DEPARTMENT FOR ENVIRONMENT, FOOD AND RURAL AFFAIRS
CEFAS, LOWESTOFT LABORATORY, SUFFOLK, ENGLAND

2006 RESEARCH VESSEL PROGRAMME

PROGRAMME: RV CEFAS ENDEAVOUR: CRUISE 17/06

STAFF: J. van der Kooij (SIC), D. Righton (2IC), J. Pinnegar, G. Engelhard, K. Vanstaen, C. Houghton, K. Burnett, C. Stewart, V.Hobson.

DURATION: 27th September to 9th October 2006

LOCALITY: North Sea

AIMS:

1. To use a 2m beam trawl to collect representative samples of benthic organisms on the sandeel fishing grounds on the North West Riff & The Hills.

2. To use fishing survey methods to estimate the abundance and distribution of predatory fish feeding on sandeels and benthos at the same stations.

3. To use fishing survey methods to estimate the habitat occupancy of sandeels on the same grounds.

4. To process multibeam data recorded on the minigrids.

PLAN: (all times are British Summer Time)

Narrative

The scientific crew joined the Endeavour at Lowestoft at 1030hrs on Wednesday, 27th September. Endeavour then steamed to The Hills (~54° 25' N, 1° 00' E). Surveying for sandeels and their predators commenced at 2100hrs that evening. Surveying took place over established grids on the Hills and the North West Riff. Each day a 2m beam was trawled to sample benthos on 4 pre-selected stations and at the same 4 stations a granton was used to trawl for predators. During the first two days the beam was trawled in the morning (07:00~12:00) and the granton in the afternoon (13:00~17:30). The rest of the trip granton was shot in the morning (07:00~12:00) and the beam in the afternoon (13:00~17:00). During the morning shift (06:45hrs~11:00hrs) the vessel steamed across all 6 stations of two transects to record fisheries acoustics data. Dredging for sandeels began at 2100hrs, and was usually completed between 02:00 and 03:00hrs. The shift pattern operated continuously for the first 10 days of the cruise. Surveying was completed on 8th October at 11:00hrs, whereupon Endeavour set a course for Lowestoft, arriving inshore on the evening of the 8th. Due to strong southerly winds, however, Endeavour could not dock until 10:00hrs on the 9th.

Results

1. To use a 2m beam trawl to collect representative samples of benthic organisms on the sandeel fishing grounds on the North West Riff & The Hills.

Assessing the composition of benthic communities began at 07:00 hrs on Saturday 28th September. For the next nine days, the Endeavour surveyed 8 north-south transects within the survey area (Appendix) plus 3 X stations. Each transect was 10 miles long and consisted of three stations (one at each end and one in the middle). Each day two alternate transects (e.g. C and E) were surveyed and four of the six stations were randomly selected for the assessment of benthos. A 2-metre beam trawl was towed for 5 min at between 1 and 1.5 knots (warp: depth ratio was ~3-4 depending on weather and bottom depth). Catches were sorted to species in most cases, then all individuals of each species were counted and weighed to the nearest 0.1g. Subsamples were taken if the abundance of a particular species was very high. On each station one specimen of each species was preserved in formaldehyde (5%) for reference.

	All species			Fish removed		
	Grid 1	Grid 2	Overall	Grid 1	Grid 2	Overall
Overall						
Total count of individuals	7101	2251	9352	5231	1385	6616
Biomass (kg)	27.02	9.12	36.14	21.58	2.95	24.53
Species count	92	72	113	70	58	91
Found only on this grid	41	20		30	17	
H' (counts)	1.21	1.27	1.34	1.29	1.22	1.23
H' (biomass)	1.22	0.98	1.24	1.09	1.18	1.16
Station averages						
	Grid 1	Grid 2	Overall	Grid 1	Grid 2	Overall
Number of individuals	355.05	118.47	239.79	303.08	72.00	74.89
Biomass (Kg)	1.35	0.48	0.93	961.74	129.09	132.20
Species count	22.1	19.11	20.64	16.20	13.37	13.67
H' counts	0.91	0.99	0.95	0.70	0.83	0.84
H' biomass	0.84	0.64	0.74	0.60	0.54	0.54

Table 1. Summary results of the beam trawl catches

A total of 42 stations were sampled with the beam (20 in grid 1 and 22 in grid 2). Grid 1 was more productive and speciose (Table 1): the total catch weight and numbers in grid 1 was nearly three times the weight in grid 2 and also the number of species found in grid 1 was higher, both overall and at each station. Similar patterns were found if the fish species were discounted from the analysis (Table 1).

The most numerous species found in the beam trawl are summarised in table 2. Most species were more abundant in grid 1, but *Liocarcinus holsatus* and *Pomatoschistus minutus* were more abundant in grid 2.

Important species by count	Grid 1	Grid 2
Asterias rubens	1921	18
Entelurus aequoreus	157	4
Galatheidae	391	38
Liocarcinus holsatus	182	347
Macropodia rostrata	268	17
Ophiothrix fragilis	215	16
Pagurus bernhardus	304	84
Pomatoschistus minutus	159	489
Processa canaliculata	335	18
Psammechinus miliaris	1368	6

Table 2. Most important benthos and fish species caught in the 2m beam trawl (numbers) for both grids.

Figure 1 shows the spatial distribution of the most common invertebrate benthos in the two study grids. Although quantities varied between the two grids, most species were found on both grids.

