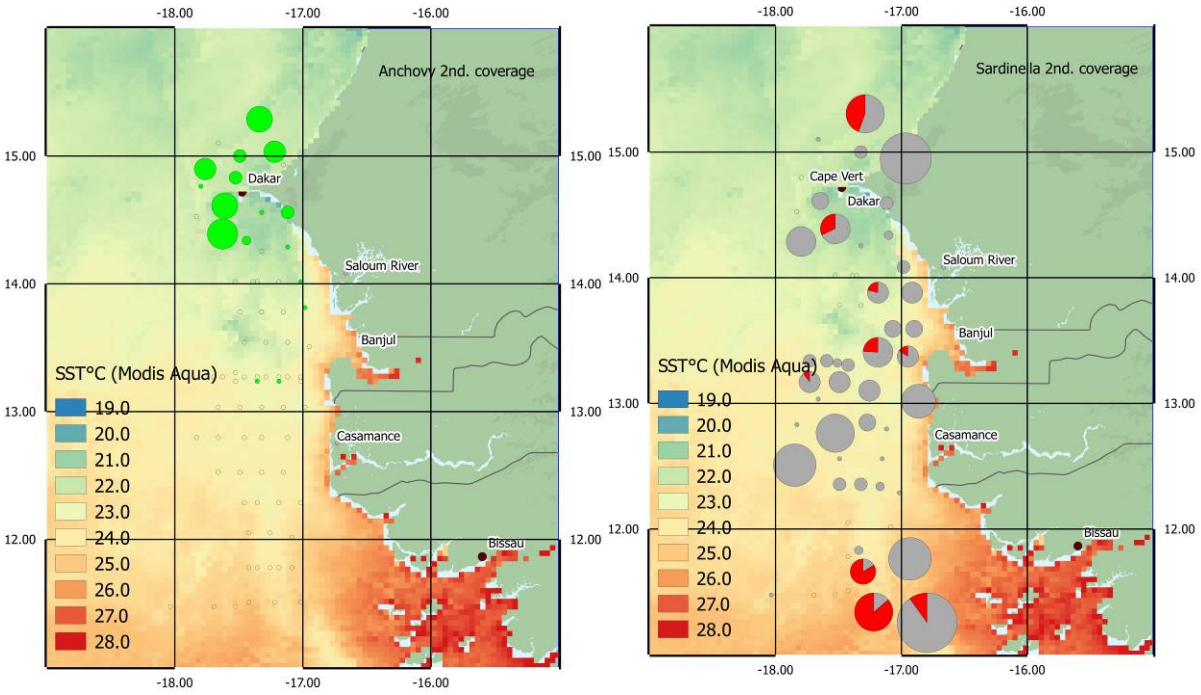

Figure 4.4. Horizontal distribution of anchovy larvae (light green) ,no eggs detected, and sardinella egg (red) and larvae (grey) per station during the second coverage. Open circles are stations without observations. The map is overplayed a map of satellite derived SST (Modis Aqua).

Vertical distribution of eggs and larvae of sardinella and anchovy

Studies on vertical distributions of anchovy and sardinella eggs and larvae (Figure 4.5-4.8), were conducted in the northern, the central, and the southern part, of the sampling area. In the northern region, there was a mix of both species, while sardinella dominated in the central and southern regions. Only stations with catches of more than ten or more eggs/larvae are here reported.

Anchovy

Anchovy eggs were found in relatively high concentrations on two inshore stations immediately south of Cape Vert (Figure 4.5 St. 107, 109, 111). The innermost station was conducted in shallow water and only 20 m of the water column could be sampled. High concentrations of anchovy eggs were found there. On the second station anchovy eggs were found in similar concentrations in the two depth-strata that could be sampled (0-25 and 25-40 m). Generally, anchovy eggs were found in temperatures ranging from 17 to 23^{o}C.

Anchovy larvae were found at nine of the stations with vertical resolution but four of these had less than 10 larvae. Stations with more than 10 larvae were located in the northern region (Figure 4.6, St. 103, 105, 113, 115, 117). Larvae were found in highest concentrations in the upper 25 m while lower concentrations were found between 25 and 50 m. Only few larvae

were observed deeper than 50 m. Anchovy larvae were found above the thermocline which was also associated with a peak in fluorescence.

