

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

2013 RESEARCH VESSEL PROGRAMME

PROGRAMME: RV CEFAS ENDEAVOUR: SURVEY 15

STAFF:

Part A

Fishing:

S McCully (SIC)

B Harley (2IC)

R Humphreys

B Hatton

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Part B

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L Cox

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Plus:

A Pliru

D Sivyer

R Coombes

A Rosales Villa

G Tomlinson

M Lilley

E Capuzzo

R Coombes

P Gardiner

A Marshall

DURATION: 3 August – 3 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 standard 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 CTD rosette and Niskin Bottle.
 - f) Length weight & maturity information using individual fish measurements, in support of the EU Data Framework.
 - g) Record litter caught in the trawl.
2. Fish a minimum of 10 selected stations with 'Poly GOV' in over parts of the survey grid.
3. Total alkalinity and dissolved in/organic carbon analysis of seawater by filtration at every station.

SECONDARY AIMS:

4. As part of a project looking at the improvement methods for jellyfish monitoring (ACOJEL), we aim to collect:
 - Acoustic data in order to identify jellyfish distribution and relative density in the North Sea.
 - Catch data (weight and umbrella lengths) for jellyfish caught in the GOV.
 - Jellyfish tissue samples for population genetics and species haplotype profiling if possible, freeze animals for post-survey analysis if not.
 - Freeze mucus and bell material from *Cyanea* species for work at L'Observatoire Oceanologique de Villefranche sur Mer, France.
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), *Sebastes* spp., and any unusual fish species, which may also be used in otolith research.
7. To freeze samples of smooth-hound (*Mustelus* spp.) for biological studies.
8. Record sightings of sea birds and cetaceans for JNCC and Sea Watch Foundation.
9. Retain all dead species of shad and lamprey for study by Cefas scientists.
10. Collect plankton biodiversity samples from selected stations for pigment and analytical flow cytometry analysis, in support of the EU project, DEVOTES.
11. To develop capabilities using the new litter/ plankton passive sampler system and collect zooplankton samples for size spectra analysis in support of DEVOTES.
12. Collect stomachs of hake, grey gurnard, mackerel and red mullet from selected hauls throughout the North Sea – as part of the EU Contract MARE/2012/02 “*Study on stomach contents of fish to support the assessment of good environmental status of marine food-webs and the prediction of MSY after stock restoration*”.
13. Collect a minimum of 10 carbonate samples from the gut and otoliths of all species caught where possible, to estimate the contribution of calcium carbonate produced by marine teleosts, contributing to the global ocean inorganic carbon cycle and influencing surface ocean chemistry and potentially contributing to carbonate sediments. This work is in support of NERC funded research by the University of Exeter in collaboration with Cefas, and the Met Office (global carbon cycle modelling).

14. Sampling of sediments using a box corer and taking Sediment Profile Images (SPI) to improve understanding of the nitrogen cycle in North Sea sediments. In particular, focus will be on using oxygen penetration depth (OPD) and redox depth (aRPD) from SPI to describe organic matter breakdown through nitrogen. The sediments will be characterised and incubations undertaken at 10-15 sites across the muddy/sand parts of the North Sea.
15. Deploy a baited underwater camera system at selected stations across the grid.
16. Deploy a 2000m rated self recording HD format underwater camera, built by Plymouth University in deepwater stations as a system trial.
17. Collect continuous fisheries acoustic data at three operating frequencies (38 kHz, 120 kHz and 200 kHz), using the Simrad EK60 split beam sounder. The data will contribute to the existing 13 year time series of acoustic data in the North Sea and will be used as part of the Defra funded project Poseidon to extract information on mackerel distribution and abundance.
18. Retain and freeze whole specimens of mackerel, herring, sardine/pilchard, sprat, sea bass, dogfish, halibut, turbot and blue whiting (where above minimum landing sizes if applicable) for testing tissue samples for contaminants, in support of the EU Marine Strategy Framework Directive, descriptor 9 (relating to levels of contaminants in fish and shellfish for human consumption).
19. Collect additional biological information (disc width, disc width and pre-pelvic length) for starry ray *Amblyraja radiata*, as a test species to better inform on conversion factors of *Amblyraja* spp. in the Antarctic, in support of an FCO project.
20. Collect fin clips from all turbot *Scophthalmus maximus*, for DNA analysis by the Agricultural and Fisheries Research (ILVO) in Ostend, Belgium.

NARRATIVE:

(All times BST)

RV Cefas Endeavour sailed from Lowestoft at 07:00h on Saturday 3 August. Onboard were six Cefas fisheries staff, a further two Cefas staff (one collecting and analysing jellyfish and plankton samples, and the other collecting and analysing water and sediment samples), one environmental PhD student from the University of East Anglia (UEA), a masters student from the University of Exeter, and a JNCC seabird and marine mammal observer. Before work on the primary stations commenced, a 'shakedown' tow was carried out to 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. A standard station consisted of a cast to collect surface and bottom water samples, with either the Rosette carousel (containing up to ten 10-litre Niskin bottles) or a single 30-litre Niskin bottle along with an ESM2 logger, measuring additional parameters throughout 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 the start of the survey, whilst steaming between and on every station, fisheries acoustic data were collected continuously at three operating frequencies (38 kHz, 120 kHz and 200 kHz), using the Simrad EK60 split beam sounder. The shakedown tow was carried out at prime station 1. The net was shot away successfully, with all rigging in correct

order, thus good readings were obtained from all Scanmar units. The accurate fishing of this tow and a good catch of sprat, horse mackerel, mackerel, herring and smooth-hounds allowed this tow to be considered as a valid tow, and thus was the first prime station completed. The vessel then steamed eastwards to prime station 2, which due to wind farm and pipeline installation was an indirect (and thus time consuming) passage. Prior to arrival it was noted that new pipelines had been installed directly across the tow, therefore we had to search the surrounding area for another clear tow. Unfortunately the ground was full of peaks and troughs (up to 10m high), and thus was not safe to trawl across. Given the loss of daylight, we conducted a rosette water station and deployments were concluded for the evening. We got some clear tow positions from another country, and thus steamed to this area (25 nm away) overnight. The following morning we shot the trawl over the new line which was much smoother, and the scanmar readings were stable. Unfortunately when the net was brought back onboard, the codend liner had come away from the bag, and thus fish had escaped from the codend, and was therefore an invalid tow. The trawl was then re-shot over the same line, however after erroneous scanmar readings; we hauled and found there had quite a lot of net damage to the top panel near to the kite. This was mended and the gear was redeployed over the same ground and hauled at 10 am. This catch comprised of 60 kg of greater sandeel and 25 kg horse mackerel. We then steamed west to prime station 3 and shot the trawl, after 12 minutes the ground had become very rough and the scanmar readings erratic so we hauled early. Some damage to the codend was sustained upon hauling, although a large (ca. 2 t) bag of sprat and herring was caught. The tow was invalid, and after mending was reshot but in a different position yielding a catch of mainly sprat, herring, and horse mackerel. Seven smooth-hounds, including 6 mature males, were also tagged. This was followed by another rosette dip. Overnight we steamed to prime 6 off the Dutch coast.

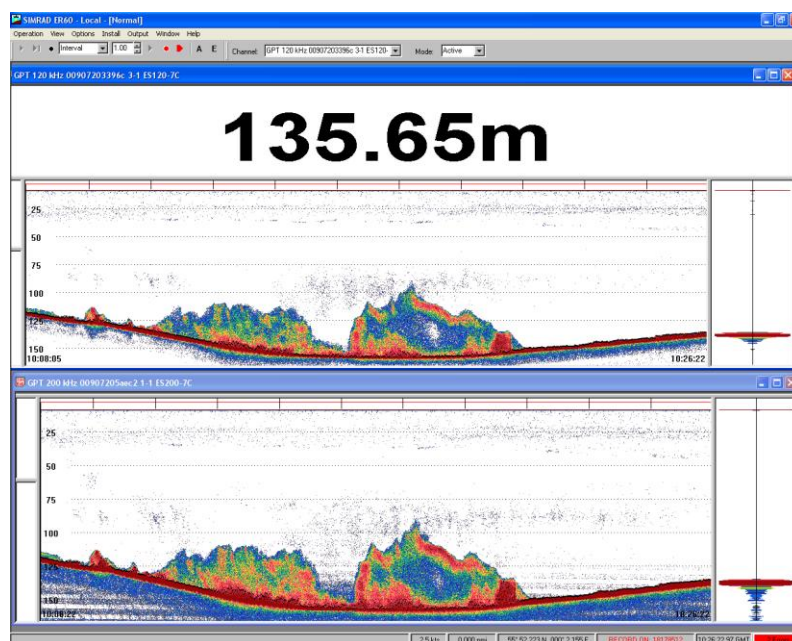
The following day (5 August) we successfully fished three prime stations (6, 5 and 4). The first tow was invalid with fish outside the liner, so the net was reshot, and the catch consisted of half a tonne of horse mackerel. The following tow yielded a small sandeel and mackerel catch, with the final tow consisting of half a tonne of mackerel. We then steamed northwards overnight to prime station nine and fished east to complete prime stations 9-12 towards the Dutch coast. Dab were the main species of the day, with sprat, plaice and whiting also seen. At prime station 11, 16 kg of 0-group whiting were caught, along with the largest jellyfish catch we have seen to date – weighing approximately 0.5t.



On 7 August, we steamed slightly north and continued to fish eastwards around the German coast. Four prime stations (18-21) were completed, resulting in large pelagic catches of herring and sprat, with 1.5t at prime station 20. Over the next two days, we fished prime stations 25-30 and 39, across the central North Sea to the Danish coast, with very similar catches seen, mainly comprising dab and grey gurnard, with ca. 50kg of plaice also seen at prime station 29.

Over the next two days, we moved across the central North Sea and Dogger Bank region and fished prime stations 25-28 and 15-17, with catches consisting of dab, grey gurnards and sprat. On both evenings, SPI camera dips and NIOZ cores were taken. On 11 August we only fished two prime stations (8 and 7) towards the Northeast coast, after which we steamed to Scarborough to pick up an engineer to fix the satellite communications system. During this time two dips with the BRUVS camera were completed. Overnight we then steamed to prime station 14, where we then fished northwards and completed two more stations (13 and 22), where good catches of gadoids were finally seen, with catches of haddock, whiting and also 1.5t of herring. That evening, we did a SPI camera drop, and 3 NIOZ cores. After completing the southern section of the survey grid, it became apparent that we had seen some extremely large catches of jellyfish across the stations – more than seen in previous years.

On 13 August we continued to fish off the northeast coast, and picked up three prime stations (24, 23 and 31). The first yielded a small catch of 35kg of haddock. The second station tows right through Swallows Hole, with the depth dropping from 100 to 155m. Historically, this tow can yield large catches, and with several large marks on the sounder during the tow, and one of the largest marks on the ground we have seen coming into view, we took the decision to haul early, because of the size of it, extending 75m off and 700m along the seabed (see below). Upon hauling, we found that the marks were herring, which was unexpected, as they were tight to the seabed. This 20 min tow yielded 0.5t of herring and 100kg of Norway pout. The last tow of the day was also dominated by pelagic species, with 2.5t of mackerel and 0.5 t of herring caught. That evening, two SPI camera drops were completed, but the ground was not suitable for coring.



