FRV *Clupea*

Cruise 1893C

REPORT

23 September-12 October 1993

Personnel

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F Armstrong	SO
I M Gibb	SO
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Objectives

To carry out an echo-integrator survey to determine the biomass and distribution of pelagic fish in the Moray Firth and to determine fish species and size composition through trawl sampling. To assess predatory fish abundance through demersal trawl sampling and to collect stomach samples for dietary and food consumption analysis. To determine the number and distribution of mammalian and avian predators using transect census methods and record instances of seabirds carrying prey items. To determine spatial variation in water temperature, salinity and nutrient concentrations and to assess the biomass and distribution of phytoplankton and zooplankton.

Narrative

The scientific equipment was loaded onto *Clupea* on 20 and 21 September. Scientific staff joined the ship on the morning of 23 September at Fraserburgh. The ship sailed at 1400. Acoustic survey work started on the morning of 24 September and continued during daylight hours until deteriorating weather conditions prevented further acoustic survey on the evening of 30 September. Figure 1a shows the acoustic survey track covered. Concentrations of pelagic fish were sampled at positions shown in Figure 1b using an International Young Gadoid Pelagic trawl (PT154) with 10 mm mesh size cod-end fitted with a 6 mm mesh size cover. Otolith samples were collected from herring and sprats in each haul, and samples of clupeids and gadoid fish were weighted to determine length weight relationships.

While *Clupea* was carrying out acoustic survey work the density of seabirds, seals and cetaceans was assessed using standard survey methods; Figure 1c shows the sections of cruise track where these top predators surveys were undertaken. In addition to these formal surveys, all casual sightings of seals and cetaceans were noted. Observations of seabirds carrying prey in their bills were recorded to provide dietary information.

An attempt was made to carry out hydrographical and plankton sampling work on 1 October, but severe weather forced *Clupea* to seek shelter in Buckie. *Clupea* left Buckie during the evening of 2 October and worked through 24 hours, and then again through daylight hours on 4 October, visiting 24 hydrographic and plankton sampling stations (Fig. 1d). Water temperature, salinity, nutrient levels and phytoplankton abundance were sampled using reverser bottles positioned on the wire immediately below the water surface, at a depth of 10 m, and approximately 5 m above the sea bed. Zooplankton were sampled using a Dutch Gulf III sampler; single oblique tows were employed in water deeper than 50 m, double oblique tows in water between 20 m and 50 m depth. At one station the water was too shallow, at less than 20 m, to allow the Dutch Gulf III zooplankton sampler to be deployed.

On 5 October an attempt was made to complete the acoustic survey track, but problems with the anchor prevented the required early start and only half of the final leg at the extreme eastern edge of the study area was surveyed. At midday survey work was halted and *Clupea* steamed for Buckie for the half landing. On the morning of 6 October the pelagic fishing gear was exchanged for demersal gear, a Jackson Rockhopper trawl with 20 mm mesh size cod-end and 10 mm cover.

Bad weather kept *Clupea* in Buckie until 1630 on 8 October. Fourteen demersal fishing stations (Fig. 1e) were sampled over the following two and a half days. Stomach samples were collected from piscivorous fish and samples of fish were weighed each day to provide length-weight relationships. Fishing ceased at 1430

on 11 October and *Clupea* returned to Fraserburgh. The scientific equipment was offloaded and scientific staff left the ship on the morning of 12 October.

Results

The principle objectives of this cruise were to describe the pelagic part of the marine foodweb of the Inner Moray Firth and to quantify the flux of biomass and energy between various components of the web.

The acoustic survey data have yet to be worked up. However initial appraisal of the echo-sounder printout suggests that pelagic fish, particularly clupeids, were much more abundant and more widely distributed than on previous cruises. More fish shoals were encountered covering a wider area than ever before, consequently the pelagic fishing gear was fished more frequently and samples were obtained from all regions of the study area (see Fig. 1b). Most catches were dominated by clupeid species, although 0-group whiting contributed significantly to the catch weight of 5 samples and Norway pout were the dominant species in the catch made at station 3 (Table 1). Sandeels were almost completely absent from the pelagic samples. The following Length-Weight relationships were obtained:

Herring	W	=	$0.0037572 \, . \, L^{3.239330}$
Sprat	W	=	$0.0039041 \, . \, L^{3.275971}$
Whiting	W	=	$0.0110565 \, . \, L^{2.883122}$

The total weight of each species in each catch was calculated. The percentage contributions, both by number and biomass, of sprats in the clupeid fraction of each catch were also determined (Table 1). In ten (66%) of the hauls sprats contributed over 75% of the clupeid biomass, but in only six samples (40%) did the sprat fraction of the clupeid biomass exceed 90%. The sprat proportion was highest close to the north-western shore and in a broad band stretching west to east across the southern region of the study area (Fig. 2).

