CEND20_14 Cruise report

PELTIC14: Small pelagic fish in the coastal waters of the western Channel and Celtic Sea

Jeroen van der Kooij, Elisa Capuzzo, Joana Silva, Nigel Symes

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1. Outline of the survey

STAFF:

Part 1 (30th Sept-11th of October)

Jeroen van der Kooij (SIC)
Elisa Capuzzo (2IC)
Joana Silva (2IC)
Dave Brown*
Ken May
Mark Etherton*
Richard Humphreys
Samuel Roslyn*
James Pettigrew
Scott Davis
Kate Collingridge*
Conor Mulholland (Irish Observer)
Nigel Symes (Marinelife observer)
Ruth Molloy (Marinelife observer)

Part 2 (11– 19th of Oct)

Jeroen van der Kooij
Elisa Capuzzo
Joana Silva
Richard Ayers*
Chris Lynam*
Ken May
Richard Humphreys
Matt Eade*
James Pettigrew
Scott Davis
Conor Mulholland
Nigel Symes
Ruth Molloy

**staff involved in part of the survey*

1.1 Duration
30th September –19th of October

1.3 Location
Western Channel and Celtic Sea coastal zone (embarking in Portland and disembarking in Swansea)

1.4 Objectives

1. To carry out the third in a series of five annual multidisciplinary pelagic survey of the Western Channel and Celtic Sea waters to estimate the biomass of-, and gain insight into the population of the small pelagic fish community (sprat, sardine, mackerel, anchovy, horse mackerel, herring).
    a. To carry out a fisheries acoustic survey during daylight only using four operating frequencies (38, 120, 200 and 333 kHz) to investigate:
        - distribution of small pelagic species
        - abundance of small pelagic species
        - distribution of the pelagic species in relation to their environment
    b. To trawl for small pelagic species using a 20x40m herring (mid-water) trawl (taking the Cosmos Fotø and Engels 800 as back up) in order to obtain information on:
        - Species- and size composition of acoustic marks
        - Age-composition and distribution, from all small pelagic species
        - Length weight and maturity information on pelagic species
        - Stomach contents (stomach will be extracted frozen for future work)
2. To collect plankton samples using 2 different mesh ringnets (80 µm, and 270 µm mesh) at fixed stations along the acoustic transects at night and at a subset of trawl stations during the day. Samples will be processed aboard:
    a. Ichtyoplankton (eggs and larvae, 270 µm) of pelagic species will be identified and counted onboard and combined with information from maturity to identify spawning areas.
    b. Zooplankton will be stored for further analysis back in the lab.
3. To undertake a comprehensive survey of the vertical profile of the water column in the study area using a rosette, ESM2 and Ferrybox methods. At ~30 fixed stations along the acoustic transect, a Rosette and ESM2 will be deployed to obtain a vertical profile of the water column. Water column profile and surface water samples will provide information on chlorophyll, oxygen, salinity temperature, nutrients and the relevant QAQC samples for calibration of the equipment. Water samples will be collected and fixed on board for analysis post-hoc.
4. To record the locations, species, numbers and activities of seabirds and marine mammals in the survey area during daylight hours.
5. To further test the ability of a new (continuous) passive zooplankton sampler (CALPS) to supplement ringnet plankton nets with high resolution data on the surface. Focus includes sardine spawning, and key zooplankton prey.
6. To conduct continuous on-line measurement of Phytoplankton Functional types by flow cytometry as part of the internal Cefas seedcorn project DP366
7. To collect acoustic data with the new high (333 kHz) frequency echosounder and map the acoustically derived zooplankton densities. These will be compared with data collected under 2 (and where possible 6) as part of a new Defra funded project HAZARD, supplemented by Seedcorn project DP366.
8. 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.
9. 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)
10. To collect where possible 40 specimens each of adult and juvenile mackerel from the English Channel for Paula Alvarez (AZTI).

1.5 Narrative

Cefas staff joined the RV Cefas Endeavour in the afternoon of Monday the 29th of September. The vessel left Portland the following morning at 6:30 of the 30th of September and steamed straight to the calibration site off Portland Head (50° 36.180 N, 002° 35.762 W), to calibrate the echosounders. During the first calibration attempt tide was still too strong and the time was used to collect a relevant local sound velocity profile for the echosounder calibration, conduct a muster drill and safety walks with all scientific staff. At 14:00 BST the tide started to drop below 0.5 knots and by 16:30 the three frequencies were successfully calibrated. Whilst for anchor the Rosette plus ESM2 logger were deployed and tested and finally, after coming off anchor, the plankton ringnets were tested on the drift.

Wednesday morning the 1st of October the RV Cefas Endeavour sailed to deeper waters of the eastern English Channel. Two shake-down tows were undertaken with the pelagic trawl between 10:00 and 16:00, to get the crew used to the gear, fine-tune her geometry and make some small alterations to the rig.

On Thursday morning the 2nd of October, the survey started proper. Whilst during the previous two years transects were ran for 24 hours, this year fisheries acoustic transects, trawling and bird and mammal observations were conducted during daylight hours only, and CTD and plankton stations were covered during the night. When appropriate, the pelagic trawl was deployed to ascertain the species- and length composition of acoustic targets, or ‘marks’. In total 16 valid tows were made. On Wednesday the 8th of October at 19:00 the survey work was suspended due to bad weather associated with a series of westerly depressions, and the Endeavour was forced to seek shelter Northwest of the Isles of Scilly until 13:30 BST the next day when survey work could be resumed. Trawl operations were however not possible due to the remaining swell and wind conditions.

On the morning of 11th October, after completing all but two transects in the western Channel and most of the Isles of Scilly sub-area, the Endeavour steamed to Falmouth for a planned staff changeover which commenced at 8:00. D. Brown, M. Etherton, S. Roslyn and K. Collingridge left the vessel, whilst R. Ayers, C. Lynam and M. Eade joined.

After changeover, at 10:00 BST the Endeavour sailed to the start of the last two transects left in the Channel subarea which were completed that day. After completion of the necessary CTD and plankton stations the Endeavour steamed overnight to complete the last of the Isles of Scilly subarea on the 12th of October and set an eastward course to begin the survey of the Bristol Channel sub-area. Between the 13th and the 16th of October most of the south-west to north east running transects were completed in the Bristol Channel sub-area and on the night of the 16th saw the last of the primary CTD and zooplankton stations were completed. Whilst the western-most Bristol Channel transects showed very few fish, schools gradually started to appear in large numbers both offshore, parallel to the coast and inshore. Prior to completing the last three of the conventional Bristol Channel transects, the expected increase in southerly winds over the weekend lead to a decision to run the 100 nmi transect from the inner Bristol Channel to the Celtic Deep on the 17th of October. Two planned transects were completed on the 18th of October and deteriorating weather conditions meant that only one trawl could be performed in the morning.

On the morning of the 19th the Endeavour completed the final transect which ran from the north Devon coast into Swansea bay where the pilot was booked for 13:30. The RV Cefas Endeavour docked at 15:30 in Swansea port.

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. Trawls were undertaken opportunistically, depending on the presence and type of acoustic marks observed.

