Cruise report CEND20_13

PELTIC13: small pelagic fish in the coastal waters of the western Channel and Celtic Sea

Preliminary version V1.0

Prepared by:
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Abstract

A 20 day multidisciplinary pelagic survey was undertaken in the western Channel and the Celtic Sea ("Mackerel box") between the 12th of October and the 31st October. The main aim was to investigate the distribution and abundance of the small pelagic fish community in the area and the environmental drivers of the pelagic ecosystem.

1. Outline of the survey

1.1 Staff

Part 1 (11-20th of October)	*Part 2 (20th – 22nd of Oct)*	*Part 3 (22nd-31st of Oct)*
Jeroen van der Kooij (SIC)	Jeroen van der Kooij (SIC)	Jeroen van der Kooij (SIC)
Rob Bush (2IC)	Rob Bush (2IC)	Rob Bush (2IC)
David Righton (2IC)*	David Righton (2IC)*	Joana Silva
Elise Capuzzo	Elise Capuzzo	Elise Capuzzo
Ken May	Ken May	Ken May
Dave Brown	Dave Brown	Dave Brown
Joana Silva	Joana Silva	Mark Etherton
Mark Etherton	Mark Etherton	James Pettigrew
James Pettigrew	James Pettigrew	Joanne Smith*
Richard Humphreys	Richard Humphreys	Richard Humphreys
Antonio Plirú	Antonio Plirú	Antonio Plirú
Ian Gardiner (PhD)*	David Pearce*	Paul Bouch*
Tom Brereton (Marinelife)	Lavinia Suberg (NOC)*	Lavinia Suberg (NOC)*
Nigel Symes (Marinelife)	Sam Ward (NOC)*	Sam Ward (NOC)*
	Tom Brereton (Marinelife)	Tom Brereton (Marinelife)
	Nigel Symes (Marinelife)	Nigel Symes (Marinelife)

**staff involved in part of the survey*

1.2 Duration

12th October to 31st October

1.3 Location

Western Channel and Celtic Sea coastal zone (embarking/disembarking in Lowestoft)

1.4 Objectives

1. To carry out a multidisciplinary pelagic survey of the Western Channel and Celtic Sea waters to estimate the biomass and distribution of the small pelagic fish community (sprat, mackerel, sardine, anchovy, horse mackerel, herring) using acoustic and pelagic trawl methods.
2. To take biological samples of a representative sample of the pelagic species present to determine population structure and feeding ecology.
3. To collect plankton samples using two different mesh ringnets (80 μm, 270 μm) at fixed stations within the survey area.
4. To undertake a comprehensive survey of the vertical profile of the water column in the study area using a rosette, ESM2 and Ferrybox methods.
5. To record the locations, species, numbers and activities of seabirds and marine mammals in the survey area during daylight hours.
6. To retrieve two gliders, after a one-month deployment between the Scilly Isles and Land's end.
7. To conduct an inter-platform calibration exercise of the acoustic information collected on the glider, using a combination of vessel based acoustic equipment, plankton nets and mid-water fishing trawls.
8. To further test the ability of a new (continuous) passive zooplankton sampler to supplement ringnet plankton nets with high resolution data on the surface. Focus includes sardine spawning, and key zooplankton prey.
9. To collect water samples for nutrient and TA/DIC analysis in support of a programme on ocean acidification (Naomi Greenwood) to continue autumn time-series in area.
10. To collect, where possible, and freeze 2 kg samples each of mackerel, herring, sardine, sprat, blue whiting and dogfish for dioxin analysis as part of MSFD monitoring (Robin Law)

1.5 Narrative

Due to strong northerly winds, the RV Cefas Endeavour left Lowestoft port, with a 24 hour delay, at 13:00 during the afternoon high tide of the 12th of October and steamed overnight to deeper waters of the eastern English Channel. Two shake-down tows were undertaken with the new pelagic trawl between 10:00 and 14:00 on the 13th October, to fine-tune her geometry and get a feel of the gear. Given the favourable weather conditions the RV Cefas Endeavour then steamed to eastern Lyme Bay (near Portland 50° 36.180 N, 002° 35.762 W) to calibrate the echosounders. During the calibration attempt, the Rosette plus ESM2 logger were deployed with a SAIV mini CTD to test the equipment was working and collect a relevant local sound velocity profile for the echosounder calibration. Due to a combination of loss of daylight, strong tides and snagging of the mono filament calibration lines, the calibration could not be conducted and by 19:00, it was decided to commence the survey and the three easternmost survey transects of the western Channel sub-area were run overnight and into the following morning (recording acoustics, plankton, water-sampling and, during daylight hours, birds/mammals). A second calibration attempt was made in daylight hours during the afternoon. The calibration spheres were in place by 16:00 and the 38 kHz calibration was completed but, due to strong tides, the 120 kHz and 200 kHz calibrations could not be continued until slack water at 00:00. Calibration was completed at 01:30 on the 14th October and, after a short westward steam, the survey work recommenced at 03:00 and continued for 6 days. Typically, inshore sections of the transects were covered during daylight to avoid running foul of inshore static gear, however in order to avoid bias 50% of the offshore legs were also covered at during daylight. When appropriate, the pelagic trawl was deployed to ascertain the species- and length composition of acoustic targets, or 'marks'. Variable success was achieved: of 14 attempts, 10 resulted in valid trawls. One invalid tow resulted in the trawl becoming entangled requiring ~12 h of work. One tow resulted in a large catch of mackerel, causing damage to the trawl upon hauling and necessitating ~6 h of repair. Catches were processed and biological samples taken according to standardised protocols. On the 20th October at 05:00, after completing the western Channel sub-area, the Endeavour steamed for Falmouth for a planned staff changeover. I. Gardiner left the vessel, while L. Suberg, S. Ward (both NOC) and D. Pearce joined.

After changeover, the Endeavour started the 10 hour steam at 9:30 towards the Scilly Isles sub-area to begin the inter-platform calibration exercise of the acoustic information with glider 194, in sub-Area 2 (the Scilly Isles) at night and collect the gliders at first light the following morning. Two parallel calibration transects were run using acoustics with a number of stations at which vertical profiles of the water column, water sampling and plankton dips were undertaken. The first transect was an existing leg of the Peltic survey design and was used as a reconnaissance transect, in east-west direction to explore the position of the mixed (east) and stratified (west) waters either side of the front. Once this was established, the second dedicated glider transect was adapted to cross the front at [50N, 6.5W] and the position of five CTD/plankton stations were determined along this transect. This work took place between 19:30 on the 20th October and 05:30 on the 21st and was completed under deteriorating weather conditions (heavy rain, a 3m south-westerly swell, and force 5 to 7 south-easterly winds). On completion of the transects, Endeavour steamed to the north-west to collect the first of the NOC SLOCUM seagliders (Zephyr) at first light. The glider was spotted at 08:00 and successfully retrieved by 09:30, before Endeavour took a course back to the second glider (194) to the south-east. Despite finding the glider and bringing the Endeavour alongside, the glider's recovery line failed to deploy and, after several unsuccessful attempts to trigger the recovery line release remotely and also directly, the attempt was abandoned. A section of a transect in the Bristol Channel sub-area was surveyed overnight, before a course was set for St Ives for exchange of staff as early as possible on the morning of the 22nd of October. D. Righton and D. Pearce departed the Endeavour and were replaced by P. Bouch and J. Smith. NOC glider staff S. Ward stayed onboard with L. Suberg, to coordinate any possible further glider retrieval attempts should they arise later on in the survey.

