

**CENTRE FOR ENVIRONMENT, FISHERIES AND AQUACULTURE SCIENCE
LOWESTOFT LABORATORY, LOWESTOFT, SUFFOLK NR33 0HT**

**2016 RESEARCH VESSEL PROGRAMME
REPORT: RV CEFAS ENDEAVOUR: SURVEY 18**

STAFF:

Part A

Fishing:

B Hatton(SIC)

I Holmes (2IC)

R Humphreys

M Eade

L Cox

P Jones

E Capuzzo

J Ellis (8-11 August)

Part B

B Hatton (SIC)

I Holmes (2IC)

R Humphreys

M Eade

R Masefield

S Barnett

N Hampton

W Dawson (23-30 August)

Plus:

R Wright (University of East Anglia)

N Trifonova (Brunel University London)

S Painter (National Oceanography Centre)

S Painter (National Oceanography Centre)

S Miller (Sea Watch Foundation)

H Nutt (Sea Watch Foundation)

O Lambert (University of East Anglia)(8-10 August)

DURATION: 8 August – 7 September

LOCATION: North Sea

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. Carry out water sampling for Caesium/Tritium for an internal Cefas contract (SLA21).

SECONDARY AIMS:

3. 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.
4. 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), *Sebastes* spp., and any unusual fish species, which may also be used in otolith research.
5. To freeze samples of dead starry smooth-hound (*Mustelus asterias*) for biological studies.
6. Retain all dead species of shad and lamprey for study by Cefas scientists.
7. 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 and will be used as part of the Defra funded project Poseidon (MF1112) to monitor changes in mackerel distribution and abundance.
8. To retain empty skate and ray egg cases with corresponding positional information for subsequent identification by the Shark Trust.
9. Cetacean observations will be recorded by a dedicated observer from the SeaWatch Foundation.
10. Collect data on incidental mortality of edible crabs caught in the trawl in support of Defra projects.
11. Identification, count, measure and weight all jellyfish caught in GOV trawl will allow the continuation of the North Sea jellyfish dataset started in August 2012. As the dataset grows from year to year, this should allow for the evaluation of changes in jellyfish community and biomass over time.
12. To collect maturity and life history information for lesser-spotted dogfish *Scyliorhinus canicula* from the southern and northern North Sea.
13. To collect and filter on board water samples for determination of chlorophyll and suspended particulate materials, and to carry out Photosynthetically Available Radiation (PAR) profiles with the ESM2; data collected will be used for calibrating SmartBuoy, Ferrybox and ocean colour space-borne data (for the EU FP7 project HIGHROC, C5878).

14. To collect and freeze samples of whole predatory fish for investigation into feeding relationships with jellyfish.
15. Water sampling and analysis using fluorescence techniques and additional chlorophyll, salinity, nutrient and dissolved organic carbon analyses to investigate terrestrial organic matter transfer to the North Sea. (LOCATE project, carried out by National Oceanography Centre)
16. Collecting samples to measure carbon dioxide, methane and nitrous oxide in surface waters across the North Sea, with a view to developing and refining these techniques for future use.

NARRATIVE

(All times GMT, prime stations referred to can be seen in Figure 1.)

RV Cefas Endeavour sailed from Lowestoft at 00:30 hrs on Monday August 8th. On board were seven Cefas fisheries staff, two PhD students (both from University of East Anglia), Suzie Miller, a volunteer observer from the Sea Watch Foundation and Stuart Painter, a marine bio-geochemist from the National Oceanography Centre. A standard station normally consisted of collecting surface water and a cast with a single 10-litre Niskin bottle (to collect bottom water samples) and an ESM2 logger, to measure additional parameters through the water column (temperature, salinity, fluorescence, light, turbidity and oxygen). These deployments were then followed by a 30-minute tow with the standard IBTS rigged GOV (Grand Overture Verticale) trawl. From 2014 onwards a net variation has been used during this survey, with a polyethylene net with nylon sleeve and codend being used (Plate 1). From the start of the survey, whilst steaming between and on every station, 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.



Plate 1: Hauling the GOV net, note green polyethylene panels with white nylon lowers and cod end

By first light, at 05:30 hrs, 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 particular work areas. The station was completed successfully with a small-to-medium catch of elasmobranchs, including thornback ray *Raja clavata*, lesser-spotted dogfish *Scyliorhinus canicula* and starry smooth-hound *Mustelus asterias*. Of note, was a single brown trout *Salmo trutta* (26 cm, 175 g).

The ship then steamed east to fish prime 2, which resulted in an extremely small catch of dab with a few other species. Of note, was the presence of three large specimens of greater weever *Trachinus draco*. The 'small' size of this catch, combined with the potential auditory disturbance caused by a 'pile-driver' rig operating nearby influenced the decision to classify the station an 'additional' tow (i.e. not valid) and move 9 miles west to try again. This tow, which was shortened to 20 minutes duration due to the unfamiliar ground, comprised a moderate catch of mackerel *Scomber scombrus*, horse mackerel *Trachurus trachurus* and whiting *Merlangius merlangus*. Unfortunately, at the end of the tow, with the warp starting to be brought in, one of the barrel swivel joints on the starboard sweep parted from the trawl door. This took a huge effort from the deck crew to recover and then re-rig the gear as the ship headed into Dutch waters. Thankfully, this was completed in time to be shot at prime 3, where just under 100 kg of horse mackerel and whiting was caught.

Overnight, the ship travelled north to prime 6 where approximately 0.3 t of fish was caught. The major component of the catch was horse mackerel, with a good proportion of those being 0-groups. Mackerel was also abundant. Further west, prime 5 saw a smaller catch of mainly whiting and horse mackerel, although the station being further offshore meant the lack of juvenile horse mackerel this time was unsurprising. The final station on August 9th was west again at prime 4. This catch was dominated mainly by whiting, although there were also comparatively large numbers of velvet swimming crab *Necora puber* and edible crab *Cancer pagurus*.

August 10th started with a delay, as the barrel-swivel joints were swapped out for the swivels used in 2015's survey, to prevent the problem noted the previous day. Prime station 12 yielded a small catch, mainly of dab *Limanda limanda* (75 kg). RV Cefas Endeavour then headed west to prime 11, where dab was in abundance again (<180 kg), along with a significant amount of plaice *Pleuronectes platessa*. Whilst heading on to prime 10, a medical emergency developed on-board. After the casualty being assessed by the master, and following advice from an on-shore doctor, a helicopter medi-vac was organised to the Netherlands. Whilst plans were being developed to remove the casualty, prime 10 was completed with a shortened 20-minute tow, yielding a small catch of flatfish. However, the time and course correction to facilitate the helicopter medi-vac meant that prime 9 was missed that day.

Overnight, the survey moved north-east to prime 15. This was completed successfully and brought in a small catch dominated by dab. The ship then moved west to prime 14 and deployed the GOV. Despite the net appearing to go away clear, the upper and middle bridles twisted around the port side of the headline. This twisted the floats and kite and fouled the headline, and the tow was thus deemed invalid. The GOV was re-

shot but was reduced to a 20-minute tow due to erratic Scanmar headline readings. However, whilst hauling, a 20m-high shoal of herring *Clupea harengus* was observed on the EK60 sounder (Plate 2). The catch comprised 2.75t catch of herring, a large catch, but still much less than the 4.5 t seen at this station in 2015. Damage sustained to the outer mesh of the cod-end whilst getting the catch on board meant a delay in shooting at near-by prime station 13. This station was completed successfully and yielded over a 100 kg of herring, sprat *Sprattus sprattus*, whiting and the first Norway pout *Trisopterus esmarkii* of this year's survey. Upon hauling, unfortunately, the starboard wing was caught on the deck and ripped along its entire length, which needed mending either side of a pre-planned dis-embarkation of a scientist into Whitby.

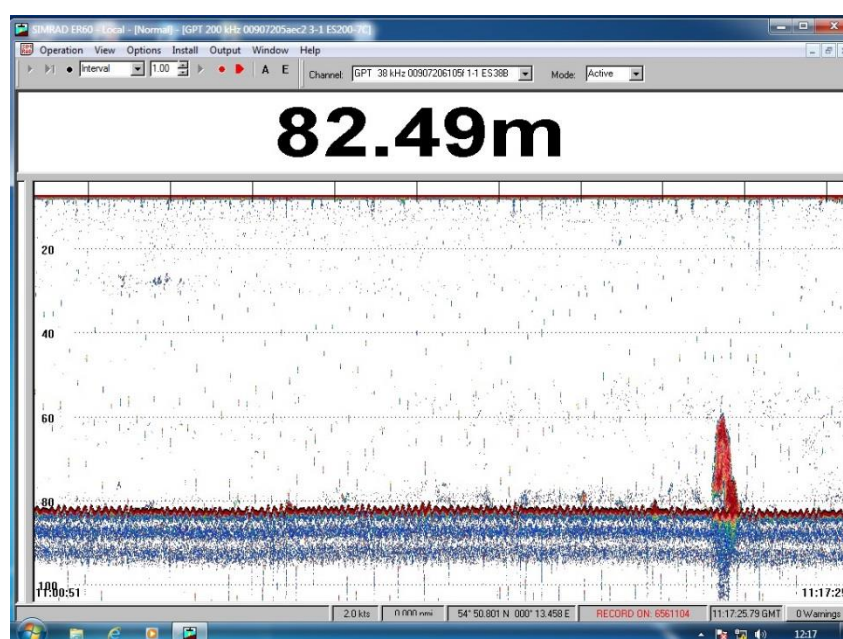


Plate 2. Screen capture of 20m high herring shoal seen at prime 14 from the Simrad EK60 sounder

The next day, RV Cefas Endeavour moved south to prime 7. This first tow of the day resulted in a large catch of horse mackerel (350 kg+), whiting (285 kg+) and mackerel (~415 kg), along with a large benthos component (200 kg+). The catch at prime 8, further east, was much smaller, with 60 kg of dab being the dominant component of the catch. Further east at prime 9, dab were still abundant in a catch of over 100 kg.

The survey then moved further north overnight and completed primes 16, 17 and 18 working east. Catches on all these stations were mainly made up of dab, grey gurnard *Eutrigla gurnardus* and sprat, with the largest amount (~150 kg) at prime 16. On August 14th primes 19, 20 and 21 were fished successfully. The first station of the day, prime 19, proved to be the largest with just under 600 kg of sprat and 130 kg of herring. Primes 20 and 21 consisted mainly of dab and herring, but of note was a significant amount of juvenile '0' group horse mackerel on prime 21.

Day 8 was spent in Danish waters, starting at prime 30 with a large catch of mackerel and dab (~1.5 t). This was followed up with the successful completion of the nearby prime 29, which yielded a more modest catch (250 kg+ of dab and just under 150 kg

mackerel). RV Cefas Endeavour then steamed north to prime 39. The EK60 sounder showed this area was replete with large herring shoals, with four appearing on the sounder during the tow; additionally, two pelagic fishing vessels were operating in the vicinity. This tow was reduced to 20-minutes, and led to over 1.5 t being brought on board, with the majority being herring (~850 kg) and sprat (over 500 kg).



Plate 3: 18 cm female saithe *Pollachius virens* caught at prime 28.

August 16th began to the south west, at prime 28. The survey worked west, successfully completing primes 28, 27, 26 and 25. Dab and grey gurnard were the mainstay species at all four stations in varying quantities, with a large haul of grey gurnard on prime 27 (over 450 kg). Of note, on prime 28, was the first saithe *Pollachius virens* of the survey, which was a small juvenile (Plate 3). By the next day the ship had steamed further west, to prime 38. The day was spent working west through primes 38, 37, and 36, and then north-west to prime 44. As with the previous day, dab and grey gurnard were dominant throughout the day, with over 600 kg of dab caught at prime 36, along with almost 30 kg of whiting. The catch at prime 36 yielded numerous juvenile gadoids, namely Norway pout and whiting, but also many cod *Gadus morhua*, both '0-groups' and larger juveniles (Plate 4).