The following day we fished four prime stations eastwards of the Scottish coast. The first station (prime 32) was a mixed catch, of mainly mackerel and haddock, followed by 0.8t of herring at station 41. The next tow, was a new tow from this year onwards (now prime station 76) located in ICES rectangle 43F0. When we arrived at this new position, there was a fishing vessel towing across our positions. We therefore moved to a different tow location, and caught 1.5 t of herring. Prime station 33 yielded a mixture of mackerel, herring, Norway pout and haddock. That evening as the ground was soft mud, a SPI camera dip and nine NIOZ cores were completed. Of note, throughout the first three stations, spurdog pups were caught. In total 11 were caught, 7 females and 4 males, from 25-43cm total length. The following day (15/8/13), was again a day of mainly pelagic catches, with 0.9t of herring caught at both prime stations 34 and 42, and a further 120 kg and 235 kg of herring caught at prime stations 46 and 47 respectively. Norway pout and haddock made up the remainder of the catches. Again a SPI camera dip and three NIOZ cores were completed overnight. With deteriorating weather forecast for the weekend, we decided to steam back westwards towards the UK coast in order to be in the best location to enable fishing. On 16 August we therefore fished three stations (55, 54 and 45), again with herring being the dominant species in catches. Approximately 2.5 t of herring were caught throughout the day, with 350kg of Norway pout, 90kg of haddock and 50kg of hake. Overnight four SPI camera dips, and nine NIOZ cores were completed. The weather on the following day was due to deteriorate after midday, so we tried to deploy at prime station 51, before it became unworkable. This station yielded a small catch of haddock, mackerel, hake, grey gurnard and lesser-spotted dogfish. Of note was the capture of a species of jellyfish not recorded in this survey before, the mauve stinger, *Pelagia noctiluca*. Following this, we aimed to steam to prime station 59; however the weather did not allow fishing therefore we steamed back to shelter in the Moray Firth overnight.

Late the next morning, the weather had died away, and thus we steamed to the closest stations to shore and fished these. The first station (prime 52) comprised mainly haddock (185kg), herring, Norway pout and whiting, while the following station (prime 53) caught 1.5t of herring. Following these stations, we then started the long steam eastwards to prime station 38 overnight, to allow us to pick up the remaining south-eastern stations and work westwards back towards Aberdeen for the mid-cruise break. During this steam through the central North Sea surrounded by a large number of oil rigs, there were a lot of seismic vessels and surveys being undertaken. On 19 August we started fishing back in the Danish and Norwegian sectors (prime stations 38-36) but only made a small catches of mainly dab at each. At station 37, there was a seismic vessel operating within 5 nm of our tow line. The following day we completed three prime stations (35, 44 and 43), again with another seismic vessel operating ca. 8-10 nm from both the first and second stations. Both of these yielded just small catches of dab, and haddock. The final station of the first half of the survey resulted in 1.25t of herring. We then steamed overnight back to Aberdeen where we docked at midday on 21 August.

The Cefas Endeavour sailed in the early morning of 23 August to prime station 40, which was 12 nm south east of the port of Aberdeen. With an almost full change of P&O crew and a large change of scientists, this station was fished and processed like a shakedown tow. This catch yielded a large catch of haddock (265kg). This was completed at around 14:00h and then a steam of 150 nm was undertaken to get us back out to the most easterly part of the remaining grid in Norwegian waters.

The following day started with a brisk easterly wind which did not hamper our progress. We started the day at prime station 56, during this tow; at around 5 minutes before hauling the

scanmar sensors momentarily became erratic. No action was taken and the tow was fished for the full 30 minutes. On hauling 25kg of blue tangled net with a large cod and monk were attached to the port sweep, this was obviously the reason for the erratic sensors reading but was considered very unlikely that this impacted on the catchability of the gear so the tow was deemed valid, with a good catch of haddock (103.5kg). This tow also included the first real sighting of small Norway pout (*Trisopterus esmarkii*). As the day progressed the catches of haddock reduced, however, we started to catch saithe (*Pollachius virens*), firstly at prime station 48 with only 0.66 kg but then this increased to 10.7kg at prime station 49 and finally on the last tow of the day, at prime station 50, the catch of saithe was 110.3 kg. Throughout the day we encountered small catches of cod (up to 26kg) at each of the stations.

With the easterly winds dying away the 25 August started well. The first tow of the day had three Norwegian vessels fishing within 2nm of it. On hauling the catches were similar to that of the last tow the day before, and we maintained catches of between 23-132kg of saithe for the remainder of the day. Cod were seen at three of the four stations, with a few 1-year olds in each catch. During the second station there was once again fishing vessels, this time two from the UK and three from Norway.

Continuing in good weather and fortune, working westward, another 4 stations were fished on 26 August (prime stations 63, 62, 61 and 60). At each station approximately a basket of cod, haddock, and hake were seen, with relatively large catches of herring (86 and 669kg) and Norway pout (57 and 147kg) also seen at two of them. Of note on prime station 60 was a very small monk fish (*Lophius piscatorius*). These are rarely caught on RV surveys at this size and it was at a stage when it had just moved from its semi pelagic stage. The pectoral and pelvic fins were very large compared to its body size, something which changes when it becomes fully demersal (picture below).

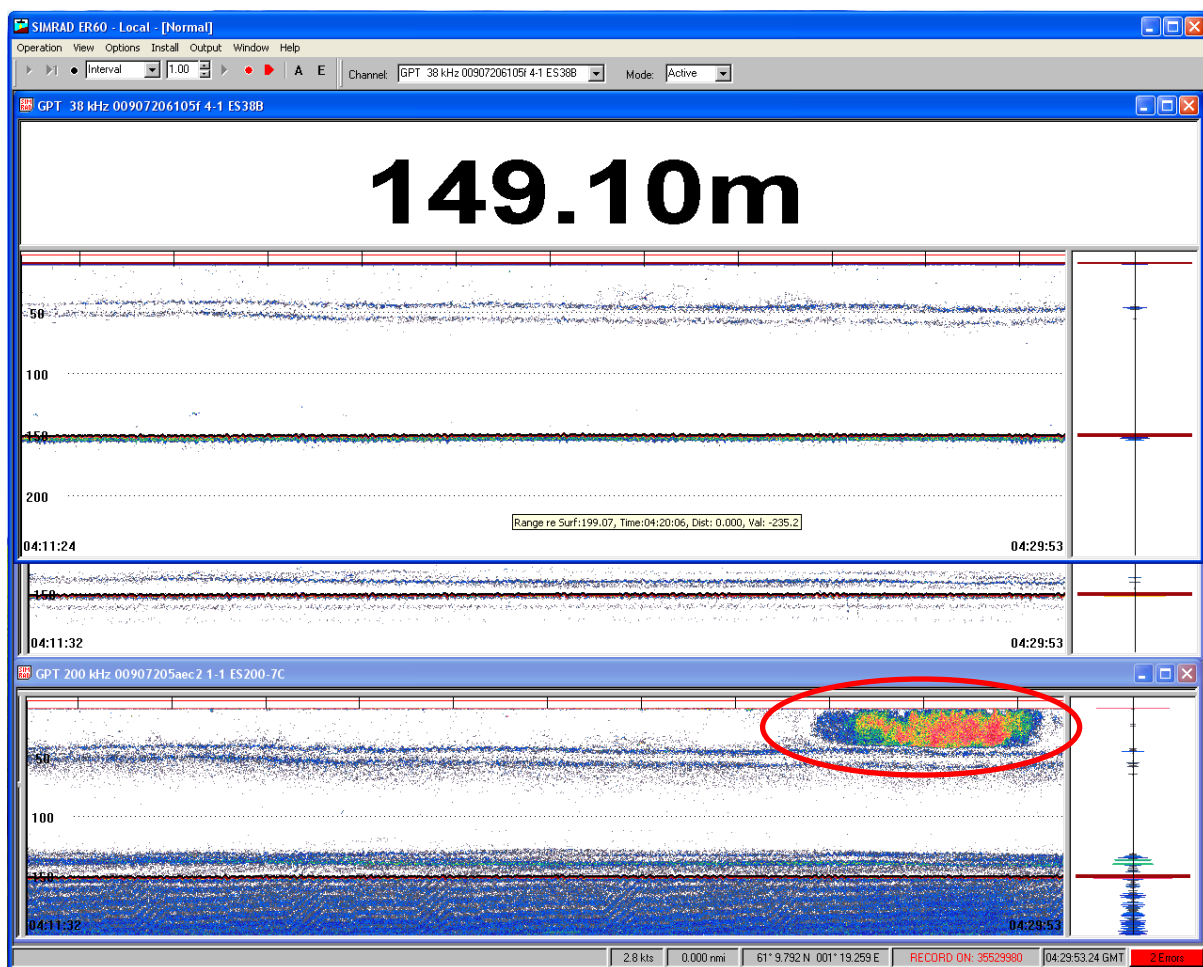


Having steamed westward for all of the previous day, the morning of the 27 August found us back on the Scottish coast to fish prime 59. Unfortunately it left us with a very long steam (75nm) to the second station of the day, having had to drop this station on the first half of the trip due to poor weather. The first tow saw us catch around 150kg of horse mackerel, a species that has not often turned up in the catches this far north. The second station was the

usual mix of haddock, hake, cod and saithe. Continuing to steam back east towards Norwegian waters, the final tow of the day saw us haul a good mix of herring, hake and Norway pout.

The first tow on the 28 August saw good catches of herring (224kg), saithe (76.5kg), hake (72.5kg) and Norway pout (60kg). The rest of the day saw some of the smallest catches of the survey with the second and third catches of the day having almost no small bodied fish in them at all. The net was thoroughly checked for holes and with none found, these catches were deemed unusual, but valid. The catches consisted of mainly saithe and hake, with cod and haddock also present in lesser amounts.

On 29 August, with the last four stations of the nylon part of the survey to complete, the day started overcast and rainy. On the first tow, during deployment, the 200 KHz echo sounder showed a large, dense mark (300m long by 40m high) above the thermo-cline to the surface (picture below). Given this only showed up on this frequency sounder, it was very likely to be a mackerel school within a dense zooplankton bloom (there were some very big copepods in the onboard plankton sampler at that station), marks of this size are not seen often on this survey. This shall be verified following the survey using an acoustic mackerel detection algorithm.



The first two tows of the day (primes 74 and 73) yielded good catches of Norway pout, hake and horse mackerel. The third catch (prime 72), saw a relatively small catch (total 145kg) however it did contain over 18kg of argentines, the largest catch of that species for the survey

this year. The last tow of the day (prime 71) was also the last tow with the last of the nylon nets that we have. On the second half of the survey, we have had no issues with deployment however, it took 5 attempts and 45 minutes to deploy on this occasion. On hauling we had the largest catch of the day (nearly 1 tonne in total), which consisted of primarily horse mackerel (410kg), Norway pout (220kg), mackerel (120kg) and herring (101kg) - certainly a good catch to finish the main primary aim of the survey on.

In the morning of 30 August, the crew changed the nylon net over to the poly GOV and fishing recommenced at 10:15. The first tow was abandoned after 5 minutes when the headline readings were showing 15m (three times the normal height), this Poly GOV had a new configuration of floatation on it, which turned out to be too buoyant. We removed six 8" plastic floats from each side near the top of the headline and redeployed. Readings were well within acceptable limits on the second attempt and thereafter fishing with the Poly GOV started in earnest. Two successful tows were completed on prime station 59 and 51. On prime station 51, a 2m long male common skate (identified as the *Dipturus intermedia* form.) was caught, tagged and released. This is the largest specimen caught and tagged on this survey in recent memory.