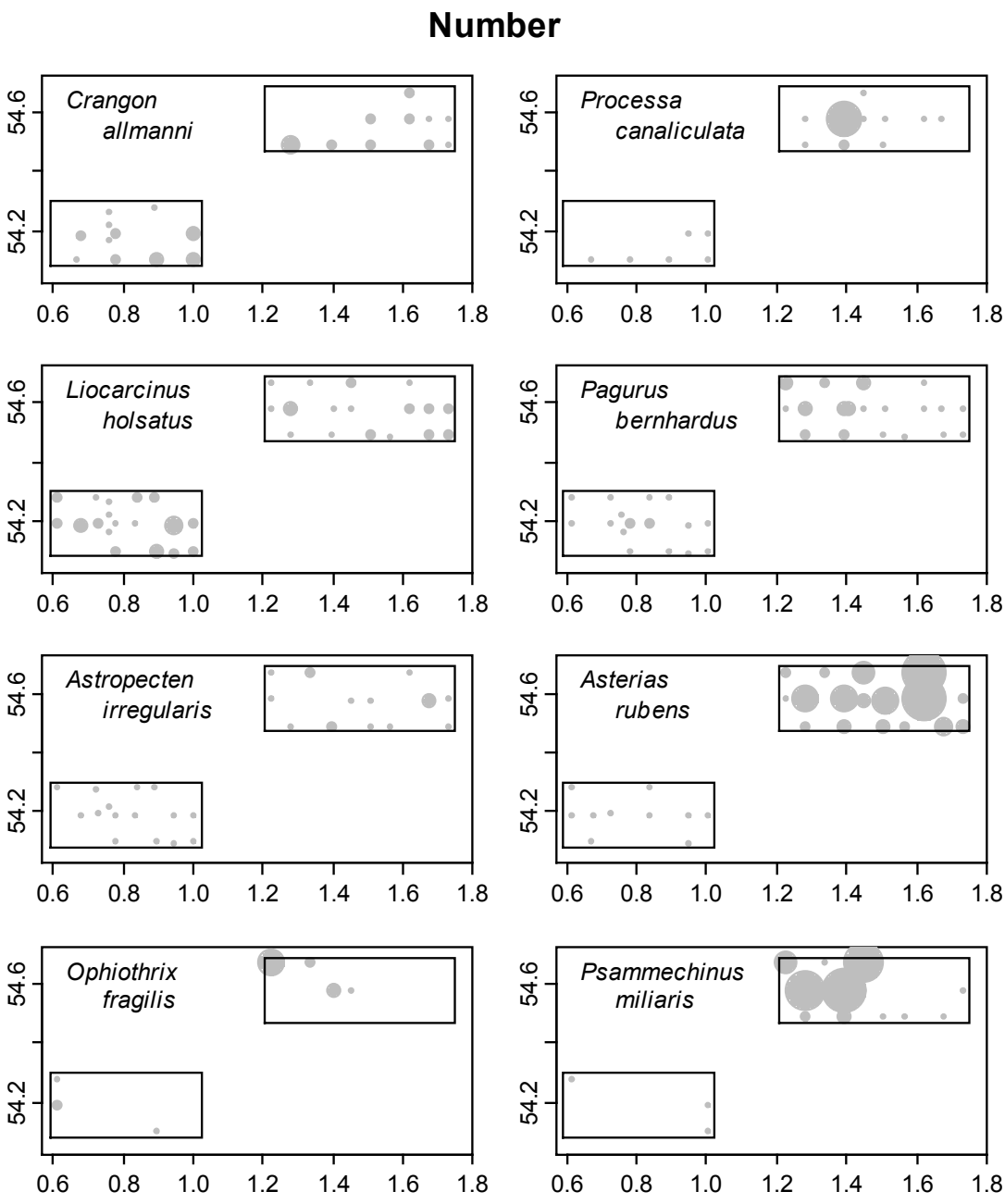


Figure 1. Spatial distribution of numbers of the eight most common benthic species in the two study grids. Rectangles indicate surveyed areas.

2. To use fishing survey methods to estimate the abundance and distribution of predatory fish feeding on sandeels and benthos at the same.

Trawl surveying for predatory fish was undertaken successfully at the same 42 stations that were sampled with the beam. The aim was to explore any links between availability of benthic prey and the stomach contents of the predatory fish. Over 24,000 fish were caught, weighing approximately 2 metric tones (Table 3). The most abundant species by number and weight was dab (*Limanda limanda*), constituting 45% and 61% of the catch respectively. The next most abundant species by weight was the spurdog (*Squalas acanthias*) but all were caught at one station. Grey gurnards were the next most abundant species by weight (16%). Lesser weevers and grey gurnards were the second most abundant species by numbers (both about 13.5%). Figure 2 shows the relative distribution of the predatory fish on each survey grid.

		Biomass (Kg)			Count		
Species	Code	Grid 1	Grid 2	Total	Grid 1	Grid 2	Total
Dab	DAB	551.137	344.53	895.7	8150	6726	14876
Spurdog	DGS	0	381.21	381.2	0	70	70
Grey gurnard	GUG	225.348	87.698	313.0	2260	1016	3276
Whiting	WHG	22.166	123.941	146.1	261	819	1080
Mackerel	MAC	33.465	56.135	89.6	183	303	486
Lesser Weever	WEL	18.537	56.638	75.2	844	2436	3280
Plaice	PLE	14.497	20.705	35.2	50	115	165
Haddock	HAD	6.708	9.416	16.1	76	133	209
Sprat	SPR	7.13	0.274	7.4	396	15	411
Lemon sole	LEM	5.9	1.401	7.3	49	12	61
Cod	COD	1.605	2.685	4.3	4	6	10
Spotted ray	SDR	0	3.99	4.0	0	3	3
Thornback ray	THR	0	3.46	3.5	0	1	1
Brill	BLL	0	2.18	2.2	0	3	3
Long-rough dab	PLA	1.785	0.209	2.0	35	2	37
Solenette	SOT	1.857	0.087	1.9	218	10	228
Lesser spotted dogfish	LSD	0.885	0.94	1.8	1	1	2
Herring	HER	0.135	1.304	1.4	1	9	10
Greater sandeel	GSE	1.094	0.335	1.4	27	7	34
Tub gurnard	TUB	0	0.97	1.0	0	1	1
Turbot	TUR	0	0.89	0.9	0	1	1
Dragonet	CDT	0.26	0.601	0.9	6	24	30
John Dory	JOD	0	0.835	0.8	0	1	1
Bullrout	BRT	0.643	0.081	0.7	4	1	5
Scaldfish	SDF	0.207	0.284	0.5	13	14	27
Red mullet	MUR	0.455	0	0.5	3	0	3
Horse mackerel	HOM	0.235	0.1	0.3	1	1	2
Smooth sandeel	SMS	0.289	0.03	0.3	23	2	25
Sole	SOL	0	0.26	0.3	0	1	1
Five bearded rockling	FVR	0.065	0	0.1	1	0	1
Pogge	POG	0.01	0.045	0.1	1	3	4
Snake pipefish	SKP	0.025	0.019	0.0	6	3	9
Straight nosed pipefish	SNP	0	0.003	0.0	0	1	1
Sand goby	POM	0	0.001	0.0	0	0	0
Total		894.438	1101.257	1995.7	12613	11740	24353

Table 3. Biomass (kg) and abundance of the most common fish species on survey grids 1 and 2.