Initial analysis suggested that over 200,000 seabirds used the area on a day to day basis. As in previous cruises, the two most abundant seabird species were guillemots and kittiwakes with population estimates of 105,200 and 41,700 respectively. Knowing their daily food requirements, these population size estimates suggest that approximately 20 to 25 tonnes of fish were being consumed daily by seabirds. Three observations of guillemots with prey items in their bill all involved clupeid fish 5-6 cm in length.

Whiting and haddock were the only potential predatory fish species encountered in any significant number; biomass estimates of 4,485 and 7,232 tonnes respectively were calculated for the whole study area. Assuming food consumption rates of 1% of body weight per day and diets consisting of 30% clupeid fish, these biomass estimates suggest that approximately 35 tonnes of herring and sprat were eaten daily by predatory fish. Analysis of the stomach samples collected from predatory fish will allow more precise determination of their diets and daily food consumption rates, and hence, a more definite estimate of their daily consumption of the clupeid resource.

Approximately 1,300 common seals, 600 grey seals and 100 bottlenose dolphins feed within the confines of the Inner Moray Firth, together with small, but unknown, numbers of harbour porpoise and minke whale. Figure 3 shows the distribution of marine mammal sightings obtained during the cruise. Assuming that common seals eat 2.5 kg of fish per day, grey seals 5 kg and bottlenose dolphins 8 kg, then these population estimates suggest that these three predators consume 7 tonnes of pelagic fish prey per day. If minke whales and porpoises are allowed for, this figure might reach 10 tonnes per day.

Combining the consumption estimates of the three groups of top predators gives a daily loss of some 70 tonnes of pelagic fish per day. Once the pelagic fish biomass has been estimated from the acoustic data, this figure can be put into some perspective, in terms of pelagic fish daily mortality.

The abundance and distribution of phytoplankton and zooplankton in the Inner Moray Firth will be determined and the influence of water temperature, salinity and nutrient concentration on plankton distribution will be examined. Relationships between zooplankton distribution and pelagic fish distribution will be investigated and the daily impact of pelagic fish on their zooplankton prey will be estimated.

S P R Greenstreet

16 November 1993

Seen in draft: S Clark

Table 1: Sandeel (SE), Herring (H), Sprat (St), Whiting (Wht) and Norway Pout (NPt) numbers at length in pelagic gear samples.