In order to catch up on lost time from the first half in order to meet our primary aims we attempted to fish five Poly GOV stations on 31 September. Prime stations 46, 76, 41, 33 and 32 were all fished successfully. Catches were dominated by herring (476-1256kg). When comparing prime stations 33 and 32, which were fished over 2 weeks ago with the nylon GOV, the catches of primary species of haddock (62kg nylon/64kg poly) and whiting (14kg nylon/13.6kg poly) were almost identical, however the catches of herring (148kg nylon/2008kg poly) were vastly different. This highlights the massive variability in pelagic catches over a period of just of a couple of weeks.

With the change in the month came a change in the weather. 1 September started with rough conditions, with 30 knots winds and 3m seas. The first tow of the day (prime 33) was delayed until 08:00h to ensure the safety of the crew. This was fished successfully and with the weather moderating slightly, we steamed east to pick up prime 34. We once again saw a large catch of herring on this tow (1250kg) with only Norway pout making any other real showing (95kg). On arriving at the last station of the day, the weather had deteriorated once more and fishing for the day had to be concluded.

The vessel steamed south west overnight in an attempt to get below the weather and after an uncomfortable night, fishing commenced on 2 September at 10:45 on prime station 15, in moderating weather. Catches were light consisting of mainly dab and grey gurnard. A second station was fished (prime 14), which contained a light catch of similar species.

On the final day of the survey, two stations of Flamborough Head (prime 7 and 8) were fished. The catches consisted of mainly dab, sprat and whiting along with a very diverse range of non-commercial species (bullrout, dragonet, long-rough dab, lesser weever and horse mackerel to name a few). Once the gear was safely onboard after the final station, the vessel steamed for Lowestoft, docking at 21:06h.

Results

Aim 1: A valid GOV trawl haul was successfully completed at all of the 76 primary station positions (Table 1, Figure 1). Also shown in Table 1 is the number of additional stations fished using the polyethylene GOV net. There were 4 invalid tows, which were all repeated to obtain valid samples. The survey was fished using GOV trawl number 1, and the gear trials were fished using the poly GOV net number 2. A chart indicating the position of each trawl station is attached (Figure 1). Scanmar equipment was used to monitor headline height, wing width and door spread. At each station, the catch of each species was weighed and all fish, cephalopod and common shellfish or representative samples, were measured. Table 2 lists the species caught that are sampled for length and Table 3 ranks the top 15 species by weight compared with the last three year's survey. Samples of otoliths for age determination and for maturity information were taken (Table 4) as specified in standard instructions. Benthic invertebrates and crustacea were identified to the species wherever possible and recorded as present. The resultant data were input to computer database using the Cefas Electronic Data Capture System. These data will be analysed at Cefas Lowestoft and will provide a major input to the ICES assessment of North Sea gadoids and pelagic species. Once checked and validated, all data will also be submitted to the ICES DATRAS database.

Vertical profiles of temperature, salinity, chlorophyll fluorescence, optical backscatter, oxygen, and Photosynthetically Available Radiation (PAR) were carried out at 75 of the 76 prime sampling stations using an ESM2 profiler and, up to the 8 August 2013, also with the FSI CTD mounted on the Rosette sampler. In addition to this, measurements of water transparency (45 in total) were carried out using two types of Secchi disk (black and white, and white).

A total of 79 fish species were recorded during the cruise. Noteworthy records included a mature male flapper skate *Dipturus batis* (cf. *intermedia*) of 200 cm total length (157 cm disc width), three specimens of the eelpout *Lycodes gracilis* (pictured below), three juvenile monkfish (*Lophius piscatorius*), and a lump sucker (*Lumpenus lampretaeformis*). Although a few redfish were caught, these were all *Sebastes viviparus*.

Two gravid hagfish were examined; the first specimen (321 mm total length) contained 17 eggs, whilst the other (302 mm total length) contained nine eggs. Only one of the *Lycodes gracilis* caught was female, and this specimen (178 mm total length) contained 42 large follicles in the ovary. Otoliths from a small number of non-commercial species were collected for the CEFAS otolith collection.



Figures 3-12 show distribution and relative abundance (kg 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, over the last 4 years.

The total weight of cod caught has decreased from last year to 343kg (485 kg in 2012, 626 kg in 2011); however 2011 was a particularly good year for cod. The catch seen this year is lower than that of 2010 (395 kg) and certainly the lowest in recent years. Cod were caught at 37 stations this year, down from 46 stations in 2012 and 50 stations in 2011. The haddock catch this year was almost half of that of 2012, the lowest of the last 4 years. Once again, many haddock caught exhibited a disease that rots away the nasal area – this along with parasites in the gills has been once again evident this year.



Continuing the trend of reduced roundfish catches, whiting catches were also at their lowest in recent years (1129kg), although they were the most abundant by distribution of all the fish species caught (69 of the 76 stations fished). Saithe catches this year were lower than the highs of 2011 and 2012 but still almost twice that of the 2010 survey. Norway pout catches rallied this year (1732kg), almost 50% higher than the previous year. On a positive note the catches of herring, mackerel and sprat were up on last year. Herring were again the dominant species by weight, and catches this year (15035 kg) were up by >5t on 2012 levels and the highest of the time series. Mackerel catches (3825 kg) were not very different from the 2012 level. After the disappointing catches of 2012, sprats have recovered to 2128kg, a lot higher than those of 2012 but not as high as the 3644kg caught in 2011. Once again catches of hake have increased to a new series high of 705kg, with a good number of these being 1 year olds (by length). Plaice catches are slightly down on last year at 453kg, but still remain in the top 15 of species, by weight, caught. Similarly dab, grey gurnards and lemon sole all achieved catches on par with that seen over the last 4 years. Horse mackerel saw a resurgence this year with catches of around 1300kg, however this is still lower than the high catches of 2010 (2181kg).

In addition to the routine biological sampling of commercial fish species, length-weight data were collected for selected fish species to augment data collected in previous years, including smooth sandeel *Gymnammodytes semisquamatus* (n = 138), greater sandeel *Hyperoplus lanceolatus* (n = 40), hagfish *Myxine glutinosa* (n = 30), silvery pout *Gadiculus argenteus* (n = 16). Data were also collected for other species (*Anarhichas lupus*, *Belone belone*, *Cyclopterus lumpus*, *Lumpenus lampretaeformis*, *Lycodes gracilis*, *Micromesistius poutassou*, *Phycis blennoides*, *Sebastes viviparous* and *Lithodes maia*), although sample sizes for these species were ≤ 10 .

Table 1. Number of trawls, Rosette and MIK net tows made during the survey

Gear	Valid	Additional	Invalid	Total
GOV (IBTS Standard gear)	76	0	4	80
Niskin Bottle + CTD/Rosette	76	0	0	76
Poly GOV stations	13	0	0	13
SPI camera drops	13	0	0	13
NIOZ cores	13	0	0	13
Baited Camera Deployments	2	0	0	2

Table 2. List of measured species caught during the survey and number of stations at which they were recorded.

Species	Common Name	Stns	Species	Common Name	Stns
<i>Agonus cataphractus</i>	Pogge (Armed bullhead)	12	<i>Molva molva</i>	Common ling	9
<i>Alloteuthis subulata</i>		16	<i>Mullus surmuletus</i>	Red mullet	3
<i>Anarhichas lupus</i>	Wolffish	2	<i>Mustelus asterias</i>	Starry smooth-hound	3
<i>Arctica islandica</i>	Ocean Quahog	1	<i>Myoxocephalus scorpius</i>	Bullrout	3
Argentinidae	Argentine	29	<i>Myxine glutinosa</i>	Hagfish	9
<i>Arnoglossus laterna</i>	Scaldfish	8	<i>Nephrops norvegicus</i>	Norway lobster	10
<i>Aspitrigla cuculus</i>	Red gurnard	2	<i>Octopodidae</i>	Octopus spp.	2
<i>Belone belone</i>	Garfish	2	<i>Todaropsis eblanae</i>		1
<i>Buglossidium luteum</i>	Solonette	17	<i>Ommastrephes sagittatus</i>	Flying squid	1
<i>Callionymus lyra</i>	Common dragonet	21	<i>Pecten maximus</i>	Scallop	1
<i>Callionymus maculatus</i>	Spotted dragonet	25	<i>Phycis blennoides</i>	Greater forkbeard	1
<i>Cancer pagurus</i>	Edible crab	7	<i>Phrynorhombus norvegicus</i>	Norwegian topknot	2
<i>Clupea harengus</i>	Herring	62	<i>Platichthys flesus</i>	Flounder	1
<i>Cyclopterus lumpus</i>	Lumpsucker	1	<i>Pleuronectes platessa</i>	European plaice	60
<i>Enchelyopus cimbrius</i>	Four-bearded rockling	9	<i>Pollachius virens</i>	Saithe	27
<i>Eutrigla gurnardus</i>	Grey gurnard	66	<i>Raja clavata</i>	Thornback ray	2
<i>Gadiculus argenteus</i>	Silvery pout	10	<i>Raja montagui</i>	Spotted ray	1

<i>Gadus morhua</i>	Cod	37	<i>Amblyraja radiata</i>	Starry ray	16
<i>Gymnammodytes semisquamatus</i>	Smooth sandeel	6	<i>Rossia macrosoma</i>		5
<i>Glyptocephalus cynoglossus</i>	Witch	6	<i>Sardina pilchardus</i>	Pilchard	1
<i>Gobius Spp.</i>	Gobies	1	<i>Scomber scombrus</i>	European mackerel	41
<i>Hippoglossoides platessoides</i>	American plaice (Long-rough dab)	54	<i>Scophthalmus maximus</i>	Turbot	5
<i>Homarus gammarus</i>	European lobster	1	<i>Scophthalmus rhombus</i>	Brill	2
<i>Hyperoplus lanceolatus</i>	Greater sandeel	14	<i>Scyliorhinus canicula</i>	Lesser spotted dogfish	15
<i>Illex (loligo) illecebrosus</i>	Northern shortfin squid	1	<i>Sebastes viviparus</i>	Redfish	2
<i>Lepidorhombus whiffiagonis</i>	Megrim	8	<i>Sepiolidae</i>		1
<i>Leucoraja naevus</i>	Cuckoo ray	7	<i>Sepia elegans</i>	Cuttlefish	2
<i>Limanda limanda</i>	Dab	66	<i>Sepiola atlantica</i>	Little cuttle	8
<i>Lithodes maja</i>	Stone crab	7	<i>Solea solea</i>	Sole	2
<i>Loligo forbesi</i>	Northern squid	18	<i>Sprattus sprattus</i>	Sprat	20
<i>Lophius piscatorius</i>	Anglerfish (Monkfish)	16	<i>Squalus acanthias</i>	Spurdog	6
<i>Lophius budegassa</i>	Black bellied anglerfish	1	<i>Syngnathus rostellatus</i>	Nilssens pipefish	1
<i>Lumpenus lampretaeformis</i>	Snake blenny	1	<i>Trachinus vipera</i>	Lesser weever	13
<i>Lycodes gracilis</i>	Eelpout	1	<i>Trachurus trachurus</i>	Horse-mackerel	34
<i>Melanogrammus aeglefinus</i>	Haddock	49	<i>Trigla lucerna</i>	Tub gurnard	5
<i>Merlangius merlangus</i>	Whiting	69	<i>Trisopterus esmarki</i>	Norway pout	34
<i>Merluccius merluccius</i>	European hake	34	<i>Trisopterus luscus</i>	Bib	1
<i>Microchirus variegatus</i>	Thickback sole	2	<i>Trisopterus minutus</i>	Poor cod	24
<i>Micromesistius poutassou</i>	Blue whiting	4	<i>Zeus faber</i>	John Dory	2
<i>Microstomus kitt</i>	Lemon sole	63			