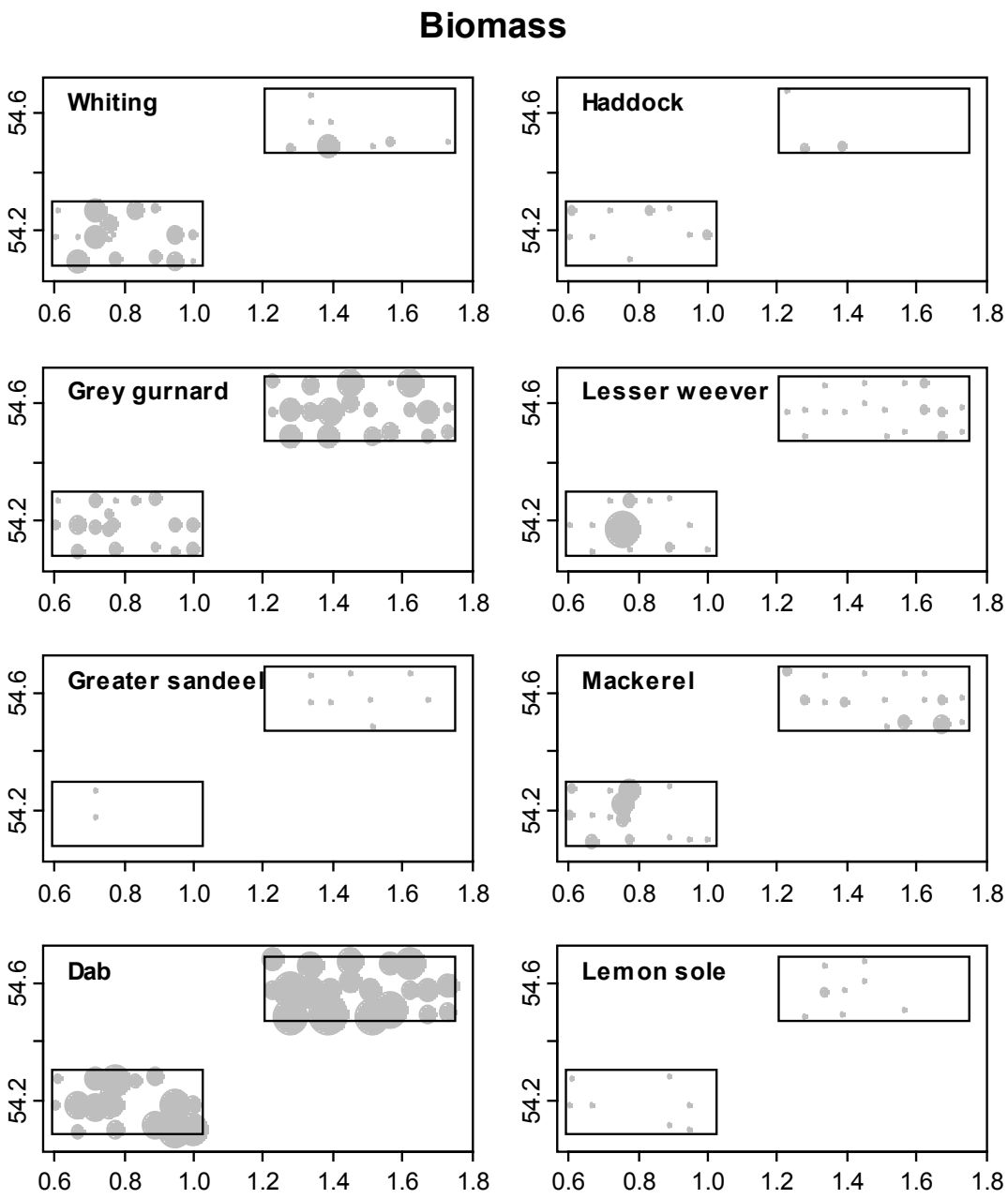


Figure 2. The relative catches and spatial distribution of biomass of the eight most common predatory fish species in the two study grids. Rectangles indicate surveyed areas.

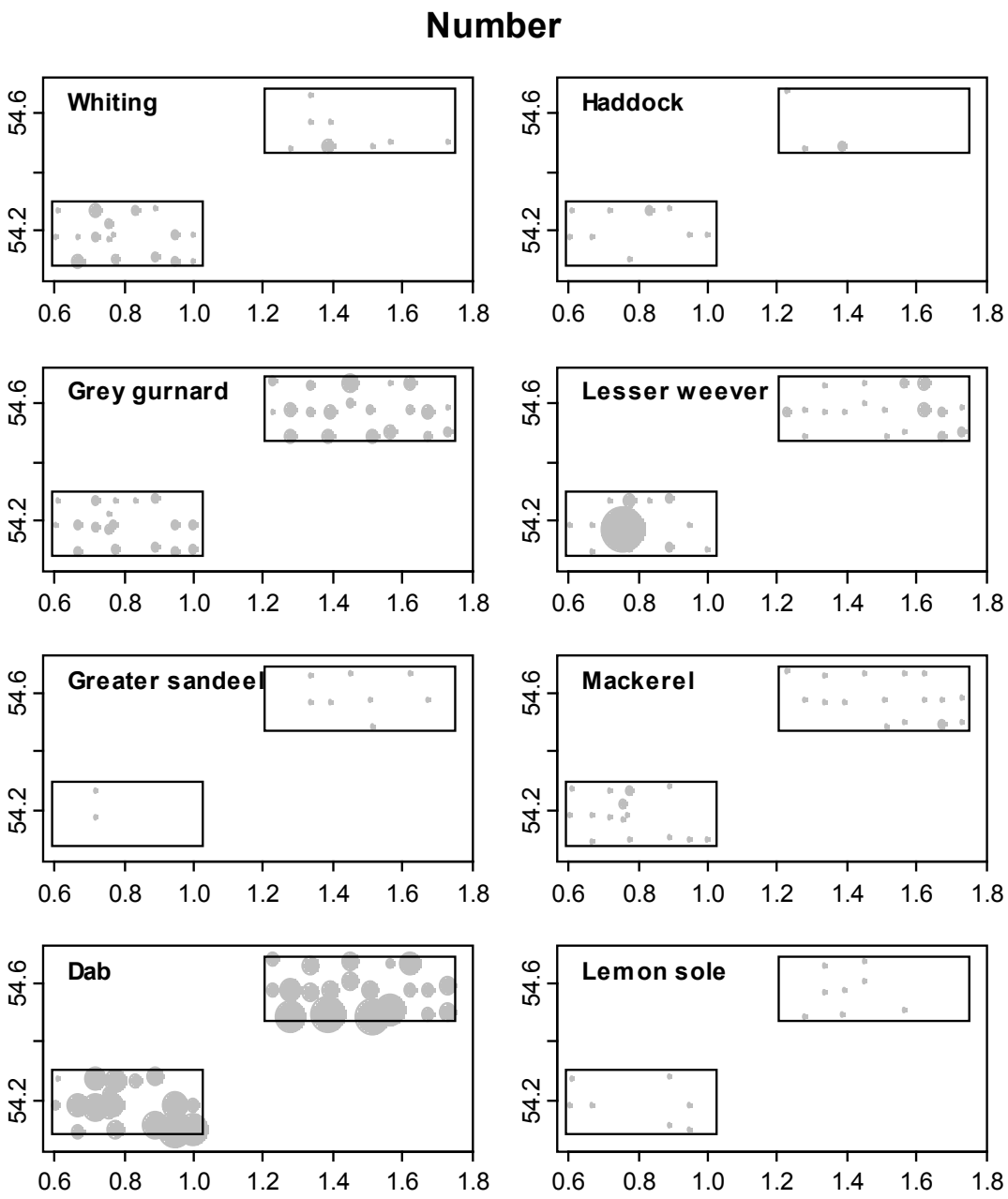


Figure 3. Spatial distribution of numbers of the eight most common predatory fish species in the two study grids. Rectangles indicate surveyed areas.

