

**CENTRE FOR ENVIRONMENT, FISHERIES
AND AQUACULTURE SCIENCE**

LOWESTOFT LABORATORY, LOWESTOFT, SUFFOLK NR33 0HT

2018 RESEARCH VESSEL PROGRAMME

REPORT: RV CEFAS ENDEAVOUR: SURVEY CEND 15/18

STAFF:

Part A

(August 10-23)

B Hatton (SIC)
R Humphreys (2IC)
M Eade
L Aislabie
P White
R Beckett
N Hampton

Part B

(August 24 – September 10)

B Hatton (SIC)
L Cox (2IC)
R Humphreys
L Aislabie
K Duggan
G Burt
G Robson

Plus:

(August 10-23)

T Hull
E Fitton
M Bristow (University of East Anglia)
T Ehmen (University of Exeter)

DURATION: August 10 – September 10

LOCATION: North Sea (ICES divisions IVa, b and c)

PRIMARY AIMS:

1. To carry out a groundfish survey of the North Sea (Figure 1) as part of the ICES coordinated IBTS, using a hybrid GOV trawl in order to obtain information on:
 - a) Distribution, size composition and abundance of all fish species caught.
 - b) Age – length distribution of selected species.
 - c) Distribution of fish in relation to their environment.
 - d) Distribution of macrobenthos and anthropogenic debris.
 - e) Surface and bottom temperature and salinity data using ESM2 profiler/mini-CTD logger and Niskin Bottle.
 - f) Length weight & maturity information using individual fish measurements, in support of the EU Data Regulation.

2. To carry out additional 'zero-minute' and associated 15-minute tows to investigate the potential catch during deployment and retrieval of hauls that may fall outside tow duration.
3. Collect surface sea water samples for Caesium/Tritium testing to be performed post-survey.
4. Retrieval of three unmanned underwater vehicles, deployment of a wave glider and zooplankton ring net sampling as part of the Alter-Eco project.

SECONDARY AIMS:

5. Tag and release specimens of starry smooth-hound (*Mustelus asterias*), greater-spotted dogfish (*Scyliorhinus stellaris*), spurdog (*Squalus acanthias*), tope (*Galeorhinus galeus*), common skate (*Dipturus batis*) species-complex, and blonde ray (*Raja brachyura*), in support of the ICES Working Group for Elasmobranch Fishes work to inform on stock units for demersal elasmobranchs.
6. To freeze any unusual fish species for subsequent identification / verification in the laboratory, including specimens of eelpout (*Zoarces*, *Lycodes* and *Lycenchelys*), sea scorpions (Cottidae, sub-area IVa only), and any unusual fish species, which may also be used in otolith research.
7. To retain any dead specimens of tope and common skate for biological studies.
8. Retain any dead specimens of shad (*Alosa spp.*) and lamprey (*Lampetra fluviatilis*) for biological studies.
9. Collect fisheries acoustic continuously data at four operating frequencies (38 kHz, 120 kHz, 200 kHz and 333kHz), using the Simrad EK60 split beam sounder. The data will contribute to the existing 15-year time series of acoustic data in the North Sea.
10. Cetacean observations will be recorded where possible and sent to the Sea Watch Foundation.
11. Identify, count, measure and weight all jellyfish caught in GOV trawl to contribute to and continue the North Sea August jellyfish dataset started in 2012. As the dataset grows from year to year, this should allow the evaluation of temporal changes in jellyfish community and biomass.
12. Collect squid egg samples to map spawning grounds. This could be highly relevant in studying squid stock's structure.
13. To collect biological information from four-bearded rockling (*Enchelyopus cimbrius*). Including length, weight & maturity information.

14. Collect suitable examples of benthic organisms from a select number of prime stations to test for Paralytic Shellfish Poisoning toxins. This is with a view to assessing ongoing presence and geographical extent of PSP following evidence of consumption from an unusual source on the East Anglian coastline.
15. Near sea-bed water samples will be collected using a Niskin at seasonally stratified sites. These data will be used in the assessment of eutrophication under MSFD and OSPAR for which near bed oxygen concentrations are an indicator.
16. Retain any dead specimens of *Loligo spp.* and approximately 25 *Alloteuthis* for maturity and age analysis, respectively.
17. Determine buoyancy periods for deceased sprat (*Sprattus sprattus*) to add to a data set examining bird predation (Cefas, BEEMS).
18. To collect genetic samples from anglerfish (*Lophius piscatorious*) in support of the GECKA project.

RESULTS

Aim 1. A valid 30-minute GOV trawl was completed at all targeted 77 prime stations (Table 1, Figure 7). An additional 13 comparative tows were completed, comprising of four 15-minute and eight “zero-minute” tows, plus one standard tow that was repeated due to gear damage potentially occurring during hauling. Six tows, which were invalidated due to gear damage or problems with the GOV trawl that became apparent upon hauling, were all re-fished successfully. A supplementary 30-minute tow was completed at the request of the Danish Institute of Fisheries Research for a repeat of their own tow in 35F0. This was processed in the same way as a valid English prime station. Surface and bottom salinity samples, along with a vertical cast of the ESM2 logger profiler were completed at 31 of the prime stations (Figure 8), with an additional two ESM2 profiles taken at separate prime stations.

Gear: The survey was fished using GOV hybrid trawl number 1. Electronic net geometry sensors were used to monitor headline height, wing spread and door spread (Figure 8).

Catches: At each station, the catch of each species was weighed and all fish, or representative sub-samples, were measured. Table 2 ranks the top 15 species by weight, compared to that seen over the previous four years, whilst Table 3 lists the species that were weighed and measured/counted across the survey’s prime stations. Table 4 shows the number of fish sampled for otoliths for age determination and other biological information. All data were recorded to computer database using Cefas’ Electronic Data Capture (EDC) system.

Table 1. Details of gear deployments during the survey

Gear	Valid	Additional	Invalid	Total
GOV (IBTS standard gear)	78 ^[1]	12 ^[2]	7	97
Niskin Bottle/ESM2 profiler	31	0	0	31
ESM2 profiler only	0	2 ^[3]	0	2
CTD Rosette	29	0	0	29
Plankton ring net (200µm mesh)	25	0	0	25

^[1] Includes 77 prime stations, plus one additional tow carried out for Denmark

^[2] Tows completed as per primary aim no. 2, plus one standard 30-minute tow

^[3] Additional ESM2 profiles as per Cefas internal request

Figures 9-18 show distribution and relative abundance (raised numbers per hour) of cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*), saithe (*Pollachius virens*), Norway pout (*Trisopterus esmarkii*), herring (*Clupea harengus*), mackerel (*Scomber scombrus*), sprat, plaice (*Pleuronectes platessa*) and hake (*Merluccius merluccius*), respectively.

Table 2. Top 15 species by weight, English IBTS Q3 survey 2014 - 2018

English name	Scientific name	2018 weight (kg)	2017 weight (kg)	2016 weight (kg)	2015 weight (kg)	2014 weight (kg)
Herring	<i>Clupea harengus</i>	10380	24963	34945	17520	8887
Whiting	<i>Merlangius merlangus</i>	3943	2858	2468	3002	2355
Dab	<i>Limanda limanda</i>	3364	3201	3587	3101	3089
Mackerel	<i>Scomber scombrus</i>	2336	2365	3450	3597	3214
Haddock	<i>Melanogrammus aeglefinus</i>	2266	2845	2525	2432	2542
Sprat	<i>Sprattus sprattus</i>	1983	1868	2367	1919	3724
Saithe	<i>Pollachius virens</i>	1907	2563	2349	1497	1189
Horse mackerel	<i>Trachurus trachurus</i>	1635	4395	1905	5613	1115
Grey gurnard	<i>Eutrigla gurnardus</i>	1359	1108	1301	1490	1638
Norway pout	<i>Trisopterus esmarkii</i>	1086	2793	1813	2519	1712
Plaice	<i>Pleuronectes platessa</i>	561	425	506	467	529
Long-rough dab	<i>Hippoglossoides platessoides</i>	395	397	305	172	305
Cod	<i>Gadus morhua</i>	371	723	753	615	501
Hake	<i>Merluccius merluccius</i>	341	718	1084	762	548
Lemon sole	<i>Microstomus kitt</i>	250	326	336	234	222

Table 3. List of fish, cephalopods and commercial shellfish caught during the survey and number of prime stations at which they were recorded.