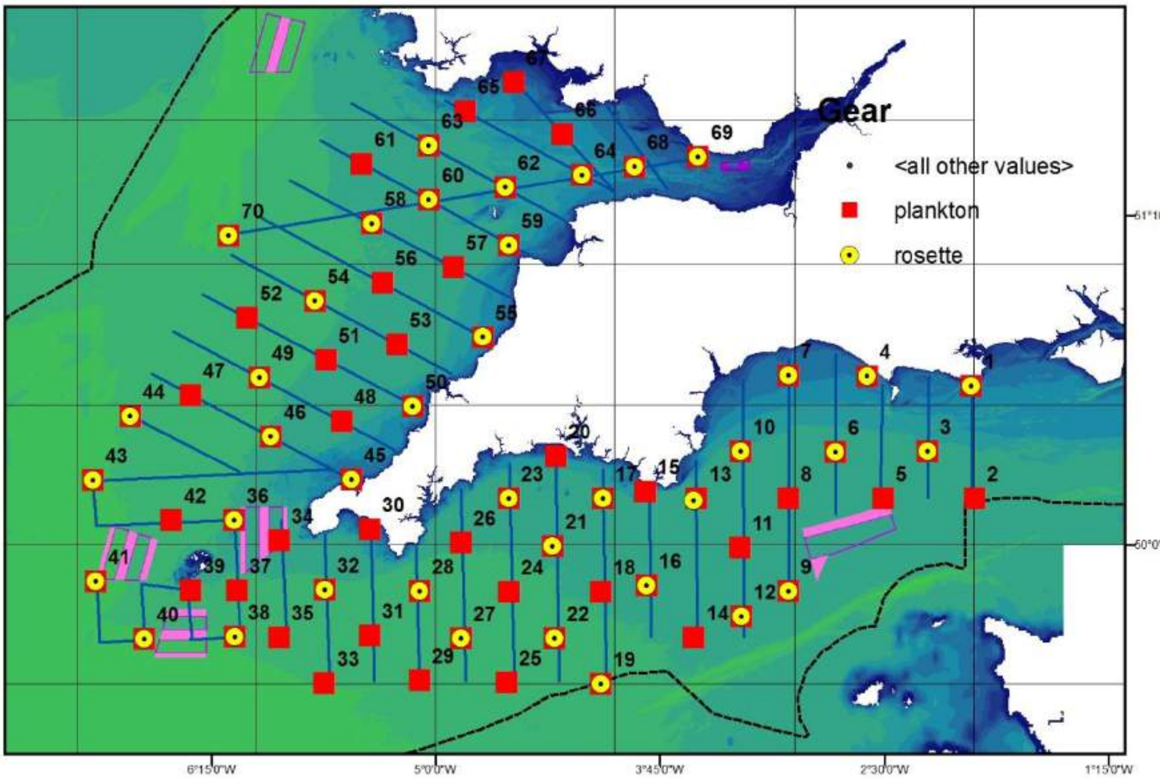


Figure 1. Overview of the survey area, with the acoustic transect (blue lines), plankton stations (red squares) and hydrographic stations (Yellow circles).

2.2 Fisheries acoustics

2.2.1. Acquisition

All three frequency echosounders present were successfully calibrated off Portland on the 14th of October. On the 11th of October a 333kHz GPT was brought onboard following some noise test tests by Simrad. Whilst data were recorded during the second half of the survey no calibrateion of the 333 kHz could be conducted. There were still issues with noise rendering data deeper than ~50m useless. After some experiments with pulse duration these were changed to 1.024 ms which appeared to improve the range of good data to 70m.

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 0.512 ms 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 occasional strong windy conditions and Atlantic swell. Occasional spells of very bad weather adversely affected some of the surface data due to aeration but only on one occasion was it necessary to hold acoustic data collection. 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. Both the on-transect data and those collected during the steam between transects were retained. Only the former was used for further biomass estimates but the inter-transect data was retained and cleaned for future studies on spatial distribution of predators and prey. 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). The echogram with only the echoes from fish with swimbladders was then scrutinised and split into a number of categories:

1. Diffuse echoes in the bottom 10 m above the seabed consisting of loosely aggregated gadoids, and scattered mackerel and/or clupeids
2. Schools in mid-water consisting predominantly of sprat, sardine, anchovy
3. Mackerel schools, either in mid-water or near the seabed – extracted from 200kHz and occasionally pixels need to be removed from 38kHz.
4. Diffuse Unidentified Scattering Targets (DUST) in mid water, often containing fish.
5. 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
6. 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.

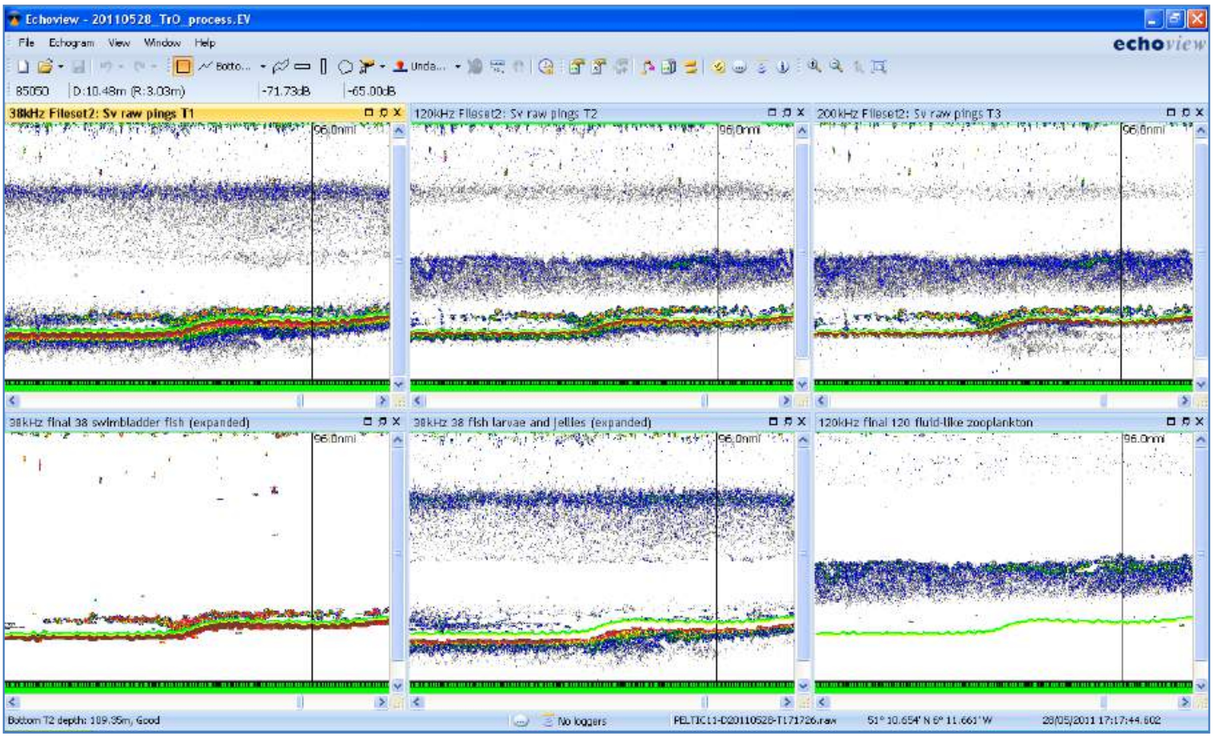


Figure 2. Dataflow of algorithm (top) used to divide the acoustic data by echotype. Screen-shot example (bottom) with raw echograms of 38, 120 and 200 kHz (top panels) and three examples of extracted echotypes (bottom panel from left to righ): fish with swimbladder (sardine schools at surface and myctophids 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. This was applied only on files which were affected by bad weather.

2.3 Fishing and catch sampling

A 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 2nd of 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 Electronic Data Collection (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 (up to 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 up to 25 stomachs were taken across the various length categories per species per catch.

2.4 Zooplankton

The various planktonic size components were sampled at 71 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. 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 during the survey. Ichthyoplankton (eggs and larvae) and macrozooplankton from the 270 μm samples were counted and, in the case of clupeid larvae, measured and raised using flow meter derived sample volumes. Samples from the 80 μm mesh were transferred into jars and preserved with 4% buffered formaldehyde for later analysis using a zooscan in the lab.

At a subset of 18 prime stations two water sample were taken and fixed on lugol, one for phytoplankton analysis back in the lab and one for micro-zooplankton analysis. In addition, this year at 40 stations surface samples of zooplankton were taken using the new CALPS (Cefas Autonomous Litter and Plankton Sampler). For an hour at each of these stations a sample was taken using an 80 μm mesh net to be compared with the vertical casts.

2.5 Oceanography

The main physical, chemical and biological environmental variables were investigated collecting discrete and continuous *in situ* measurements, and via remote sensing. Daily and weekly maps of chlorophyll concentration (OC5 algorithm), sea surface temperature and frontal systems were obtained from Neodaas (www.neodaas.ac.uk).

Discrete in situ measurements of temperature, salinity, fluorescence, optical backscatter, dissolved oxygen and Photosynthetically Available Radiation (PAR) were collected at 39 sampling stations using an ESM2 profiler. The Rosette water sampler (equipped with an FSI CTD) was used for collection of water samples at discrete depths at 10 sampling stations. At the other stations, where the Rosette could not be deployed due to rough sea conditions, surface samples were collected from the continuous water pump that supplies the Ferrybox.

Samples for determination of Total Alkalinity (TA), dissolved inorganic nutrients and dissolved organic matter (for PML, Shelf Sea Biogeochemistry project), salinity, dissolved inorganic nutrients (for this project), samples for flow cytometry and pigments analysis were collected only at the surface. At 18 stations, samples for analysis at the microscope of phytoplankton and microzooplankton composition and abundance were collected at the surface. Samples for dissolved oxygen analysis were collected at 8 sampling stations for calibration of the oxygen sensor of the ESM2 profiler. A summary of the samples collected and of the CTD casts carried out during the survey is given in Table 2.

	Total
Salinity	18
Dissolved oxygen	8(x3)
TA/DIC	23
Dissolved inorganic nutrients (PML)	23
Dissolved organic nutrients (PML)	23
Dissolved inorganic nutrients (Cefas)	18
Chlorophyll/Pigments analysis (HPLC)	39(x2)
Flow Cytometry	39(x2)
Phytoplankton	18
Microzooplankton	18
CTD casts with ESM2	39

Table 1. Samples collected during the survey and number of vertical casts carried out.

