Centre for Environment Fisheries & Aquaculture Science

Cefas

RESEARCH VESSEL SURVEY REPORT

RV CEFAS ENDEAVOUR
Survey: C END 15 - 2023.

STAFF:

Name	Role	Name	Role
28th Sept -11th Oct		**11th Oct – 1st Nov**	
Fabio Campanella	SIC/Acoustics	**Jeroen van der Kooij**	SIC/Acoustics
Joana Silva	SIC/Fish/Oceanography	**Fabio Campanella**	SIC/Acoustics
Samantha Barnett	Deckmaster/Acoustic	**Samantha Barnett**	Shift-lead
Richard Humphreys	Lead Fish-room	**Richard Humphreys**	Lead Fish-room
Allen (Spike) Searle	Fish	**Allen (Spike) Searle**	Fish
Nicola Hampton	Fish	**Benjamin Hatton**	Fish
Matt Eade	Fish	**Daniel Jones**	Fish
Izzy Lake	Oceanography/eDNA	**Elise Brabben**	Oceanography/eDNA
Nevena Almeida	Zooplankton	**Nevena Almeida**	Zooplankton
Aimee Cuskeran	Zooplankton	**Amy Mace**	Zooplankton
Susan Kenyon	Fish/genetics	**Joseph Watson**	Fish/genetics
Peter Howlett	ML Observer	**Peter Howlett**	ML Observer
Tim Dunn	JNCC Observer	**Robin Langdon**	ML Observer
Sarah Money	JNCC Observer	**Debbie Welham**	JNCC Observer
		Sarah Fenn	JNCC Observer

DURATION: 28 September – 1 November (35 days)

LOCATION: Western Channel, Celtic Sea, Cardigan Bay (ICES Divisions 7.e-f and parts of 7.a,g)

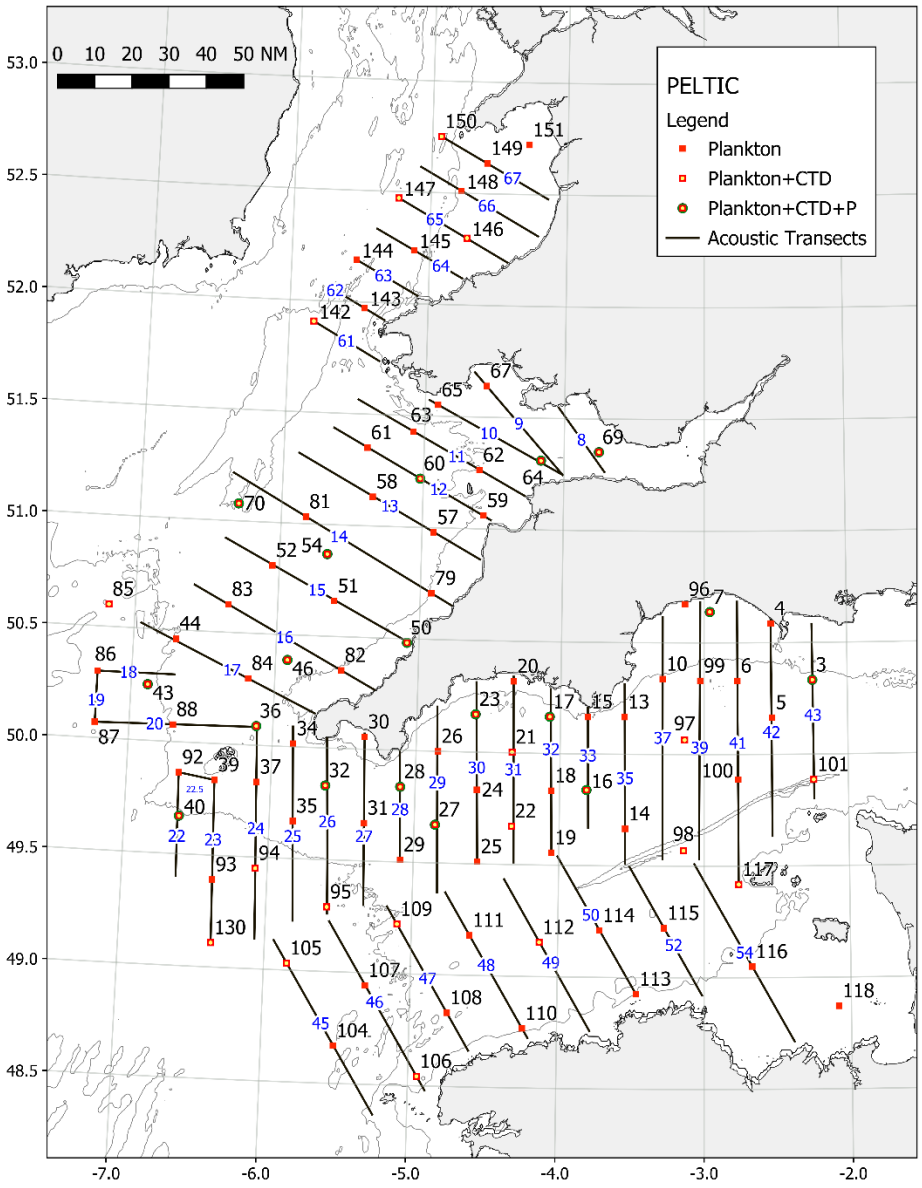

Figure 1. Overview of the planned 2023 PELTIC survey design, with the acoustic transect (black lines, numbers in blue), plankton stations (red squares) and hydrographic stations (yellow circles). Priority CTD stations marked in green.

AIMS:

1. To carry out the eleventh autumn PELTIC survey: pelagic ecosystem survey of the western Channel, Celtic Sea, including (for the fourth time) Cardigan Bay for Welsh Government, to estimate the biomass of-, and gain insight into the populations of the small pelagic fish community including sprat *Sprattus sprattu)*, sardine *Sardina pilchardus*, mackerel *Scomber scombrus*, anchovy *Engraulis encrasicolus*, horse mackerel *Trachurus trachurus*. The PELTIC derived sardine biomass in ICES Subarea 7 will feed into its stock assessment (WGHANSA) and sprat biomass data from the western Channel will feed into the stock assessment of sprat in ICES divisions 7.d-e (HAWG).

   a. To carry out a fisheries acoustic survey during daylight hours only using four operating frequencies (38, 70, 120, 200 and 333 kHz) to map and quantify the small pelagic species community.
   b. To conduct approximately 45 trawls targeting small pelagic species using a 20x40m VDK herring (mid-water) trawl in order to obtain information on:
      - Species and size composition of acoustic marks
      - Age-composition and distribution, for small pelagic species
      - Length weight and maturity information of pelagic species

2. To Calibrate the Simrad EK80 broadband echosounder at frequencies: 38, 70, 120, 200 and 333 kHz.
3. To collect biological data (size, weight, age and maturity) on range of data-limited fish species, including European seabass *Dicentrarchus labrax*, black seabream *Spondyliosoma cantharus*, striped red mullet *Mullus surmuletus*, garfish *Belone belone*, saury pike *Scomberesox saurus*.

4. To collect plankton samples using two ring-nets with 80 µm, and 270 µm mesh sizes at fixed stations (red squares on map below). Carried out at night by vertical haul and samples will be processed onboard:
   a. Ichthyoplankton (eggs and larvae, 270 µm) of pelagic species will be identified, counted and (in case of clupeids) staged and measured onboard to identify spawning areas.
   b. Zooplankton (80 µm) will be stored for zooscan analysis back in the lab.

5. Water column sampling (yellow stations on map below). At fixed stations along the acoustic transect, a CTD (either an ESM2 profiler or a Seabird mounted on a Rosette sampler) will be deployed to obtain measurements of environmental properties within the water column. Water column profile and water samples will provide information on chlorophyll concentration, dissolved oxygen, salinity, temperature, turbidity, and dissolved inorganic nutrients concentration as well as the relevant QA/QC samples for calibration of the equipment. Water samples will be collected and fixed on board for analysis post-survey. Relevant data within UK EEZ will feed into the eutrophication assessment under the SLA25 eutrophication monitoring programme (N. Greenwood – Cefas). Samples for analysis of the phytoplankton and microzooplankton communities will also be collected at the subsurface at fixed sampling stations.

6. Seabirds, Marine Mammals and tuna. Locations, species, numbers and activities observed will be recorded continuously during daylight hours by external observers located on the bridge.

7. FerryBox Continuous CTD/Thermo-salinograph. Continuously collect oceanographic data at 4 m depth during steaming, including chlorophyll concentration (from calibrated fluorescence).

8. Flowcytometry: high frequency sampling of the phytoplankton functional groups and size of phytoplankton community (V. Creach– Cefas)

9. Plankton Imager (PI): to collect continuous high frequency data on the sub-surface copepod composition (S. Pitois & J. Scott – Cefas).

10. eDNA: collect water-samples for ongoing studies to assess method as monitoring tool for pelagic fish, cetaceans and wider biodiversity (V. Creach - Cefas)

11. Monitoring the critically endangered Balearic shearwater *Puffinus mauretanicus* as well as other seabirds and marine mammals using ESAS methodology by JNCC observers on the bridge (T Dunn - JNCC).

12. To collect a zooplankton sample using the 200 µm mesh ring-net at the West Gabbard2 SmartBuoy, for the Lifeform project (Defra) as part of the UK monitoring network of zooplankton (S. Pitois – Cefas).

13. To collect between 25-50 specimens per species (anchovy, mackerel, sardine) and freeze for further analysis in the lab supporting a study on microplastics in fish stomachs (A. Bakir/ A. McGoran - Cefas).

14. To collect otoliths and genomic samples from data limited pelagic fish species to improve the assessment and support ongoing population studies (E. Garnacho/D. Murray/V. Visconti - Cefas).

15. To collect specimens of *Alloteuthis* sp. with associated photography for identification studies into the potential increase of *A. media* in UK waters. (P. White - Cefas)

16. To collect opportunistic body length measurements of undamaged garfish *Belone* spp. and saury pike *Scomberesox saurus* to assist with total and body length conversion factors (J. Silva, Cefas)

17. Record macro-litter observations in the trawl (B. Silburn - Cefas)

NARRATIVE[1]:

All staff joined RV CEFAS Endeavour in Swansea by 1800hr, 27 September, with the aim to sail early on 28 September. Departure was postponed to 0700hr, 29 September due to unfavourable weather conditions. Shortly after sailing survey activities commenced with acoustic transect 8, which was interrupted to carry out a shakedown tow. No signal was received from the headline sensor, which is critical equipment providing details about gear position in the water column, and therefore the trawl operations were interrupted. A second trawl deployment was also abandoned due to continuing issues. Overnight the first plankton and CTD deployments were completed successfully. The FerryBox stopped working during the night and the GPS on the rosette failed as well. While an alternative solution was found for the latter, issues with the FerryBox persisted throughout the survey, thought to be caused by issues with the flow. On 30 September, another fishing attempt was made using an alternative headline sensor, which worked. However, issues with trawl geometry during subsequent attempts led to unsuccessful trawls which turned out to be caused by rigging issues. These were resolved on the third attempt on 1 October. On the morning of 2 October echosounders were calibrated in Bideford Bay which was completed successfully by 13:35 GMT. Surveying resumed that afternoon and continued following typical design with acoustic transects being run during daylight and plankton and CTD stations being conducted at night. Cardigan Bay (3-5 October), Bristol Channel and the transects north of the Isles of Scilly were completed as planned and at 0800hr on 11 October the vessel docked in Falmouth, for crew and staff change. The vessel sailed later that evening and continued working from south of the Isles of

[1] All times in BST

Scilly eastwards on both sides of the Channel, avoiding adverse weather conditions. On 27 October all staff moved to daytime shifts with remaining plankton and CTD data to be completed during the day. As good progress was made throughout the survey, some adverse weather on 28 and 29 October did not have an impact on delivery and the final transects on the French side of the Channel were completed on 29 October. The final, eastern-most transect in the western channel (Tr 43) and a trawl were completed on 30 October before starting the steam home in the afternoon. In the morning of 31 October, the West-Gabbard plankton station was sampled before the pilot was picked up off Lowestoft at 2100hr and the vessel docked around 2130hr, 31 October.