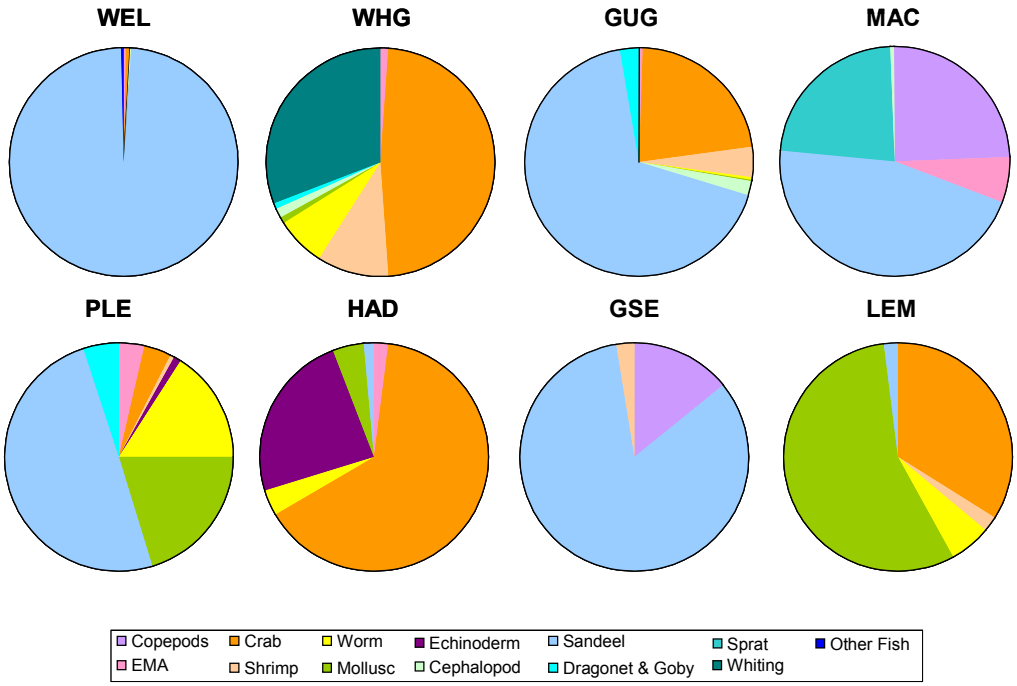
More than 1700 predator stomachs were sampled (Table 4). Analysis of the gut contents of predatory fish revealed that sandeels were the most significant single prey species group in the diets of predatory fish (Figure 4; Table 5).

Species	Code	Grid 1		Grid 2		Total stomachs
		Number of stomachs	Prey records	Number of stomachs	Prey records	
Brill	BLL	0	0	3	3	3
Bullrout	BRT	2	4	1	1	3
Cod	COD	4	18	5	11	9
Dab	DAB	18	22	11	15	29
5-Bearded Rockling	FVR	1	1	0	0	1
Greater Sandeel	GSE	27	32	7	8	34
Spurdog	DGS	0	0	9	9	9
Grey Gurnard	GUG	328	522	300	429	628
Haddock	HAD	18	47	32	51	50
Herring	HER	0	0	4	4	4
Horse Mackerel	HOM	1	1	1	1	2
John Dory	JOD	0	0	1	1	1
Lemon Sole	LEM	35	37	11	14	46
LS-Dogfish	LSD	1	1	0	0	1
Mackerel	MAC	77	102	88	95	165
Red Mullet	MUR	3	9	0	0	3
LR-Dab	PLA	15	20	2	2	17
Plaice	PLE	56	74	105	126	161
Sole	SOL	0	0	1	3	1
Tub Gurnard	TUB	0	0	1	2	1
Turbot	TUR	0	0	1	1	1
Lesser Weever	WEL	135	166	118	131	253
Whiting	WHG	66	132	217	306	283
Grand Total		787	1188	918	1213	1705

Table 4. Stomachs sampled by CEFAS research cruise CEnd-17/2006. (Grid 1 - stations 34-107; Grid 2 - stations 1-33, 108-156)

Other significant prey items in the diets of the predatory fish sampled were pelagic and benthic crustaceans (gurnards and mackerel), bivalves (plaice) and echinoids (haddock). A greater proportion of predation on sandeels occurred on grid 1, where the majority of sandeels were found in the water column and in the sediment.

Grid 1 (biomass of prey in stomachs)



Grid 2 (biomass of prey in stomachs)

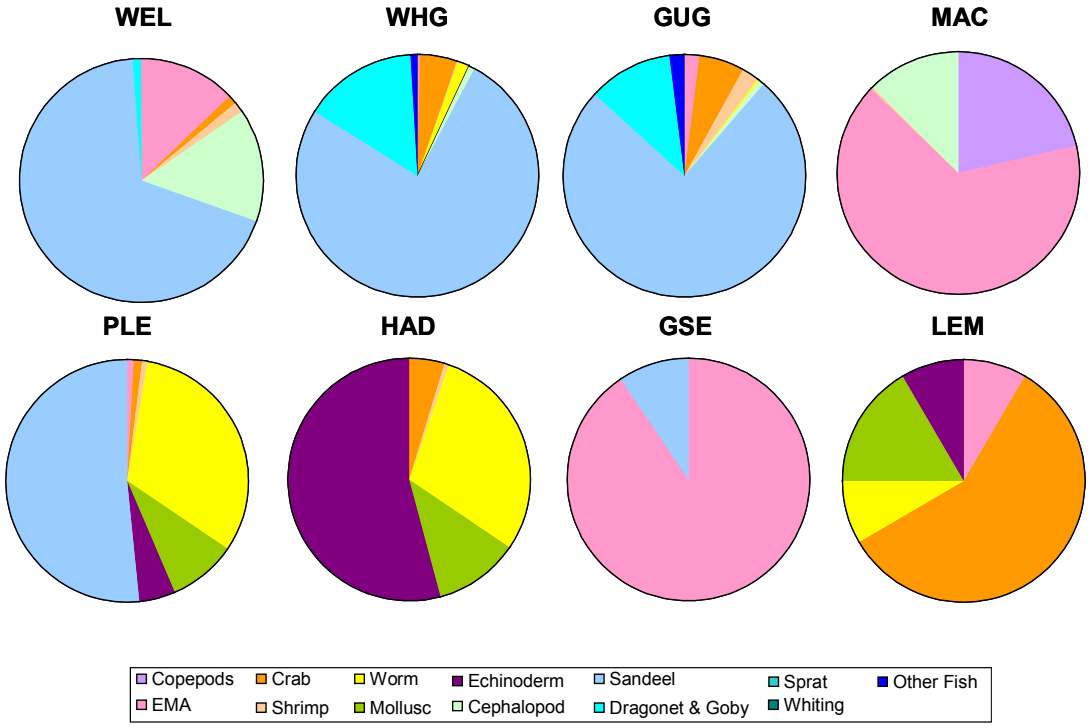


Figure 4. The proportion of identifyable prey items (by number).