After changeover, the Endeavour steamed an eastward course at 09:00 to begin the survey of the Bristol Channel sub-area. Between the 22nd and the 25th of October a series of south-west to north east running transects were completed in the Bristol Channel sub-area. On the 22nd significant damage to the trawl took 20 hours to repair. Weather gradually deteriorated and with storms forecasted to arrive within 24 hours the final inshore transects were completed on the night following the 25th, to start the 110 nmi "Bristol-Celtic Deep" transect at first light of the 26th of October. Before completion of this transect it was decided that weather conditions were sufficiently adverse, and headed for shelter in Falmouth Bay, some 11 hours steam away, with westerly force 11 and 12 winds forecasted to arrive imminently. The Endeavour dropped the anchor at 3:00 AM on the morning of the 27th, and apart from lifting the anchor at 7:00 AM to move closer into Falmouth Bay, stayed at that location until the morning of the 29th of October. The planned 6:00 AM anchor lift was delayed by 1.5 hour as several old pots and nets were wrapped around the anchor chain and had to be removed by searider. It already had been decided to drop the Isles of Scilly subarea and two remnant parts of Bristol Channel transects as the large swell combined with force 8/9 westerly and North-westerly winds, would not yield any useful data.

Swell and weather conditions were limiting possibilities for the last few days of the survey and it was decided to use the next 48 hours to conduct a number of shorter, more closely spaced (5 nmi) transects in the English Channel bays to test the effects of higher sample resolution on the acoustic densities and to shoot the trawl and increase marine mammal and bird coverage. At night some of the inshore CTD/plankton primary stations were repeated to investigate the difference in species and size composition compared to 2 weeks ago. One trawl haul was conducted on the 29th but had to be abandoned and a final trawl was shot on the morning of the 30th. The trawl came back with damage at 12:00 and it was decided to set a course for Lowestoft, picking a final 3 repeat stations up in Lyme Bay along the way. Endeavour arrived off Lowestoft at around 14:00, docking at 19:12 on the 31st of October.

2. Material and Methods

2.1. Study area

The survey were conducted according to the PELTIC survey grid (Figure 1) established in 2012. Acoustic transects, plankton and water sampling were undertaken along the predefined transects, undertaken in a generally east to west direction for the first half of the survey, then a south-west to north east direction for the second half of the survey following a vessel-seaglider intercalibration exercise close to the Scilly Isles at the survey midpoint. Trawls were undertaken opportunistically, depending on the presence and type of acoustic marks observed.

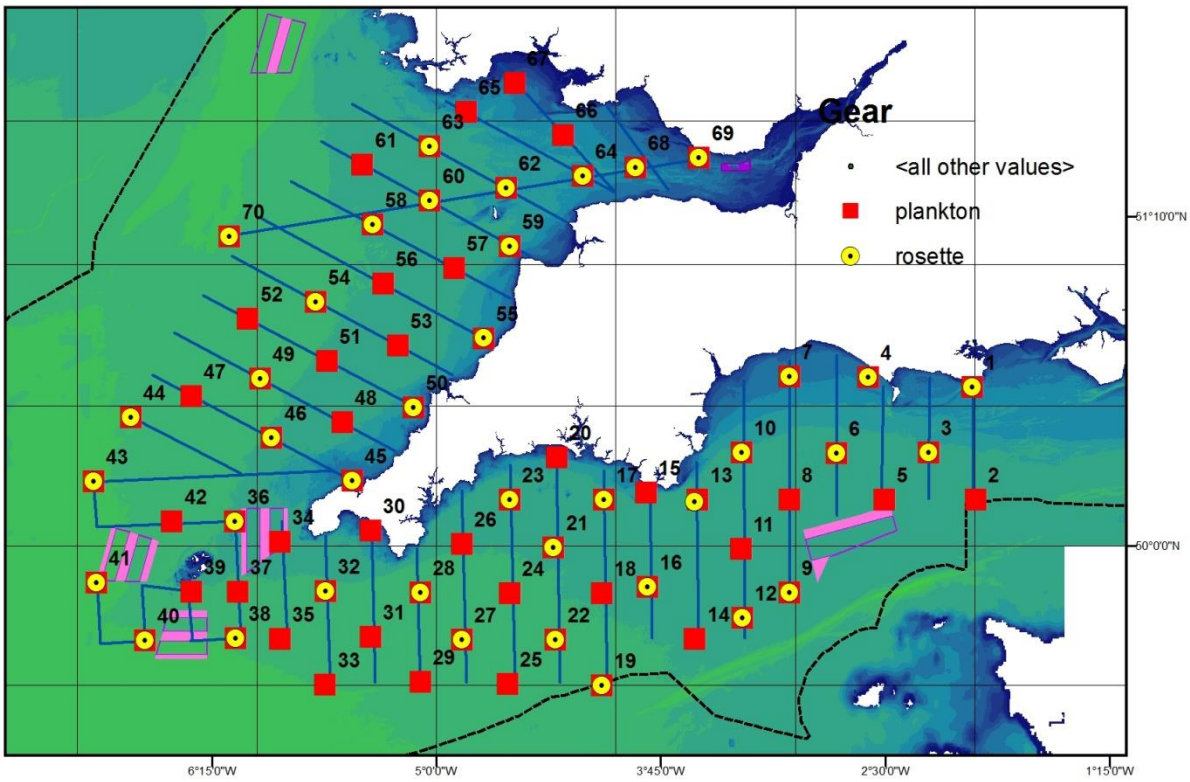

Figure 1. Overview of the survey area, with the acoustic transect (blue lines), plankton stations (red squares) and hydrographic stations (Yellow circles).

2.2 Fisheries acoustics

2.2.1. Acquisition

All three frequency echosounders were successfully calibrated off Portland on the 14th of October.

Fisheries acoustics were recorded along the pre-designed transects (Fig. 1) at three operating frequencies (38, 120 and 200 kHz). The transducers were mounted on a drop keel which was lowered to 3.0 m below the hull, 8.2 m below the sea surface, which reduced adverse effects of weather. Pulse duration was set to 0.516 µs for all three frequencies and the ping rate was set to 0.6 pings s^{-1}. Acoustic data were generally of very high standard despite fairly constant strong windy conditions and Atlantic swell, although occasional spells of very bad weather adversely affected some of the surface data due to aeration. At all times on-transect live acoustic data were monitored and when unidentified acoustic marks appeared the trawl was shot where possible to identify these marks.

2.2.2. Processing

Acoustic data were cleaned, which included removal of data collected during plankton and oceanographic stations, fishing operations and the steam between transect, retaining only the on-transect data. Surface aeration caused by bad weather was removed by setting a surface exclusion line and acoustic data below 1 m above the seabed were also removed, to exclude the strong signals from the seabed. Large amounts of plankton were present throughout the survey, often represented in layers on all three acoustic frequencies (although at different strengths depending on the organisms). Fish schools and plankton were often mixed and a simple extraction of fish echoes was not possible. Therefore to distinguish between organisms with different acoustic properties (echotypes) a multi-frequency algorithm developed in 2012 was refined to separate echograms for each of the echotypes (Fig. 2). A dedicated mackerel detection algorithm was applied separately. The echogram with only the echoes from fish with swimbladders was then scrutinised and split into a number of categories:

1. Echoes in the bottom 10 m above the seabed consisting of loosely aggregated gadoids, and scattered mackerel and/or clupeids
2. Dense schools in mid-water consisting predominantly of sprat
3. Diffuse Unidentified Scattering Targets (DUST) in mid water, often containing fish. This was particularly apparent at night but also during day in particularly the offshore areas of the western Channel?
4. Probable sardine schools: groundtruth trawl not successful or available, but acoustic features match those of sardine from adjacent areas and/or sardine eggs were recorded in nearby plankton stations
5. Probable horse mackerel or boarfish schools – apparent in deeper waters near the seabed, no valid trawl data.
6. Residual mackerel schools, either in mid-water or near the seabed
7. Residual plankton scatterings from very dense plankton layers that could not be removed by the filter

The acoustic density within each of these categories was then attributed to individual species based on the nearest relevant trawls, using imagery of sonar and netsonde collected during the trawling process to assess the sampling performance in relation to the acoustic marks.