RESULTS:

All aims were successfully completed, apart from the continuous oceanographic surface sampling by the FerryBox (Objective 7). A summary of the echosounder calibration settings are provided in Table 1. Biological data (some or all of the following parameters: size, weight, age and maturity) of the following data-limited species were collected (objective 3): 6 European seabass; 2 John dory; 5 black seabream; 47 saury pike. eDNA samples (objective 10) were collected at 19 stations. In total, 14 samples of 25-50 whole specimens of small pelagic fish (3 species) were collected from 8 different stations for micro-litter analysis (objective 13, Annex 1). *Alloteuthis* sp. were collected from 7 different stations (objective 15, Annex 1). A total of 48 body length (and associated total length) were collected for saury pike (objective 16). More details on the other aims are provided in the relevant sections below.

Table 1. Summary of echosounder (EK80 in CW mode) calibration settings obtained on 2 October while on drift in Bideford Bay, and applied during PELTIC 2023. The 333 kHz was not calibrated. *Drop-keel down

Variable	38 kHz	70 kHz	120 kHz	200 kHz	333 kHz
Transducer type	ES38-7	ES70-7C	ES120-7C	ES200-7C	ES333-7C
Transducer depth (m)	5.3 (8.3)*	5.3 (8.3)*	5.3 (8.3)*	5.3 (8.3)*	5.3 (8.3)*
Transducer power (W)	2000	750	250	120	50
Pulse length (milliseconds)	0.512	0.512	0.512	0.512	1.024
2-way beam angle (dB)	-20.7	-20.7	-20.7	-20.7	-
Transducer gain (dB)	27.23	28.40	27.86	28.54	-
Sa correction (dB)	-0.3943	-0.30	-0.104	-0.2202	-
3dB beam along (°)	6.59	6.69	6.33	5.80	-
3dB beam athwart (°)	6.68	6.62	6.28	5.60	-
Along offset (°)	-0.07	0.11	0.13	0.27	-
Athwart offset (°)	-0.04	-0.06	0.10	-0.17	-
RMS (Root Mean Square error)	0.065	0.038	0.142	0.2828	-

Pelagic Ichthyofauna

All acoustic transects were completed covering a total of 2109 nm of acoustic sampling units. A total of 38 out of 43 trawl hauls were conducted successfully (Fig 2) to provide ground-truth information about the species and size composition and to collect biological information.

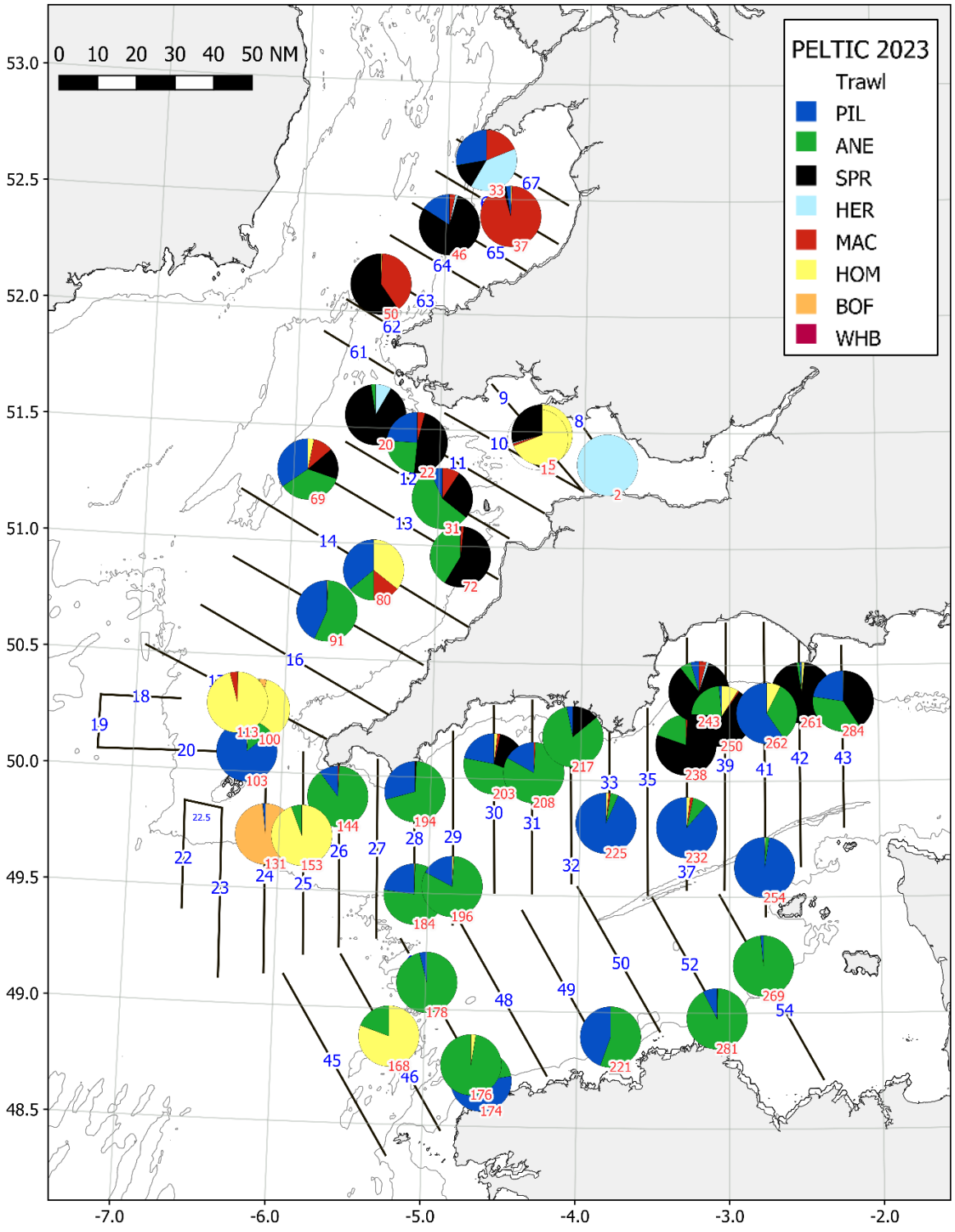

Figure 2. Overview map of the adjusted PELTIC23 survey area. Acoustic transects (black lines) and Trawl stations (pies) with relative catch composition by key species. Three letter codes: PIL=sardine, ANE=anchovy, SPR=sprat, HER=herring, MAC=mackerel, HOM= horse mackerel, BOF=boarfish and WHB=Blue whiting.

A summary of the number of individuals sampled for length and biological parameters is provided for key species (Table 2).

Table 2. Summary of lengths measured and biological parameters (including weight, age, maturity) collected for small pelagic fish species.

Species	Scientific name	Measured	Biological samples
Sprat	*Sprattus sprattus*	3236	359
Sardine	*Sardina pilchardus*	5609	834
European anchovy	*Engraulis encrasicolus*	4803	614
Horse mackerel	*Trachurus trachurus*	1543	243
European mackerel	*Scomber scombrus*	2103	298
Herring	*Clupea harengus*	444	83
Boarfish	*Capros aper*	196	54
Blue whiting	*Micromesistius poutassou*	NA	NA

Sprat *Sprattus sprattus* biomass in the western Channel was estimated at 61,270 t (CV 0.53). This was comparable to long-term average, and slightly higher than recent values (from 2017) which fluctuated around 30,000 t (Fig. 3). The only exception was the very high biomass in 2021 which was driven by a strong recruitment pulse (0-group). The 2023 age composition was again driven by 0-group (Fig. 4). Highest densities were found in Lyme Bay although high numbers were also found in coastal waters further west around the Eddystone (Fig. 5). High densities were also found in the Bristol Channel and sprat was again the most abundant small pelagic fish in Cardigan Bay with a biomass of 15,475 t (CV 0.33).

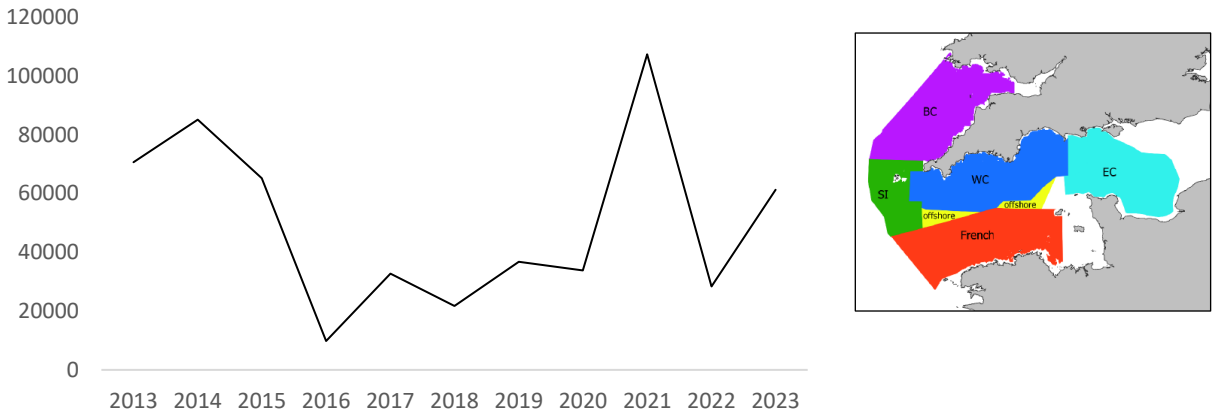

Figure 3. Sprat biomass trend (left) for the consistently sampled stratum in the western Channel: WC (blue) in map of strata (right).

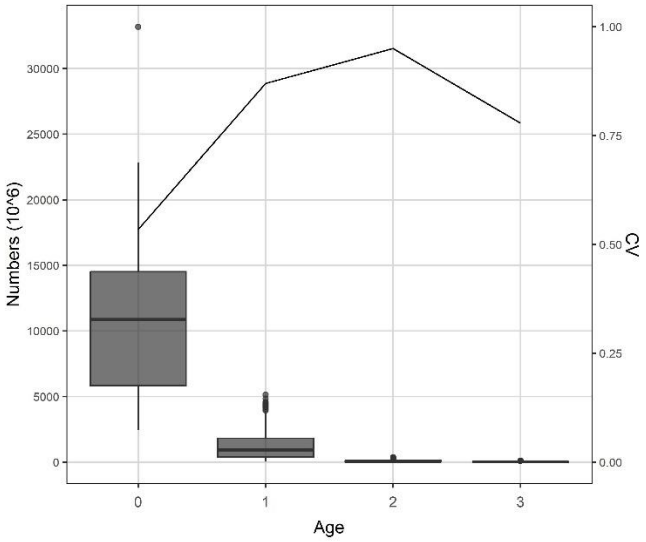

Figure 4. Sprat numbers at age (boxplots, primary y-axis) and CV (line, secondary y-axis) in the consistently sampled western Channel stratum (see Fig 3).

Modal sprat size at around 8 cm total length (L_T) was smaller in the northern areas (Cardigan Bay and Bristol Channel) compared to in the western Channel (Fig 5).

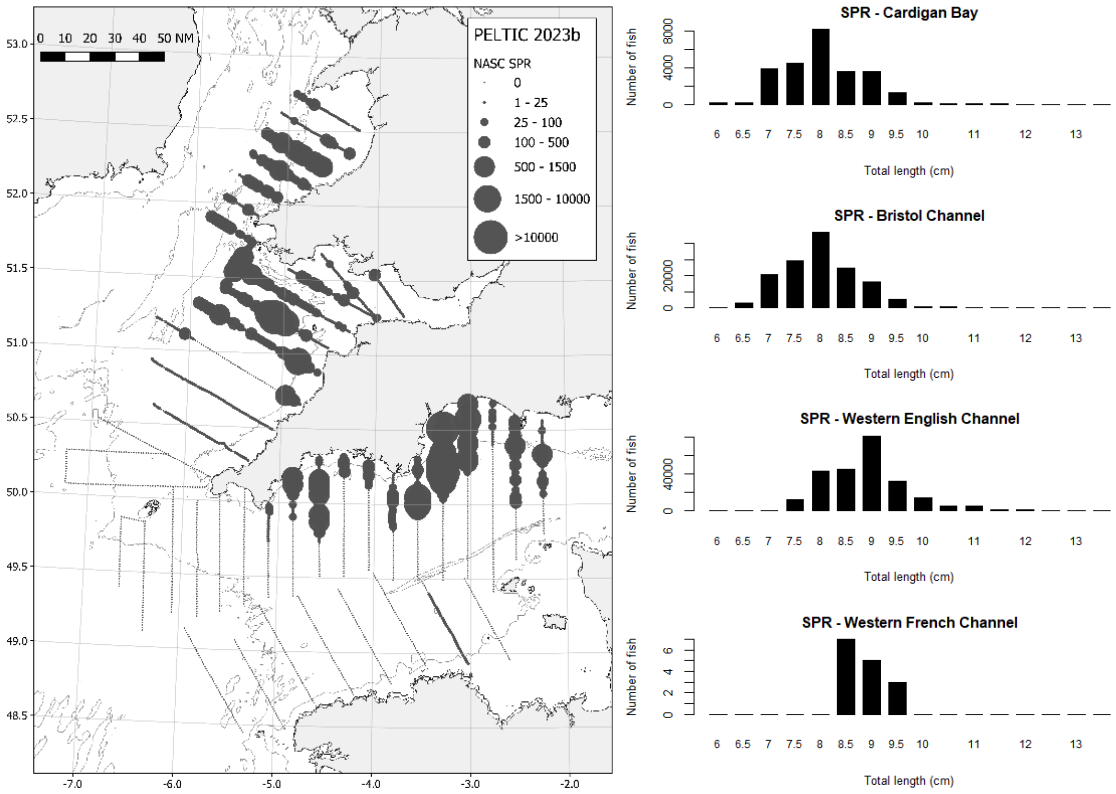

Figure 5. Relative acoustic sprat density distribution (Nautical Area Backscattering Coefficent – NASC, left) and trawl-derived length frequency distribution by region (right), for sprat as observed during PELTIC. Note that only very few sprat were caught in French waters of the western Channel.