Species	Code	Grid 1 Number of empty stomachs	% empty stomachs	Stomachs containing sandeels	% stomachs containing sandeels
Cod	COD	0	0	0	0
Dab	DAB	5	28	4	22
Gt. sandeel	GSE	15	56	7	26
Grey gurnard	GUG	117	36	42	13
Haddock	HAD	1	6	1	6
Lemon sole	LEM	16	46	1	3
Mackerel	MAC	18	23	9	12
Plaice	PLE	19	34	3	5
Lesser weever	WEL	79	59	38	28
Whiting	WHG	7	11	0	0
Total		277		105	

Table 5. Empty stomachs and stomachs containing sandeels sampled by CEFAS research cruise CEnd-17/2006 at Grid 1 (stations 34-107).

Species	Code	Grid 2 Number of empty stomachs	% empty stomachs	Stomachs containing sandeels	% stomachs containing sandeels
Cod	COD	1	20	1	20
Dab	DAB	8	53	1	7
Gt. sandeel	GSE	0	0	0	0
Grey gurnard	GUG	105	35	25	8
Haddock	HAD	6	19	0	0
Lemon sole	LEM	2	18	0	0
Mackerel	MAC	40	45	0	0
Plaice	PLE	48	46	14	13
Lesser weever	WEL	61	52	15	13
Whiting	WHG	77	35	37	17
Total		348		93	

Table 6. Empty stomachs and stomachs containing sandeels sampled by CEFAS research cruise CEnd-17/2006 at Grid 2 (stations 1-33, 108-156).

3. To use fishing survey methods to estimate the habitat occupancy of sandeels on the same grounds.

(a) Dredge

Each night all six stations on two transects were dredged. In total, 68 dredge tows were undertaken and sandeels were caught in 63 of these. A total of 27 kg of sandeels were caught in the dredge; catch size ranged from 0 to 1978

individuals, with an average of 124 per tow. The relationship between sandeel length and weight is shown in Figure 5. There was no difference in this relationship between survey grids.

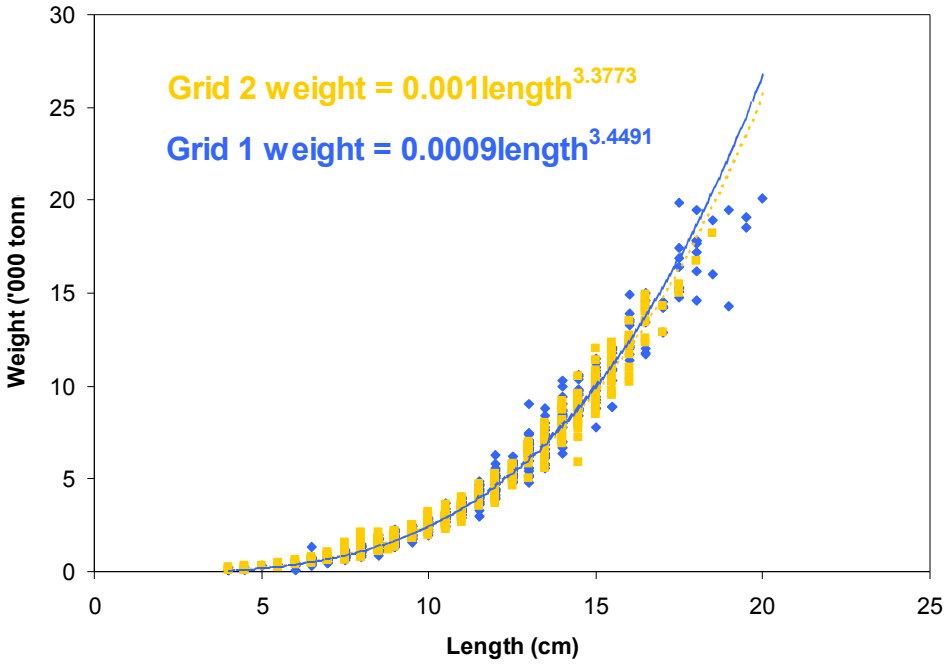


Figure 5: Length-weight relationship of sandeels from the dredge.

Relative catch numbers were slightly greater in Grid 1 and highest densities of sandeels were found in the Northwestern part of the grid (Figure 6). The length-frequency of sandeels on the different survey grids is shown in Figure 7. Overall catch was only slightly greater on grid-1 (shallower and more heavily fished). Larger sandeels were more common in Grid 1.

