## Annex 5e: Peltic

# DRAFT Survey report CEND22_15

## PELTIC15: Small pelagic fish in the coastal waters of the western Channel and Celtic Sea

Jeroen van der Kooij, Elisa Capuzzo, Joana Silva, Mike Bailey

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## 1. Outline of the survey

STAFF:

| Part 1 (3rd -13th of October) | Part 2 (13– 21st of October) |
|---|---|
| 1. Jeroen van der Kooij (SIC) | Jeroen van der Kooij (SIC) |
| 2. Elisa Capuzzo (2IC) | Elisa Capuzzo (2IC) |
| 3. Joana Silva (2IC) | Joana Silva (2IC) |
| 4. John Pinnegar | Dave Brown |
| 5. Dave Brown | Ken May |
| 6. Buster Rook Bishop | Richard Humphreys |
| 7. Richard Humphreys | Matt Eade |
| 8. Matt Eade | Paul Bouch |
| 9. Paul Bouch | James Pettigrew |
| 10. James Pettigrew | Phil Lamb (PhD student) |
| 11. Samantha Barnett | Mike Bailey (observer) |
| 12. Philip Lamb (PhD student) | Pete Akers (observer) |
| 13. Mike Bailey (observer) | Jack Lucas (observer) |
| 14. Pete Akers (observer) | |
| 15. Jack Lucas (observer) | |

**1.2**. **Duration**: 3rd –21st 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 map, 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. Water column sampling. At fixed stations along the acoustic transect, an ESM2 will be deployed to obtain a vertical profile of the water column. Water column profiles and water samples will provide information on chlorophyll concentration, dissolved oxygen concentration, salinity, temperature, inorganic nutrients concentration 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. Additional high resolution ESAS observations will be conducted on critically endangered Balearic shearwaters and other seabirds as part of a collaborative Defra funded project between MarineLife, Natural England and Cefas.
6. Ferrybox Continuous CTD/Thermo-salinigraph/pCO2. Continuously collect oceanographic data at the sea surface (4 m depth) during steaming.
7. To conduct further experiments with the online flow-cytometer to obtain continuous data on phytoplankton functional groups in collaboration with project JERICO NEXT.
8. To collect discrete samples of phytoplankton and micro-zooplankton at predetermined 18 primary stations for further analysis back to the lab (species composition, abundance, biomass and size distribution)
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 map the acoustically derived zooplankton densities using the new 333 kHz frequency and compare it with data collected under 2 (and where possible 7) as part of Defra project HAZARD.
11. To collect genetic samples of gut contents and jellyfish for a UEA PhD studentship aiming to identify and quantify predation of jellyfish (Philip Lamb)
12. To collect and freeze samples of jellyfish for isotope work (Clive Trueman, NOC)
13. To quantify the size, biomass, distribution of the gelatinous species as part of a collaboration with the Nerc-Defra funded Marine Ecosystem Research Programme (MERP)

### 1.5 Narrative

Cefas staff joined the RV Cefas Endeavour in the afternoon of Friday the 2nd of October. The vessel left Portland the following morning at 6:00 AM of the 3rd of October 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 which commenced at 9:00, slack tide was just missed and currents rapidly became too strong (+0.8 knots) so the attempt was interrupted until next the next slack tide at ~14:30. Instead a toolbox talk, muster drill and safety walks with all scientific staff were conducted before lunch. The aim was to use the two hours between lunch and scheduled resumption of the calibration to conduct shakedown tows with the ESM2, and plankton nets. However as those gears were prepared for deployment, a distress call came in at 13:30 requiring the RV Cefas Endeavour to abandon all planned operations and leave the calibration site to aid a yacht which had engine issues and could not move due to lack of wind. Despite the fact that there was no threat to life and the engine was working again, the RV's searider had to act as safety vessel and escort the yacht back into port. At approximately 16:30 the searider was back onboard the RV. However by this time the slack tide window was missed again rendering the calibration futile; even a shakedown tow with the pelagic trawl was by this point not possible due to specialist fishing staff on deck (bowson) being out of their 12 hours. The next slack tide was due after sunset and as the calibration spheres had not been located and previous experience had demonstrated that doing that in darkness was pointless, it was decided to postpone the calibration until a suitable future window and start the first of the primary stations that evening continuing through the night.

On Saturday morning the 4th of October survey started proper commencing with the eastern most of the acoustic transects. Similar to last year's survey, 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. The first trawl of the survey took a bit of time; firstly after the trawl was shot it appeared that the wrong trawl rigged. Secondly after the correct trawl was rigged on the netdrum 1½ hours later, the crew needed to get familiar with the gear. After only a few trawl operations this improved notably and before long the quickest recorded time to the survey series was achieved consistently to shoot and retrieve the trawl gear. For the duration of the survey, when appropriate, the pelagic trawl was deployed to ascertain the species- and length composition of acoustic targets, or 'marks'. In total 23 valid tows were made, the highest for the survey series.

On the morning of 13th 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. J. Pinnegar, S. Barnett and B. Rook Bishop left the vessel, whilst K. May joined.

After changeover, at 10:15 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 14th of October and set an eastwards course to begin the survey of the Bristol Channel sub-area. Between the 15th and the 18th of October all but four of the south-west to north east running transects were completed in the Bristol Channel sub-area and on the night of the 18th saw the last of the primary CTD and zooplankton stations completed. This year distinct "bands" of fish biomass were present parallel to the coast both halfway along the transects and at the end of the transects. Prior to completing the last four of the conventional Bristol Channel transects, the excellent forecast for the Monday lead to a decision to run the 100 nmi transect from the inner Bristol Channel to the Celtic Deep on the 19th of October. Two planned transects were completed on the 20th of October and deteriorating weather conditions meant that only one trawl could be performed in the morning.

Weather conditions throughout the survey were exceptionally favourable with the worst conditions on the 5th of October not exceeding much beyond 30 knots of wind. Unusually most of the wind was from an easterly direction.

On the morning of the 21st the Endeavour completed the final two transect which ran from the north Devon coast into Swansea bay where the pilot was booked for 13:00. The RV Cefas Endeavour docked at 15:00 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.