Sardine *Sardina pilchardus* was again the most abundant small pelagic fish species in the study area with a biomass of 456,482 t (CV 0.19) estimated for the Total Area (Fig 6). Biomass in Cardigan Bay was an order of magnitude higher than encountered previously 4,921 t (CV 0.29).

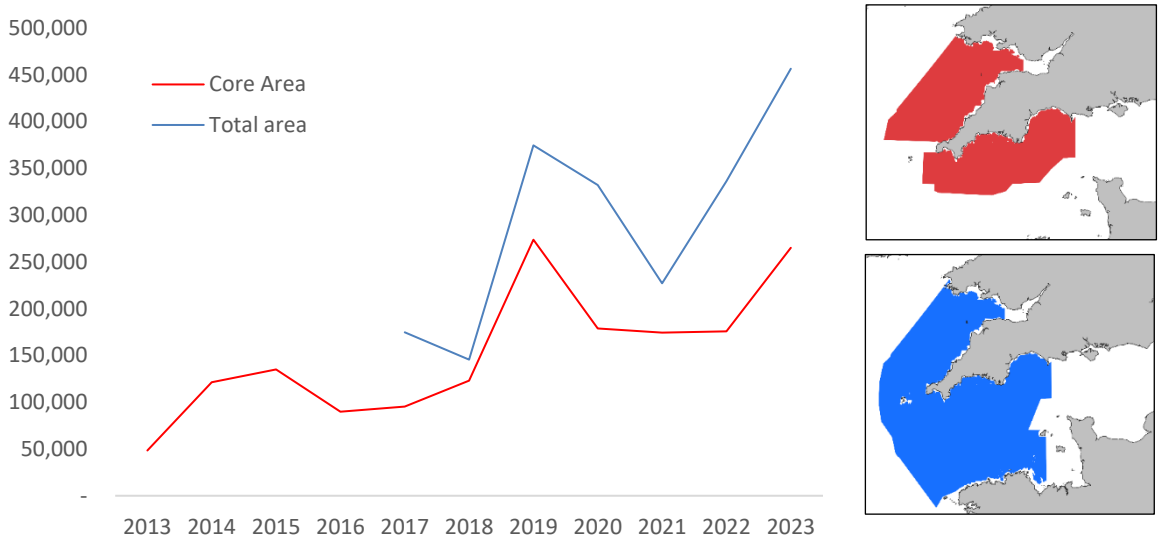

Figure 6. Sardine biomass (tonnes) trends (left) based on two available survey strata: the core area, consisting of the English waters of the western Channel and the Bristol Channel, surveyed consistently from 2013 (top right, red) and the total area, which also includes the Isles of Scilly and French waters of the western Channel, surveyed from 2017 (bottom right, blue). Note that the 2022 "Core Area" biomass is representative of only the western Channel stratum, a smaller area than indicated in the map. The 2022 Total Area biomass was extrapolated based on the ratio of biomass observed in the surveyed area.

Highest sardine densities were found around the Isles of Scilly, which is also where the largest sardines were found with two modes visible in the length frequency data (at 19 and 22 cm L_T). Another area of high densities was located offshore south of Mounts Bay (Fig 7).

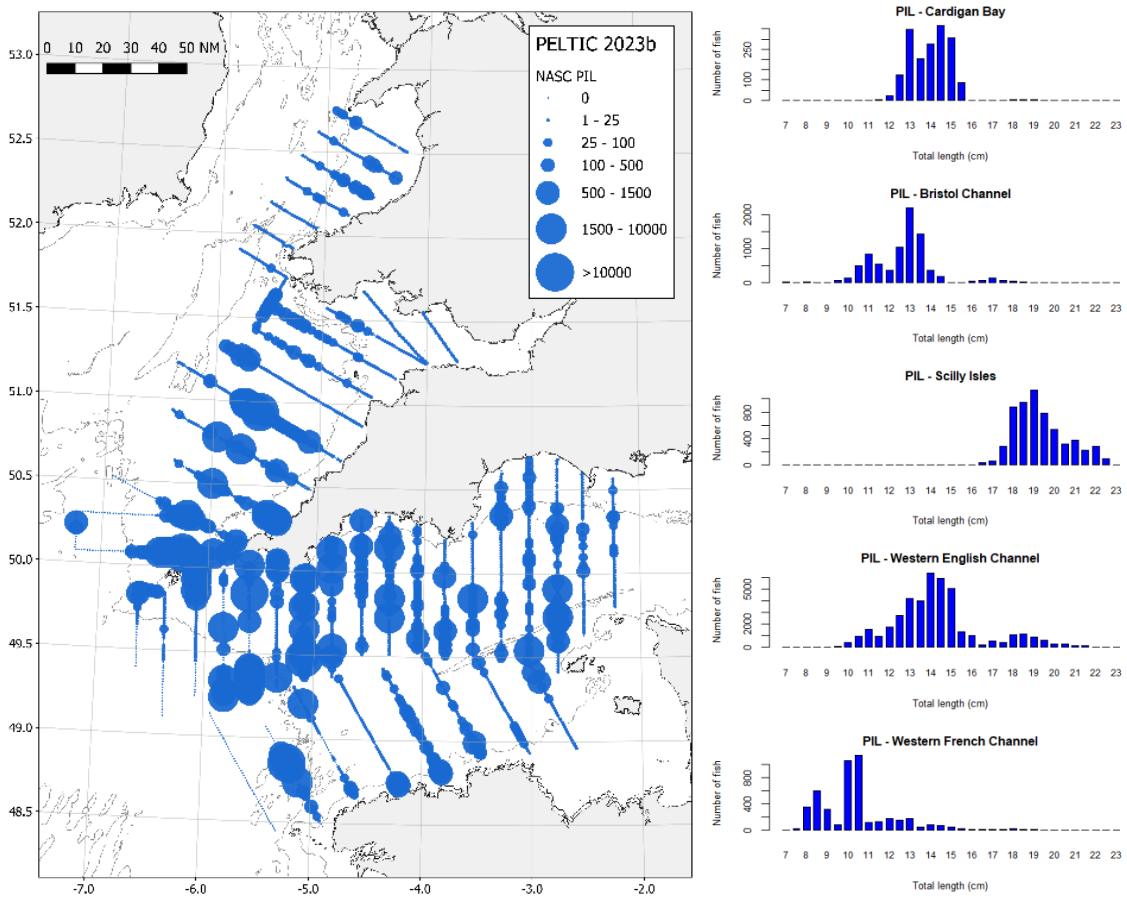

Figure 7. Relative acoustic sardine density distribution of sardine (Nautical Area Backscattering Coefficient - NASC, left), and trawl-based length frequency histogram for sardine in the subareas of the PELTIC survey (right).

The sardine population was made up of fish between 0-group and six years old, although a particularly strong 0-group suggested a significant recruitment pulse coming through (Fig 8). The 0-group sardine appeared to consist of several length modes, suggesting different spawning times and locations. The smallest sardines (8.5 cm L_T) were found in French waters.

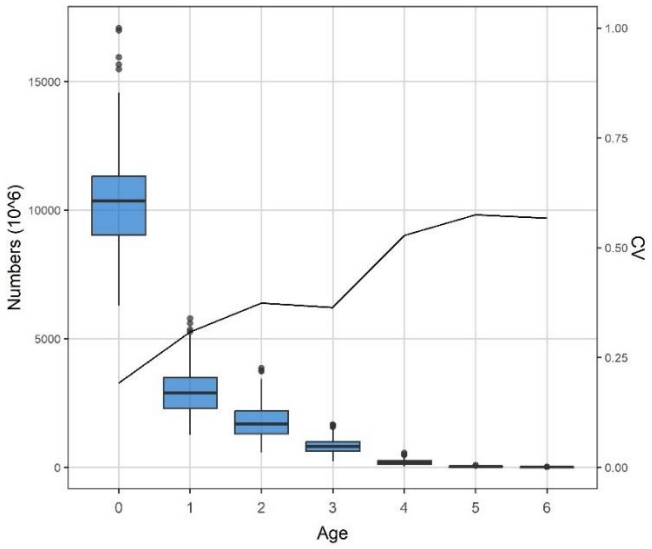

Figure 8. Sardine numbers at age (boxplots, primary y-axis) and CV (line, secondary y-axis) in the consistently sampled total area.

Anchovy *Engraulis encrasicolus* biomass was the highest value of the PELTIC time series at 243,392 t (CV 0.20). This included a significant amount of post-larval, early juvenile anchovy in surface schools on the north coast of Brittany. Ongoing studies have concluded that these are Bay of Biscay fish moving north into the channel, potentially mixing in the channel with "northern" anchovy spawned in the southern North Sea.

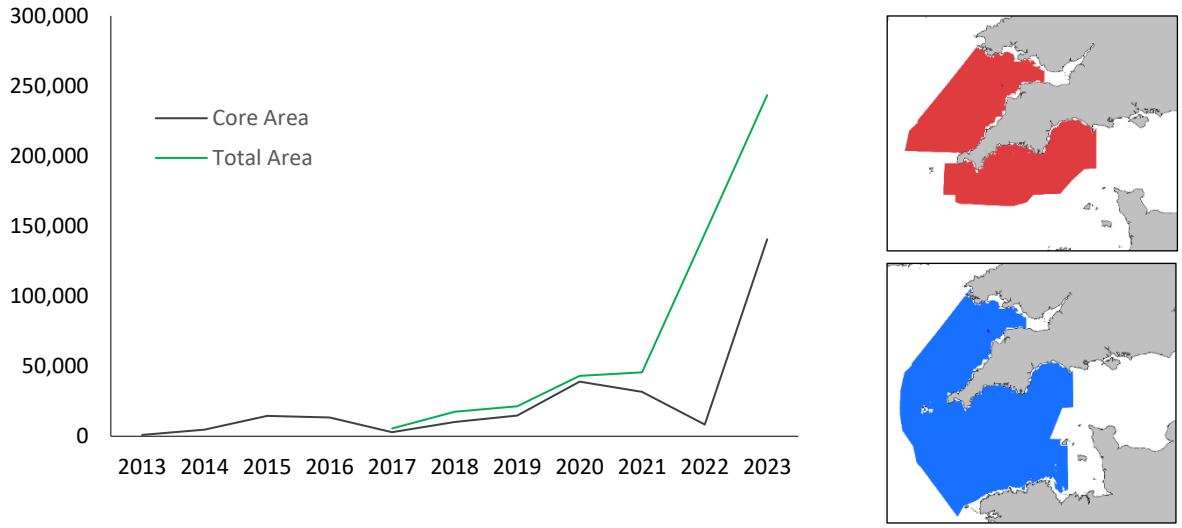

Figure 9. Anchovy biomass (tonnes) trends (left) based on two available survey strata: the core area, consisting of the English waters of the western Channel and the Bristol Channel, surveyed consistently from 2013 (top right, red) and the total area, which also includes the Isles of Scilly and French waters of the western Channel, surveyed from 2017 (bottom right, blue). Note that the 2022 biomass is representative of only the western Channel stratum and therefore a smaller area than the red core area indicated in the map. No Total Area estimate was calculated for 2022 due to incomplete survey coverage.