Plate 4: Juvenile cod caught at prime 36

RV Cefas Endeavour steamed a short distance north-west to start the next day on prime 43. This was completed successfully with a catch of mainly herring (675 kg). As the day went on it became clear that herring were in abundance in the area from images on the EK-60 sounder. After the good catch at prime 43, this was followed up by a 20-minute tow at prime 42, slightly further to the west, which produced a large bag (3.2 t) of mainly herring. This was eclipsed further west again at prime 76 where 6.8 t of herring was brought aboard after a 20-minute tow. Finally, at prime 44 to the north, a more modest 1.1 t of herring were caught.

The next day, herring were once again in abundance. Prime 41 was the first station fished, yielding just under 800 kg. This was followed up by another very large catch (6.2 t) at prime 33 to the south-east and another 3.1 t at prime 34 further to the west. In summary; the seven hauls completed on August 18th and 19th resulted in over 22 tonnes of herring which, by way of comparison, was more than recorded in the entire survey in 2015 (~17.5 t). The final station fished on August 19th, prime 34, comprised a small selection of dab (~125 kg), lemon sole *Microstomus kitt* (~30 kg) and long-rough dab *Hippoglossoides platessoides* (~30 kg).

Overnight, the survey moved south to prime 24. This was completed successfully with a haul of mainly of herring (~180 kg) and just under 50 kg of haddock *Melanogrammus aeglefinus*. Primes 23 and 22 were then fished as the ship moved west. Prime 23 is often an interesting station; fishing through a gulley known as “Swallow Hole”. This year was no exception, with a very large mark observed on the sounder. For safety and practical reasons, the net was hauled after 18 minutes, which was deemed to also provide a representative subsample. Whilst over 750 kg of herring were brought on board, the EK60 revealed a huge mark of fish filling the bottom of the gulley itself (Plate 5). Of note in the catch was a snake blenny *Lumpenus lampretaeformis*. Prime 22 provided a much more modest sample of over 90 kg of whiting and some more herring (~20 kg).

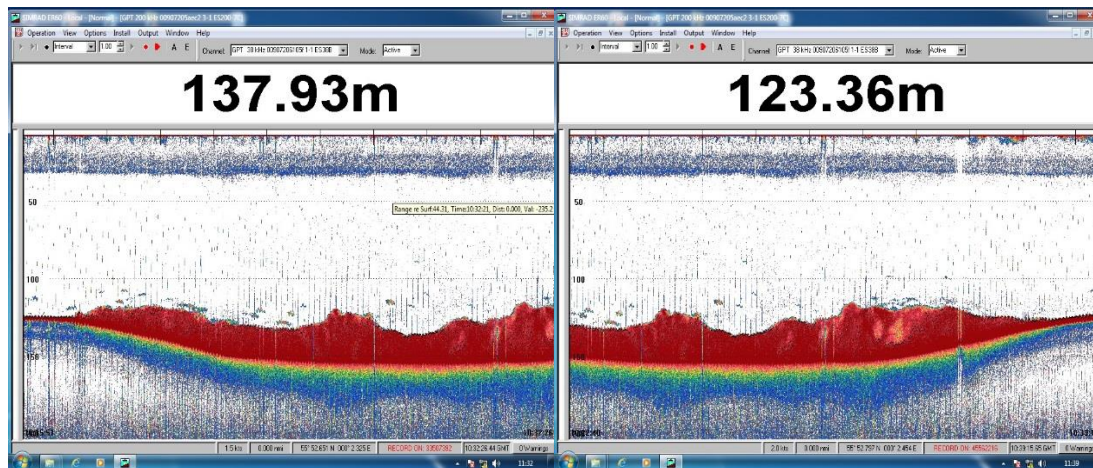


Plate 5. EK60 sounder images of “Swallow Hole”, shortly after completing prime 23

August 21st began further north at prime 32. Once again, herring was the dominant species caught, although not in the quantities seen a few days earlier. Over 0.5 t of clupeids were caught, along with almost 50 kg of haddock. After moving further west, to prime 31, the weather had become more unsettled and there was a small delay once on station, as time was taken for the swell to change direction before the net was shot. The station was fished successfully and another 0.5 t was brought on board. This catch consisted mainly of herring again, although there was a benthic component (~50 kg) and dab (~45 kg). Of most interest was the haddock, with ~50 kg caught, almost all of which were “0 group” juveniles. Once the gear was back on board RV Cefas Endeavour steamed for the port of Aberdeen, docking at 09:00hrs on August 22nd, to take on supplies and to allow a changeover of crew and some scientific staff. A slightly extended mid-survey break was scheduled this year to allow RV Cefas Endeavour to host a showcase event whilst in Aberdeen on 23rd August.

PART TWO

The survey resumed at 04:30hrs on August 24th, with a short steam from Aberdeen to prime 40. This served as a shakedown tow for the newly-joined crew and scientific staff and was successfully completed, yielding a small catch of mainly benthos (~65 kg), adult whiting (~55 kg) and a large number of juvenile gadoids – consisting of haddock, Norway pout and whiting. A long steam north-west to prime 51 gave plenty of time for staff to familiarise themselves with the task at hand. By 16:00 hrs the station had been fished with almost 400 kg of haddock and small amounts of whiting and Norway pout being caught.

The next day, work began at prime 52 and moved east during the day, through primes 53 and 45. All were successfully completed, with over 300 kg of haddock, nearly 400 kg of mackerel and over 100 kg of whiting caught at prime 52. Primes 53 and 45 saw the return of large concentrations of herring, with nearly two tonnes caught at prime 53 and then a larger bag of ~2.5 t brought in at prime 45. Along with the significant amounts of herring were gadoids of various size. At prime 53 it was noted that half the weight of Norway pout caught were “0 groups” (30 kg of 60 kg total).

By August 24th RV Cefas Endeavour was further north-east at prime 54. The first attempt to fish here was marred by the cod-end becoming tied up by the dog rope attached to the halving beckett. The station was classed as additional and re-fished, this time successfully, with a small catch of cod (20 kg), herring (40 kg+), Norway pout (150 kg+) and hake *Merluccius merluccius* (under 25 kg). Fishing progressed east and then south through primes 55 and 47, which saw approximately 650 kg of herring caught on each.

Overnight, the ship steamed north-east to prime 56. This station was completed successfully, with over 100 kg of haddock brought on board. To the south-east, prime 48 provided a slightly bigger catch of ~0.25 t of whiting and horse mackerel, before prime 49, further east again, saw a mix of benthos and Norway pout, along with some haddock (under 50 kg). In the catch at prime 49 was also a large female cod (108 cm, 12.2 kg). The final tow of the day, prime 50 - just a short distance to the east, yielded more benthos and Norway pout, along with over 200 kg of mackerel and just under 100 kg of saithe.

This composition would be a feature of catches over the next two days as the survey moved north through the Norwegian sector and then on to the most northerly stations. Primes 58, 57 and 65 all saw benthos and Norway pout, along with varying amounts of saithe, horse mackerel and mackerel. Of note, Prime 58 provided over 300 kg of saithe, although mainly juvenile fish and prime 65 had a large amount of blue whiting *Micromesistius poutassou*. By August 29th the ship was at prime 74 and work progressed west, successfully completing primes 74, 73, 72 and 71. Benthos and Norway pout were evident at all tows, as were saithe; at prime 74 almost 800 kg were caught – mainly juveniles but also a couple of large adults. At prime 71 it was also observed that a number of juvenile red fish *Sebastes viviparus* were part of the catch.

The next day started off at Lerwick, Shetland Isles, as a scheduled staff transfer was made to shore. With that successfully completed, there was a short steam to prime 66, with over 250 kg of hake, 150 kg of Norway pout, ~150 kg of saithe and haddock and around 70 kg of cod being caught, including another large female cod (104 cm, 11.3 kg). Unfortunately, it was later discovered that this tow had been wholly fished just south of the 60° line of latitude meaning it had been fished in ICES rectangle 48E9 instead of the planned rectangle 49E9. Moving east to prime 67, the station was declared invalid as, upon hauling, it was discovered that the headline had become fouled by the kite. The net was re-shot and after another 30-minute tow the gear came back aboard with severe damage to the belly (another invalid station). This brought an abrupt end to the fishing for the day.

Overnight the ship remained on station as the net was repaired; at first light the tow was attempted for a third time, and was successful. As the net came on board it was apparent that a large elasmobranch was caught in the sleeve. A 450 cm basking shark *Cetorhinus maximus* was removed from the net and returned to the sea as quickly as possible. Although alive when released, it was in a sluggish condition. The rest of the catch comprised of mainly saithe, Norway pout and benthos, which was indicative of the following hauls further east at primes 68 and 69. Of note during the day were two large saithe (prime 67, 108 cm, female, 11.7 kg and prime 68, 115 cm, male, 13.3 kg).

Prime 67 also had a large cod (108 cm, female, 16.7 kg) and a sea lamprey *Petromyzon marinus* (72 cm, 700 g, Plate 6), which was in good condition and released once station sampling was complete.



Plate 6: Sea Lamprey caught at prime 67

By the start of September 1st, RV Cefas Endeavour was at prime 75, the deepest of the survey at a depth of over 230 m. As in previous years, an interesting catch was brought aboard, mainly dominated by blue whiting (almost 200 kg) and horse mackerel (150 kg+). There was also a number of large *Argentina* spp. which had been seen here in 2015. Also of note was a common skate *Dipturus batis* (cf. *intermedia*) (99 cm, female, 4.76 kg) and a soft head rat-tail *Malacocephalus laevis* (37 cm total length, 125 g, Plate 7). Due to the distance involved, only one other station could be reached during daylight; prime 70 to the south yielded almost 250 kg of horse mackerel and around 130 kg of saithe. There was, however, time to complete two additional experimental tows on this station, both resulting in similar species composition aside from a larger proportion of saithe.



Plate 7: Soft head rat-tail caught on prime 75

During the night the survey moved south-west to prime 64. Tows were completed successfully here and further west at primes 63 and 62. Norway pout were in abundance at each station, along with varying quantities of haddock, herring and whiting. At prime 64, over 35 kg of cod were caught, mainly in the 2–3 year class range. As with the previous day, there was time to attempt two additional experimental tows at prime 62. Again, they were similar in composition, although a number of wolffish *Anarhichas lupus* were also found to be present.

On September 3rd fishing commenced at prime 59, close to the Orkney Isles. While this tow was completed successfully, there was a large amount of curly weed *Alcyonidium diaphanum* amongst the catch. This was present at all three stations fished during the day and gave diverse catches of smaller fish that may have been associated with this bryozoan, such as dragonets *Callionymus* spp., small rays *Raja* spp., and juvenile gadoids. Prime 59 also comprised of haddock and some herring; haddock was also the most abundant species by weight at the following prime 60. The final station of the planned survey was at prime 61; this yielded a large quantity of Norway pout, saithe and over 0.25 t of cod – the largest catch seen on this survey for many years; 113 individuals ranged from 31 cm–87 cm.

With the Cefas survey complete, RV Cefas Endeavour steamed south-east to complete two stations (ICES rectangles 41F4 and 41F5) that Marine Scotland Science had been unable to complete during their IBTS survey. En-route, on September 4th, there was enough time to stop at primes 54 and 55 and complete two additional experimental tows at each. Both stations saw catches dominated by herring and Norway pout, as seen a week earlier.