Species	Common Name	Stns	Species	Common Name	Stns
<i>Aequipecten opercularis</i>	Queen scallop	12	<i>Lumpenus lampretaeformis</i>	Snake blenny	2
<i>Agonus cataphractus</i>	Pogge (Armed bullhead)	15	<i>Lycodes gracilis</i>	Vahl's eelpout	1
<i>Alloteuthis subulata</i>		17	<i>Melanogrammus aeglefinus</i>	Haddock	52
<i>Alosa fallax</i>	Twait shad	1	<i>Merlangius merlangus</i>	Whiting	76
<i>Amblyraja radiata</i>	Starry ray	28	<i>Merluccius merluccius</i>	Hake	30
<i>Ammodytes marinus</i>	Lesser sandeel	2	<i>Microchirus variegates</i>	Thickback sole	4
<i>Anarhichas lupus</i>	Wolf-fish	5	<i>Micromesistius poutassou</i>	Blue whiting	7
<i>Arctica islandica</i>	Ocean quahog	4	<i>Microstomus kitt</i>	Lemon sole	63
Argentinidae	Argentines	34	<i>Molva molva</i>	Common ling	13
<i>Arnoglossus laterna</i>	Scaldfish	21	<i>Mullus surmuletus</i>	Red mullet	8
<i>Aspitrigula cuclus</i>	Red gurnard	6	<i>Mustelus asterius</i>	Starry smooth-hound	3
<i>Belone belone</i>	Garfish	1	<i>Myoxocephalus scorpius</i>	Bullrout	7
<i>Buglossidium luteum</i>	Solonette	1	<i>Myxine glutinosa</i>	Hagfish	7
<i>Callionymus lyra</i>	Common dragonette	24	<i>Necora puber</i>	Velvet swimming crab	6
<i>Callionymus maculatus</i>	Spotted dragonette	35	<i>Nephrops norvegicus</i>	Norway lobster	16
<i>Cancer pagurus</i>	Edible crab	32	Ocopodidae		23
<i>Capros aper</i>	Boarfish	16	<i>Ommastrephes sagittatus</i>	Flying squid	1
<i>Clupea harengus</i>	Herring	62	<i>Pecten maximus</i>	Scallop	12
<i>Dicentrarus labrax</i>	European sea bass	1	<i>Pholis gunnellus</i>	Butterfish	4
<i>Dipturus batis (cf. flossada)</i>	Blue skate	1	<i>Phycis blennoides</i>	Greater forkbeard	1
<i>Dipturus batis (cf. intermedia)</i>	Flapper skate	1	<i>Platichthys flesus</i>	Flounder	4
<i>Enchelyopus cimbrius</i>	Four-bearded rockling	13	<i>Pleuronectes platessa</i>	Plaice	60
<i>Engraulis encrasicolus</i>	European anchovy	1	<i>Pollachius pollachius</i>	pollock	1
<i>Eutrigula gurnardus</i>	Grey gurnard	69	<i>Pollachius virens</i>	Saithe	22
<i>Gadiculus argenteus</i>	Silvery pout	10	<i>Raja brachyura</i>	blonde ray	1
<i>Gadus morhua</i>	Cod	45	<i>Raja clavata</i>	Thornback ray	6
<i>Gaidropsarus vulgaris</i>	Three-bearded rockling	1	<i>Raja montagui</i>	Spotted ray	5
<i>Galeorhinus galeus</i>	Tope	2	<i>Rossia macrostoma</i>		10
<i>Galeus melastomus</i>	Black-mouth dogfish	2	<i>Sardinia pilchardus</i>	Pilchards	5
<i>Glyptocephalus cynoglossus</i>	Witch	22	<i>Scomber scombrus</i>	European mackerel	57
<i>Gobius spp.</i>	Gobies	7	<i>Scophthalmus maximus</i>	Turbot	8
<i>Hippoglossoides platessoides</i>	American plaice (long rough dab)	55	<i>Scophthalmus rhombus</i>	Brill	3
<i>Hippoglossus hippoglossus</i>	Halibut	2	<i>Scylliorhinus canicula</i>	Lesser spotted dogfish	21
<i>Homarus gammarus</i>	Lobster	2	<i>Sebastes viviparus</i>	Redfish	13
<i>Hyperoplus lanceolatus</i>	Greater sandeel	14	Sepiolidae		6
<i>Illex (loligo) coindetii</i>	Northern shortfin squid	28	<i>Solea solea</i>	Dover sole	8
<i>Lampetra fluviatilis</i>	Lamprey	2	<i>Sprattus sprattus</i>	Sprat	22
<i>Lepidorhombus whiffiagonius</i>	Megrim	13	<i>Squalus acanthias</i>	Spurdog	5
<i>Leucoraja naevus</i>	Cuckoo ray	12	<i>Trachinus draco</i>	greater weever	1
<i>Limanda limanda</i>	Dab	66	<i>Trachinus vipera</i>	Lesser weever	14
<i>Liparis montagui</i>	Montague's sea snail	1	<i>Trachurus trachurus</i>	Horse mackerel	42
<i>Lithodes maja</i>	Stone crab	21	<i>Trigla lucerna</i>	Tub gurnard	5
<i>Loligo forbesi</i>	Northern squid	29	<i>Trisopterus esmarkii</i>	Norway pout	37
<i>Loligo vulgaris</i>	European squid	2	<i>Trisopterus luscus</i>	Bib pouting	5
<i>Lophius budegassa</i>	Black-bellied anglerfish	4	<i>Trisopterus minutus</i>	Poor cod	26
<i>Lophius picatorius</i>	Anglerfish (monkfish)	31			

Table 4. Number of biological samples taken by species

Species	Number of samples taken
Plaice	1473
Whiting	1417
Herring	1227
Haddock	1110
Cod	414
Mackerel	414
Hake	319
Norway pout	318
Saithe	306
Lemon Sole	261
Dab	251
Grey Gurnard	236
Four-bearded rockling	122
Anglerfish (monkfish)	73
Witch	52
Ling	36
Red Mullet	12
Red Gurnard	10
Tub gurnard	10
Turbot	9
Brill	6
White-bellied anglerfish	4
Starry smooth-hound	261
Starry ray	148
Spotted ray	110
Thornback ray	105
Cuckoo ray	57
Spurdog	15
Tope	13
Blonde ray	4
Black-mouth dogfish	3
Flapper skate	3
Blue skate	1
Total	8800

Gadiformes

The weight of cod caught on this year's survey was the lowest for five years, being less than half of what was seen in 2017 (Table 2; 371 kg compared to 723 kg). Cod's distribution was also reduced, having been sampled at 57 prime stations in 2017, this year it was only seen on 45 (Table 3). The reduced number of cod sampled during the survey is also reflected in the number of otoliths collected this year, with 414 taken in 2018 (Table 4), compared to 725 last year.

Haddock catch weight was also reduced this year, the lowest since 2015, with 2266 kg caught after a five year high in 2017 of 2845 kg. This is despite little change in their distribution from 2017, seen at only one less station (52) than last year. The largest catches of haddock were seen in the waters east of Scotland, although after seeing a large number of skeletal deformities at prime station 40 in 2017, only two fish were affected in the catch there this year. It was also notable that the gill parasites that had been observed in haddock over the last five years seemed much reduced this year.

Whiting were, once again, the most widely distributed fish species caught on the survey, being present at all but two of the prime stations fished (76 in total). Total catch weight was also up by over 1 t from 2017 (3943 kg, compared to 2858 kg), marking the highest catch weight for whiting in the last five years. Despite this, however, a larger size range was caught in 2017, which is evident by 150 fewer otoliths taken from the larger catch weight (1417 in 2018, compared to 1567 in 2017). Saithe catch weight was reduced from the previous two years (1907 kg, compared to 2563 kg in the 2017 and 2349 kg in 2016), and this was reflected in their distribution; caught at 22 stations this year, compared to 29 station last year. It is worth noting that 1175 kg were caught in just one station, prime station 71, where over 2000 juveniles were estimated, and it noticeable in their abundance plot (Figure 13).

Norway pout's distribution was reduced slightly from 2017, caught on 37 stations compared to 41 last year. However, much less was caught this year, with catch weight down to 1086 kg, the lowest since 2005. Despite this, the number of otoliths collected were similar (371 in 2017 to 318 in 2018). Hake catches were also down, with catch weight in 2018 less than half that caught in 2017 (341 kg, compared to 718 kg). Hake was also caught on seven fewer stations than in 2017; 30, compared to 37 last year.

Pleuronectiformes

This year saw the highest catch weight for plaice in five years with 561 kg caught at 60 stations. This is an increase of 136 kg from the same number of stations in 2017. The larger weight of plaice is also reflected in the number of otoliths collected; 1473, which was the most collected for a single species on the survey. This is the first time in five years that plaice had more otoliths collected than any other species.

After similar survey catch weights in 2016 and 2017 (336 kg and 326 kg, respectively), lemon sole (*Microstomus kitt*) catches were down to 250 kg in 2018. This is despite only a small reduction in distribution across the survey prime stations, having been caught at 60 prime stations in 2018, compared to 63 in 2017.

Dab (*Limanda limanda*) continue to be one of the widest distributed species on the survey, caught on 66 stations, down by two from 2017. Catch weight however, increased slightly, totalling 3364 kg, compared to 3201 kg in 2017. It is noticeable that dab catch weight is one of the most consistent over the previous five years, only varying by just over 500 kg (3089 kg in 2014, compared to 3587 kg in 2016).

Pelagic fish

Compared to previous years, the largest change in catch weight for any species recorded in this year's survey was for herring. Despite being the largest catch weight of a single species again this year, the 10380 kg caught was the lowest since 2014 (8887 kg). Large catches of herring (>1 t), which have typified the species during the previous three years, were much reduced, with only three prime stations producing catches of this size; 33, 54 and 77 (2717 kg, 2296 kg and 1157 kg, respectively). Herring's distribution was also reduced, caught on 62 stations, compared to 65 in 2017. The herring caught at prime station 77 were in a state of spawning (i.e. running; free flowing eggs and milt), which is noteworthy as it's the first time this has been seen in more than just a few individuals on this survey for eleven years.

Sprat was caught on a similar number of stations this year (22), compared to 2017 (23), although catch weight increased slightly from last year (1983 kg, compared to 1868 kg). It is worth pointing out, however, that a large amount of the total sprat catch weight on the survey this year came from just one haul, from prime station 3 off Belgium, where 1318 kg were caught.

Mackerel (*Scomber scombrus*) catch weight this year was similar to that seen in 2017, with 2336 kg caught compared to 2365 kg, but still much reduced from larger catches observed in 2015 and 2016. This is despite a notable decrease in distribution, with mackerel caught on ten less stations in 2018 than in 2017 (57, compared to 67). A similar decrease in distribution was seen with horse mackerel (*Trachurus trachurus*), which were sampled at 42 stations, compared to 53 in 2017. Catch weight was also markedly reduced, with 1635 kg caught, compared 4395 kg in 2017. It is noticeable that catch weight of horse mackerel over the last five years has varied each year, with larger amounts caught in 2015 and 2017 (5613kg and 4395 kg, respectively), and much lower catch weights in the intervening years (1115 kg in 2014, 1905 kg in 2016 and now 1635 kg in 2018).