Anchovy was more widely distributed in 2023 than at any time during the PELTIC time series. Biomass in the northern most area of Cardigan Bay was low albeit comparable to previous survey efforts with an estimate of 567 t (CV 0.72). Highest densities were found in Eddystone Bay in the northwestern Channel although relatively high number of schools were found in the Bristol Channel. The smallest anchovy were found along the French coast where surface- and midwater schools, first seen in 2019 and demonstrated to be Bay of Biscay fish, suggested that 12.5 cm L_T (Fig 10).

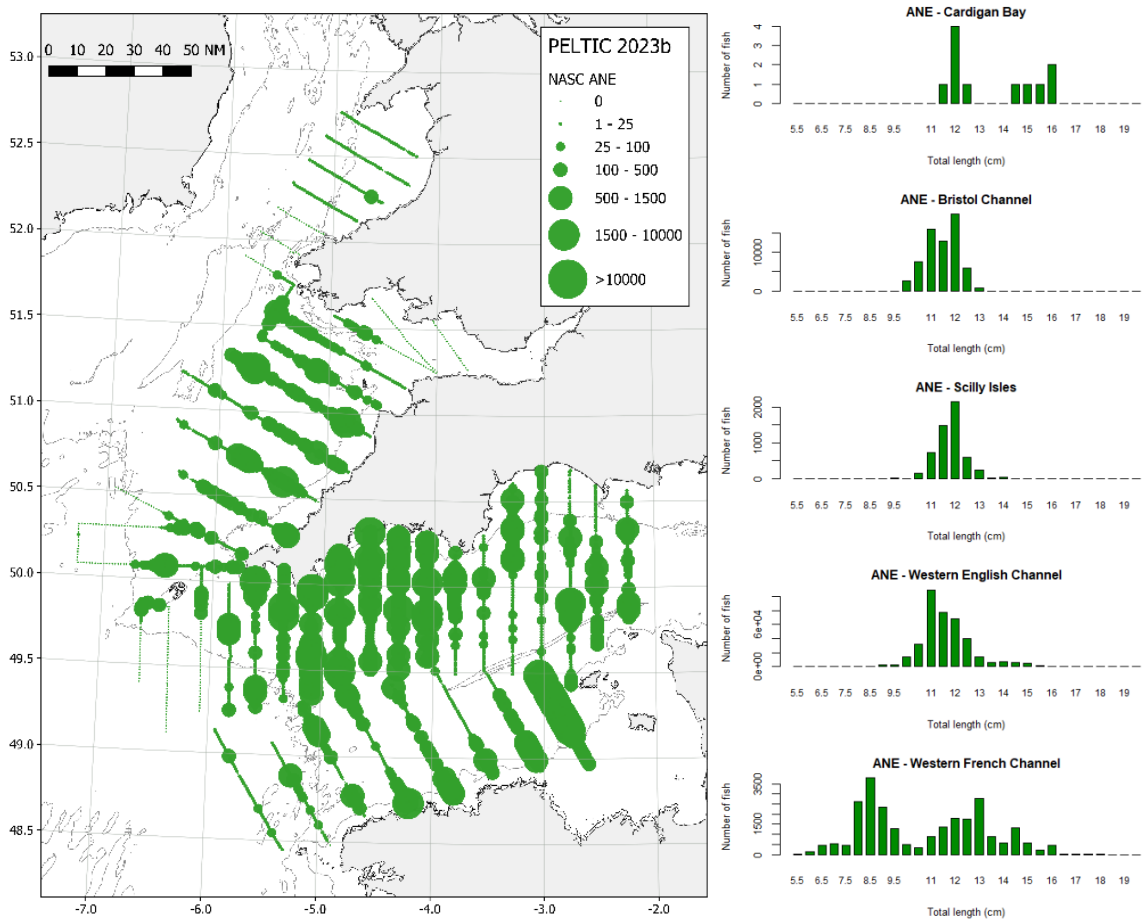

Figure 10. Relative acoustic anchovy density distribution (NASC, left), and trawl-based length frequency histogram for anchovy in the subareas of the PELTIC survey (right).

Anchovy is the shortest lived small pelagic species in the study area and the oldest fish found during this survey were 3-year old (Fig 11). The dominant age were 0 group fish.

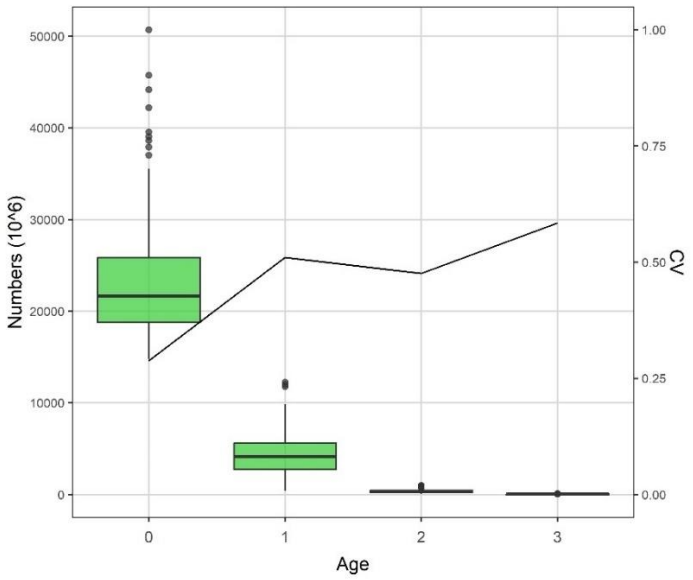

Figure 11. Anchovy numbers at age (boxplots, primary y-axis) and CV (line, secondary y-axis) in the reduced survey area.

Other pelagic fish species (no biomass estimates available at the time of reporting): no clear patterns in **Mackerel *Scomber scombrus*** distribution were observed and it was widespread in the area. Length frequency of mackerel suggested the presence of two cohorts age 0 and 1 (Fig 12). **Horse mackerel *Trachurus trachurus*** was also widespread, although typically in deeper waters of the survey area. As found in previous years, these were mainly made up of juvenile fish with modal length of 9 cm, age 0 (Fig 12). **Boarfish *Capros aper*** (9-15 cm L_T) were found around the Isles of Scilly although small specimens (2-3 cm) were found more widespread in deeper waters. **Herring *Clupea harengus*** were again found mixed in among the sprat schools, primarily in Cardigan Bay, where it was the second most abundant small pelagic fish with a biomass of 4,969 t (CV 0.45), which was comparable to the estimate in March 2023. The other hotpot of herring was in Lyme Bay. Herring were larger than in recent years with two or three modes in the length frequency distribution (Fig 12).

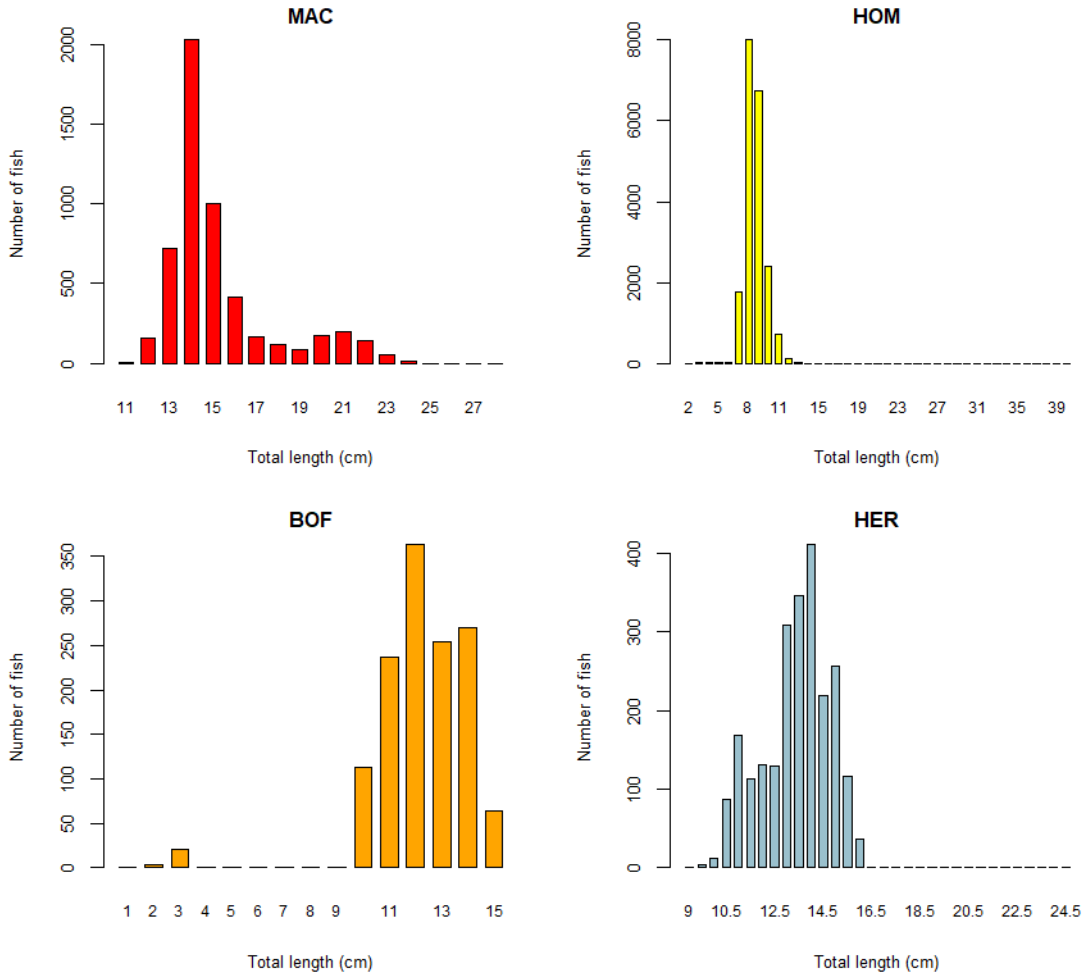

Figure 12. Length frequency histograms for mackerel (MAC), horse mackerel (HOM), boarfish (BOF), herring (HER), and derived from the PELTIC23 trawl catches. Note that these have not been raised by acoustic densities.

Plankton and Oceanography

Mesozoo- and ichthyoplankton samples were collected at 95 stations with ring nets with mesh size of 80 µm and 270 µm, respectively (Table 3). One station could not be completed due to time constraints and location now surrounded by windfarm (Prime 118) , and three stations (prime stations 65, 88 and 143) were repeated due to issues with deployment (including gear damage). Mesozooplankton samples were stored on 4% buffered formaldehyde for zooscan processing post-survey. All results will be stored on the ZooTaxa database. All but five Ichthyoplankton stations were processed aboard with all eggs and larvae staged and measured respectively. Significant densities of salps *Salpa maxima* prevented the remaining stations from being processed aboard. Sardine eggs and larvae dominated the ichthyofauna with numbers comparable to some of the higher values seen in previous surveys. The location of highest densities of sardine eggs corresponded well with the distribution of the main acoustic sardine backscatter with hotspots around the Isles of Scilly and south of the tip of Cornwall (Fig 13). As expected, sardine larvae were more widespread in the survey area, including in Cardigan Bay although they were absent from the western offshore stations.