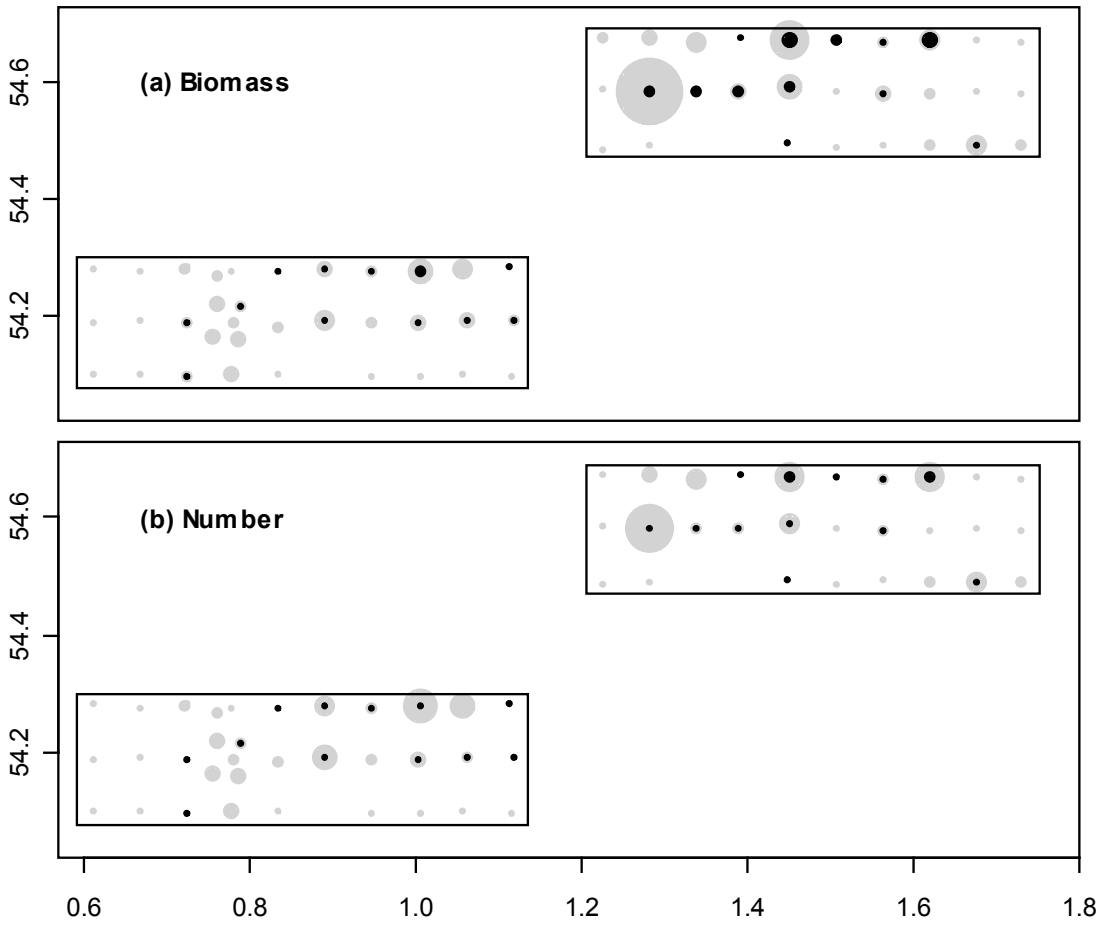


Figure 6. Spatial distribution of (a) sandeel biomass and (b) sandeel numbers in the two study grids (indicated by rectangles), as observed through nightly dredge hauls. Grey circles: common sandeel Ammodytes marinus; black circles: smooth sandeel Gymnammodytes semisquamatus.

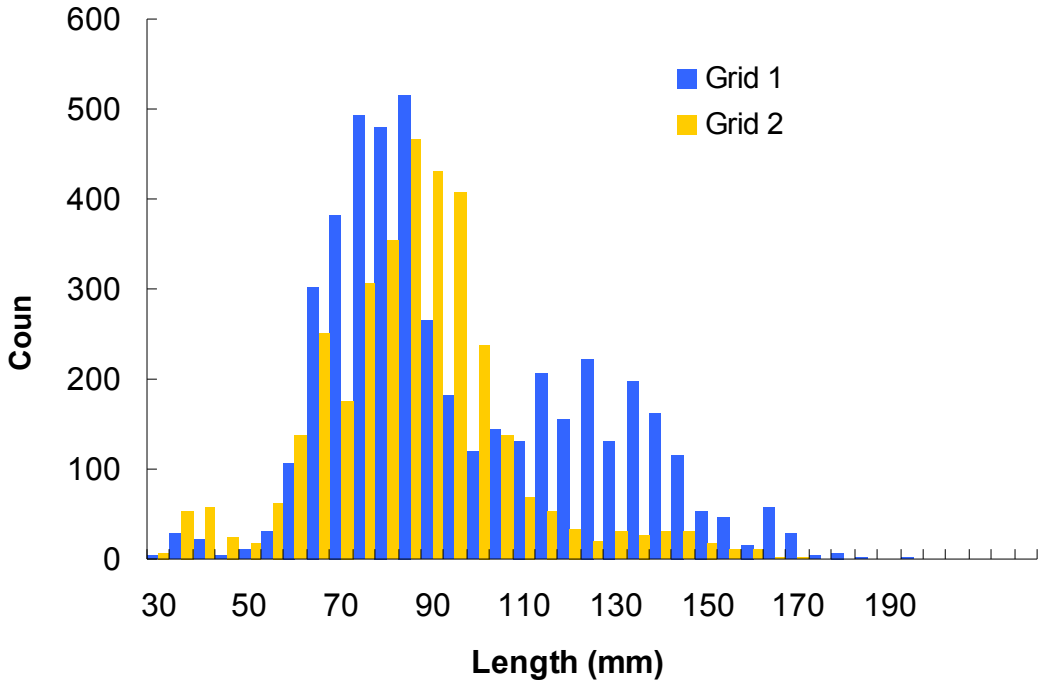


Figure 7. Histogram of sandeel length frequencies.

(b) Acoustics

To confirm that sandeels were largely inactive during the day at this time of year, fisheries acoustics were recorded during the morning. Echograms were scrutinised for the presence of sandeel schools in the watercolumn. Sandeel schools were identified using the Simrad EK60 splitbeam echosounder. Classification of acoustic 'marks' into species was based on their vertical position, location with regards to bottom structure, shape and by comparing the 120 kHz and 38 kHz echograms. Due to absence of a swimbladder, sandeels show up stronger on the 120 kHz. This is in contrast to many other locally abundant species like clupeids and gadoids.

In total only 7 sandeel schools were found in Grid 1 and 3 in Grid 2. The low abundance of sandeels schools in the water column confirmed assumptions that most sandeels remained buried in the sediment during the day at this time of year. Due to the low number of schools identifed, no biomass estimates of sandeels were calculated.

4 To process multibeam data from Endv5_05 and 9_06

Data recorded using a Simrad EM3000 dual head multibeam sonar during two previous cruises were processed, and its application for habitat assessment was explored. Apart from high-resolution bathymetry to provide a fine scale map of the seabed, the seabed characteristics of the two grids were assessed using the backscatter.

