Centre for Environment Fisheries & Aquaculture Science

Cefas

RESEARCH VESSEL SURVEY REPORT

RV CEFAS ENDEAVOUR
Survey: C END 16 - 2022.

STAFF:

24 Sept – 4 October 2022		15 - 28 October 2022	
Name	**Role**	**Name**	**Role**
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 Fishroom	**Richard Humphreys**	Lead Fishroom
Allen (Spike) Searle	Fish	**Allen (Spike) Searle**	Fish
Nicola Hampton	Fish	**Benjamin Hatton**	Fish
Joseph Watson	Fish	**Joseph Watson**	Fish
Izzy Lake	Oceanography/eDNA	**Izzy Lake**	Oceanography/eDNA
Nevena Almeida	Zooplankton	**Nevena Almeida**	Zooplankton
Robert van Ree	Zooplankton	**Amy Larter**	Zooplankton
Peter Howlett	ML Observer	**Sylvan Benaksas**	PhD
Nuala Campbell	ML Observer	**Peter Howlett**	ML Observer
		Nuala Campbell	ML Observer

DURATION: 24 September - 28 October (35 days, 12 on survey)

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

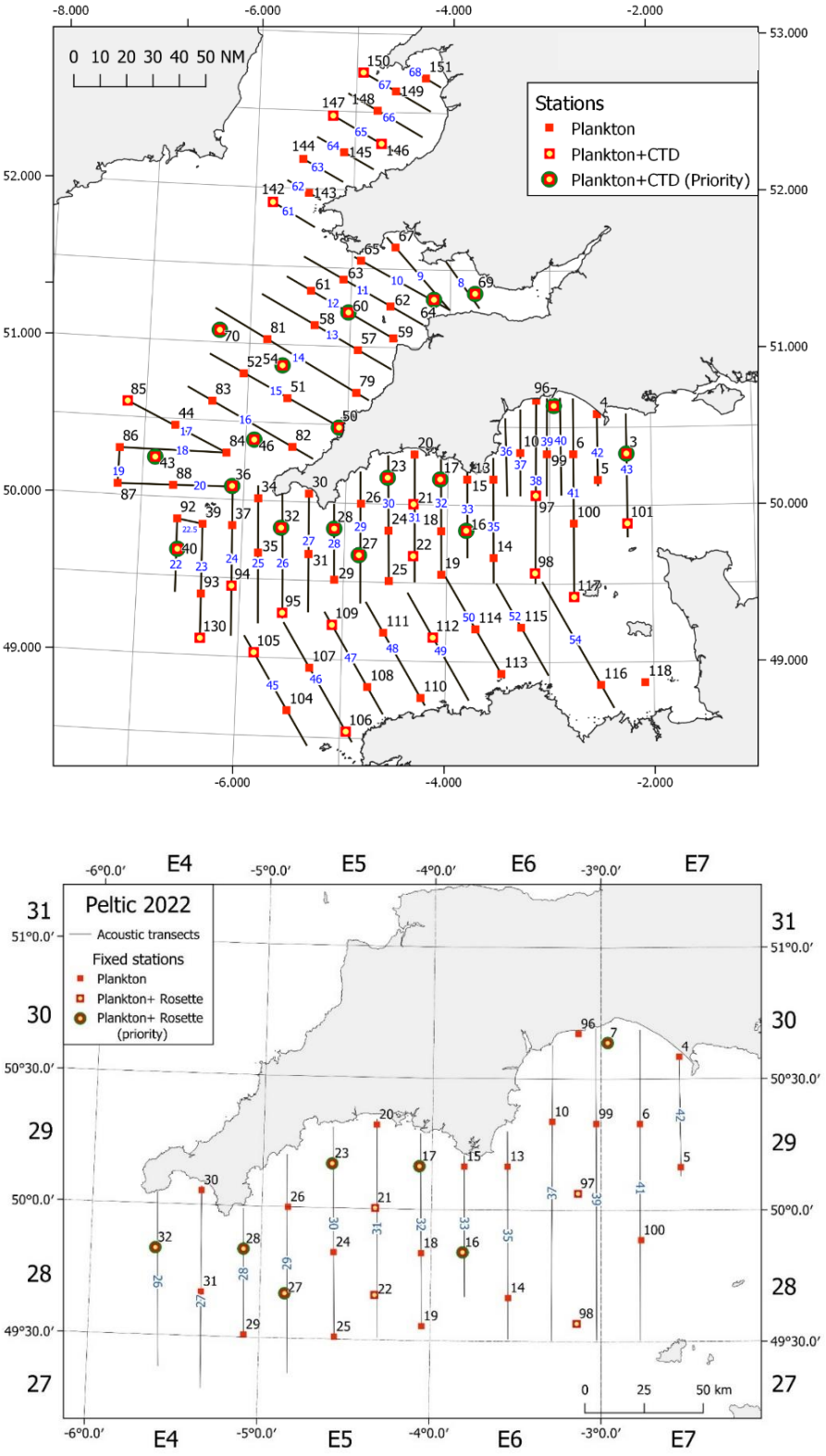

Figure 1. Overview of the original (top) and adjusted (bottom) planned survey designs, with the acoustic transect (black lines, numbers in blue), plankton stations (red squares) and hydrographic stations (yellow circles). Priority stations indicated in green.

AIMS:

1. To carry out the twelfth autumn PELTIC survey: pelagic ecosystem survey of the western Channel, Celtic Sea, including (for the third 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 sprattus*, sardine *Sardina pilchardus*, mackerel *Scomber scombrus*, anchovy *Engraulis encrasicolus* and horse mackerel *Trachurus trachurus*. The PELTIC derived sardine biomass in area 7 will feed into its stock assessment (WGHANSA) and sprat biomass data from the western English Channel will feed into the stock assessment of sprat in area 7de (HAWG).

    a. To carry out a fisheries acoustic survey during daylight hours only using four operating frequencies (38, 120, 200 and 333 kHz) to map and quantify the small pelagic species community.
    b. To trawl for 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
        - Stomach contents of selected species

2. 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* and saury pike *Scomberesox saurus*.

3. 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.

4. Water column profile and water sample (yellow stations on map below). At fixed stations along the acoustic transect, a CTD (ESM2 profiler or Seabird on Rosette sampler) will be deployed to obtain measurements of environmental properties within the water column: chlorophyll, dissolved oxygen, salinity, temperature, turbidity, dissolved inorganic nutrients 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. Samples for analysis of the phytoplankton and microzooplankton communities will also be collected at the subsurface at fixed sampling stations.

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

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

7. Flowcytometry: high frequency sampling of the phytoplankton functional groups and size of phytoplankton community (V. Creach, Cefas - Lowestoft)

8. Plankton Imager (PI): to collect continuous high frequency data on the sub-surface copepod composition (S. Pitois, Cefas - Lowestoft).

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

10. Genetic samples herring: to bag and freeze herring from different parts of the survey area (D. Clarke, Swansea University)

11. To collect between 15-20 (similar sized) specimens per species (anchovy, boarfish, herring, horse mackerel, mackerel, sardine) and freeze (Debbie Walsh, NMBAQC)

12. 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, Cefas - Lowestoft).

13. To collect 30 sardine larvae each at up to six different stations across the survey area for preliminary work on otolith microchemistry (R. Nash, Cefas - Lowestoft).

14. Record macro-litter observations in the trawl (B. Silburn, Cefas - Lowestoft)

15. To collect 100 specimens of anchovy for a study on growth (Filipe Martinho, University of Coimbra, Portugal)

16. To collect samples of sprat for a study on population genetics (D. Murray, Cefas - Lowestoft)

NARRATIVE[1]:

Scientific personnel joined the RV Cefas Endeavour in Swansea on 23 September 2022 with the intention to sail the following morning (24 September). Upon arrival, SICs were made aware of a delay in the scheduled departure due to issues with fuel delivery, with electrical switchboard and of a medical nature. The vessel left Swansea on the 25 September at 1800hr, with a 36 hours delay, to head to the calibration site near Portland Bill. However, in the early hours of 26 of September, a fault with the main starboard generator required the vessel to head into Falmouth port. On the 27 September the cause of the engine issue was identified and an external company scheduled to come onboard the next day. After investigation, it was clear that the repair needed was expected to take a minimum of 15 days. Arrangements were therefore made for scientific personnel to leave the vessel on different dates (1, 4 of October).