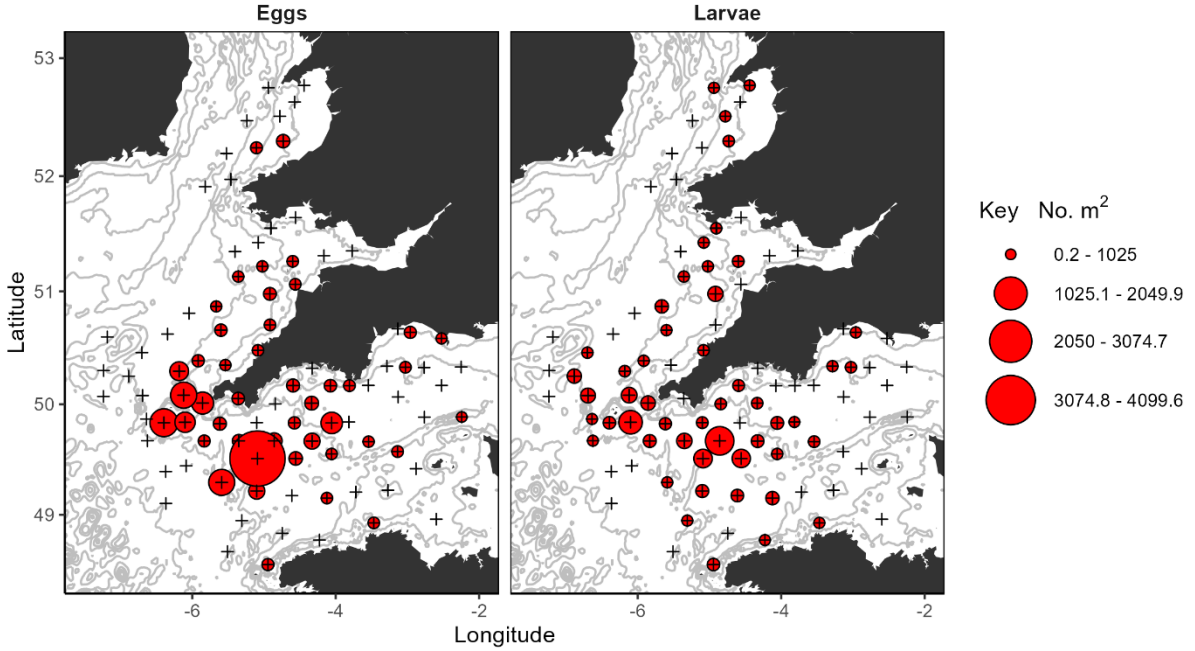

Figure 13. Distribution of sardine eggs (left) and larvae (right) at the sampling stations derived from samples collected with the 270 µm ring net and analysed on board.

Oceanography

Vertical profiles of temperature and salinity of the water column were carried out at 95 plankton stations using a SAIV mini CTD. Prime station 118 was dropped for reasons mentioned above. At a subset of 34 of the sampling stations a Rosette with SeaBird CTD and 12 Niskin bottles was deployed to collect information using temperature, salinity, PAR (Photosynthetic Active Radiation), dissolved oxygen, turbidity and fluorescence sensors and collect water samples for future analysis of phytoplankton (microscope) and microzooplankton (Flowcam) communities, dissolved oxygen, salinity, phytoplankton pigments (including chlorophyll-a) and dissolved inorganic nutrients (nitrate, nitrite, ammonium, phosphate, silicate). Due to adverse weather conditions, at two stations (Prime

16 and 32), the Rosette was replaced with an ESM2 logger and a Niskin bottle, and the surface water samples were collected from the FerryBox outflow (at 4 m depth).

Issues with the FerryBox system meant that no reliable continuous subsurface conditions were available during the survey and the SAIV mini-CTD and Rosette deployments provided the main source of oceanographic information. The Flow cytometer had periodic issues but ran fine otherwise, as did the Plankton Analyser.

Dissolved oxygen samples from water near the bottom were analysed on board by the Winkler method using an auto-titrator, while salinity and inorganic nutrient samples were stored for analyses in the Laboratory. Triplicate inorganic nutrient samples were collected at all stations, to compare between two different preservation methods (freezing vs. mercuric chloride), and, for the latter, between different defrosting times. Chlorophyll and pigments samples were stored at -80 °C for future HPLC (High Performance Liquid Chromatography) analysis by DHI (Denmark). Phytoplankton samples were fixed with Lugol for processing in the Lowestoft Laboratories using an inverted microscope, while microzooplankton samples (also fixed with Lugol) will be analysed with the FlowCam at a future time. Samples for dissolved oxygen, salinity and chlorophyll-a were collected to calibrate sensors on the FerryBox and on the SeaBird profiler. This year chlorophyll-a samples were collected in triplicates, except for at two prime stations where duplicates were collected (Prime 64 and 69).

Table 3. Number of samples collected and number of profiles carried out during PELTIC 23.

	Total
Salinity	39
Dissolved oxygen (triplicates)	25
Chlorophyll/Pigments analysis (HPLC – duplicates or triplicates)	36
Inorganic nutrients (2 methods)	36
Phytoplankton	36
Phytoplankton (trial clear bottles)	10
Microzooplankton	36
Mesozooplankton (80 µm) (excludes invalids)	95
Mesozooplankton (270 µm)* (excludes invalids)	95
eDNA samples	19
CTD profiles with Rosette	34
CTD proflies with ESM2	2
CTD profiles with SAIV MiniCTD (excluding two invalid profiles)	95

* One station (Prime 63) was partially lost and will not be used quantitatively.

Sea surface temperature was highest in the Bristol Channel with eastern part of the western Channel and southwestern offshore areas also warm (Figure 14). Maximum temperature recorded by SAIV mini-CTD was 17.15 °C. Lowest surface temperatures were recorded offshore south of the Cornish peninsula (Figure 14). The lowest surface temperature recorded this year was 13.89 °C. Westernmost stations in the Channel and a single station north-west of Guernsey were seasonally stratified (Delta_T > 0.5 °C; Figure 14). The strength of stratification observed was relatively low with Delta_T values not greater than 1°C, likely due to fresh conditions throughout the survey.

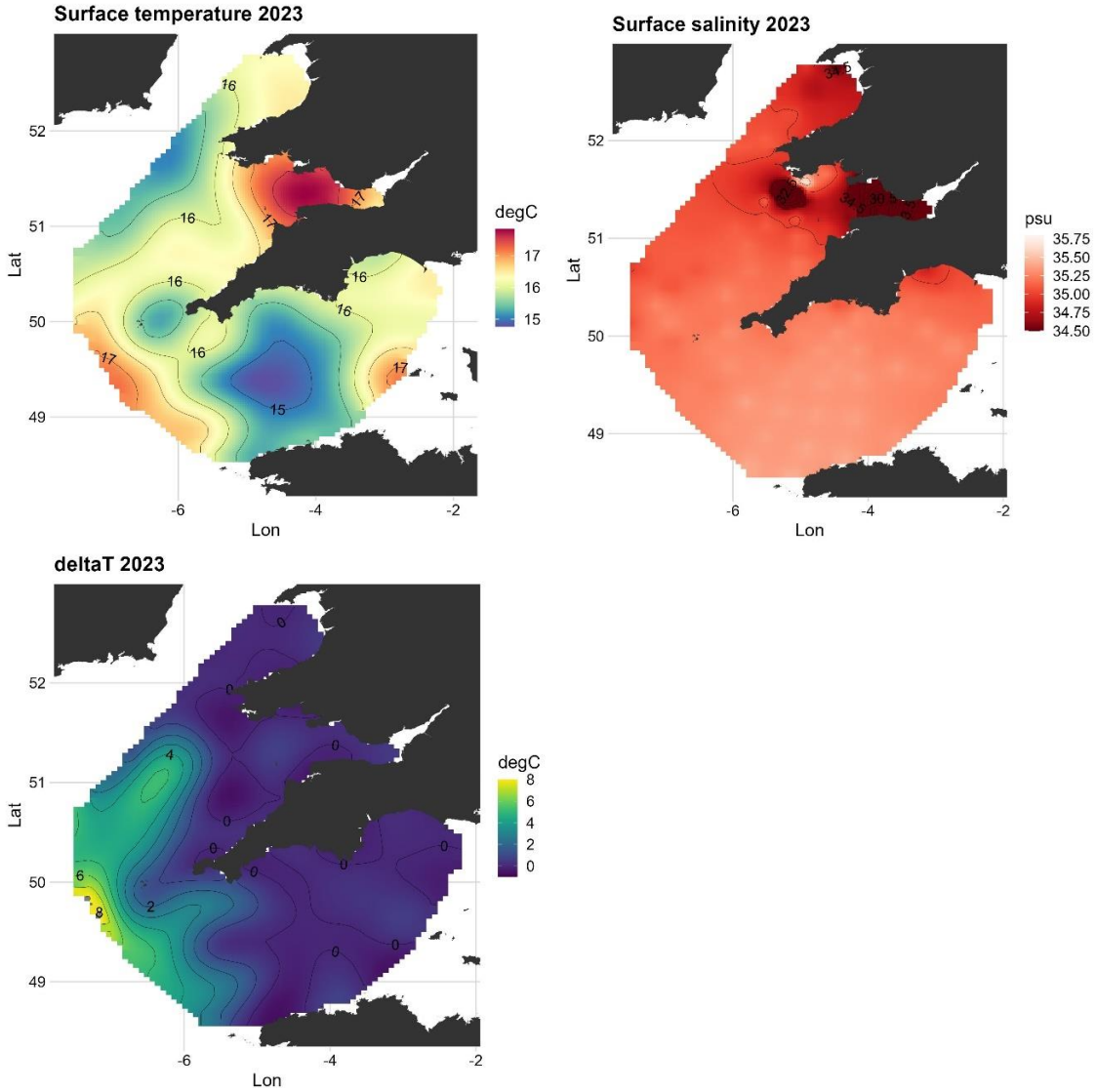

Figure 14. Sea surface temperature (°C ,top left), Sea surface salinity (top right) and Delta_T (°C), difference in temperature between surface and bottom (bottom) as recorded by the SAIV MiniCTD at the 95 sampling stations. The isotherm of Delta_T = 0.5 °C distinguish between mixed (Delta_T < 0.5 °C) and stratified waters (Delta_T > 0.5 °C).

Offshore salinity showed little variation (Figure 14). Highest salinity (35.24) was recorded in the in the middle of the western Channel, and lowest (34.68) in the westernmost part of the study area off the Cornish peninsula. Salinity stratification (Delta_S) was highest at the coastal stations in Eddystone Bay (Figure 15).

Table 4. Summary statistics (minimum, maximum, mean, standard deviation, and number of observations) of temperature, salinity, fluorescence and turbidity measurements, recorded by the FerryBox underway system.

	Temperature	Salinity	Fluorescence	Turbidity
Mean	15.91	35.14	3.40	2.86
Min	13.89	34.68	1.12	3.16
Max	17.15	35.24	5.40	6.19
Std Deviation	0.96	0.09	0.20	0.96
Number	15439	15439	15439	15439

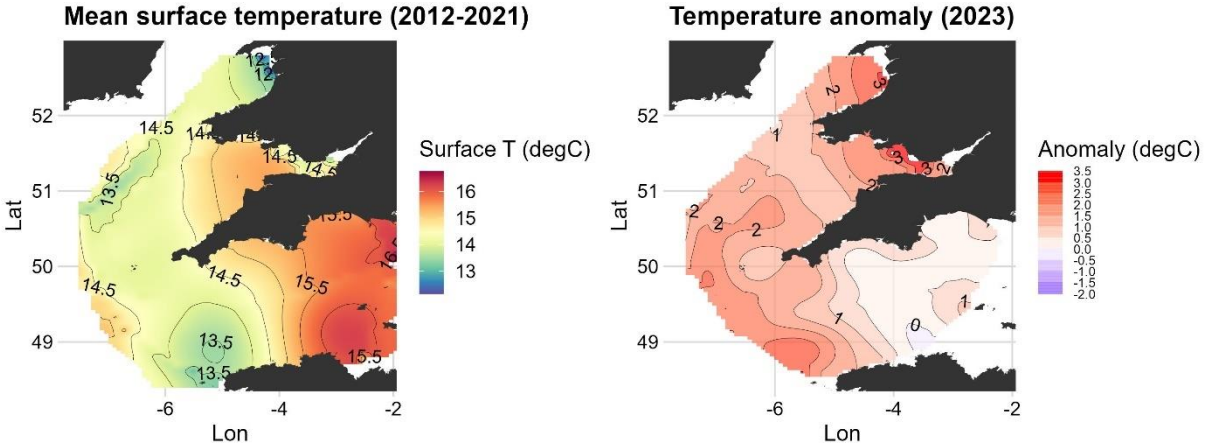

Figure 15 Mean Sea Surface Temperature for 2012-2021 (left) and 2023 temperature anomaly map (right).

As mentioned above, due to issues with the FerryBox no *in situ* surface distribution of chlorophyll was available. Images of surface chlorophyll distribution from satellite remote sensing (Figure 16) suggested the presence of a bloom in the Eddystone Bay area offshore area and in the central western Channel, although the latter may be an artefact due to the persistent cloud cover reducing satellite coverage.