Elasmobranchs

Elasmobranch catches on the survey this year were nearly double that seen in 2017, with 933 kg caught, compared to ~470 kg last year. This increase can be attributed to large increases in tope (up by 180 kg from 2017), starry smooth-hounds (almost double the 60 kg caught in 2017 at 117 kg) and spotted ray (*Raja montagui*, up from 16 kg in 2017, to 109 kg this year). It is worth noting that almost all the 203 kg of tope caught on this year's survey was from the 12 adult males tagged at the additional station conducted on behalf of Danish Institute of Fisheries Research. As in previous years, lesser-spotted dogfish (*Scyliorhinus canicular*) had the highest catch weight for elasmobranch species on the survey, with 287 kg, an increase of 50 kg from 2017. Of note this year was the blue skate (*Dipturus batis* (cf. *flossada*) caught on prime station 72 and the four adult black-mouth dogfish (*Galeus melastomus*) caught on prime stations 64 and 65.

Cephalopods and commercial shellfish

Squid catch weight for this year's survey were much lower than in 2017. Northern squid (*Loligo forbesi*) catch weight saw a large decrease this year compared to the 110 kg caught last year, with only ~10 kg caught in 2018. It was observed that many of the large adult squid present last year were not seen on the survey this year. The European common squid (*Loligo vulgaris*) also saw a large decrease in catch weight, down from 17 kg in 2017 to only 5.5 kg this year. Northern shortfin squid (*Illex (loligo) coindetii*) also saw a decrease in catch weight compared to 2017, down 8.6 kg to 5.2 kg. Although catch weights are much reduced from 2017, it is worth noting, however, that last year saw a large increase in squid catches and what was sampled this year is closer to previous year's catch weights. This can also be said for the curled octopus (*Eledone cirrhosa*), which saw a large increase between 2016 and 2017 (2.5 kg to 7.5 kg), which was reduced this year to 4.2 kg.

Compared to 2017, the edible crab (*Cancer pagurus*) catch weight this year increased by 34 kg to 111 kg, albeit 64 kg was sampled at just one station; the additional tow requested by the Danish Institute of Fisheries Research. The distribution of this species has also increased, having been caught at 32 prime stations this year, compared to 25 in 2017. Velvet swimming crab (*Necora puber*) catches, however, were just half of that sampled last year, with 23 kg caught at 6 prime stations. European lobster (*Homarus gammarus*) catches in 2018 were similar to last year (8.7 kg, compared to 10.6 kg in 2017), although only sampled at two prime stations, compared five the previous year.

Ichthyological observations

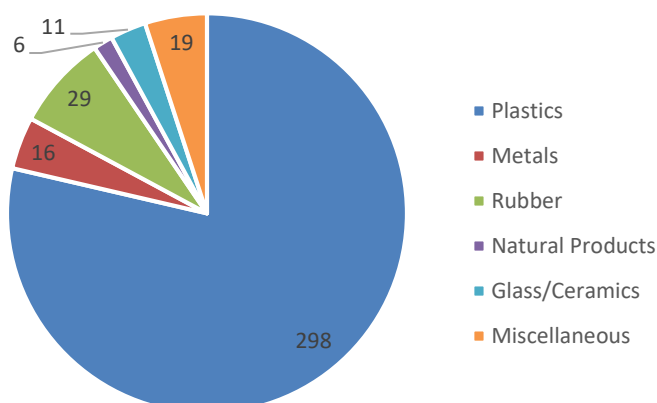
79 fish species were sampled on this year's survey, an increase of two from 2017. Species of note were Montague's sea snail (*Liparis montagui*), garfish (*Belone belone*) and the greater weever fish (*Trachinus draco*). John Dory (*Zeus faber*) were not caught on this survey, as in 2016, which is notable for a species which had been seen regularly in previous surveys. Length-weight relationships were recorded to a greater accuracy for less frequently caught species such as butterfish (*Pholis gunnellus*), redfish (*Sebastes viviparus*) and wolf-fish (*Anarhichas lupus*).

Macrobenthos

138 species of macrobenthos were observed during the survey, with the common starfish (*Asterias rubens*) the most widely distributed, having been recorded on 65 prime stations.

Marine Litter

Marine Litter collected during IBTS Q3 GOV survey 2018 (n = 379)



Litter was recorded on 76 out of the 78 prime stations sampled, with 379 individual items detailed. As seen on previous surveys, plastics made up a large proportion of the total litter recorded on the survey. The most notable example during the survey was at prime station 46, where a step ladder was found in the catch.

Aim 2. Comparative tows were made at four primary stations, with four 15-minute tows and eight “zero-minute” tows completed. Data was recorded as per a standard 30-minute tow, albeit with no biological samples collected. Timing of GOV deployment and retrieval was recorded during these fishing operations.

Aim 3. A total of 38 of the 39 targeted locations for water sampling had ~50 l of water collected for subsequent Caesium testing at Cefas. The same locations also had 1 l samples taken for Tritium analysis.

Aim 4. The AlterEco project is exploring the potential for autonomous vehicles to form part of the UK monitoring program and using these novel observations help to improve our understanding of shelf-sea ecosystem processes.

The National Oceanography Centre slocum buoyancy glider #345 "Cabot" was successfully recovered without issue on the afternoon of August 15 after surveying the north Dogger Bank area. Cefas' SV3 waveglider "Lyra" was deployed later that evening.

A total of 6 calibration CTD profiles were performed with Niskin samples collected for chlorophyll, oxygen, salinity and nitrate. These samples will be used to verify the biogeochemical sensors on Lyra and the other buoyancy gliders which are in the area. 24 zooplankton hauls were then taken on each hour to collect validation data for Lyra's WBAT fisheries echosounder.

SECONDARY AIMS

Aim 5.

Table 5. Number of elasmobranchs tagged on the survey

Species	Number tagged
Tope	12
Cuckoo ray	5
Starry smooth-hound	4
Flapper skate	3
Blonde ray	1
Spotted ray	1
Thornback ray	1
Total	27

As can be seen in table 5, a total of 27 elasmobranchs were tagged and released using Petersen discs during the survey. The station with the most abundant fish in a good condition for tagging was the additional standard tow completed by the request of the Danish Institute of Fisheries Research, where 12 adult male tope were tagged.

Aim 6. In total, 40 separate samples were retained for identification confirmation including species such as Vahl's eelpout (*Lycodes gracilis*), Jeffrey's Goby (*Buenia jeffreysii*) and the red crab *Geryon tridens*. Juvenile redfish caught at prime station 71 were an example of an unusual species caught at that size, which were also retained for further study.

Aim 7. One tope was found dead upon inspection of the catch at prime station 12 and was retained for biological studies.

Aim 8. Two twaite shad and two river lamprey were caught during the survey and were returned to Cefas for further study.

Aim 9. Acoustics data was recorded continuously throughout the survey. The information will also be relevant to the Alter-Eco project in relation to the data recorded by the Lyra glider.

Aim 10. With no dedicated observer on board, no cetacean sightings were recorded during the survey.

Aim 11. Jellyfish catches were recorded during the survey to better understand the species distributions and abundance in the North Sea, and how they change in relation to fishing practices, the abundance of other organisms, hydrological conditions and climate change.

"Jellyfish" were sampled at each station of the survey. This term includes scyphozoans, hydrozoans, ctenophores and salps. For each station jellyfish were first separated into species, or species groups. Then each species was bulk weighed, and the number of individuals counted. Finally, specimens in good condition were individually weighed

and measured (by diameter). Any specimens too damaged to identify were bulk weighed and recorded. The results can be seen in Table 6.

Lion's mane jellyfish (*Cyanea capillata*) was the most abundant species surveyed, making up 92 % of the total weight of jellyfish caught and 54% of the individuals. Lion's mane jellyfish were also present at 90% of the 77 prime stations.

Table 6. Details of jellyfish caught during the survey

Jellyfish species/group	Total weight (g)	No. of Individuals	Weight range (g)	Length range (cm)	Prime station with highest:	
					Weight	No.
<i>Aurelia aurita</i> Moon jellyfish	9855	15	6-390	4-21	10	27
<i>Cyanea lamarckii</i> Blue jellyfish	7378.5	247	1-280	2-52	27	27
<i>Cyanea capillata</i> Lion's mane jellyfish	252574	613	2-6090	4-56	1	8
<i>Cyanea</i> species	2213	75	1-366	3-22	27	27
<i>Chrysaora hysocella</i> Compass jellyfish	2480	161	1-255	3-19	3	3
<i>Aequorea</i> species Cristal jellyfish	609	15	4-269	4-17	64	1+3
Unidentified species	-	-	-	-	11	-

Aim 12. No squid eggs were found during the survey for retention.

Aim 13. 200 four-bearded rocklings were sampled for length, weight and maturity, as well as sagittal otoliths for subsequent age information to be determined.

Aim 14. Suitable examples of benthic organisms were collected at all seven targeted prime stations, with an additional sample taken at prime station 77 due to sharing similar criteria with other sample locations.

Aim 15. Bottom water samples were taken at 21 prime stations during the survey and processed for dissolved oxygen.

Aim 16. A total of 12 samples of *Loligo spp.* were retained during the survey, 10 were identified as *Loligo forbesi* and two as *Loligo vulgaris*. Two samples of *Alloteuthis subulata* were also collected.

Aim 17. The work to examine deceased sprat for buoyancy periods was cancelled before the start of the survey.

Aim 18. Fifty genetic samples were collected from individual anglerfish captured during the survey in sampling area A (ICES sub areas IVa-c).