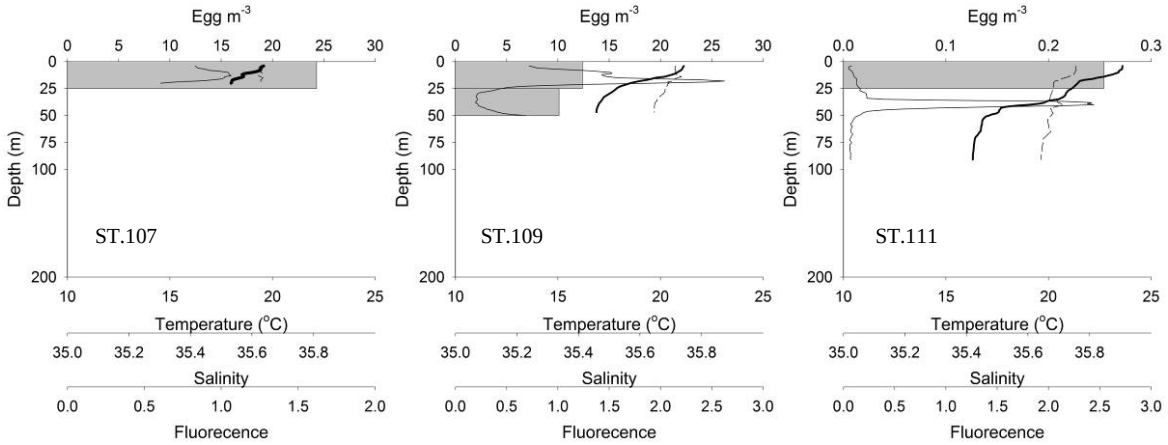

Figure 4.5. Vertical distribution of anchovy eggs and vertical profiles of temperature (bold line), salinity (dashed line) and fluorescence (thin line).

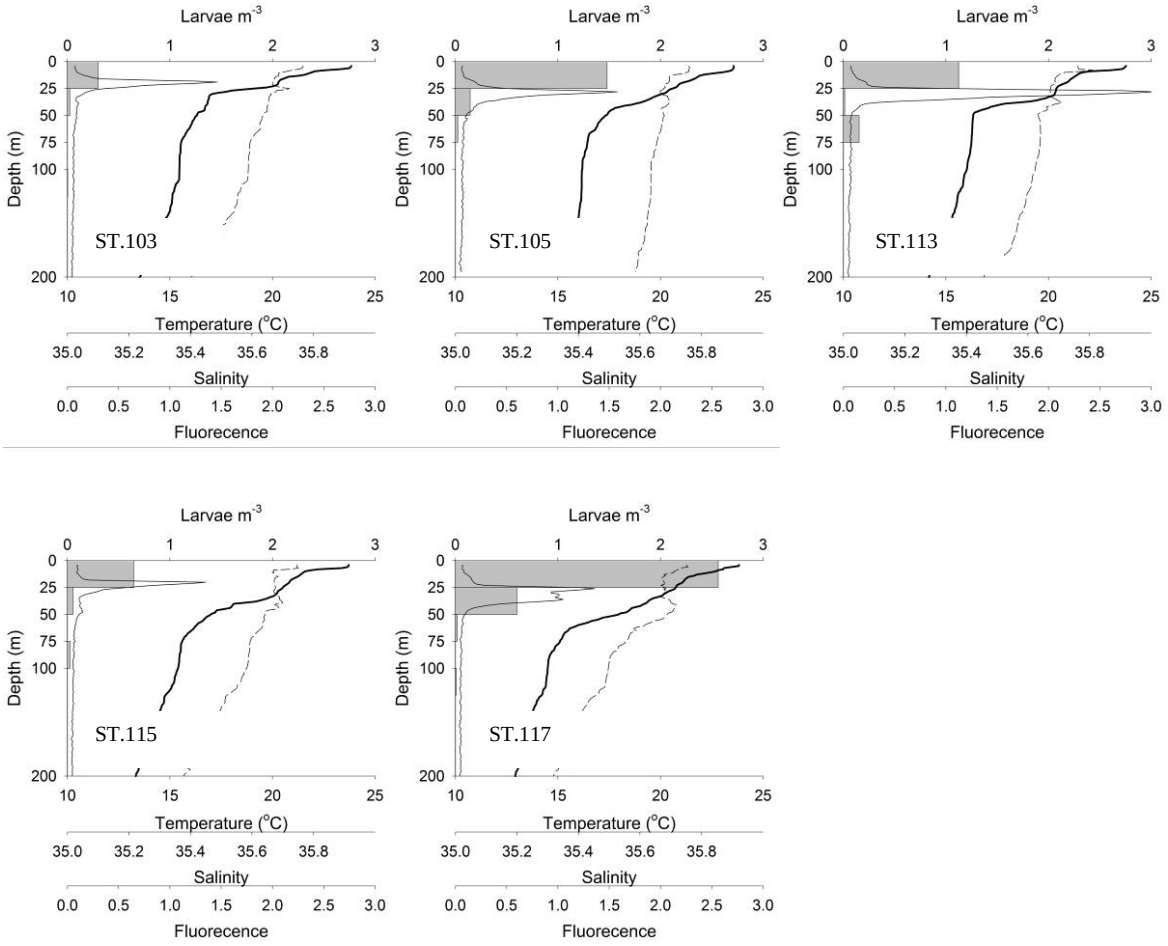

Figure 4.6. Vertical distribution of anchovy larvae and vertical profiles of temperature (bold line), salinity (dashed line) and fluorescence (thin line).