Table 3. Top 15 species by weight compared with the last three years surveys

Species common name	Scientific name	2013 weight (kg)	2012 weight (kg)	2011 weight (kg)	2010 weight (kg)
Herring	<i>Clupea harengus</i>	15035.99	9402.01	5310.42	7636.15
Mackerel	<i>Scomber scombrus</i>	3825.90	3821.50	3564.11	2442.41

Dab	<i>Limanda limanda</i>	2135.60	2466.15	2403.13	1582.01
Sprat	<i>Sprattus sprattus</i>	2128.63	456.12	3644.49	2305.76
Norway Pout	<i>Trisopterus esmarkii</i>	1732.14	1182.22	1453.87	2730.32
Haddock	<i>Melanogrammus aeglefinus</i>	1625.84	2264.92	3233.58	2826.90
Horse Mackerel	<i>Trachurus trachurus</i>	1324.90	868.67	969.81	2181.85
Whiting	<i>Merlangius merlangus</i>	1129.20	2257.61	2163.29	2356.44
Grey Gurnard	<i>Eutrigla gurnardus</i>	1041.08	1000.37	1019.53	625.96
Saithe	<i>Pollachius virens</i>	866.26	1426.91	1596.85	457.73
Hake	<i>Merluccius merluccius</i>	705.46	588.71	465.26	479.94
Plaice	<i>Pleuronectes platessa</i>	452.90	522.64	592.37	361.21
Cod	<i>Gadus morhua</i>	343.49	485.81	626.68	395.05
Long-Rough Dab	<i>Hippoglossoides platessoides</i>	146.51	280.83	332.84	153.77
Lemon Sole	<i>Microstomus kitt</i>	128.03	225.36	250.32	136.67

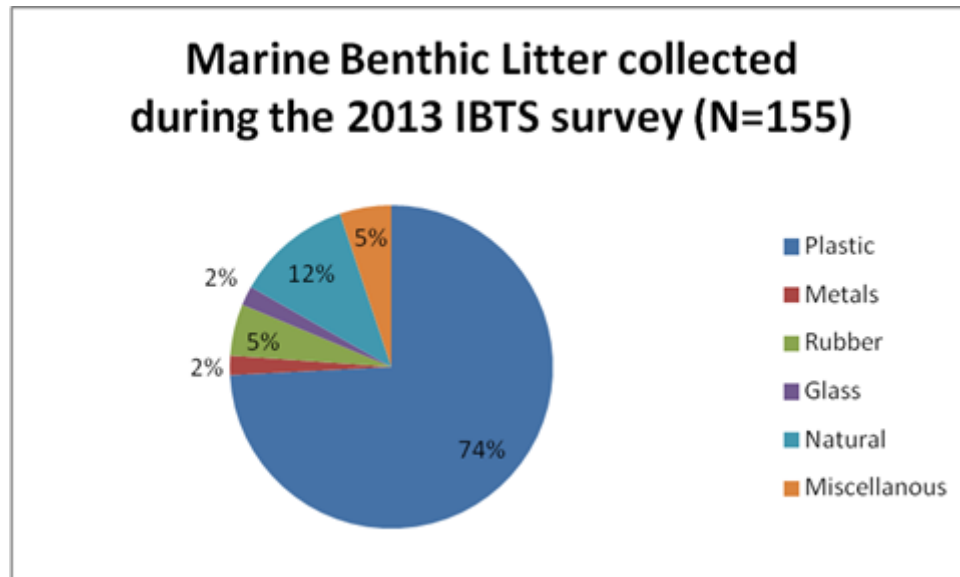
A total of 6957 biological samples were taken for the primary target species (Table 4). In addition, a total of 87 maturity samples were also taken from elasmobranchs captured during the survey.

Table 4. The number of biological samples taken by species

Species	Number of samples taken
Plaice	1067
Whiting	1264
Herring	901
Haddock	930
Hake	479
Mackerel	418
Saithe	632
Dab	222
Cod	243
Lemon Sole	192
Norway Pout	313
Grey Gurnard	213
Ling	21
Monkfish	17
Witch	9
Tub Gurnard	8
Turbot	6
Brill	2
Black Bellied anglerfish	1

Red Gurnard	15
Red Mullet	3
John Dory	1

In total 155 pieces of litter were recorded from all trawl stations. Litter was present in 64 of the stations fished. From the plot below it can be seen that plastics made up the majority of the litter caught.



Aim 2: 13 stations were fished using the polyethylene GOV net. Data from this will be combined with those collected previously to do catch comparisons between the nylon and polyethylene GOV over recent years.

Aim 3: Water samples for analysis of dissolved inorganic nutrients, salinity, and total alkalinity were collected at the bottom and at the surface at prime stations. Up to the 8 August, samples were collected using the Rosette sampler. Once the Rosette sampler stopped working, the bottom samples were collected with a Niskin bottle connected to a wire, while surface samples (4 m depth) were collected from the continuous flow which supplies the Ferrybox. A total of 152 samples were collected for both nutrients and salinity, while 150 samples were collected for analysis of TA/DIC.

SECONDARY AIMS:

Aim 4: Jellyfish were present at all but three of the 75 prime stations in 2013. A total of 7275 jellyfish were caught, with up to 1200 jellyfish per haul. Total biomass across the survey was 722.8 kg. Over 1 kg of jellyfish was caught at 46 of the stations, while Prime station 11 in the southern North Sea was responsible for the heaviest catch and 62.5% of all jellyfish biomass caught - around 450 kg, 99% *Aurelia aurita*.

Eight different species were caught, with localised high abundances of each species. The Lion's Mane jellyfish *Cyanea capillata* or closely related Blue jellyfish *C. lamarckii* species were present at the 66 of the 76 stations, with many juveniles in the southern half of the North Sea. Additionally southern stations had many Moon jellyfish *Aurelia aurita* and

Compass jellyfish *Chrysaora hysoscella*. At the deeper northern stations jellyfish were less abundant, with larger *Cyanea* most common. Despite lower numbers, the biomass caught at these stations was comparable to most of the shallower southern stations.

In addition to the species mentioned above two rarer species were also caught, which had not been recorded during the 2012 survey. *Periphylla periphylla* is a deepwater jellyfish which is common in the Norwegian fjords. A total of nine individuals across four stations were caught in 2013 with a size range of 5-18.5cm bell diameter and 4-194g wet weight. The mauve stinger, *Pelagia noctiluca*, has occasionally been recorded from this region in the past, but is typically a species associated with the Mediterranean Sea. 231 individuals were caught from thirteen stations, all in the north areas, and included 13 individuals of a greater size than the 14.5cm maximum recorded in the scientific literature to date. Juveniles found off northern Shetland would also suggest that this species is actively reproducing in the area and may be expanding its range. However, 2013 also appears to be a productive year for *Pelagia* in the Mediterranean and the abundances observed here may be a short-term response to climatic fluctuations.

Finally, comparisons between the Nylon and Polypropylene nets at ten prime locations would presently suggest that the poly' net catches a similar jellyfish species composition to the nylon net, but in 80% of the tows the jellyfish catch was greater (2-45 times the biomass) using the newer poly' net. Additionally, 362 jellyfish tissue samples were taken for genetic analysis of the population dynamics within the North Sea.

Aim 5: Fifty-seven fish were tagged during the survey, comprising starry smooth-hound *Mustelus asterias* (n = 24), cuckoo ray *Leucoraja naevus* (n = 18), spotted ray *Raja montagui* (n = 7), blonde ray *Raja brachyura* (n = 5) and single specimens of flapper skate *Dipturus batis* (cf. *intermedia*), spurdog *Squalus acanthias* and wolf-fish *Anarhichas lupus*.

Aim 6: One saithe (*Pollachius virens*) was retained and frozen for further analysis due to abnormal growth characteristics and deformed gonads. Also a small number of spurdog was retained and frozen for dissection on return to the lab.

Aim 7: No samples of smooth-hound (*Mustelus* spp.) were retained and frozen for biological studies as all specimens were tagged or sampled on board.

Aim 8: A total of 3121.2 km were surveyed from the bridge wings of the CEFAS Endeavour from the 3 August until the 3 September 2013 using standard European Seabird at Sea (ESAS) methodologies. A total of fifty-two species of bird and four species of mammal were observed from the vessel during the thirty-three day period. During the 142 hours and 10 minutes of ESAS survey a total of twenty-four species of seabird and thirteen species of wader were noted. The remaining species were incidental sightings of land migrants or seabirds seen passing the vessel during non-survey periods.

The most numerous species throughout the trip were fulmar and gannet, with Lesser-black backed gull being the most numerous in the southern North Sea. Bird densities were low throughout much of the survey with the only major hotspot being south-east of Flamborough Head between prime stations 7 and 8 where diversity and density of seabirds increased compared to the rest of the voyage. Here auk and kittiwake numbers were much higher with rafts of 100+ individuals, which were absent during the rest of the survey. There was also an increase in diversity and density in the area east of Fair Isle and on the transit out of Aberdeen to fishing station 40, but numbers were not as significant as the Flamborough area.

There were no sightings of rare or scarce seabirds but birds of note included pomarine skuas, storm petrels, and sooty and Manx shearwaters. Large numbers of great skuas were often seen with the gannet and fulmars during the hauls. There were also good numbers of little gulls seen between prime stations 7 to 8 on the 11 August with the largest group reaching thirty-five individuals

White beaked dolphins were the most numerous marine mammal of the trip, with a total of twenty-four sightings which involved at least 86 individuals (assuming no pod was recorded twice). The dolphins sightings were the highlight of the whole survey with many pods coming into bow ride. As many as eight could be seen at the bow at one time. Harbour porpoise were noted on three days and grey seal on four. A total of three minke whales recorded in Scottish waters around the Northern Isles. The fourth species was recorded as an incidental sighting as the almost resident population of bottle-nosed dolphins were observed whilst leaving Aberdeen port on the 23 August.

Aim 9: As there were no catches of shad and lamprey, none were retained for study by Cefas scientists.

Aim 10: Samples for phytoplankton pigment analysis (HPLC) and flow cytometry were only collected at the surface and in duplicates. Water samples for microzooplankton analysis were also collected at the surface at 13 locations.

Aim 11: To develop capabilities using the new litter/ plankton passive sampler system and collect zooplankton samples for size spectra analysis, the continuous sampler for macrozooplankton was running regularly during the cruise with 2 types of net (80 μ m and 270 μ m), and a total of 58 samples were collected during the whole survey.

Aim 12: As part of the EU Contract MARE/2012/02-SI2.632886 stomachs from Hake, Grey Gurnards, Mackerel and Red Mullet were collected. Along with the stomachs, other characteristics such as gall bladder colour and stage, sex, maturity, weight and length were also required. The maximum sample per species was 20 across 4 size classes at each station. Altogether, 1372 stomachs were collected, which came from 704 grey gurnards, 356 mackerel, 308 hake and 4 red mullet. Grey gurnards were found at almost every station. Mackerel were seen throughout the North Sea, although rarer in the eastern part of the grid. Hake were found predominately in northern stations. However, there were fewer stomachs per hake catch compared to other species due to the higher frequency of inverted stomachs. Red mullet were the rarest but this was expected. Two were caught off the coast of the Netherlands, and two just below Dogger Bank.

Aim 13: No samples of gut contents and otoliths for the use in the project to estimate the contribution of calcium carbonate produced by marine teleosts.

Aim 14: At the stations listed below sediment samples for intact sediment core incubations (in order to measure nitrogen gas production) and samples to measure fluxes and nutrients concentration in the pore water of the sediments, were taken. Additionally, 14 deployments with the SPI camera were carried out, in order to determine the apparent redox potential discontinuity.