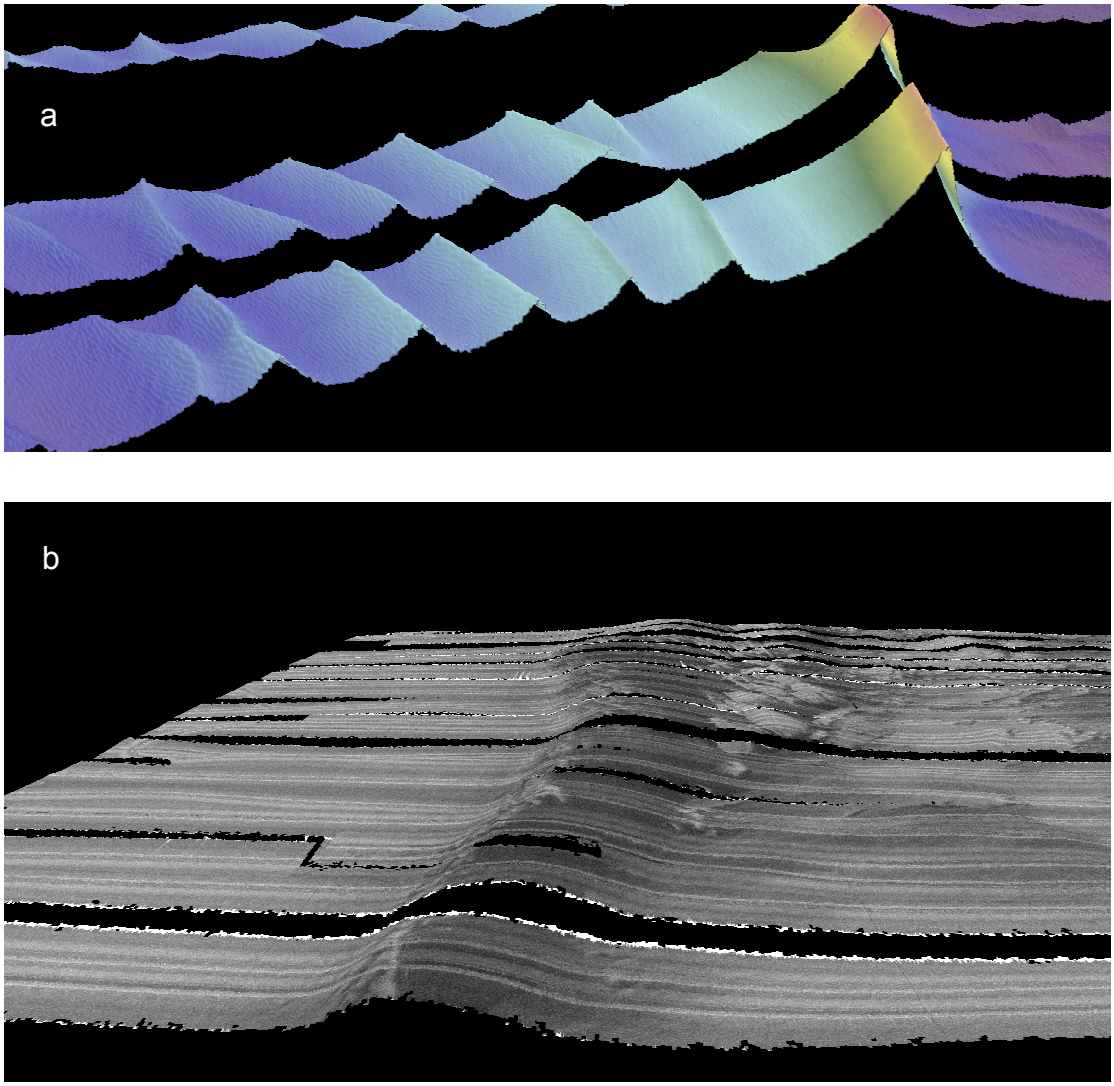
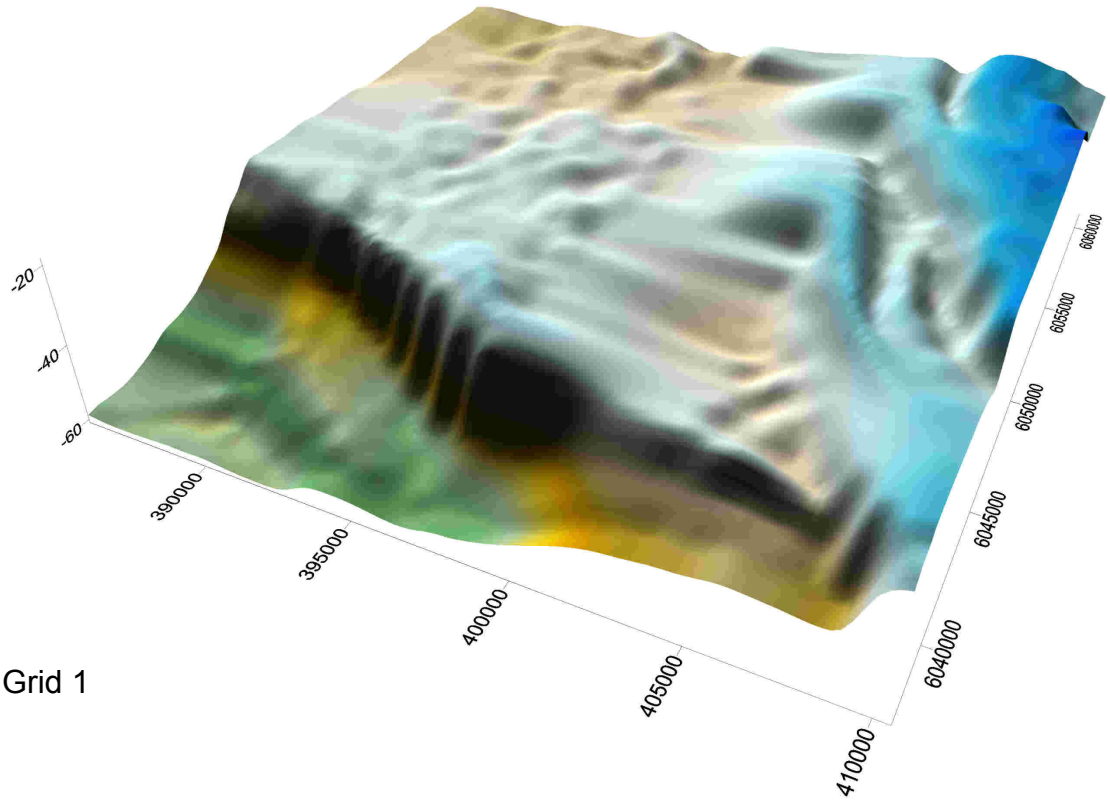


Figure 8. Results of multi-beam survey. (a) Fine scale bathymetry map of the seabed of grid 2. (b) Backscatter layer containing information of seabed characteristics overlaid over bathymetry (darker shades of gray represent course sediments). (c, next page) bathymetry of survey grids.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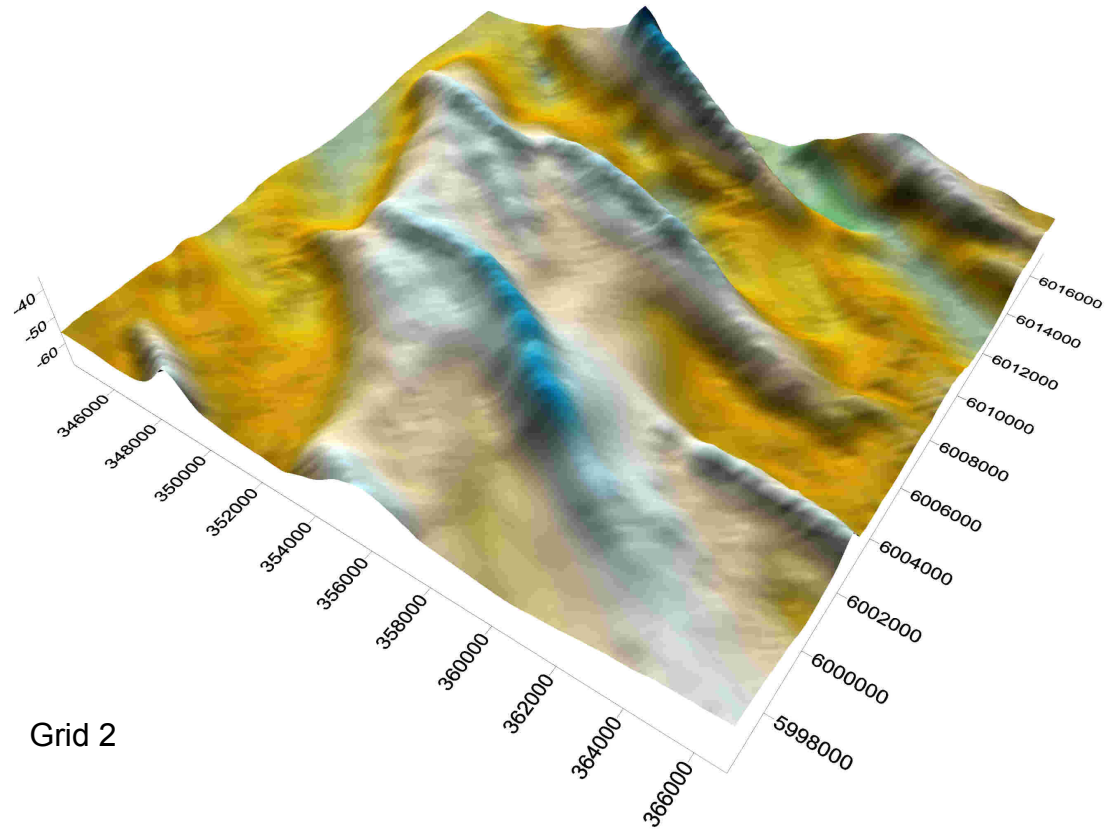
Grid 1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6012000
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6016000