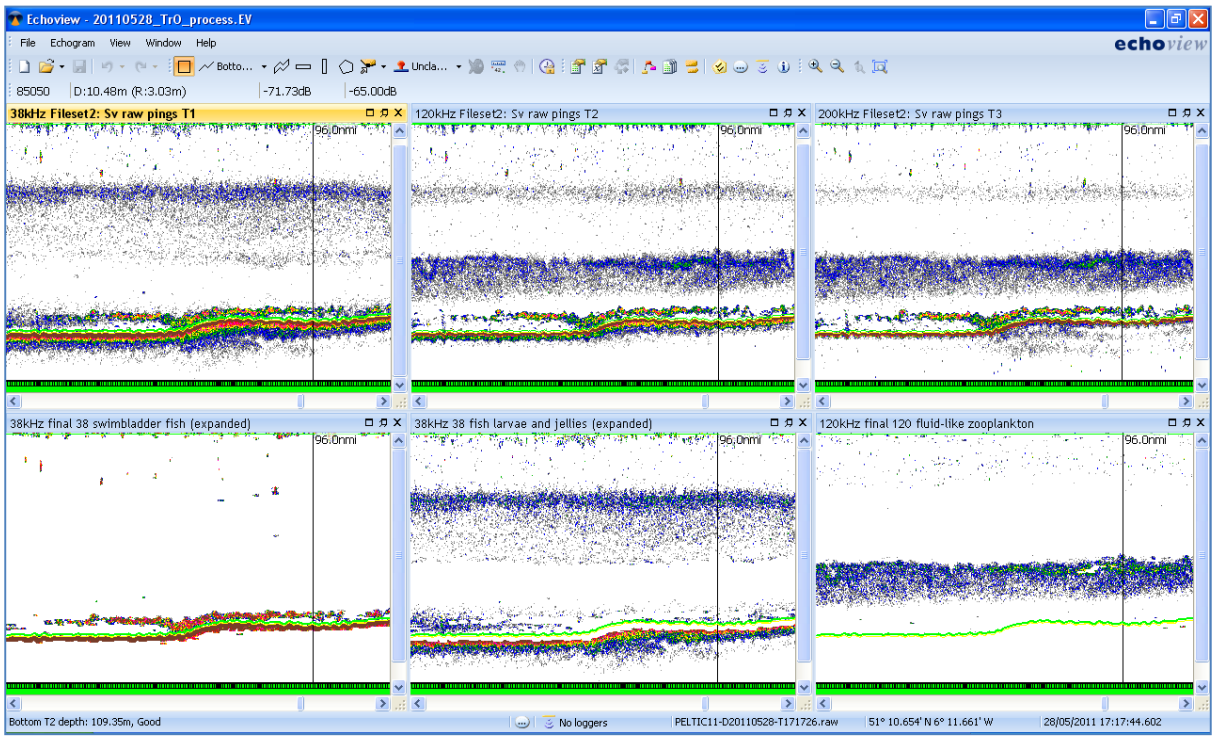

Figure 2. Dataflow of algorithm (top) used to divide the acoustic data by echotype. Screen-shot example (bottom) with raw echograms of 38, 120 and 200 kHz (top panels) and three examples of extracted echotypes (bottom panel from left to righ): fish with swimbladder (sardine schools at surface and myctophids layer near seabed), fish larvae/ jellyfish and zooplankton (dense krill layer).

In the case of mackerel a separate algorithm was used (following Korneliussen 2010). An additional bad weather filter was developed which removed "empty" pings as a result of adverse weather conditions.

2.3 Fishing and catch sampling

A new heavy duty 'herring' trawl (20 x 40m v d K Herring trawl, KT nets) was used to sample the pelagic community for the purpose of validating acoustic marks and collecting biological samples. The trawl was tested and tuned during the morning of the 13th October by experimenting with different weights, speeds and warp. A wireless 50 kHz Marport net-sonde was mounted on the head-rope of the trawl at the mouth of the net, which allowed for live monitoring of the trawling performance. In general, the trawl performed well and caught a broad range of species and size classes.

Fish were sorted to species and size categories before the total catch was weighed and measured using the Cefas EDC system. In the case of very large catches, subsamples were taken before weighing and measuring. The sex and maturity of the pelagic species in each trawl was assessed (10 per length class of mackerel, sprat, sardine, anchovy, horse mackerel, garfish, herring), and their otoliths and stomachs were dissected out and removed for later analysis. For the stomachs a total of 25 stomachs were taken across the various length categories per species per catch.

2.4 Plankton

The various planktonic size components were sampled at ~70 fixed plankton stations along the various transects using two ringnets of different mesh: 270 μm (ichtyoplankton and macro-zooplankton) and 80 μm (zooplankton). The two ringnets were fixed to a frame which enabled them to be deployed simultaneously. Both nets had flowmeters (General Oceanics mechanical flowmeters with standard rotor, model 2030R) mounted in the centre of the aperture of the net and a mini-CTD (SAIV) was attached to the bridle. At each zooplankton station a water sample was taken and fixed on lugol for phytoplankton analysis back in the lab and at a subset of stations another water sample was collected for future micro-zooplankton analysis. Position, date, time, seabed depth, sampled depth (from CTD attached to net) and flowmeter reading were recorded. Nets were washed down on hauling and samples were transferred from the terminal mesh grid. When possible, samples from the 270 μm mesh were transferred into jars and immediately analysed under a binocular microscope before the full sample was preserved in 4% buffered formaldehyde. If immediate analysis was not possible, samples were transferred into 1 lb glass jars and preserved before analysis on a later day. Ichthyoplankton (eggs and larvae) and macrozooplankton from the 270 μm samples were counted and, in the case of clupeid larvae, measured and raised using the flow meter records. Samples from the 80 μm mesh were transferred into jars and preserved with 4% buffered formaldehyde for later analysis.

2.5 Oceanography

The main physical, chemical and biological environmental variables were investigated by in situ measurements, with collection of samples at discrete depths, and via remote sensing.

Vertical casts with an ESM2 logger at 46 regularly spaced stations along the acoustic transects provided data on the properties of the water column including temperature, salinity, fluorescence, optical backscatter, dissolved oxygen and Photo-synthetically Available Radiation, PAR. The Rosette water sampler (equipped with a FSI CTD) was used for collection of water samples at discrete depths at a total of 20 sampling stations. At the other stations, where the Rosette could not be deployed due to rough sea conditions, bottom water samples were collected by mean of a single Niskin bottle attached to a hydro-wire while surface samples were collected from the continuous water pump that supplies the Ferrybox. Additional temperature profiles had been obtained from the SAIV CTD attached to the plankton ringnets. PAR profiles will be analysed to calculate the vertical light attenuation coefficient (K_d) and the depth of the photic zone. Information on the light penetration through the water column was also derived from the measurement of the Secchi disk depth.

Samples for determination of Total Alkalinity (TA), salinity and dissolved inorganic nutrients were collected at the bottom and at the surface of each station; while samples for flow cytometry and HPLC (High Performance Liquid Chromatography) analysis were collected only at the surface, and in duplicates. At 18 stations, samples for microscopy analysis of phytoplankton and microzooplankton were also collected at the surface. Dissolved oxygen samples were collected for calibration of the oxygen sensor of the ESM2 profiler.

Secchi depth measurements were carried out at 6 stations and details of the measurements were sent to http://www1.plymouth.ac.uk/marine/secchidisk/Pages/default.aspx, therefore contributing to the Secchi project by Plymouth University. A summary of the samples collected and of the CTD casts carried out during the survey is given in the table below.

Maps of chlorophyll concentration (OC5 algorithm), sea surface temperature and frontal systems were provided by remote sensing. In particular, maps of frontal systems were downloaded from Neodaas (www.neodaas.ac.uk) while sea surface temperature and chlorophyll maps were prepared by Kate Collingridge using ArcGIS and data downloaded from My Ocean (www.myocean.eu.org). The temperature maps were a gap-filled Ostia product from the Met office via MyOcean. During the survey, continuous measurements of different environmental parameters (e.g. temperature, salinity, fluorescence, oxygen saturation, pH, pCO2) were carried out by a Ferrybox and a pCO2 analyser.