Given the significant reduction of available survey days, with some of the core aims no longer achievable, vessel downtime was used to plan best use of the (expected) available vessel time and minimise impact. Once the repair had been completed, scientists re-joined the RV on 15 October in Falmouth. The next day, sailing time was adjusted from 1000hr to 1800hr to conduct additional tests on the starboard engine and the vessel ultimately sailed at 2100hr. Although sign-off of certification of (separate) trawl block works was still pending, green light was given to proceed with survey mobilisation as the trawl block would not be required during the first survey activities. On the morning of 17 October the vessel arrived in Lyme Bay, where issues with the flowrate of the flow cytometer could not be resolved onboard. Calibration of the echosounders commenced at 0700hr and took most of the day due to challenging tidal and wind conditions and lack of shelter; calibration was successfully completed at 1800hr. Due to fading light, no attempt was made to start an acoustic transect and as the trawl block had still not been signed off, no shakedown tow could be conducted with the trawl. Instead, the first plankton/CTD stations were sampled overnight. At first light on 18 October, acoustic surveying started (transect 41), until permission to use the trawl block was received late morning, and a shakedown tow was planned soon after. During deployment of the trawl, it became apparent that the gear was not rigged correctly, upon which the trawl process was interrupted, and the gear retrieved with the aim to rectify the issue and redeploy in the same area some 30 minutes later. During recovery, an accident occurred involving a crew member. Immediately, the trawling operation was halted, and the individual was tended to. Any further attempts to trawl were abandoned and the vessel resumed running the acoustic transects. For the next few days, survey operations continued with acoustic transects being run during the day and plankton and CTD stations were conducted at night.

On several occasions during the subsequent days, regular maintenance to the starboard engine, meant that survey speed and transit time (at night) were compromised for several hours and also prevented the ability to trawl. On Thursday 20 October, another attempt was made to conduct a (first) trawl to collect essential biological and ground truth data. However, apparent further issues with rigging of the gear again led to the trawl operations being aborted. After some alterations a second and third attempt were also not successful. On 21 October, poor weather prevented any further attempts to trawl and despite having completed the Lyme Bay transects, the decision was made to stay in the area the following day and have another attempt at shooting the trawl to provide the now critical validation and biological data. As planned, on the morning of Saturday 22 of October, the trawl

[1] All times in BST

was deployed for the first fishing station of the day with the hope that the previous evening's amendments to the trawl doors pockets had fixed door spread issues. Whilst the gear was being deployed, rigging of the weights/clumps appeared to be incorrect and the trawl was retrieved. After some amendments, a second trawl was attempted late morning and while cut short, a catch sample was collected and processed. A third trawl was attempted early afternoon and yielded a useful catch as well despite some issues remaining. After inspection of the gear, issues with one of the bridles were identified and addressed but unfortunately the alterations were not completed in time for another trawl before dark. No overnight sampling was conducted as all local plankton and CTD stations had been previously completed. On the morning of 23 October another trawl was attempted and, for the first time this survey, no issues were encountered. Normal survey operations could commence and for the next few days the vessel continued to work its way westwards, running acoustic transects during the day and validating the acoustic marks with the trawl when needed. On Wednesday 26 October a member of the deck crew got injured while the trawl gear was deployed to sample a large acoustic mark. The crew member was immediately attended to and fishing operations were suspended for the day. For the rest of the survey, trawling could only be conducted during the morning (8:00-10:30) due to reduced numbers of deck staff available for gear deployment/recovery activities at other times. Despite this restriction, careful planning meant that validation trawls were continued to be collected across the study area, although the quantity was lower than expected. Despite the many challenges, it looked like the redesigned transects would be completed until on 28 October, the captain notified of the need to come into Falmouth so that medical attention could be given to the injured deckhand. This meant that the final transects could not be completed within the remainder of allotted time and the survey was aborted. The vessel docked at approximately 1800hr, 28 October in Falmouth.

RESULTS:

Due to significant impact of the reduced survey time, none of the core objectives were fully completed. Even the adjusted (reduced) survey was not completed in its entirety due to the need to dock early: two short transects in the western part of the grid were not surveyed. The number of trawl catches was lower than planned.

Table 1. Summary of echosounder (EK60 transceivers; EK80 operating software) calibration settings obtained on 18 October while on drift in Lyme Bay, and applied during PELTIC 2022. The 333 kHz was not calibrated, and settings used were from a previous on-axis calibration performed in 2019. Given the poor calibration results obtained at 200 kHz, settings from 2021 calibration were applied to process the data. *Drop-keel down

Variable	38 kHz	120 kHz	200 kHz	333 kHz
Transducer type	ES38B	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)*
Transducer power (W)	2000	250	120	50
Pulse length (milliseconds)	0.512	0.512	0.512	1.024
2-way beam angle (dB)	-20.7	-20.7	-20.7	-20.7
Transducer gain (dB)	23.11	27.36	27.43	27.58
Sa correction (dB)	-0.957	-0.355	-0.369	-0.64
3dB beam along (°)	6.83	6.25	6.27	7
3dB beam athwart (°)	6.61	6.14	6.48	0
Along offset (°)	0.18	0.00	-0.25	7
Athwart offset (°)	0.08	0.06	0.05	0
RMS (Root Mean Square error)	0.106	0.32	0.43	-

A summary of the echosounder calibration settings are provided in Table 1. Biological data (size, weight, otoliths and maturity) on the following data-limited species were collected (objective 2): three John Dory *Zeus faber*. The Flow cytometer (objective 7) was operational during the survey. The Plankton Imager (objective 8) was not operational at the time of the survey. eDNA samples (objective 9) were collected at 10 locations of which two were deemed invalid, one after processing and another one as not filtered due to survey ending prematurely. At three stations, 15-20 (similar sized) specimens per species were collected for anchovy, horse mackerel, mackerel, sardine (objective 11, Annex 1). In total three samples of ca. 25 whole specimens of small pelagic fish (3 species) were collected for micro-litter analysis (objective 12, Annex 1). No larvae were collected (objective 13). Genetic samples for sprat were collected at five stations (objective 16, Annex 1). More details on the other aims are provided in the relevant sections below.

Pelagic Ichthyofauna

In total 10 of the planned 12 acoustic transects were completed covering a total of 479 nm of acoustic sampling units. As mentioned, survey time was significantly reduced (to 30%) compromising objectives. However, the most important areas of the sprat stratum were covered. A total of 11 valid and five invalid trawl hauls were conducted (Fig 2) to provide ground-truth information about the species and size composition and to collect biological information.

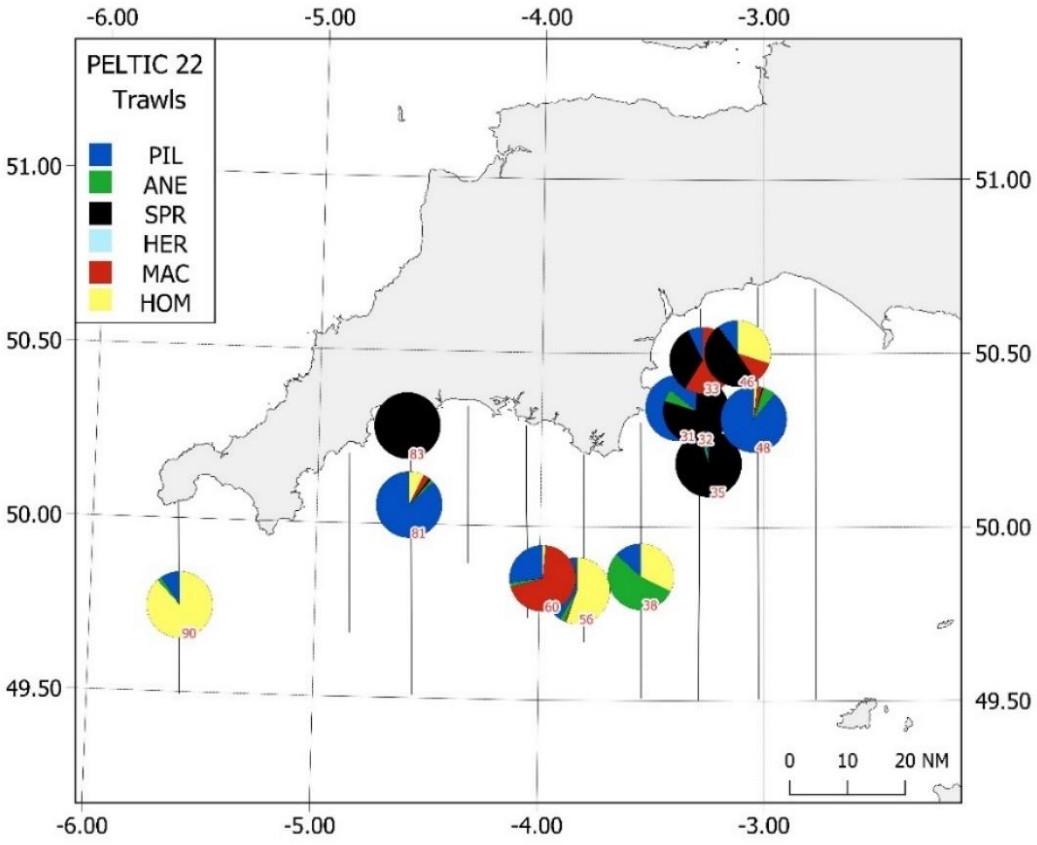

Figure 2. Overview map of the adjusted PELTIC22 survey area. Acoustic transects (black lines) and Trawl stations (pies) with relative catch composition by key species. Three letter codes: PIL=sardine, ANE=anchovy, SPR=sprat, HER=herring, MAC=mackerel, HOM= horse mackerel.