OPPORTUNISITC AIMS

It is also worth noting other work that took place during the survey, such as:

- 107 water samples for analysis of the pigment composition of phytoplankton to determine phytoplankton diversity.
- Retention of dissected haddock spinal tissue in examples with skeletal deformity.
- Pictures of nautical twilight to help establish digital celestial navigation.
- Details and photos of 31 fish afflicted with five different diseases.
- Standard length v total length relationships recorded for 32 grey gurnard and 19 poor cod for a Cefas BEEMS project.
- Otoliths from uncommon species and extremes of length range retained as part of an on-going otolith reference collection.
- Plankton sample in the Gabbard area of the Thames estuary to add to an existing UK zooplankton monitoring network (Lifeform Defra project) time-series.

NARRATIVE

All times stated are GMT.

PART ONE

RV Cefas Endeavour sailed from Lowestoft at 20:00 hrs on Friday August 10. There were nine Cefas scientific staff on board plus, Martina Bristow, a student from University of East Anglia, and Tobias Ehmen, a student from University of Exeter. During the night the ship travelled south toward prime station 1. A standard station normally consisted of collecting surface water and CTD Rosette (Figure 1), to measure additional parameters through the water column (temperature, salinity, fluorescence, light, turbidity and dissolved oxygen) and provide salinity samples and water samples for our additional aims. These deployments were then followed by a 30-minute tow with the standard IBTS rigged GOV (Grand Overture Verticale) trawl. Since 2014, a net variation has been used during this survey, with a polyethylene net with nylon sleeve and codend being employed. Throughout the survey, fisheries acoustic data were continuously collected at four operating frequencies (38 kHz, 120 kHz, 200 kHz and 333 kHz), using the Simrad EK60 split beam sounder.



Figure 1. CTD Rosette being deployed

By 04:30 hrs on August 11, the ship had arrived on prime station 1 ready for the “shakedown” tow, which would allow for the deployment of the gear, to check that all sensors were working correctly and to allow scientists and crew to familiarise themselves with their work areas. Following a “tool box talk” and a CTD rosette cast, the net was deployed and the “shakedown” tow completed successfully, yielding a moderately sized catch of whiting (85 kg), thornback ray (*Raja clavata*, 51 kg) and both adult and juvenile starry smooth-hounds (68 kg, 24 cm – 90 cm). With no problems encountered, this was taken as prime station 1 completed and the survey moved to the east to prime station 2. As in previous years, this resulted in a very small catch of mackerel and some epibenthos. However, of note was four seabass (*Dicentrarchus labrax*, 3.7 kg). Prime station 3, located off the Belgium coast was the last station that could be completed on 11 August. A large catch of sprat (1.3 t) was caught at this

prime station, along with some herring (68 kg) and pilchard (*Sardinia pilchardus*, 36 kg).

Overnight, the ship moved north east to prime station 6 and then worked west through the day, successfully completing prime stations 6, 5 and 4. Prime station 6 yielded a small catch of which the largest component was juvenile Horse mackerel (16 kg, 5 cm – 9 cm). A larger amount was also sampled further offshore to the west at prime station 5, where 57 kg were caught, ranging from 6 cm – 10 cm. Here, mackerel was the largest weight caught; 117 kg. At prime station 4, mackerel were caught in similar amounts (158 kg), alongside 270 kg of whiting. With not enough time to reach another prime station, two “zero-minute” tows were completed at prime station 4, with species compositions very similar to what was seen in the 30 minute tow.

By August 13, RV Cefas Endeavour was north of the Dutch West Frisian Islands at prime station 12. During the day four stations were successfully completed as the survey moved west through prime stations 12, 11, 10 and 9. While the catch weight increased at each station (~100 kg/~150 kg/~180 kg/~415 kg, respectively), the species compositions were all very similar, with dab observed consistently, along with whiting and smaller amounts of plaice. Of note, was a deceased juvenile male tope (30 cm) caught on prime station 12, which was retained for further study. One river lamprey (0.09 kg, 31 cm) and one twaite shad (*Alosa fallax*, 0.625 kg, 42 cm) were caught at prime station 9 and retained for further study as per aim 8. In addition, a large quantity of moon jellyfish (*Aurelia aurita*, 40 kg) were sampled at prime station 10.

The next day began at prime station 8 with a small catch of 40 kg each of dab and lesser spotted dogfish, along with 58 kg of lion’s mane jellyfish. A short distance west, at prime station 7 off Flamborough Head, 1.2 t of whiting were caught with an abundance of epibenthos as well, consisting mainly of porifera sponges. Of note here were five lobsters, including two large berried females (1.6 kg, 102-104 mm) and several juvenile cod (21 individuals, 7-12 cm). The survey then moved north to prime 13, where the first catch of haddock was sampled (67 kg), along with over 100 kg of whiting. Cod ranging from 34 cm to 59 cm, were also observed here (4.8 kg). Further east, at prime 14, 270 kg of herring were sampled.

With the weather forecast to worsen, the decision was made to make earlier than planned attempts at retrieving the SLOCUM glider and deploying the Lyra glider, as part of the Alter-Eco project. Overnight, the ship moved to “Swallow Hole” at prime station 23, where a tow was successfully completed and nearly 300 kg of herring were caught, along with haddock (37 kg) and whiting (43 kg). At prime station 24 to the east, a small catch of haddock (50 kg) was sampled. Of note here were three juvenile spurdog were caught; a male (0.052 kg, 24 cm) and two females (0.031 kg, 29-31 cm). Once this station was complete, the Alter-Eco team successfully retrieved the SLOCUM glider at 15:48 h and then deployed the Lyra glider at 17:20 h (Figure 2). RV Cefas Endeavour then spent the next 36 hours completing 24 zooplankton ring net and eight rosette deployments in order to collect data for the calibration of Lyra’s sensors.

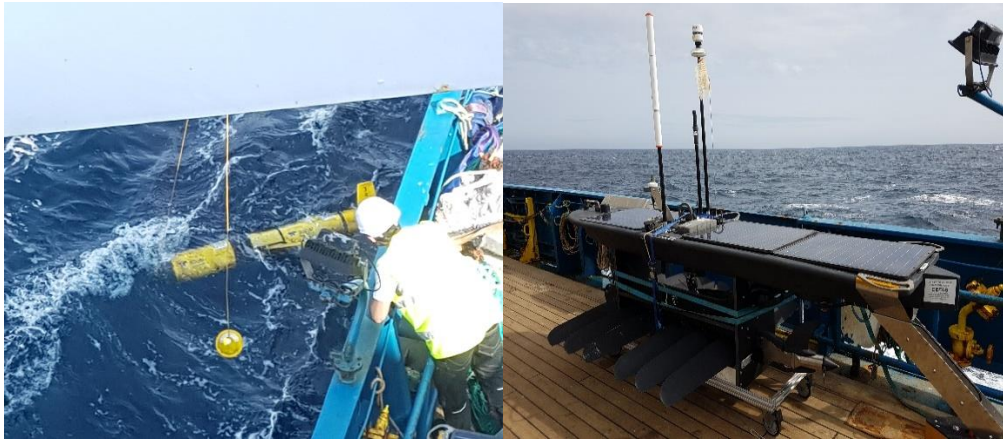


Figure 2. Recovery of SLOCUM (left) and the glider Lyra of the Alter-Eco project

On the morning of August 17, the survey had returned to the IBTS grid, resuming operations at prime station 25. Over the course of the day, four stations were completed; 25 through to 28. The species assemblage seen were similar, with grey gurnard and dab being the most abundant, as well as lion's mane jellyfish. By the next day the weather had worsened due to the tail-end effects of tropical storm 'Ernesto'. Prime station 39 was completed (91 kg of herring, 60 kg of dab and 31 kg of plaice) but by the time passage was made to prime 29 to the south, the swell had increased, and fishing had to be paused for the remainder of the day.

Overnight, the weather improved and allowed prime stations 30 and 29 to be completed. With only 15 nm distance between the stations the catches were similar; with nearly 300 kg of dab caught on each. Of interest was only 1 kg difference in catch weight for dab at prime station 30 from this survey last year (2017 = 286 kg, 2018 = 287 kg). A total of 256 kg of mackerel was also caught on prime station 30. The RV Cefas Endeavour then moved south to prime station 21 for another >200 kg catch of dab, before a 15-minute tow and associated "zero-minute" tows were also completed. These additional catches were very similar to the standard 30-minute tow, with dab and grey gurnard in smaller quantities. A female blonde ray was caught in the 15-minute tow (3.54 kg, 74 cm), which was tagged and released.

The next day began at prime station 20. The catch consisted of 467 kg of sprat, with 124 kg of juvenile herring. Of note here was a river lamprey (0.095 kg, 34 cm). The survey moved west to prime station 19, where sprat and herring were also caught, but in smaller quantities (104 kg and 19 kg, respectively). At prime station 18, sprat were no longer present in a small catch of dab and grey gurnards (77 kg in total). A very similar catch was sampled at prime station 17.

On August 21, two stations were completed prior to a ~140 nm passage to Aberdeen. Prime station 16 saw 191 kg of mackerel and 155 kg of dab caught, whilst at prime station 15, dab was the most abundant species caught at 66 kg, with ~22 kg of grey gurnard also caught. Arrival at prime station 40 off Aberdeen was early the next morning. With the approval for construction of the Aberdeen Bay wind farm the previous year, the tow position previously fished had to be abandoned and a new tow further to the northeast was located and fished successfully. This new tow yielded a varied catch of haddock, herring and whiting. There was also a large number of juvenile gadoids, including cod, whiting, haddock and Norway pout observed here.

Once this station was complete, RV Cefas Endeavour headed into Aberdeen for a scheduled port visit for change of crew/scientists and to take on fresh supplies, docking at 12:55 hrs.