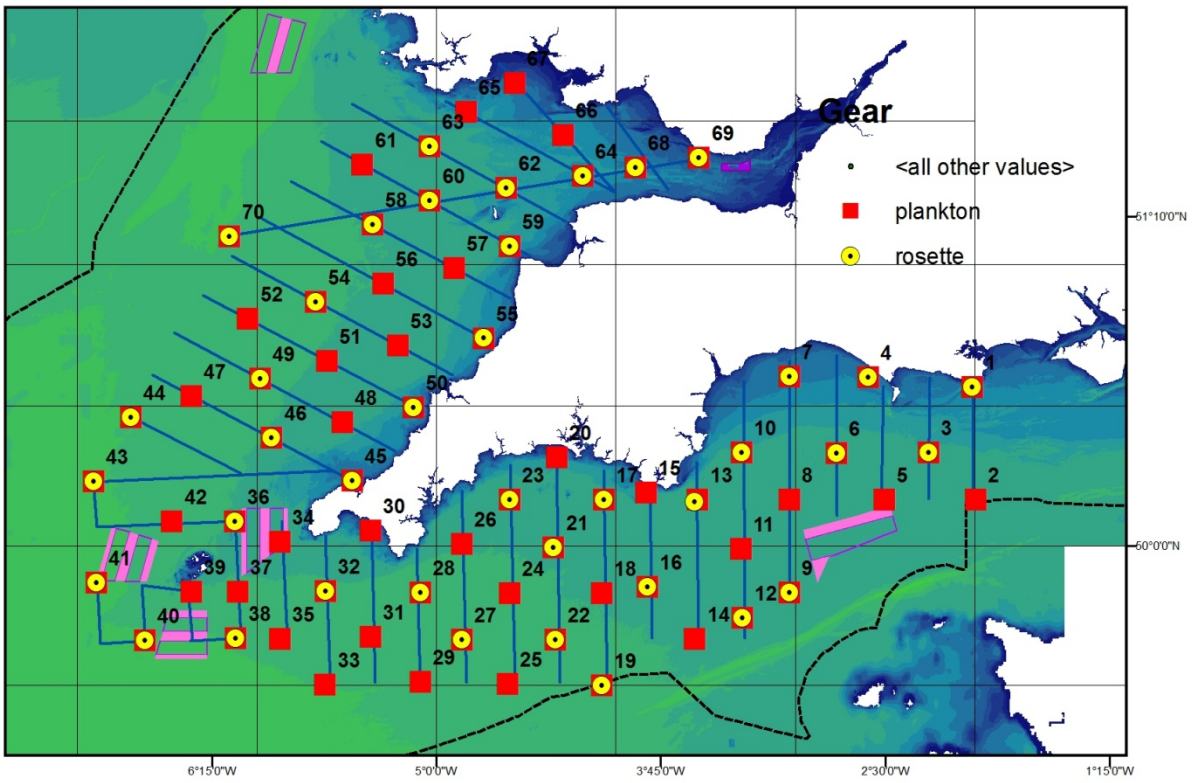


**Figure 1.** Overview of the survey area, with the acoustic transect (blue lines), plankton stations (red squares) and hydrographic stations (Yellow circles).

## 2.2 Fisheries acoustics

### 2.2.1. Acquisition

Due to the lack of a successful calibration at the start of the survey, the calibration settings from the previous survey were loaded. This excluded calibration settings for the 333 kHz which was not available for calibration at the time.

Fisheries acoustics were recorded along the pre-designed transects (Fig. 1) at the four operating frequencies (38, 120, 200 and 333 kHz). The transducers were mounted on a drop keel which was lowered to 3.0 m below the hull, 8.3 m below the sea surface. Pulse duration was set to 0.512 ms for the 38-200 kHz frequencies and to 1.024 for the 333 kHz frequency (as better results were obtained) and the ping rate was set to 0.5 pings $s^{-1}$. Due to the exceptionally favourable weather conditions, acoustic data were of very high standard. Poor quality surface data due to aeration was only encountered on the 5$^{th}$ and 21$^{st}$ of October and at no time was it necessary to hold acoustic data collection altogether. 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 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. A surface exclusion line was set at 13 m 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 attributed to individual species based on expertise and 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.