General patterns of fish distribution in the western Channel were similar to those observed for the time series. Due to the reduced survey time, French waters of the western Channel, the Isles of Scilly, Bristol Channel and Cardigan Bay could not be surveyed. The latter was rescheduled to a separate, dedicated 5-day survey in Cardigan Bay in March 2023. 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*	1317	158
Sardine	*Sardina pilchardus*	2567	381
European anchovy	*Engraulis encrasicolus*	1227	177
Horse mackerel	*Trachurus trachurus*	714	102
European mackerel	*Scomber scombrus*	609	71
Herring	*Clupea harengus*	59	28
Blue whiting	*Micromesistius poutassou*	NA	NA

Sprat *Sprattus sprattus* biomass in the western Channel was estimated at 28,439 t (CV 0.28) which was comparable to the area's long term average biomass observed since 2017 (Fig. 3). The only exception to this trend was the very high biomass in 2021 which was driven by a strong recruitment pulse (0-group). While 0 group were the dominant age group found in 2022, high numbers of age 1 sprat suggested the 2021 cohort was still present (Fig. 4). Highest densities were found in Lyme Bay although high numbers were also found in coastal waters further west (Fig. 5). Weather conditions were fresh throughout the survey. Several observations of birds feeding on what appears to be small sprat at the surface suggested that a component of the fish biomass occurred in the acoustic blindzone.

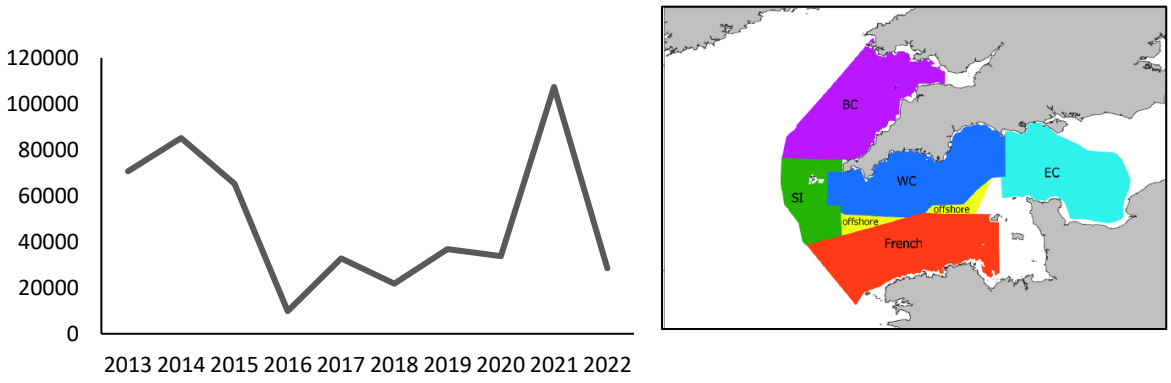

Figure 3. Sprat biomass trend (left) for the consistently sampled stratum in the western Channel: WC (blue) in map of strata (right).

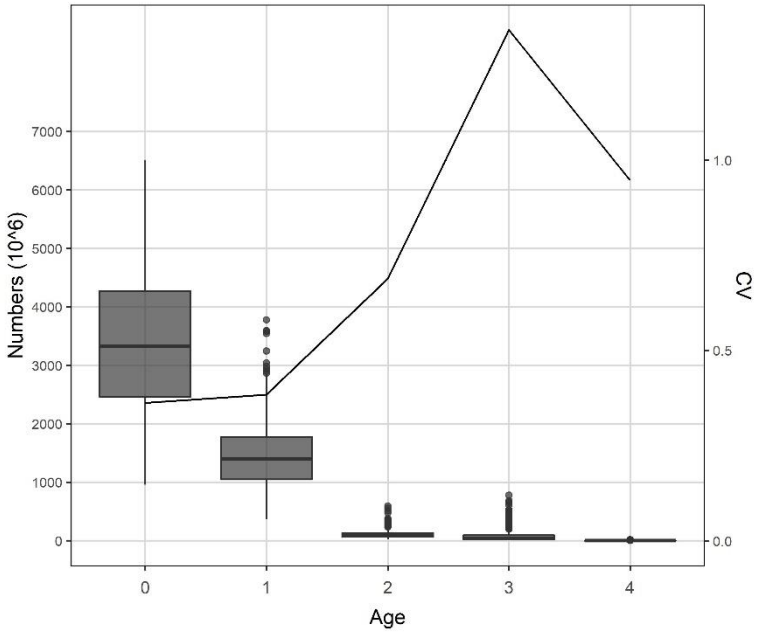

Figure 4. Sprat numbers at age (boxplots, primary y-axis) and CV (line, secondary y-axis) in the consistently sampled western Channel stratum (see Fig 3).

Sprat size distribution was centred around 8 cm total length (L_T) although larger specimens were encountered (Fig 5).

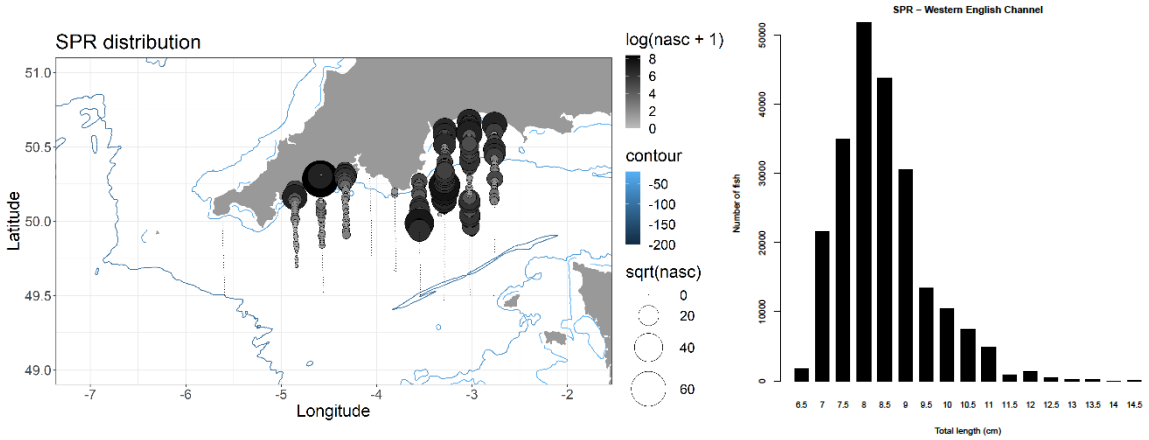

Figure 5. Relative acoustic sprat density distribution (Nautical Area Backscattering Coefficent - NASC, left) and trawl-based length frequency histogram for sprat in the subareas of the PELTIC survey (right).

Sardine *Sardina pilchardus* was again the most abundant small pelagic fish species with a biomass of 175,896 t (CV 0.26) estimated for the survey area (Fig 6). This represents a likely increase of the population given that only 30% of the total areas and 50% of the core area was surveyed.

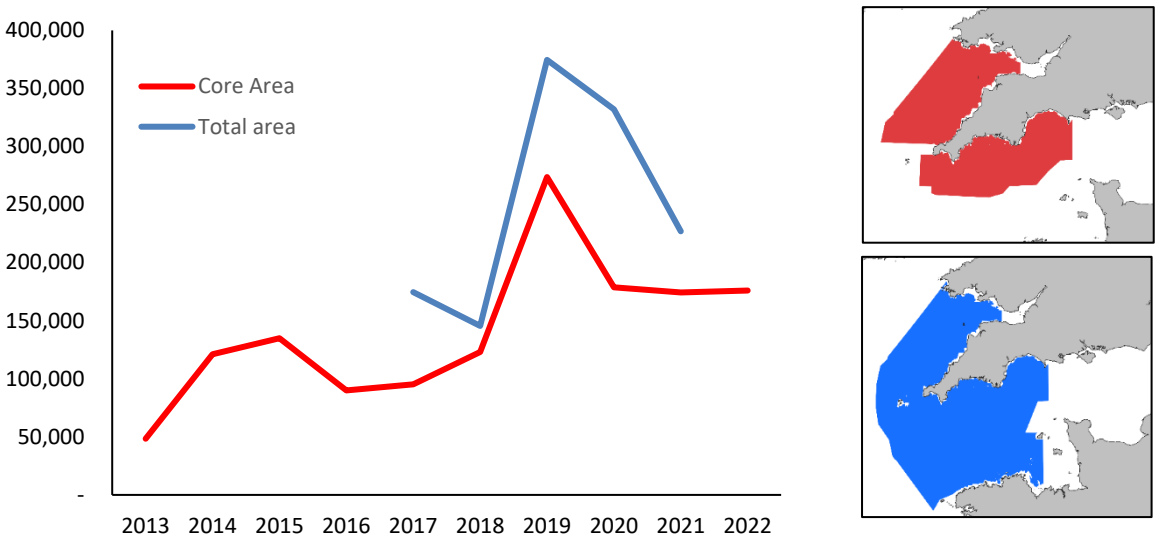

Figure 6. Sardine biomass (tonnes) trends (left) based on two available survey strata: the core area, consisting of the English waters of the western Channel and the Bristol Channel, surveyed consistently from 2013 (top right, red) and the total area, which also includes the Isles of Scilly and French waters of the western Channel, surveyed from 2017 (bottom right, blue). **Please note that the 2022 biomass is representative of only the western Channel stratum and therefore represents a smaller area than the red core area indicated in the map.**

Highest densities were found from the Eddystone to Mounts Bay with modal length of 14 cm L_T most dominant (Fig 7).