PART TWO

At approximately 07:00 hrs on August 24, the survey resumed, and the vessel made passage south east from Aberdeen to prime station 31. Due to changes in personnel, the CTD rosette which had been utilised on the first half was replaced with an ESM2 profiler and single 10 l Niskin, which would be used for the remainder of the survey. The 30-minute GOV tow was completed and a catch abundant in epibenthos was completed, with over 100 kg caught. In addition, 47 kg of dab and 25 kg of grey gurnard was also present in the catch. Further to the east, at prime station 32, a larger catch of whiting (81 kg), herring (63 kg) and grey gurnard (61 kg) was also recorded.

The next day, four prime stations were completed; 41, 46, 76 and 33. Catches, for the first three stations, were ~250 kg and abundant in haddock and herring, with smaller quantities of mackerel and whiting. At prime station 33 however, a large catch of herring was caught (2.7 t). Of interest at prime station 76 was a large number of purple heart urchin (*Spatangus purpureus*), making up a large proportion of the 59 kg of epibenthos sampled there.

Further east, another four stations were completed the next day. Prime station 34 yielded a small catch of herring (129 kg) and some whiting (12 kg). Of note here were three snake blennys (*Lumpenus lampretaeformis*). This was followed by another small catch on prime station 42 of 87 kg of herring. The red crab (*Geryon tridens*) species seen in last year's survey was also recorded at this station. The catch at prime station 35, consisted of dab (88 kg), whiting (39 kg) and lemon sole (23 kg). By the end of the day, prime station 43 was also successfully completed, with 77 kg of haddock, 70 kg of whiting and 50 kg of dab sampled. This station's catch also contained a young wolf fish (0.475 kg, 39 cm, Figure 3).



Figure 3. Young wolf fish caught at prime station 43

By August 27, the survey had moved further east to prime station 44. 153 kg of dab were sampled here, along with 52 kg of lion's mane jellyfish. A juvenile redfish (10 cm) was also caught here. Prime station 36 yielded a larger catch of dab (436 kg) and grey gurnard (320 kg), but of note was also a large number of lesser sandeel (*Ammodytes*

marinus, 44 kg), two juvenile saithe (18-28 cm) and “0-group” gadoids such as haddock, whiting and some cod. At prime station 37, further again to the east, was a small catch of dab and grey gurnard again (155 kg and 60 kg, respectively). By the end of the day prime 38 was sampled too, with a small catch of dab and sprat (<50 kg in total).

Overnight, the ship moved northwest to prime station 49. During the course of the day this, and three other stations, were successfully completed. Prime station 49 saw small amounts of haddock (29 kg), cod (17 kg) and grey gurnard (15 kg) caught. A short distance to the east, at prime station 50, horse mackerel (28 kg) was sampled in a catch abundant in epibenthos. A halibut (*Hippoglossus hippoglossus*, 3.34 kg, 68 cm) was also caught here. Prime station 58, to the northeast, provided a larger catch of mackerel and horse mackerel (>750 kg together), along with Norway pout and the green urchin (*Psammechinus miliaris*). Noteworthy species captured here included a large wolffish (8 kg, 90 cm) and three Vahl’s Eelpout, 44 g, 11-16 cm). The last tow of the day was completed at prime station 48, which yielded a small catch of dab (47 kg) and whiting (36 kg).

The next day, fishing began at prime station 56. Haddock was the most abundant species sampled here (70 kg), along with grey gurnard (20 kg) and cod (20 kg). The cod comprised of 27 individuals; 24 juveniles and three adults over 70 cm. An attempt was made at prime station 57 but gear damage was sustained towards the end of the tow which required eight hours of mending. Once repairs were complete, there was enough time for a reduced 20-minute tow to be completed before sunset, which yielded a small catch of Norway pout and green urchins.

By August 30, RV Cefas Endeavour was further north at prime station 65. A larger catch of mainly horse mackerel (840 kg) and some mackerel (91 kg) was brought aboard here. Interestingly, two adult male black-mouth dogfish (*Galeus melastomus*, 1.74 kg, 66-68 cm, Figure 4) were also found in the catch. Further west, at prime stations 63 and 64, the close proximity of the two stations resulted in similar catches; both were abundant in green urchin and Norway pout, and other gadoids, including haddock (50 kg total), hake (*Merluccius merluccius*, ~10 kg total) and cod (55 kg total). At prime station 62, Norway pout and green urchins were sampled again, with 167 kg of herring.



Figure 4. Black-mouth dogfish (*G. melastomus*) caught at prime station 65

Overnight, passage was made to prime station 69. A successful tow was completed here with saithe the most abundant, with over 150 kg caught, along with 30 kg of

mackerel. Approximately 30 nm east was prime station 70, which was a smaller catch of Norway pout and green urchin, with some mackerel (42 kg) and hake (13 kg). Further north, prime station 75 was sampled, which, at 239 m, was the deepest tow of the survey. 130 kg of blue whiting (*Micromesistius poutassou*) were brought aboard, and the catch included bigger argentinines (*Argentinidae spp.*), a large size range of hake (42 kg, 20-87 cm), two large cod (15.7 kg, 86-95 cm) and four greater forkbeards.

On September 1, the ship began the day east of the Shetland Isles. Prime station 74 comprised mostly of saithe, with 111 kg caught, as well as 132 kg of epibenthos. Some mackerel (87 kg), horse mackerel (47 kg), hake (43 kg) and cod (30 kg) were also sampled here. Mackerel and horse mackerel were caught again at prime station 73 (located to the west of the previous station), with the catch weight for both species over 100 kg. An attempt was made to fish at prime station 72, but unfortunately a rip in the belly of the net invalidated the tow. As repairs were made, the ship moved westwards to prime 71 north of the Shetland Isles. The tow here was also unsuccessful, with a larger tear in the net taking four hours to mend. Interestingly, a large number of juvenile redfish were present here; over 100 individuals between 6 cm and 12 cm (Figure 5).



Figure 5. Juvenile redfish (*S. viviparous*) caught at prime station 71

The two invalid tows were repeated the next day, with prime station 72 successfully completed providing ~200 kg of mackerel and some hake (~30 kg). A noteworthy young female grey skate (*Dipturus batis cf. flossada*, 2.26 kg, 73 cm) was recorded here but was deemed too small to tag. Prime station 71 was also successfully repeated two hours later, yielding a large catch of juvenile saithe; over 2000 individuals between 32 cm and 42 cm were caught, weighing 1.175 t. Similar to the previous day's tow at this station, more juvenile redfish were present (91 individuals, 5-13 cm). There was enough time to progress southeast to prime 66 and complete a tow here. A smaller catch of Norway pout, green urchin and some saithe (41 kg) were recorded, as well as a large wolf fish (4.5 kg, 78 cm).

Overnight, the survey moved east to prime station 68. This was fished successfully, along with prime station 67, both having similar catches (~200 kg) of Norway pout, green urchin and saithe. The vessel then transited southwest to prime station 61, where two tow attempts were made after the first was found to have a fouled halving becket upon hauling. This was invalidated, and then re-shot successfully; capturing 780 kg of herring.

The next day began at prime station 60, east of the Orkney Isles. This yielded a catch abundant in gadoids; 188 kg of whiting, 98 kg of haddock and 61 kg of cod. Prime station 59, to the west-southwest, was completed next, with 154 kg of haddock caught here. A large number of elasmobranchs were also in this catch; 123 kg of lesser spotted dogfish, 95 kg of spotted rays, some cuckoo rays (*Leucoraja naevus*, ~6 kg), two spurdogs (2.76 kg) and three flapper skate (~17 kg, 88–103 cm), which were tagged and released. Two attempts were made at prime station 51, the first resulted in a tear in the belly of the net. With static gear also in the immediate area, a tow was identified to the southwest. Unfortunately, upon hauling, the location of the tow was found to be just outside the correct ICES statistical rectangle, and the catch had to be classed as additional only.

On September 5, prime stations 53 and 52 were completed during the morning. The former had a catch abundant in herring (154 kg) and haddock (124 kg), the latter was much larger in terms of weight caught; with near identical amounts of whiting and haddock (~385 kg each), plus over 100 kg of herring. With these stations completed, prime station 51 was attempted again during the afternoon using a tow previously sampled by Scotland. This was successful, resulting in 169 kg of haddock and 78 kg of plaice.

By the next morning the survey had moved east to prime station 45, where almost 1 tonne of herring were caught, along with approximately 200 kg of haddock and 167 kg of whiting. Prime station 54 then saw the heaviest catch of the survey, with over 2.5 tonnes caught, the vast majority of which were herring. The near-by prime station 55 yielded a much smaller catch of herring (92 kg), epibenthos (88 kg) and lion's mane jelly fish (33 kg). There was also time to complete prime station 47 before sundown, with another small catch of haddock (32 kg), herring (30 kg) and dab (23 kg).

On September 7, the survey started the day at prime station 77, off the English north-east coast. Over 1 tonne of herring were caught in a state of spawning, which had not been seen on the English IBTS Q3 survey for eleven years. Then, a short distance to the east, prime station 22 was successfully completed which contained a catch of non-spawning herring (440 kg). This was the last of the 77 prime stations targeted for primary aim 1.

Overnight RV Cefas Endeavour moved back to prime station 8. Here, two 15-minute comparative tows and three "zero-minute" tows were completed, with catches abundant in dab and grey gurnard. A 30-minute tow was then attempted in 35F0, as requested by the Danish Institute of Fisheries Research. Unfortunately, a large rip on the belly of the net had to be mended and another attempt could not be completed until the following morning. This was completed further north in Silver Pit and was abundant in more sedentary species such as the brittle star *Ophiothrix fragilis*, edible crab (64 kg) and velvet swimming crab (14 kg), along with 346 kg of whiting. Two noteworthy species were captured here; 12 male adult tope (203 kg, 144-162 cm), which were all tagged and released, and seven large great spider crabs (*Hyas araneus*, Figure 6).