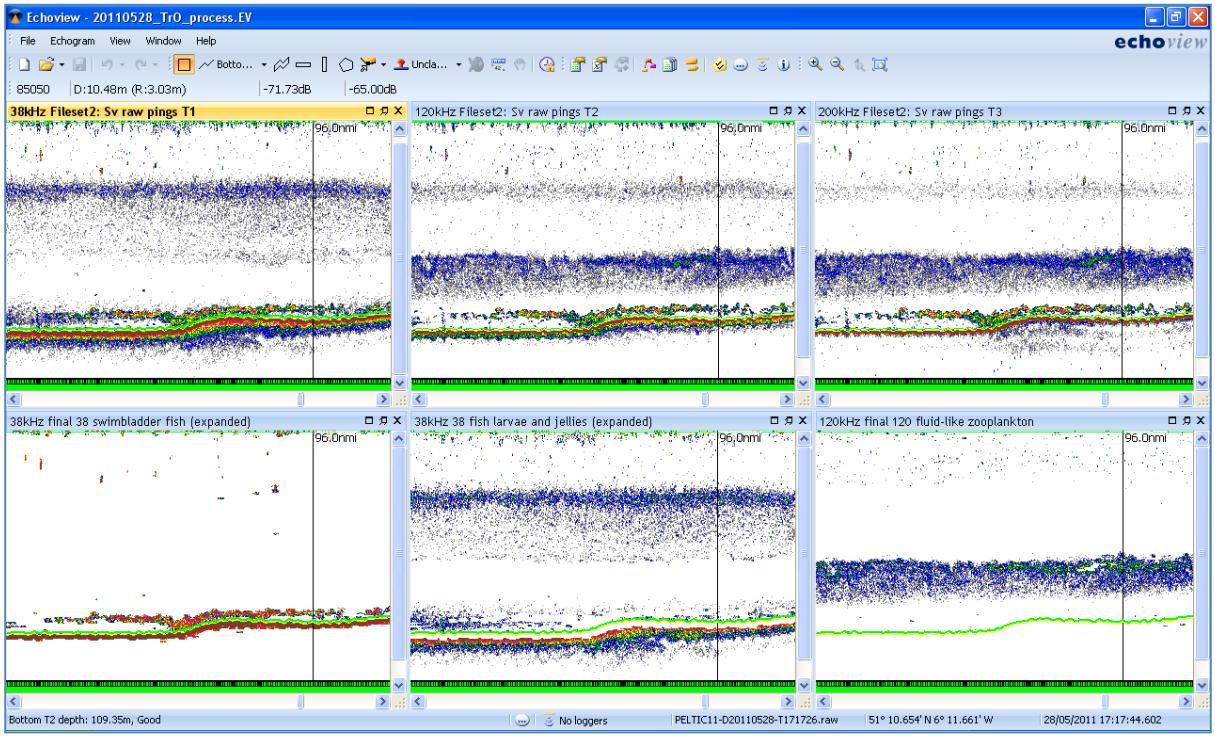


**Figure 2**. Dataflow of algorithm (top) used to divide the acoustic data by echotype. Screen-shot example (bottom) with raw echograms of 38, 120 and 200 kHz (top panels) and three examples of extracted echotypes (bottom panel from left to righ): fish with swimbladder (sardine schools at surface and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

Physical, chemical and biological properties of the water column were investigated using different platforms of observations (Ferrybox, CTD, remote sensing) and by collecting of discrete water samples at the subsurface.

The Ferrybox provided continuous measurements in real time at the subsurface of different variables including temperature, salinity, fluorescence and dissolved oxygen concentration. Daily and weekly maps of chlorophyll concentration (OC5 algorithm), sea surface temperature and frontal systems were downloaded from Neodaas (www.neodaas.ac.uk). The Ferrybox, was connected to a flow cytometer, which performed hourly measurements of the size and abundance of pico- and nanoplankton populations. A pCO2 analyser carried out continuous measurements of the dissolved carbon dioxide in water and air during the whole survey.

Vertical profiles of temperature, salinity, fluorescence, optical backscatter, dissolved oxygen and Photosynthetically Available Radiation (PAR) were collected at 39 sampling stations using an ESM2 profiler. At 18 of these stations, water samples were collected at the surface from the continuous water pump that supplies the Ferrybox, for analysis of salinity, dissolved inorganic nutrients (for this project), samples for flow cytometry and pigments analysis, as well as for analysis of phytoplankton and microzooplankton communities.

Surface samples for determination of Total Alkalinity (TA), dissolved inorganic nutrients and dissolved organic matter (for PML, Shelf Sea Biogeochemistry project), and samples for dissolved oxygen analysis were collected from a Niskin bottle connected to the hydrowire of the ESM2 logger.

Samples for analysis of dissolved oxygen concentration, salinity and chlorophyll will be used for calibrating the sensors on the ESM2 profiler and on the Ferrybox.

A summary of the samples collected and of the CTD casts carried out during the survey is given in Table 1.

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

| | Total |
|---|---|
| Salinity | 21 |
| Dissolved oxygen | 24 |
| TA/DIC | 13 |
| Dissolved inorganic nutrients (PML) | 13 |
| Dissolved organic nutrients (PML) | 13 |
| Dissolved inorganic nutrients (Cefas) | 18 |
| Chlorophyll/Pigments analysis | 38 |
| Flow Cytometry | 38 |
| Phytoplankton | 18 |
| Microzooplankton | 18 |
| | |
| CTD casts with ESM2 | 39 |

### 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. This year, two different but complimentary approaches were taken to record birds and marine mammals. On the Bridge wing of one side of the vessel (selected as appropriate to minimise sun glare), two experienced JNCC-accredited European Seabirds At Sea (ESAS) surveyors employed an effort-based distance sampling straight-line transect survey following strict ESAS methodology, whilst on the other Bridge wing, a single volunteer MARINElife surveyor employed an adapted and slightly simplified version of this methodology. As a result, a 90° bow-to-beam scan area was surveyed by the ESAS team continuously during daylight hours, including all transit cross-lines, and with the additional coverage provided by the MARINElife surveyor, a 180° scan area was surveyed almost continually throughout the entire survey. Furthermore, observations were conducted during the net-retrieval stage of each trawl to identify species of birds associated with the fishing activity of the survey vessel. All species of birds (both seabirds and terrestrial migrants) were recorded, along with all sightings of marine mammals.

ESAS methodology aims to achieve an assessment of the numbers and distribution of animals in a designated quantifiable area by employing a sampling method so that numbers can be extrapolated into the entirety of the study zone. ESAS methodology is an internationally recognised sampling method conforming to internationally accepted standards enabling data to be compared with surveys elsewhere. It is recommended that ESAS surveys only occur in sea state 4 or less, although the effects of environmental conditions on surveyability are very vessel dependent. Fortunately, the weather conditions during the entire 2015 Peltic survey rarely reached sea state 5 or above, facilitating almost constant useable data gathering.

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.

## 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 23 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 partition the acoustic data.