The next day the two standard IBTS tows were completed for Scotland, with dab and grey gurnard making up the majority of both hauls. The ship then steamed south-west and managed another two additional experimental tows at prime 26. These were both small catches, very similar to those seen earlier in the survey. The following day an additional experimental tow was fished further south at prime 10 and then prime 9. The former saw over 500 kg of sprat caught, whilst the latter was a very small catch of whiting and grey gurnard. With fishing complete, RV Cefas Endeavour then made for home port in Lowestoft, docking at 12:15 hrs, September 7th 2016.

RESULTS

Aim 1: A valid GOV trawl haul was successfully completed at all 76 prime stations (Table 1; Figure 1). During the course of the survey, another 14 stations were fished as ‘Additional’, and three recorded as ‘Invalid’ due to gear damage - all of which were repeated to gain valid samples. Another two stations were completed upon request of Marine Scotland in ICES rectangles 41F4 and 41F5. These were classed as ‘Valid’ and processed in the same vein as a Cefas prime station. Surface and bottom salinity samples, along with a vertical cast of the ESM2 logger profile were undertaken at 51 of the prime stations, with an additional 21 ESM2 profiles taken at separate prime stations (Figure 2).

Gear: The survey was fished using GOV hybrid trawl number 1. Scanmar sensors were used to monitor headline height, wing spread and door spread (Figure 3).

Catches: At each station, the catch of each species was weighed and all fish, or representative sub-samples, were measured. Table 2 lists the species caught that were sampled for length, whilst Table 3 ranks the top 15 species by weight compared with the last four year’s surveys. Samples of otoliths for age determination and other biological information were taken for a range of commercial species (Table 4). All data was recorded to computer database using Cefas’ Fisheries Electronic Data Capture (FEDC) system.

Gear	Valid	Additional	Invalid	Total
GOV (IBTS Standard gear)	76 (+2)	14*	3	95
Niskin Bottle + ESM2 profiler	51	0	0	51
ESM2 only	0	21**	0	21

Table 1. Number of trawls and CTD casts made during the survey

*11 were comparative tows, one gave non-representative catch and two had gear problems

**Requested by the HIGHROC project as per secondary aim 13

Figures 4—13 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 (*Sprattus sprattus*), plaice (*Pleuronectes platessa*) and hake (*Merluccius merluccius*), respectively.

Species common name	Scientific name	2016 weight (kg)	2015 weight (kg)	2014 weight (kg)	2013 weight (kg)	2012 weight (kg)
Herring	<i>Clupea harengus</i>	34945	17522	8887	15035	9402
Dab	<i>Limanda limanda</i>	3587	3102	3089	2135	2466
Mackerel	<i>Scomber scombrus</i>	3450	3597	3214	3825	3821
Haddock	<i>Melanogrammus aeglefinus</i>	2525	2240	2542	1625	2264
Whiting	<i>Merlangius merlangus</i>	2468	2974	2355	1129	2257
Sprat	<i>Sprattus sprattus</i>	2367	1920	3724	2128	456
Saithe	<i>Pollachius virens</i>	2349	1470	1189	866	1426
Horse mackerel	<i>Trachurus trachurus</i>	1905	5596	1115	1324	868
Norway pout	<i>Trisopterus esmarkii</i>	1813	2320	1712	1732	1182
Grey gurnard	<i>Eutrigla gurnardus</i>	1301	1488	1638	1041	1000
Hake	<i>Merluccius merluccius</i>	1084	767	548	705	588
Cod	<i>Gadus morhua</i>	753	624	501	343	485
Plaice	<i>Pleuronectes platessa</i>	506	469	529	452	522
Lemon sole	<i>Microstomus kitt</i>	336	234	222	128	225
Long-rough dab	<i>Hippoglossoides platessoides</i>	305	170	305	146	280

Table 2. Top 15 species by weight compared with the previous four year’s surveys

Species	Common Name	Stns	Species	Common Name	Stns
<i>Aequipecten opercularis</i>	queen scallop	21	<i>Lycodes gracilis</i>	Vahl's eelpout	1
<i>Agonus cataphractus</i>	pogge (Armed bullhead)	16	<i>Malacocephalus laevis</i>	Soft-head rattail	1
<i>Alloteuthis subulata</i>		22	<i>Melanogrammus aeglefinus</i>	haddock	54
<i>Amblyraja radiata</i>	starry ray	39	<i>Merlangius merlangus</i>	whiting	73
<i>Ammodytes marinus</i>	Raitt's sandeel	3	<i>Merluccius merluccius</i>	hake	32
<i>Anarhichas lupus</i>	wolf-fish	4	<i>Micromesistius poutassou</i>	blue whiting	8
<i>Arctica islandica</i>	ocean quahog	4	<i>Microstomus kitt</i>	lemon sole	60
Argentinidae	argentines	33	<i>Molva molva</i>	common ling	13
<i>Arnoglossus laterna</i>	scaldfish	17	<i>Mullus surmuletus</i>	red mullet	13
<i>Aspitrigula cuclus</i>	red gurnard	3	<i>Mustelus asterius</i>	starry smooth-hound	4
<i>Belone belone</i>	garfish	1	<i>Myoxocephalus scorpius</i>	bullrout	4
<i>Brosme brosme</i>	tusk	1	<i>Myxine glutinosa</i>	hagfish	6
<i>Buglossidium luteum</i>	solonette	20	<i>Necora puber</i>	velvet swimming crab	5
<i>Callionymus lyra</i>	common dragonette	31	<i>Nephrops norvegicus</i>	Norway lobster	12
<i>Callionymus maculatus</i>	spotted dragonette	27	Octopodidae		20
<i>Callionymus reticulatus</i>	reticulated dragonette	5	<i>Pecten maximus</i>	scallop	4
<i>Cancer pagurus</i>	edible crab	26	<i>Petromyzon marinus</i>	sea lamprey	1
<i>Capros aper</i>	boar fish	3	<i>Phrynorhombus norvegicus</i>	Norwegian topknot	1
<i>Cetorhinus maximus</i>	basking shark	1	<i>Phycis blennoides</i>	greater forkbeard	1
<i>Clupea harengus</i>	herring	71	<i>Platichthys flesus</i>	flounder	2
<i>Cyclopterus lumpus</i>	lumpsucker	1	<i>Pleuronectes platessa</i>	plaice	61
<i>Dicentrarchus labrax</i>	European seabass	1	<i>Pollachius pollachius</i>	pollack	1
<i>Dipturus batis</i> cf. <i>intermedia</i>	common skate	1	<i>Pollachius virens</i>	saithe	32
<i>Enchelyopus cimbrius</i>	four-bearded rockling	13	<i>Raja clavata</i>	thornback ray	3
<i>Engraulis encrasicolus</i>	european anchovy	8	<i>Raja montagui</i>	spotted ray	3
<i>Eutrigula gurnardus</i>	grey gurnard	71	<i>Rossia macrosoma</i>		12
<i>Gadiculus argenteus</i>	silvery pout	12	<i>Salmo trutta</i>	sea trout	1
<i>Gadus morhua</i>	cod	38	<i>Sardinia pilchardus</i>	pilchards	3
<i>Galeus melastomus</i>	black-mouth dogfish	1	<i>Scomber scombrus</i>	European mackerel	63
<i>Glyptocephalus cynoglossus</i>	witch	21	<i>Scophthalmus maximus</i>	turbot	9
<i>Gobius</i> spp.	gobies	2	<i>Scophthalmus rhombus</i>	brill	4
<i>Hippoglossoides platessoides</i>	American plaice (long rough dab)	50	<i>Scyliorhinus canicula</i>	lesser spotted dogfish	29

<i>Hippoglossus hippoglossus</i>	halibut	2	<i>Sebastes viviparus</i>	redfish	2
<i>Homarus gammarus</i>	lobster	3	Sepiolidae		4
<i>Hyperoplus lanceolatus</i>	greater sandeel	13	<i>Solea solea</i>	dover sole	7
<i>Illex illecebrosus</i>	northern shortfin squid	8	<i>Sprattus sprattus</i>	sprat	35
<i>Lepidorhombus whiffiagonius</i>	megril	10	<i>Squalus acanthias</i>	spurdog	7
<i>Leucoraja fullonica</i>	shagreen ray	1	<i>Todarodes sagittatus</i>	flying squid	1
<i>Leucoraja naevus</i>	cuckoo ray	9	<i>Todaropsis eblanae</i>	lesser flying squid	10
<i>Limanda limanda</i>	dab	67	<i>Trachinus vipera</i>	lesser weever	11
<i>Liparis liparis</i>	sea snail	1	<i>Trachurus trachurus</i>	horse mackerel	32
<i>Lithodes maja</i>	stone crab	24	<i>Trigla lucerna</i>	tub gurnard	11
<i>Loligo forbesi</i>	northern squid	26	<i>Triglops murrayi</i>	sculpin	1
<i>Loligo vulgaris</i>	European squid	2	<i>Trisopterus esmarki</i>	Norway pout	41
<i>Lophius budegassa</i>	black-bellied anglerfish	4	<i>Trisopterus luscus</i>	bib pouting	4
<i>Lophius picatorius</i>	anglerfish (monkfish)	39	<i>Trisopterus minutus</i>	poor cod	21
<i>Lumpenus lampretaeformis</i>	snake Blenny	1	<i>Alosa fallax</i>	Twait shad	1
			<i>Zeus faber</i>	John Dory	1

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

Species	Number of samples taken
Whiting	1865
Plaice	1408
Haddock	1393
Herring	1311
Saithe	616
Norway pout	442
Hake	439
Cod	420
Mackerel	407
Dab	247
Lemon sole	239
Grey gurnard	235
Monkfish	70
Tub gurnard	64
Witch	46
Ling	45
Red mullet	42
Four-bearded Rockling	22
Turbot	12
Red gurnard	7
Brill	5
John Dory	5
Lesser spotted dogfish	69
Starry smooth hound	32
Spurdog	8
Shagreen ray	1
Total	9450

Table 4. The number of biological samples taken by species

Gadiformes

As can be seen in Table 2, cod has continued to increase in annual catch weight, with its highest catch weight (753 kg) in the last five years, although it should be pointed out that over 250 kg were caught at one station (prime 61). Whilst the majority of the cod seen were juveniles, there were a number of larger adults that would have been part of the spawning stock. In terms of distribution, cod were seen at a similar number of stations to that of 2015 (Table 3; 38 in 2016 compared to 39 in 2015). Haddock catches were slightly up on last year's survey, with 2525 kg caught, compared to 2240 kg in 2014 and are at similar levels to that also seen in 2014. The increased catch weight is in line with an increase in its distribution; 54 stations in 2016, more than last year (50).

Whiting quantities were reduced somewhat from 2015, down to 2468 kg in total, but still much higher than seen back in 2013 (1129 kg). The distribution of whiting has increased to the point where it was the most widely observed species in this year's survey, caught at 73 of the 76 stations sampled. The number of otoliths collected (Table 4) indicates a larger size range seen on the survey, with over 400 more fish sampled this year compared to 2015. Norway pout catches were also reduced this year, with a drop of nearly 500 kg from the previous year. It should be noted, however, that 2015 looks to have been a singularly good year, compared to this and previous years. Despite a reduced quantity seen, the distribution of Norway pout has increased since the previous year, having been recorded at 41 stations fished (compared to 36 in 2015).

