CRUISE REPORT CEND 4-10

A survey of Irish Sea cod spawning grounds for Defra project MEMFISH

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2 Outline of the survey

2.1 Staff

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2.2 Duration

17 February – 2 March 2010

2.3 Location

Northern Irish Sea

2.4 Objectives

1. Assess the distribution of cod at known spawning areas in the Irish Sea
2. Assess the size and age compositon of the spawning cod population through data on trawl catch compositions (including collection of otoliths)
3. Assess the biological characteristics of individual cod on the spawning grounds, through information on the size, weight and body condition (including hepatosomatic index), and reproductive status (sex, age, maturity, gonad weight)
4. Collect biopsy samples from the ovaries of female cod to determine the reproductive status, egg size etc.

5. Collect tissue samples for genetic analysis on population structure, through fin-clipping
6. Assess the diet of cod through stomach contents analysis
7. Collect samples of plasma, liver, testes, muscle tissue, and bile duct from male cod, in support of Defra project C2827 'CODEND'
8. Examine spatial overlap with potential cod egg predators (including sprat and herring), including assessing the stomach contents of up to ~10 individuals per species per station
9. Examine diet of miscellaneous fish species other than cod and pelagics, in support of Defra project M1108 'DAPSTOM Phase 3'

2.5 Additional objectives

10. Assess the physical characteristics of cod spawning areas
11. Tag elasmobranchs, in support of studies on their movement patterns in the Irish Sea
12. Examine cod nursery grounds
13. Collect frozen samples of sardine and anchovy

2.6 Narrative

RV *Cefas Endeavour* left the port of Belfast at 10:00 on Wednesday 17 February 2010, heading south-east to commence a twelve-day survey on cod in the western Irish Sea. A 'shake down' tow was carried out in the early afternoon, allowing the crew to check the trawling gear and the scientists to proof-run the automated fish measuring system (EDC). The first station was then shot at 15:00. Trawls were fished continuously throughout each day, ending at approximately 2:00 AM, based on locations from last year's Memfish survey (CEnd 2-09) as well as the positions of commercial cod catches in February 2007–2009. Overnight, a multibeam survey was conducted of the area to be fished the following day to detect possible trawl hangs. For practical reasons, the survey area was divided in 5 'boxes', and a total of 107 stations were fished (see Figure 1). Survey Box 1 (north-west of Isle of Man) was sampled on 17–18 February, and fairly high cod catch rates were achieved but also damage to the trawl net (slight to major) at 5 out of 12 stations — in spite of near lack of damage at these sites in 2009. Survey Boxes 2 and 3 (between Northern Ireland and Isle of Man) was sampled on 19–20 February and 21–22 February, respectively, with good cod catches and no damage experienced. Survey Box 4 (east of Republic of Ireland, south-west of Isle of Man) was surveyed in the next 3 days; fewer cod were found but no damage to the net. Weather picked up while sampling these sites. Survey Box 5 (between Northern Ireland and Isle of Man, west of Boxes 2 and 3) was sampled on 26–27 February. On the 26th, down time resulted from the catch of a wreck of a 15-m yacht in the net, its position not shown on sea charts. It could not be retrieved, and the new position of the wreck was relayed to Belfast Coast Guard. In the last 3 days of the survey, several 'open spaces' in Boxes 2, 3 and 5 not previosuly sampled were fished. Surveying was completed at 15:00 on Monday 1 March, when Endeavour set a course for Belfast harbour, arriving alongside at 09:00 on Tuesday 2 March.

3 Preliminary results of the survey

3.1 Sampling stations

Hour-long trawls using the Portuguese high headline trawl (PHHT) were used to assess the abundance of cod, focussed on the area west and south-west of the Isle of Man, which yielded high commercial catch rates in February 2007–2009 (Figure 1). In total, 107 trawls were completed. In 100 of these, no gear damage was experienced (indicated blue in Figure 1); in 7 hauls, slight or major damage to the net was experienced (indicated red in Figure 1).

Figure 1 (*next page*). Stations sampled during the 2010 Memfish survey, 17 February–1 March 2010. Station numbers are shown where the trawl was shot, and the lines indicate the trawl haul transects. Blue are clear (valid) tows, red are tows where the net was damaged. Grey symbols indicate commercial trawlers cod cpue (February 2007–2009, averaged over fishing trips, from VMS). The five 'survey boxes' are indicated by red lines. Further, two underwater gas pipelines running from Scotland to Northern Ireland are indicated by brown dotted lines.

3.2 Sea bottom temperatures at sampling stations

A small CTD was attached to the net during each trawl haul, and temperature averages were calculated for each period the trawl was on the seabed, yielding information on sea bottom temperature at each of the sampling stations. Figure 2 shows the measured sea bottom temperatures, overlaid on a map of the study area showing the bathymetry. It is evident that relatively warmer temperatures characterised the deeper parts of the seabed, especially the central part of the channel halfway between Northern Ireland and the Isle of Man, and that colder temperatures characterised the less deep-lying areas of seabed.

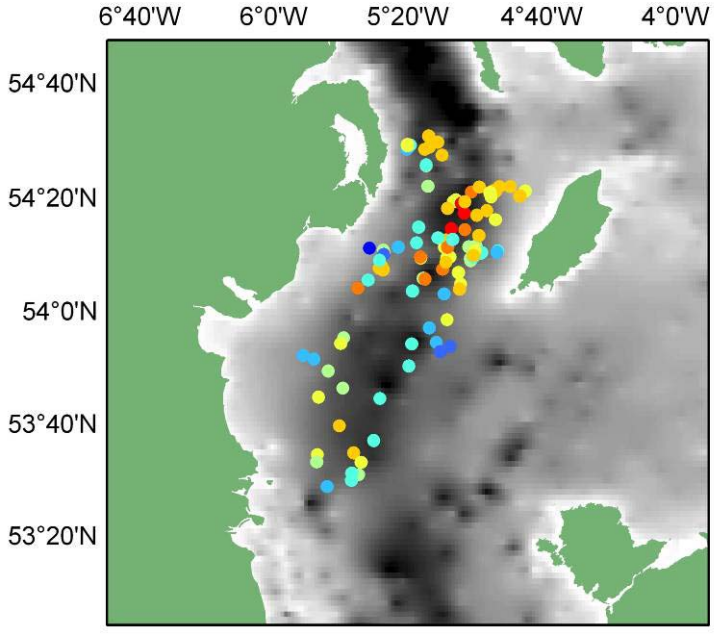
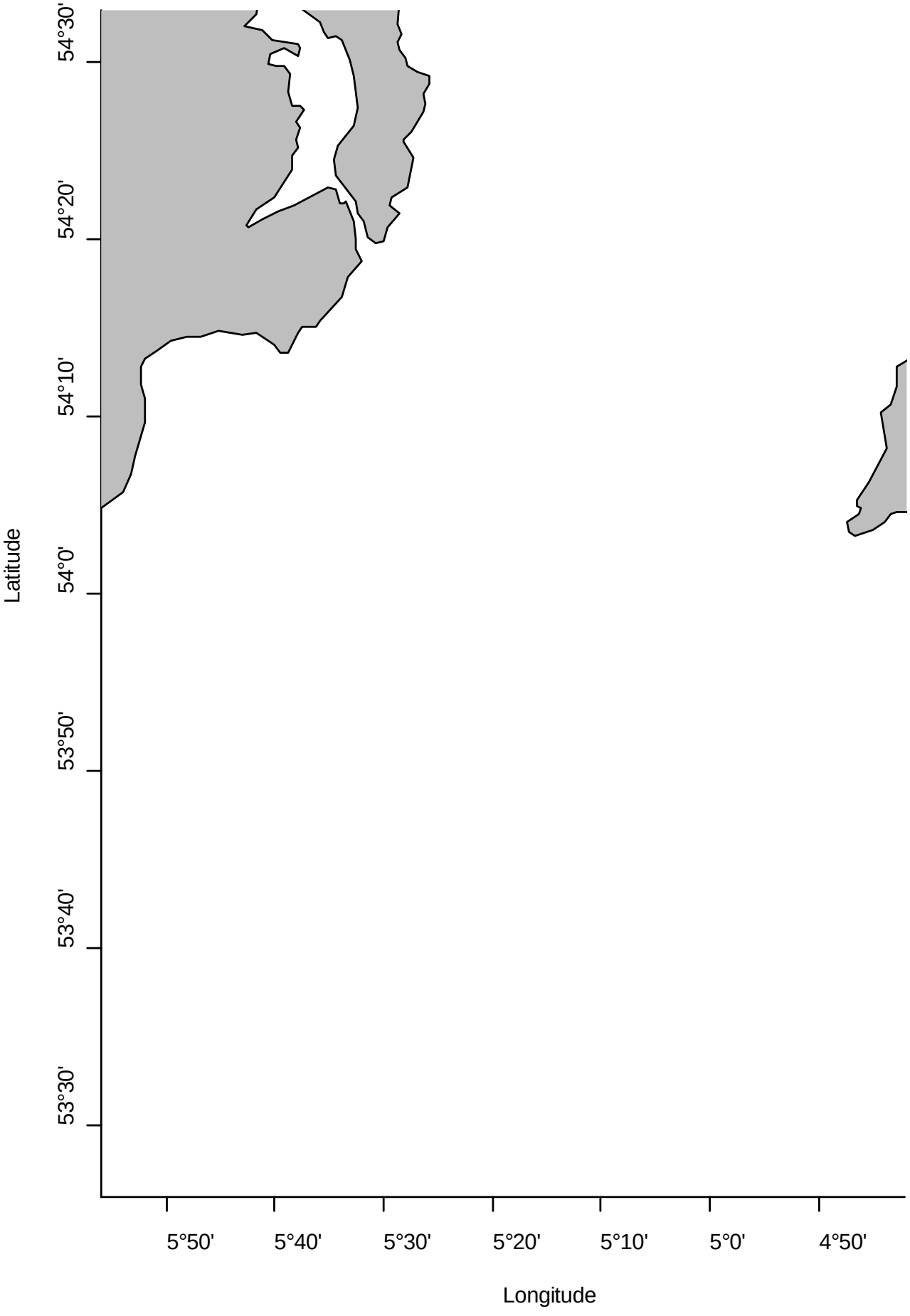