Station	Lat	Long	Activity
10	51° 48.569	003° 37.370E	SPI camera
11	52° 20.812	003° 39.272E	SPI camera

18	52° 52.709	002° 40.130E	SPI camera
19	52° 52.694	002° 40.106E	Coring, slurries,
29	53° 50.939	005° 14.244E	SPI camera
30	53° 50.941	005° 14.229E	Coring, slurries
42	54° 58.267	007° 19.144E	SPI camera
43	54° 58.277	007° 19.141E	Coring, intact sediment cores, fluxes, pore water
59	55° 14.799	002° 55.528E	SPI camera
60	55° 14.799	002° 55.509E	Coring, slurries
67	54° 08.470	001° 12.772E	SPI camera
68	54° 08.475	001° 12.757E	Coring, intact sediment cores, fluxes, pore water
81	55° 35.135	002° 52.571E	SPI camera
82	55° 35.135	002° 52.571E	Coring, slurries
89	56° 31.344	001° 23.740E	SPI camera
90	56° 31.112	001° 09.873E	SPI camera
100	56° 51.230	000° 18.291E	SPI camera
101	56° 51.222	000° 18.290E	Coring, intact sediment cores, fluxes, pore water
118	57° 58.791	001° 19.959E	SPI camera
126	57° 49.990	000° 25.647W	SPI camera
127	57° 49.977	000° 25.639W	Coring, intact sediment cores, fluxes, pore water
140	56° 57.049	003° 23.947E	SPI camera
141	56° 57.047	000° 23.928E	Coring, intact sediment cores, fluxes, pore water

Aim 15: The baited underwater camera system was deployed at two stations off Scarborough for a total of 95 minutes.

Aim 16: The deepwater HD underwater camera from Plymouth University was not ready prior to the cruise, so was not available on this survey for deployment.

Aim 17: Throughout the cruise, fisheries acoustic data was continuously collected at three operating frequencies (38 kHz, 120 kHz and 200 kHz), using the Simrad EK60 split beam sounder.

Aim 18: In support of the EU Marine Strategy Framework Directive, descriptor 9 (relating to levels of contaminants in fish and shellfish for human consumption), specimens of mackerel, herring, sprats, turbot and blue whiting were retained and frozen for testing tissue samples for contaminants.

Aim 19: Additional biological information was collected for 30 starry ray *Amblyraja radiata*.

Aim 20: No fin clips from turbot *Scophthalmus maximus*, were collected for DNA analysis by the Agricultural and Fisheries Research (ILVO) in Ostend, Belgium.

Special thanks are given to the officers and crew of Cefas Endeavour and the scientists for all of their enthusiasm and hard work in making this cruise a success and completed in good time.

S. McCully and B. Harley
4 September 2013

DISTRIBUTION:

Basic list +

S McCully

R Humphreys

S Davis

D Doran

L Cox

A Pliru

G Tomlinson

E Capuzzo

A Marshall

N Greenwood

T Dunn

M Etherton

M Nicolaus

J Pinnegar

B Harley

B Hatton

J Silva

J Ellis

P Gardiner

D Sivyver

A Rosales Villa

R Parker

R Coombes

G Burt

M Lilley

C Lynam

R Wilson

J Van der Kooij

Figure 1. Station positions for primary aims on CEFAS Endeavour 15/13.

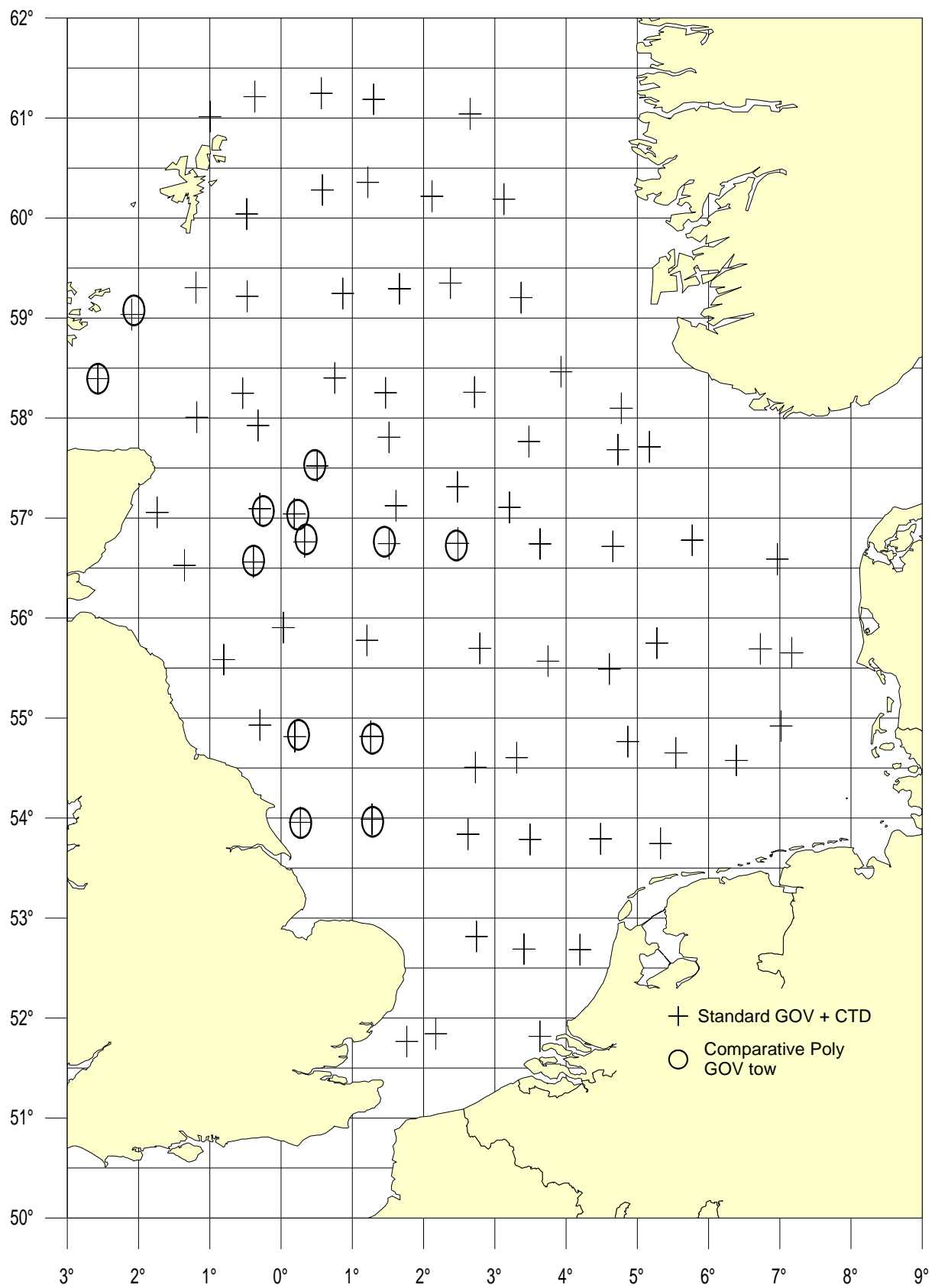


Figure 2. Station positions for secondary aims on CEFAS Endeavour 15/13.

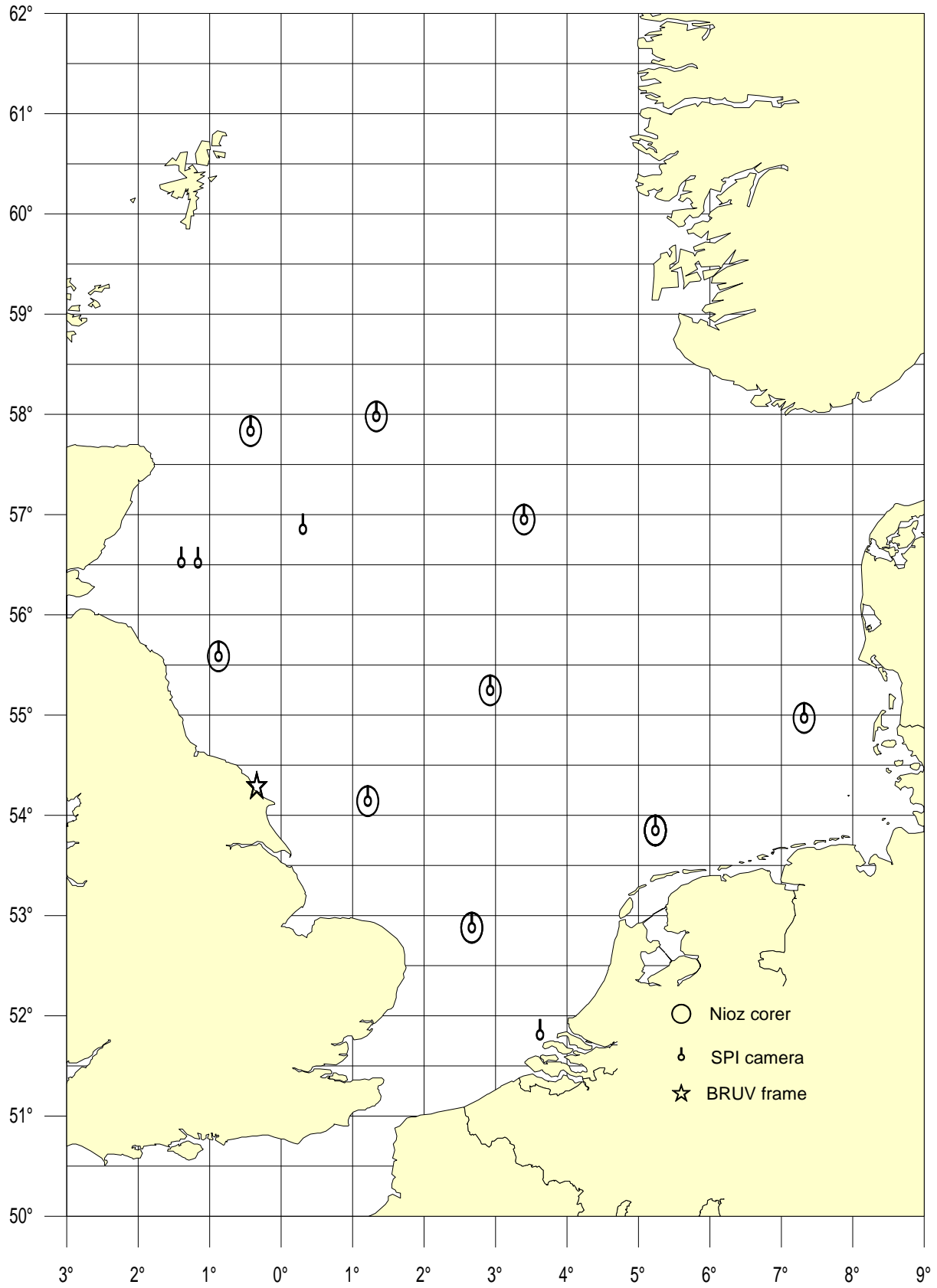


Figure 3. Distribution and relative abundance (kg) of cod for 2010 to 2013.