In contrast, this year hake has almost doubled in weight caught since 2014 with 1084 kg. Although its distribution has not changed much (seen at 32 stations, compared to 30 in 2015), and over 150 kg were seen at prime 75 alone. Hake abundance seems to be strengthening year on year. Saithe also saw a large increase in catch weight – the most seen in the last five years at 2349 kg. As with the cod, while many saithe were juvenile fish, there were also a few very large individuals present. Saithe have been seen slightly further afield this year, compared to 2015, being caught at 32 of the prime stations sampled (compared to 28 the previous year).

Pleuronectiformes

Plaice quantity saw a slight rise this year, but its 506 kg is relatively similar to that seen over the past four surveys. In terms of its distribution, plaice remains one of the North Sea's most ubiquitous flatfish species, seen at 61 of the 76 sampled stations. Lemon sole's distribution across the survey's prime stations has remained relatively unchanged since 2015 (61 in 2016 compared to 60 in 2015). Its total weight however, has risen by almost a third to 336 kg. In a similar vein to the hake and saithe, lemon sole abundance seems to show encouraging signs over the last three years.

Dab catches were at a five-year high this year, with it becoming the second highest species by weight seen by the survey in 2016 with 3587 kg. This follows on from increasing quantities observed over the last three years. Its abundance has also increased to be seen at 67 prime stations, compared to 61 in 2015.

Pelagic fish

The largest change in total fish weight was undoubtedly herring. With the 17.5 t caught last year (then as a four-year high), to be nearly doubled this year to 34.9 t, suggests a huge increase in numbers in the North Sea. Most of the catches were made up of spawning-capable fish. Over 22 tonnes were caught across just seven stations from 56.50°— 57.50° latitude and 0°—3° longitude on August 18th and 19th. The distribution has also increased from seen at 67 prime stations in 2015, to 71 this year.

The total catch of mackerel was similar to that seen in 2015, with quantities caught remaining relatively stable over the past five years. Distribution has remained close to what was seen on last year's survey, the 3450 kg caught seen across 63 stations this year. After a surprising four-year high in 2015, horse mackerel was down this year by over half. The station catches of between 500—1000 kg seen last year were much

reduced in 2016 with the largest at prime 8 having only 325 kg. The total catch of 1905 kg seen this year is still greater than what was seen prior to 2015. Despite the drop in catch weight, relative distribution has increased from being sampled at 52 stations last year, to 56 this year.

Sprat was observed on two less stations this year, compared to 2015. Despite this, total catch weight was up by over 400 kg. While not at the levels of 2014, this year's catches show similarities with what was seen in 2013. It should be noted, however, that of the 2367 kg caught this year, over two tonnes were caught in only four stations; primes 19, 20, 37 and 39. Small numbers of pilchard *Sardinia pilchardus* were seen in the first couple of days of the survey in the southern North Sea, their numbers much reduced from 2015. In a similar respect, anchovies were found in small numbers, but in a wider distribution.

Elasmobranchs

Compared to 2015, where 387 kg of elasmobranchs were caught, this year's survey has been very similar, with 362 kg sampled. Once again, lesser-spotted dogfish *Scyliorhinus canicula* was the most abundant (147 kg), an increase on 2015's 112 kg. Starry ray *Amblyraja radiata* and thornback ray *Raja clavata* had totals of 55 kg and 70 kg respectively, with thornback ray only being caught at stations in the southern North Sea. Of note this year was the basking shark *C. maximus* seen at prime 67, the first time this survey has recorded this species. Also worth noting was a shagreen ray *Leucoraja fullonica* seen at prime 59 and a common skate *Dipturus batis* (cf. *intermedia*) at prime 75; this was interesting as the previous four years had seen this species caught much further south-west and closer to Scotland.

Cephalopods and commercial shellfish

Alloteuthis subulata caught on this year's survey was up in total weight to similar levels seen in 2014. Almost 11.5 kg were surveyed, compared to the 3 kg seen last year. Northern squid *Loligo forbesi*, similarly, was also up this year to 31 kg compared to only 16 kg in 2015. After a large increase last year, the lesser flying squid *Todaropsis eblanae* was back to the quantities similar to that seen in 2014.

Edible crab *Cancer pagurus* was seen at 26 prime stations this year, compared to only 17 in 2015. As a result, catch totals were up to 70 kg.

Ichthyological observations

Sixty-six fish species were observed during this year's survey. Of note was a sea lamprey *P. marinus*, brown trout *S. trutta*, soft-head rat-tail *M. laevis* and common skate *D. batis* (cf. *intermedia*). *Sebastes viviparus* was also recorded on two stations. In keeping with previous years; additional length-weight data were collected from species such as the greater sandeel *Hyperoplus lancolatus* and pilchards *Sardina pilchardus*.

Macrobenthos

A total of 137 species of macrobenthos were observed during the course of the survey, with the common starfish *Asterias rubens* the most prolific, seen at 61 of the 76 stations sampled. Four species were brought back for identification and further study.

Marine Litter

Litter caught in the trawl was recorded at every station, with 442 pieces detailed across 72 stations. As can be seen in figure 14, plastics made up the vast majority of litter seen on the survey. It should be pointed out that although the total amount of litter items seen is much higher than last year's survey (n=198), this is due mainly to a change in the recording procedure to detail each specific item. In previous surveys, pieces of the same litter item e.g. monofilament fishing line, would have been grouped together and recorded as one piece of litter.

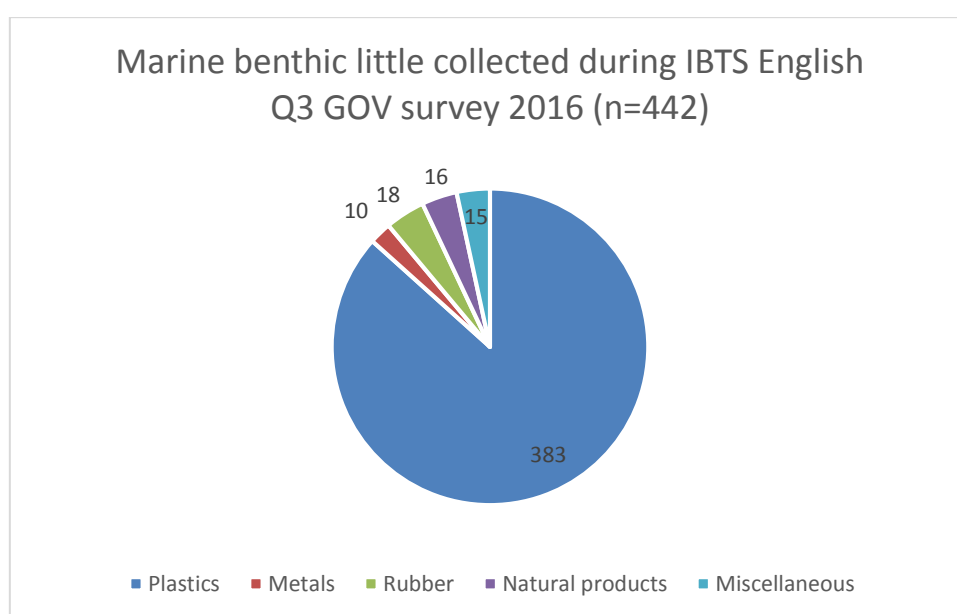


Figure 14. Breakdown by category of the marine litter collected during the survey

Aim 2: Samples were collected for Caesium/Tritium analysis at all 39 requested prime stations.

SECONDARY AIMS:

Aim 3. A total of 20 elasmobranchs were in good enough condition to be tagged and released. Length, sex and weight were recorded, along with maturity status for male specimens, before a Petersen disk was attached. Positional information was also detailed. Starry smooth-hound *Mustelus asterias* was the main species tagged (n = 14), with other species tagged being spurdog *Squalus acanthias*, shagreen ray and common skate.

Aim 4. 12 species were frozen for further study. These included the snake blenny *Lumpenus lamprettaeformis*, eelpout *Lycodes gracilis*; *Sebastes spp.* and soft nose rat-tail *M. laevis*. Elasmobranchs such as spurdog and tope *Galeorhinus galeus* were also collected if they were found to be dead upon hauling.

Aim 5. 24 smooth-hounds *Mustelus spp.* were retrieved dead on this year’s survey. These were frozen and taken back for further study.

Aim 6. One twaite shad *Alosa fallax* (43cm, 610g) was caught on prime station 6. This was frozen and retained for further study.

Aim 7. Continuous data were collected throughout the survey from the Simrad EK60 split beam sounder at four operating frequencies (38 kHz, 120 kHz, 200 kHz and 333kHz).

Aim 8. Over 100 empty ray egg cases were collected across the 96 fishing stations completed. These were frozen and brought back for analysis by the Shark Trust.

Aim 9. Cetacean monitoring was carried out by volunteers from the Sea Watch Foundation throughout the survey. Table 5 shows total individuals of each species observed over 26 days during the survey. This is a slight reduction of total days at sea due to poor conditions, such as high swell or low visibility. The total individuals recorded was 178, seen across 52 observations during the survey.

It is important to take into consideration the possibility of repeat sightings in a localised area, which could explain the larger number of individual dolphins observed.

Species	08 to 23 August 2016 (14 days/115hrs max. observing)		24 August - 6th September 2016 (12 days/97 hrs observing)	
	Individuals	Sightings	Individuals	Sightings
Baleonoptera	1	1		
Common Bottlenose Dolphin (<i>Tursiops truncatus</i>)			3-4	1
Common Dolphin (<i>Delphinus delphis</i>)			7	3
Harbour Porpoise (<i>Phocoena phocoena</i>)	44	10		
Minke Whale (<i>Balaenoptera acutorostrata</i>)	9	9	2	2
Unidentified dolphin species	27	5		
White beaked dolphin (<i>Lagenorhynchus albirostris</i>)	85	21		

Table 5. Total cetacean sightings across the survey

Aim 10. This project was completed shortly before the commencement of the survey. As a result, no data were collected regarding incident mortality of *C. pagurus*.

Aim 11. Jellyfish were sampled to better understand their species distributions and abundance in the North Sea, and how this changes in relation to fishing practices, the abundance of other organisms, hydrological conditions and climate change.

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 with a good enough body condition were individually weighed and measured by diameter, the total results can be seen in Table 6. Any specimens too damaged to identify were bulk weighed and recorded. Three stations (Prime Stations 21, 40 and 45) had no jellyfish in the catch.

	Total Weight (g)	# of Individuals	Weight Range (g)	Length Range (cm)	Prime Station with Highest	
					Weight	# Individuals
<i>Aurelia aurita</i> Moon jellyfish	2,105.3	53	2.7-144.3	3-15	STN 51 (1,318)	STN 51 (41)
<i>Cyanea lamarckii</i> Blue jellyfish	1,384.4	17	10.5-156.3	6-20	*STN 40 (199.2)	*STN 52 (3)
<i>Cyanea capillata</i> Lion's mane jellyfish	152,496.3	592	12.6-1,082	3-70	STN 53 (12,718.6)	STN 53 (49)
<i>Cyanea</i> species	1,930.7	98	1.7-95.3	3-67	STN 54 (399)	STN 54 (19)
<i>Periphylla</i> <i>periphylla</i> Helmet jellyfish	572.4	13	7.8-92.9	4-11	STN 72 (359.9)	STN 72 (6)
<i>Pelagia noctiluca</i> Mauve stinger	847	19	9.7-103.3	4-12	STN 71 (474.2)	STN 71 (11)
<i>Aequorea</i> species Cristal jellies	497.8	17	3.5-105	4-12	STN 60 (166.4)	STN 10 and 60 (3)
Unidentified species	656.9	**4	13.5-132	4-15	STN 66 (409)	**STN 52 (2)

Table 6 Summary of total cnidarians sampled during survey

*The highest weight and number of Blue jellyfish was actually found at the additional station done for Scotland at ICES rectangle 41F1 but there was no prime number station to be recorded.