Sardinella

Four of the vertical resolution stations had 10 or more sardinella eggs (Figure 4.7), of which two were located in the northern region (St. 109, 111) and two in the central region (St. 196 and 197). Egg were only observed in the upper 50 m with highest concentrations in the upper 25 m on three stations while the highest concentration was found at 25-50 m on one station where the thermocline was also slightly deeper compared to the other stations. Sardinella larvae were found on stations with sampling of vertical distributions that were located in the central St. 192-197) and southern regions (St. 133 and 143). On all stations, the highest concentrations were observed in the upper 25 m, and only low concentrations were found deeper than that. Larvae were found above the thermocline associated with peak fluorescence.

It is reasonable to assume that the eggs have positive buoyancy as most other pelagic fish eggs and they would therefore ascend towards the surface in the salinity profiles experienced during the survey. The results indicate that eggs of sardinella might be spawned slightly deeper than the eggs of anchovy but that larvae of both species are mostly distributed above the thermocline in the upper 25 m.

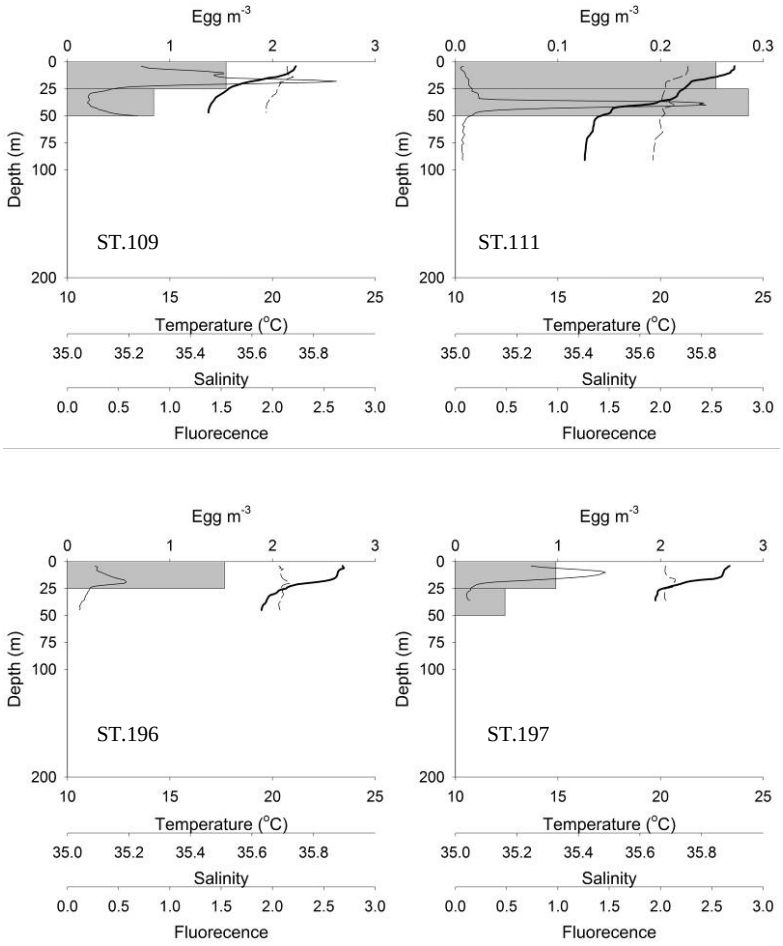

Figure 4.7. Vertical distribution of sardinella eggs and vertical profiles of temperature (bold line), salinity (dashed line) and fluorescence (thin line).