Figure 6. *H. araneus* caught on the additional tow for the Danish Institute for Fisheries Research

By September 10, the survey had moved south back to prime station 1. A 15-minute tow and two “zero-minute” tows were conducted here, yielding a similar species composition to the 30-minute tow completed at the start of the survey; whiting, thornback ray and starry smooth-hounds. Once this was complete, the ship moved to the Outer Gabbard, off the Thames river estuary, and collected a Cefas requested plankton sample. After this was completed, RV Cefas Endeavour then transited back to Lowestoft, docking at approximately 21:00hrs.

Special thanks are given to the crew of the RV Cefas Endeavour for their enthusiasm and hard work throughout the survey.

Figure 7. Deployment positions for valid and additional GOV tows

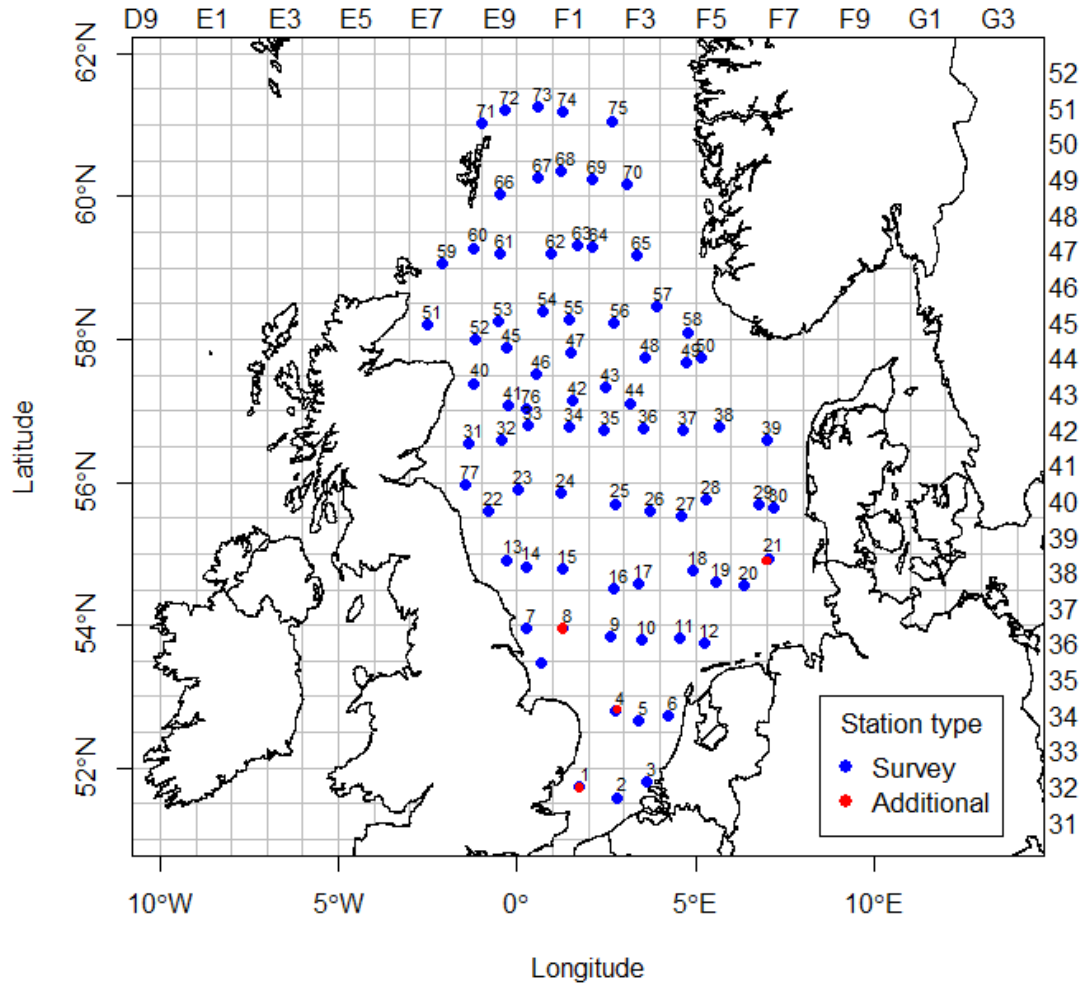


Figure 8. Relationships between mean headline height, wing spread and door spread with water depth, as recorded in valid hauls

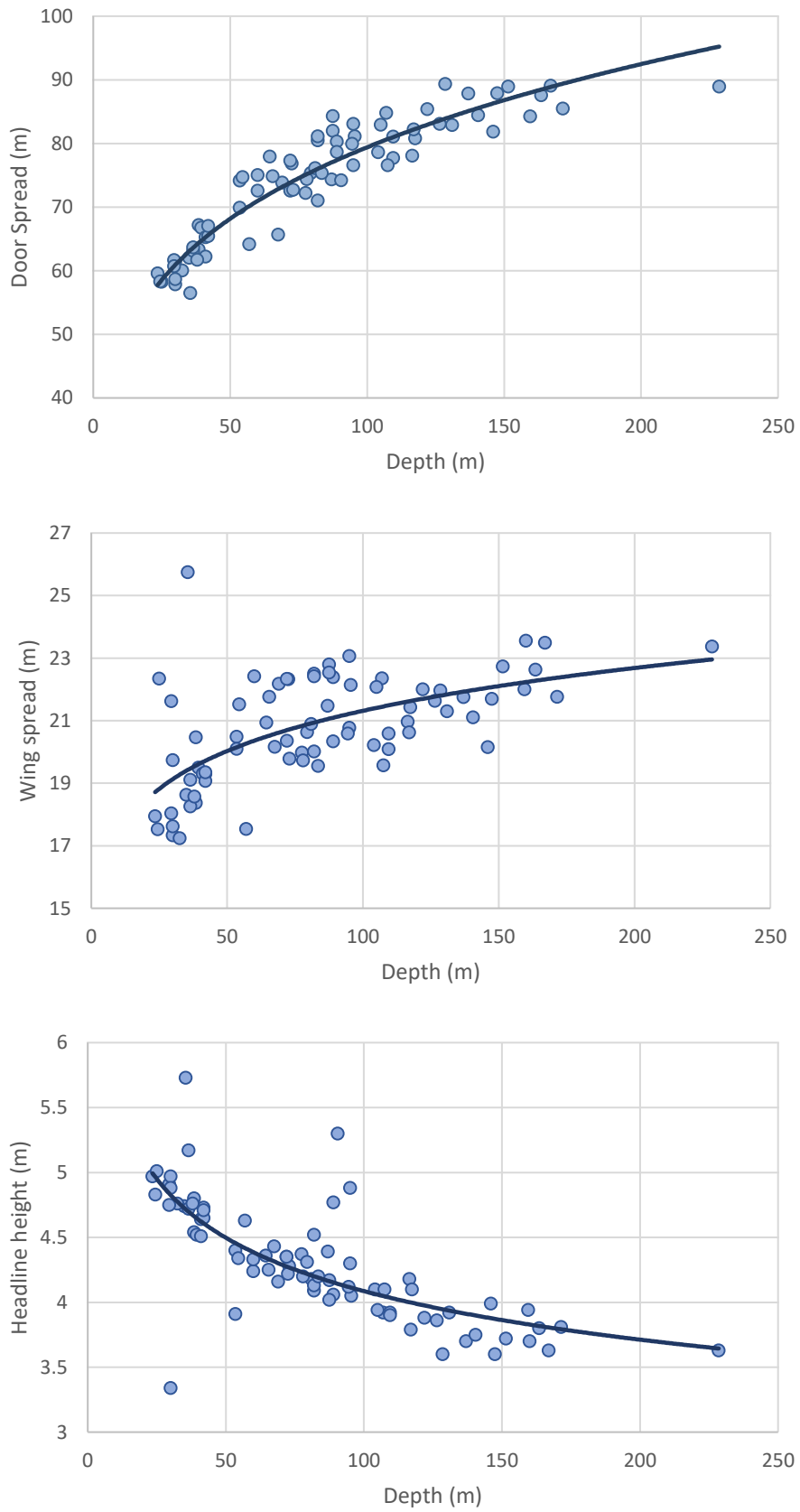


Figure 9. Abundance plots of Cod (*Gadus morhua*) across the survey.