**At prime station 66 the bulk weight of unidentified number of species was taken (409g) because it was not possible to distinguish the number of separate individuals.

Aim 12. A total of 69 lesser spotted dogfish were sampled for maturity and life history information. Dead specimens were assessed for length, weight, sex, maturity, ovary weight, shell glad width and maximum follicle diameter.

The smallest dogfish analysed was a 38 cm female, weighing 156 g from prime 10; the largest, a 74 cm male weighing 1271 g from prime 67.

Aim 13. Discrete water samples for analysis of chlorophyll and suspended particulate materials (SPM), phytoplankton functional groups (by flow cytometry) and salinity were collected at the sub-surface (4 m depth, from the de-bubbler of the Ferrybox) and at the bottom (using Niskin bottles), at different sampling stations (Table 1).

Vertical profiles of temperature, salinity, chlorophyll fluorescence, optical backscatter (turbidity), dissolved oxygen concentration, and Photosynthetically Available Radiation (PAR) were carried out at prime sampling stations using an ESM2 profiler (Table 1). Throughout the survey, the Ferrybox collected continuous measurements of surface temperature, salinity, chlorophyll fluorescence, turbidity, oxygen concentration and water pH.

The discrete samples collected (salinity, chlorophyll, SPM) will be used for validation of measurements from the ESM2, the Ferrybox, as well as ocean colour space-born maps under the EU FP7 project HIGHROC (HIGH spatial and temporal Resolution Ocean Colour products and services; <http://www.highroc.eu/>). PAR profiles will be used to estimate the underwater light attenuation coefficient (K_d), which in turn will be used to validate ocean colour maps of K_d .

	Total	Surface	Bottom
		Ferrybox	Niskin
Salinity	110	55	55
Chlorophyll (duplicates)	57	57	
SPM	57	57	
Flow Cytometry (duplicates)	56	56	
CTD profiles with ESM2	72		

Table 7. Number of samples collected for analysis of salinity, chlorophyll and SPM concentration, and phytoplankton functional groups by flow cytometry, during the course of the survey. Total number of vertical profiles carried out with ESM2 are also given.

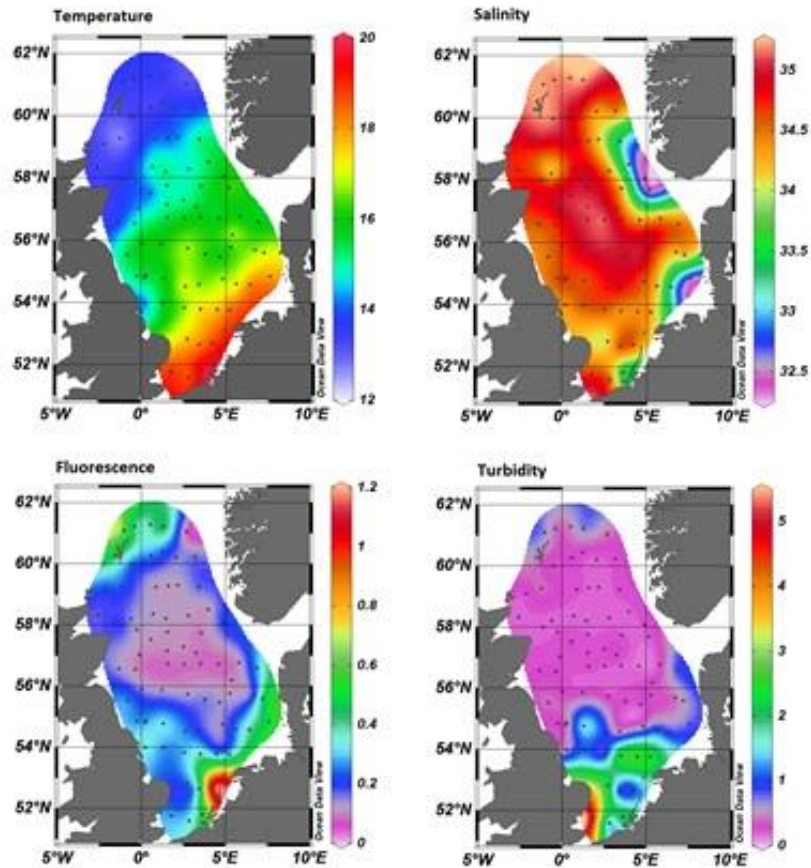


Figure 15. Temperature, salinity, fluorescence and turbidity distribution, at 4 m depth, recorded by the Ferrybox during the survey. Maps were prepared with the software Ocean Data View.

Preliminary analysis of data collected by the Ferrybox at the sampling stations shows that surface temperature was highest in the southern North Sea and gradually decreased towards the northern sampling stations (range 12.5 – 19.8 °C). The lowest salinity was observed in the German Bight and off the Skagerrak / Norwegian Trench (range 32.3 – 35.24; Figure 15).

Phytoplankton chlorophyll fluorescence was highest off the Dutch coast, in the German Bight and in the northern North Sea (Shetland Islands); while the lowest fluorescence was detected mainly north of the Dogger Bank, in the central and northern North Sea (Figure 15).

Turbidity of surface water, measured by the Ferrybox, was highest off the Thames estuary and in the southern North Sea, the highest level of turbidity was likely the result of re-suspension of sediments from the sea floor.

Aim 14. Over 200 whole individuals covering 12 species were kept for further study into feeding relationships with jellyfish. These include haddock, mackerel, lemon sole and saithe.

Aim 15. Survey CEnd 18/16 presented an opportunity to collect samples across the North Sea in support of the N.E.R.C. funded LOCATE project. LOCATE is investigating the land-to-ocean transfer of carbon and how such fluxes relate to land type around the UK. Data collected during this survey will provide the marine context for carbon

fluxes obtained during LOCATE fieldwork activities to be conducted around the UK throughout 2017/18.

Water samples were collected from the ship's non-toxic underway seawater supply (after passing through the Ferrybox system), on a 2-3 hourly basis throughout the day (Figure 15). This typically resulted in 7 samples per day for the following parameters. In total 148 samples were collected.

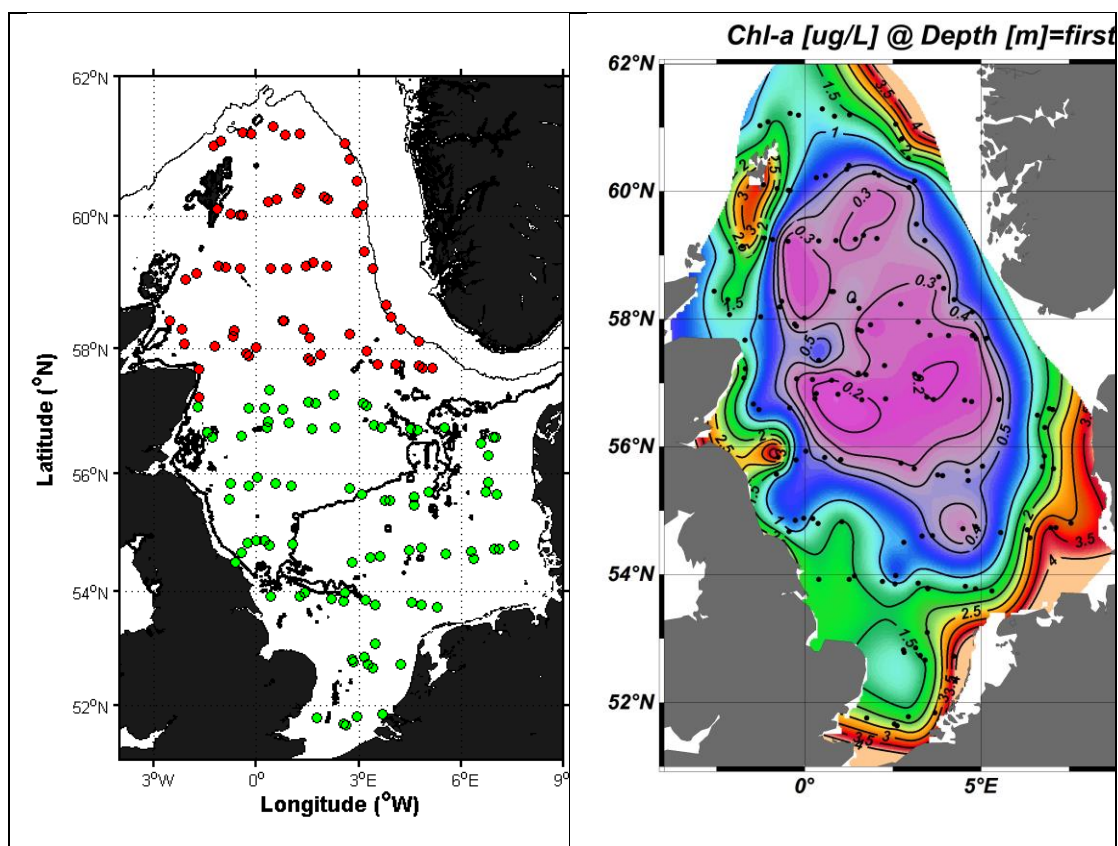


Figure 15: Map of sampling locations. Green dots Leg 1, red dots Leg 2 of survey.

Figure 16: Preliminary surface chlorophyll

Chlorophyll-a: 250 ml of seawater was filtered through a 25 mm glass fibre filter (GF/F nominal pore size 0.7 μm), inoculated with 6 ml of 90% acetone and placed in a refrigerator for 16-20 hours. After this time sample fluorescence was measured on a calibrated Turner Trilogy fluorometer and results converted to chlorophyll concentration. A preliminary map of surface chlorophyll is shown in Figure 16.

Particulate organic matter (POC/PON/POP): 1 litre of seawater was filtered onto pre-ashed (>6 hours at 450°C) and acid cleaned (24 hours in 10% HCl) 25 mm glass fibre filters for POC/PON and POP sample collection. POC/PON filters were placed into plastic cryovials and POP samples were placed into pre-ashed glass test tubes and sealed with parafilm. All filters were frozen (-20°C) and transported back to NOC for subsequent analysis.

Salinity: A single salinity sample was collected at each sampling point into a glass salinity bottle. All samples will be analysed after return to NOC.

Inorganic nutrients: Seawater samples were filtered through 0.2 µm syringe end filters into 60 ml HDPE bottles and frozen (-20°C). Samples will be sent to Malcolm Woodward at Plymouth Marine Laboratory for analysis.

Dissolved organic nutrients (DOC/DON/DOP): Duplicate seawater samples for subsequent DOC/DON and DON/DOP analysis were collected into 125 ml HDPE bottles and frozen (-20°C). Samples 1-21 were filtered through 47 mm 0.2 µm polycarbonate filters but difficulties with the inline filtration system meant that confidence in the filtration were low (the filter frequently leaked). Use of the inline filtration system could not be sustained and samples 22 onwards were not filtered.

Fluorescent Dissolved Organic Matter (FDOM): Seawater samples were filtered through 0.2 µm syringe end filters into 50 ml plastic centrifuge tubes and placed into a refrigerator until analysis. At the end of each day all samples were allowed to warm to room temperature before analysis on a Cary Eclipse Fluorescence Spectrophotometer and a Cary 60 UV-Vis absorbance instrument using protocols provided by BGS.

Aim 16. Due to the medical emergency occurring on day three of the survey, this work could not be completed.

Special thanks are given to the officers and crew of RV Cefas Endeavour and the scientists for all of their enthusiasm and hard work in making this survey a success. Also, to Sophy McCully Phillips, Jim Ellis and Ian Holmes for their support before, during and after the survey was completed.