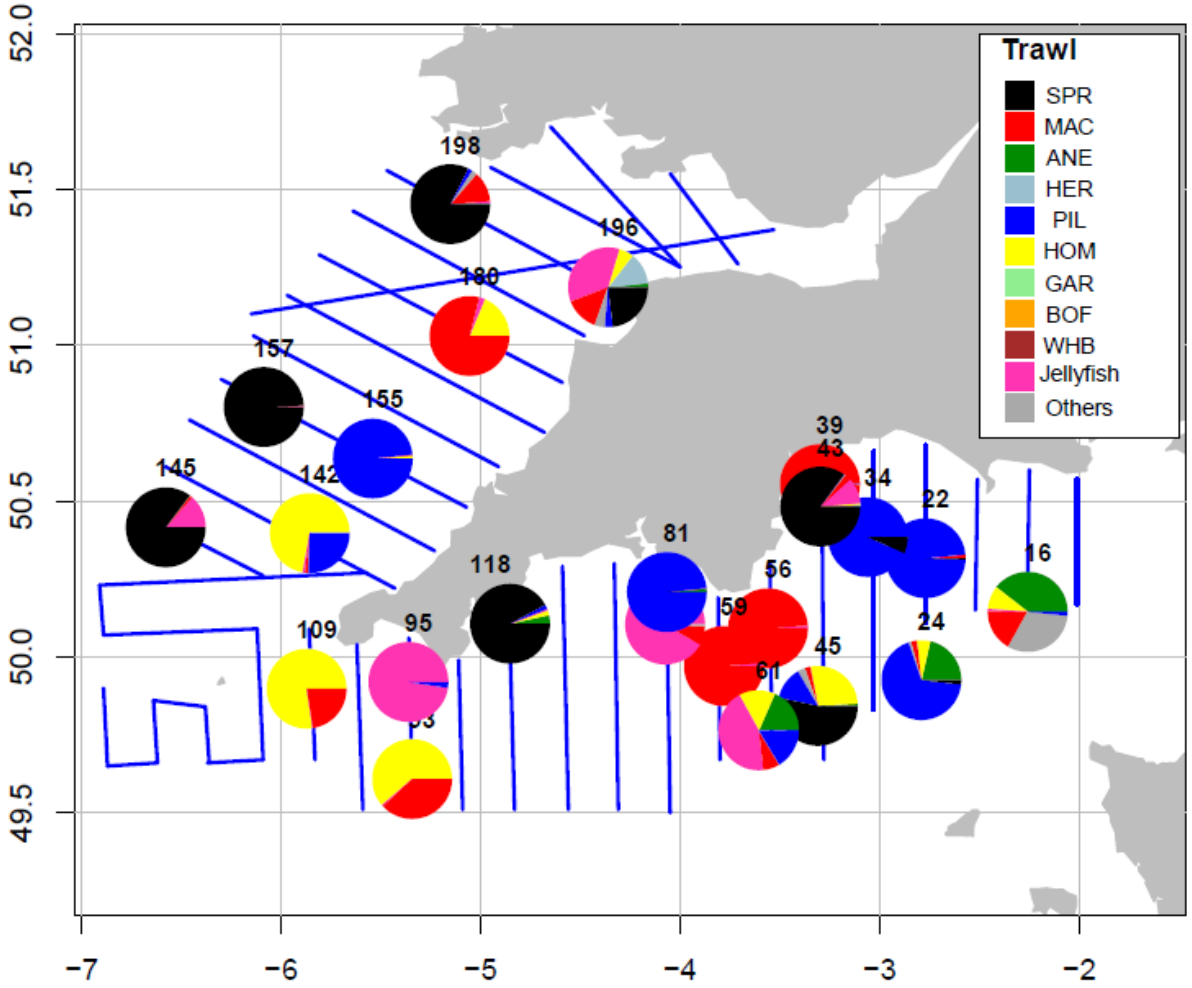


**Figure 3**. Overview map and detail of the survey area. Acoustic transects (blue lines) and trawl catches (pies) with relative catch composition by key species. Three letter codes: SPR=sprat, MAC=mackerel, ANE=anchovy, HER=herring, PIL=sardine, HOM= horse mackerel, GAR=garfish, BOF=Boarfish, WHB=Blue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