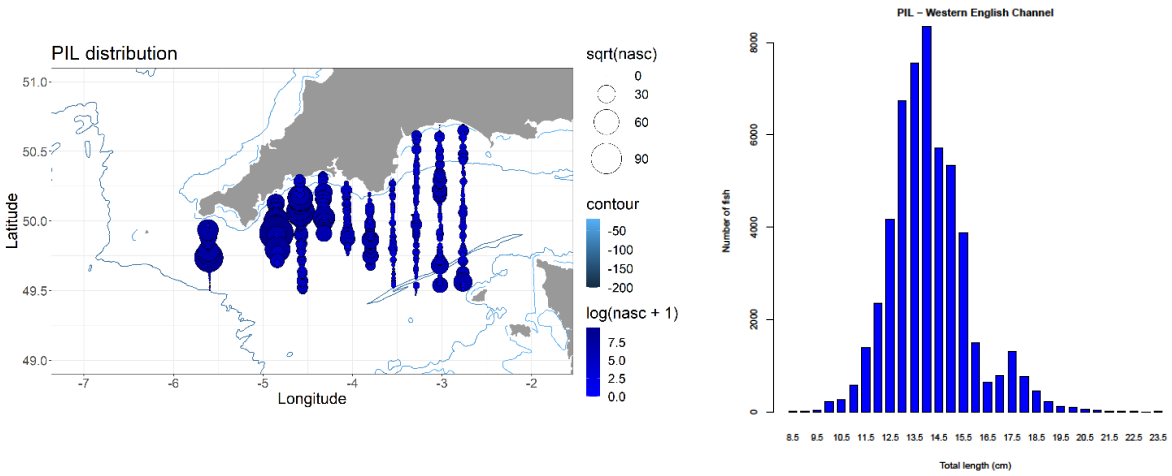

Figure 7. Relative acoustic sardine density distribution of sardine (Nautical Area Backscattering Coefficient - NASC, left), and trawl-based length frequency histogram for sardine in the subareas of the PELTIC survey (right).

The sardine e population was dominated by age 0 fish with a notable age 2 cohort also visible (Fig 8).

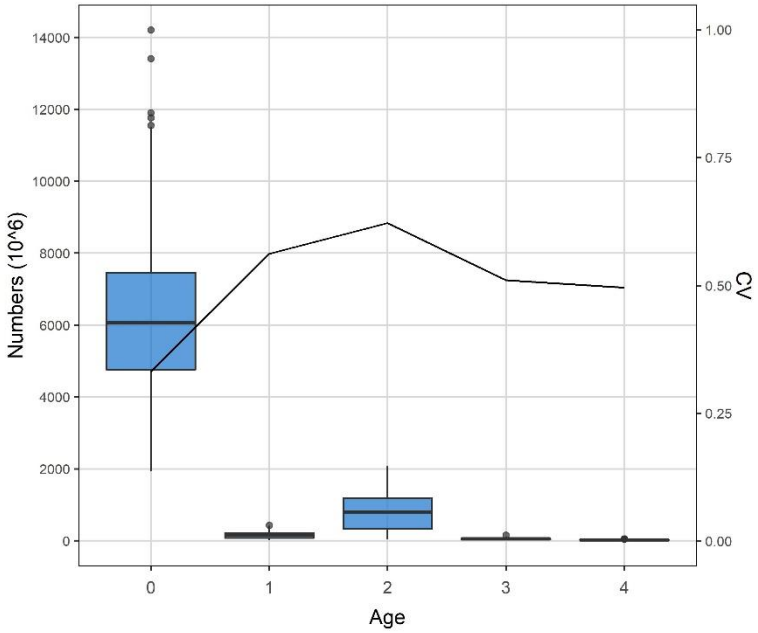

Figure 8. Sardine numbers at age (boxplots, primary y-axis) and CV (line, secondary y-axis) in the consistently sampled total area. Note that this graph excludes the 9,8 billion juvenile sardine recorded in French surface waters.

Northern **Anchovy *Engraulis encrasicolus*** biomass was low at 8,370 t although only small component of the total or core area were sampled.

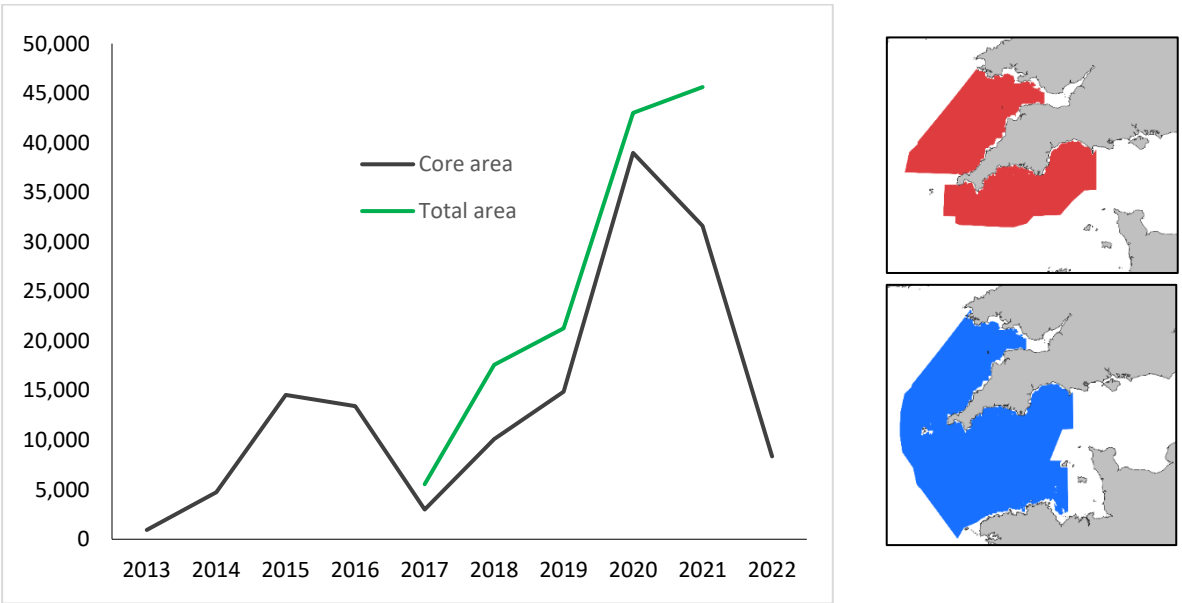

Figure 9. Anchovy biomass (tonnes) trends (left) based on two available survey strata: the core area, consisting of the English waters of the western Channel and the Bristol Channel, surveyed consistently from 2013 (top right, red) and the total area, which also includes the Isles of Scilly and French waters of the western Channel, surveyed from 2017 (bottom right, blue). **Please 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.**

Anchovy was mainly distributed in the offshore waters off Lyme Bay in the east of the survey and were comprised of fish with modal length of 12.5 cm L_T (Fig 10).

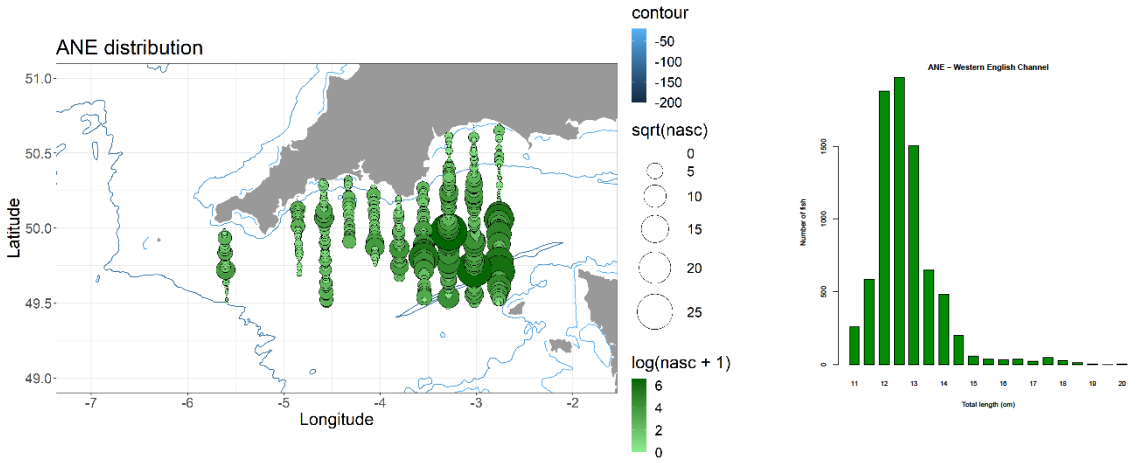

Figure 10. Relative acoustic anchovy density distribution for the northern population (NASC, left), and trawl-based length frequency histogram for anchovy in the subareas of the PELTIC survey (right).