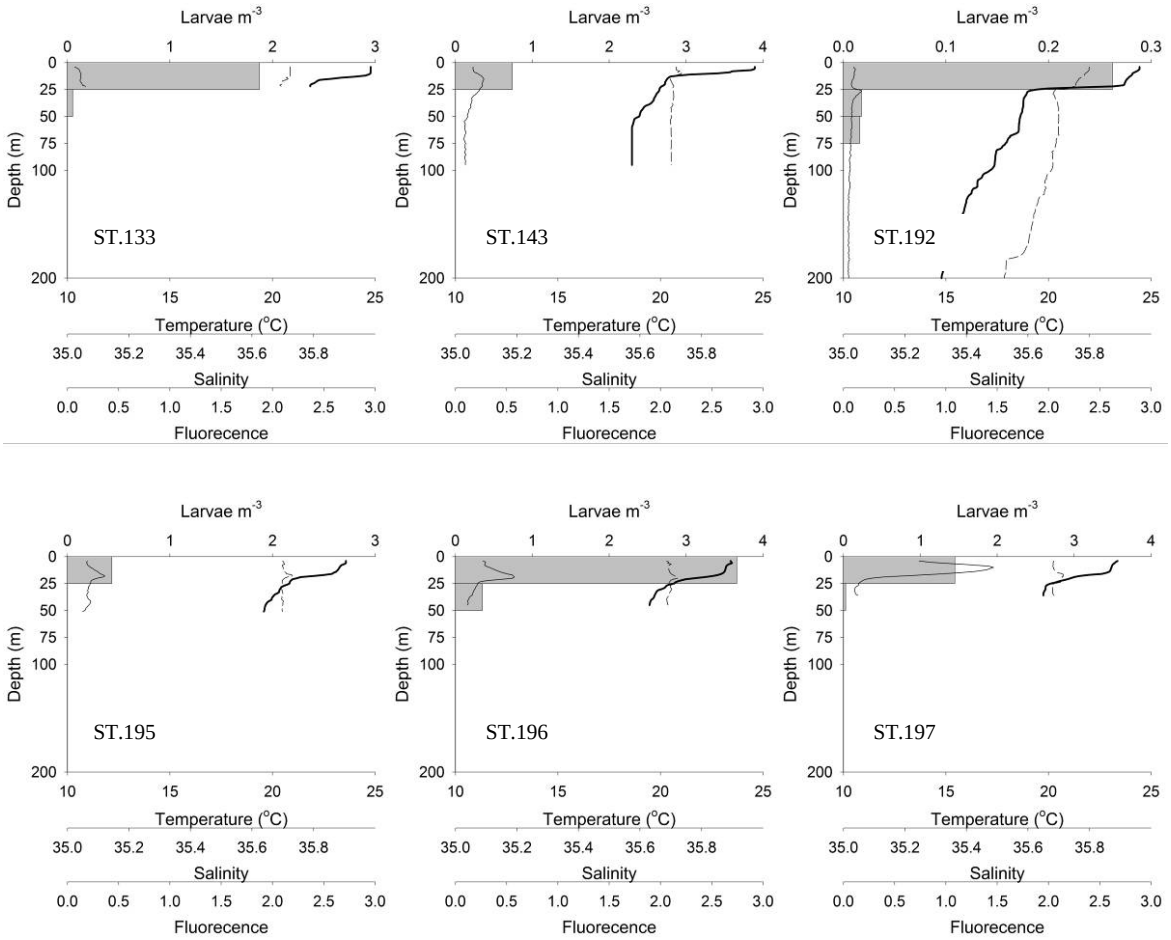

Figure 4.8. Vertical distribution of sardinella larvae and vertical profiles of temperature (bold line), salinity (dashed line) and fluorescence (thin line).

CHAPTER 5 RESULTS OF CETACEAN SURVEY

The following summary is taken from an unpublished report to UNESCO/FUST (Van Waerebeek and Djiba, 2013). Total visual search effort for marine mammals from 1-22 May 2014 amounted to 190 h 21 min over an effective survey distance of 2,081 km, covering coastal waters from central Senegal, The Gambia and northern Guinea-Bissau. Of total survey effort, 6301 min (1,794.74 km) and 5120 min (313.82 km) were implemented, respectively, at cruise speed and at slow speed or stationary. For 99.4% of time the Beaufort sea state ranged 2-4, with visibility either good (6507 min) or moderate (4834 min). As in prior surveys (2011-2012), mainly continental shelf waters and some slope areas were covered. A total of 52 cetacean sightings, one of which a potential resighting, were registered in EEZ waters of Senegal (n=30), The Gambia (n=12) and Guinea-Bissau (n=10). These comprised 19 (36.5%) sightings of common dolphins *Delphinus* sp., 4 (7.7%) of like-common dolphins, 5 (9.6%) of common bottlenose dolphins *Tursiops truncatus*, 3 (5.8%) of killer whales *Orcinus orca*, 2 (3.8%) of short-finned pilot whales *Globicepala macrorhynchus*, 1 of Clymene dolphins *Stenella clymene*, 1 of pantropical spotted dolphin *Stenella attenuata*, 1 of blue whale *Balaenoptera musculus*, 2 of unidentified mid-sized rorquals (*Balaenoptera* sp.), 12 (23%) of unidentified delphinids and 2 of unidentified large baleen whales. All bottlenose dolphins sighted appeared to be of the inshore ecotype, considering small group size (1-10), behaviour and shallow waters (<40m). No obvious cutaneous diseases were detected in cetaceans photographed close to the vessel. Time-stamped seabird photographs were provided for analysis to a University of Dakar associated ornithologist. Of three sea turtles observed, at least two were loggerheads *Caretta caretta*.