Figure 2. Mean sea bottom temperatures as measured at each station during the survey. Colours ranging from red through yellow to blue indicate relatively warmer and colder temperatures, respectively.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Longitude

3.3 Distribution and abundance of cod

Overall, catch rates of cod were comparable to those experienced in the 'Western Survey Area' of the 2009 Memfish survey (which coincides with Boxes 1–3 of the 2010 survey). In total, 269 cod were caught on the 107 stations of this survey (and 2 during the shake-down tow). On average, this was 2.50 cod per haul — slightly higher than the average catch rate of 2.34 per haul during the 2009 Memfish survey. Out of a total of 73 fish species (including a few shellfish species) encountered during the survey, cod ranked 17th in terms of total numbers caught.

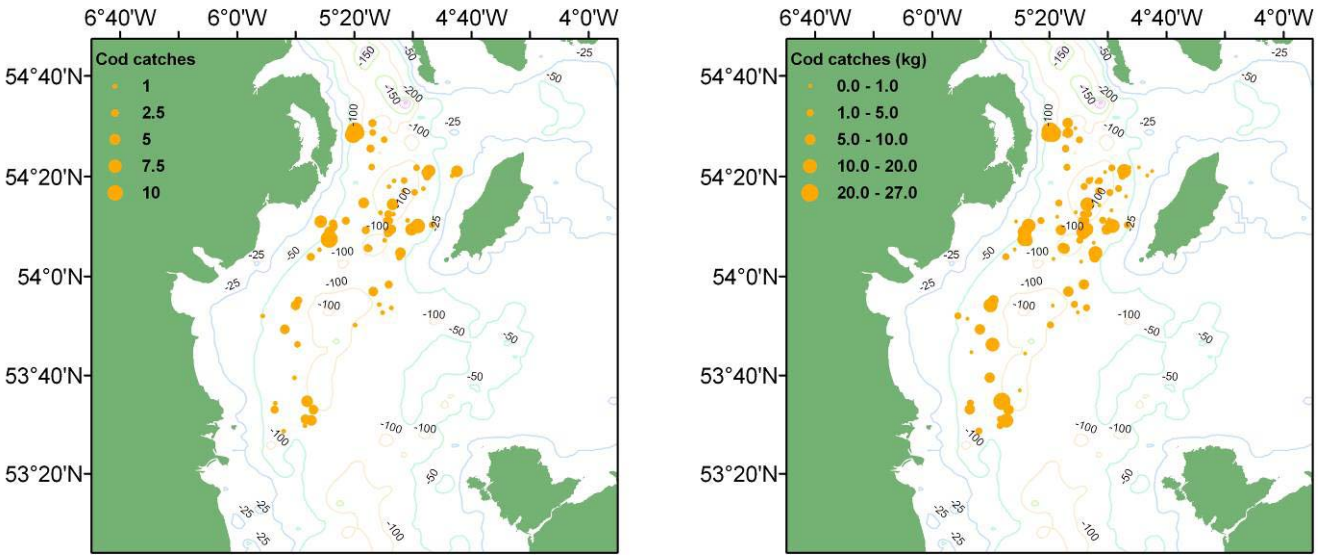


Figure 3. Distribution of cod catch rates in the western Irish Sea. Symbol sizes indicate catch rates expressed as numbers caught (left) and as weight of catch (right) per hour of fishing.

Generally, higher cod catch rates were achieved in the deeper area between the Isle of man and Northern Ireland, which is characterised by milder sea bottom temperatures than the shallower areas (cf. Figure 1). Locally, good catch rates were also obtained on hard grounds off the Ards Peninsula (Northern Ireland), and at a deeper site off Skerries (north-east of Dublin, Republic of Ireland).

3.4 Size composition of cod at spawning areas

Although the overall catch rate in this survey was comparable to that during the 2009 Memfish survey in the western Irish Sea, the size distribution and sex ratios were quite different (Figure 4).

Size distribution. In 2009, the part of the survey west of the Isle of Man had yielded a broad size distribution of cod with peaks at several length modes: a strong peak at 10–25 cm (probably juveniles of 1 year old); a small peak at 35–45 cm (probably 2 year olds); but the majority of cod >55 cm (ages 3+). In 2010, there was a smaller peak at 10–25 cm (1 year olds) but the majority of cod were about 40–60 cm long (probably a mixture of many 2 year olds and fewer older fish). Many more large cod of >60 cm were caught in 2009 (mostly females) than in 2010, but the very largest fish of the 2010 survey (>85 cm) were bigger than the largest cod in 2009.

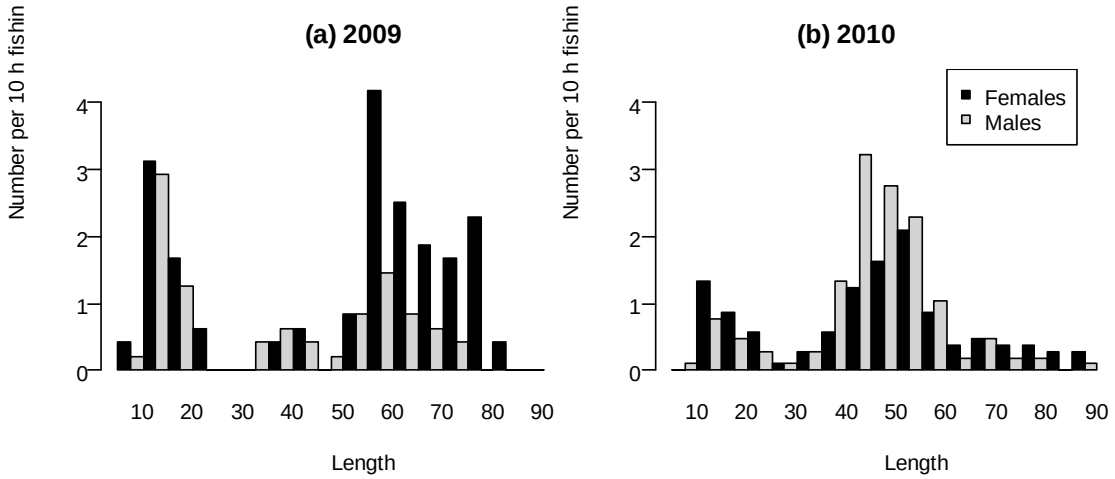


Figure 4. Length distributions of female (*black bars*) and male cod (*grey bars*) observed in the western Irish Sea during (a) the 2009 and (b) the 2010 Memfish surveys.

Sex ratio. In contrast to the 2009 survey in the western Irish Sea, when far more female cod (67%) than male cod (34%) had been caught, the sex ratio was now closer to unity with males somewhat more often caught (46% females, 54% males). Amongst smaller (<50 cm) cod, females predominated slightly (53%); amongst larger cod (>50 cm), males predominated slightly (57%).

Table 1. Numbers of female and male cod (and one unsexed individual) smaller and larger than 50 cm caught in the 2009 and 2010 surveys, and sex ratios expressed as % females and % males of the total numbers of known-sex cod. Figures for 2009 only include cod caught in the western Irish Sea.

All sizes	2009	99	49	0	67%	33%
	2010	123	145	1	46%	54%
<50 cm	2009	30	26	0	54%	46%
	2010	41	36	0	53%	47%
>50 cm	2009	69	23	0	75%	25%
	2010	82	109	1	43%	57%

3.5 Maturity and reproductive characteristics of individual cod

In this year's survey, maturity stages were determined for 267 cod (Figure 5). Females and males at all stages of gonad maturity except for the spent stage were observed. All cod <30 cm were immature, and all cod >60 cm were mature. Above these lengths, the majority of fish had maturing gonads. Apart from females of 40–50 cm length, maturity was slightly more advanced than observed during the western leg of the 2009 survey (compare Figure 5a–b with 5c–d). Although 2 spent females were observed then, greater numbers of hyaline and running females, and of running males, were observed in 2010. This was in line with the slightly later timing of this year's survey. One 90.4 cm female caught in 2010 showed atretic ovaries.

One very large cod, with a length of 93.4 cm and body weight of 9.3 kg, stood out through complete absence of developed gonad tissue, and its sex could not be determined, although based on body size alone it would have been judged to be a female. Otherwise the animal appeared to be in healthy condition. Some connective tissue was present in the body cavity near where the gonad would normally have been present.