Sample	1				2				3				4		5				6			7	
Haul Number	C93/139				C93/140				C93/141				C93/142		C93/143				C93/144			C93/145	
Date	240993				250993				250993				260993		260993				260993			270993	
Latitude	5754.62N				5750.27N				5813.60N				5756.20N		5756.47N				5741.70N			5736.64N	
Longitude	0257.22W				0307.20W				0305.90W				0337.13W		0337.13W				0341.15W			0400.94W	
Length	H	St	Wht	NPt	H	St	Wht	NPt	H	St	Wht	NPt	St	Wht	H	St	Wht	NPt	H	St	Wht	SE	H
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0	0	0	0	0	0	514	0	0	0	0	0	0	0	0	0	0
4.0	0	0	9	0	0	0	0	0	0	0	0	0	701	4	0	0	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0	0	0	0	0	0	1004	0	0	0	0	0	0	0	0	0	0
5.0	0	4	3	0	0	0	0	0	0	0	0	0	1518	0	0	0	2	0	0	0	1	0	0
5.5	0	40	0	0	0	8	0	0	0	0	0	0	934	0	0	8	0	0	0	0	0	0	0
6.0	0	152	12	0	0	32	7	0	0	0	0	0	747	3	0	30	1	0	0	0	4	0	0
6.5	0	592	0	0	0	96	0	0	0	0	0	0	70	0	0	149	0	0	0	0	0	0	0
7.0	0	1316	9	0	0	367	17	0	0	0	0	0	47	4	0	581	0	0	0	0	35	0	1
7.5	0	2567	0	0	0	1252	0	0	0	2	0	0	0	0	0	730	0	0	0	0	0	0	1
8.0	7	2106	5	0	0	2440	27	12	0	11	0	30	0	0	0	1371	3	0	0	0	85	0	4
8.5	12	494	6	0	5	605	0	0	1	6	0	0	0	0	0	760	0	0	0	0	0	0	6
9.0	42	8	7	2	7	28	43	7	6	2	0	171	0	0	9	21	7	0	0	0	78	0	4
9.5	46	40	0	0	40	16	0	0	2	0	0	0	0	0	66	16	0	0	0	1	0	0	0
10.0	101	24	33	7	166	36	61	6	13	3	0	824	0	0	541	5	3	2	0	4	29	0	0
10.5	89	0	0	0	252	8	0	0	21	2	0	0	0	0	749	21	0	0	0	3	8	1	0
11.0	103	4	47	7	139	16	41	1	34	6	0	661	0	0	607	53	6	0	0	3	23	0	0
11.5	69	12	0	0	83	12	0	0	30	3	0	0	0	0	123	32	0	0	0	0	0	0	0
12.0	24	4	29	1	13	8	16	0	13	2	1	15	0	0	11	27	2	0	0	0	31	0	0
12.5	18	8	0	0	3	8	0	0	5	6	0	0	0	0	5	48	0	0	0	0	0	0	0
13.0	3	0	27	0	0	0	4	0	0	1	0	0	0	0	0	21	2	0	0	0	13	0	0
13.5	0	20	0	0	0	4	0	0	0	1	0	0	0	0	11	27	0	0	0	1	0	0	0
14.0	0	20	7	0	1	4	2	0	0	0	1	0	0	0	0	37	0	0	0	1	9	0	0
14.5	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
15.0	0	4	5	0	0	0	1	0	0	0	1	7	0	0	0	0	0	0	0	1	6	0	0
15.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
16.0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
16.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
17.0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	2	0	1	0	0
17.5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4	0	0	0	0
18.0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	2	0	0
18.5	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0
19.0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	2	0	21	0	1	0	0
19.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0
20.0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	0	0
20.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0
21.0	0	0	1	0	0	0	0	0	1	0	4	0	0	0	0	0	2	0	11	0	1	0	0
21.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
22.0	0	0	2	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	1	0	0	0	0
22.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
23.5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24.0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
30.0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Species Number	520	7423	201	17	712	4940	219	26	128	45	21	1708	5535	11	2127	3934	30	2	108	14	311	1	16
Total Clupeid Number		7943				5652				173			5535			6061				122			16
Sprat Percentage		93.5				87.4				26.0			100			64.9				11.5			0
Species Weight (g)	4284	23289	2569	159	5724	17216	1796	152	1333	372	1761	15479	4312	20	16869	16165	469	16	5896	162	2726	3	59
Clupeid Weight (Kg)		27.57				22.94				1.70			4.31			[redacted]				6.06			.059
Sprat Percentage		84.46				75.05				21.8			100			48.93				2.67			0

Table 1: Sandeel (SE), Herring (H), Sprat (St), Whiting (Wht) and Norway Pout (NPt) numbers at length in pelagic gear samples.