The Ferrybox provided continuous measurements of different environmental variables at the surface (4 m depth) including temperature, salinity, fluorescence, dissolved oxygen. The pCO2 analyser worked correctly from the start of the survey (13th October 2013) until the 24th October when, due to an air-lock, the optimal water flow through the system could not be obtained.

The total number of samples collected and CTD profiles carried out during the cruise are given in Table 2. Samples for dissolved oxygen, chlorophyll and nutrients concentrations, as well as samples for TA/DIC and salinity, will be processed in the lab. CTD casts derived with the ESM2 profiler will be downloaded in the lab and processed for deriving temperature, salinity, fluorescence, dissolved oxygen and downward irradiance profiles.

	Total	Surface	Bottom
Dissolved oxygen (triplicates)	24	12	12
TA/DIC	68	34	34
Salinity	85	42	43
Inorganic nutrients	74	40	34
Chlorophyll/Pigments (duplicates)	118	98	20
Flow Cytometry (duplicates)	81	80	1
Phytoplankton	18	18	
Microzooplankton	18	18	
Secchi depth	6		
CTD casts with ESM2	46		
CTD casts with FSI/Rosette	26		

Table 2. Summary of samples collected and number of CTD casts derived during Poseidon cruise CEnd 20_13 Depth and collection method of the samples are also specified.

2.6 Top predators

Effort-related surveys were made for top predators daily on the cruise during all daylight hours whenever the ship was moving on or between transects. For cetaceans, distance sampling methods were used, whilst seabirds were sampled by a strip transect containing two distance bands (300m and 1km), with sightings grouped into one minute intervals. Special attention was given to gathering data on Balearic Shearwaters, as the waters off south west England are considered an increasingly important habitat for this globally and critically endangered seabird. For each Balearic

Shearwater encountered, more detailed recording was made including initial and any subsequent behavioural activity. At ~20 minute intervals, or whenever the ships course moved, 'effort data' was recorded including ship's position, speed, direction of travel and environmental conditions (e.g. sea state and swell height). Finally, all seabirds were counted on each trawl, with a maximum count for each species logged over the trawl duration.

3. Results

3.1. Pelagic Ichthyofauna

After removing the off-transect data a total of 1159 nautical miles of acoustic sampling units were collected for further analysis (Fig. 3). A total of 14 trawls were made (Fig. 3), of which 10 were successful. The trawls were evenly spread across the survey area, providing a suitable source of species and length data to adequately partition the acoustic data. However it fell below the originally planned number of trawls mainly due to the fact that at times trawling was not possible due to weather busy traffic, traffic separation zones, gear repairs and presence of static gear.

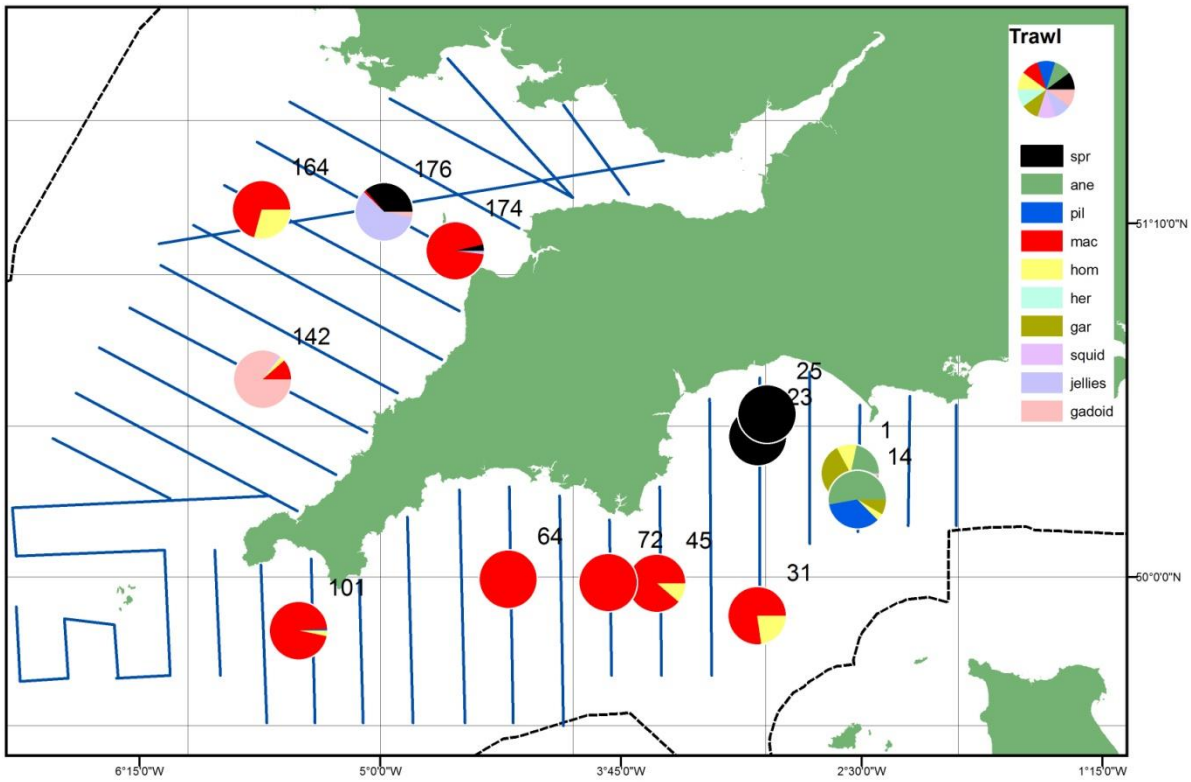

Figure 3. Overview map (inset) and detail of the survey area. Acoustic transects (red lines) and trawl catches (pies) with relative catch composition by key species. Three letter codes:, SPR=sprat, ANE=anchovy, PIL=sardine, MAC=mackerel, HOM= horse mackerel, HER=herring, GAR=garfish.

A total of 25 species were caught consisting predominantly of fish and some cephalopods. Several trawls included jellyfish of at least three species. Sprat (*Sprattus sprattus*) dominated the inshore waters of England, both in the English Channel and in the Bristol Channel. However sprat in the Bristol Channel consisted nearly entirely of small specimens of age 0 and 1, whereas those from the Lyme Bay area were more mature. Some very high densities of sprat were encountered in Lyme Bay.

Apart from the usual small numbers of juvenile mackerel distributed across the study area, this year very large schools of mackerel (*Scomber scombrus*) were observed in the acoustic data particularly in the western channel.