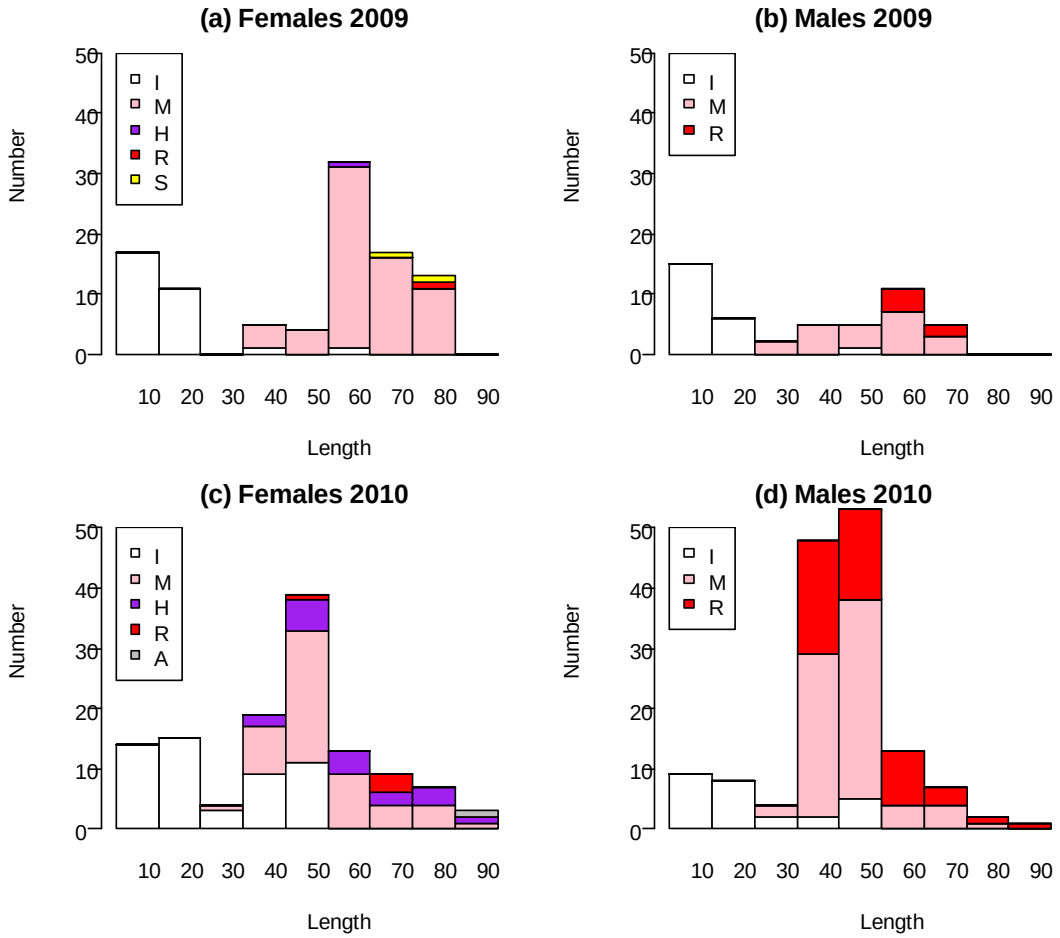


Figure 5. Maturity stages by 10-cm length groups of (a) female and (b) male cod in 2009 (western part of survey) and (c) female and (d) male cod in 2010. I immature; M maturing; H hyaline (females only); R running; S spent; A atretic.

Length–weight relationships and length–gonad weight relationships are shown in Figure 4, for female and male cod separately. These relationships underline that the largest of fish invest disproportionately more in reproduction. For example, in the largest female, body weight was 11.23 kg and ovary weight 2.1 kg, i.e. 18% of body weight; this was on average 10% in females between 3 and 4 kg body weight. The highest ovary weights in relation to body weight were observed in females with hyaline gonads. One obvious exception to this was the large female with atretic, strongly reduced ovaries (ovary weight only 134.7 g).

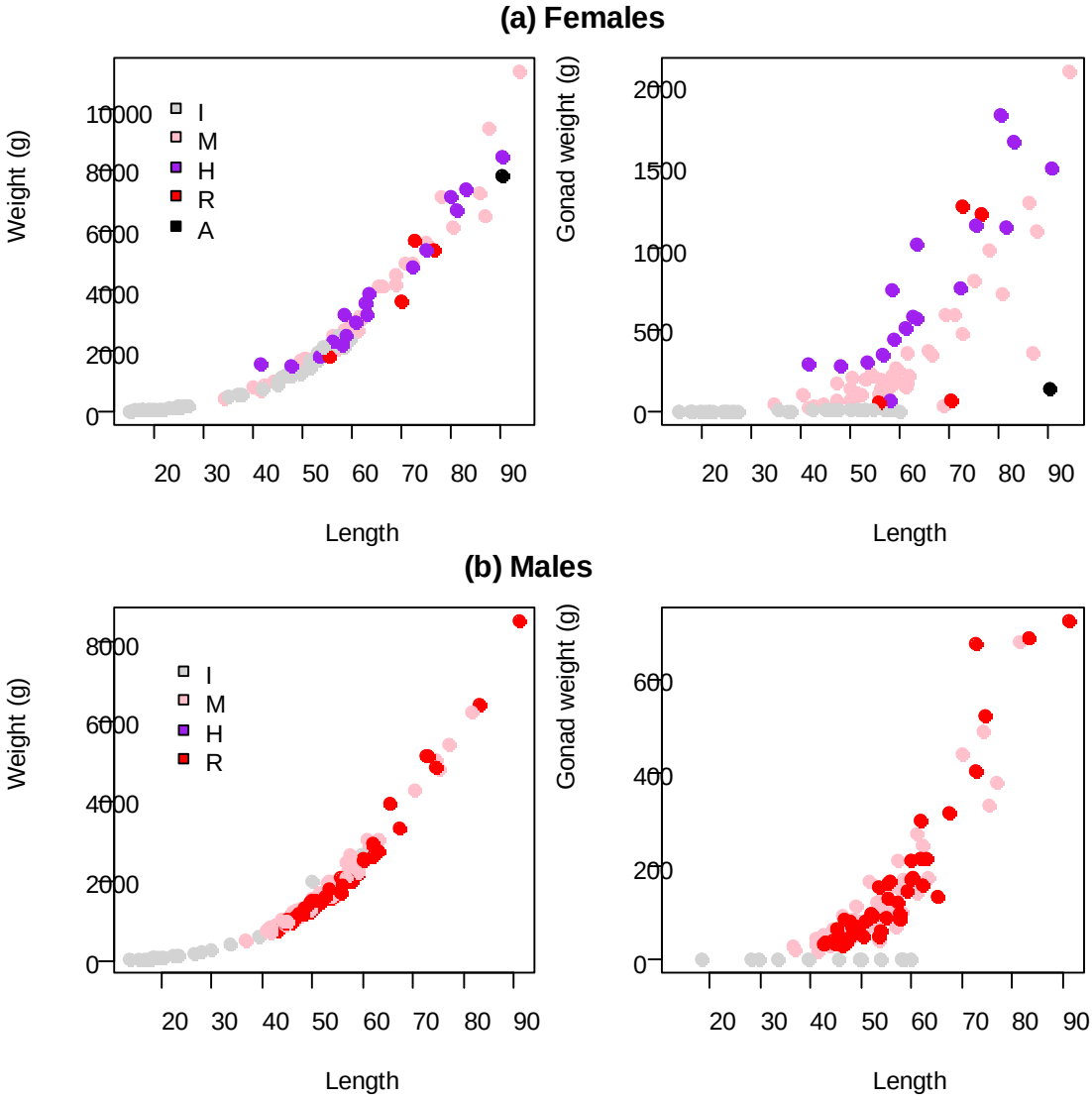


Figure 6. Length–weight relationships (*left panels*) and length–gonad weight relationships (*right panels*) of (a) female and (b) male cod caught in the 2010 survey. For each individual fish, the colour of the symbol indicates its maturity stage (see legend: I immature; M maturing; H hyaline [females only]; R running; A atretic).

2.1 Length–weight relationships

The length–weight relationships in the 2009 and 2010 Memfish surveys were highly similar (Figure 7), although the weight-at-length for female cod tends to de slightly higher than for male cod. Hence based on length–weight relationships there was no indication of a change in the body condition of the cod.