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Annex I Fishing Stations

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 1
DATE :02/05/13 GEAR TYPE: BT NO: 26 POSITION:Lat N 12°28.02
start stop duration Lon E 17°17.40
TIME :08:22:05 08:49:14 27.1 (min) Purpose : 1
LOG : 7810.15 7812.08 1.9 Region : 1300
FDEPTH: 24 24 Gear cond.: 0
BDEPTH: 24 24 Validity : 0
Towing dir: 0° Wire out : 0 m Speed : 4.3 kn
Sorted : 56 Total catch: 415.24 Catch/hour: 918.33

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Galeoides decadactylus	303.74	694	33.07	6
Pseudotolithus senegalensis	247.70	248	26.97	2
Alectis alexandrinus	126.63	170	13.79	8
Pseudotolithus typus	55.73	7	6.07	
Trachurus trecae	34.68	77	3.78	4
Pomadasys peroteti	27.71	31	3.02	3
C R A B S	18.58	155	2.02	
Balistes sp.	17.49	15	1.90	
Scorpaena angolensis	17.34	294	1.89	
Pseudupeneus prayensis	16.72	139	1.82	5
Dasyatis margarita	11.77	15	1.28	
Arius parkii	10.84	46	1.18	
Dentex congoensis	8.20	46	0.89	1
Molluscs	5.73	77	0.62	
Sphyraena guachancho	5.73	15	0.62	
Trichiurus lepturus	4.95	46	0.54	7
Pagrus caeruleostictus	4.80	15	0.52	
Total	918.33		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 2
DATE :04/05/13 GEAR TYPE: BT NO: 26 POSITION:Lat N 12°29.05
start stop duration Lon W 17°17.47
TIME :12:30:02 12:50:45 20.7 (min) Purpose : 1
LOG : 8011.78 8012.92 1.1 Region : 1300
FDEPTH: 25 24 Gear cond.: 0
BDEPTH: 25 24 Validity : 0
Towing dir: 0° Wire out : 150 m Speed : 3.3 kn
Sorted : 0 Total catch: 170.97 Catch/hour: 495.09

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
J E L L Y F I S H	298.26	0	60.24	
Sardinella maderensis	145.34	733	29.36	9
Decapterus rhonchus	19.84	58	4.01	10
Arius parkii	15.09	29	3.05	
Sardinella aurita	8.66	46	1.75	
Trachurus trecae	2.11	75	0.43	
Dasyatis margarita	1.88	3	0.38	
Zanobatus shoenleinii	1.59	3	0.32	
Brachydeuterus auritus	1.22	6	0.25	
Pagellus bellottii	0.61	38	0.12	
Sepia bertheloti	0.26	6	0.05	
Fistularia petimba	0.06	6	0.01	
PORTUNIDAE	0.06	9	0.01	
Loligo vulgaris	0.06	23	0.01	
Engraulis encrasicolus	0.03	3	0.01	
Selene dorsalis	0.03	3	0.01	
Total	495.09		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 3
DATE :05/05/13 GEAR TYPE: BT NO: 26 POSITION:Lat N 13°43.59
start stop duration Lon W 17°6.95
TIME :01:24:40 01:46:30 21.8 (min) Purpose : 1
LOG : 8278.44 8279.80 1.4 Region : 1300
FDEPTH: 35 35 Gear cond.: 0
BDEPTH: 35 35 Validity : 0
Towing dir: 0° Wire out : 100 m Speed : 3.7 kn
Sorted : 0 Total catch: 155.13 Catch/hour: 426.38

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	350.77	4117	82.27	13
Boops boops	42.88	495	10.06	
Sardinella aurita	9.34	71	2.19	11
Pagellus bellottii	5.98	69	1.40	12
Not found	3.44	27	0.81	
Brachydeuterus auritus	3.23	22	0.76	
Dicologoglossa cuneata	2.95	27	0.69	
Sphoeroides spengleri	2.47	69	0.58	
Calappa sp.	2.40	723	0.56	0
Sepia bertheloti	1.79	8	0.42	
Zeus faber	0.69	3	0.16	
Fistularia petimba	0.27	22	0.06	
Calappa sp.	0.07	8	0.02	
Trigla lyra	0.07	8	0.02	
Loligo vulgaris	0.03	5	0.01	
Total	426.38		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 4
DATE :05/05/13 GEAR TYPE: PT NO: 1 POSITION:Lat N 13°59.87
start stop duration Lon W 17°21.12
TIME :08:32:31 08:47:35 15.1 (min) Purpose : 1
LOG : 8331.65 8332.49 0.8 Region : 1300
FDEPTH: 30 60 Gear cond.: 0
BDEPTH: 68 72 Validity : 0
Towing dir: 0° Wire out : 140 m Speed : 3.3 kn
Sorted : 14 Total catch: 83.25 Catch/hour: 331.45

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus trecae	105.75	1027	31.90	15
Sardinella aurita	82.50	486	24.89	14
Scomber japonicus	66.57	287	20.08	18
Decapterus rhonchus	61.31	131	18.50	20
Pagellus bellottii	4.82	44	1.45	16
Trichiurus lepturus	4.38	12	1.32	17
Boops boops	3.30	20	1.00	
Sphyraena guachancho	2.83	8	0.85	19
Total	331.45		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 5
DATE :09/05/13 GEAR TYPE: PT NO: 1 POSITION:Lat N 14°49.94
start stop duration Lon W 17°19.88
TIME :09:12:30 09:38:35 26.1 (min) Purpose : 1
LOG : 8544.63 8546.12 1.5 Region : 1300
FDEPTH: 20 20 Gear cond.: 0
BDEPTH: 54 57 Validity : 0
Towing dir: 0° Wire out : 80 m Speed : 3.4 kn
Sorted : 16 Total catch: 1316.24 Catch/hour: 3028.16