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.

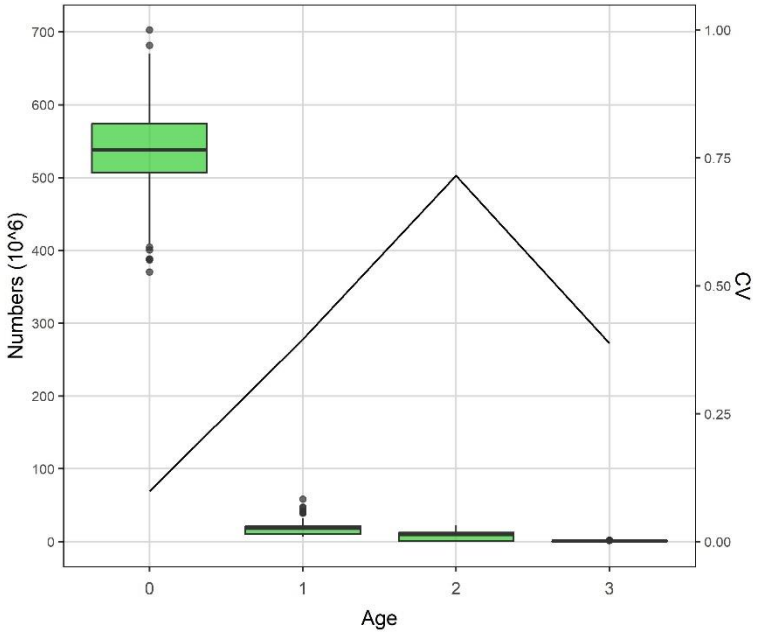

Figure 11. Anchovy numbers at age (boxplots, primary y-axis) and CV (line, secondary y-axis) in the reduced survey area.

Other pelagic fish species (no biomass estimates available at the time of reporting): **Mackerel *Scomber scombrus*** was widespread in the area. No biomass estimate could be calculated due to a continuation of the noise issue with the 200 kHz which is the reference frequency used to calculate the biomass. Length frequency of mackerel suggested all fish sampled were age 0 (Fig 12). **Horse mackerel *Trachurus trachurus*** was 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 10 cm, age 0 (Fig 12). A small number of **Herring *Clupea harengus*** were again found mixed in among the sprat schools,

primarily in Lyme Bay. In addition to the juvenile fish with modal length of 10 cm, a few larger herring were caught (Fig 12).

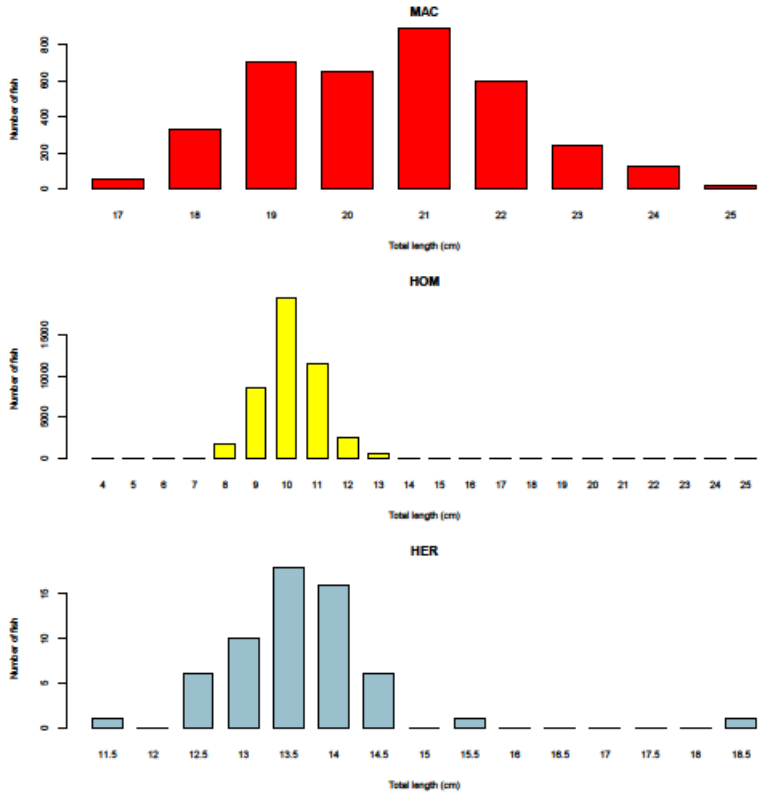

Figure 12. Length frequency histograms for mackerel (MAC), horse mackerel (HOM) and herring (HER), derived from the PELTIC22 trawl catches. Note that these have not been raised by acoustic densities.

Plankton and Oceanography

Mesozoo- and ichthyoplankton samples were collected at 26 stations with ring nets with mesh size of 80 µm and 270 µm, respectively (Table 3). Two stations could not be completed due to time constraints and invalid sample respectively (prime stations 30 and 100), and three stations (prime stations 14, 26, 99) were repeated because of issues. Mesozooplankton samples were stored on 4% buffered formaldehyde for zooscan processing post-survey. All results will be stored on the ZooTaxa database. All but two Ichthyoplankton stations were processed aboard with all eggs and larvae staged and measured respectively. Sardine eggs and larvae dominated the ichthyofauna although numbers were lower than previous years. The location of highest densities of sardine eggs corresponded well with the distribution of the main acoustic sardine backscatter suggesting typical main spawning grounds in the Eddystone Bay (Fig 13). As expected, sardine larvae were more widespread in the survey area although they were absent from the offshore stations.

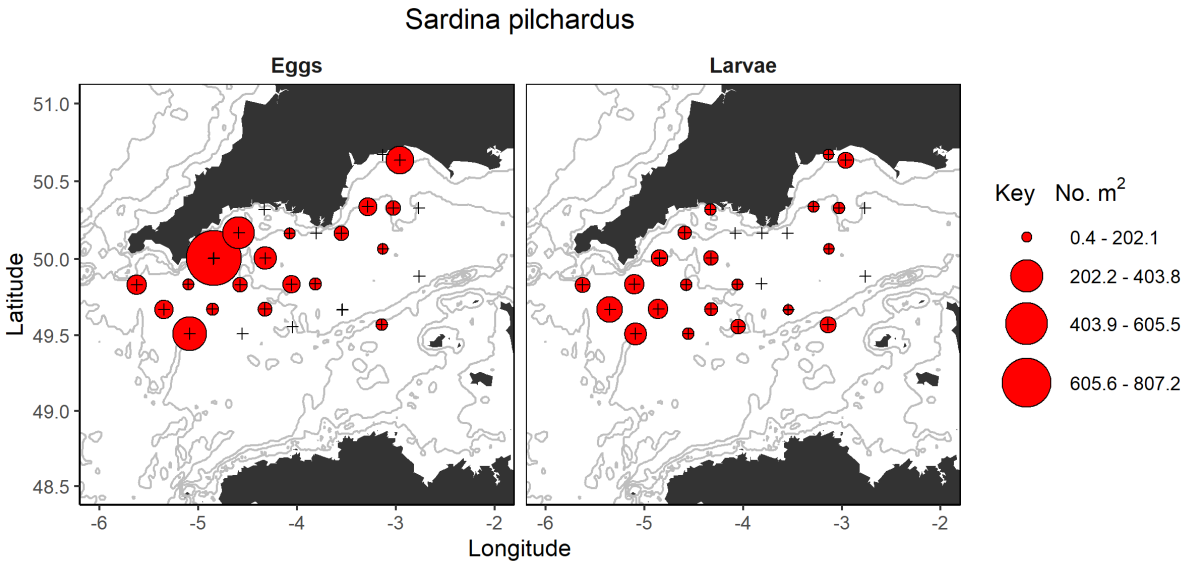

Figure 13 . Distribution of sardine eggs (left) and larvae (right) at the sampling stations derived from samples collected with the 270 µm ring net and analysed on board.

Oceanography

Vertical profiles of temperature and salinity of the water column were carried out at 26 plankton stations using a SAIV mini CTD, although no profile is available at prime station 100 due to failure during the deployment caused by the plankton nets get entangled. Prime station 30 was dropped because not enough time was left before going into Falmouth at the end of the survey. At a subset of 10 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).

Subsurface (4 m) conditions were continuously monitored by the FerryBox, which recorded temperature, salinity, fluorescence, turbidity, and oxygen (Figure 14). The Plankton Analyser was not available this year due to uses with the instruments and associated softwares.

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. Duplicate inorganic nutrient samples were collected at all stations, to allow comparison between two different sample preservation methods (freezing vs. mercuric chloride). Chlorophyll and pigments samples were stored at -80 °C for subsequent HPLC (High Performance Liquid Chromatography) analysis at 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 by Plymouth Marine Laboratory. Samples for dissolved oxygen, salinity and chlorophyll-a were collected to calibrate sensors on the FerryBox and on the SeaBird profiler.

Table 3. Number of samples collected and number of profiles carried out during PELTIC 22.