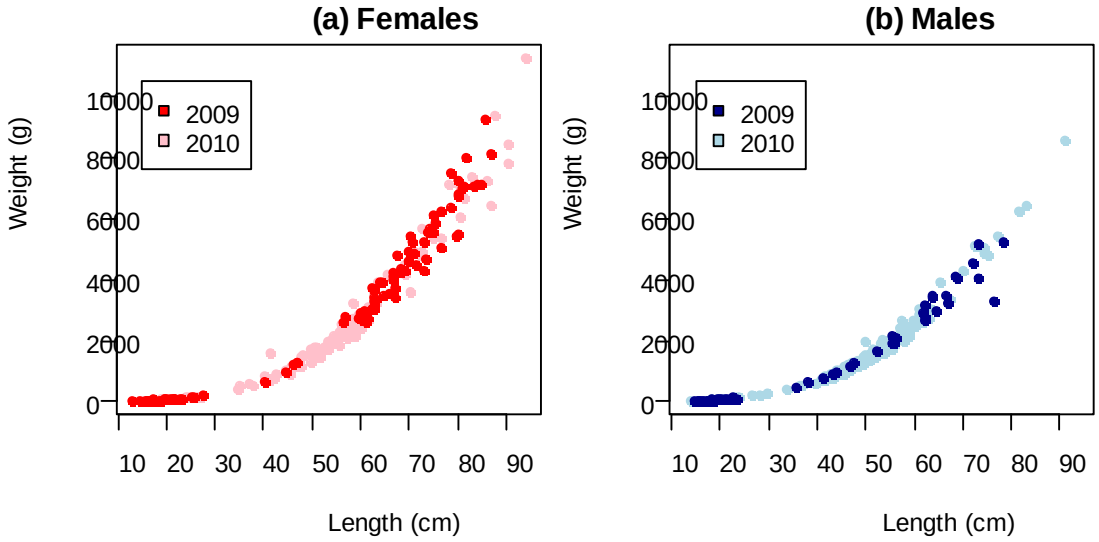


Figure 7. Length–weight relationships of (a) female and (b) male cod, compared between the 2009 and 2010 western surveys, indicated by darker and lighter symbols respectively. The 2009 data only include those from the western Irish Sea.

2.2 Diet of cod on spawning grounds

All cod sampled were examined for stomach contents, except 9 fish where the stomach was everted. Most had been feeding extensively, and in only 49 out of 259 cod the stomach was found to be empty (19.1% of all cod). The fullness of cod stomachs tended to be less than that observed last year in the western Irish Sea, albeit not consistently so at all length groups (Table 2).

Table 2. Mean weight of total stomach contents (in g) of female and male cod by length group, compared between the 2009 (West) and 2010 Memfish surveys.

	2009	**2010**	**2009**	**2010**
10-19	0.5	0.4	0.4	0.3
20-29	0.6	1.5	1.9	2.5
30-39		7.2	4.6	2.7
40-49	17.9	20.7	13.6	15.7
50-59	40.6	31.7	19.0	20.1
60-69	53.5	27.6	44.8	21.8
70-79	59.4	28.2	26.5	50.8
80-89	86.7	46.9		27.9
90-99		59.7		0
All	**58.5**	**21.3**	**29.5**	**17.2**

The cod had a very broad diet in both 2009 and 2010, with 28 and 27 different prey species recorded, respectively. Prey species in 2010 belonged to the following phyla or classes: polychaetes (2 species), molluscs (2 species), crustaceans (12 species), tunicates (1 species) and fish (12 species; see Table 3 for an overview of all prey species eaten by cod).

Table 3. Overview of all prey items found in the stomachs of 167 Irish Sea cod in 2009, and 269 Irish Sea cod in 2010, identified to species or lowest taxonomic level. *N* is the total number of prey individuals recorded.

Polychaetes[1]	AAC	Seamouse	*Aphrodita aculeata*	5	7
Molluscs[2]	TNT	Thin tellin	*Tellina tenuis*	1	
	DEE	Tusk shell	*Dentalium entalis*	1	1
	ATS	Squid	*Alloteuthis subulata*	1	
	OCV	Octopus	*Octopus vulgaris/Eledone cirrhosa*	2	
Crustaceans		Mysid	Mysidacea		1
	NEP	Nephrops	*Nephrops norvegicus*	205	134
	CPR	Common prawn	*Palaemon serratus*	49	19
	PRM	Pink shrimp	*Pandalus montagui*	36	24
	CRN	Brown shrimp	Crangonidae	2	10
	GLX	Squat lobster	*Galathea, Munida* sp.	9	12
	PSO	Ghost shrimp	*Pasiphaea sivado*	1	4
	XAP	Risso's crab	*Xantho pilipes*	1	5
	Gonoplax	Angular crab	*Gonoplax rhomboides*		6
	Liocarcinus	Swimming crab	*Liocarcinus* sp.	1	4
		Porcelain crab	Porcellanidae		4
	Macropodia	Spider crab	*Macropodia* sp.	5	
	PEB	Hermit	*Pagurus bernhardus*	3	3
Echinoderms	OPF	Common brittlestar	*Ophiothrix fragilis*	2	
	URX	Sea urchin	*?Echinocardium cordatum*	1	
Tunicates		Tunicate	Tunicata		1
Fish	SPR	Sprat	*Sprattus sprattus*	7	3
	HAD	Haddock	*Melanogrammus aeglefinus*		3
	WHG	Whiting	*Merlangius merlangus*	6	23
	WHB	Blue whiting	*Micromesistius poutassou*	28	21
	NOP	Norway pout	*Trisopterus esmarki*	16	12
	POD	Poor cod	*Trisopterus minutus*	4	2
	Rockling	Rockling	*Gaidropsarus/Ciliata/Enchelyopus*	2	5
	Pipefish	Pipefish	*Syngnathus* sp.	1	
	CDT	Common dragonet	*Callionymus lyra*	1	1
	POM	Sand goby	*Pomatoschistus* sp.	2	
	DAB	Dab	*Limanda limanda*		5
	PLA	Long rough dab	*Hippoglossoides platessoides*		2
	WIT	Witch	*Glyptocephalus cynoglossus*	3	
	SOL	Sole	*Solea solea*		1
	SOT	Solenette	*Buglossidium luteum*	1	
	TBS	Thick-backed sole	*Microchirus variegatus*		6

[1] Also, 2 unidentified polychaetes.
[2] Also, 4 unidentified bivalve shelles and 3 siphons.

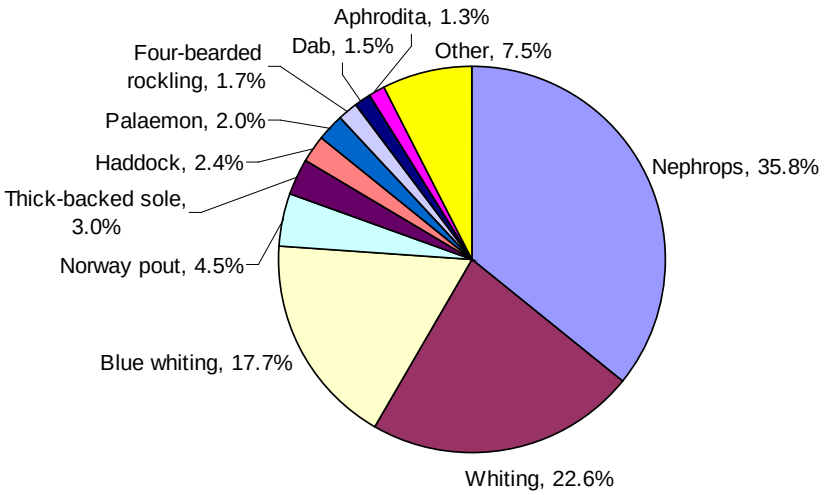


Figure 8. Irish Sea cod diet composition by prey weight. Diagram shows the % of total prey weight, comprised by each of the 10 principal prey species, and by all other prey species combined

Although Irish Sea cod were truly omnivorous, a few prey species constituted the majority of all food consumed in terms of weight (Figure 8). As in 2009, *Nephrops* dominated cod diet and comprised over 35% of cod diet (45% in 2009): the slightly lower figure this year might relate to the extension of the survey area beyond the most important *Nephrops* grounds. Over 50% of cod diet was comprised of gadoids (mostly whiting and blue whiting; also Norway pout, haddock, poor cod and [four-bearded] rockling). Some flatfish species were also eaten (thick-backed sole, dab, long-rough dab, sole). A variety of small crustacean species were also eaten, including common prawn, pink shrimp, brown shrimp, squat lobsters, and various small crabs (Table 3).

3 Ovary and fin tissue samples collected

During the survey a total of 51 biopsy samples of ovary tissue were taken in triplicate from adult female, maturing cod, and an additional 27 samples were taken from haddock females. Samples are to be analysed in the laboratory for egg number and mean egg size. Each sample consisted of 104 mg (or 0.1 ml) ovary tissue, taken in triplet and stored in microtubes pre-filled with 0.1 M sodium phosphate buffered, 3.6% formaldehyde. The microtubes were labelled 1–88.

Further, a total of 269 fin tissue samples were collected from male and female, adult and juvenile cod, to be analysed using molecular techniques to further insight into cod population structure. The samples were taken in support of a NERC-Defra Sustainable Marine Bioresources project. Each sample consisted of a ‘fin clip’ of very approximately 0.5 by 1.5 cm, and was stored in Eppendorf tubes pre-filled with a 90% ethanol solution. The tubes were labelled E1–E275.

4 Predation on cod eggs by pelagic fishes

We examined the stomach contents of up to 10–15 herring and sprat at each station; these pelagic species have been hypothesised to have a possible top-down effect on cod population dynamics through predation on the eggs. Some evidence of cod egg predation by herring was found. Of 432 herring, most had empty stomachs (n = 299),

but many had fed on euphausiids (n = 75) and/or copepods (n = 27); in 17 herring, a total of 59 fish eggs were found including ‘cod/haddock-size’ eggs. Out of 196 sprat sampled, 190 had empty stomachs; in 5 sprat, a total of 41 fish eggs were found. Overall, herring and sprat were the second- and third-most abundant fish species sampled during this survey.