Sample	8			9			10		11	12		13		14		15			
Haul Number	C93/146			C93/147			C93/148		C93/149	C93/150		C93/151		C93/152		C93/153			
Date	270993			270993			280993		280993	280993		290993		290993		051093			
Latitude	5736.45N			5744.79N			5753.40N		5756.38N	5746.60N		5753.19N		5759.30N		5801.15N			
Longitude	0401.70W			0350.30W			0353.20W		0347.60W	0327.30W		0322.20W		0312.80W		0243.42W			
Length	H	St	Wht	H	St	Wht	H	St	St	H	St	H	St	H	St	H	St	Wht	NPt
3.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4.0	0	0	0	0	1	0	0	32	171	0	0	0	0	0	0	0	4	0	0
4.5	0	0	0	0	4	0	0	480	1101	0	0	0	0	0	0	0	8	0	0
5.0	0	0	0	0	0	1	0	544	1542	0	0	0	0	0	0	0	4	1	0
5.5	0	0	0	0	0	0	0	3768	1517	0	42	0	55	0	0	0	16	0	0
6.0	0	532	0	0	0	4	0	13434	367	0	798	0	826	0	0	0	20	2	0
6.5	0	58516	0	0	8	0	0	13434	49	0	2183	0	1818	0	0	0	220	0	0
7.0	0	3192	0	0	63	1	0	3604	0	0	2393	0	1625	0	13	0	463	9	0
7.5	2	0	0	0	404	0	0	160	0	0	3779	0	1102	0	20	0	1542	0	0
8.0	12	0	0	0	251	0	24	64	0	2	2099	0	578	0	445	2	1894	10	10
8.5	52	0	0	0	13	0	124	0	0	8	210	0	220	5	684	0	705	0	0
9.0	148	0	1	4	0	0	376	0	0	44	0	0	0	9	73	5	0	23	89
9.5	48	0	0	24	0	0	188	0	0	86	0	0	0	32	10	34	4	0	0
10.0	0	0	0	44	0	0	16	0	0	132	0	1	0	96	12	67	16	56	146
10.5	2	0	0	12	0	0	0	0	0	78	0	0	0	283	10	83	8	0	0
11.0	0	0	0	0	0	0	0	0	0	12	0	0	0	365	14	58	28	39	34
11.5	0	0	0	0	0	0	0	0	0	6	0	0	0	224	8	34	48	0	0
12.0	0	0	0	0	0	0	0	0	0	6	0	0	0	132	18	34	48	15	14
12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	59	22	19	64	0	0
13.0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	28	10	56	8	0
13.5	0	0	0	0	0	0	0	0	0	0	0	0	0	6	20	8	36	0	0
14.0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	12	3	16	5	0
14.5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	4	0	0
15.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1
15.5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
16.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
19.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0
20.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
21.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
22.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Species Number	264	62240	1	84	736	6	728	35520	4747	376	11504	1	6224	1235	1389	361	5204	187	295
Total Clupeid Number		62504			820			36248	4747		11880		6225		2624		5565		
Sprat Percentage		99.6			89.8			98.0	100.0		96.8		100.0		52.9		93.5		
Species Weight (g)	1209	113215	6	530	2154	12	3438	56264	4002	2506	29763	7	14358	11421	7205	3260	20524	2252	2396
Clupeid Weight (Kg)		114.42			[redacted]			59.70	4.00		32.27		14.36		18.6		23.78		
Sprat Percentage		98.9			81.8			94.2	100.0		92.2		100.0		38.7		86.3		

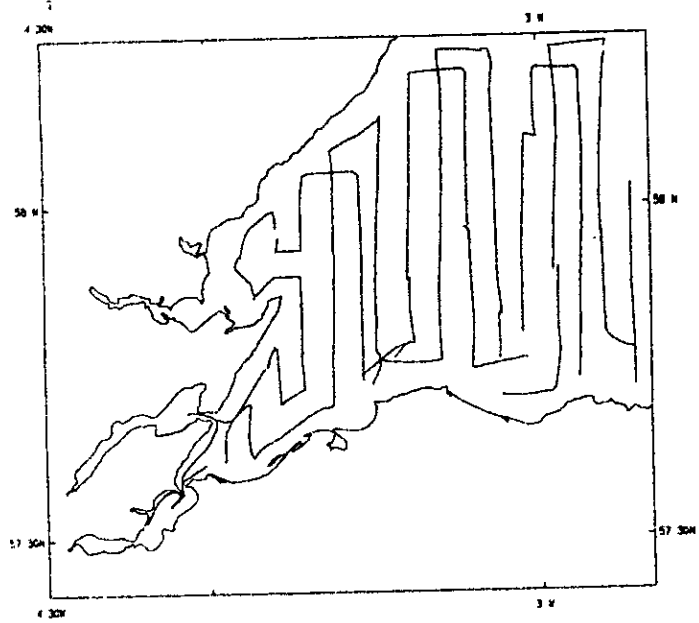


Figure 1D: Hydro and Plankton sampling stations: October 1993.