	Total
Salinity	23
Dissolved oxygen (triplicates)	9
Chlorophyll/Pigments analysis (HPLC - duplicates)	11
Inorganic nutrients (2 methods)	11
Phytoplankton	11
Microzooplankton	11
Mesozooplankton (80 µm)	26
Mesozooplankton (270 µm)	26
eDNA samples	8
CTD profiles with Rosette	11
CTD profiles with SAIV MiniCTD	26

Sea surface temperature was highest in the eastern part of the western Channel (Figure 14). Maximum temperature recorded by the FerryBox at the subsurface 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 thermally 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.

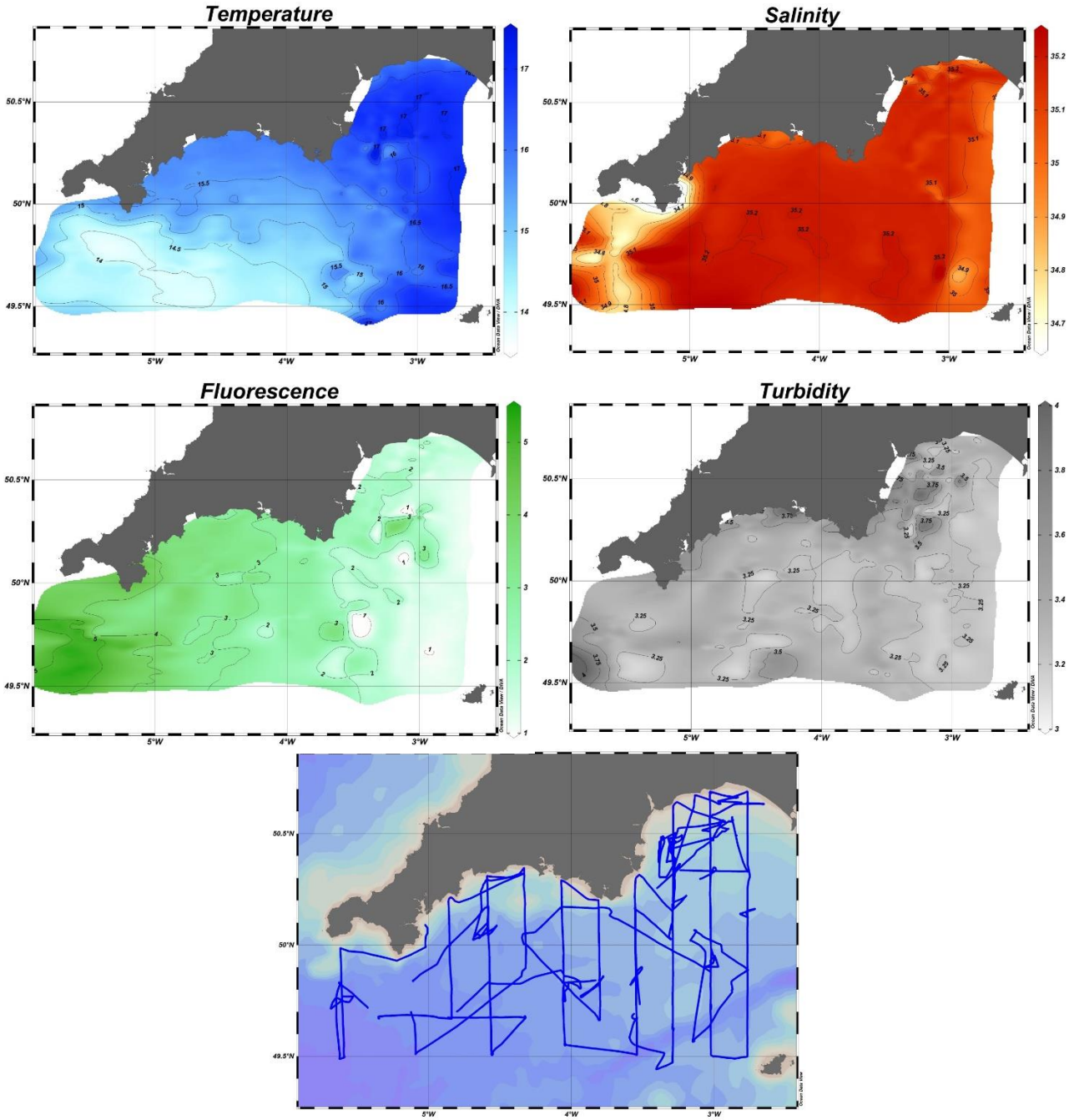

Figure 14. Sea surface temperature, salinity, chlorophyll fluorescence, and turbidity measurements (at 4 m depth) from the FerryBox underway system (track shown bottom), between 17/10 and 28/10/2022.

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

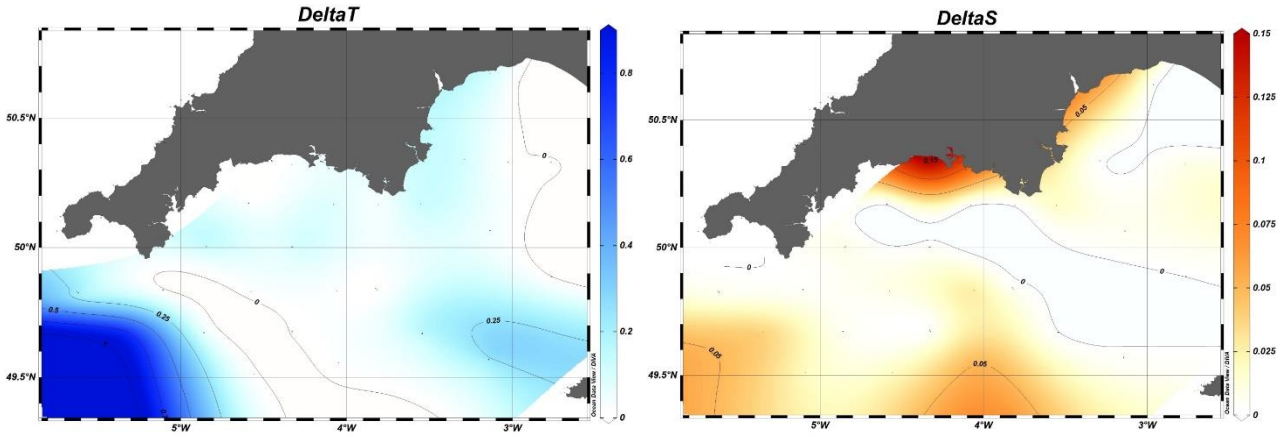

Figure 15**.** Delta_T (°C), difference in temperature between surface and bottom (left) and Delta_S, difference in salinity between surface and bottom (right) as recorded by the SAIV MiniCTD at the 23 sampling stations. The isotherm of Delta_T = 0.5 °C distinguish between mixed (Delta_T < 0.5 °C) and stratified waters (Delta_T > 0.5 °C).

Surface distribution of chlorophyll was estimated by fluorometer on the FerryBox. Fluorescence values (proxy for chlorophyll-a) were highest in the south-western part of the study area off the Cornish peninsula (Figure 14). This coincided with the easterly edge of the 0.5 °C isotherm, perhaps indicative of enhanced productivity in the frontal area between mixed and stratified waters. Images of surface chlorophyll distribution from satellite remote sensing (Figure 16) confirmed the presence of a bloom in the offshore area south of the Cornish peninsula.

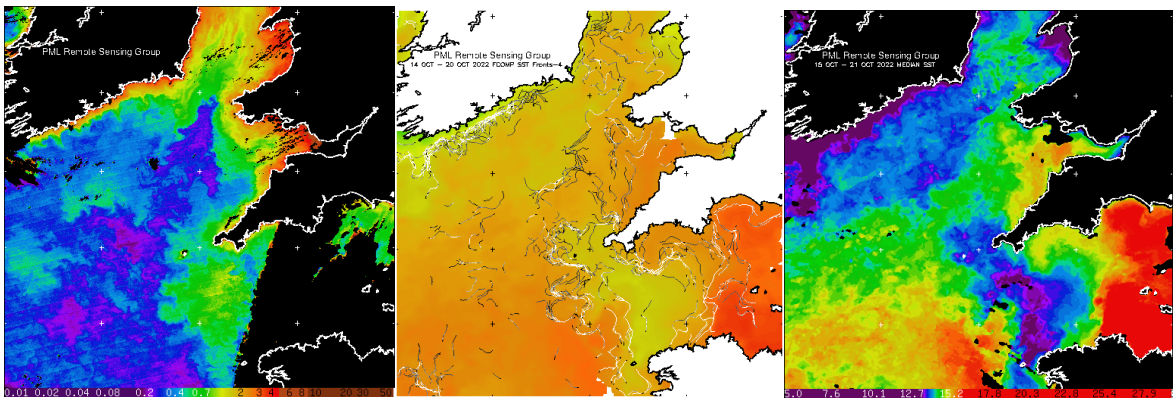

Figure 16 From left to right, satellite derived surface chlorophyll distribution (OC4ME algorithm), position of frontal areas and Surface temperature between 14-21st October 2022, from https://data.neodaas.ac.uk/).