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trichiurus lepturus	3008.97	4560	99.37	21
Sphyraena guachancho	9.39	14	0.31	
Trachinotus goreensis	6.00	12	0.20	
Selene dorsalis	3.80	16	0.13	22
Total	3028.16		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 6
DATE :10/05/13 GEAR TYPE: PT NO: 7 POSITION:Lat N 15°28.50
start stop duration Lon W 16°47.45
TIME :07:41:56 08:04:11 22.3 (min) Purpose : 1
LOG : 8725.90 8727.04 1.1 Region : 1300
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 25 31 Validity : 0
Towing dir: 0° Wire out : 90 m Speed : 3.1 kn
Sorted : 107 Total catch: 107.04 Catch/hour: 288.65

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trichiurus lepturus	96.76	132	33.52	
Decapterus rhonchus	51.40	151	17.81	28
Pagellus bellottii	40.18	140	13.92	34
Galeoides decadactylus	28.53	86	9.88	29
Pomadasys jubelini	15.07	27	5.22	25
Chloroscombrus chrysurus	13.00	70	4.50	30
Lagocephalus laevigatus	8.14	16	2.82	
Sardinella maderensis	7.42	22	2.57	27
Pomadasys peroteti	7.39	24	2.56	24
Pagrus caeruleostictus	6.34	8	2.20	31
Plectorhinchus mediterraneus	6.09	11	2.11	33
Brachydeuterus auritus	5.02	35	1.74	32
Sphyraena guachancho	2.53	3	0.88	26
Sardina pilchardus	0.43	5	0.15	35
Ilisha africana	0.35	3	0.12	36
Total	288.65		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 7
DATE :12/05/13 GEAR TYPE: PT NO: 7 POSITION:Lat N 14°30.51
start stop duration Lon W 17°9.85
TIME :08:06:53 08:12:21 5.5 (min) Purpose : 1
LOG : 8911.58 8911.93 0.4 Region : 1300
FDEPTH: 10 15 Gear cond.: 0
BDEPTH: 24 25 Validity : 0
Towing dir: 0° Wire out : 80 m Speed : 3.8 kn
Sorted : 37 Total catch: 3035.60 Catch/hour: 33297.26

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Sardina pilchardus	15488.12	1384256	46.51	38
Engraulis encrasicolus	11746.62	1765931	35.28	39
Sardinella aurita	6062.52	490947	18.21	37
Total	33297.26		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 8
DATE :12/05/13 GEAR TYPE: PT NO: 1 POSITION:Lat N 14°29.93
start stop duration Lon W 17°19.23
TIME :11:00:56 11:22:04 21.1 (min) Purpose : 1
LOG : 8924.58 8925.71 1.1 Region : 1300
FDEPTH: 25 27 Gear cond.: 0
BDEPTH: 50 45 Validity : 0
Towing dir: 0° Wire out : 100 m Speed : 3.2 kn
Sorted : 31 Total catch: 216.23 Catch/hour: 614.00

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Boops boops	278.28	3737	45.32	42
Trachurus trecae	209.50	2405	34.12	41
Sardinella aurita	70.36	358	11.46	43
Scomber japonicus	55.85	1451	9.10	40
Total	614.00		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 9
DATE :14/05/13 GEAR TYPE: PT NO: 1 POSITION:Lat N 11°27.47
start stop duration Lon W 17°5.03
TIME :10:03:45 10:17:49 14.1 (min) Purpose : 1
LOG : 9263.99 9264.74 0.8 Region : 2100
FDEPTH: 20 20 Gear cond.: 0
BDEPTH: 41 42 Validity : 0
Towing dir: 0° Wire out : 80 m Speed : 3.2 kn
Sorted : 29 Total catch: 29.28 Catch/hour: 124.86