Ben Hatton
Scientist in Charge
09/09/16

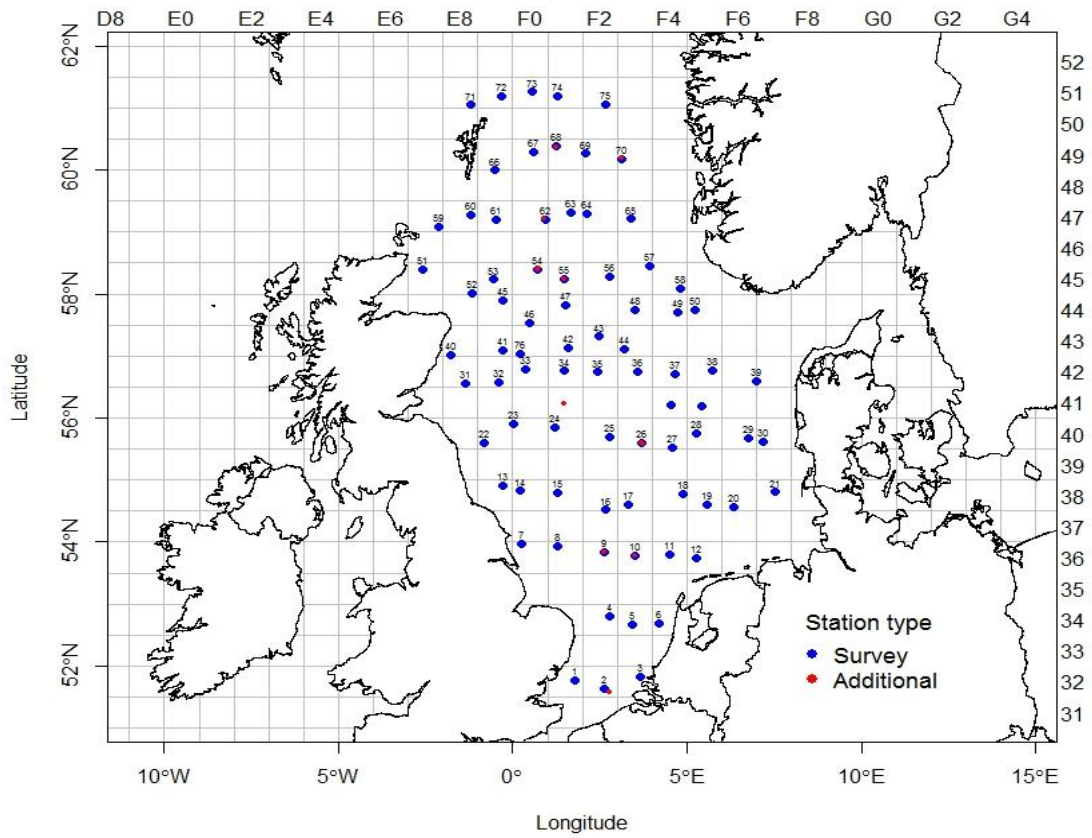


Figure 1: Fishing stations of IBTS North Sea Ground Fish Survey 2016

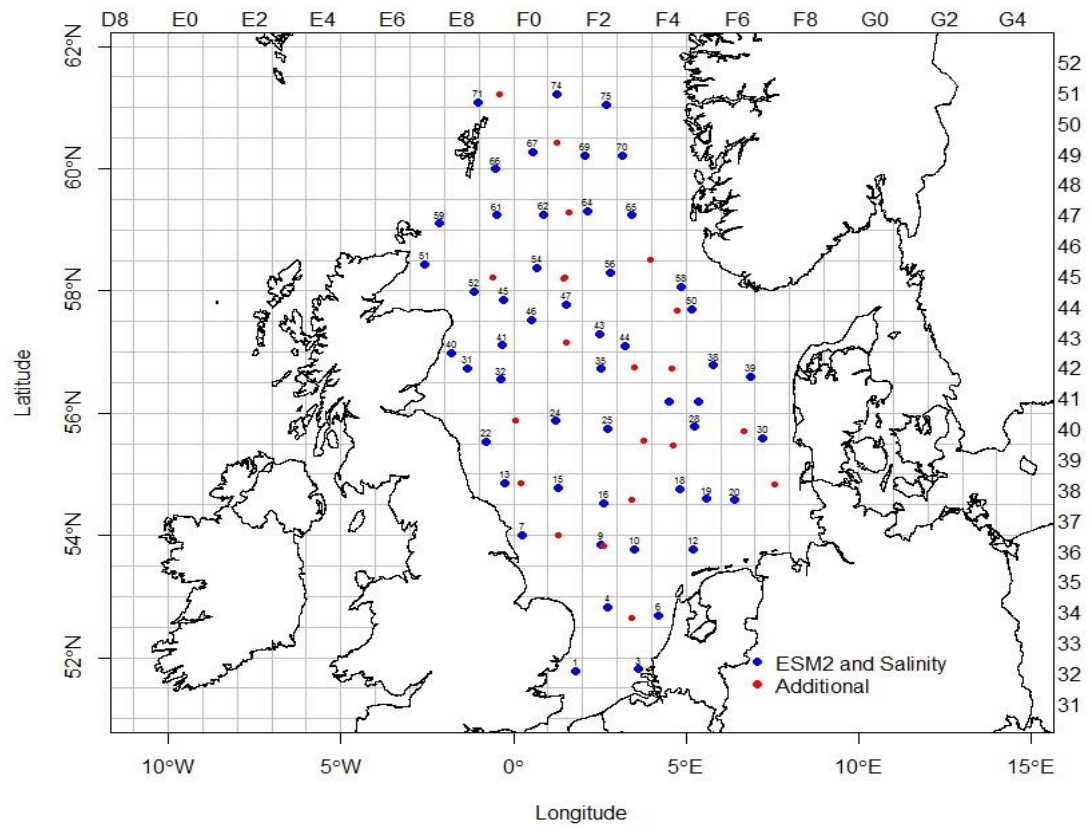


Figure 2: Station positions where vertical casts with ESM2 logger and Niskin bottle were undertaken

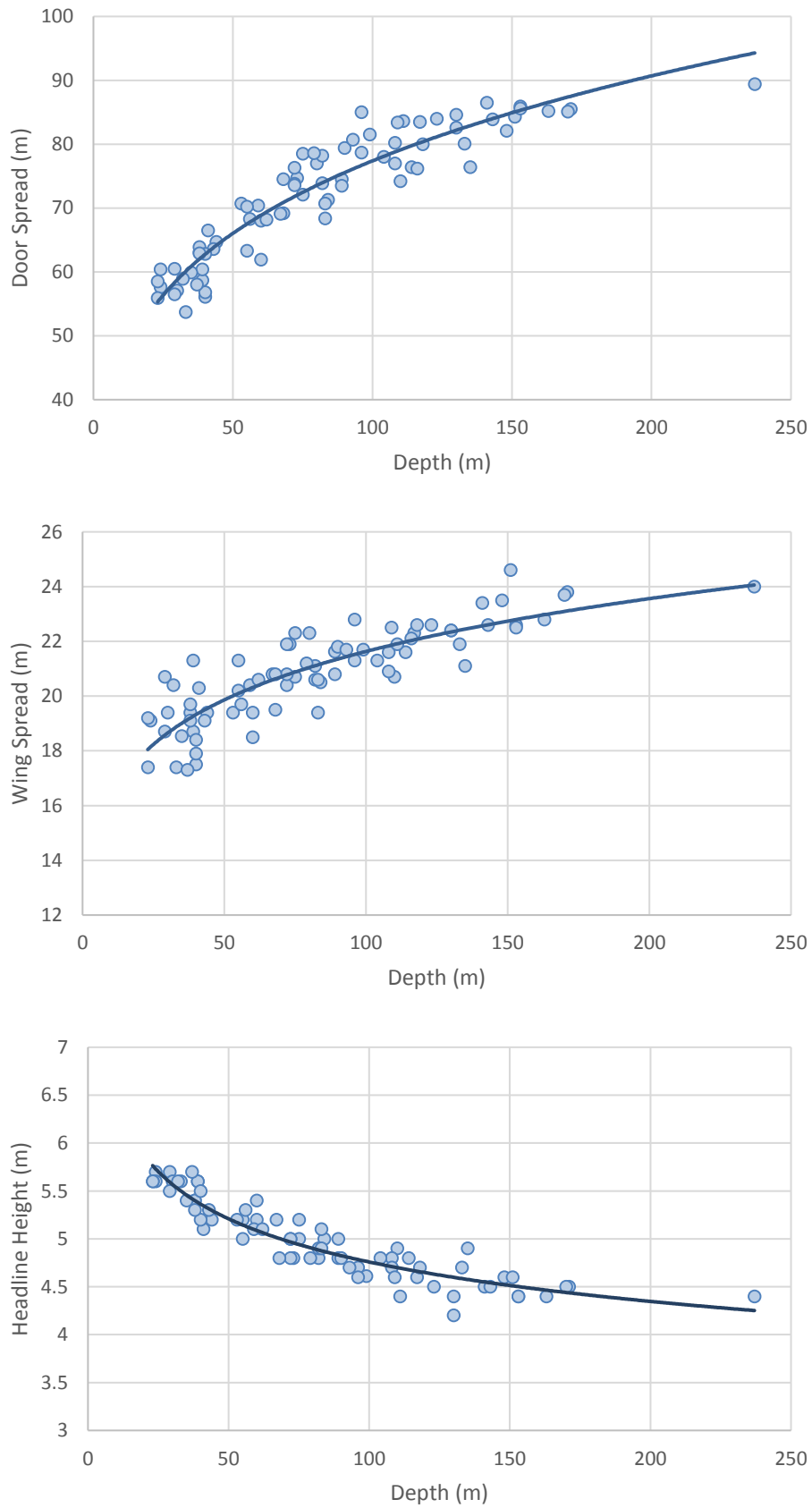


Figure 3: Relationships between mean headline height, wing spread and door spread with water depth, as recorded during valid hauls.