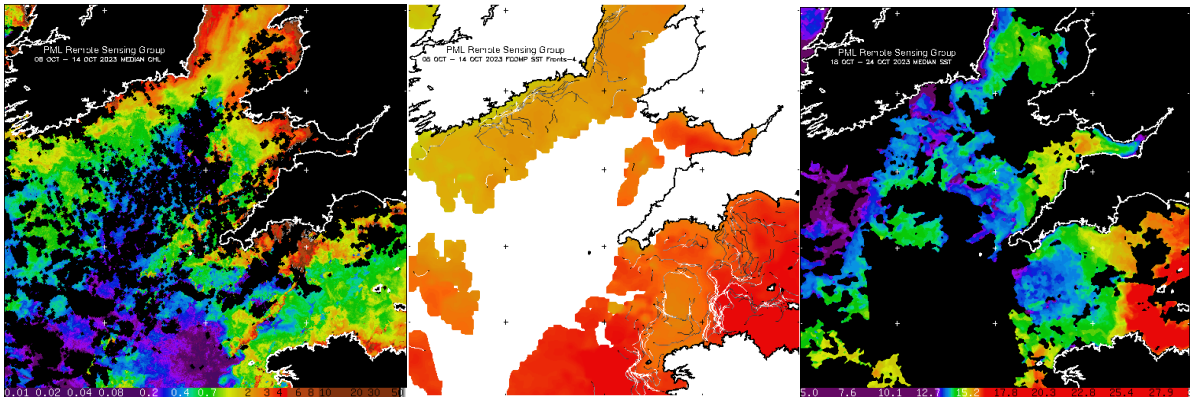

Figure 16 From left to right, satellite derived surface chlorophyll distribution (OC4ME algorithm) and position of frontal areas between 8-14 October 2022 and Surface temperature between 16-24 Oct, from https://data.neodaas.ac.uk/). Note that persistent cloud cover caused patchy coverage throughout the survey.

Observer data: apex predators

For the eleventh year running, during both survey parts, one (part 1) and two (part 2) volunteer MARINElife surveyors were stationed on the bridge in a central position and employed an effort-based 300m box methodology for recording birds, marine mammals and tuna (an adapted version of ESAS methodology) with an additional 180° area scanned to survey each transect line. During transits between transects, the team recorded incidental observations when possible, logging significant species only. Furthermore, casual observations were recorded during the net-retrieval stage of trawls to identify species of birds associated with the fishing activity of the survey vessel but only where there was a significant gathering of birds. During survey transects, all species of birds (both seabirds and terrestrial migrants) were recorded, along with all sightings of marine mammals and pelagic fish such as tuna. The effort-based 300m box methodology employed was developed by the Cetacean Group of the Mammal Society for use from platforms of opportunity such as commercial

ferries. The aim of this method is for the observer to record and identify as many seabirds and cetaceans as possible that pass through the 300m box while recording birds and marine mammals outside the box out to a distance of 1km. In 2023 surveyors recorded cetaceans and seabirds.

Data recorded for sightings by MARINElife methodology includes:

1. Time of recording (start and end time for cetacean observations)
2. Number of individuals
3. Species (or family group)
4. Behaviour (flying/searching/feeding/sitting on water)
5. Plumage/age
6. In or out of the 300m box
7. Angle of sighting (for cetaceans and Balearic Shearwater)
8. Distance of first sighting (for cetaceans and Balearic Shearwater)

Survey effort was made on 31 days from 29 September to the 30 October, surveying approximately 3607 km during 185 h and 22 min spent on survey effort. Only short sections of the transects were not surveyed due to the acoustic sampling continuing after sunset and due to fog.

The weather conditions this year were “middle of the road” with very little calm weather but also no days lost due to storms (Table 5). For around 60% of the survey effort, sea state was 4-6, with only 5% (nine hours) sea state 2 or less. Wind direction was predominantly from the west with 65% of survey effort having wind with a westerly component and only 20% with any easterly component.

Table 5: Survey effort 2013-2023 by MARINElife teams on the PELTIC Survey. *Only parts 1&2 of the 2017 survey during which both survey teams were present are included in this table.

	2013	**2014**	**2015**	**2016**	**2017***	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Transect length (km)	2092 (+278*)	3058	2447	2990	2644	3706	3025	3741	4039	882	3607
No. survey days	16 (+2*)	20	18	16	24	32	26	30	29	10	31
Mean sea state	5.01	3.78	3.08	5.34	4.32	3.86	3.24	4.83	3.92	5.1	4.47
Modal sea state (% of total)	4	3	4	3	3	5	3	5	5	5	4
% Effort sea state 4 or less	37	67	92	45	53	63	81	39	56	39	54
Modal wind direction (% of effort)	SW (33)	SW (30)	NE (30)	ENE (24)	SW (40)	NE (28)	TBC	SW (15)	W (17)	SW (31)	SW (27)

*Southern North Sea

Bird observations

A total of 7,473 sightings of 24,665 birds were recorded throughout the survey (Table 6), exceeding the record set in 2021 for the longer surveys undertaken since 2017. Cardigan Bay was very quiet for seabirds this year, the additional transects adding just 1,386 birds (5.6%), considerably fewer than in the previous two autumn surveys these transects were run. Without the Cardigan Bay transects 23,279 birds were recorded which is higher than any 2017-2021 total.

Table 6: List of all bird species recorded on effort during PELTIC survey 2023

Species	Scientific Name	No of sightings	No of Birds
Brent Goose	*Branta bernicla*	2	4
Common Scoter	*Melanitta nigra*	6	30
Stock Dove	*Columba oenas*	1	1
Golden Plover	*Pluvialis apricaria*	4	32
Ringed Plover	*Charadrius hiaticula*	1	1
Curlew Sandpiper	*Calidris ferruginea*	1	3
Dunlin	*Calidris alpina*	1	5
Snipe	*Gallinago gallinago*	1	1
Grey Phalarope	*Phalaropus fulicarius*	1	1
Kittiwake	*Rissa tridactyla*	727	3061
Sabine's Gull	*Xema sabini*	1	1
Black-headed Gull	*Chroicocephalus ridibundus*	3	3
Little Gull	*Hydrocoloeus minutus*	102	295
Mediterranean Gull	*Larus melanocephalus*	30	69
Common Gull	*Larus canus*	11	22
Great Black-backed Gull	*Larus marinus*	185	285
Herring Gull	*Larus argentatus*	110	307
Yellow-legged Gull	*Larus michahellis*	1	1
Lesser Black-backed Gull	*Larus fuscus*	104	333
Larus sp.	*Larus sp.*	9	78
Gull sp.		7	7
Common Tern	*Sterna hirundo*	5	6
Arctic Tern	*Sterna paradisaea*	4	4
Tern sp.		1	1
Great Skua	*Stercorarius skua*	94	107
Pomarine Skua	*Stercorarius pomarinus*	1	1
Arctic Skua	*Stercorarius parasiticus*	19	20
Long-tailed Skua	*Stercorarius longicaudus*	1	1
Skua sp.	*Stercorarius sp.*	2	4
Guillemot	*Uria aalge*	876	1823
Razorbill	*Alca torda*	487	2045
Puffin	*Fratercula arctica*	25	35
Auk sp.		310	2457
Great Northern Diver	*Gavia immer*	3	3
Storm Petrel	*Hydrobates pelagicus*	61	248

Leach's Petrel	*Hydrobates leucorhoa*	2	2
Petrel sp.	*Hydrobates sp.*	1	1
Fulmar	*Fulmarus glacialis*	20	23
Cory's Shearwater	*Calonectris borealis*	545	1568
Sooty Shearwater	*Ardenna grisea*	125	244
Great Shearwater	*Ardenna gravis*	485	4412
Manx Shearwater	*Puffinus puffinus*	261	585
Balearic Shearwater	*Puffinus mauretanicus*	130	289
Shearwater sp.		16	106
Gannet	*Morus bassanus*	2629	5921
Cormorant	*Phalacrocorax carbo*	6	12
Shag	*Phalacrocorax aristotelis*	9	9
Grey Heron	*Ardea cinerea*	4	20
Merlin	*Falco columbarius*	2	2
Skylark	*Alauda arvensis*	1	1
Swallow	*Hirundo rustica*	21	122
Starling	*Sturnus vulgaris*	3	8
Meadow Pipit	*Anthus pratensis*	13	41
Chaffinch	*Fringilla coelebs*	1	1
Goldfinch	*Carduelis carduelis*	1	2
Siskin	*Spinus spinus*	1	1

The standout observation in 2023 were four species of shearwater. The influx of Great Shearwaters into the western Channel in autumn 2022, largely missed by the PELTIC survey due to it being cut short, was thought to be a one-off event. This year proved that was not the case. In addition to the Great Shearwaters *Ardenna gravis*, large numbers of Cory's *Calonectris borealis*, Sooty *Ardenna grisea* and Manx Shearwater *Puffinus puffinus* were also observed.

Shearwater numbers had started to build in the Western Channel during July and August with anecdotal reports of hundreds being recorded from various seawatching sites along the south coast, as well as pelagic records from ecotourism trips off Penzance, Falmouth Bay, Plymouth Bay, and Lyme Bay. During September, counts ramped up with over 1000 Great and several hundred Cory's Shearwaters featuring regularly at the various seawatching sites and at sea. Earlier in the autumn, the Cory's shearwaters were seen in good numbers up the Channel in western Lyme Bay but by the time of the PELTIC survey they appeared to be restricted to warmer waters around the Isles of Scilly. Having not been recorded on PELTIC since 2013, on transects just north of the Isles of Scilly, Cory's Shearwater were the most abundant species recorded.

Great Shearwaters were much more widespread, although the largest numbers were found in an area of cooler water in the centre of the mouth of the Channel. The 4412 recorded on the PELTIC survey is exceptional but the number of Great shearwaters in the Channel during October would have been in the tens of thousands as suggested by 11,000 seen passing Start Point on 13 October. These birds were not migrating at that time, and appeared to still be

moving around the Channel in search of food; land-based sightings still recorded good numbers off Cornwall into mid-November.

Table 7: List of bird species recorded off-effort either at sea or onboard CEFAS Endeavour in 2023

Species	Scientific name	No recorded 2023
Stock Dove	*Columba oenas*	1
Purple Sandpiper	*Calidris maritima*	1
Sabine's Gull	*Xema sabini*	2
Little Gull	*Hydrocoloeus minutus*	5
Mediterranean Gull	*Larus melanocephalus*	2
Yellow-legged Gull	*Larus michahellis*	3
Pomarine Skua	*Stercorarius pomarinus*	1
Cory's Shearwater	*Calonectris borealis*	10
Great Shearwater	*Ardenna gravis*	360
Sooty Shearwater	*Ardenna griseus*	24
Balearic Shearwater	*Puffinus mauretanicus*	78
Manx Shearwater	*Puffinus puffinus*	6
Grey Heron	*Ardea cinerea*	4
Short-eared Owl	*Asio otus*	2
Kestrel	*Falco tinnunculus*	1
Merlin	*Falco columbarius*	1
Empidonax sp.		1
Skylark	*Alauda arvensis*	2
Chiffchaff	*Phylloscopus collybita*	4
Blackcap	*Sylvia atricapilla*	1
'Eastern' Lesser Whitethroat	*Curruca curruca*	1
Wren	*Troglodytes troglodytes*	2
Song Thrush	*Turdus philomelos*	1
Redwing	*Turdus iliacus*	3
Blackbird	*Turdus merula*	1
Robin	*Erithacus rubecula*	2
Northern Wheatear	*Oenanthe oenanthe*	1
Grey Wagtail	*Motacilla cinerea*	1
Pied Wagtail	*Motacilla alba*	4
Snow Bunting	*Plectrophenax nivalis*	1
Chaffinch	*Fringilla coelebs*	2
Goldfinch	*Carduelis carduelis*	2

Manx Shearwaters are usually only seen in small numbers on the PELTIC survey, so a count of 585 is another exceptional one. It was notable that many of the birds seen feeding with Balearic Shearwaters off the north coast of Brittany were in active primary moult so unlikely to be moving on anywhere until they had completed their moult. It would be interesting to know the origin of these birds, whether they are non-breeders from the Irish Sea populations, or birds from further south that have moved north with the Balearics.

Another notable observation was the 295 Little Gull passing through the Channel, usually a scarce bird on the PELTIC surveys. Two species recorded in much lower numbers are Gannet *Morus bassanus* and Great Skua *Stercorarius skua*. Both species have been hard hit by bird flu and, although Gannet colonies are showing tentative signs of recovery, the reduced numbers being seen are a cause for concern. In the case of the Great Skua the situation may be even

more dire, surveys of breeding areas suggest some colonies may have been reduced by as much as 90%.