Grid 2

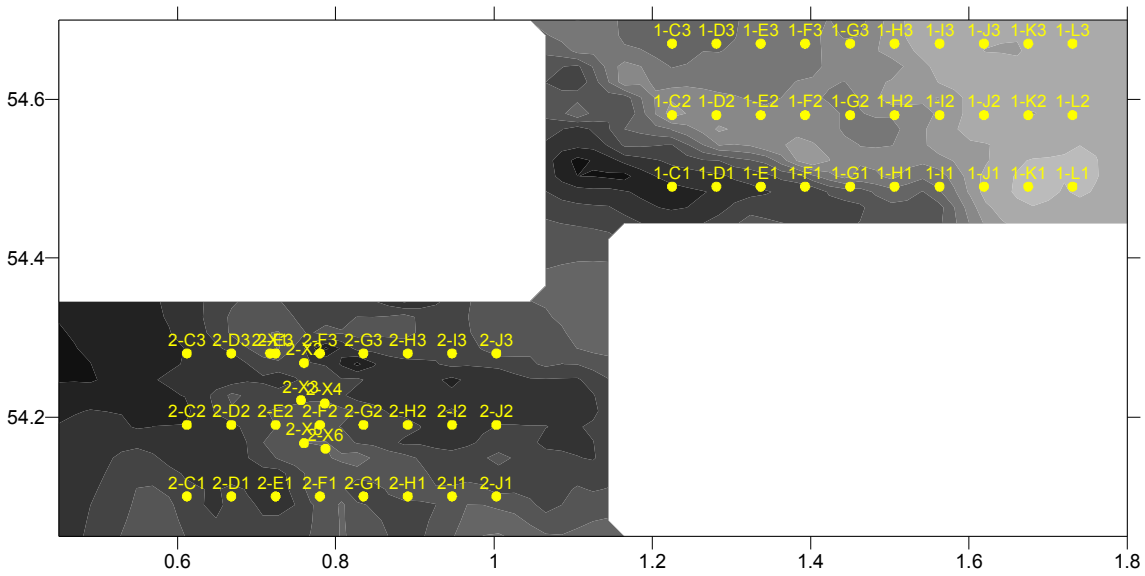
Distribution list:

Basic list + scientific staff, Steve Mackinson, Julia Blanchard, Ewen Bell, Georg Engelhard, Eastern Region and Northeastern Region Sea Fisheries District, Sea Fisheries Inspectorate.

Appendix

The survey strategy and fish sampling.

The survey took place on the west side of the Dogger Bank, on and around the shoals of the North West Riff. Two survey grids (Figure A), each containing 48 stations, were sampled independently. Grid 2 (54 6.0 N, 0 36.708 E to 54 16.8 N, 1 0.186 E) on the Hills in a relatively unfished area, and Grid 2 (54 29.4 N, 1 13.489 E to 54 40.2, 1 43.884 E) on the south western edge of the Dogger bank, usually heavily fished by Danish sandeel vessels. Survey legs each 10.8 nm (20 km) long, spaced 1.9 nm apart (3.6 km) running north-south, with sampling stations space every 5.4 nm apart were defined for each grid. Grid legs were surveyed alternately (i.e, C, E, G, I). Surveying began on the western-most side of Grid 2, moving eastwards towards the eastern-most point of Grid 1, then turning back and surveying the alternate legs skipped first time round. Grid 1 was therefore completed in full before surveying finished on Grid 2.



Layout of stations and transents on the survey grids

Acoustic surveying for fish shoals was carried out using a split beam, dual frequency (38 & 120 kHz) scientific echosounder (EK60, Simrad) starting at 0645 h GMT (just before dawn) and proceeding at speeds of between 7 and 9 kts depending on weather until two transects were covered.

During each acoustic survey, four out of six stations were sampled for potential sandeel predators (groundfish) using a standard Granton trawl with a 12 mm mesh liner, towed at 4 kts for 20 minutes through each trawl station. During the afternoon, the benthos on those same 4 stations was sampled using a 2-meter beam trawl (12:00-16:00), towed for approximately 5 minutes. Starting at 21:00 hrs, six stations on two transects were subsequently sampled using a 1.2 m sandeel dredge, towed for approximately 10 minutes at 3 to 4 kt. Accurate estimates of the duration of beam and dredge tows were obtained from a temperature and depth recording data storage tag, programmed to record data every 10 s, attached to the head of the dredge.

The feeding habits of the most abundant predatory fish (whiting, haddock, cod, gurnard, lesser weever, mackerel, plaice and greater sandeel) were investigated at each station. Five fish in each 5cm length class were taken from the total catch and their gut contents identified and weighed.

A dredge survey for sandeels was undertaken during hours of darkness. The survey was carried out using a 1.2 m sandeel dredge from 2100 h to about 0300 h each night. 10-minute tows were carried out at each dredge station. Sandeels were counted as whole fish or heads, heads were subsequently discarded and only whole fish measured or weighed. Other species were either counted directly (small catches), or numbers were calculated by raising the total weight of the catch by the number in a weighed sub-sample. A note was also made of the typical benthic fauna associated with the catch in the dredge.

Processing and recording

All samples were recorded adhering to defined protocols. Fish lengths and weights were entered directly into a database using the CEFAS Electronic Data Capture system. Other data were entered in to a central database and quality controlled by subsequent independent checking.