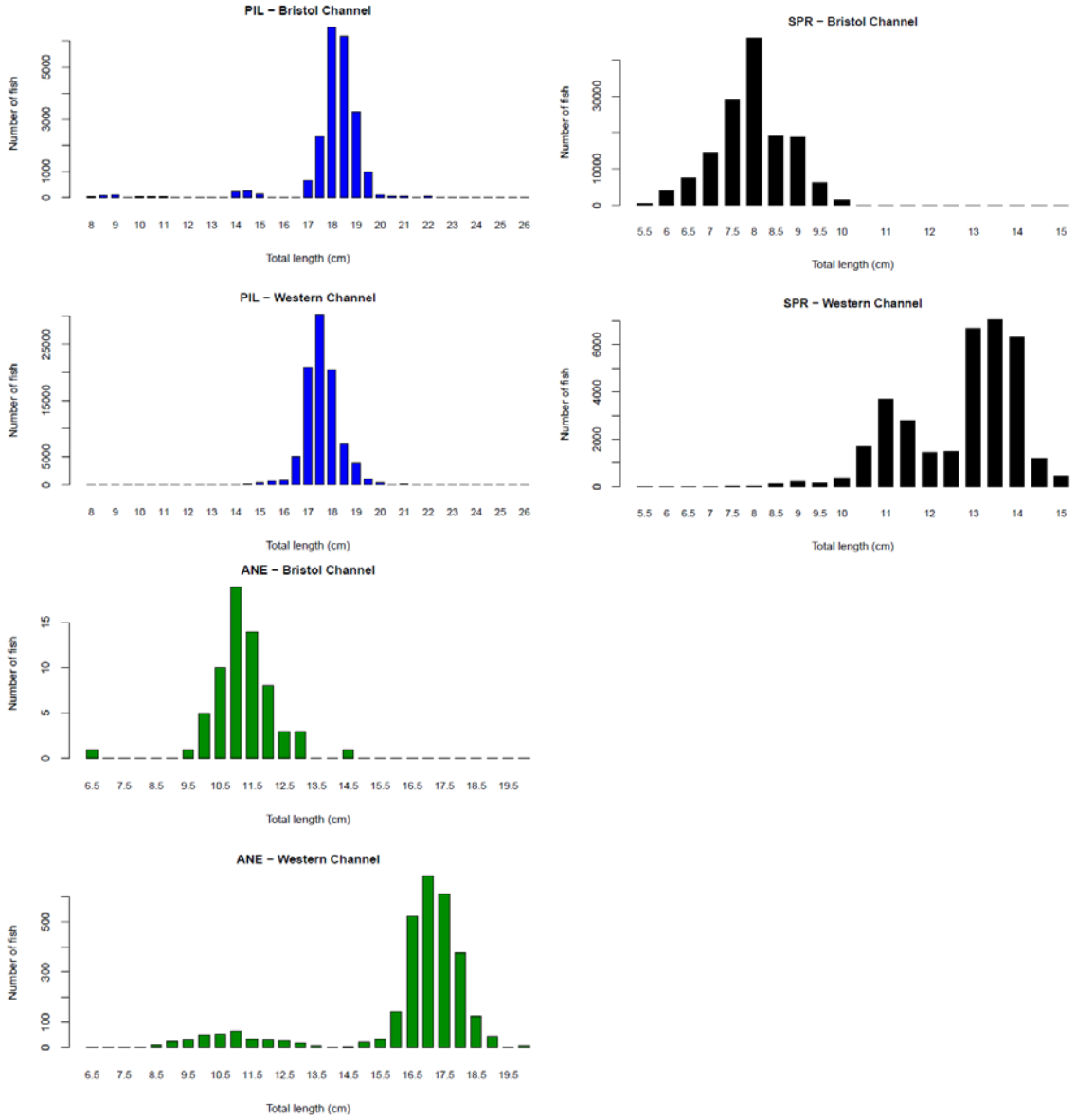


**Figure 4**. Trawl-caught numbers by length of sardine (*Sardina pilchardus*) (top left) sprat (*Sprattus sprattus*) (top right) and anchovy (*Engraulis encrasicolus*) by subarea. Please note that these numbers were not yet raised by the acoustic data.

Mackerel (*Scomber scombrus*) observations appeared to be in line with those in 2012 and 2014 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.

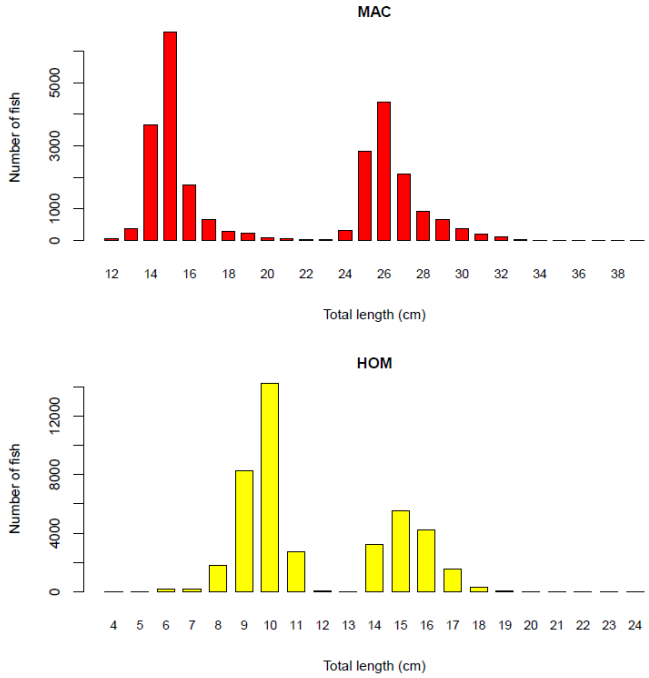


**Figure 5**. Trawl caught numbers by length of mackerel and horse mackerel for survey.

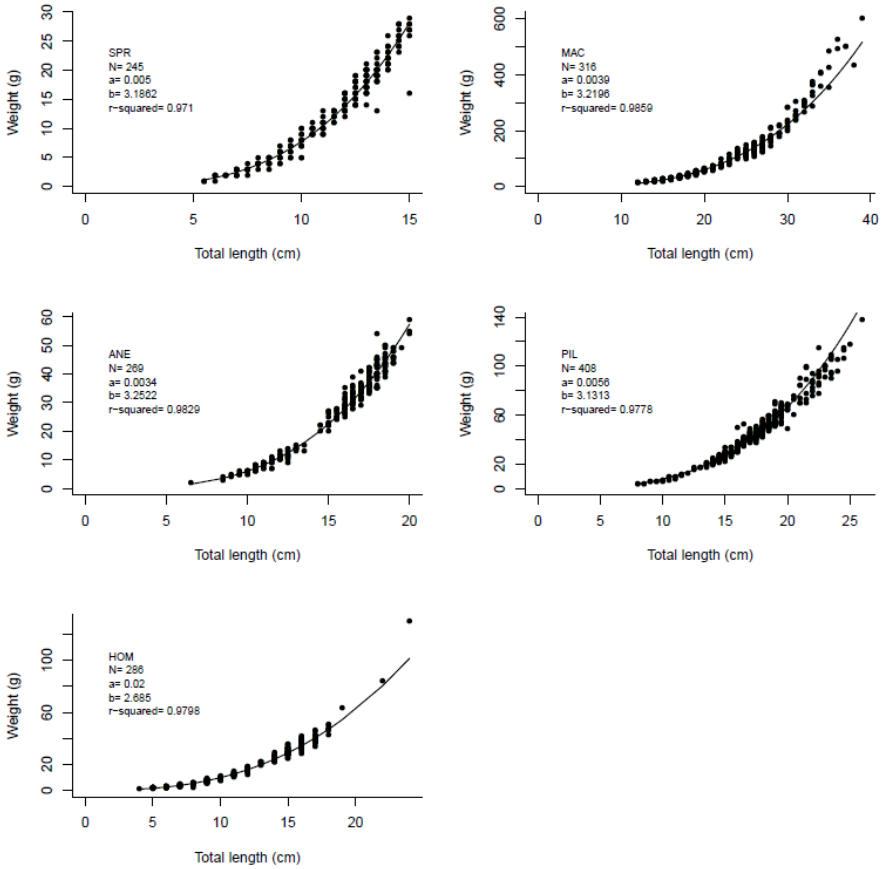


**Figure 6**. Length weight relationships of dominant pelagic species across the survey area.

### 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, with

small numbers of sprat, lemon sole and sandsol making up the remaining categories. 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 with smaller numbers in the Isles of Scilly. This year for the first time small numbers of eggs were found in the Bristol Channel. A detailed size based (zooscan) and taxonomic analysis of the zooplankton will be undertaken on return to the laboratory.