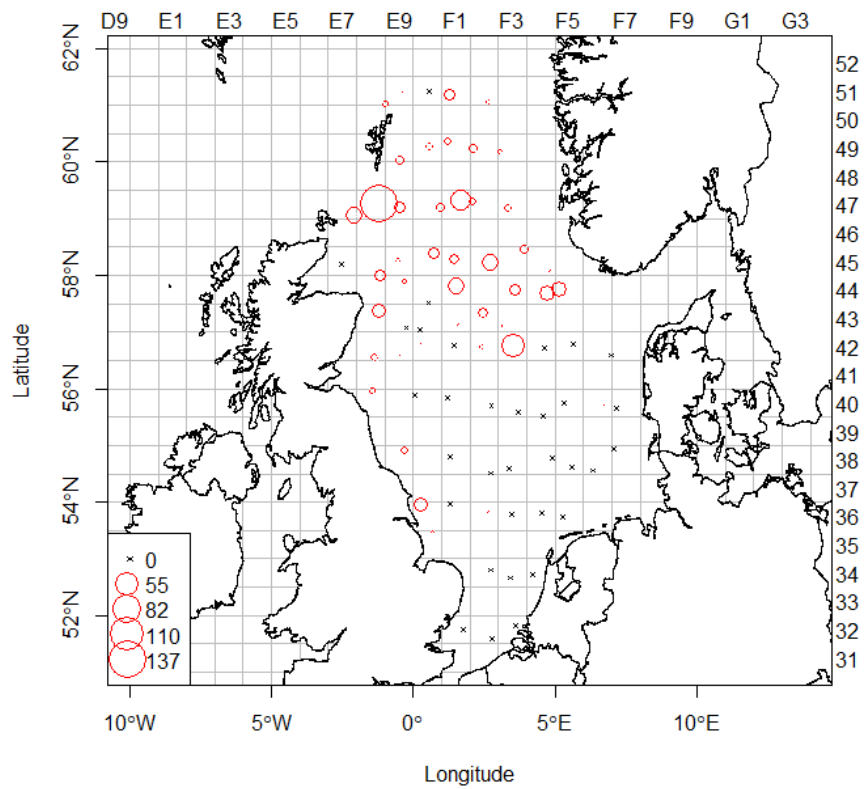


Figure 10. Abundance plots of Haddock (*Melanogrammus aeglefinus*) across the survey.

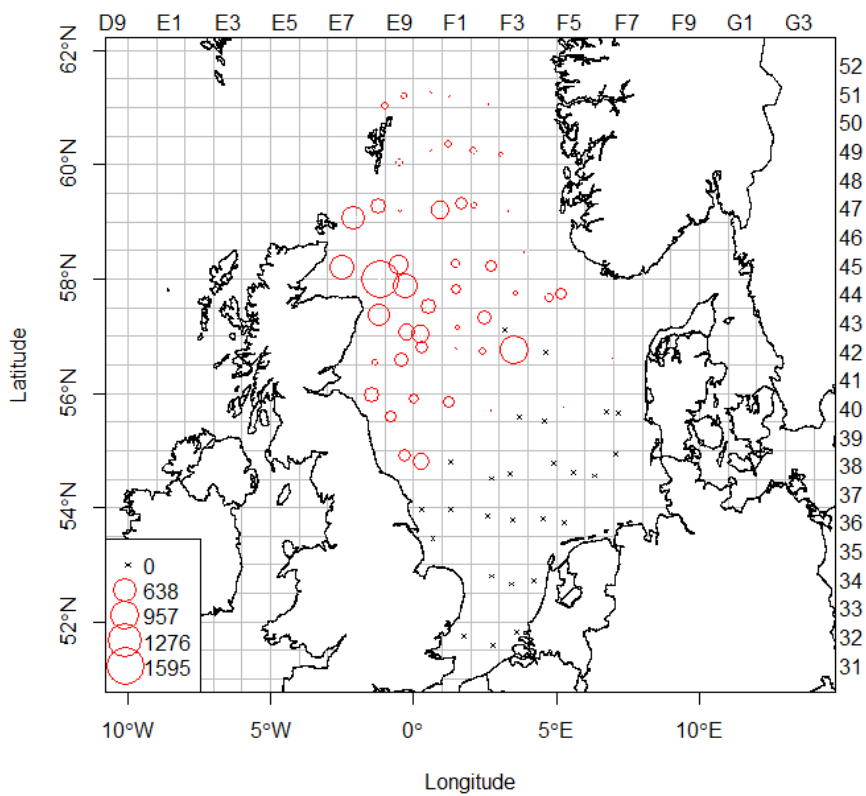


Figure 11. Abundance plots of whiting (*Melanogaster merlangus*) across the survey.

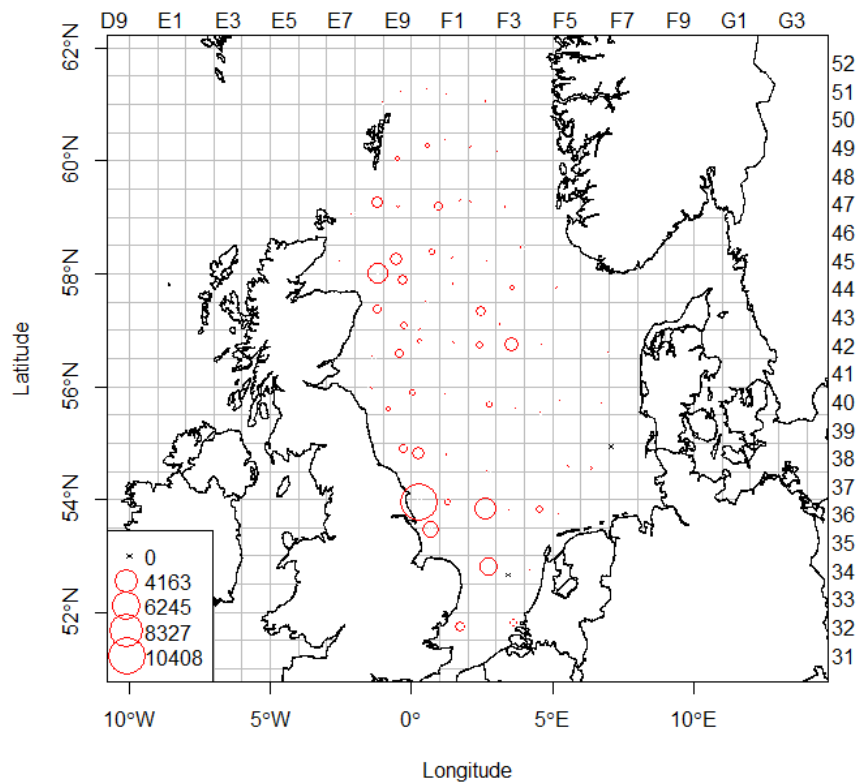


Figure 12. Abundance plots of saithe (*Pollachius virens*) across the survey.

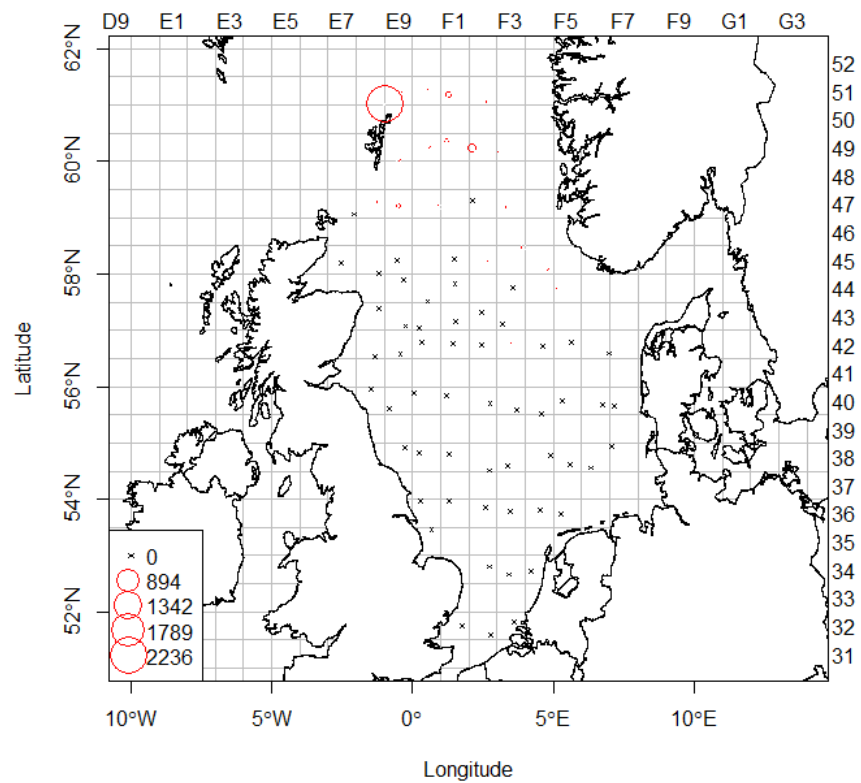


Figure 13. Abundance plots of Norway pout (*Trisopterus esmarkii*) across the survey.

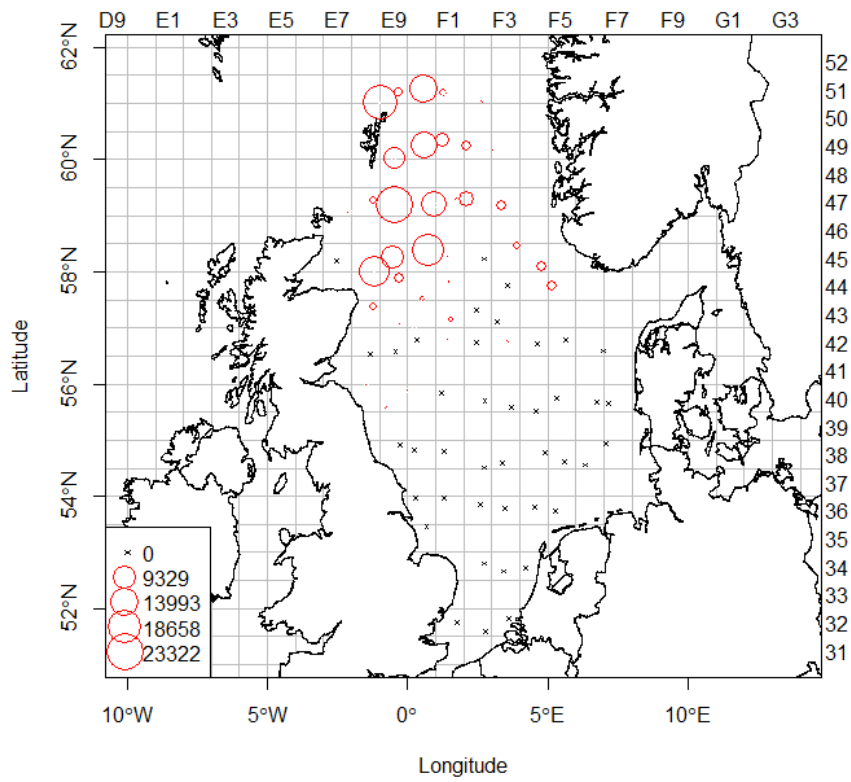


Figure 14. Abundance plots of herring (*Clupea harengus*) across the survey.