A Ferrybox provided continuous surface measurements of different environmental variables including temperature, salinity, fluorescence, dissolved oxygen. This year it was also connected to a flow cytometer, which performed hourly measurements (continuously) of the size and abundance of pico- and nanoplankton populations. The pCO2 analyser carried out continuous measurements of the dissolved carbon dioxide in water and air during the whole survey.

2.6 Top predators

Effort-related surveys were made for top predators daily 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 critically endangered seabird. For each Balearic Shearwater encountered, more detailed recording was made including precise location, 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. Preliminary results

3.1. Pelagic Ichthyofauna

After removing the off-transect data a total of ~1400 nautical miles of acoustic sampling units were collected for further analysis (Fig. 3). A total of 16 successful trawls were made (Fig. 3). 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 mainly due to weather and presence of static gear.

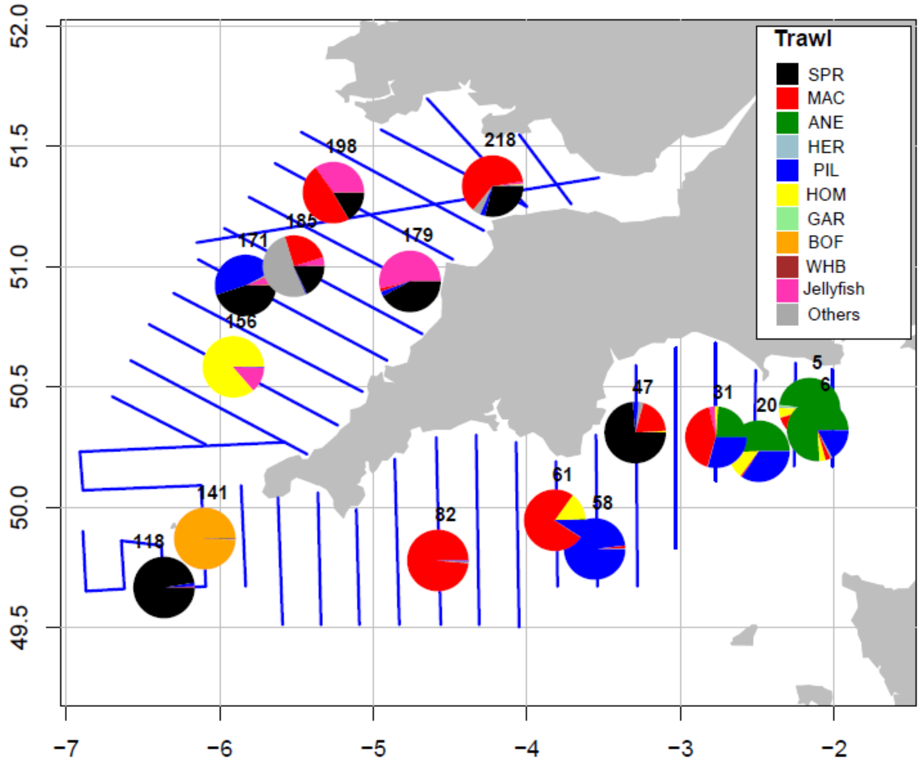


Figure 3. Overview map and detail of the survey area. Acoustic transects (blue lines) and trawl catches (pies) with relative catch composition by key species. Three letter codes: SPR=sprat, MAC=mackerel, ANE=anchovy, HER=herring, PIL=sardine, HOM= horse mackerel, GAR=garfish, BOF=Boarfish, WHB=Blue whiting.

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, whereas those from the Lyme Bay area were more mature (fig. 4). Some very high densities of sprat were encountered in Lyme Bay. For the first time sprat were found in deeper waters around the Isles of Scilly and large offshore aggregations mixed with sardine in the Bristol Channel.

Sardines (*Sardina pilchardus*) were much more widespread than in previous years according to the trawl stations (fig. 3), with predominantly juvenile specimens found in most hauls, including around the Isles of Scilly and offshore in the Bristol Channel (fig. 3 and 4). This year for the first time large spawning aggregations were observed in the acoustic data of the western channel (Fig 4).

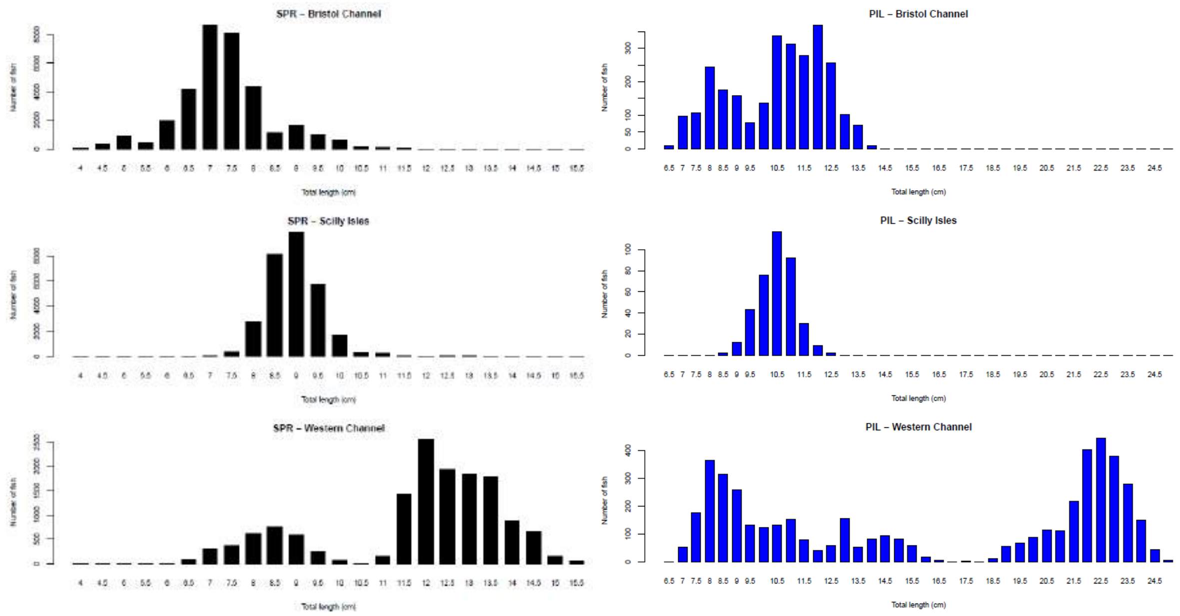


Figure 4. Trawl-caught numbers by length of sardine (*Sardina pilchardus*) (left) and sprat (*Sprattus sprattus*) by subarea. Please note that these numbers were not yet raised by the acoustic data.

Mackerel (*Scomber scombrus*) observations appeared to be in line with those in 2012 when only small numbers of juvenile mackerel were found. None of the very large mackerel schools as seen in 2013 were observed in the western channel this year despite the large overlap in timing of the surveys.

This year, anchovy appeared in larger numbers than in previous years but again only in the Lyme Bay trawl stations (Fig 3, 5). However three length classes could be identified in the catches with good numbers of large fish. 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.

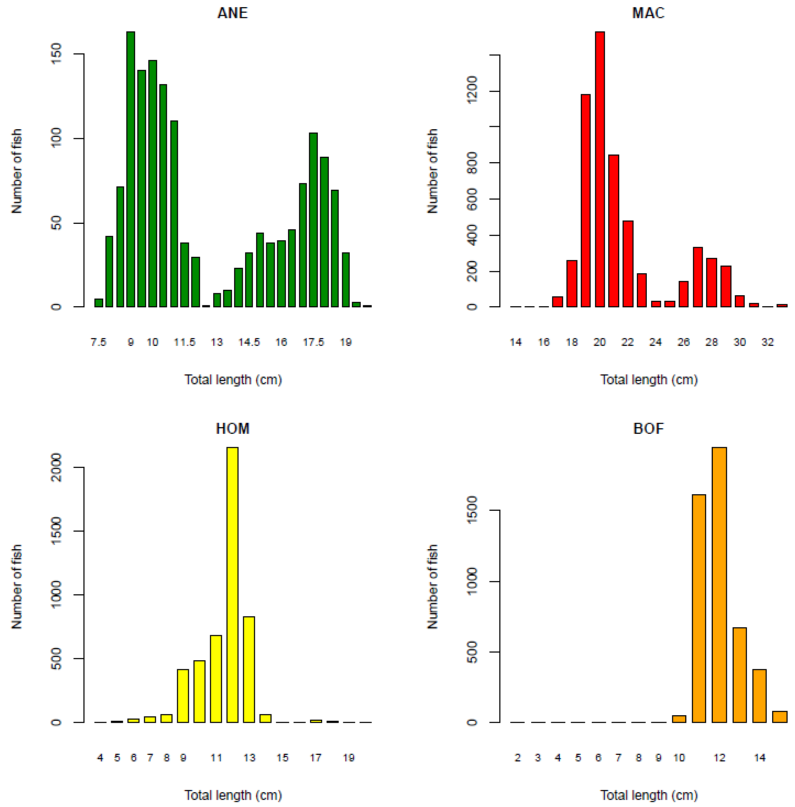


Figure 5. Trawl caught numbers by length of anchovy, mackerel, horse mackerel and boarfish for survey.