Appendix 1:

Elusive Irish Sea cod: the search continues (a diary of an SIC)

Elusive Irish Sea Cod: the search continues

Narrative of survey CEND 4-10, Irish Sea, 16 February–2 March 2010

Georg H. Engelhard (SIC)

Prologue

Much was learned about the Irish Sea cod last year, during survey CEnd 2-09 for Defra project 'Memfish' — from 7–17 February 2009, onboard Defra's research vessel, *Cefas Endeavour*. Firstly, that looking at cod fishermen's behaviour can help identifying good fishing locations, which can be crucial for obtaining decent sample sizes of this elusive species. Secondly, that many more large, spawn-ready males and females of Irish Sea cod are to be found to the west than to the east of the Isle of Man; in the east we found very few cod, although the largest few individuals came from there. Thirdly, that also here it holds true that the largest female cod have disproportionately larger ovaries than small to medium-sized females, confirming the importance of large, old repeat spawners for population reproductive potential. Fourth, that cod in the Irish Sea cod have an exceptionally broad diet: no less than 28 different species of prey were recorded during our survey. It appeared to be the rich *Nephrops* grounds that really attracted the cod. Fifth, no more than sporadic evidence of cod eggs in stomachs of herring and sprat was found — predation on cod eggs by pelagics is suspected to play a role in the lack of recovery of cod stock — but our survey was timed slightly before the main spawning time of cod, so that few cod eggs would have been present in the water column. Overall, at the end of the survey, we found the cod less elusive than when we started.

Now we are at the start of the 2010 'Memfish' survey, again onboard *Endeavour* and back on the Irish Sea. Our cruise aims are similar to last year's, though different in detail: to study Irish Sea cod at known spawning grounds in February, but now timed slightly later hopefully to have a better match with peak cod spawning; to measure and record as much as we can of the cod we manage to catch; again, to study potential predators of cod eggs, i.e. herring and sprat (not worrying about squids this time); to look at cod diet; and to get a good idea of the fish that are around at the spawning sites, by studying the composition of our trawl catches. We also aim to do tagging studies, not on plaice but on large charismatic elasmobranchs such as spurdog.

Wednesday 17 February 2010

North-west of the Isle of Man (Box 1)

We have left Belfast this morning at 10:00, and our first hauls have already been shot and hauled. We are fully 'up and running', with a good sample of cod already caught. A very first 'shake-down' tow of half hour duration, not far from Belfast, helped us to get ourselves set up and check if everything is running smoothly. The first two proper stations were fished for a full hour each, and they gave us good hits of cod: 12 at station 1, 15 at station 2 (including one 9 kg female with very high ovary weight). It took us many hours to record all important data for these fish, including the dissection, maturity staging, stomach contents identification, and

collection of blood, tissue and ovary samples into Eppendorf tubes for later analysis in the lab. No wonder perhaps: the first day is typically somewhat slow and chaotic, and the numbers of cod we were catching in these first hauls were unexpectedly high (they did include mostly medium-sized fish).

Whilst David, Ruth (from Cefas Weymouth) and myself tended to focus more on the cod dissection, Ben and Mark trained all others up with the handling of the catch, the sorting and measuring, and the use of the EDC system allowing rapid measurement of large numbers of fish. Meanwhile, John, Tina and Louise helped kick-start the pelagics stomach analysis, with John collecting additional stomach data from those 'interesting' fish species where his expert knowledge tells him that more diet data are needed. For four of my team members, Abigail, Sam, Chris and Tina, this is the first Cefas survey, and they must be somewhat overwhelmed by the new impressions; yet so far I am finding happy and positive spirits in them.

Ben, especially, deserves to be applauded for setting up the wet lab so efficiently, including virtually all equipment needed for this survey. He had stayed onboard after the previous cruise, and had spent the 'empty' hours inbetween to do these preparations for us. I saw him only this morning, for yesterday night when we arrived he was in the pub; when I entered an immaculate wetlab, I saw proof of his hard labours of the earlier part of the day.

Praise then also for the 'night shift', who are still active in the wetlab now, though it's after midnight; they will continue till al least after two, and I hope for them the last hauls will not be huge.

Thursday 18 February 2010

North-west of the Isle of Man, close to Northern Ireland, in fairly deep waters (Box 1)

A cold but beautiful day with open sky. It was scheduled to be the first full day of work with the day shift active from breakfast till tea, and the night shift starting after tea and finishing deep in the night. But during three trawl hauls the net suffered damage. This caused several of our crew to spend many a cold hour of net mending out on the deck. During such a lull, we scientists can do little more than bringing them some hotdrinks (and a good catching up with the data entry was achieved). Fortunately no major holes were experienced and the net was fixed each time. Only about ten cod were caught during 4 day time hauls; the first haul for the night shift gave us 8 cod, but also resulted in net damage.

This was somewhat surprising, as last year at the same sites we had good cod catches, and no problems with the net except for one haul. Brian, our captain, however, considers that the currents have changed the grounds here and made them rougher. He can deduct this from the movement of the ship when it is trawling, thanks to many years of trawling experience before he started working for Cefas: both beam and otter, British and Dutch vessels, in the southern North Sea, off Scotland, Barents Sea and elsewhere.

That was also when Dave and I made some video footage about the gear damage, and its implications. A few weeks before this cruise, we have been asked to provide about 1–2 hours of video footage about life onboard *Endeavour* during a research survey. It will then be edited to five slots of 5 minutes each, and these will be placed on the website of Defra during the second half of March. The aim is to provide the public with an informal insight into the wide range of activities that are going on at Defra: currently, similar footage is also being collected about other field- and office-based activities of Defra and its agencies.

The bit of footage we shot today, was more or less as follows (we practiced it a few times before filming, which initially was not possible due to background noise): Dave would ask me, “So George — what’s going on here?” and I would answer something like: “The net is damaged. And our crew are mending it.” David: “So how did this happen?” Me: “We were fishing for cod, and we were getting good catches. So it was all running smoothly. But the seabed is rather rough here, apparently rougher than last year; the net got stuck somewhere and it was torn. So here we are!” David: “And what’s the plan now, what’s next?” And I: “Our crew have almost fixed it, and now we will move westward, to an area of softer seabed, where we also think we can be successful in getting good cod catches.”

I hope it can be used; we have filmed a bit before, while we were steaming out of Belfast, and will do our best in the coming days to get more material, as I am not sure how selective the editors will need to be to make it into something worth watching.

Friday 19 February 2010

West of the Isle of Man (Box 2)

I encountered Rolie at half past six on the bridge, during his shift. He informed me, “The lads are still working on the net! We had very big tears from that last haul last night! I think they have been working for on it 3 hours now. Give them one hour, and they’re ready to shoot again. But,” he continued, pointing at the chart on the plotting screen, “we’re now here, south-east of where we were yesterday. I had a *very* tired Dave up here on the bridge, a few hours ago. He could hardly stand upright anymore. He was frustrated from all the delays, so we left, and now we’re in this box here, hope it’s all right with you. Hey! Yesterday morning you brought me such a nice coffee, you didn’t bring any?” I said I’d forgotten, and that I’m perfectly happy with where we are now. The ‘box’ on the map where we have been on the first 2 days is now more or less covered by our trawling stations, and it is time to move on. I said, “That first ‘box’ has given us a lot of net damage. Five times the net was torn. But it has given us very good cod catches. What I thought we’d be catching in a day or so, we have been catching there in one or two hauls. Surprising though that we were so unlucky with the net. We had damage at only one station last year, and we had marked the site on the map.”

So the trawling started late this morning, and the day shift did only 4 stations. They did not give us many cod, less than 10. Still, these stations kept us busy all day long. The catches tended to be a real mix of three to four quite similar looking gadoid species to sort through: whiting, blue whiting, Norway pout and poor cod. There were also very many *Nephrops*, as these muddy grounds are well-known fishing grounds for *Nephrops.* The crew (and fishermen) simply call them prawns, and are very fond of them; they gathered big bags full of them. For us, the *Nephrops* are quite laboursome, as they need to be sorted by sex and then the carapaces measured (to 0.1 cm accuracy). We caught, as is typical, far greater numbers of males than females; the latter tend to remain hidden deep in their burrows, keeping them safe from the trawls. In this species we distinguish a “third sex”, berried females, which were caught occasionally, and Ben carefully kept them in a skip with seawater, so that he could set them alive back to sea.

In the late afternoon, an amazing fish was caught — though some scientists wouldn’t call him a fish: sea lamprey! We found it attached to the side of a cod, and you’d have trouble taking it off. The animal was well alive when we gaped at it in the wetlab. After removal, the cod showed a big round wound at the spot where its

attacker had been attached, and in the lamprey's mouth we could clearly see the numberous little rasping teeth. I am not sure if the lamprey had attached itself to the cod before the haul or during, whilst the fish were herded together in the net. So far, I certainly consider this lamprey as the most spectacular fish of the survey.

A few anchovies and a sardine were encountered. We bagged these fish and chuck them in the freezer, to be saved for Jeroen, a fellow Dutchman scientist at Cefas who is interested in pelagics, especially distribution changes. Abundance of these two species in northerly waters is increasing, likely related to climate change; and Jeroen wants to study the origin of these northerly schools. Although this is quite far north for anchovy, it is not fully abnormal; as I learned from Jeroen through email (responding to my notes to him) our observations fit in an annual migration pattern along different parts of the Irish Sea, reported earlier by Mike Armstrong.