Observer data: apex predators

For the tenth year running, two volunteer MARINElife surveyors were stationed on the bridge in a central position and employed an effort-based 300m box methodology for recording birds (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 2022 both surveyors recorded cetaceans and seabirds.

As mentioned, survey effort was restricted to 12 days from 17-28 October, sampling 882km of 10 transects (compared to 4,039 km in 2021). Given the restricted coverage this year direct comparisons with the complete surveys from previous years is not possible. Therefore, data for the same transects from the 2020 and 2021 surveys were extracted to provide some comparison (Table 5 and sightings Tables 6 and 7). Differences in transect lengths between the years was due to slight adaptation of the traditional Lyme Bay transect design in 2022.

Adverse conditions (mean sea state of 5.1) were similar to 2020 and contrasted the light winds experienced in 2021. This will have compromised observations of distant cetaceans or auks sat on the water. The wind direction was between east and southwest for the entire period, with no northerly component, which may well have had an influence on some of the bird sightings, encouraging some species (such as Great Shearwater) to loiter in the area.

Table 5: Survey effort and sea state conditions from 2020-2022 by MARINElife team on the PELTIC Survey. *For 2020 and 2021 data were extracted for subset of area surveyed in 2022.

	2022	**2021**	**2020**
Transect length (km)	882	819	851
No. survey days	10	10	11
Mean sea state	5.1	3.1	4.6
Modal sea state (% of total)	5	3	5
% Effort sea state 4 or less	39	78	46
Modal wind direction (% of effort)	SW (31)	SW (28)	NW 22)

A total of 1972 sightings of 9704 birds involving 28 species were recorded on effort (Table 6), with a further number of interesting observations off-effort (Table 7).

Table 6: List of all bird species recorded on effort during Peltic survey 2022

Species	Scientific Name	No of sightings	No of birds
Common Scoter	*Melanitta nigra*	1	2
Common Snipe	*Gallinago gallinago*	1	3
Kittiwake	*Rissa tridactyla*	249	1250
Black-headed Gull	*Chroicocephalus ridibundus*	1	1
Little Gull	*Hydrocoloeus minutus*	2	2
Mediterranean Gull	*Larus melanocephalus*	12	13
Common Gull	*Larus canus*	9	10
Great Black-backed Gull	*Larus marinus*	69	81
Herring Gull	*Larus argentatus*	50	75
Lesser Black-backed Gull	*Larus fuscus*	60	82
Larus sp.	*Larus sp.*	18	171
Great Skua	*Stercorarius skua*	25	34
Pomarine Skua	*Stercorarius pomarinus*	1	1
Arctic Skua	*Stercorarius parasiticus*	10	14
Skua sp.	*Stercorarius sp.*	1	1
Guillemot	*Uria aalge*	230	548
Razorbill	*Alca torda*	120	439
Puffin	*Fratercula arctica*	3	4
Auk sp.		177	869
Great Northern Diver	*Gavia immer*	1	1
European Storm Petrel	*Hydrobates pelagicus*	39	304
Fulmar	*Fulmarus glacialis*	5	11
Sooty Shearwater	*Ardenna griseus*	6	7
Great Shearwater	*Ardenna gravis*	171	1169
Manx Shearwater	*Puffinus puffinus*	12	19
Gannet	*Morus bassanus*	660	4504
Shag	*Phalacrocorax aristotelis*	3	5
Grey Heron	*Ardea cinerea*	1	1
Long-eared Owl	*Asio otus*	1	1
Starling	*Sturnus vulgaris*	1	8
Fieldfare	*Turdus pilaris*	1	1
Blackbird	*Turdus merula*	1	1
Pied Wagtail	*Motacilla alba yarrellii*	6	10
Meadow Pipit	*Anthus pratensis*	17	46
Chaffinch	*Fringilla coelebs*	1	1
Goldfinch	*Carduelis carduelis*	1	6
Total		**1972**	**9704**

The standout species for this year was great shearwater *Ardenna gravis*, with 1169 birds logged, compared with none in 2021. The autumn of 2022 had seen large numbers in the southwest of the UK during September and October, with regular sightings of hundreds in the Channel south of Devon and Cornwall and at least two days with several thousand passing the Isles of Scilly. In the past, peak numbers are more often in August-September, so to see large numbers into the latter half of October is unusual. Birds were seen daily from the first day during sonar calibration offshore in Lyme Bay, through to the last day when good numbers were seen just outside Falmouth. A feeding flock of *c.*500, along with *c.*3500 gannets *Morus bassanus* (pink circle in Figure 18) was a spectacular sight. Sightings were

most often of birds quartering the sea in search of food rather than any definite movement – as might be expected given how long birds have been present.

The total gannet observations of 4504 birds seems healthy but is largely accounted for by the feeding flock mentioned above. It was striking that the flock consisted almost entirely of second and third calendar year birds, with few adults. The other surprising feature of this flock was that all the birds were feeding from the surface; none were diving. A small feeding group photographed later revealed a gannet able to scoop several small sprat fry up in one beakful (Figure 17) and this is presumably what was happening with the big flock.

Figure 17: Surface feeding seabirds including gannet with a beakful of small fish (© Pete Howlett)

Table 7: List of bird species recorded off-effort either at sea or onboard CEFAS Endeavour in 2022

Species	Scientific name	No of birds
Pomarine Skua	*Stercorarius pomarinus*	2
Long-tailed Skua	*Stercorarius longicaudus*	1
Sandwich Tern	*Thalasseus sandvicensis*	1
Balearic Shearwater	*Puffinus mauretanicus*	2
Merlin	*Falco colombarius*	1
Skylark	*Alauda arvensis*	8
Blackcap	*Sylvia atricapilla*	2
Robin	*Erithacus rubecula*	1
Black Redstart	*Phoenicurus ochruros*	2
Chaffinch	*Fringilla coelebs*	6

Outside of this flock just over 1000 Gannet were logged, less than half that recorded in the previous two years in the same area. This is likely to be due to reported impact of bird flu (Highly Pathogenic Avian Influenza, HPAI) on gannet populations over the summer. During the survey, a large number of gannet were seen with dark eyes, a result of haemorrhaging, which appears to lead to eventual blindness and death, suggesting the disease is still rife in the population.

Scavengers such as great skua *Stercorarius skua* are also known to have been severely affected by bird flu and the downward trend in this species' numbers is of concern. There have also been reports on bird flu impacting gulls and all three of the regularly recorded large gull species were seen in very low numbers during this year's survey. Perhaps most striking were the 81 great black-backed gull *Larus marinus* recorded cf. 540 in 2020 and 75 herring gull *Larus argentatus* cf. 347 in 2022. Lesser black-backed gull *Larus fuscus* numbers were also very low but that could be because this species is migratory. Three colour-ringed birds were photographed this autumn: two adult great black-backed and one first winter lesser black-backed gull. One of the great black-backed gulls, also carrying a satellite transmitter, had been ringed as a chick at Le Havre port in 2014 and seen regularly around the Channel Islands and the south coast since. The other was ringed on Looe Island, Cornwall in 2014 and has spent the last eight years in the vicinity. The lesser black-backed gull had been ringed at a colony in southwest Norway in July and had travelled 1044km in 102 days.

Another notable observation was the large numbers of kittiwake *Rissa tridactyla*, with nearly four times more birds seen this year than in 2021 or 2020. A possible reason is food availability, particularly the apparent shallow distribution of forage fish which would have aided surface feeding birds. Two sizeable feeding flocks were recorded, one of 600, the other 110 and several other very large, distant, feeding flocks of hundreds of birds, beyond our one-kilometre recording range, were seen in Lyme Bay and Falmouth Bay. The possible abundance of food may have also been the reason for the substantial numbers of auks observed, with guillemot *Uria aalge* numbers twice that seen in the previous two years and Razorbill numbers similar to the record seen last year. The 304 European storm petrel *Hydrobates pelagicus* recorded is the second highest total since the 1265 in 2017, remarkable given the short time spent on survey. The birds were concentrated in a relatively small area mid-Channel on the first transect and included a flock of c.100 birds sat on the water.

As Europe's most endangered seabird, Balearic shearwater *Puffinus mauretanicus* 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. No Balearic shearwaters were recorded on effort although two birds were recorded off-transect in Lyme Bay on the first day whilst the sonar system was being calibrated.

Cetaceans

A total of 44 cetacean encounters were made, totalling approximately 728 animals of three species (Table 8). Common dolphin *Delphinus delphis* was the most frequently recorded species, with 41 sightings of 728 animals, 400 of those in one pod seen travelling east in mid-Channel. The only other notable pod was a feeding group of approximately 70 animals seen south of Start Point, Devon. The rest of the sightings were of 1-17 animals dotted around the transects. There were two sightings of three fin whales *Balaenoptera physalus* on the last day south of Land's End. The only other cetacean sighting was two possible bottlenose dolphins *Tursiops truncatus* close in shore at the end of transect 30.