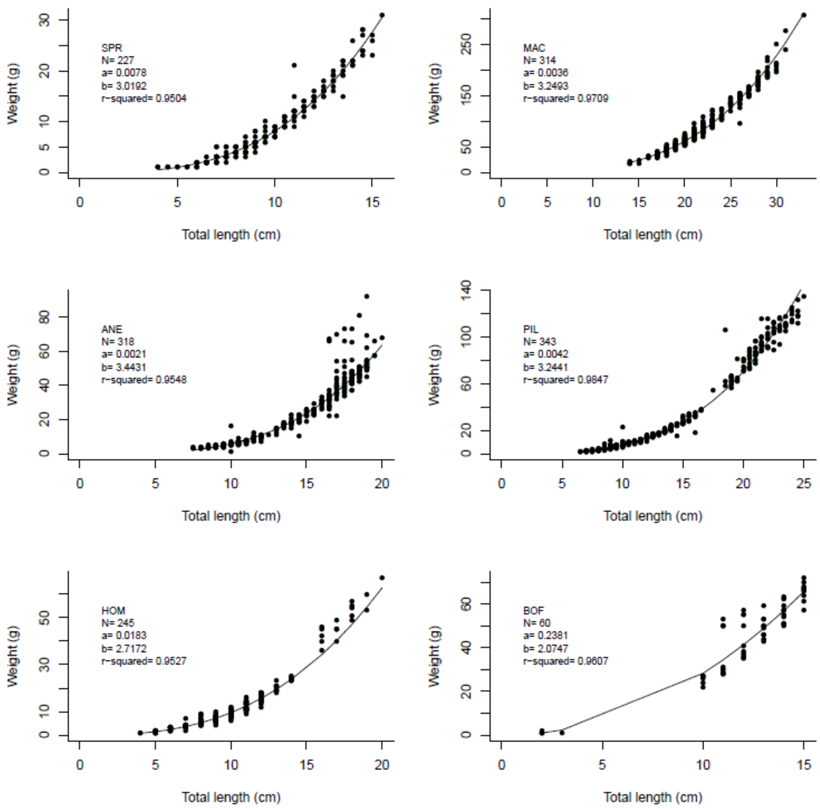


Figure 6. Length weight relationships of dominant pelagic species across the survey area.

3.2. Plankton data

Zooplankton samples were collected at 70 stations with the two ringnets. Whilst water samples were taken from 39 stations, only a subset of 18 “key” stations will be further analysed to extract micro-zooplankton. Onboard ichthyoplankton processing revealed that the bulk of eggs were sardine (fig. 7), with small numbers of sprat, lemon sole and sandsol making up the remaining categories. Most abundant were sardine eggs (Fig 7) and larvae (Fig. 8) 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 (fig. 7) with smaller numbers in the Isles of Scilly. No eggs were found in the Bristol 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, although those in the latter area consisted of larger specimens and may have drifted there (fig. 8a, b). These results matched those of 2013. 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.

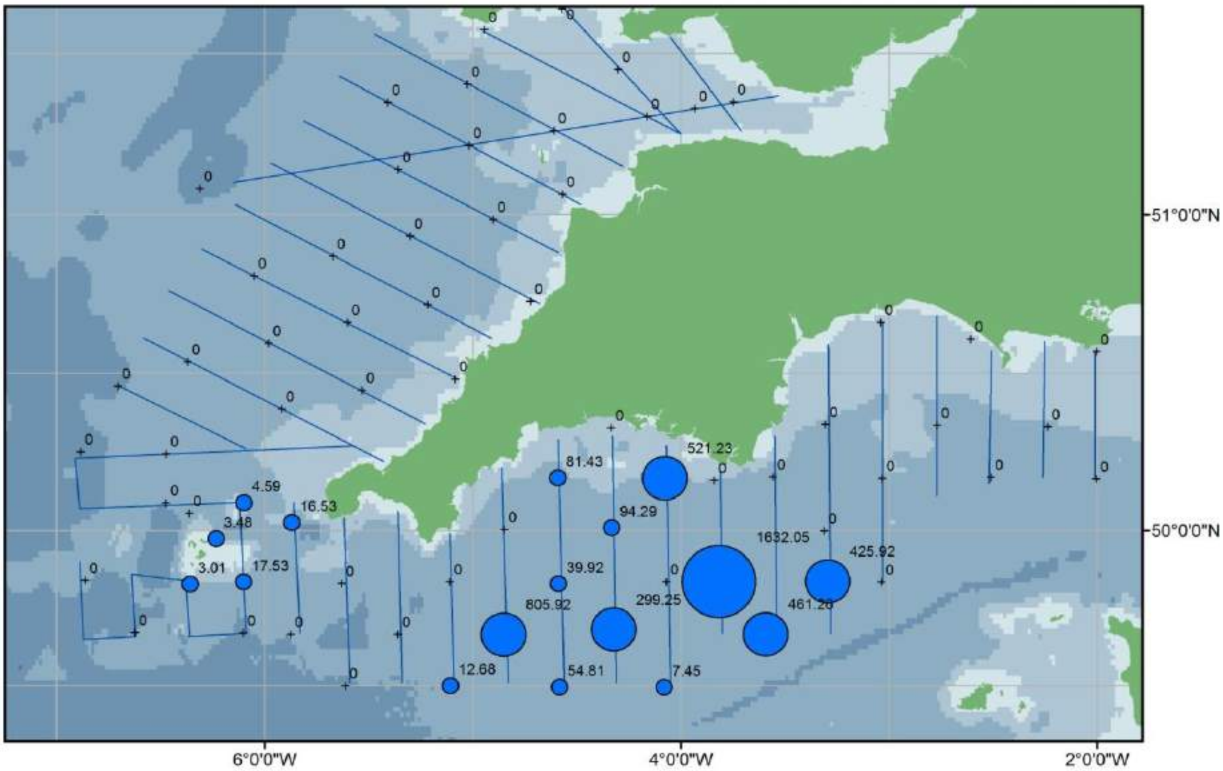


Figure 7. Ichtyo-plankton stations with sardine eggs. Bubble size relative to numbers caught.