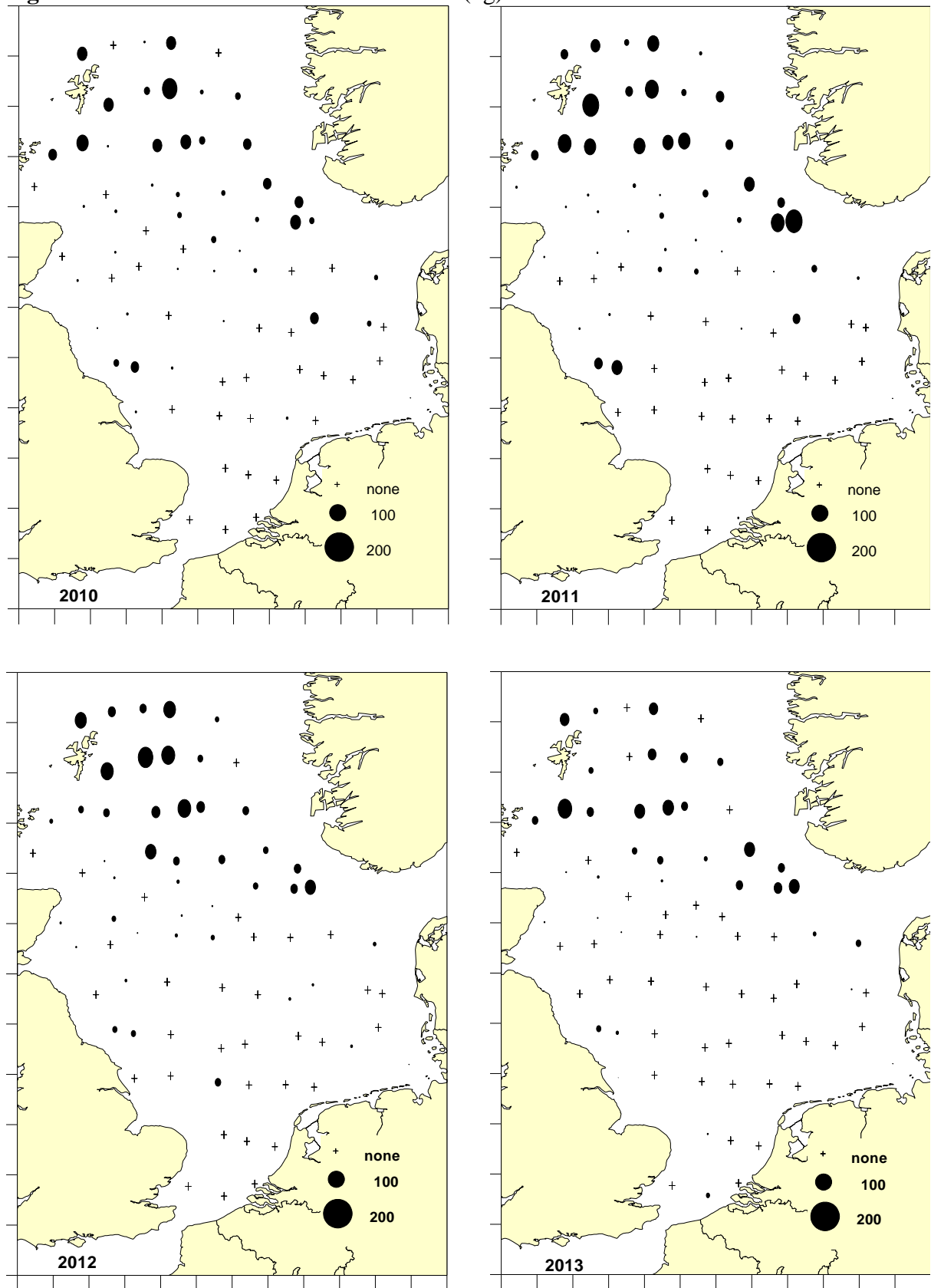


Figure 4. Distribution and relative abundance (kg) of haddock for 2010 to 2013.

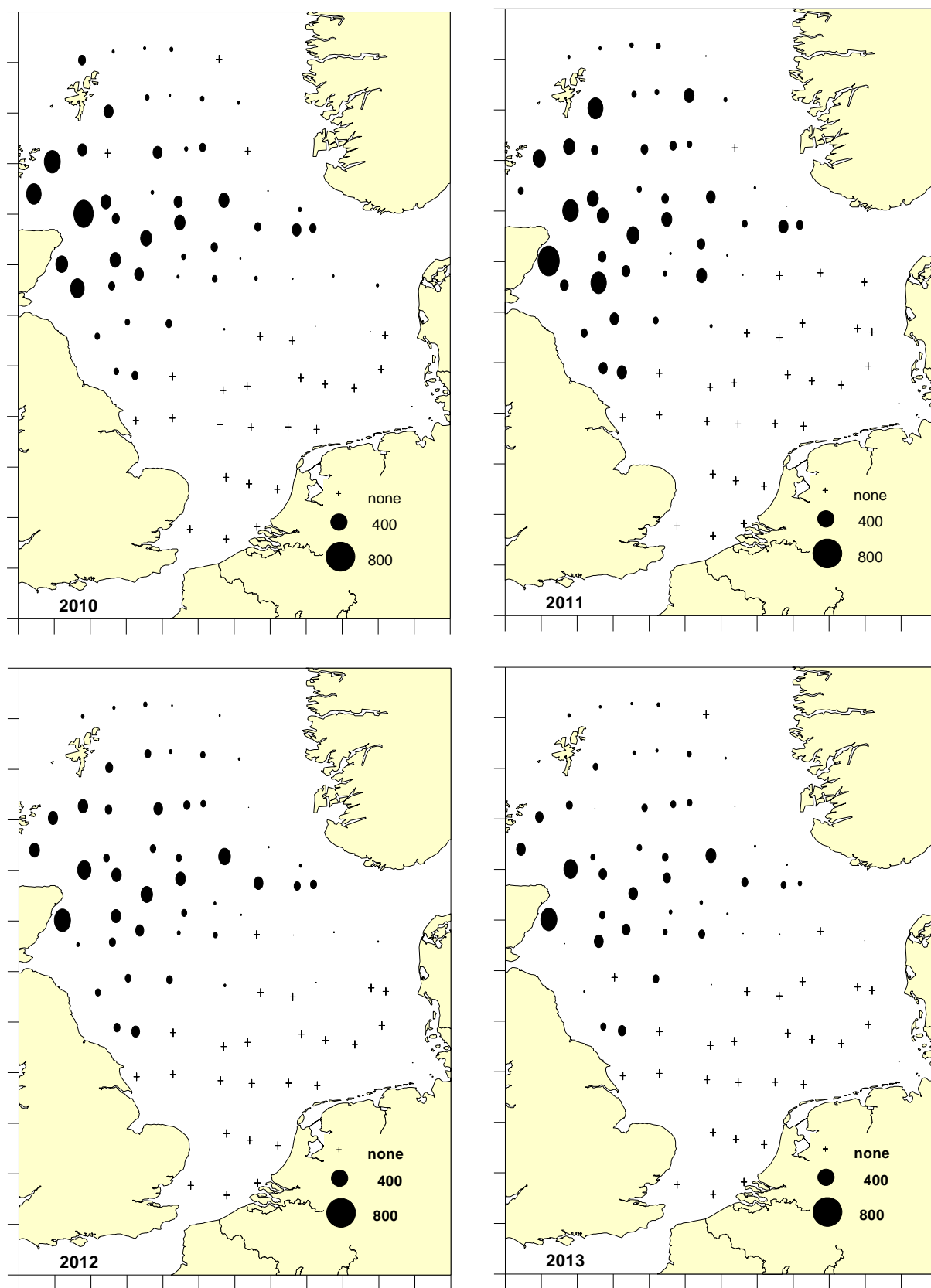


Figure 5. Distribution and relative abundance (kg) of whiting for 2010 to 2013.

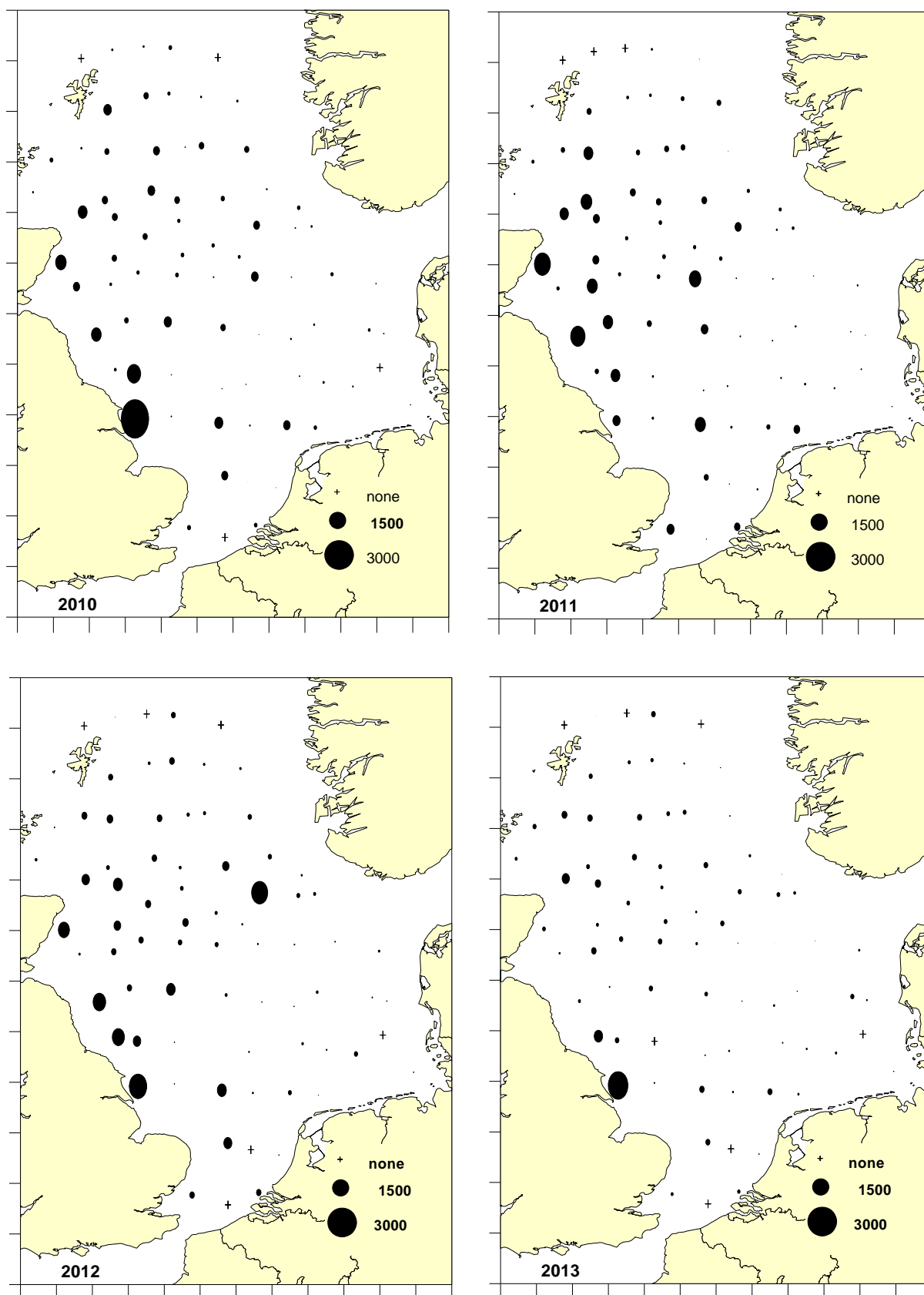


Figure 6. Distribution and relative abundance (kg) of saithe for 2010 to 2013.