Saturday 20 February 2010

West of the Isle of Man (Box 2)

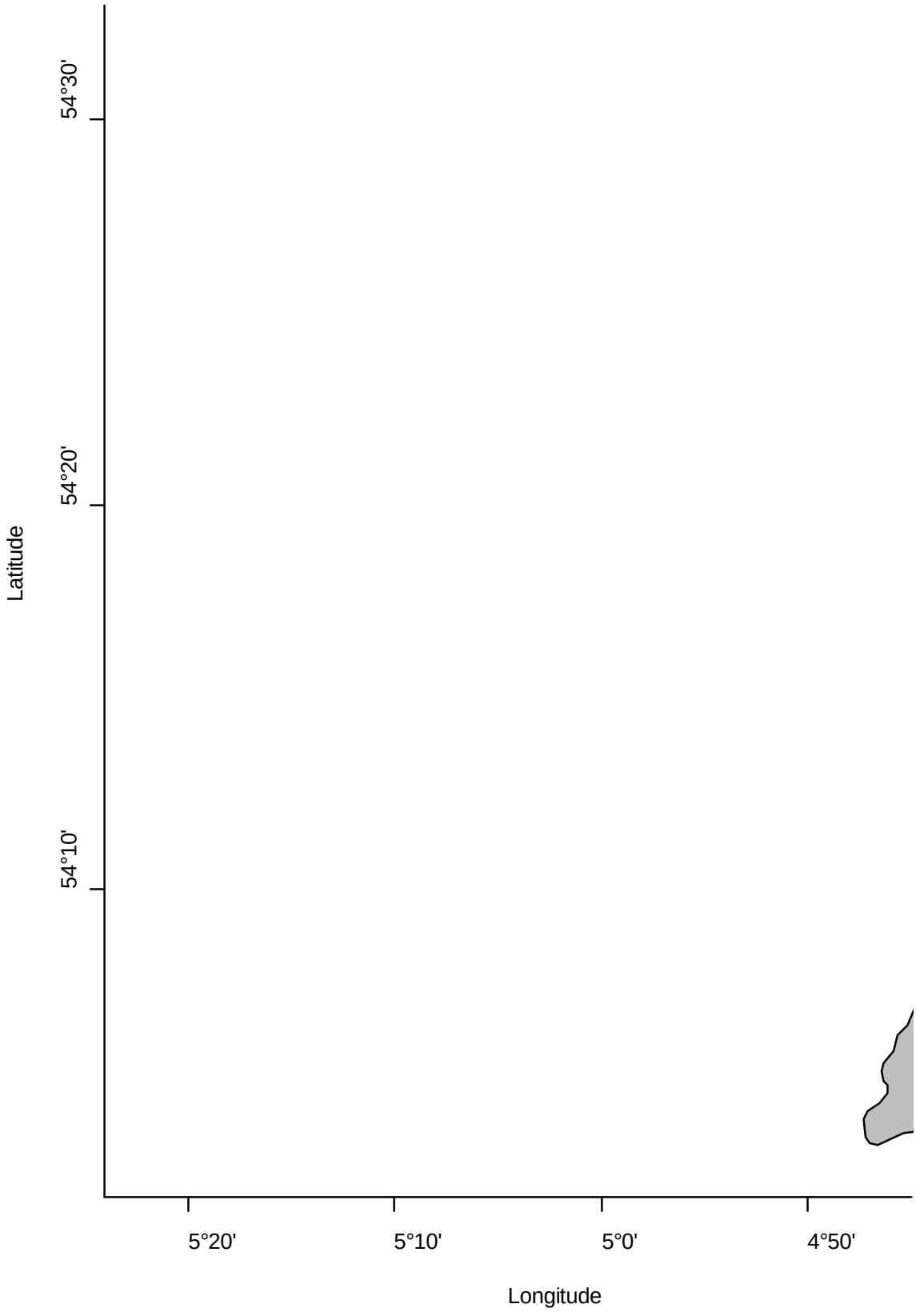
Second day in the same 'box' as yesterday. Though our cod catches are lower than in the first 2 days, this is well compensated by fully clear tows without any gear damage. Clearly, our first 2 days were spent in a much rockier area. I started now to look in more detail into where we have been catching cod, and came up with 2 maps.

Map 1 shows all our station tracks so far (by 18:45 today), and I added little numbers for each station's shooting position. I also colour-coded each of the 5 tracks where the net got ripped: those are the red lines. Clearly, our 'Box 1' caused us much more damage and loss of time than 'Box 2' where we are now. But then I also made Map 2, showing for all stations the numbers of cod we caught there. Clearly, Box 1 gave us better catches per haul than Box 2, so that even with all the loss of time from the damage, more cod per day were caught there than here. So I am happy that that Box is done.

By plotting everything out, it also became clear that Brian so far is our winner in terms of the highest number of cod per haul: 13 in station 2 (without damage). Rolie is runner-up: 12 cod in station 3. Will these numbers be beaten later on during this cruise?

Meanwhile around teatime, our 'cod tally' had risen to 97. Ruth is happy with a sample of over 30 blood samples of male cod. "What number are you actually aiming for?", I asked her. "A hundred. But 50 would be an absolute minimum. On the other hand, these are the *very* first blood samples for this purpose that our lab has been taking of male cod, so we are happy with anything." The very first male cod samples; this cruise is already writing history.

In the evening, the day shift was happily watching a movie in the lounge when the telephone rang. It was the night shift, from the wetlab, telling us about an amazing cod they had, very worth looking at. I ran down to the lab, and on the working bench there I saw that David and Ruth were just dissecting a very large cod, probably the largest so far. But there was something really strange about it. It was healthy looking from the outside. But upon dissection, we could see no sign at all of the gonads: we couldn't even determine whether it was a male or a female. From the size alone, you would judge it to be a female. But females of that size usually have a kilogram of ovaries in their body. This cod seems to have never developed the gonads, and perhaps for that reason has been better able to grow. Otherwise there were no clear signs of disease or parasites, except for a few nematodes in the liver as commonly found in bigger cod. I tend to agree here with Ben, who suggested it to be a genetic abnormality.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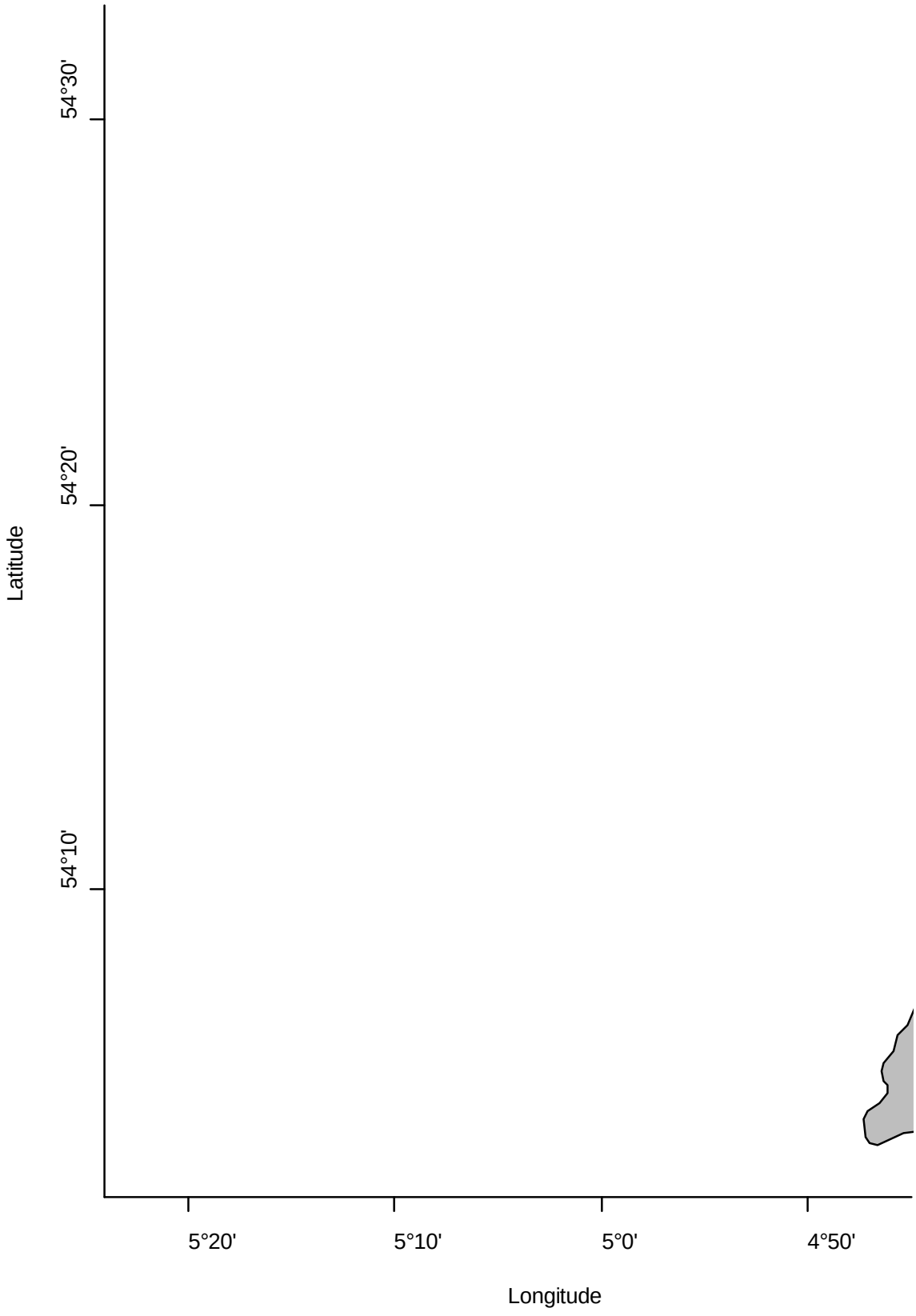
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Sunday 21 February 2010

Just west of the Isle of Man (Box 3)

It began to snow overnight, and the night shift saw how the ship's deck and the nets became covered with a layer of snow. By dawn, when the day shift came out, snow had covered the hills of the Isle of Man: a spectacular sight when seen from the ship. And background scene for us all day, while we were sorting our catches.