### 3.3. Oceanographic data

#### 3.3.1. Temperature and salinity

With temperatures up to 16°C, surface waters of the Western English Channel were warmer than surrounding waters of the Celtic and Irish Seas (Figures 7 and 8). The average, minimum and maximum temperatures recorded at the 39 sampling stations during this survey (Table 2) were comparable with temperatures recorded during the survey in 2013 (Cend20_13); however, they were lower than temperatures measured in 2014 (Cend20_14). Particularly, the maximum temperature recorded in 2015 (15.95°C) was approximately 2°C lower than the maximum temperature measured in 2014 (18.14°C). Salinity of surface water at the different sampling stations was similar except for the inner stations in the Bristol Channel, which had a lower salinity as result of increased freshwater influence from the river Severn. The salinity range was comparable with the other three surveys (Table 2).

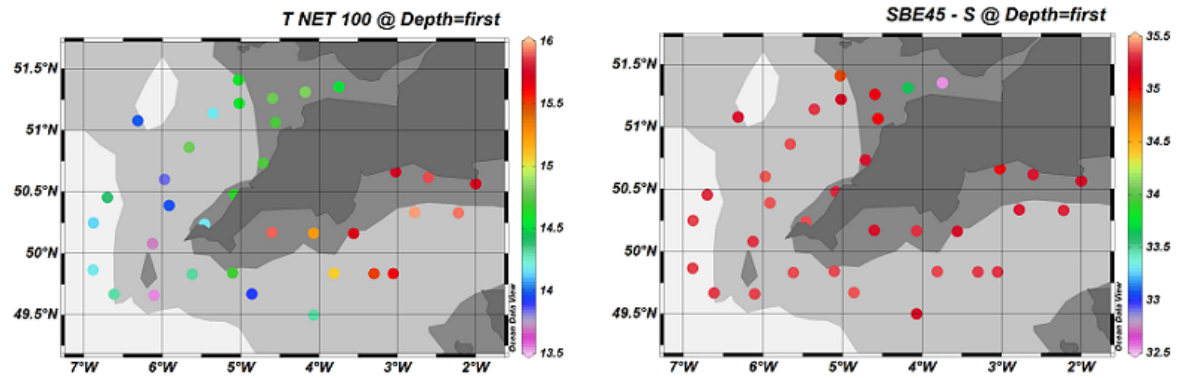


**Figure 7**. Temperature (T Net 100, °C) and salinity (SBE45) at 4 m depth measured by the Ferrybox at the 39 oceanographycal sampling stations between 3rd October and 19th October.

Remote sensing images (Figure 7) showed that a patch of slightly cooler water (approximately 14°C (Figures 7 and 8) was located south of Eddystone Bay and the Isles of Scilly south to the France coast. During the course of the survey the location of this patch of cooler water did not change, likely as result of the calm weather conditions and sea state. A similar patch of cooler water was also clearly visible in the remote sensing images from the 2014 survey, althought in 2014 it extended westward during the course of the survey.

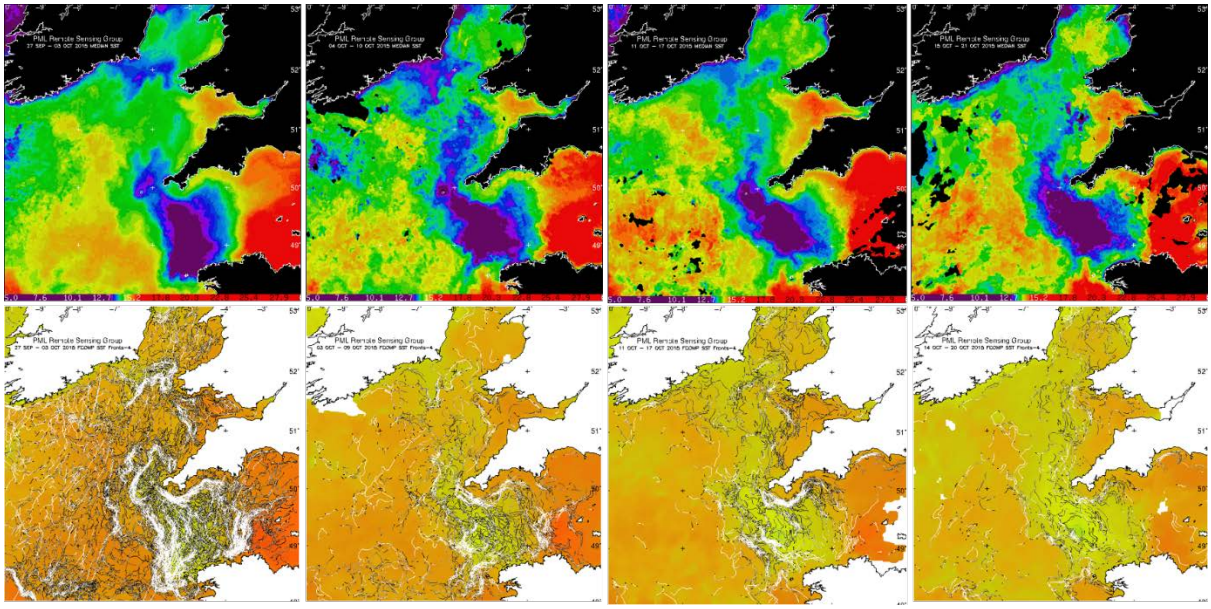

**Figure 8.** Composite surface maps for the periods 27 September - 3 October, 4 – 10 October, 11 – 17 October and 14-20 October 2015 of temperature (upper row of images) and thermal frontal systems (lower row) from Neodaas.co.uk.

The northern, eastern and western boundaries between the cool water patch and the warmer waters of the English Channel and the Celtic Sea was marked by a series of frontal systems (Figure 7), clearly visible particularly in the composite image for the week 27 September – 3 October. The frontal systems were present throughout the survey although they became weaker over time (Figure 7).