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*	2	3
Common Bottlenose Dolphin	*Tursiops truncatus*	1	2
Common Dolphin	*Delphinus delphis*	41	723
Total		**44**	**728**

This autumn was poor for the variety of cetaceans, especially when compared to 2021 and 2020 (Table 6). As previously mentioned, weather conditions were not conducive to spotting the more secretive species such as bottlenose dolphin and Risso's dolphin, let alone the diminutive harbour porpoise. However, more common dolphin were recorded this autumn than in 2020, perhaps indicative that feeding conditions were also good for cetaceans. The fin whales were also seen near an area where a large plankton bloom had been observed.

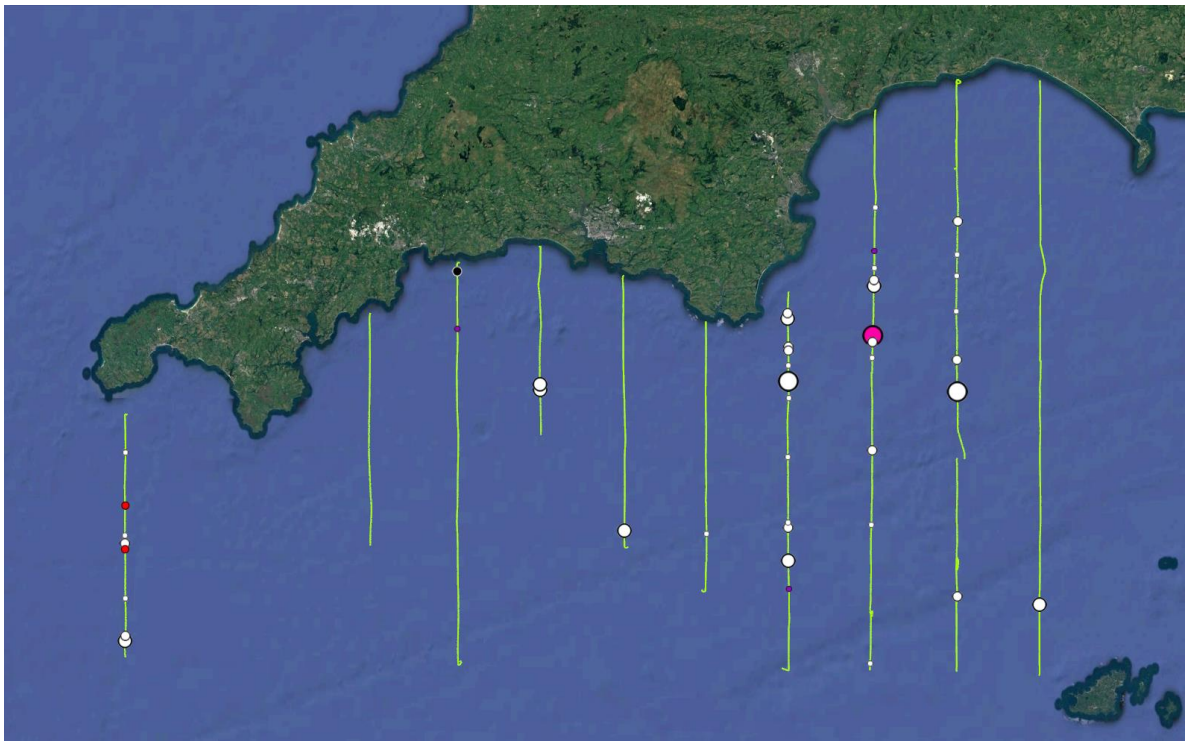

Figure 18: Distribution of cetacean and tuna sightings in 2022, scaled to abundance. Abundance categories (small to large circles): 1-5, 6-10, 11-20, 20+. Yellow lines mark survey effort. Red circles are fin whale, black possible bottlenose dolphin, white common dolphin, and purple presumed Atlantic bluefin tuna. The pink circle marks the location of the large feeding flock of seabirds.

Bluefin tuna

Just three tuna and one probably tuna were recorded in three encounters on the survey transects (Fig 16), which is significantly lower than in previous years (Table 9). Sea conditions are likely to be main cause for reduced number of observation. 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

Table 9: Comparison of cetacean and large fish recorded 2020-22

	2020		2021		2022	
Species	**No**	**Encounters**	**No**	**Encounters**	**No**	**Encounters**
Fin whale			1	1	3	2
Minke whale			3	3		
Long-finned pilot whale			8	1		
Risso's dolphin	8	1	6	2		
White-beaked dolphin	6	1				
Bottlenose dolphin	8	1	17	3	2 (poss.)	1
Common dolphin	253	38	1207	86	723	41
Harbour porpoise	5	2	12	7		
Unidentified dolphin sp.			58	7		
Tuna sp.	44	19	81	20	4	3
Basking shark			3	3		

Summary

The 2022 PELTIC survey was severely impacted by a range of issues, most significantly engine failure, which reduced available survey time from 35 to 13 days. Coverage was reduced to less than 30% of the originally planned area and the English waters of the western Channel were prioritised as this would minimise impact on the two stock assessments (sprat in 7.d.e and sardine in 7). Even when the vessel was operational, fishing activities were compromised, particularly during the early part of the survey. The catches provided good quality biological data and sufficient information on the species composition of the acoustic backscatter.

Sprat biomass in the core survey area used for the assessment was 28,439 t which was a significant reduction from the exception 2021 value but more in line with the average biomass since 2017. Another recruitment pulse was observed in the data. 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 biomass for the reduced survey area was 175,896 t. While this represented only a subsection of the area considered in the assessment, it included wat is historically one of the most important areas. Biomass in 2020 and 2021 for the same area as surveyed this year were lower (157,799 and 124,433 t respectively) than in 2022 which would suggest an increase in the population size if the wider distribution was the same. Anchovy biomass was significantly lower than in previous years, but this was likely due to the reduced coverage and absence of data from areas where anchovy has been found in higher densities (Bristol Channel and west of Cornwall).

Very few Atlantic bluefin tuna were observed although the adverse weather conditions will have affected the ability to detect them. Due to reduced survey time, the planned extension into Cardigan Bay was postponed until March 2023.

Jeroen van der Kooij, Fabio Campanella and Joana Silva
Scientists in Charge
01/03/2023

Acknowledgement: This report was compiled by JvdK with contributions from FC, JS and PH. We would like to thank all scientists, the officers and crew of the RV Cefas Endeavour for their help, support, advice, skill and cooperation, which were critical to the completion of the survey.

DISTRIBUTION:
Survey participants
I Holmes (PI)
P Falconer (PL)
D Pettengell (PM)
Cefas Fisheries Survey SICs/2ICs
G Burt (CDP)
C O'Brien
R Nash
D Evans (AW)
B Salter (AW)
Master and skipper (*RV* Cefas Endeavour)
T Brereton (MarineLife)
C O'Donnell (Marine Institute)
G Boyra (AZTI)
I Glasgow (Defra)
M Hackett (Defra)
B Badger (Defra)
R Caslake (Seafish)
Marine Management Organisation (MMO)
Southern, Devon & Severn, Cornwall, Isle of Scilly IFCAs

Annex 1

Objective 10: Genetic samples herring: to bag and freeze herring from different parts of the survey area (D. Clarke, Swansea University). Note: Survey stratum WEC corresponds to western English Channel.

Trawl station	Survey stratum	Species code	Scientific name	Number
32	WEC	HER	*Clupea harengus*	Not specified
33	WEC	HER	*Clupea harengus*	Not specified
35	WEC	HER	*Clupea harengus*	Not specified
			Total	28

Objective 11: To collect between 15-20 (similar sized) specimens per species (anchovy, boarfish, herring, horse mackerel, mackerel, sardine) and freeze (Debbie Walsh, NMBAQC). Note: Survey stratum WEC corresponds to western English Channel.

Trawl station	Survey stratum (label in bag)	Species code	Scientific name	Number
32	WEC	ANE	*Engraulis encrasicolus*	20
		PIL	*Sardine pilchardus*	20
33	WEC	MAC	*Scomber scombrus*	18
38	WEC	HOM	*Trachurus trachurus*	20

Objective 12: 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). Note: Survey stratum WEC corresponds to western English Channel.

Trawl station	Survey stratum	Species code	Scientific name	Number
33	WEC	PIL	*Sardina pilchardus*	25-50
35	WEC	ANE	*Engraulis encrasicolus*	25-50
46	WEC	MAC	*Scomber scombrus*	25-50

Objective 15: To collect 100 specimens of anchovy for a study on growth (F Martinho, University of Coimbra, Portugal). Note: Survey stratum WEC corresponds to western English Channel.

Trawl station	Survey stratum	Species code	Scientific name	Number
35	WEC	ANE	*Engraulis encrasicolus*	25 (small)
38	WEC	ANE	*Engraulis encrasicolus*	25 (small)
56	WEC	ANE	*Engraulis encrasicolus*	25 (small)
81	WEC	ANE	*Engraulis encrasicolus*	25 (large)
90	WEC	ANE	*Engraulis encrasicolus*	25 (small)

Objective 16: To collect samples of sprat (including fill biological parameters) for a study on population genetics (D Murray). Note: Survey stratum WEC corresponds to western English Channel.

Trawl station	Survey stratum	Species code	Scientific name	Number
46	WEC	SPR	*Sprattus sprattus*	30