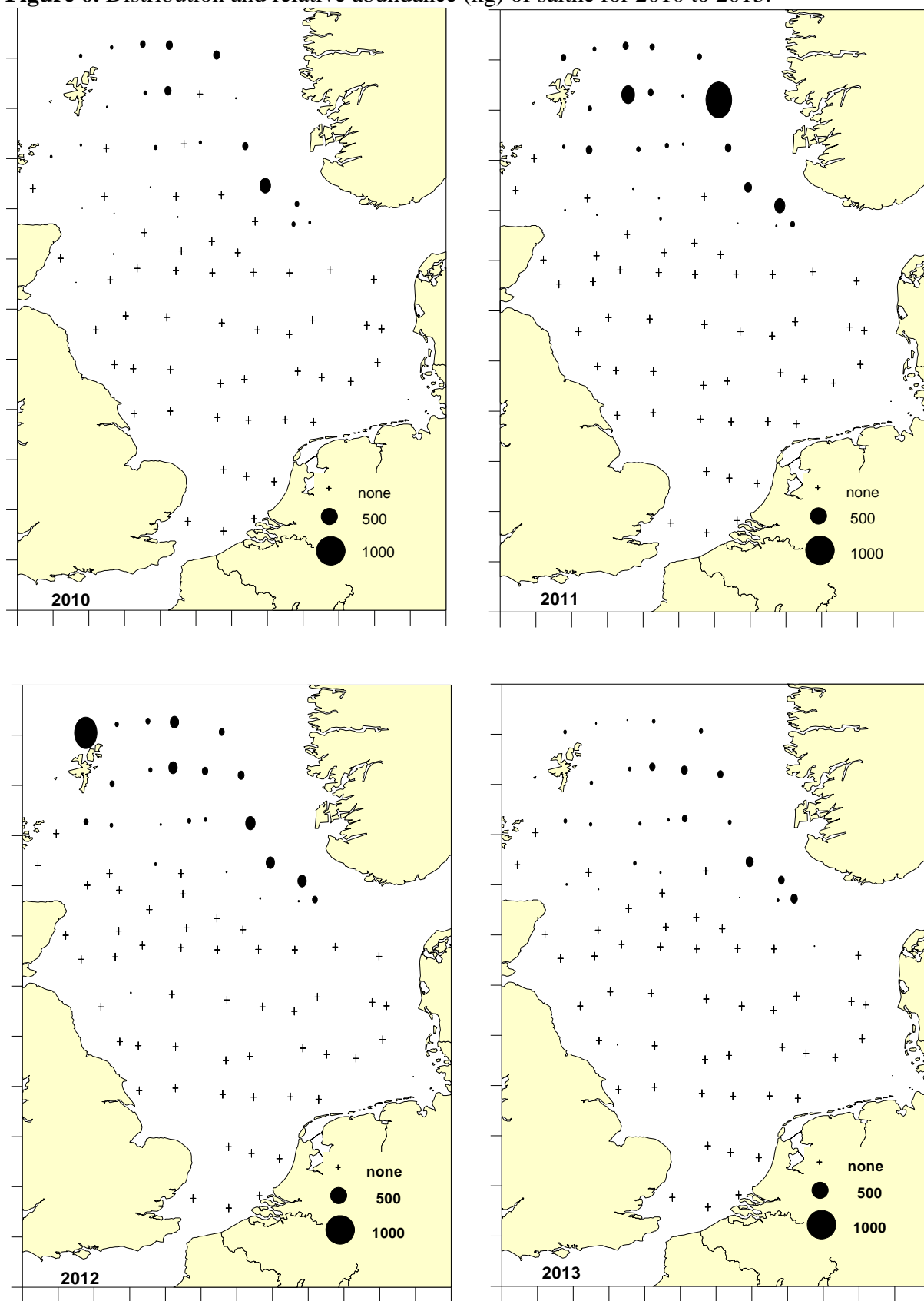


Figure 7. Distribution and relative abundance (kg) of Norway pout for 2010 to 2013.

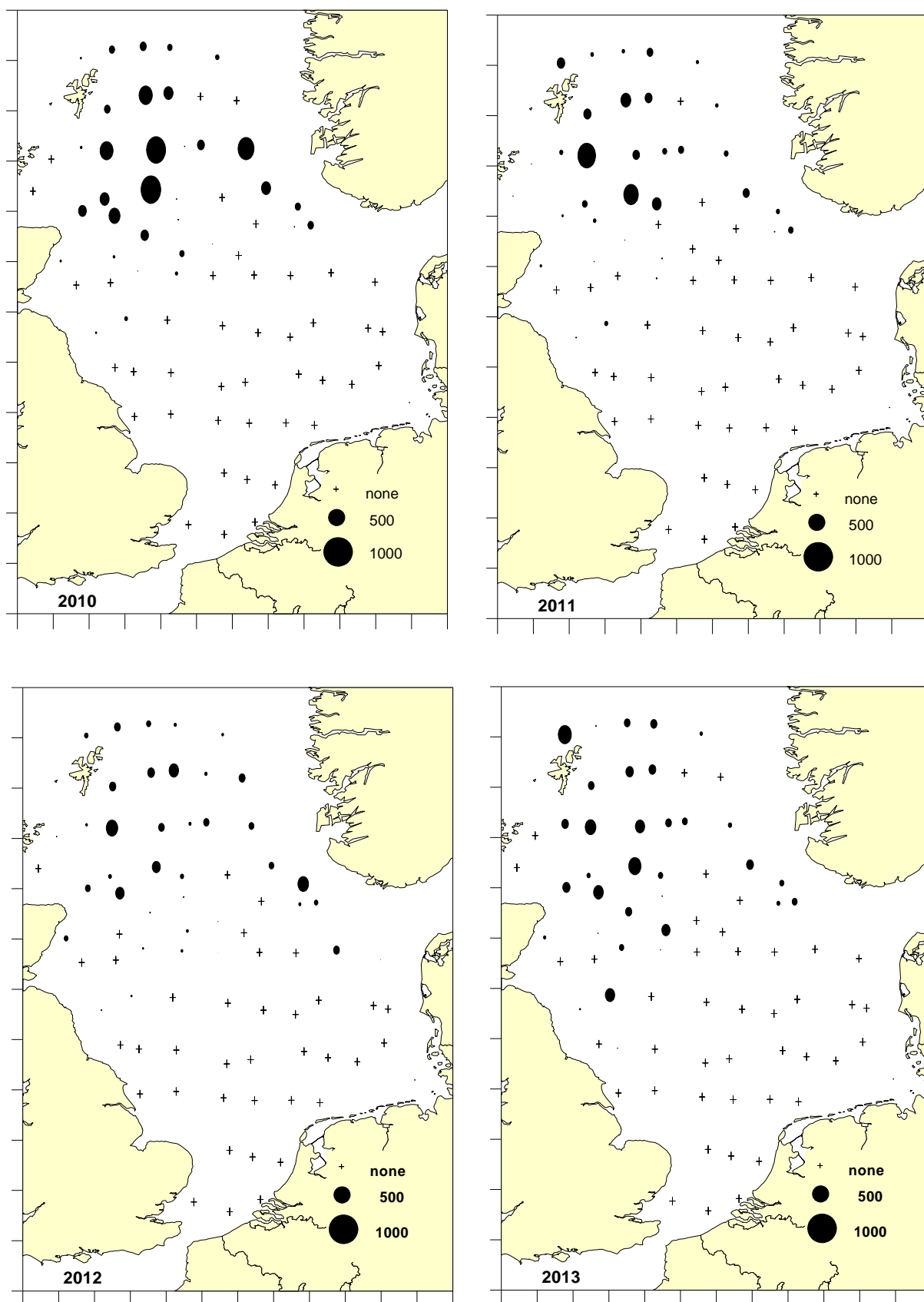


Figure 8. Distribution and relative abundance (kg) of herring for 2010 to 2013.

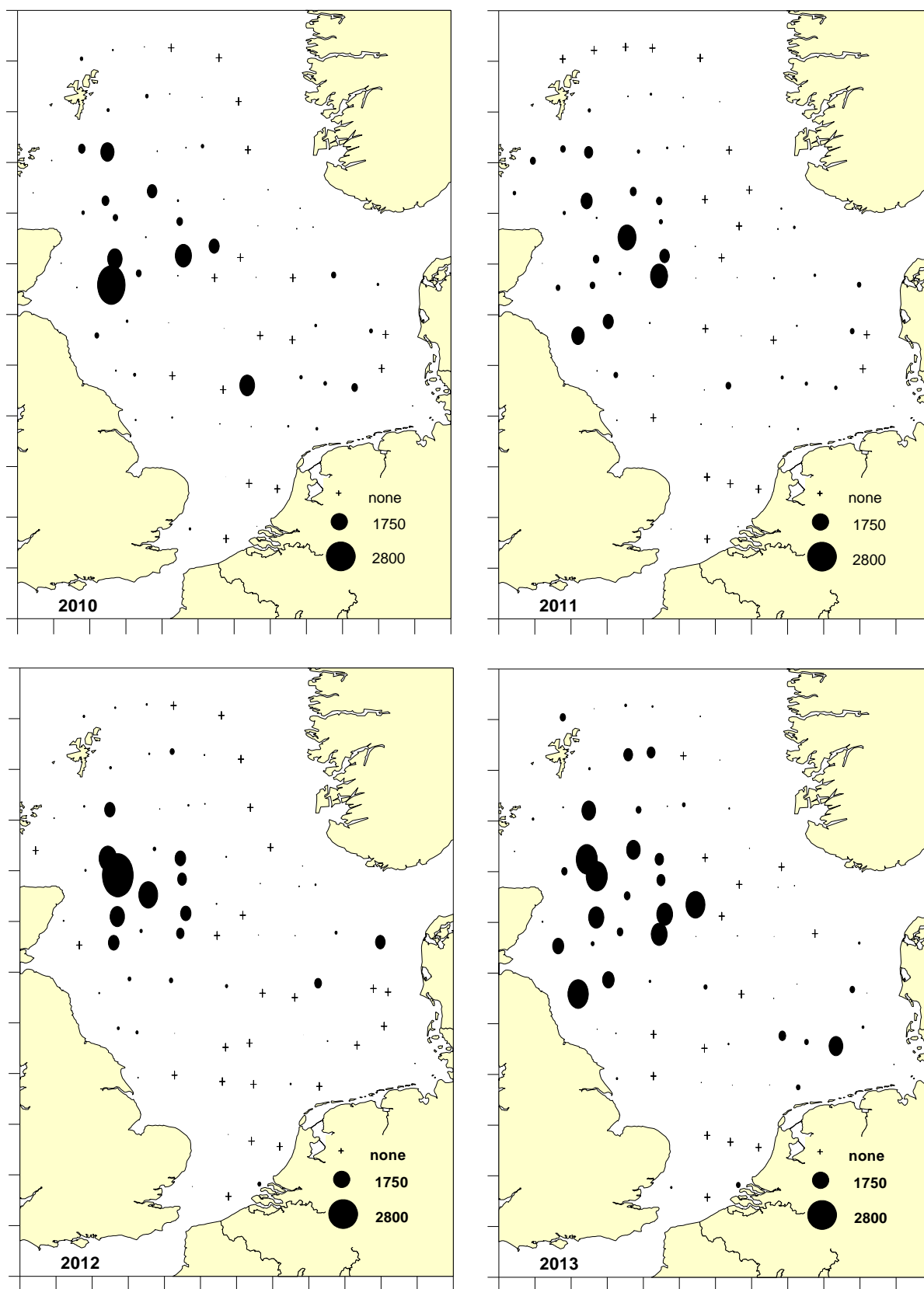


Figure 9. Distribution and relative abundance (kg) of mackerel for 2010 to 2013.