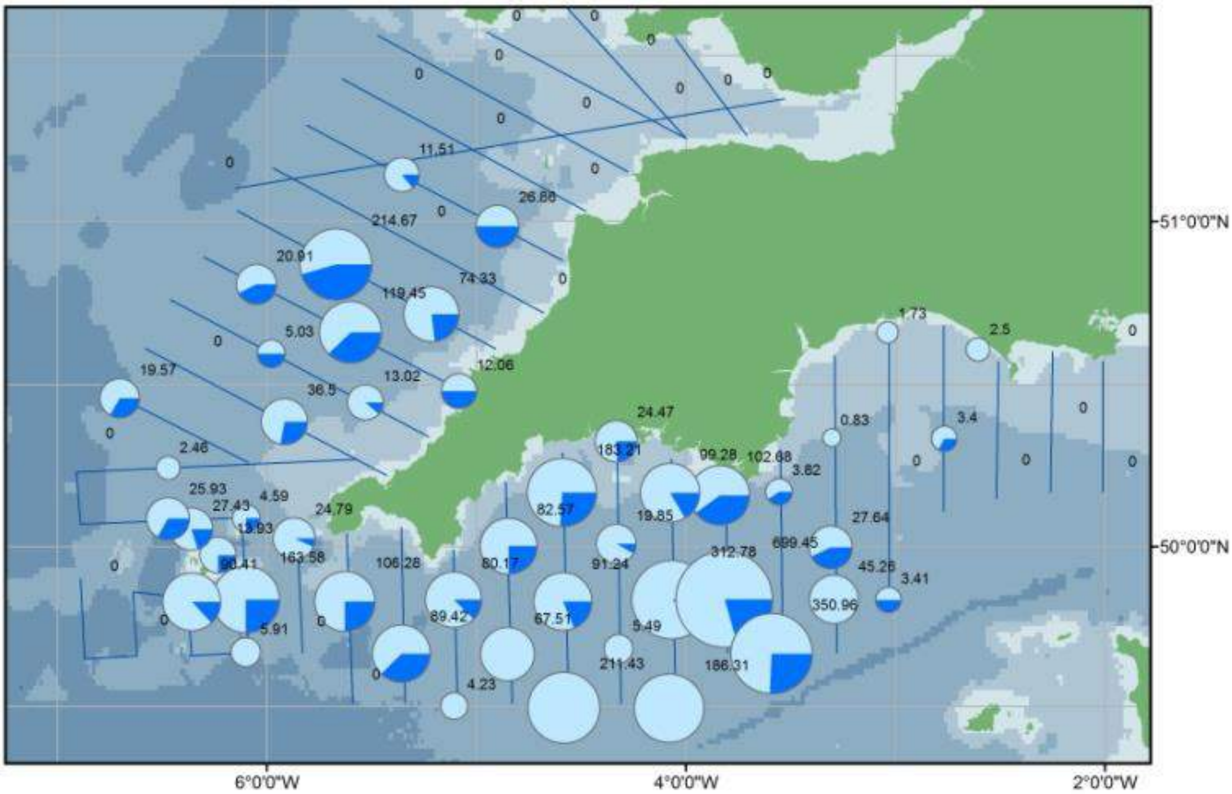


Figure 8a. Ichtyo-plankton stations with unidentified clupeid (light blue) and sardine (dark blue) larva. Pie size relative to total larvae numbers caught; numbers of sardine larvae m^{-2} indicated in centre.

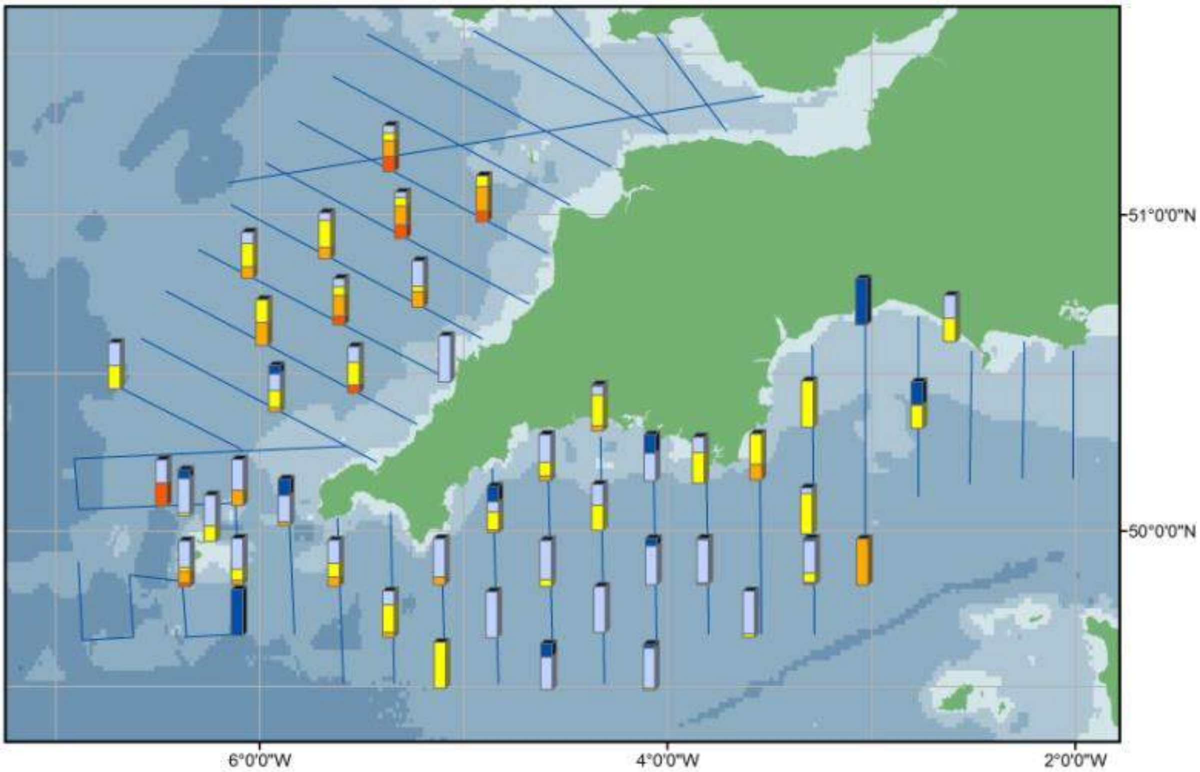


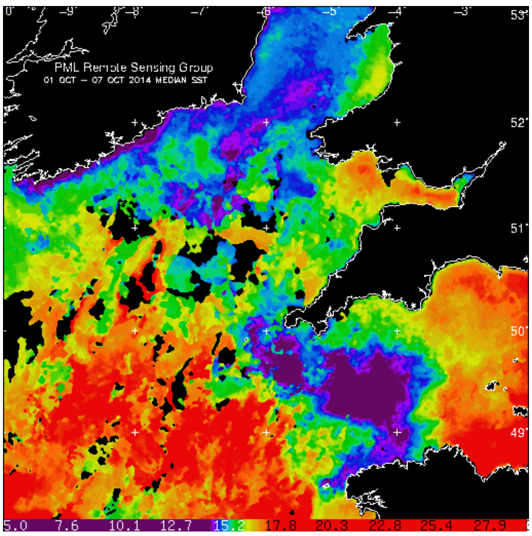
Figure 8b).distribution of positively identified sardine larvae by size class, dark blue (3mm) .

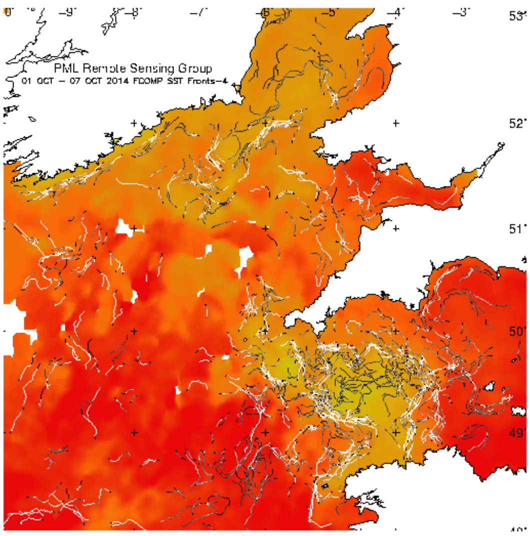
3.3. Oceanographic data

3.3.1. Temperature and salinity

Surface waters of the Western English Channel and of the shelf edge were warmer than the rest of the Celtic Sea with temperature > 18°C (Figure 9a and Table 1). A patch of slightly cooler water (approximately between 14-15°C), was located south of Eddystone Bay down to the France coast (Figure 9a). During the course of the survey this patch of cooler water extended west towards the Celtic Sea including also the Scilly Isle (Figure 9c).

The boundary layer where the cooler waters south of Eddystone Bay meet the warmer waters of the English Channel and the Celtic Sea was marked by a series of frontal systems (Figure 9b and d).

a 

b 

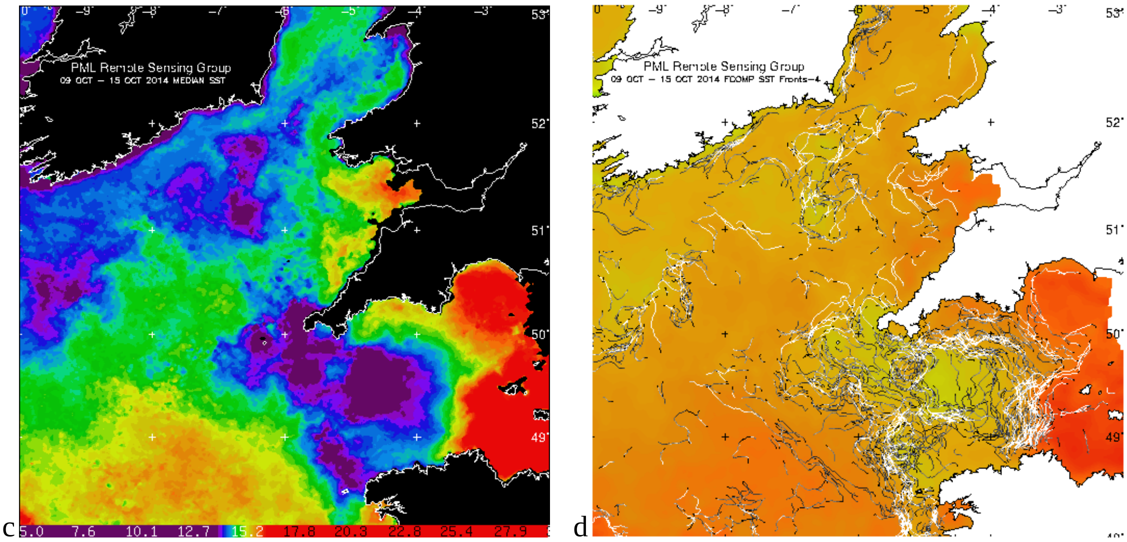


Figure 9. Composite surface maps for the periods 1-7 October and 9-15 October 2014 of temperature (a and c) and thermal frontal systems (b and d) from Neodaas.co.uk.