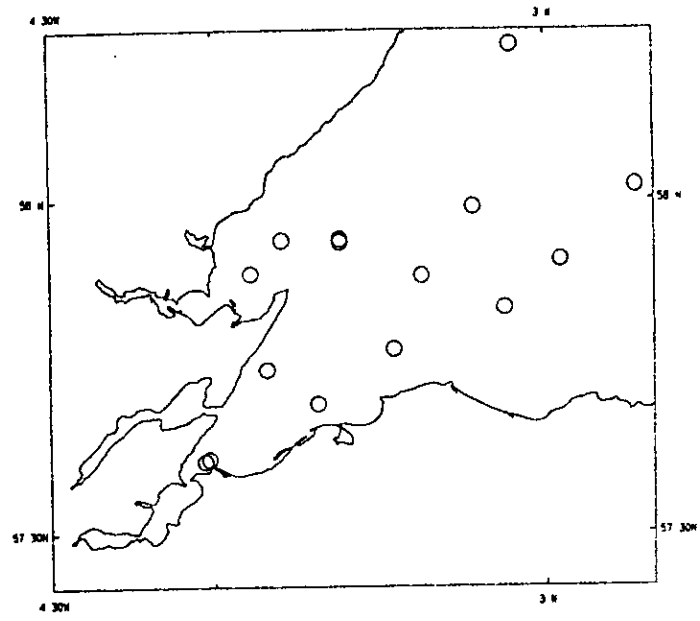
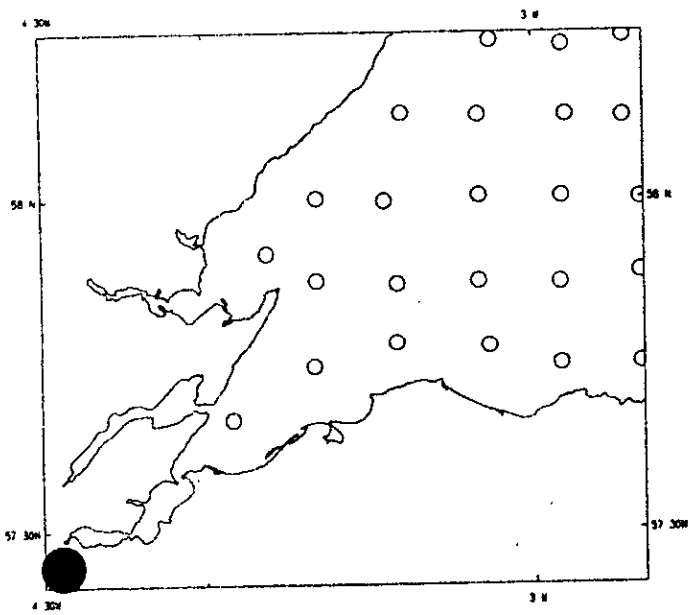


Figure 1C: Seabird survey track: September 1993.



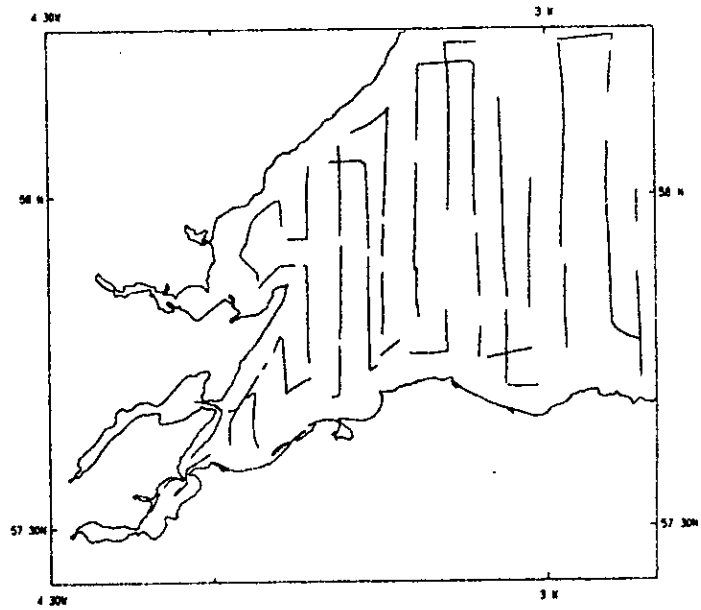


Figure 1E: Demersal fish sampling sites: October 1993.

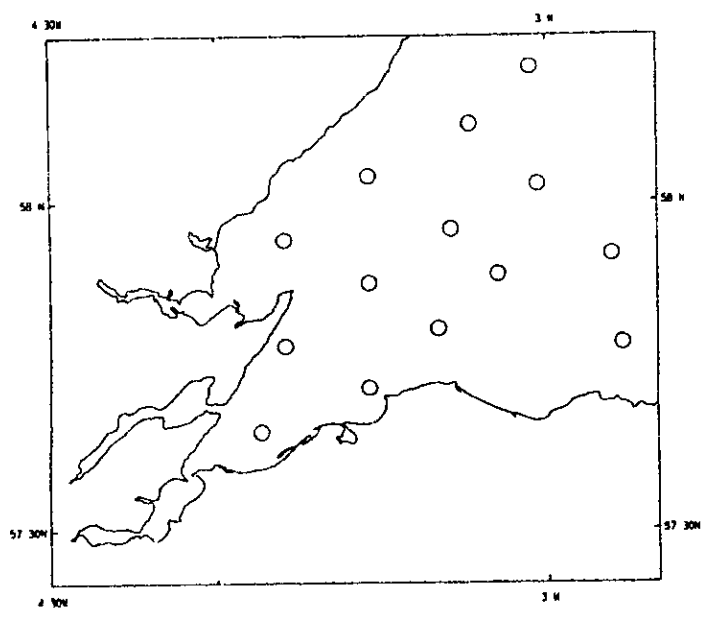


Figure 2:

Sprat fraction in the clupeid component of the catch.