**Table 2**. Average, minimum and maximum values at 4 m depth of temperature, salinity and fluorescence, measured by the Ferrybox at the 39 oceanographycal sampling stations, during surveys in 2015 (Cend22_15), 2014 (Cend20_14) and 2013 (Cend20_13).

| Survey | Average | Minimum | Maximum |
|---|---|---|---|
| Cend22_15 – Temperature (°C) | 14.72 | 13.53 | 15.95 |
| Cend22_15 – Salinity | 35.14 | 32.53 | 35.14 |
| Cend22_15 – Fluorescence | 1.17 | 0.46 | 2.32 |
| Cend20_14 – Temperature (°C) | 15.98 | 14.62 | 18.14 |
| Cend20_14 – Salinity | 35.09 | 33.33 | 35.37 |
| Cend20_14 – Fluorescence | 0.19 | 0.08 | 0.44 |
| Cend20_13 – Temperature (°C) | 14.91 | 13.65 | 16.15 |
| Cend20_13 – Salinity | 35.28 | 33.36 | 35.61 |

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 7) 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 10), although waters in the Bristol Channel were not as warm as in Lyme Bay (16.33 and 18.08 °C respectively; Table 2).

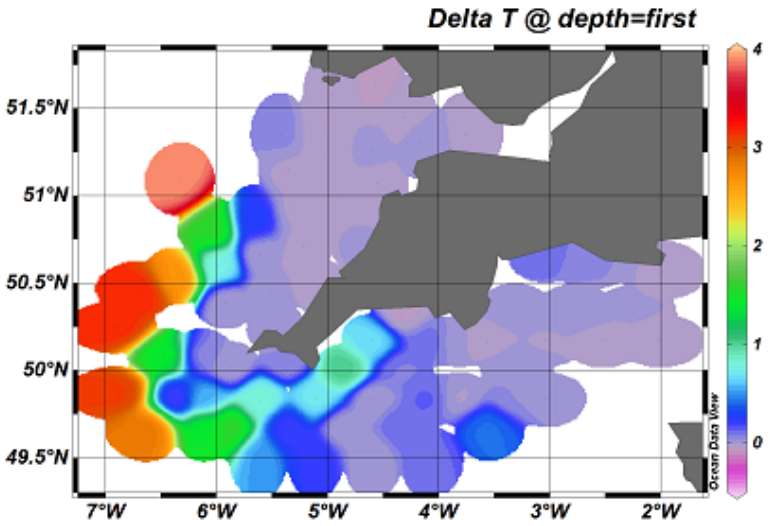


**Figure 9.** Values of ΔT (surface temperature – bottom temperature; °C) at the 69 sampling stations, as measured by the SAIV MiniCTD. The water column is considered stratified when ΔT > 0.5 (°C).

### 3.3.2. Chlorophyll and fluorescence

Higher levels of chlorophyll concentration were observed offshore, south of Edddystone Bay and around the Scilly Isles (Figure 10), corresponding with the frontal systems around the cool patch of water in the Western English Channel. In these frontal systems, nutrient-rich waters are mixed with nutrient-depleted surface waters leading to an observed increase in phytoplankton biomass.

Chlorophyll concentration was higher south of Lyme Bay and off the Scilly Isles, as shown by the Ferrybox raw fluorescence (Figure 11). Remote sensing images also 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 4 and 5). This was 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.

Remote sensed images (Figure 10) shows that the autumn bloom was well developed during the week before the survey (27 September - 3 October); however high level of fluorescence were recorded throughout the survey in different areas. On average, fluorescence measurements at the different sampling stations, recorded by the Ferrybox during this survey, were 6 time higher than average fluorescence measured during the previous year survey (Cend20_14).

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.