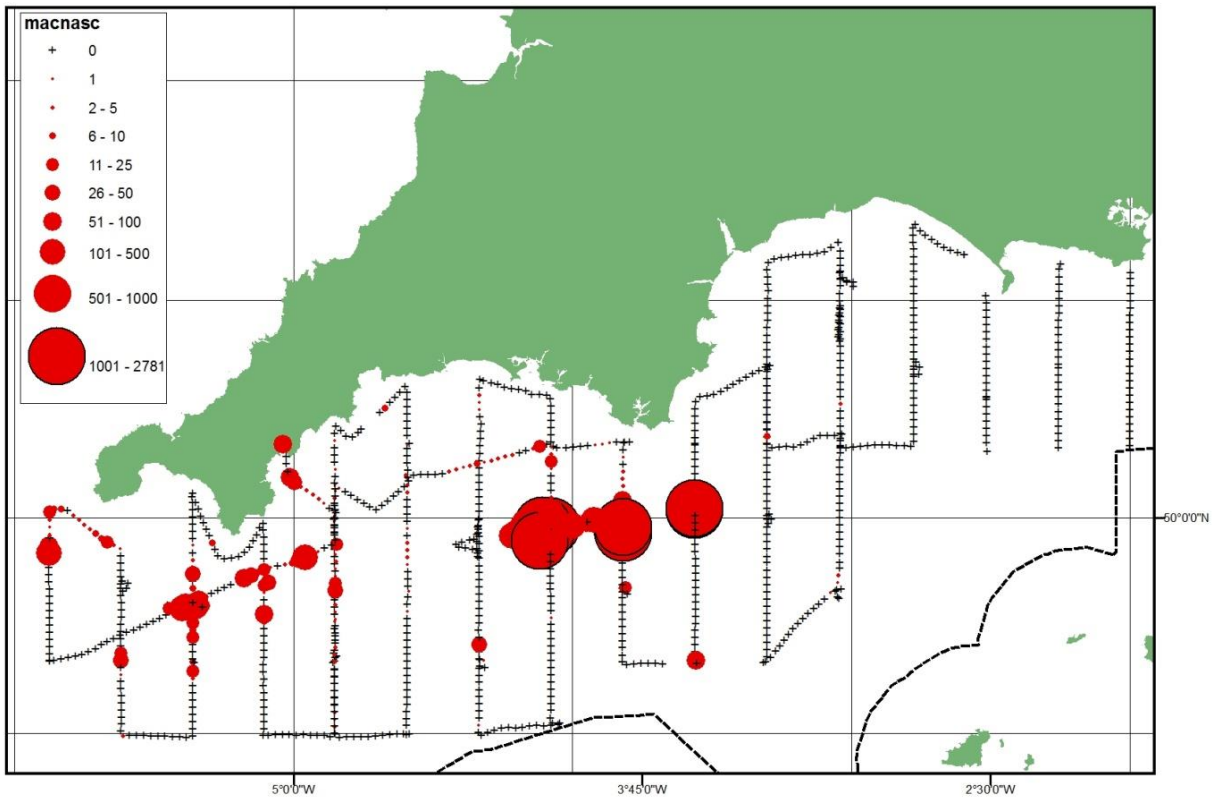

Figure 4. Acoustically derived mackerel densities in Western Channel

As was the case in 2012, anchovy occurred in reasonable numbers but only in the Lyme Bay trawl stations. Sardines (*Sardina pilchardus*) were caught in small numbers in several trawls stations although some schools, though to consist of sardine were observed close inshore where presence of static gear prevented trawls. Acoustic, trawl and egg data suggest that sardine is mainly distributed south of the Cornish Peninsula (in the western Channel) with very little e to a lesser extend in the northeastern parts of the Celtic Sea (fig. 3). Horse mackerel (*Trachurus trachurus*) and herring (*Clupea harengus*) were found in the study area (fig. 3) although generally not in dense schools, but mixed in with other small pelagic species. Herring typically displayed a more coastal distribution whereas horse mackerel were found pretty much across the entire study area notably also in surface waters off the shelf edge. Acoustic data processing will be completed in the lab and will be use dto provide information on abundance and distribution of the key pelagic species in the area.

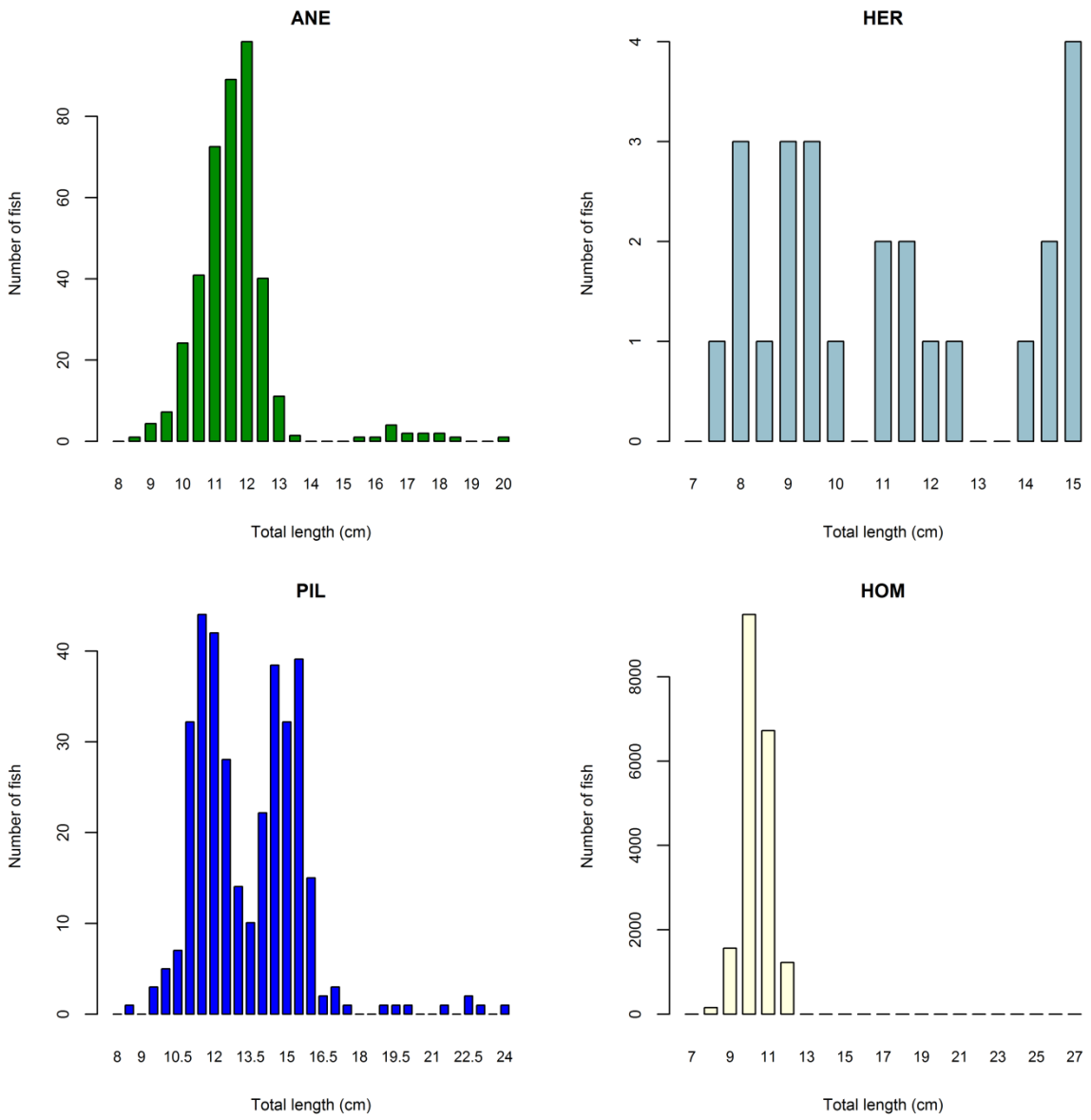

Figure 5. Length frequencu distribution by species (ANE, anchovy; HER, herring; PIL, sardine; HOM, horse mackerel).

3.2. Plankton data

Zooplankton samples were collected at 70 stations with the two ringnets. Water samples were taken from a subset of 18 stations for phytoplankton and micro-zooplankton analysis. Onboard ichthyoplankton processing revealed eggs of sardine, sprat, lemon sole and sandsol, and the larvae of sprat and sardine were present in the survey area. Most abundant were sardine eggs and larvae and "unidentified clupeid" larvae the vast majority of which were thought to comprise of sardine as few other clupeid species are spawning at this time of year. Sardine eggs were patchily distributed predominantly in the western part of the English Channel. Although the distribution of sardine eggs was comparable with last year numbers were much higher. Sardine larvae were prevalent throughout the study area, particularly in the western channel but also in Bristol Channel. In 2012 the distribution was much more restricted to a handful of stations across a diagonal line running southeast from around the Isles of Scilly. A detailed size based (zooscan) and taxonomic analysis of the zooplankton will be undertaken on return to the laboratory.