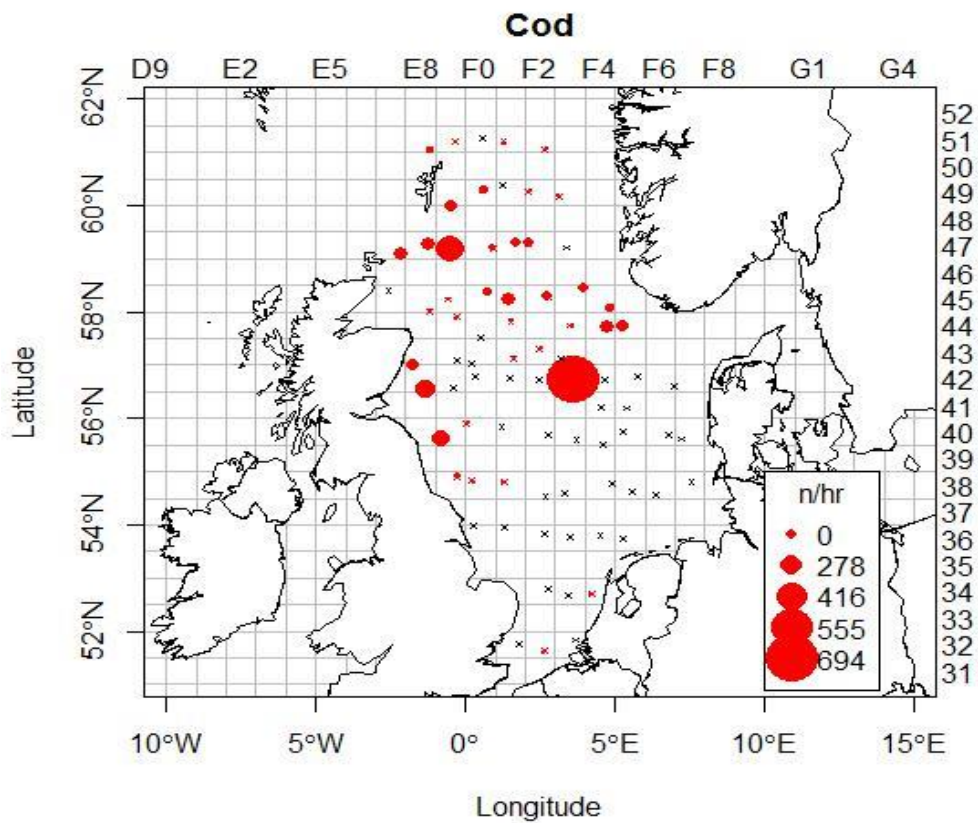


Figure 4: Distribution and relative abundance (raised numbers per hour) of cod (*Gadus morhua*)

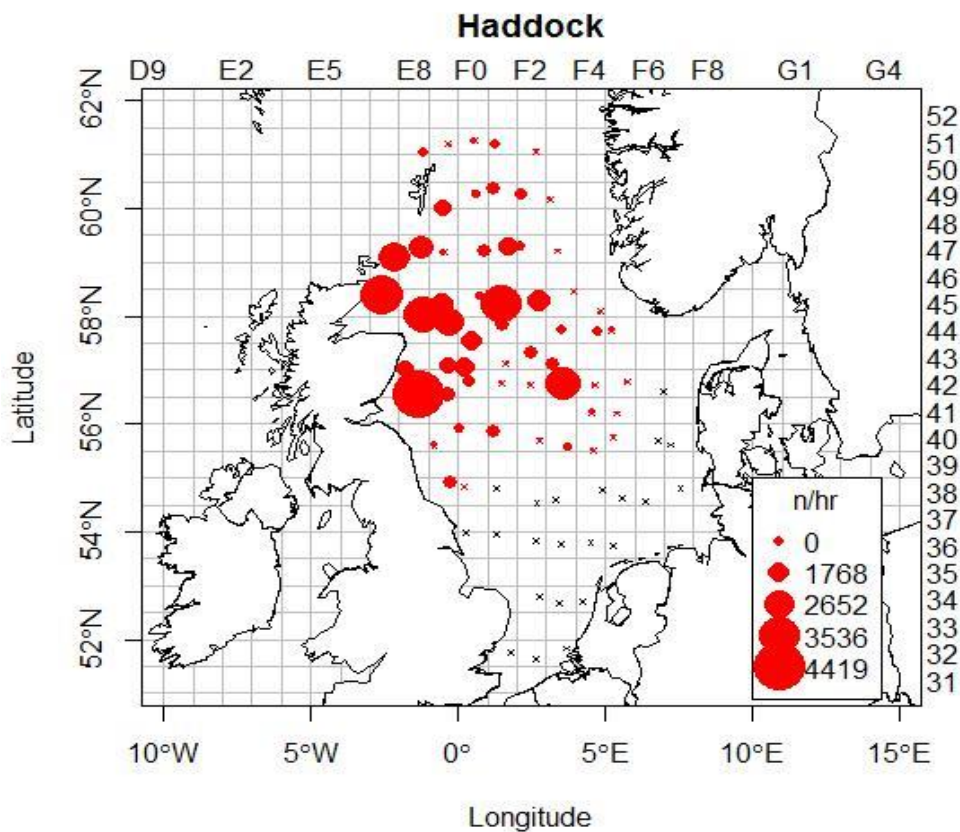


Figure 5: Distribution and relative abundance (raised numbers per hour) of haddock (*Melanogrammus aeglefinus*)

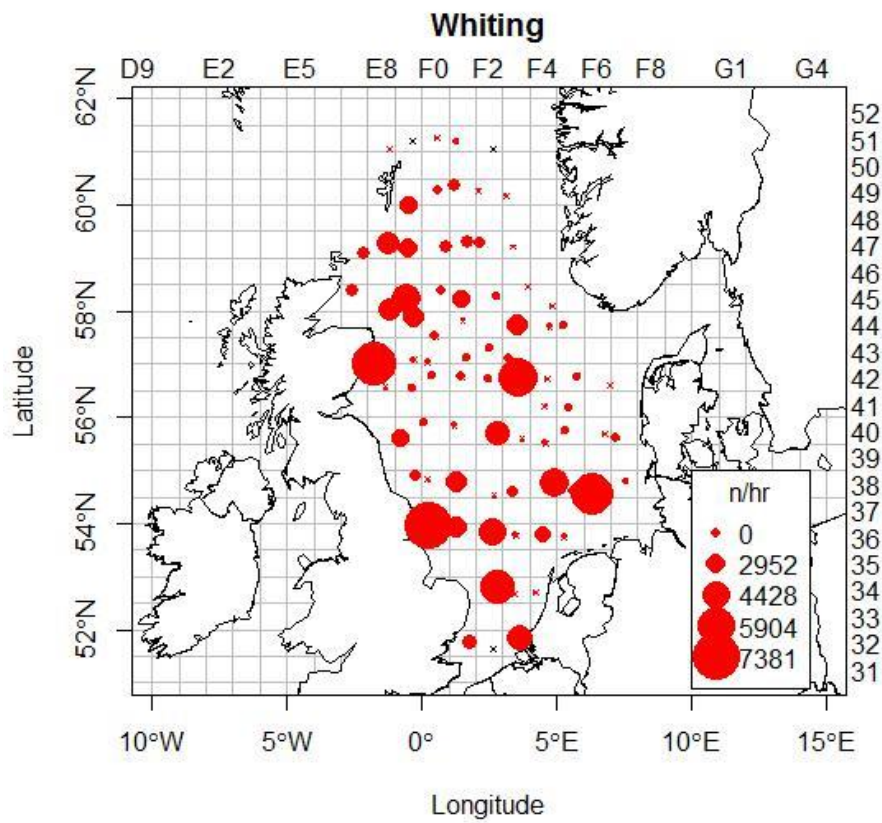


Figure 6: Distribution and relative abundance (raised numbers per hour) of whiting (*Melangius Merlangus*)

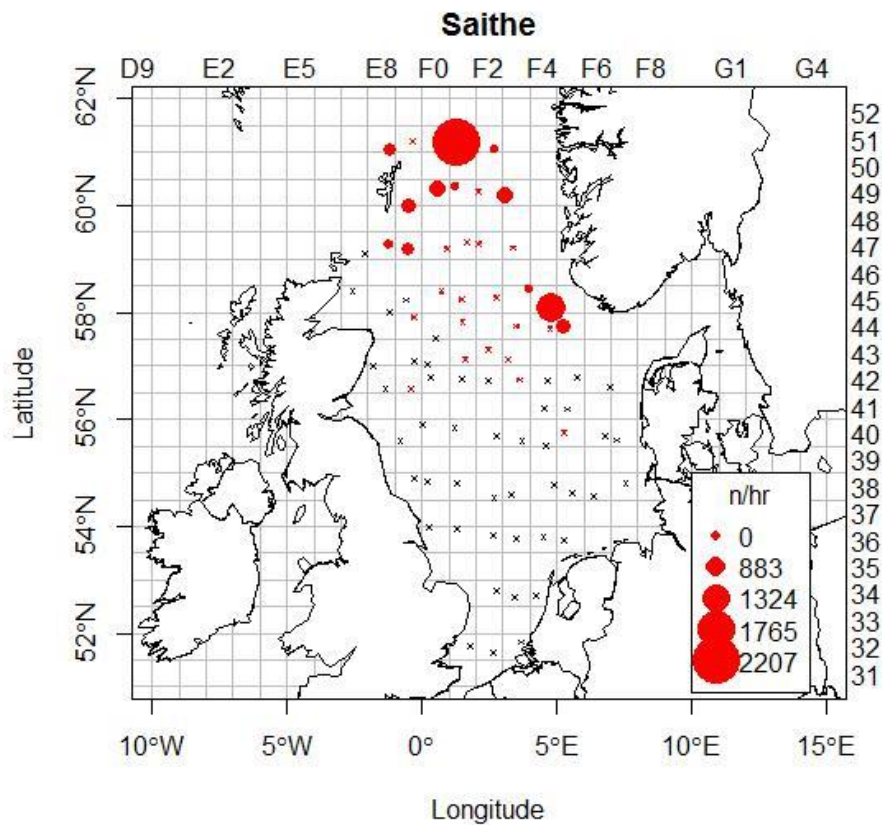


Figure 7: Distribution and relative abundance (raised numbers per hour) of saithe (*Pollachius virens*)

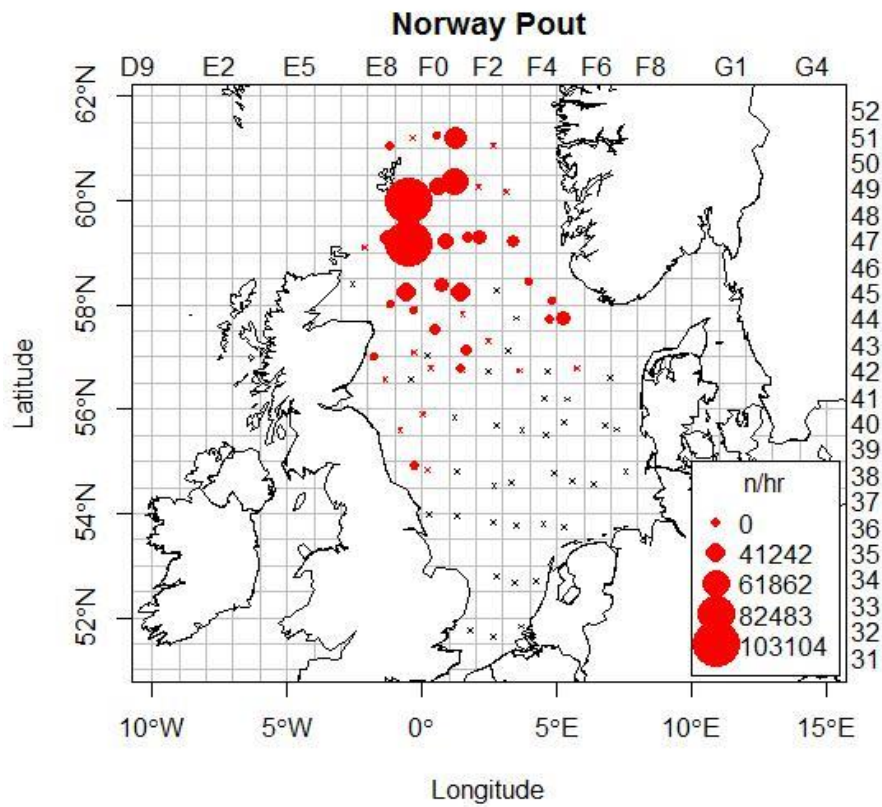


Figure 8: Distribution and relative abundance (raised numbers per hour) of Norway pout (*Trisopterus esmarkii*)