Balearic Shearwater

As Europe's most endangered seabird, Balearic Shearwater has been a target species of the PELTIC survey for some years and extra data is recorded for all sightings. This extends to recording 30 minutes effort after any off-transect sightings, where possible, to increase the usefulness of the data.

This year a total of 289 birds were recorded, slightly down on the high of 2021 but still far more than any other year. Unfortunately, the truncated 2022 survey didn't cover the transects off the north Brittany coast, so there were no records last year. Figure 17 shows the distribution of all the sightings recorded in 2023, with 289 recorded on transects. The large orange dot marks a flock of 70 seen off transect, the largest flock recorded on a PELTIC survey, and very late in the season for such a large number. Up until 2018 there had been a hotspot for sightings to the west of Lundy in the Bristol Channel but once again this year, none were seen that far north, with just a single bird seen north of Land's End.

This year, as with 2021, most of the large numbers of birds were seen shortly after dawn close to the French coast, the exceptions being the Channel SSE of Portland, Dorset, and the area to the southwest of Guernsey, an area known to be home to large numbers of Balearic Shearwater through July and August recent years.

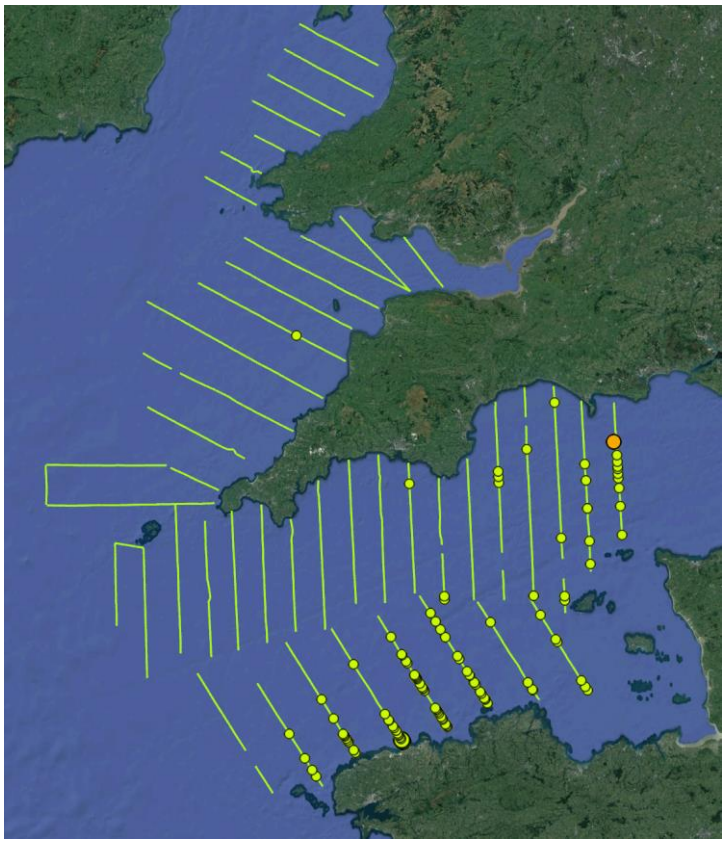

Figure 17: Map showing abundance of Balearic Shearwater sightings in 2023. Small to large circles: 1-10, 11-20, 20+. Green dots were birds recorded on transect, orange dot off transect.

Cetaceans

The MARINElife observers recorded a total of 440 cetacean encounters, totalling 2,339 animals of seven species (Table 8). While the number of species is typical for the PELTIC surveys, some of the numbers of individuals are quite low, particularly Harbour Porpoise *Phocoena phocoena*.

Table 8. Cetacean species recorded by MARINElife surveyors on effort during PELTIC survey 2021

Species	Scientific Name	No. sightings	No. animals
Fin Whale	*Balaenoptera physalus*	1	2
Minke Whale	*Balaenoptera acutorostrata*	1	1
Risso's Dolphin	*Grampus griseus*	1	6
Common Bottlenose Dolphin	*Tursiops truncatus*	2	58
Common Dolphin	*Delphinus delphis*	356	2242
Harbour Porpoise	*Phocoena phocoena*	6	12
Grey Seal	*Halichoerus grypus*	2	2
Whale sp.		2	13
Dolphin sp.		3	3
	Total:	440	2339

Common Dolphin *Delphinus delphis* was again by far the most frequently recorded cetacean species, with 356 sightings of 2,242 animals. While this total number is lower than 2021, the number of encounters is the highest for any PELTIC survey since 2017. The survey this year was characterised by many sightings of small groups of dolphins (less than 10) with only a small number of mid-sized pods (Table 9). Day totals exceeded 100 on 11 days with a maximum of 229 on 12 October and only another two days with over 200 seen. The top three maximum count for a single pod was just 75, 60 and 45.

Table 9. Comparison of Common Dolphin pod sizes between 2021 and 2023

Count of pod size	2023	2021
1-5	221	79
6-10	84	77
11-15	27	37
16-20	13	16
21-30	8	5
31-40		16
41-50	1	3
51-60	1	2
61-70		4
71-80	1	1
110		1
120		2
180		1
200		1
300		1

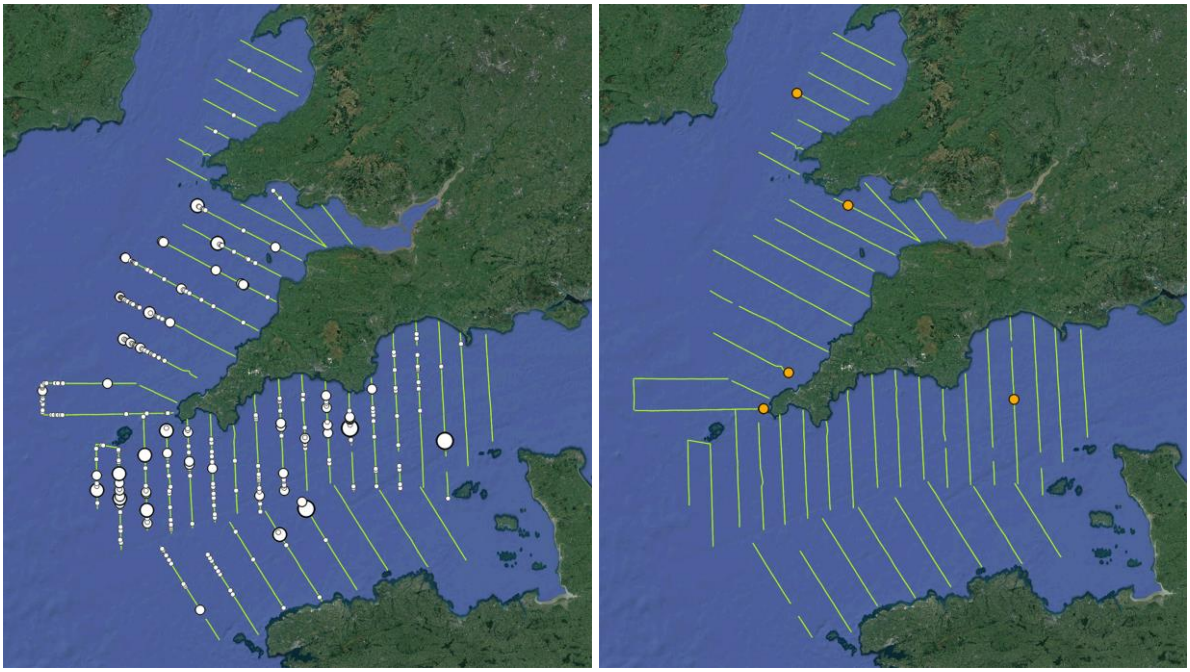

Figure 18: Distribution of all Common Dolphin sightings (left) and harbour porpoise (right) in 2023, scaled to abundance. Abundance categories (small to large dots): 1-10, 11-20, 20+. Black lines mark survey effort.

As with previous years the species is widely distributed throughout the survey area (Figure 18) but with notable hotspots in the mid-Channel, around the Isles of Scilly and the Celtic Deep.

The number of Harbour Porpoise observations was low again at 12, down from the low numbers (32) seen in 2021. Weather conditions will have contributed, but they were not seen even when there was a calm spell in areas they have been recorded before. Harbour Porpoise sightings were widely distributed around the survey area (Figure 18).

Two pods of Bottlenose Dolphin *Tursiops truncatus* were observed (black dots, Figure 19): a pod of 42 animals 21 km SW of Pembrokeshire contained several calves/young juveniles and a pod of 16 animals 16 km NW of Guernsey came leaping in to bow ride. Another highlight was a pod of six Risso's Dolphins *Grampus griseus* seen in mid-Channel NW of Guernsey, which passed close to the RV CEFAS Endeavour.

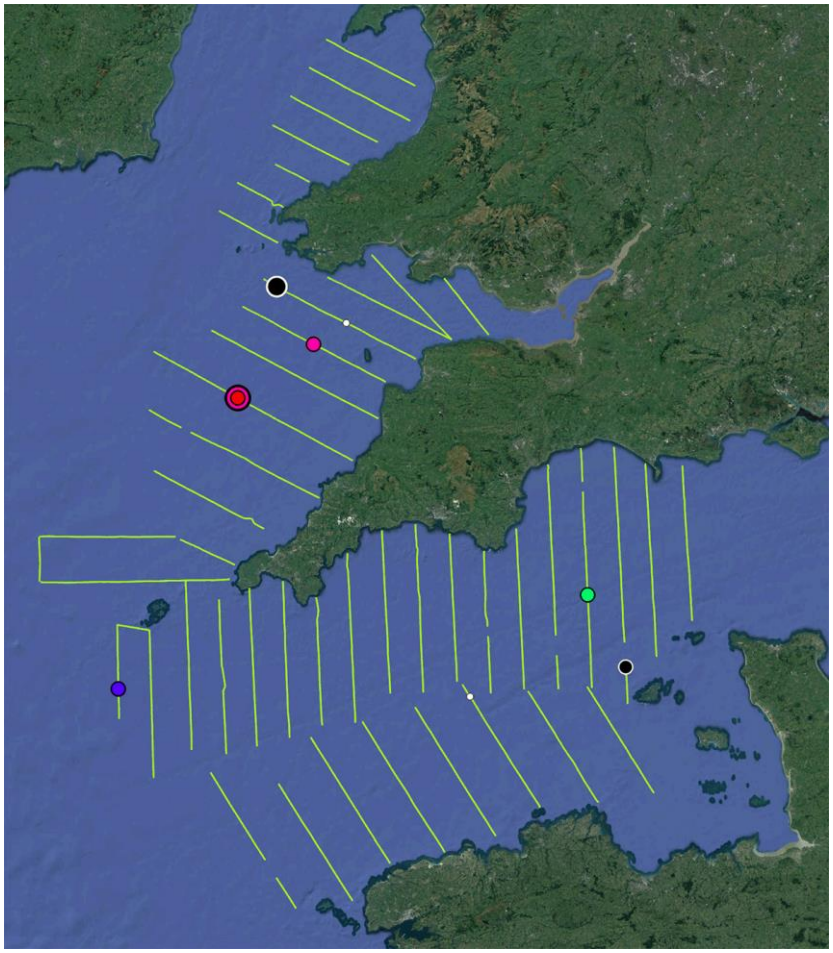

Figure 19: Distribution of scarce cetacean species sightings. Black dots = Bottlenose Dolphin, green = Risso's Dolphin, red = Fin Whale, blue = Minke Whale, pink = Unidentified whales, white = Grey Seal. Black lines mark survey effort.

Whale sightings in 2023 were low. Two Fin Whales *Balaenoptera physalus* were identified near the Celtic Deep, thanks to a photo of the back showing the dorsal fin (Figure 19). This is a classic place to record Fin Whales, based on evidence from other MARINElife surveys off southwest Britain and adjacent waters (Figure 20). At the same time as the two Fin Whales were passing a large gathering of whale blows was spotted several kilometres away (the large pink dot in Figure 19), an estimate of 12 were logged but there could have been as many as 20. The likelihood is these were Fin Whales but many of the blows were quite low and bushy, reminiscent of Humpback Whales *Megaptera novaeangliae*, which have been seen in this area. Another single Fin Whale, lunge-feeding across the bows of the RV CEFAS Endeavour, was seen off-transect between Land's End and the Isles of Scilly. Finally, a solitary whale seen W of Lundy also remained unidentified, although again in all likelihood a Fin Whale.