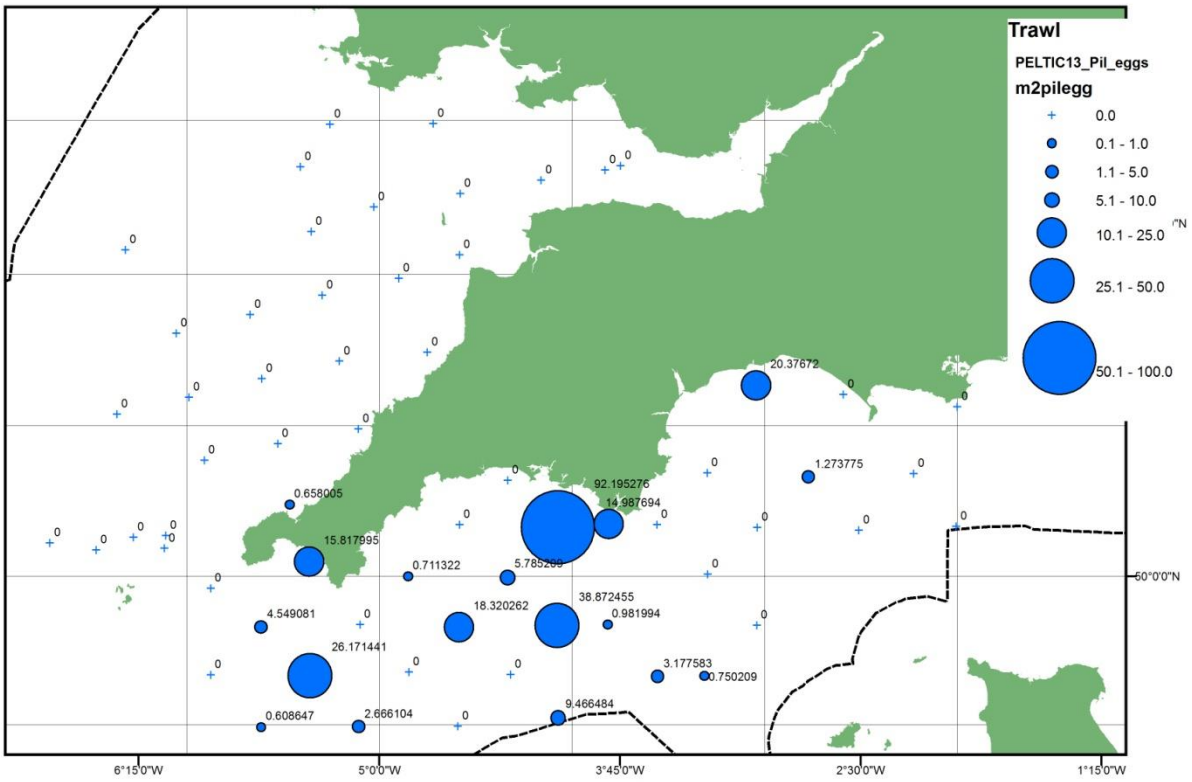

Figure 6. Ichtyo-plankton stations with sardine eggs. Bubble size relative to numbers caught.

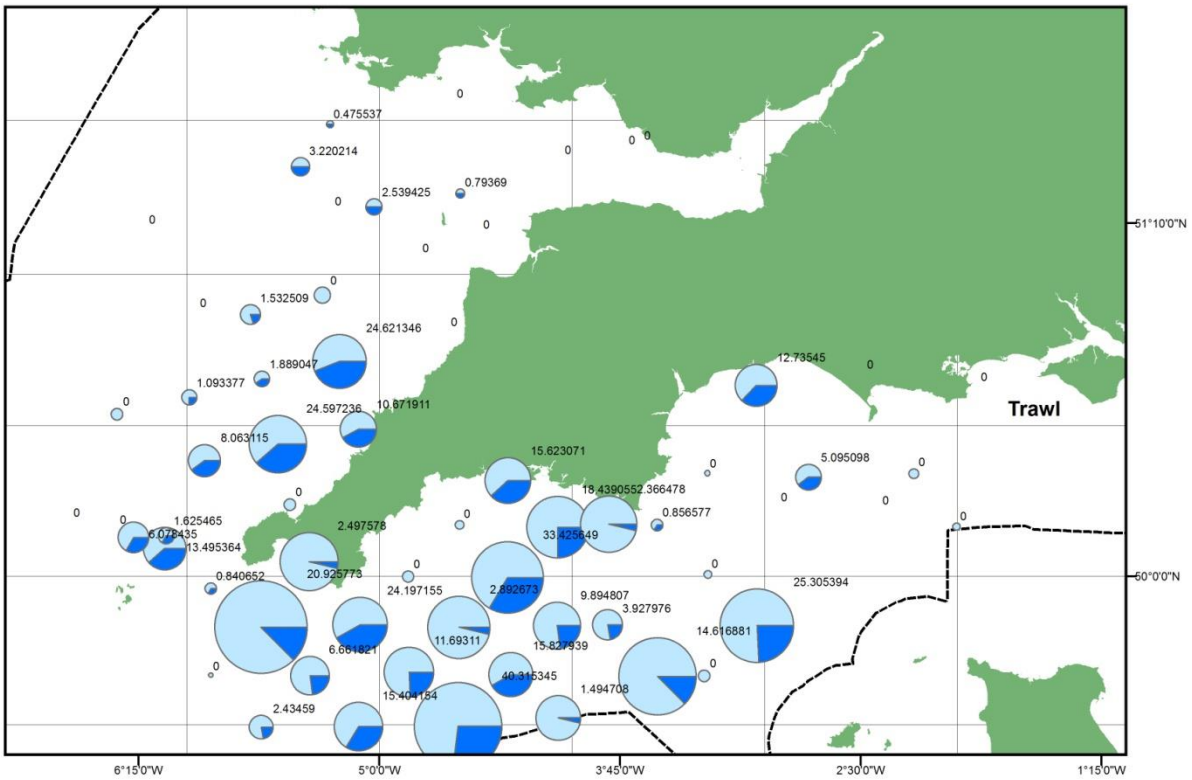

Figure 7a. Ichtyo-plankton stations with unidentified clupeid (light blue) and sardine (dark blue) larva. Pie size relative to total larvae numbers caught; numbers of sardine larvae m^{-2} indicated in centre.

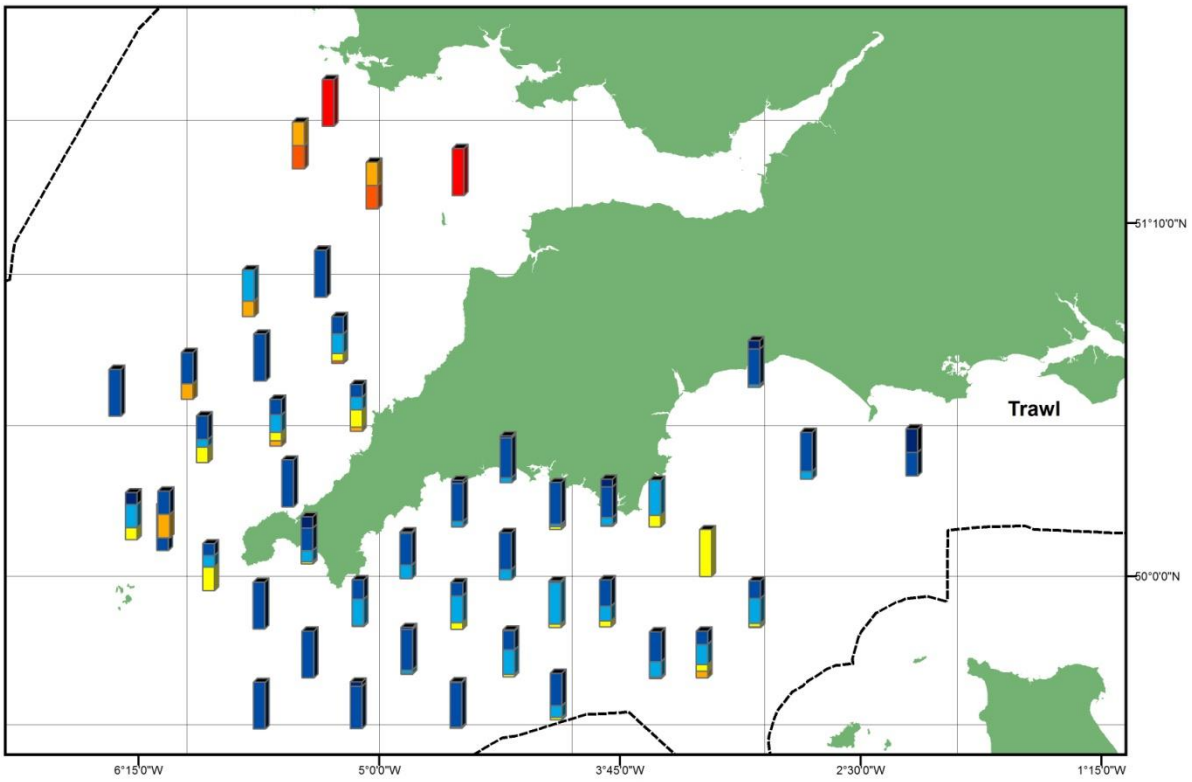

Figure 7b).distribution of positively identified sardine larvae by size class, dark blue (3mm), .