Vertical profiles of temperature and salinity (carried out with a SAIV Mini CTD mounted on the zooplankton sampling nets) were plotted using the software Ocean Data View (ODW). Surface maps from CTD measurements (Figure 10, 11 and 12) showed a temperature distribution similar to the one observed from the satellite-derived maps. The surface maps of the Western English Channel (Figure 10) show the presence of a gradient from cooler and saltier waters towards the Scilly Isle to warmer and less salty waters in Lyme Bay. Stations in the Bristol Channel showed a similar gradient (warm and less salty waters in the inner Bristol Channel, cooler and saltier waters in the outer Channel; Figure 4), although waters in the Bristol Channel were not as warm as in Lyme Bay (16.33 and 18.08 °C respectively; Table 2).

	WEC	SI	BC
Prime	1-33	34-44	45-70
Sampling period	30/9 - 11/10	8 - 12/10	12 - 17/10
Surface Temp	14.48 / 18.07	14.49 / 15.88	14.63 / 16.33
Bottom Temp	12.53 / 18.08	10.88 / 15.00	10.15 / 16.34
ΔT	-0.02 / 2.27	-0.01 / 5	-0.07 / 4.85
Surface Salinity	35.07 / 35.52	35.33 / 35.44	33.39 / 35.84
Bottom Salinity	35.07 / 35.56	35.37 / 35.50	33.42 / 35.91
ΔS	-0.13 / 0.04	-0.13 / -0.01	-0.23 / 0.01
Stratified	15 (45%)	8 (80%)	5 (10%)

Table 2. Minimum and maximum values at the surface and bottom of temperature (°C) and salinity (measured by the SAIV Mini CTD on the zooplankton nets), ΔT (surface temperature – bottom temperature) and ΔS (surface salinity – bottom salinity) for the study area. The prime station numbers, sampling period and number of stratified stations (ΔT > 0.5 °C) are also indicated. WEC = Western English Channel; SI = Scilly Isles; BC = Bristol Channel.

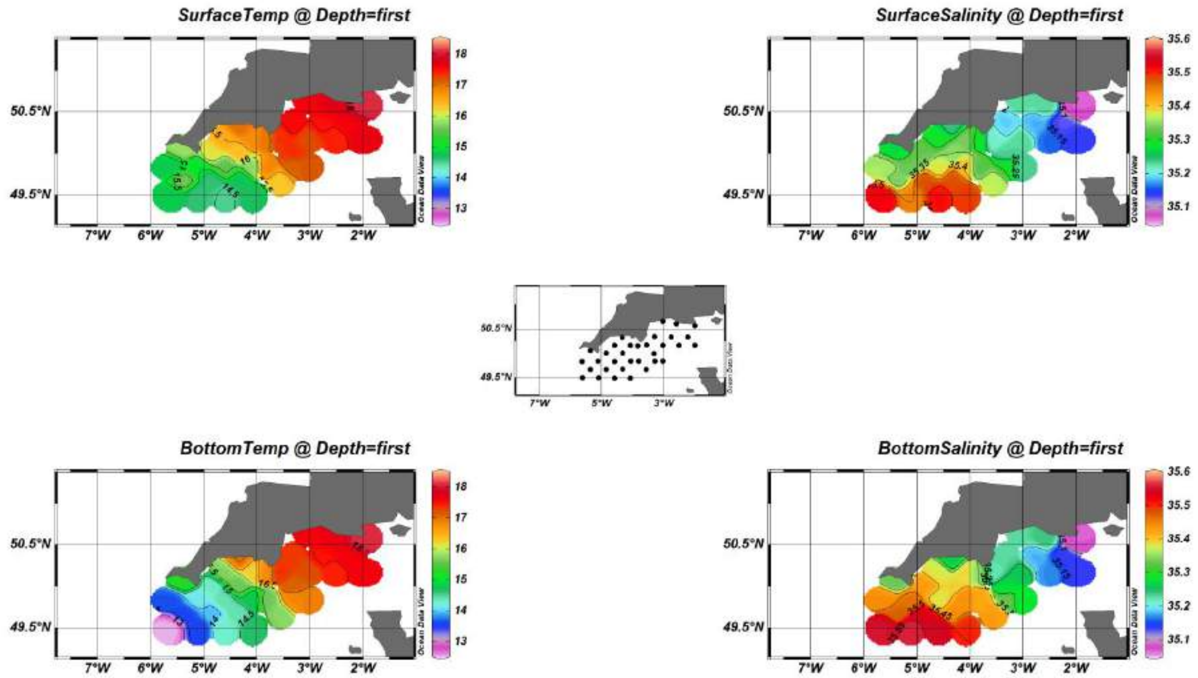


Figure 10. Values of temperature (°C) and salinity at the surface and bottom at the stations in the Western English Channel (WEC), as measured by the SAIV MiniCTD.

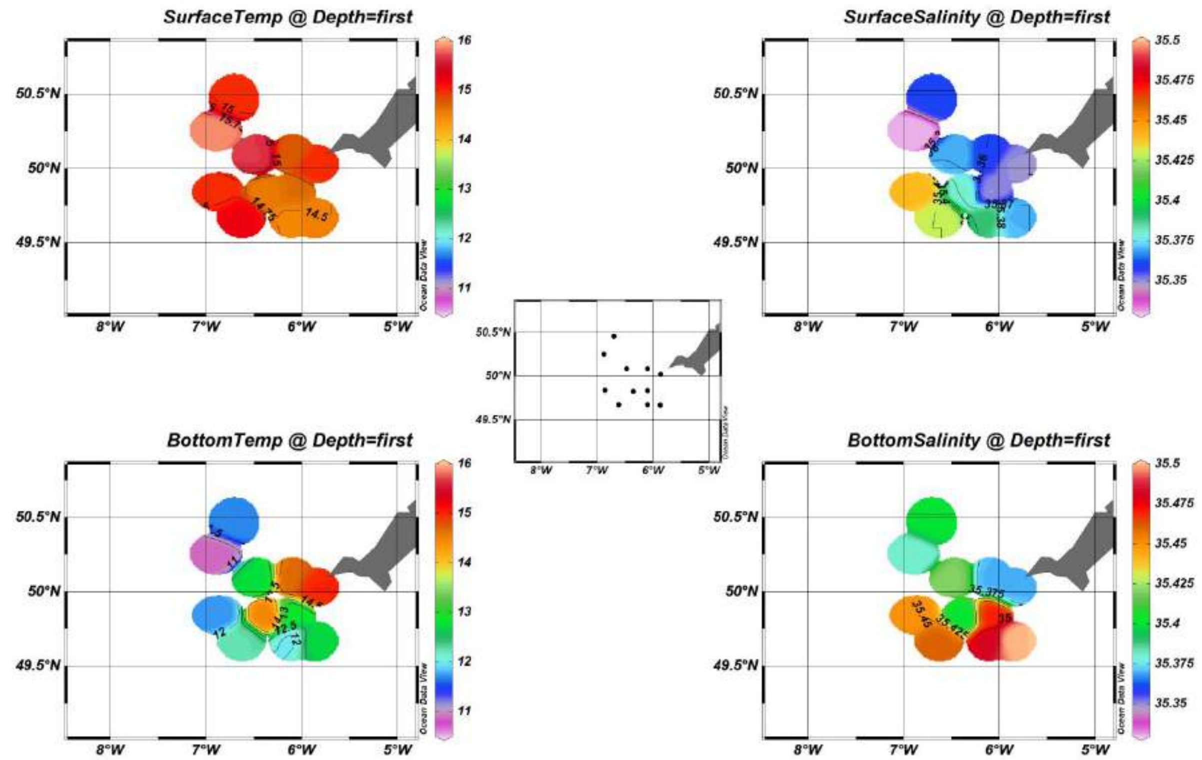


Figure 11. Values of temperature (°C) and salinity at the surface and bottom at the stations in the Isles of Scilly (SI), as measured by the SAIV MiniCTD.