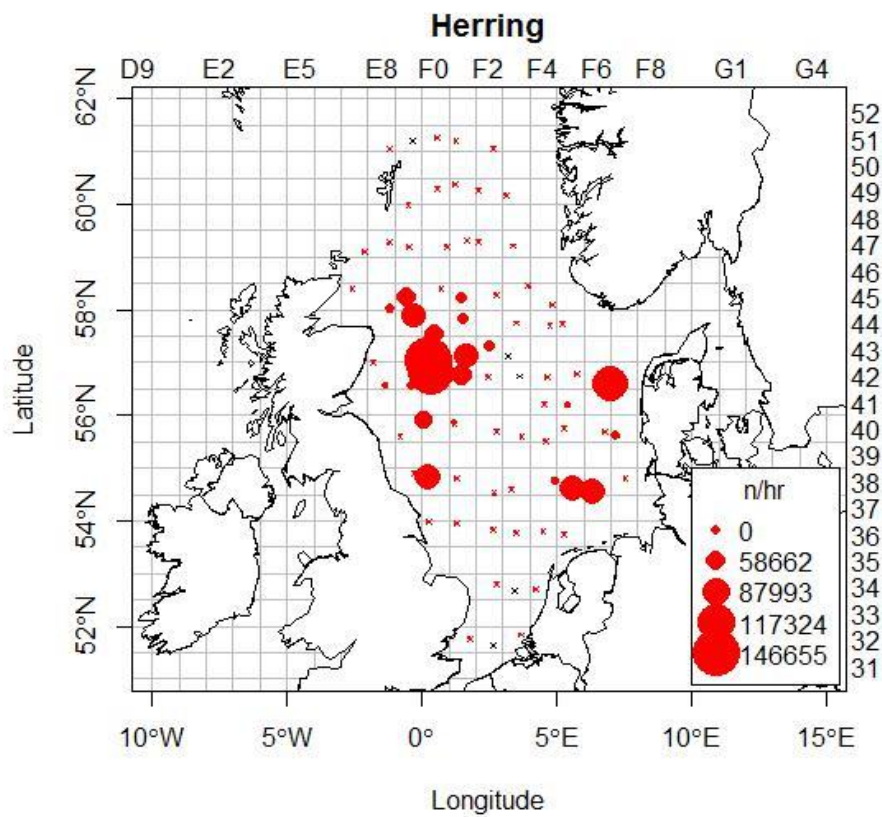


Figure 9: Distribution and relative abundance (raised numbers per hour) of herring (*Clupea harengus*)

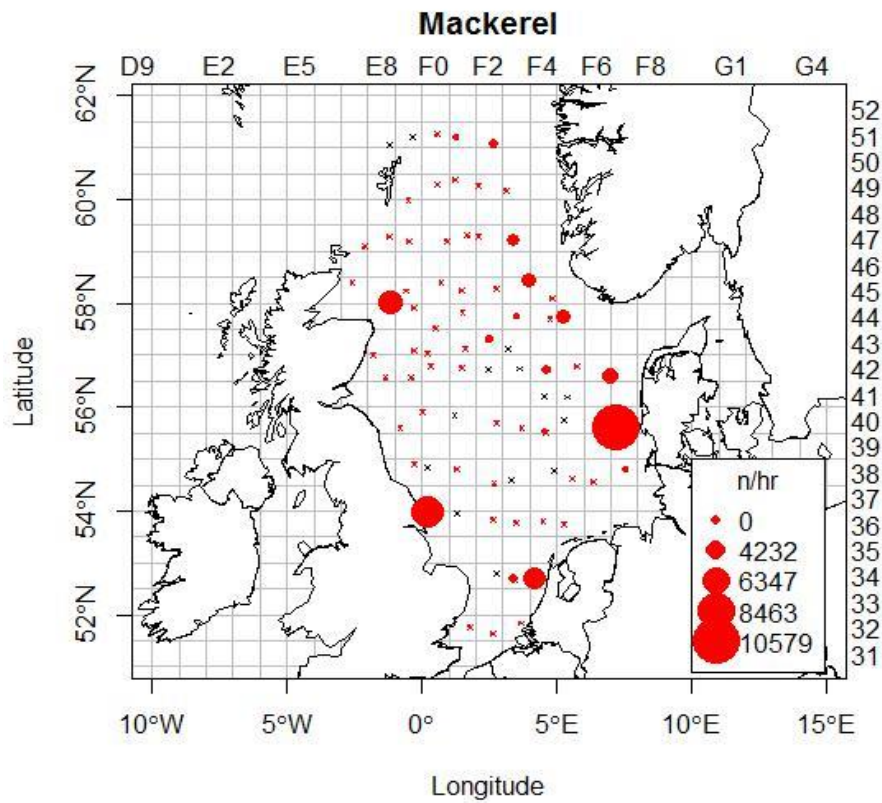


Figure 10: Distribution and relative abundance (raised numbers per hour) of mackerel (*Scomber scombrus*)

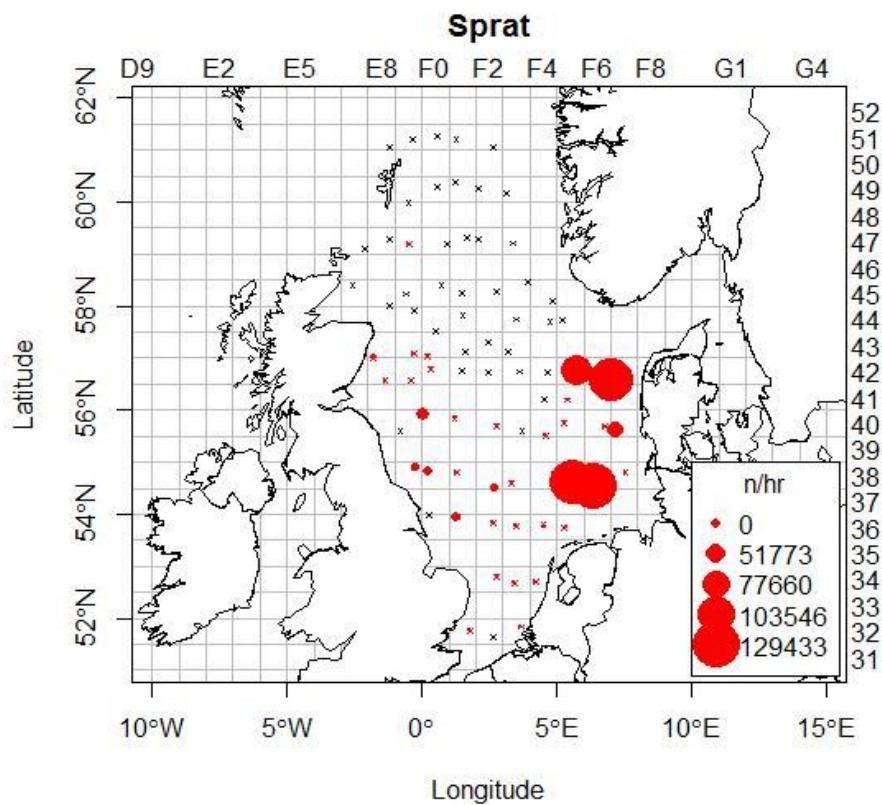


Figure 11: Distribution and relative abundance (raised numbers per hour) of sprat (*Sprattus sprattus*)

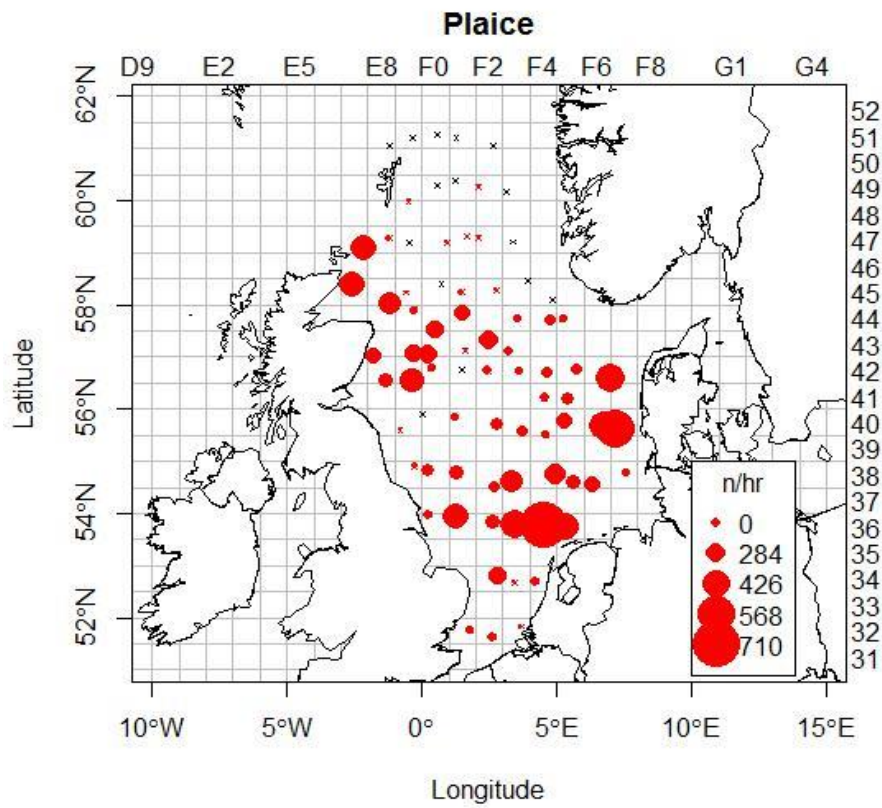


Figure 12: Distribution and relative abundance (raised numbers per hour) of plaice (*Pleuronectes platessa*)

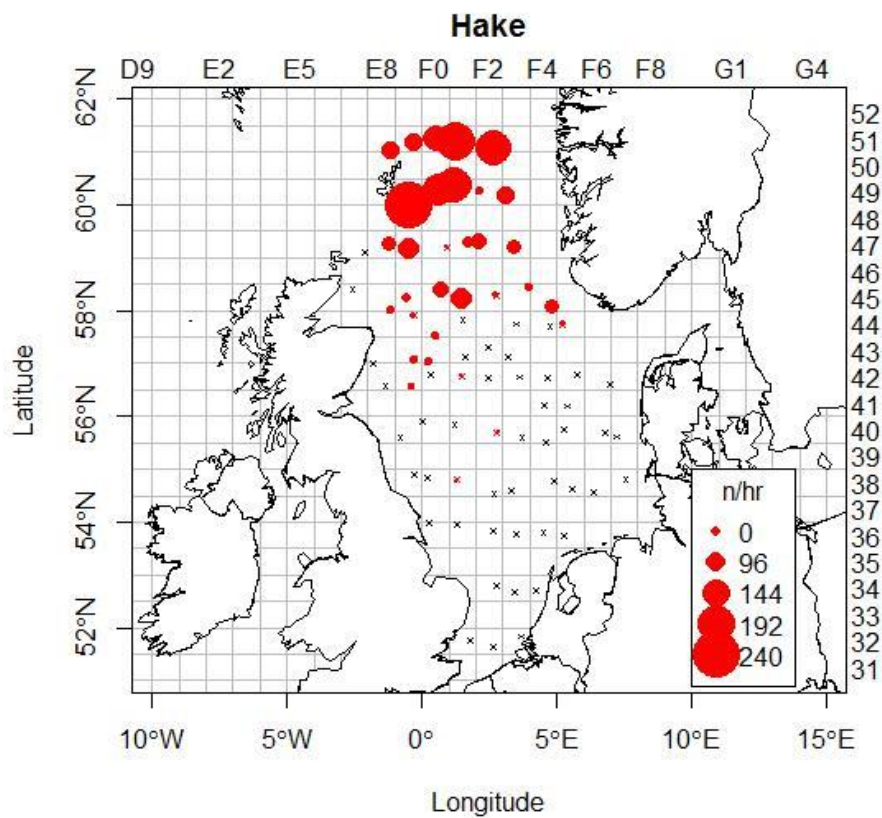


Figure 13: Distribution and relative abundance (raised numbers per hour) of hake (*Merluccius merluccius*)