3.3. Oceanographic data

Measured sea surface temperatures showed gradual cooling during the course of the survey and in particular after a storm on the 27-28th October. During the first part of the survey, surface waters of the Western Approaches and of the shelf edge were warmer than the rest of the Celtic Sea with temperature > 16°C. A patch of slightly cooler water (approximately between 14-15°C), was located at the mouth of the English Channel, between the Isles of Scilly and the coast of Brittany (Ushant Front). During the course of the survey, this patch of cool water progressively extended north and west, occupying the main part of the Celtic Sea. The boundary layer between the cooler waters south of the Scilly and the warmer waters of the English Channel and the Celtic Sea was marked by a series of frontal systems (Figure 8). In these frontal systems, nutrient-rich waters are mixed with nutrient-depleted surface waters leading to a potential increase in phytoplankton biomass as demonstrated in the central map of fig 8, where a series of eddies along the frontal systems are characterized by a higher chlorophyll concentration.

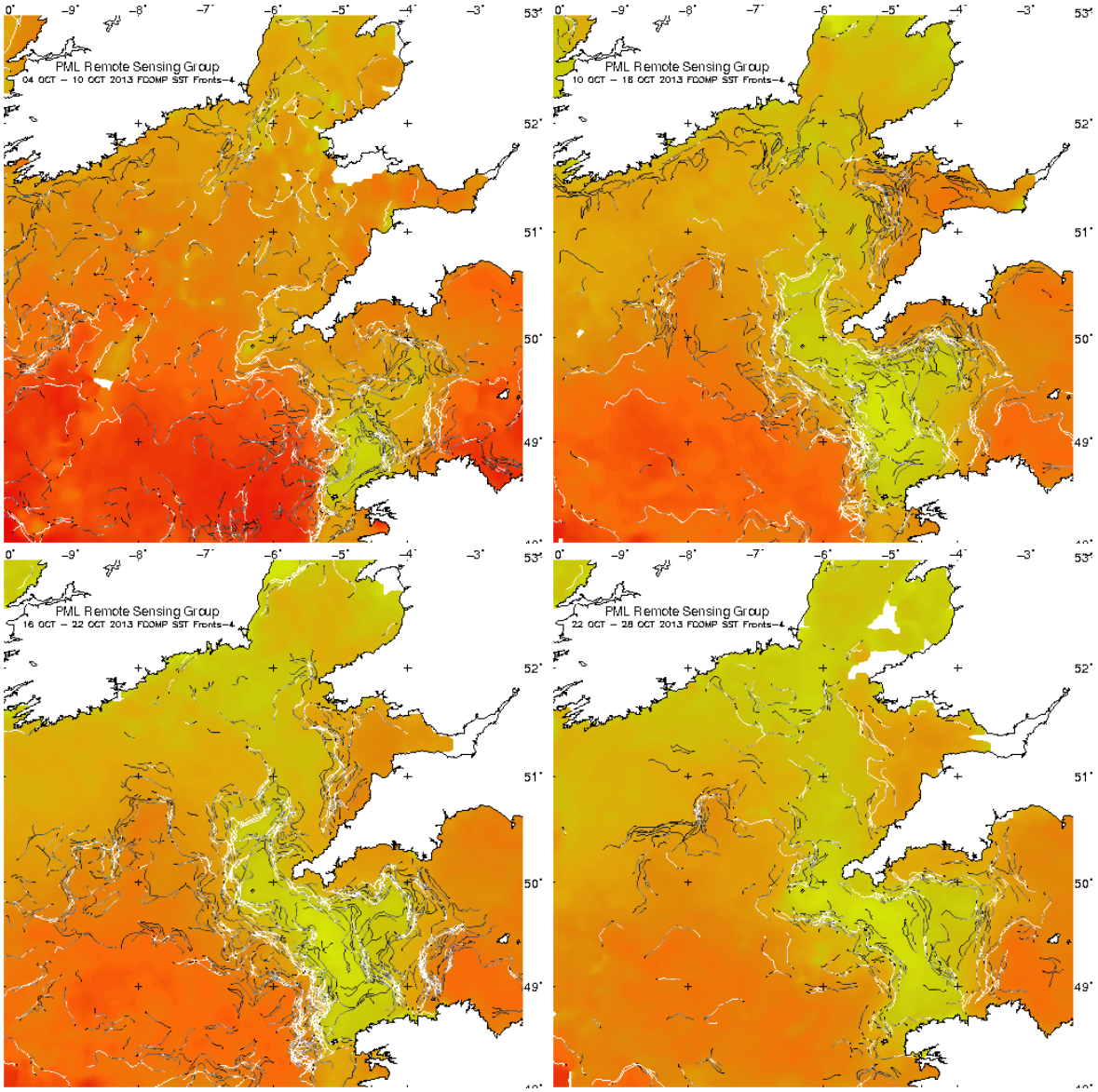

Figure 8. Composite maps of frontal systems from Neodaas for the periods 4-10 October, 10-16 October, 16-22 October and 22-28 October 2013, respectively.

The survey occurred in coincidence with the phytoplankton autumn bloom and thanks to periods of reduced cloud cover, it was possible to follow the progression of the bloom via satellite images. These images suggested that the bloom may have lasted for a couple of weeks (Figure 9). The occurrence of a phytoplankton autumn bloom was also confirmed by observations in zooplankton samples collected with an 80 µm net at the microscope. A qualitative analysis of the samples highlighted the presence of different genera of diatoms (e.g. *Odontella*, *Rhizosolenia*), dinoflagellates (e.g. *Dinophysis caudata*, *Protoperidinium*) and of the microflagellate *Phaeocystis*. Further analysis of phytoplankton samples using the inverted microscope, and of samples for HPLC and flow cytometry in the laboratory will provide details of the pico-, nano- and phytoplankton community as well their abundance and pigment composition.