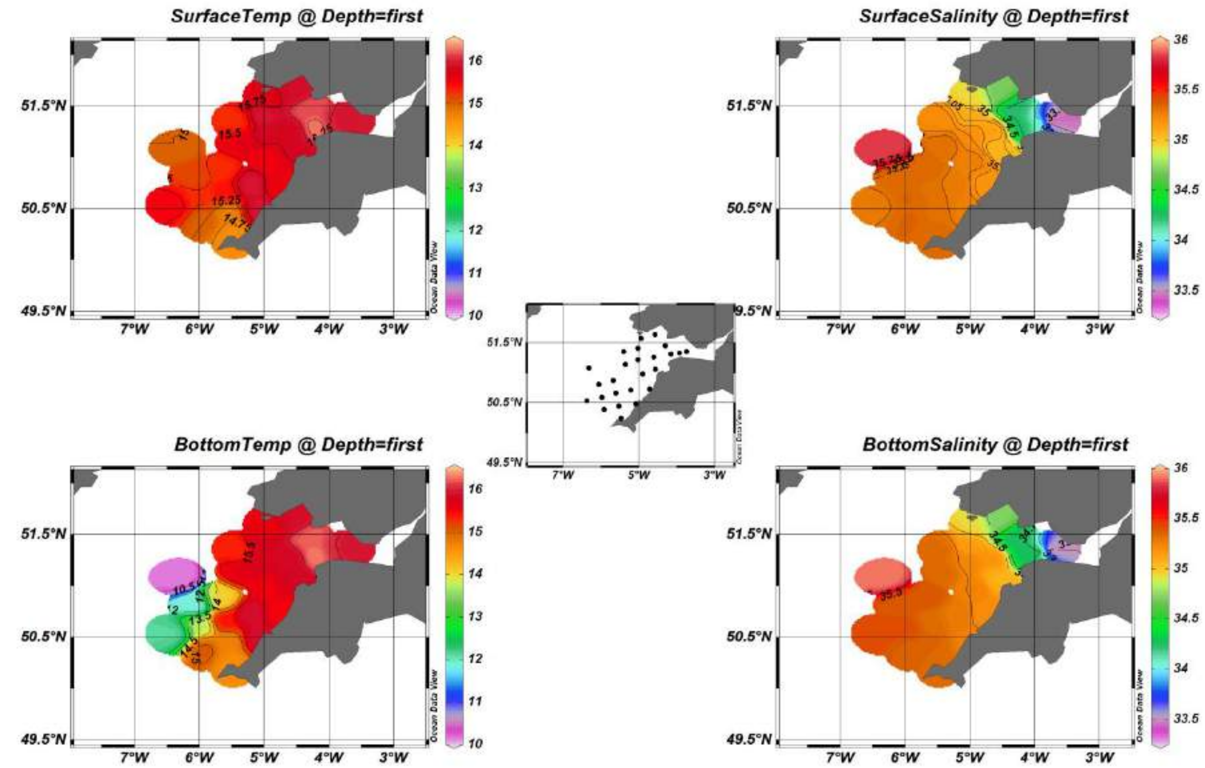


Figure 12. Values of temperature (°C) and salinity at the surface and bottom at the stations in the Bristol Channel (BC), as measured by the SAIV Mini CTD.

The main part of the stations at the Isles of Scilly and half of the stations in the Western English Channel were thermally stratified ($\Delta T > 0.5$ °C) with difference in temperature between surface and bottom of up to 5 °C (Table 2). This is particularly clear in Figure 13, where all stations in Lyme Bay, inshore of north Cornwall and Bristol Channel were vertically mixed ($\Delta T < 0.5$ °C). Differences in salinity between surface and bottom were small (-0.23 / 0.04; Table 2 and Figure 13), suggesting that the vertical stratification of the water column was mainly driven by changes in temperature rather than salinity.

At the stratified stations, the depth and width of the thermocline were variable; examples of temperature profiles are presented in Figure 14.

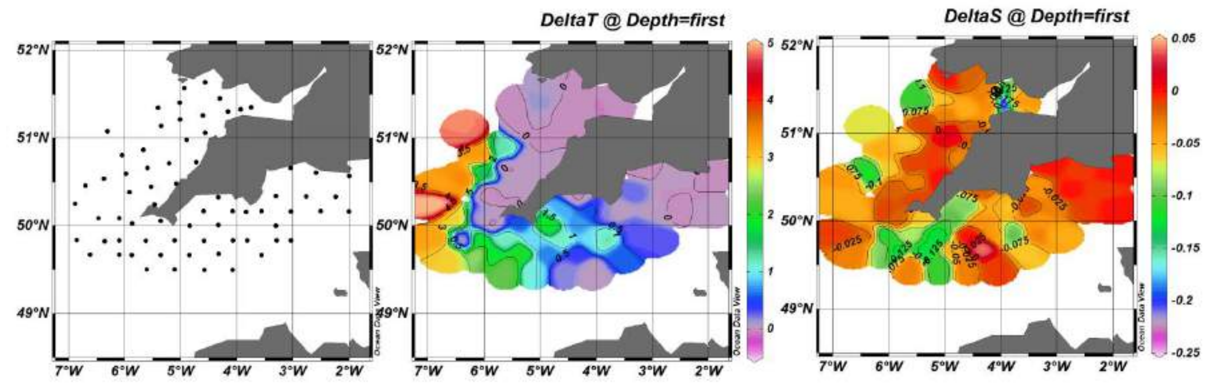


Figure 13. Values of ΔT (surface temperature – bottom temperature; °C) and ΔS (surface salinity – bottom salinity) at the 70 sampling stations, as measured by the SAIV MiniCTD. The water column is considered stratified when $\Delta T > 0.5$ (°C).

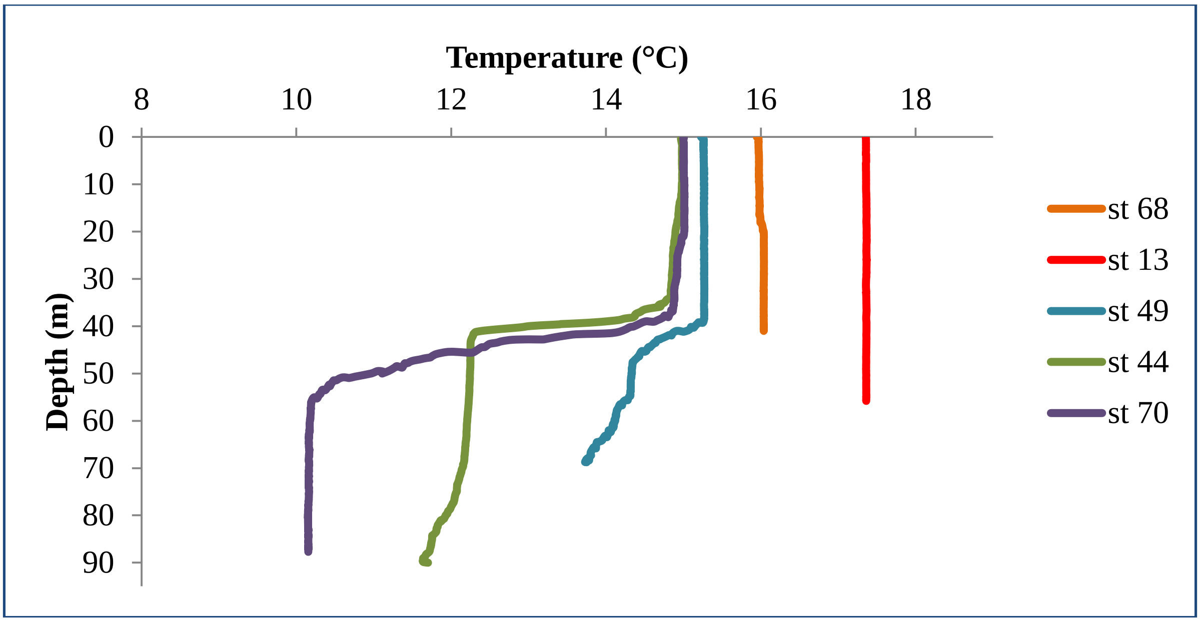


Figure 14. Examples of temperature vertical profiles, highlighting different level of stratification of the water column.

3.3.2. Chlorophyll and fluorescence

Higher levels of chlorophyll concentration were observed offshore (Figure 15) in correspondence of the Ushant front and the frontal systems around the cool patch of water in the Western English Channel (Figure 9). In these frontal systems, nutrient-rich waters are mixed with nutrient-depleted surface waters leading to a potential increase in phytoplankton biomass. These frontal systems act as ‘physical barriers’ for plankton organisms including also fish eggs and larvae.

Chlorophyll was higher in Lyme Bay compared to Eddystone Bay, as also shown by the Ferrybox raw fluorescence (Figure 16). Remote sensing images indicated high level of chlorophyll concentration in Bristol Channel. However this observation was not supported by the Ferrybox fluorescence measurements which were generally low (compare Figure 15 and 16). This is likely due to the higher level of suspended solids in the inner Bristol Channel affecting the reliability of the remote sensing algorithm for calculating chlorophyll concentration.