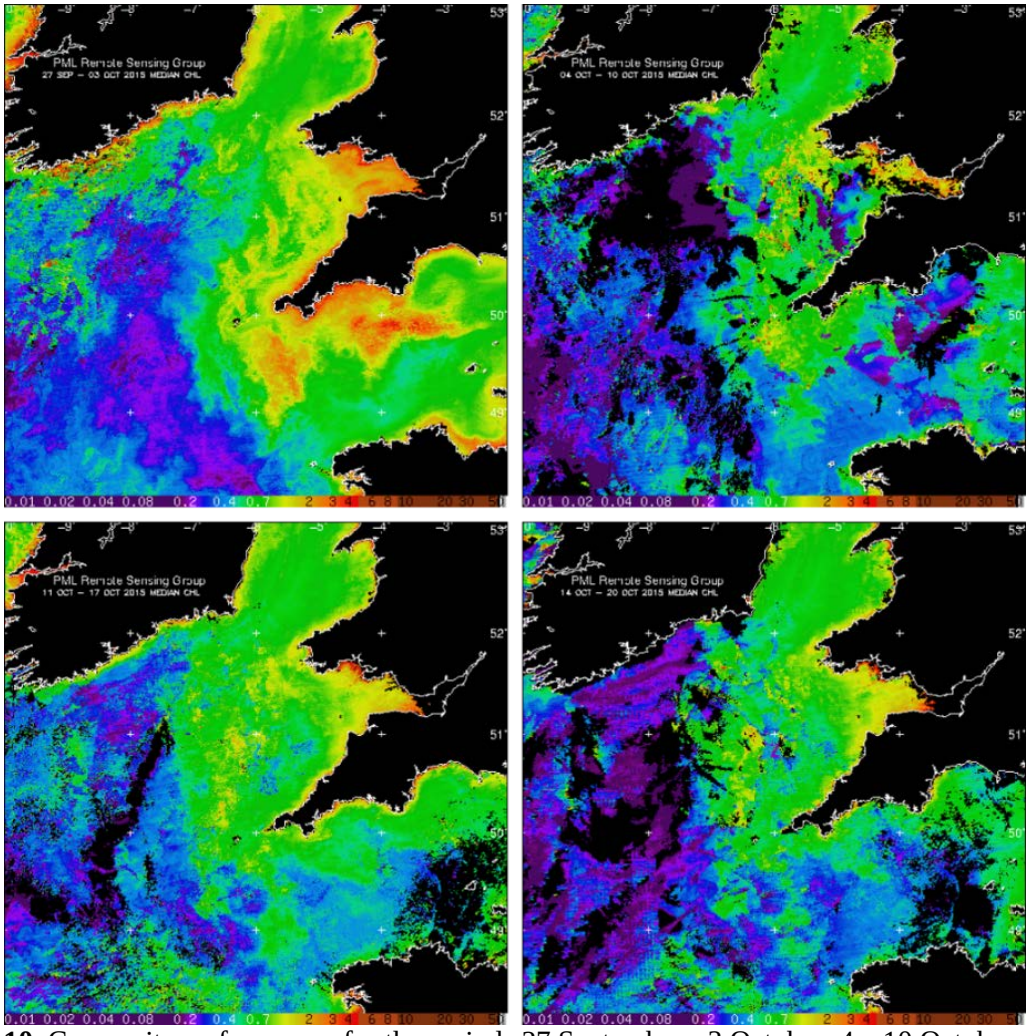


**Figure 10**. Composite surface maps for the periods 27 September - 3 October, 4 – 10 October, 11 – 17 October and 14-20 October 2015 of surface chlorophyll from Neodaas.co.uk.

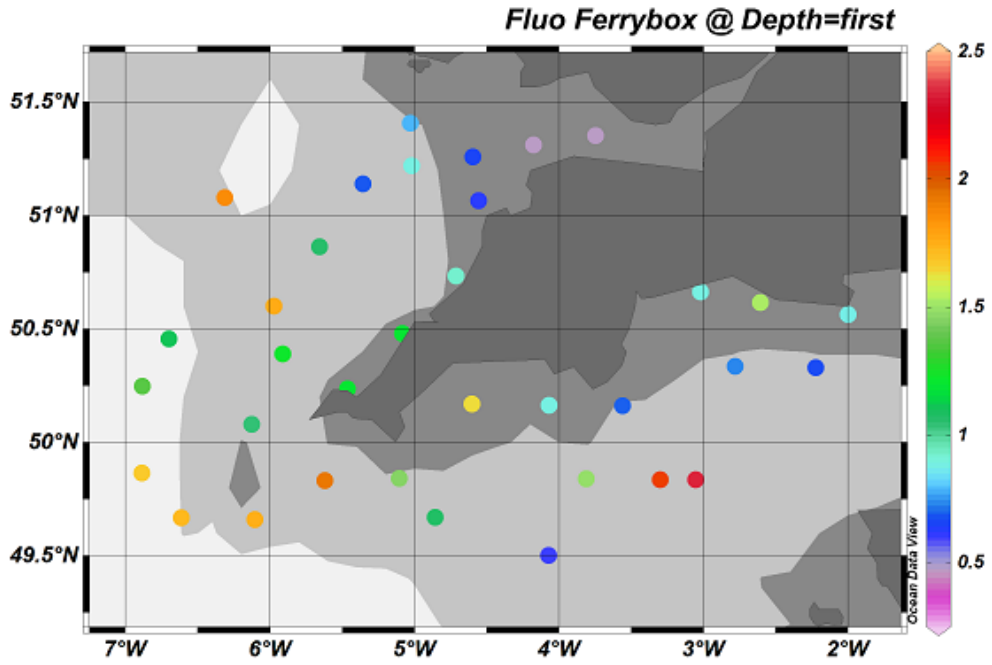


**Figure 11.** Fluorescence values at 4 m depth, at 18 sampling stations, as recorded by the Ferrybox.

### 3.4. Marine Mammals and birds

This year, as in 2014, 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. Visibility during effort surveys was generally good to excellent, and rain was infrequent and fog absent.

In total, there were 170 sightings (96 in 2014) of seven cetacean species (same as in 2014), with significantly more individual animals counted (1790 compared to 1520 in 2014).

The most abundant cetacean species encountered throughout was Common Dolphin *Delphinus delphis* with 129 (76 in 2014) sightings of 1,650 animals (1520 in 2014), chiefly but not exclusively in deeper waters (>50m) in the west and northwest of the survey area. The White-beaked Dolphin *Lagenorhynchus albirostris* were encountered in the western section of Lyme Bay as in previous years; Long-finned Pilot Whales *Globicephala melas* were found south of Plymouth and all nine Fin Whale *Balaenoptera physalus* sightings (22 confirmed individuals) were located to the north west of the Cornwall and Devon coasts. Rorqual whale encounters where the animals were too distant to see their dorsal fins were logged as Unidentified rorqual sp., although they were all presumed to be Fin Whale. A single sighting of two animals at approximately 3 km distance from the vessel whose distinctly different blows were seen well and photographed, were thought to be humpback whales. However as no diagnostic views were obtained these were logged as unidentified baleen whales.

Detailed results of the bird observations were not available at the time of writing and only a brief summary is provided here. A total of 50 species of birds were recorded during the survey. A notable observation included a flock of at least 115 Storm Petrels *Hydrobates pelagicus*, feeding in the RV Endeavour's wake during net retrieval operations, south of Portland Bill, Dorset.

Some evidence of visible migration was noted, particularly along the Dorset coast, with a steady stream of Meadow Pipits Anthus pratensis overhead. A Richard's Pipit Anthus richardi and an Alpine Swift Apus melba seen off south Devon and south Dorset respectively were both vagrant individuals presumably blown off course by the easterly airflow which dominated the weather for most of the survey period.

Unexpectedly high numbers of Balearic Shearwaters, *Puffinus mauretanicus*, chiefly in the Bristol Channel in 2013 (79) and 2014 (205) provided an important focus again for 2015. This species is the UKs only critically endangered seabird, having declined by ~95% since 1970s. 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. This year a minimum of 90 specimens were counted (subject to analysis of the two datasets recorded), the majority of which in the same general area to the west of Lundy Island in the Bristol Channel, as was the case in the previous two years. Behaviours noted include shallow plunge diving, surface pecking and active searching, particularly around feeding groups of Common Dolphin and occasionally investigating the RV Endeavour's wake during net retrievals. These data will be further analysed as part of a Defra funded project to establish the importance of the Bristol Channel as an important feeding area, and will be used to inform future conservation measures.

## 4. Summary

The fourth 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.