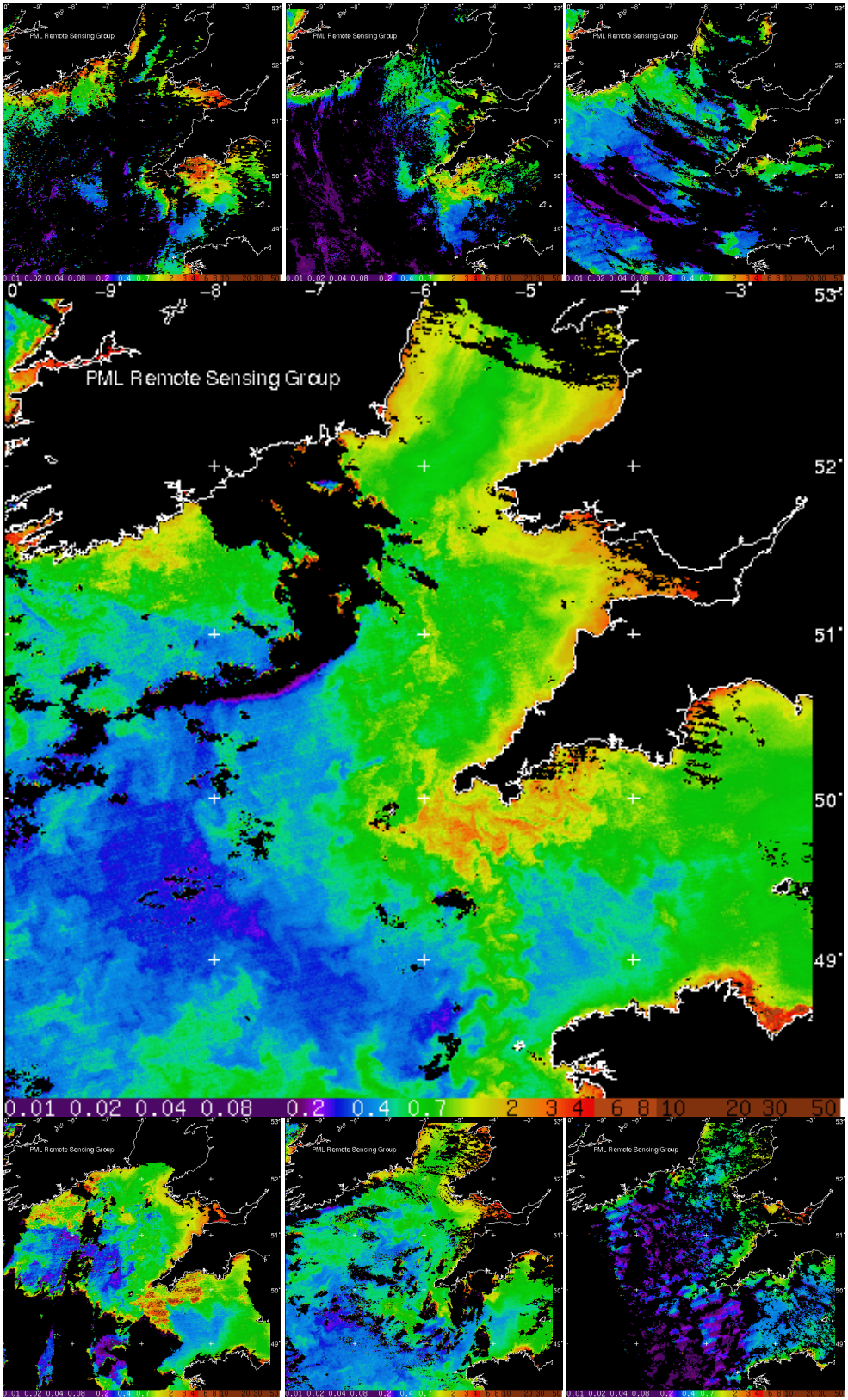

Figure 9. Satellite maps of surface chlorophyll concentration (from MODIS, OC5; www.neodaas.ac.uk) for 10, 11, 14, 16, 19, 23, and 29 October 2013 (from left to right, top to bottom).

Vertical profiles of temperature, salinity and density (carried out with the SAIV mini CTD mounted on the zooplankton sampling nets) were plotted using the software Ocean Data View (ODW). Surface maps from CTD measurements showed a temperature distribution similar to the one

observed from the satellite-derived maps and highlighted the presence of for example cooler, saltier and denser waters around the Isles of Scilly and warmer, less salty and less dense waters in the Bristol Channel and along the coast of Cornwall. The main part of the stations in the English Channel were vertically mixed while deeper offshore stations showed thermal stratification with difference in temperature between surface and bottom of up to 4.5 °C (Fig 10)

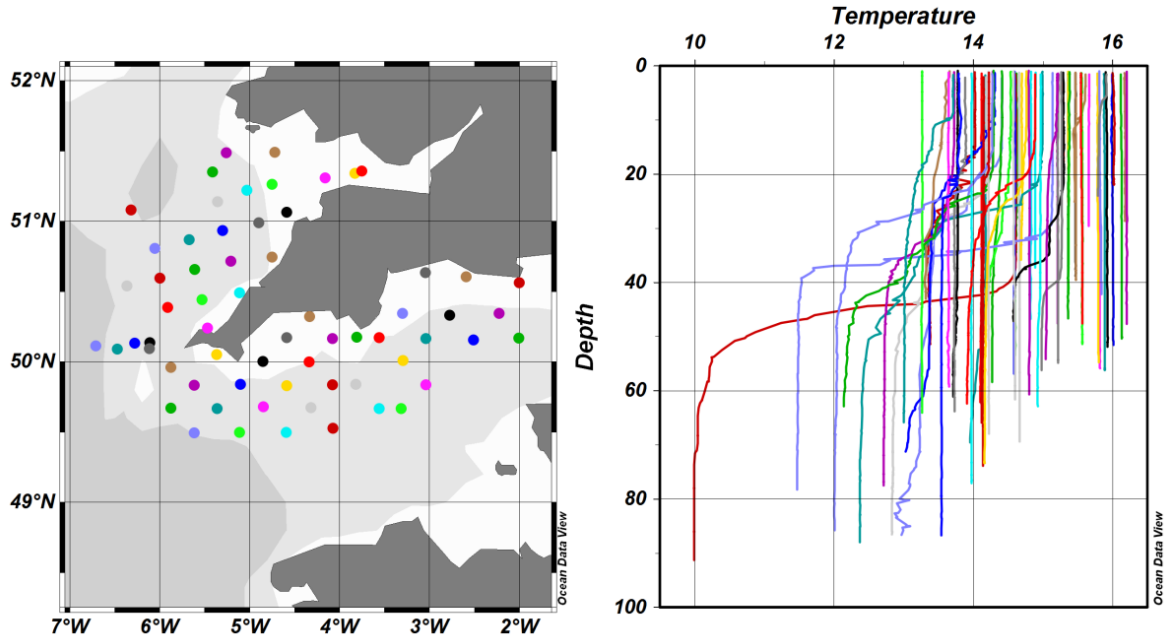

Figure 10. Vertical profiles of temperature as measured by the SAIV mini CTD (zooplankton nets); plotted with the software Ocean Data View (ODW).

3.4. Marine Mammals and birds

Both inshore and offshore transects were evenly sampled in the western English Channel, whilst offshore areas were under-sampled in the Bristol Channel and west of Land's End. Poor weather for recording predominated over the whole cruise, with good sea conditions (≤sea state 2) present on only one day. On the positive side, there was less rain than expected and visibility was generally good.

In total, there were 99 sightings of four cetacean species with 980 animals counted, including single sightings of White-beaked Dolphin (in a favoured part of Lyme Bay) and Long-finned Pilot Whale. The most abundant species was Common Dolphin with 74 sightings of 888 animals, chiefly in deeper waters (>50m). Harbour Porpoises were seen widely in Lyme Bay on the day of smooth seas.

There were ~3,000 sightings of 45 bird species with ~18,000 individuals counted. Highlights included large numbers of Gannets (~10,000) and Great Skuas (~500), unexpectedly high numbers of Balearic Shearwaters (chiefly in the Bristol Channel) and over 30 Pomarine Skuas. However, most pelagic 'Atlantic' migratory seabirds were in lower numbers than expected given the stormy sea conditions that predominated in the latter part of the cruise. Summer visitors such as Storm-petrel and Manx Shearwater had largely left the sampled areas, whilst an immigration of wintering auks was evident.

Surprisingly, no terrestrial birds of note were seen on the ship and little visible migration of diurnal passerines was evident, bar Starlings on the last day of the cruise in the southern North Sea. Although it was one of the best autumns in recent history for moth migration in south west England, just a single Hummingbird Hawkmoth was noted. Of interest four European Storm-petrels and a single Leach's Petrel were found in the ships garage over two evenings, with all birds being taken into care and released in a healthy condition on subsequent days.