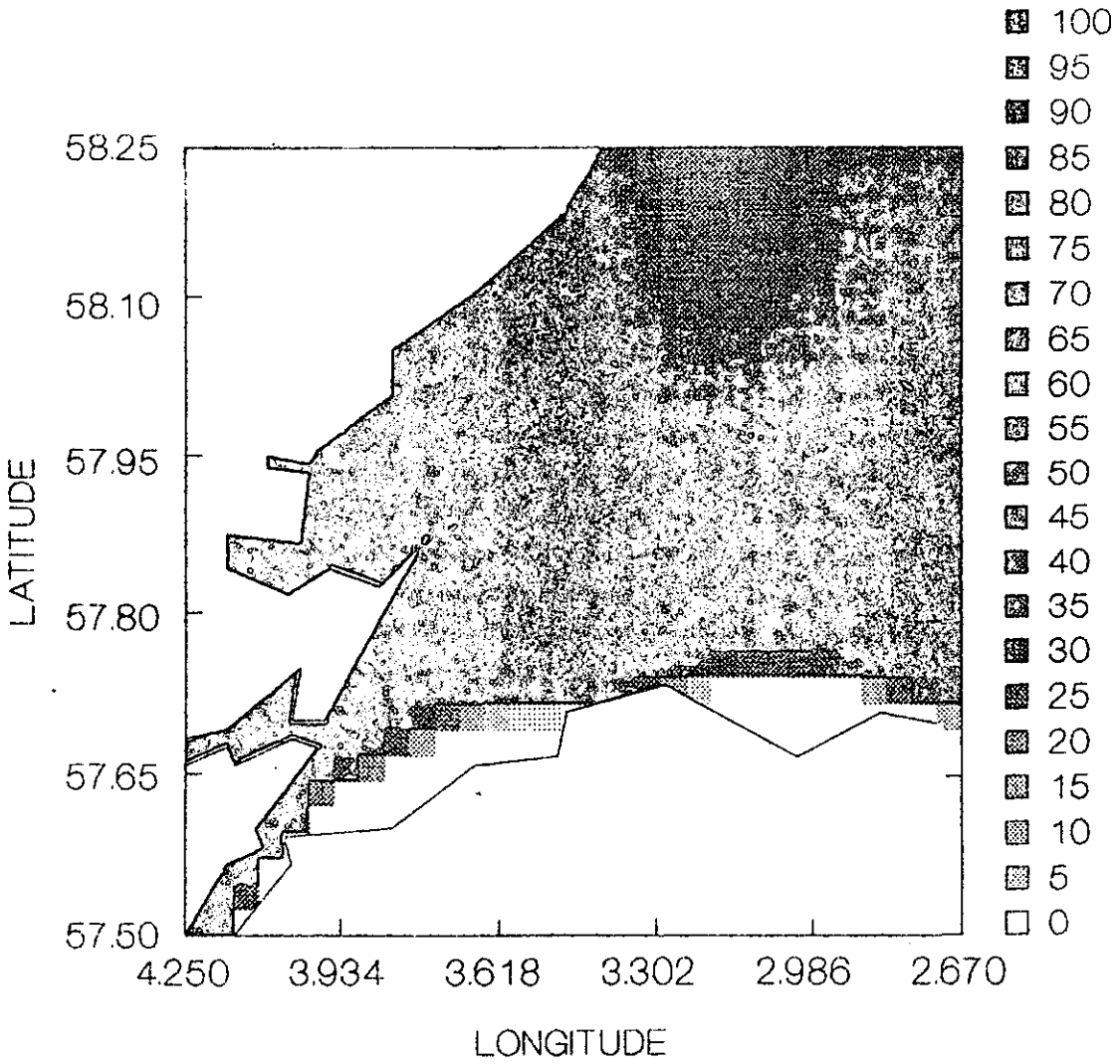


Figure 3: Marine mammal sightings: September 1993.

(Circle area is proportional to animal numbers at each location.
Filled - Common Seals; Cross-hatch - Minke Whales; Dots - Bottlenose Dolphins.)