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Sardinella maderensis	74.88	401	59.97	45
Mustelus mustelus	15.18	9	12.16	
Aequorea sp.	11.22	0	8.98	
Trichiurus lepturus	5.46	13	4.37	46
Decapterus rhonchus	5.20	13	4.17	47
Chrysaora hysoscella	5.16	90	4.13	
Sardinella aurita	2.81	13	2.25	44
Sphyraena guachancho	2.56	4	2.05	
Lagocephalus laevigatus	0.68	26	0.55	
Brachydeuterus auritus	0.60	4	0.48	
Sepia bertheloti	0.47	9	0.38	
Loligo vulgaris, juvenile	0.13	47	0.10	
Nudibranch sp	0.09	38	0.07	
Unid. juvenile fishes	0.04	4	0.03	
Trachurus trecae, juvenile	0.04	38	0.03	
PORTUNIDAE	0.04	9	0.03	
Fistularia petimba, juvenile	0.04	4	0.03	
Brotula barbata, juvenile	0.04	55	0.03	
P O L Y C H A E T A	0.04	4	0.03	
Dicologoglossa hexophthalma, juvenile	0.04	4	0.03	
Pagellus bellottii, juvenile	0.04	21	0.03	
Sphoeroides spengleri, juvenile	0.04	9	0.03	
Alectis alexandrinus, juvenile	0.04	4	0.03	
Total	124.86		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 10
DATE :16/05/13 GEAR TYPE: PT NO: 7 POSITION:Lat N 12°29.75
start stop duration Lon W 17°13.80
TIME :10:28:24 10:57:38 29.2 (min) Purpose : 1
LOG : 9445.39 9446.94 1.6 Region : 1300
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 21 22 Validity : 0
Towing dir: 0° Wire out : 60 m Speed : 3.2 kn
Sorted : 4 Total catch: 3.67 Catch/hour: 7.54

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Sardinella maderensis	3.74	21	49.59	48
J E L L Y F I S H	2.18	27	28.88	
Chloroscombrus chrysurus	1.62	12	21.53	49
Total	7.54		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 11
DATE :18/05/13 GEAR TYPE: PT NO: 7 POSITION:Lat N 13°15.08
start stop duration Lon W 17°6.70
TIME :11:29:00 11:59:44 30.7 (min) Purpose : 1
LOG : 9616.07 9617.91 1.8 Region : 1400
FDEPTH: 13 20 Gear cond.: 0
BDEPTH: 31 30 Validity : 0
Towing dir: 0° Wire out : 80 m Speed : 3.6 kn
Sorted : 54 Total catch: 54.00 Catch/hour: 105.40

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Jelly	105.40	7107	100.00	
Total	105.40		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 12
DATE :19/05/13 GEAR TYPE: PT NO: 7 POSITION:Lat N 13°23.26
start stop duration Lon W 16°59.45
TIME :11:29:00 11:35:59 7.0 (min) Purpose : 1
LOG : 9724.34 9724.79 0.5 Region : 1400
FDEPTH: 10 10 Gear cond.: 0
BDEPTH: 20 19 Validity : 0
Towing dir: 0° Wire out : 80 m Speed : 3.8 kn
Sorted : 5 Total catch: 5.20 Catch/hour: 44.70

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Sardinella maderensis	29.74	206	66.54	50
J E L L Y F I S H	14.61	129	32.69	
Sepia officinalis	0.34	9	0.77	
Total	44.70		100.00	

R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 13
DATE :20/05/13 GEAR TYPE: BT NO: 21 POSITION:Lat N 13°59.65
start stop duration Lon W 17°8.99
TIME :09:34:51 09:54:44 19.9 (min) Purpose : 1
LOG : 9883.48 9884.71 1.2 Region : 1300
FDEPTH: 36 35 Gear cond.: 0
BDEPTH: 36 35 Validity : 0
Towing dir: 0° Wire out : 100 m Speed : 3.7 kn
Sorted : 0 Total catch: 30.76 Catch/hour: 92.84

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
J E L L Y F I S H	90.54	3121	97.53	
Zeus faber	2.26	3	2.44	
Selene dorsalis	0.03	6	0.03	
Total	92.84		100.00	

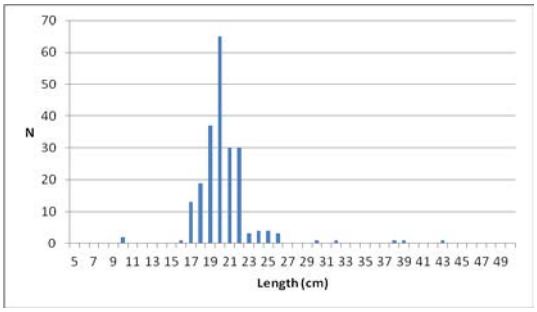
R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 14
DATE :21/05/13 GEAR TYPE: PT NO: 1 POSITION:Lat N 14°29.19
start stop duration Lon W 17°18.58
TIME :07:05:27 07:25:54 20.5 (min) Purpose : 1
LOG : 7.28 8.50 1.2 Region : 1300
FDEPTH: 19 30 Gear cond.: 0
BDEPTH: 49 46 Validity : 0
Towing dir: 0° Wire out : 90 m Speed : 3.6 kn
Sorted : 0 Total catch: 40.55 Catch/hour: 118.97

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
J E L L Y F I S H	56.04	1667	47.10	
Trachurus trecae	49.41	464	41.53	53
Scomber japonicus	4.67	62	3.92	52
Pomadasys incisus	2.55	15	2.15	55
Boops boops	1.67	18	1.41	
Trichiurus lepturus	1.58	3	1.33	
Sphyraena guachancho	1.06	3	0.89	
Sardinella aurita	0.65	3	0.54	51
Spondyliosoma cantharus	0.56	3	0.47	
Pseudupeneus prayensis	0.56	3	0.47	
Scorpaena stephanica	0.23	3	0.20	
Total	118.97		100.00	