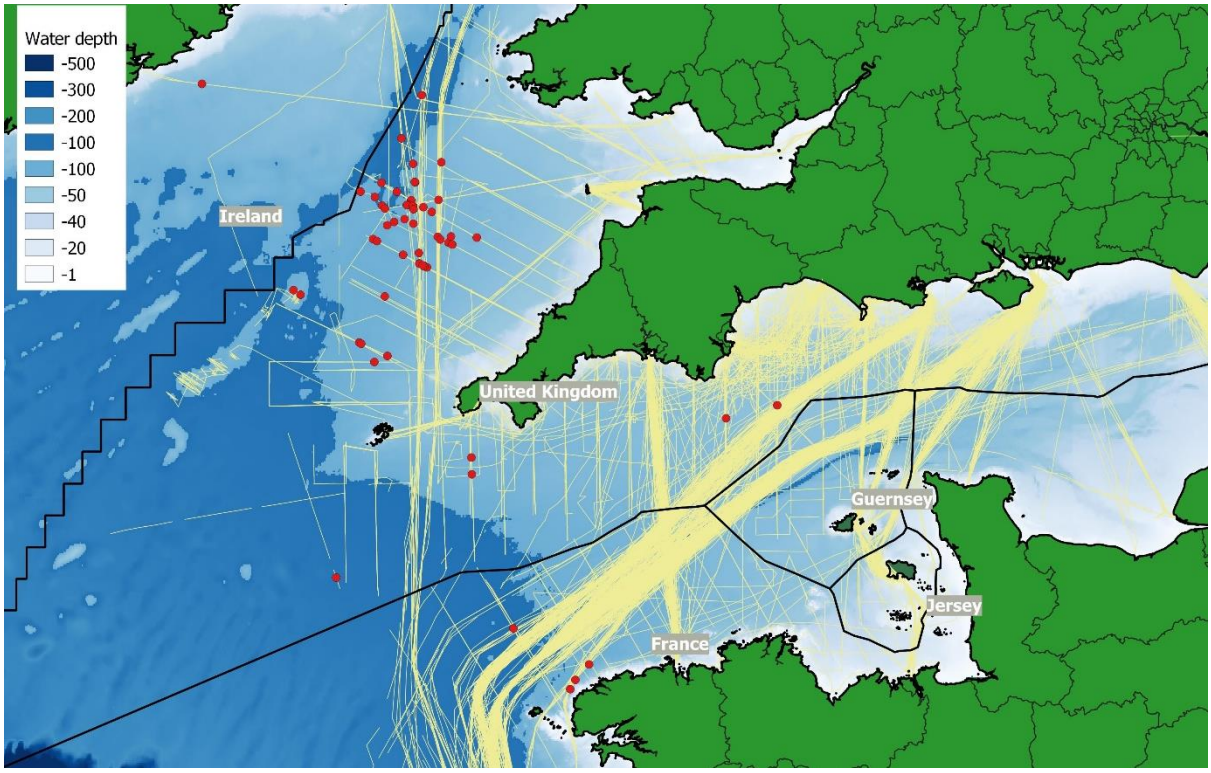

Figure 20: Distribution of Fin Whale observations on all MARINElife-sampled surveys 1995-2022 in SW Britain and adjacent waters, including PELTIC (2013-2022). Red dots = Fin Whale, Yellow lines = survey effort, Black lines = territorial water boundaries. Source: Tom Brereton, MARINElife

Just a single Minke Whale *Balaenoptera acutorostrata* was recorded in 2023. Seals are also rarely seen with two or three seen on most PELTIC surveys, 2023 kept to this with two Grey Seals *Halichoerus grypus* recorded. The one seen mid- Channel seems to be a long way from any breeding areas, the closest being Guernsey.

Bluefin tuna

A total of 285 Tuna (the majority likely to be Bluefin *Thunnus thynnus*) were recorded in 66 encounters on the survey transects (Figure 21). Three categories of sighting are distinguished:

- possible – a single erratic splash is seen, nature of splash rules out a cetacean but not another large pelagic fish species.
- probable – multiple erratic splashes with glimpses of animal but not enough to confirm identity as bluefin tuna.
- definite – enough of the animal is seen to identify it as a bluefin tuna species

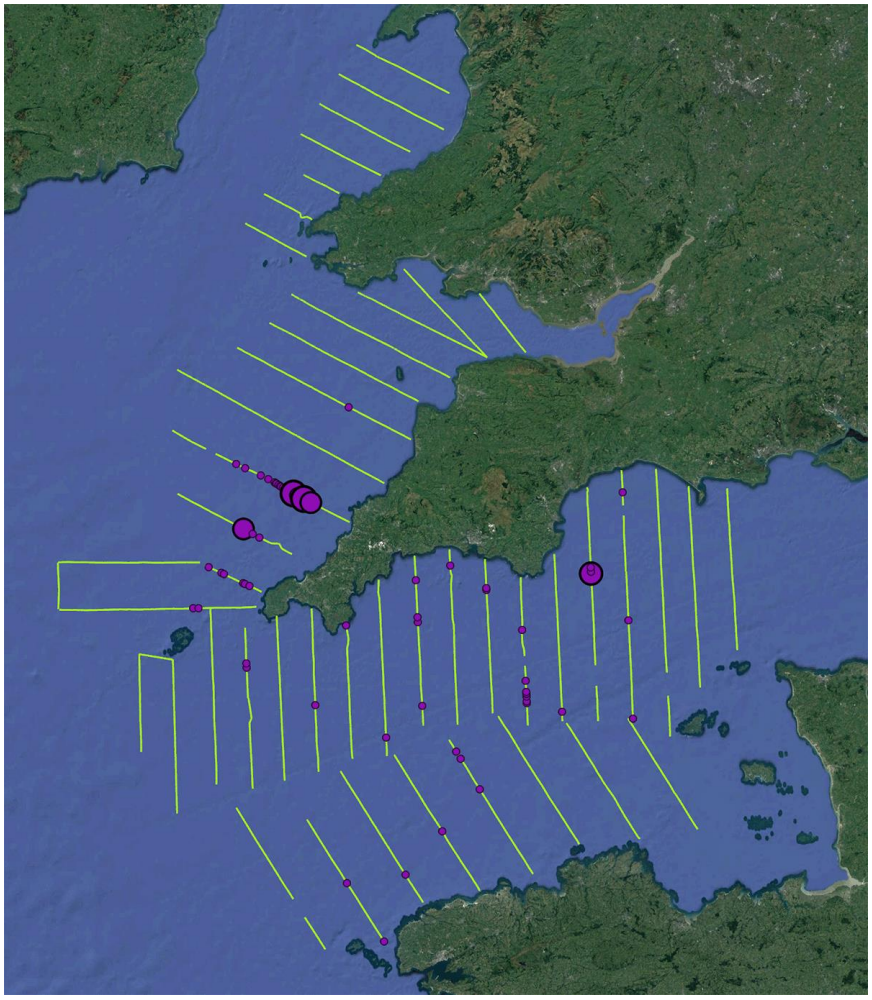

Figure 21: Distribution of all tuna sightings in 2023, scaled to abundance. Abundance categories (small to large purple dots): 1-5, 6-10, 10+. Green lines mark survey effort.

In contrast to 2021, most of the bluefin tuna sightings were in the western half of the survey area, although it should be noted that sea conditions were generally not conducive to seeing individual animals feeding. However, there were several very good sightings, especially of close feeding frenzies. A notable observation was during the steam back post-survey when a bluefin tuna was observed in the southern North Sea.

Summary. The 2023 PELTIC survey was successfully completed, with all transects covered and all plankton and CTD stations sampled. Oceanographic conditions confirmed that 2023 was more than 2 degrees warmer compared to the time-series average. Sprat biomass in the Western Channel stratum, used for the assessment (sprat 27.7de) was 61,270 (CV 0.53) which was the second highest since 2016, superseded only by the exceptional biomass of 2021. Sprat was again the most abundant small pelagic fish species in Cardigan Bay with a biomass of 15,475 t (CV 0.33), which was lower than previous estimates. Another recruitment pulse was observed in the data, with 0-group sprat making up a large component of the population. As in previous years, the highest quantities were found in Lyme Bay, although high numbers of sprat were also found further west, around Eddystone.

Sardine total biomass was the highest of the time series at 456,482 t (CV 0.19). Sardine was widely distributed as in previous years although this year two main hotspots were observed, one around the Isles of Scilly and one south of the southwestern point of Cornwall. These included the largest sardines in the survey area and the large numbers of eggs found in plankton samples at both sites suggested these were primarily spawning aggregations. Higher than usual numbers also found in the Bristol Channel and in Cardigan Bay. Biomass in the latter area was on order of magnitude higher than previously observed at 4,921 t (CV 0.29). Some of the smallest sardines were found in French waters.

Anchovy biomass in 2023 was 243,392 t (CV 0.22), approximately five times the previous highest estimate (2021), continuing an increasing trend. While some of the highest densities were found in the Eddystone Bay, anchovy was widespread throughout the survey area, including in the Bristol Channel. As was observed in 2019 and 2020, in 2023 again large numbers of surface and mid-water schools of juvenile anchovy were found off the Brittany coast, from the Isle of Ouessant in the west to the Channel Islands in the east of the survey. These fish are most likely Bay of Biscay fish moving into the Channel.

Most notable observations with regards to the top predators were the good numbers of bluefin tuna and numerous but small pods of common dolphins. Gannet numbers were still low, most likely to due bird flu but five species of shearwater were reported with particularly Great and Cory's most notable.

Jeroen van der Kooij, Fabio Campanella and Joana Silva
Scientists in Charge
21/02/2023

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Annex 1

Objective 13: To collect between 25-50 specimens per species (anchovy, mackerel, sardine) and freeze for further analysis in the lab supporting a study on microplastics in fish stomachs (A. Bakir/ A. Goran).

Trawl station	Survey stratum	Species code	Scientific name	Number
31	Bristol Channel (BC)	MAC	*Scomber scombrus*	50
31	Bristol Channel (BC)	ANE	*Engraulis encrasicolus*	25
33	Cardigan Bay (CA)	PIL	*Sardina pilchardus*	25
33	Cardigan Bay (CA)	MAC	*Scomber scombrus*	25
69	Bristol Channel (BC)	ANE	*Engraulis encrasicolus*	25
69	Bristol Channel (BC)	PIL	*Sardina pilchardus*	25
69	Bristol Channel (BC)	MAC	*Scomber scombrus*	25
91	Bristol Channel (BC)	PIL	*Sardina pilchardus*	25
103	Scilly Isles (SI)	ANE	*Engraulis encrasicolus*	25
103	Scilly Isles (SI)	PIL	*Sardina pilchardus*	25
144	western English Channel (WEC)	PIL	*Sardina pilchardus*	25
174	western French Channel (WFC)	ANE	*Engraulis encrasicolus*	25
174	western French Channel (WFC)	PIL	*Sardina pilchardus*	25
243	western English Channel (WEC)	MAC	*Scomber scombrus*	25

Objective 14: To collect samples of sprat (including biological parameters) for a study on population genetics (D Murray, E Garnacho, V Visconti). Note: Survey stratum WEC corresponds to western English Channel.

Sample	ICES Division	Species	Priority	Target	Collected
Genetics	7f	Herring	1	40	1
	7f	Sprat	1	40	40
	7f	Sardine	2	40	40
	7g	Horse mackerel	1	40	40
	7g	Sprat	2	40	30
	7g	Anchovy	3	40	
	7g	Sardine	NA	0	12
	7e	Herring	1	40	
	7e	Sprat	1	40	
	7e	Sardine	2	40	
	7e	Horse mackerel	3	12	
	7e	Anchovy	3	40	
	7d	Horse mackerel	1	40	
	7d	Sardine	2	40	
Otolith	7f	Horse mackerel	1	60	60
	7f	Sprat	1	60	44
	7f	Sardine	3	60	60
	7g	Sprat	1	60	40
	7g	Sardine	2	60	42
	7g	Anchovy	3	60	30

	7e	Sardine	1	60	
	7e	Sprat	1	60	
	7e	Horse mackerel	3	60	
	7e	Anchovy	3	60	
	7d	Horse mackerel	1	60	
	7d	Sardine	2	60	

Objective 15: To collect specimens of *Alloteuthis* sp. with associated photography for identification studies into the potential increase of *A. media* in UK waters. (P. White - Cefas)

Trawl station	Survey stratum
5	Bristol Channel (BC)
22	Bristol Channel (BC)
194	western English Channel (WEC)
225	western English Channel (WEC)
232	western English Channel (WEC)
243	western English Channel (WEC)
250	western English Channel (WEC)