Today and tomorrow we trawl at between about 15 and 20 stations in a third 'box', to the east of our box of 19–20 February and closer to the Isle of Man. We are still in 'prawn' grounds (although we have not caught as many *Nephrops* as in the previous two days) and quite good cod catches were achieved: 7 and 9 cod in our most successful hauls of the day.

We called station 35 a 'bachelor party': all 9 cod caught here, were males. This was lucky for Ruth, who saw her sample of male cod rise today to 50. Curiously, at that same station, far many male dab and male plaice were found, and no or hardly any females of these species. These days, John and I are speculating about these strange, sexually segregated, microdistributions of various fish species not closely related at all. Earlier on, we have had several tows where virtually only male lesser spotted dogfish were found, and other where females were found. And 2 years ago during the first Memfish survey (which included beam trawling), we recorded sites in the eastern Irish Sea, where either large numbers of female plaice *and* dab were found, or large numbers of males of these two species. We suggest that differences in optimal temperatures for ripening ovaries and testes tissue, respectively, might play a role here. Also, John recalls having read that of several elasmobranchs in particular, it is known that they are capable of sensing temperature differences of a tenth of a degree Celsius or less.

Monday 22 February 2010

Just west of the Isle of Man (Box 3)

We finished our work in 'Box 3' just to the west of the Isle of Man, obtaining a nice coverage of the northern and southern thirds of the box. In the middle third we couldnlt really trawl, as there are some marine cables and pipelines running over the seafloor there. Rolie told me that, although fishermen do fish there — the cod like the warmth coming from the pipes — we as a government vessel shouldn't really be going there at all, for the risk of damaging the pipeline. So we started the morning with some northeastern stations in the box, then 'hopped over the pipeline', and continued trawling in the south.

In this box, we obtained a total of 45 cod in 18 hauls, which is more than in the box west of it, where we had 30 cod in 20 hauls. Up to now we did best in our Box 1 (83 cod in 13 hauls, although including many small cod).

In the evening, the wind began to pick up and a gale set in. The night shift did only a few hauls, including one haul to the south of the Box, which yielded very much herring. Later on, however, the weather deteriorated further, so that not long after midnight the work had to be ceased.

Tuesday 23 February 2010

East of Republic of Ireland (about off Dublin) (Box 4)

The gale continued overnight. While many of us were rolling about in our bunks, Colin and Rolie steamed the ship a good 20 nautical miles west-south-west towards our new study area, which the captain has called 'Box 4'. The new area

coincides with the location where last year in late February–early March, Vicky Quayle (Fish Ecology Team) joined two commercial vessels and several days fishing for cod, to be tagged and released. They had very good catches (aided partly by a trawl with very high headline height). The site also coincides with an area where according to Mike Armstrong, a 'cod hotspot' existed during the 1980s–1990s.

For us this was a day with strong winds and heavy swell. By the afternoon, the wind blew at 37 knots and the swell was 3 m. It did not affect the work of the day shift very much, however, and 5 trawl hauls could be carried out. The first hauls in the new area gave us quite a few good-size cod, so that the cod count kept un ticking up. Later on we had less luck.

Around dinner time, the wind and swell were so strong that our captain considered it not responsible anymore to go fishing overnight; hence the night shift had their day off. We all watched a good movie in the lounge and many of us went to bed early — though not all managed to sleep well on this moving ship.

Wednesday 24 February 2010

East of Republic of Ireland (about off Dublin) (Box 4)

Seasickness and lack of sleep caused the day team to be smaller by one person this morning. Tina did arrive on the bridge at dawn to do her duty logging the station details; then quickly went back to her cabin for rest. Abigail, the day before, had also suffered from the sickness; in fact all of us were a bit tired.

Cod catches were again moderate, with about 10 fish in total. One of those, however, was our biggest cod so far: a female of 11.23 kg, with ovaries weighing just over 2 kg — truly massive.

We also caught one very remarkable fish that, when first spotted amongst the pile of other fish on the sorting table, would appear to be no more than a massive herring: an allis shad. Apart from size, it also differs by one large black spot in the neck followed by a few very small ones (not always present), but Mark had told us that the safest way to identify it from a close relative — twaite shad — is by counting the gill rakers. Ben patiently counted 120 (twaite shad has no more than 80). Both these species are of the herring family but have a behaviour similar to salmon: in spring, the adults swim up rivers and spawn there, and the juveniles grow up in freshwater before moving to sea. Allis shad is one of those fish that, when seen as an illustration in a book, looks rather plain, but that is very striking when it is held in the hand.

Lunch was quiet. But with the swell settling in the afternoon, everybody appeared again for dinner. By night time, the sea was very calm.

Thursday 25 February 2010

East of Republic of Ireland (Box 4)

This is our third day in our 'Box 4', and fortunately our last, because we are unhappy with our cod catch rates here. Some think the grounds are too soft and say the cod like more rockier grounds (hence our good catch rates on day 1 combined with all the gear damage). Others think there is no food — although we are still getting *Nephrops* at all stations, the abundance of this important prey species for cod is clearly much lower here than west of the Isle of Man. We did cover an area within the box where we know fishermen were catching cod in February last year, but the day shift caught only 3 cod in 5 hauls. It is, of course, of interest also to sample the areas where cod are less abundant, and we now have a good coverage of a fairly extensive part of the western Irish Sea, covering areas where historically important

cod spawning took place. Tomorrow we will go to a new Box 5 between Northern Ireland and the Isle of Man again, but now to the west of where we have been previously. I expect it again to be rich 'prawn' grounds, and have good hopes. We will then end up northward near our very first box, and so our last few days will be carried out close to Belfast, making it a very quick return to port early next week.

Weather was calm, everybody had had a good rest, and we could easily cope with the smallish catches that came in. We made up for the lack of cod by extensively sampling stomach contents etc. from other species, including herring, sprat, various species of gurnard, haddock and lesser spotted digfish. One particular, very large haddock struck us as it must have had a very large breakfast: we found no less than 26 prey items in its stomach, ranging from nephrops and brown shrimp to Norway pout and sprat. The dogfish had been catching small gadoid species. All sprat stomachs were empty, as usual, but we continue sampling (a few days ago we have had one fish egg remain in a sprat stomach). The herring either had empty stomachs or had eaten euphausiids or copepods. You can count the former by counting the pairs of small black eyes. On earlier days, we did record herring that had eaten 'cod-size' eggs, although in these cod-poor grounds that is perhaps not to be expected.

At the end of the shift, Ruth said she didn't mind one single, quiet day like this, but tomorrow she wants again the action, which means she wants more cod. Let's see what the new box will bring us.

Friday 26 February 2010

East of Northern Ireland (Box 5)

The morning tows in 'Box 5' gave us all the cod action hoped for: in three hauls, we had a total of 21 cod! The second haul in particular was good, with 13 cod. The work was full on from breakfast to lunch time.

During lunch I joined the table of the officers, with a euphoric conversation about the good cod catches, when our captain Brian was called away and alerted that we didn't move anymore — the trawl had got stuck on something big holding up the entire ship. The following hours were then needed to retrieve the net.

What came up from the seabed, was a true surprise. On the bridge, David overheard the radio conversation between 2nd officer Colin and lead deckhand Peter. "We've caught a whale!" is what Peter first exclaimed, down on the deck: that was his first impression of the shape that started appearing from the depths. "Impossible!" was Colin's answer. "No, it's a yacht!" was Peter's next message. "You must be kidding", was Colin's obvious answer. But we had, really, fished up a sunken yacht from the bottom of the sea. It now drifted upside down behind the ship, the hull visible entangled in the net. We tried to read the vessel's name, but could not see that part of the hull. The crew did their very best to raise the whole yacht up on the deck, until with a sudden bang it broke loose and sank away. The broken mast, however, remained entangled in the net, and by use of the crane was lifted on deck and stowed to the side. Not only the mast, but at least two old fishing nets had been caught in our trawl, complete with at least one large otter trawl door. We now have all of this as cargo onboard, and will keep it here until we drop it off in Belfast.

The location where we have caught the wreck was not indicated on the sea charts, although a mark for a wreck is shown for a site some miles away. It might be the same wreck, if it had been caught previously by a fishing net and so towed some miles away from its original resting place, until the net would have snapped. If this would have happened twice, this could explain the double fishing nets we had found the wreck entangled in. Our captain will write a report of several pages about this

encounter and hand it in to the Belfast Coast Guard and to P&O. The report will include the new location of the wreck, so it can be shown on future sea charts; this is very useful information, especially for fishermen so they can avoid trawling at this location.