Due to poor weather conditions, it was not possible to follow the evolution of the phytoplankton autumn bloom, as occurred during the previous survey (Peltic 13). Therefore it is not clear when the bloom initiated.

Analysis of phytoplankton samples at 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 as their abundance and pigment composition.

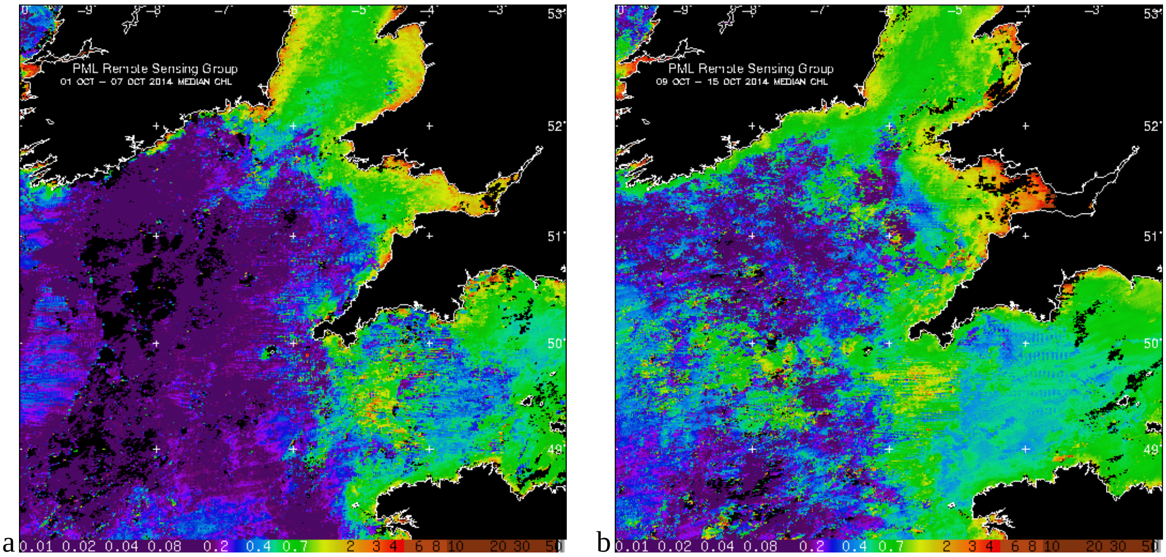


Figure 15. Chlorophyll concentration at the surface for the periods 1-7 October (a) and 9-15 October 2014 (b) from Neodaas.co.uk.

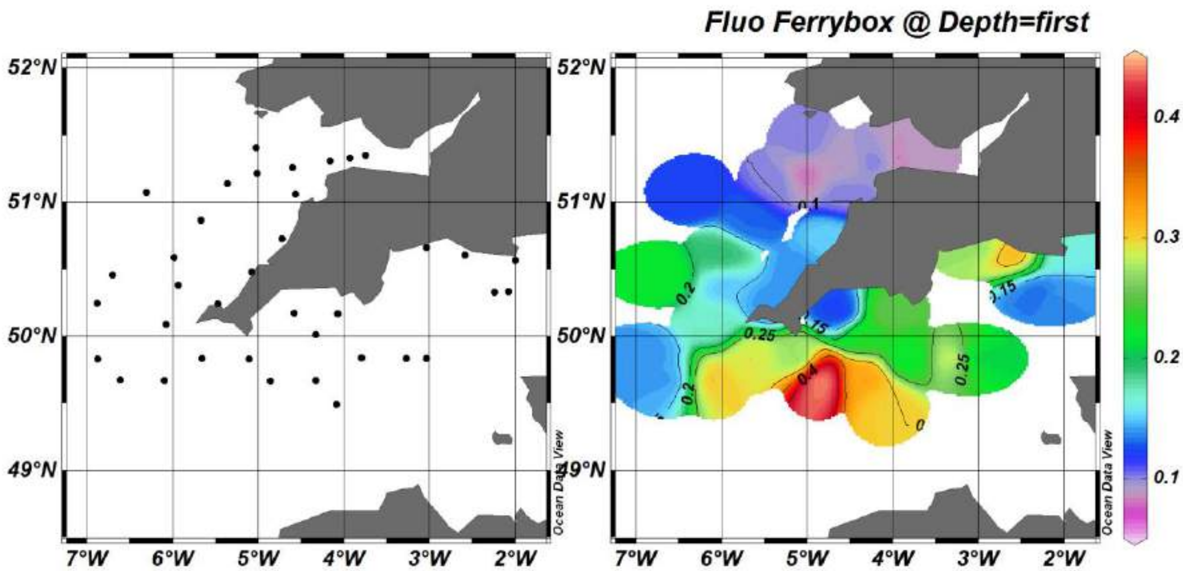


Figure 16. Fluorescence values at 4 m depth, at 18 sampling stations, as recorded by the Ferrybox.

3.4. Marine Mammals and birds

This year, because of changes made to the survey methodology, all transects were run in daylight, and with more sea time in the survey area and better weather, almost complete coverage was achieved in all sections of the survey. Poor weather, particularly high winds and sea state, is inevitable for surveys conducted late in the year, however conditions were significantly better than in 2013. Visibility during effort surveys was generally good to excellent, and rain was infrequent and fog absent.

In total, there were 96 sightings (99 in 2013) of seven cetacean species (4 in 2013), with significantly more individual animals counted. The chief highlight was of 7 Fin Whales feeding together 30 nmi north of Lands End. They were seen feeding together on dense concentrations of sprat and sardine in association with a Minke Whale, Common Dolphins and Harbour Porpoise. Blue-finned Tuna were seen foraging in the same area. Meanwhile, two single Minke Whales were found inshore off the South Devon coast.

Ten Risso's Dolphin were seen 10 nmi south of Portland, and White-beaked Dolphin were encountered within 1 nmi of where they were seen 2013, in Lyme Bay; this population is thought to be the only one in the English Channel. Meanwhile, the most abundant species encountered throughout was Common Dolphin with 76 (74 in 2013) sightings of 1,520 animals (120% of 2013), chiefly but not exclusively in deeper waters (>50m) in the west and northwest of the survey area. A single group of Bottlenose Dolphin were seen feeding offshore in the English Channel, whereas Harbour Porpoises were seen sparsely but widely mainly inshore in calmer smooth seas, however they were also noted feeding in the fin whale encounter.

There were ~2,200 sightings of 38 bird species with 17,000 individuals counted (slightly more than last year). Gannets were again by far the most numerous species recorded (~9,000, 94% of last year's total), but in many ways the demography was quite different; significantly more Manx Shearwaters and Storm Petrels, but fewer auks, Kittiwakes, and skuas.

The unexpectedly high numbers of Balearic Shearwaters (chiefly in the Bristol Channel) in 2013, provided an important focus for 2014. With only 2,000 pairs surviving in the world, all breeding on the Balearic Islands, and having declined by ~95% since 1970s, they are now classified by IUCN as Critically Endangered. UK waters are at the edge of their non-breeding range however, distinct northward shifts in range have been noted in recent years so it is likely that the UK will become increasingly important for them. 79 were logged in 2013, whereas 205 were seen this year, including 147 in the same general area of the Bristol Channel as last year, associated with concentrations of small sprat. This confirmation of an important feeding area is highly significant, and will be used to inform future conservation measures.

Terrestrial bird migration was noted particularly in the English Channel, where Meadow Pipit, was by the most abundant (>550). Swallows, Pied Wagtails and Robins were also noted. More unusually a Short-eared Owl rested on the ship in strong opposing winds in the Celtic Sea, presumably enroute from southern Ireland. Several Hummingbird Hawkmoths visited the ship over a number of days, and two or three unidentified butterflies flew past.

4. Summary

The third autumn survey in the Peltic survey provided the first opportunity to conduct the acoustic transects in daylight only, as opposed to the 24 hour regimes in 2012 and 2013. The motivation was that in previous years at least one of the species (sprat) was observed to disappear at the top of the echograms at dusk raising concerns about under-sampling. Whilst this new sampling requires more survey time, this was compensated by the fact that 3 days of survey time were freed up by being able to mob and demob in the southwest reducing the steaming time significantly. Whilst the 16 trawl hauls fell below the number aimed, all provided good and representative catches. Pending completion of the acoustic data processing, preliminary results suggested that numbers of sprat, sardine and anchovy were all up from previous two years. Mackerel quantities appeared more in line with 2012 not showing any of the large schools observed in 2013. High numbers of sardine eggs were found and larvae numbers were down suggesting that the survey took place earlier in the autumn spawning season. Despite the large temporal overlap with the 2013 survey physical conditions were different: top temperatures were higher and strong frontal features existed in several areas of the survey whilst chlorophyll values were lower than last year.