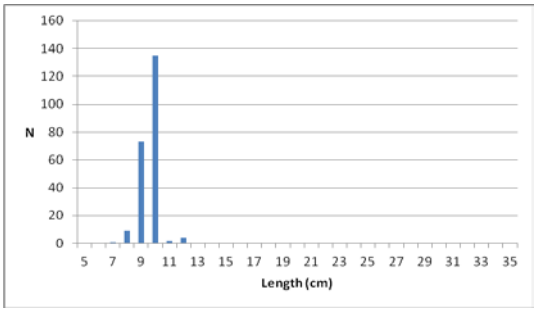
R/V Dr. Fridtjof Nansen SURVEY:2013404 STATION: 15
DATE :21/05/13 GEAR TYPE: BT NO: 21 POSITION:Lat N 14°26.85
start stop duration Lon W 17°30.02
TIME :10:40:39 11:10:53 30.2 (min) Purpose : 1
LOG : 24.69 26.24 1.6 Region : 1300
FDEPTH: 101 102 Gear cond.: 0
BDEPTH: 101 102 Validity : 0
Towing dir: 0° Wire out : 255 m Speed : 3.1 kn
Sorted : 11 Total catch: 178.37 Catch/hour: 354.03

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Dentex macrophthalmus	238.17	1670	67.28	
Plectorhinchus chaetodonoides	30.72	28	8.68	
Trachurus trecae	24.39	322	6.89	56
Sepia officinalis	14.77	14	4.17	
Umbrina canariensis	11.91	46	3.36	
Raja miraletus	10.24	14	2.89	
Priacanthus arenatus	9.82	28	2.78	
Chaetodon hoefleri	7.58	54	2.14	
Chelidonichthys gabonensis	1.87	18	0.53	
Lithognathus mormyrus	1.79	2	0.50	
Boops boops	1.61	18	0.45	
Scorpaena angolensis	0.54	10	0.15	
Dicologoglossa cuneata	0.44	8	0.12	
Anthias cooperi	0.18	8	0.05	
Total	354.03		100.00	

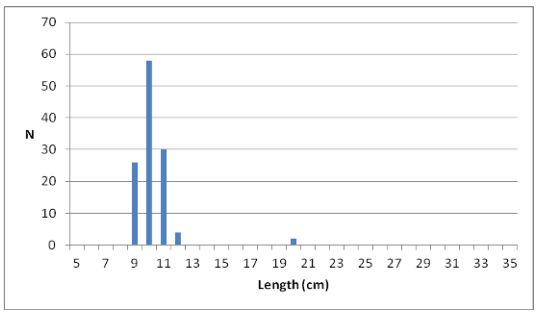
Annex II. Length frequencies of main species from trawl catches



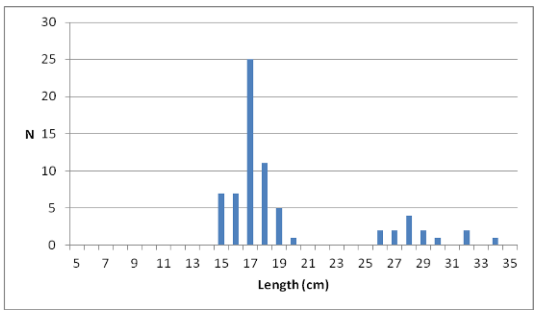
Trachurus trecae



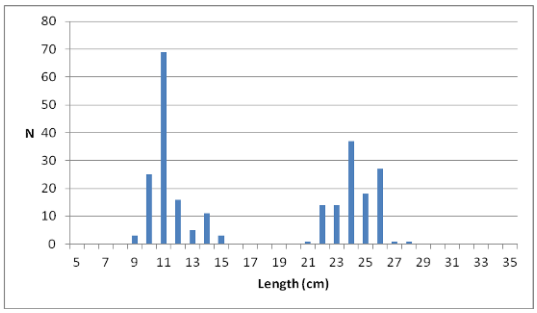
Engraulis encrasicolus



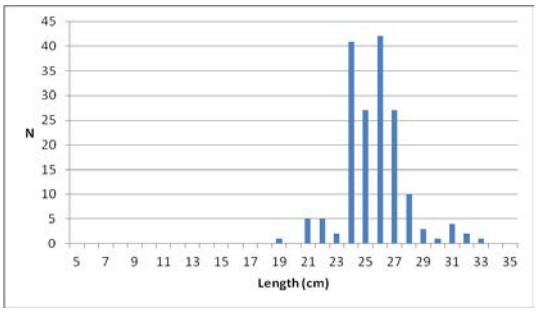
Sardina pilchardus



Scomber japonicus



Sardinella aurita



S. maderensis