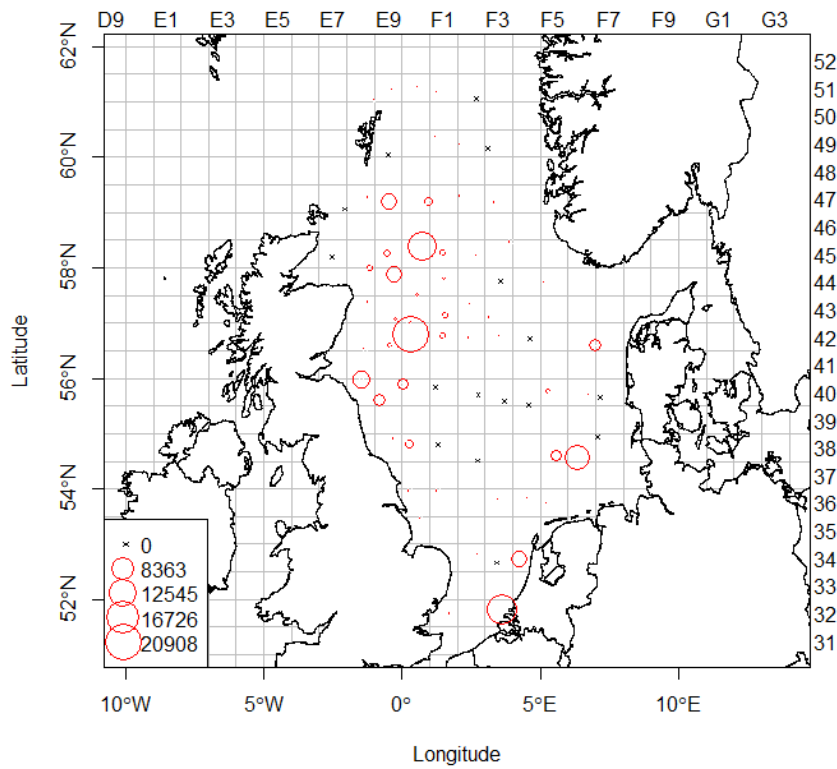


Figure 15. Abundance plots of mackerel (*Scomber scombrus*) across the survey.

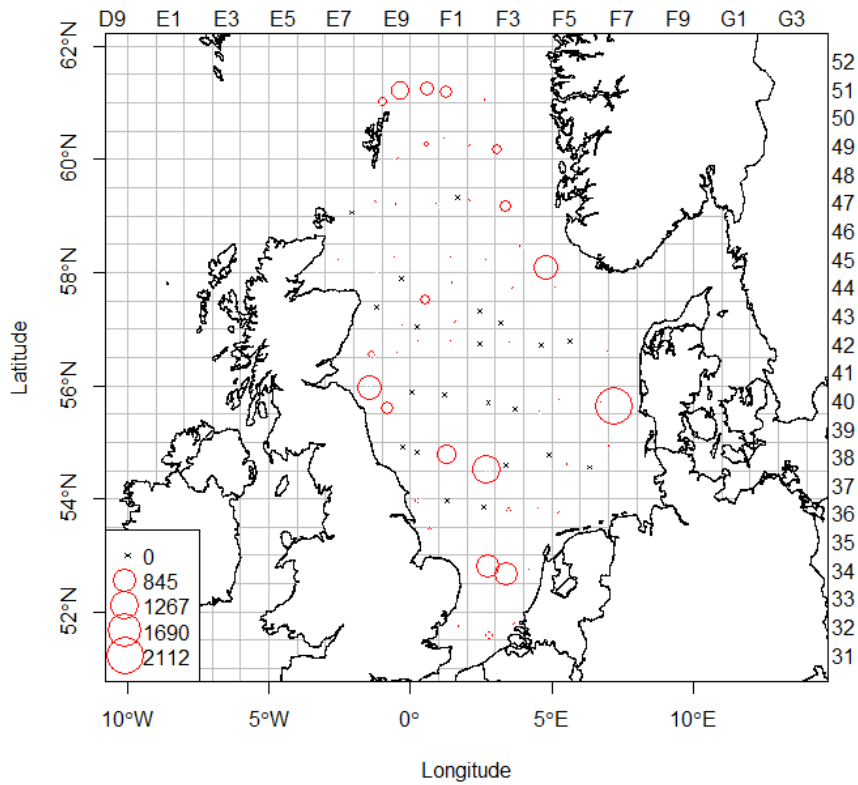


Figure 16. Abundance plots of sprat (*Sprattus sprattus*) across the survey.

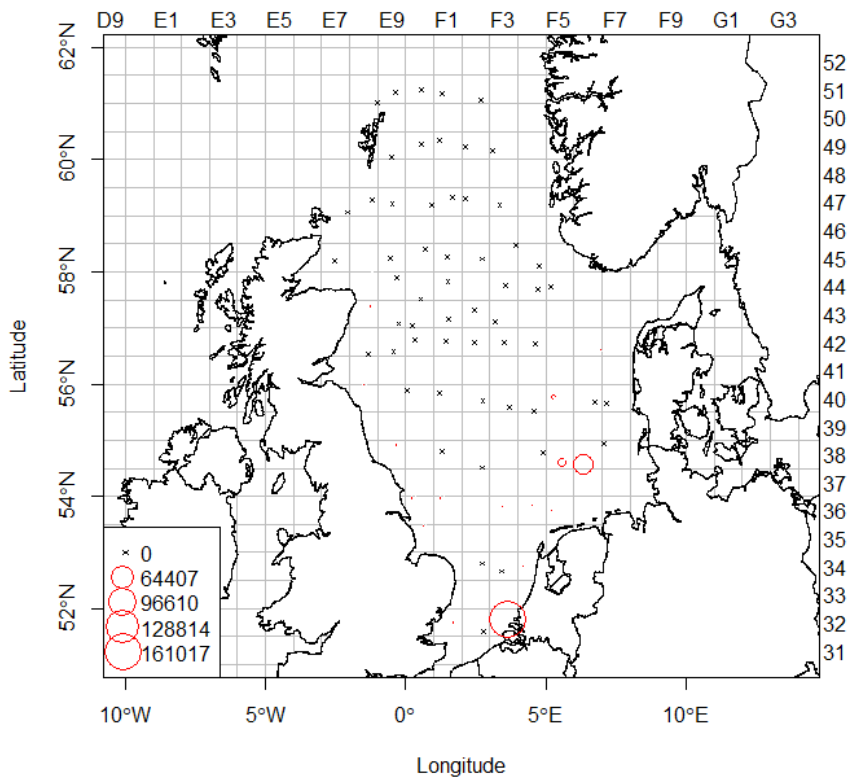


Figure 17. Abundance plots of plaice (*Pleuronectes platessa*) across the survey.

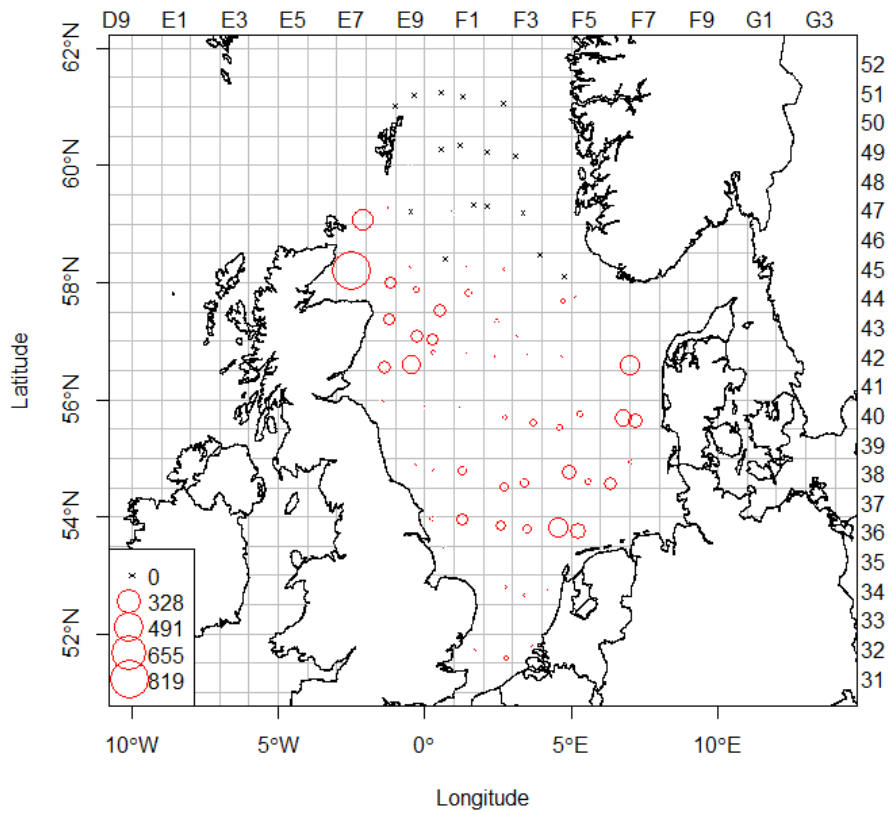


Figure 18. Abundance plots of hake (*Merluccius merluccius*) across the survey.