We had been relatively lucky with only fairly minor damage to the net. Once cleared from the yacht's masts and old nets, which was the biggest task, it took not very long to repair it. Damage had mainly been to the floats that keep the upper part of the net up, and the wire bridles had been overstrained and needed to be replaced. The full afternoon was spent on the incident; just after 7 o'clock, we started shooting again.

Saturday 27 February 2010

East of Northern Ireland (Box 5)

It was one of those days where a good start, with many cod and an optimal work spirit, was spoiled twice by extensive gear damage. The first incident happened just before lunchtime, when we had worked our way further up north in our 'Box 5' (our work of the previous day had been restricted to the southern part of this box only). With the third haul of the day, trawling in northwesterly direction, we had approached 'Box 1' of our first few days quite closely — where we had had trouble with the harder ground earlier on this survey. At the end of this haul, the net got stuck somewhere and was torn. Again, this had been a repeat of a clear tow last year, when no problems at all had been experienced.

With the damage earlier experienced to this particular trawl, including the heaving of the shipwreck, it was decided to swap the trawl, and the work was to be continued later on using a brandnew Portuguese high-headline trawl. Little was our luck. We steamed back to the southern half of Box 3, well away from the hard grounds of Box 1. One haul in fairly shallow water was carried out successfully then; the catch contained much kelp, and a mix of mainly dab, whiting and herring, but also a few small cod. All the kelp should, perhaps, have made us suspicious. The next catch then resulted in a long tear in the newly fitted trawl — the last thing we would have hoped for.

Fortunately we have Peter and Tom onboard, very good in mending the net, owing to many years of trawling. Both from Fleetwood, they first worked in that port's fleet in Icelandic waters, back in the years before the Cod Wars; when British fishing there ceased, they moved over to the North Sea (beam trawling from Lowestoft), and Tom has also worked on Brixham and Newlyn beam trawlers. Tom told me about this while working on the net. Adam, too, was helping with the mending; he is from Poland and worked on large Polish freezer trawlers, later cargo vessels, before joining the *Endeavour* crew.

After dinner, most of the day team joined the night team to help sorting the 'kelp catch'. Here I learned some of the tricks that the night team use to help them sort and measure the catches speedily. Mark asked us to pick out all species different from a whiting, dab, herring or sprat, and keep those separate as normal. The large quantity of the dominant four species was then kept as one 'whiting-dab-clupeid mix', and only a subsample of it sorted to species, weighed and measured. This probably saved at least half an hour of painstaking sorting. The night shift seem to work slightly differently from the day shift. Day deckmaster Ben makes all members of his shift do different tasks almost every second haul, so people rotate between sorting, weighing, measuring, dissection and scribing. This gives a very varied workload for each team member, with different people working together each time. By contrast,

with night deckmaster Mark on watch, a certain degree of specialisation seems to have evolved in the night team. Mark, Louise, and Abi do the majority of the sorting, weighing and measuring, and the deckmastering job itself. Dave and Chris carry the burden of the dissection and associated scribing and blood sampling. Specialisation, though at cost of some of the variability of the work, might well be what gives the night team the edge in efficiently processing the catches in the late hours.

Sunday 28 February 2010

Just west of Isle of Man (Box 3)

We are spending this day in filling up some of the empty spaces on the 'cod map' that we are creating in the course of this survey. These relate to some cables and pipelines in Boxes 2 and 3, as we had stayed well away from these in earlier days of this survey. Several underwater cables run here from Northern Ireland to the Isle of Man; and there are two long submarine pipelines (connectors) that transport gas to Northern Ireland, all the way from Scotland. The fishermen often catch cod near pipelines. "It is somewhat warmer there than the water surrounding it, and the cod like it nice and warm", as Rolie states it; Dave had come up with the idea that it could provide some sort of structure. Of course, we did not trawl on top of, or even very close to the pipeline; we do not want to bust the trawl, and we certainly do not want to cause any underwater damage.

First haul had gear damage — causing me great sorrow (after the brandnew trawl of the previous day had cought a tear). Brian said, "Don't worry, George; it's a pigeon hole, no more than that. They'll get that sorted real soon." I mentioned this down on the deck, where Peter, Tom and Adam were mending it. "Pigeon hole?" was Tom's response, "I'd say: emu hole!" but followed by "Nothing major, don't worry; we're done in half an hour." Those three men are irreplaceable.

Justy after nine Ken shot the trawl again, but we trawled only for half an hour: with all the cables and pipelines around rthere is not enough space here for a full hour's tow. I was greatly relieved when the net came up neatly intact, with a small catch but including a nice big cod.

At night, I heard from David that our cod count had crept up to 270. This was when we reached our station number 100. Ruth has collected samples from over 100 male cod, and surpassed her target; and almost 100 triplets of biopsy tubes have been filled with maturing female ovary samples. Nice achievements so far. By time of writing, we have about half a day to go; the cruise is now nearing its end.

Monday 1 March 2010

Morning of trawling; afternoon of cleaning up

This was the last full day of our survey: the ship was scheduled to be back in Belfast the following morning. As is normally the case, this last survey day was hectic. In the morning, three stations were sampled as usual. Several dozens of spurdog were caught, and we managed to tag all of these successfully (except one 'baby' spurdog too small to be tagged). All were kept for some time in the tagging tanks, and after we had observed them all to be in good, lively condition, they were released back to the sea — carefully lowered from the ship's deck down to the water using a basket attached to a long rope. The dogfish were, however, not immediately safe once back in the water: they were attacked by a whole herd of gannets, sky-diving at great speed to where the spurdogs were released, before realising that no good meal was to be had from these small sharks equipped with poisonous spines.

The big clean-up was started by Louise, before lunch; the day team was still sorting and disecting fish then. After lunch, while the day team finished working on the third station's catch, the others of the night shift joined in the cleaning process, and before long all but the SIC and 2IC were scrubbing and polishing. Dave and myself, of course, did not remain inactive; most importantly, we had to ensure that all data collected during this survey were indeed entered, checked, and stored safely in database, and we worked hard on the cruise report: the more of this can be done before the end of the cruise, the better. As soon as we will touch land, other priorities will come in the way and any delay in the reporting is to be avoided. many of us went through the datasets and 'cleaned' these up. Especially John put much effort in combining all stomach contents data into one file in line with his very large 'Dapstom' stomach contents database, combining diet data from a great number of Cefas surveys, historical and recent ones. There is no use in having different labels for essentially the same prey types: for example, 'unidentified fish', 'u.i. fish', 'fish' and 'fish remains' all mean the same thing and are best entered under one name only. Chris and John went through all station details, and discovered quite a few typos that could be corrected.

It now becomes evident that we have sampled 269 cod over the entire survey (plus two more cod during our 'shake down' tow on the first day), a lot more than the 167 cod of last year; but whereas last year we found far more females than males, we have now seen a sex ratio much closer to unity but with somewhat more males than females.

Tuesday 2 March 2010

Return to Belfast

Over night, *Cefas Endeavour* slowly steamed towards Belfast, and around breakfast time she entered the large natural harbour of this port before docking at Pollock Dock around 9:00. The scientists stored the equipment and the seakit, cleaned the day before and allowed to dry overnight, in three collicos that the crew had placed on the deck for us. These collicos, or medium-sized collapsable storage containers, were then lifted up with the crane to be stored inside the ship. Three boxes with our samples in it were stored in the 'garage' of the ship; as our samples are stored in (albeit very small quantities of) formaline and ethanol, with some risk of a spillage, this covered but otherwise open and well-vented space of the ship was recommended to us for this purpose.

Before long, the wide open space of the Irish Sea had made way for the relative confinement of Pollock Dock; *Endeavour* looked surprisingly large in here. The survey is completed now; with half a day left before our home flight, we set out for a stroll in Belfast, and not to forget, a joint dinner to celebrate the success of our survey.

Epilogue

I found that Dave Righton, a week later when we had completed the cruise report, summarised the survey very neatly, when drawing attention to the news that between 21 and 28 March "a successful survey in the Irish Sea (CEnd_0410) ... is to be featured online in video form as part of Defra's *Focus on Marine*.

"We had a crew of 11, both old and new hands, with staff from all three divisions of Cefas—Fisheries, Environment & Ecosystems, and Aquatic Health & Hygiene—spanning a wide range of skills (and ages 20 through 40). Three of the staff were Cefas students (two PhD and one MSc);

"The cruise was funded from Defra project M1102 ('MEMFISH'), but also collected data and material for five other research projects;

"Each day, the vessel worked for 20h of the 24h available (two shifts of 10h each), excepting downtime to fix equipment or ride out the mid-cruise storm (nothing major, winds gusting to force 9, but it rose and died away fairly quickly). In total, we achieved 107 hauls of the trawl (1h long tows);

"Our target species was cod, of which we caught 269 (570 kg or so) of lengths between 10 cm and 95 cm, from each of which up to seven different tissue types were sampled for further laboratory analysis.

"We also caught, weighed, counted and measured another 73 species of fish. In total, we caught over 230,000 fish, and measured more than 85,000 of these on the electronic data capture boards.

"The ship's crew (17 in total), as ever, were extremely competent and helpful, and the success of the survey is a great testament to the teamwork between P&O and Cefas, as well as between different Cefas divisions and disciplines.