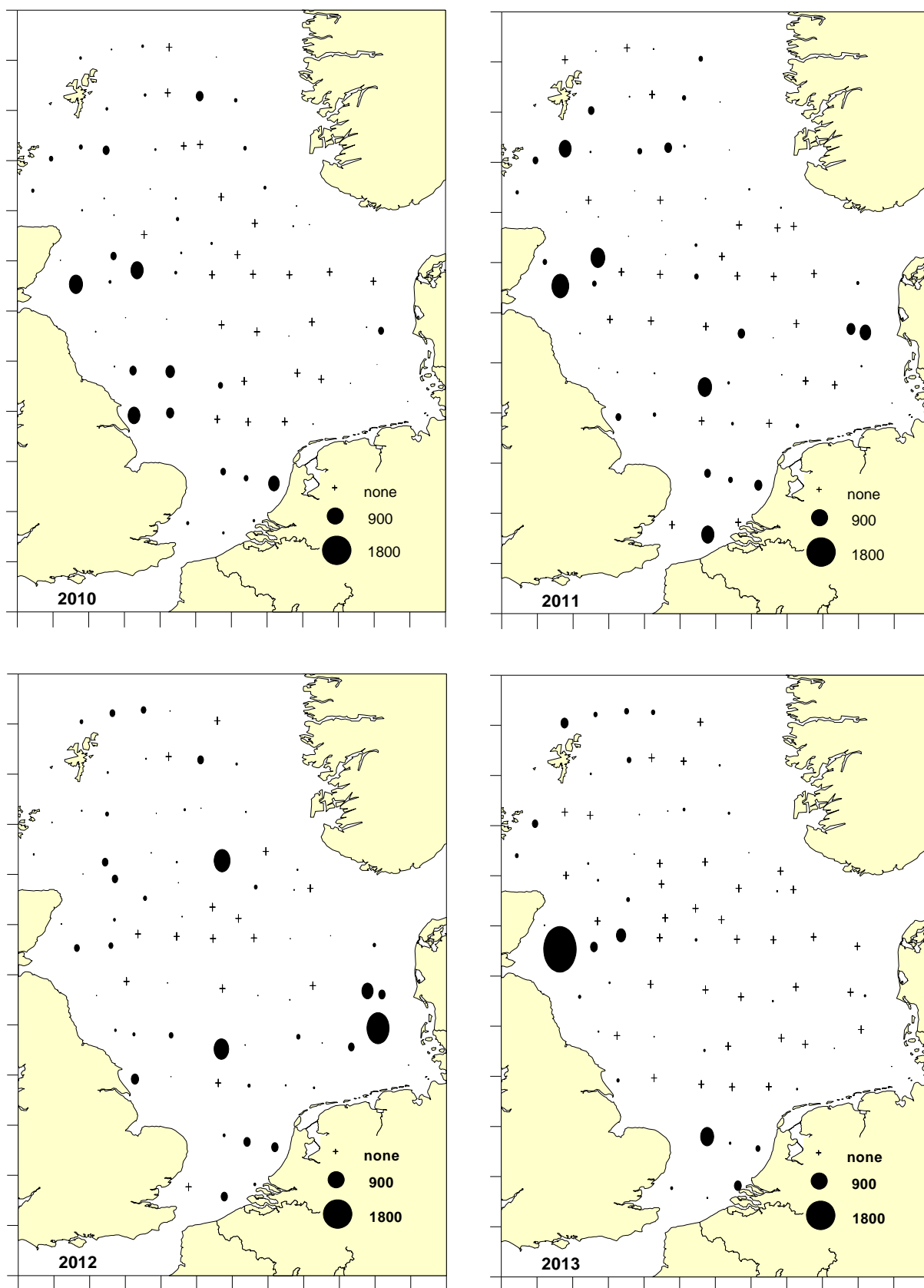


Figure 10. Distribution and relative abundance (kg) of sprat for 2010 to 2013.

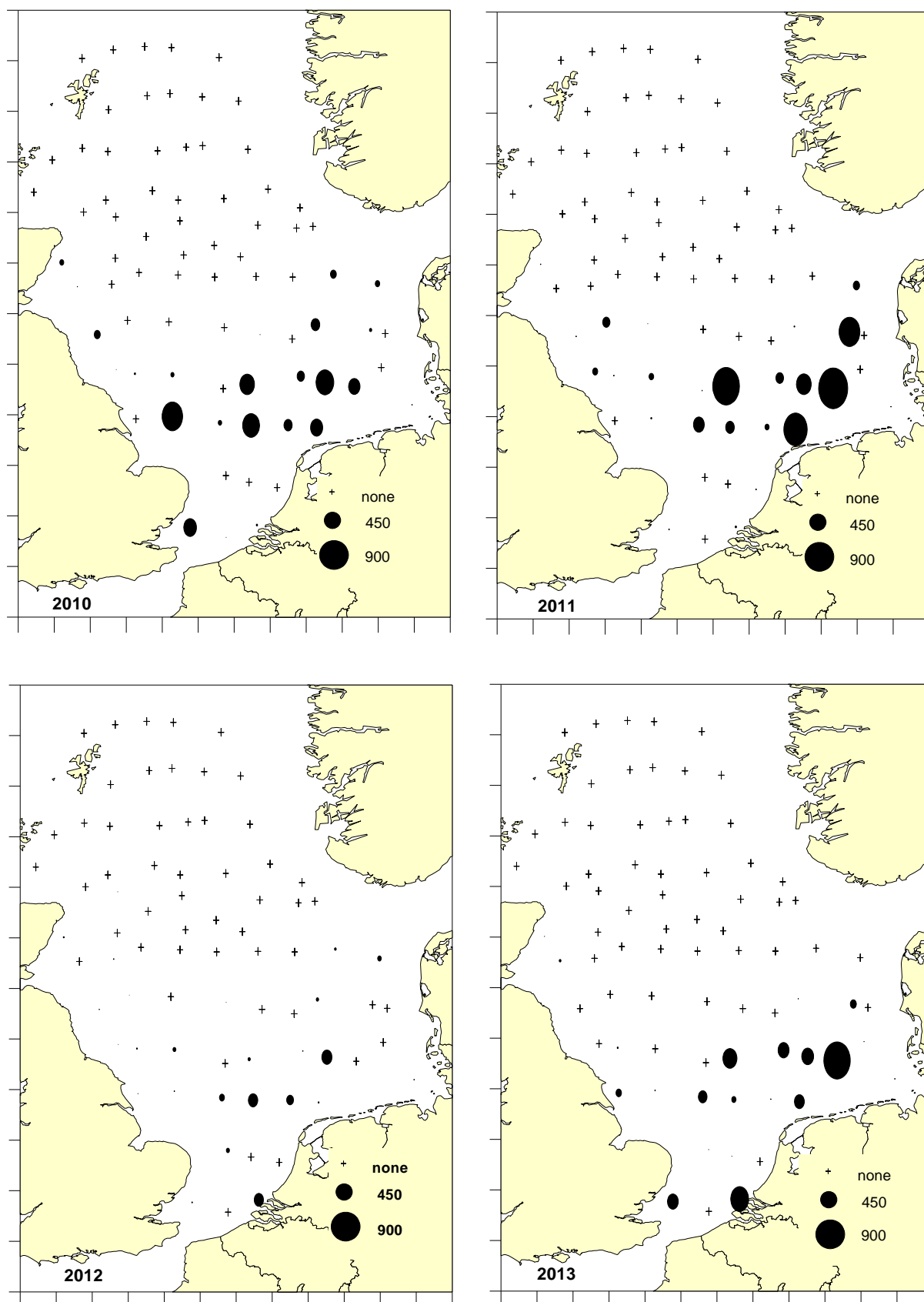


Figure 11. Distribution and relative abundance (kg) of plaice for 2010 to 2013.

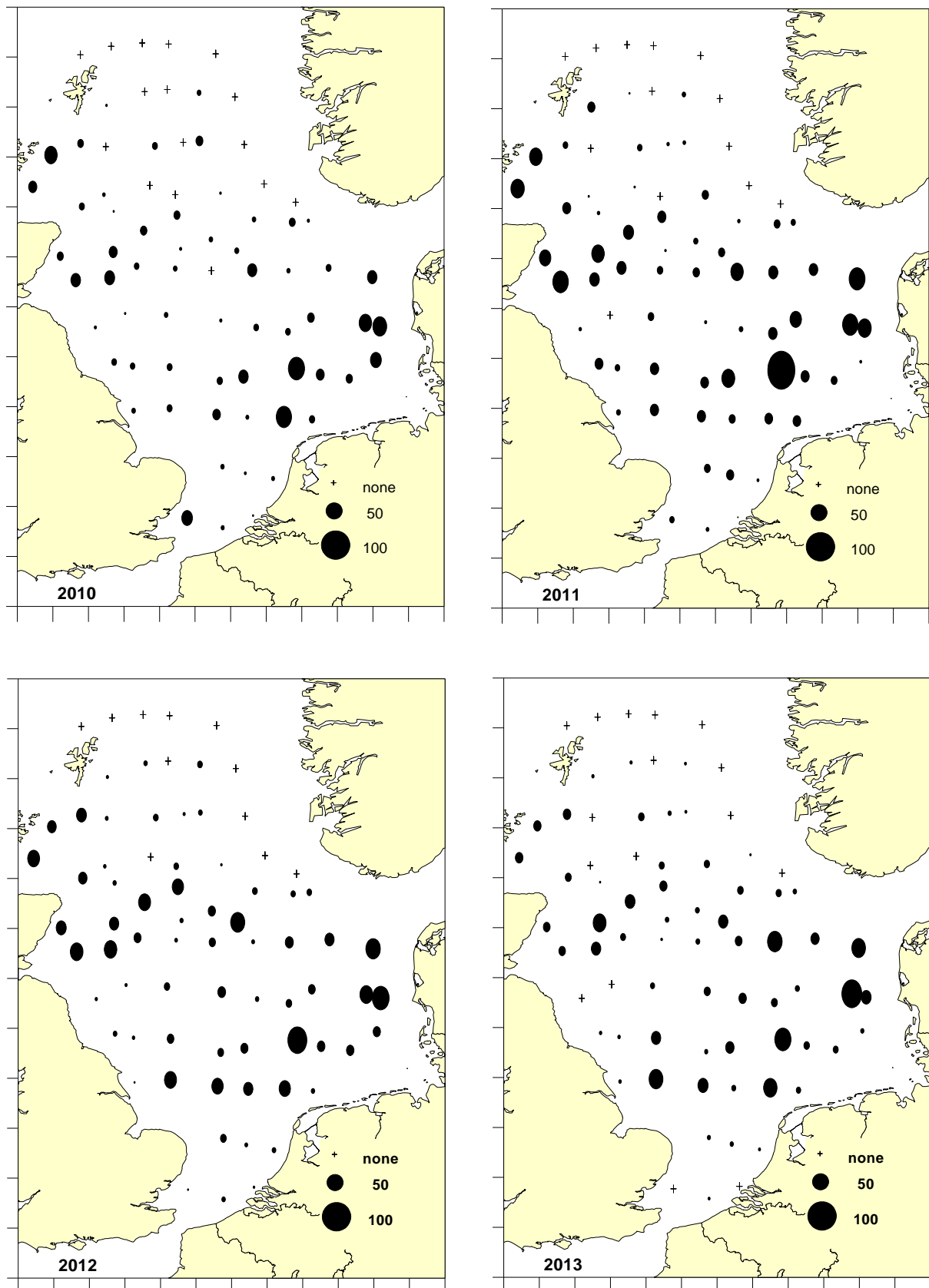


Figure 12. Distribution and relative abundance (kg) of hake for 2010 to 2013.

