SENTER FOR MARINT MILJØ
Havforskningsinstituttet
INTERN TOKTRAPPORT

SHIP: RV Michael Sars
DEPARTURE: Bergen January 6th, 1700 GMT
ARRIVAL: Bergen January 24th, 2300 GMT

AREA: WESTERN NORWAY AND THE SHETLAND ISLANDS.

PURPOSE

The primary objective of the cruise was to undertake investigations on the winter plankton communities of the fjords and the continental shelf and slope areas off Møre, western Norway. A still photo camera system, different acoustical techniques combined with traditional sampling was to be used to characterize scattering layers of zooplankton and mesopelagic fish, and if possible study the avoidance behavior of macrozooplankton on sampling gear.

However an oil spill accident close to Sumburgh Head in the southern part of the Shetland islands forced us to revise our original plans. The Institute of Marine Research (IMR) decided to take part in a joint monitoring program and assist the Marine Laboratory in Aberdeen to investigate the vertical and horizontal dispersion of oil from the wreck site of the MV Braer tanker. To obtain simultaneous information on the plankton and fish larvae assemblage in the area a sampling program was designed based on the local knowledge available. Steve Hay of SOAFD joined the crew on RV Michael Sars and acted as a liaise between the Scottish and Norwegian scientists to help coordinate and direct the sampling effort.

PERSONNEL: Berit Endresen (IMR), Magnus Johannessen (IMR), Kjell Westrheim (IMR), Karsten Hansen (IMR), Tor Knutsen (IMR), Steve Hay (Marine Laboratory, Aberdeen, 16-23rd January).

INSTRUMENT PERSONNEL: Bjarte Kvinge (IMR), Tore Mørk (IMR)

MATERIALS & METHODS

A Mesotech Mod. 971 2.0 Mhz short range scanning sonar system was used in image mode, scanning a horizontal slice of 0.4^0 by 360^0. The scanning sonar was mounted in a frame originally used for still camera photography. A cable containing 4 conductors approximately 100m long was used to control and obtain signals from the sonar. The sonar was mounted to ping horizontally and the scanning range was 5m. The image from the display processing unit was converted from RGB to PAL by a PAL encoder, recorded by a VHS video system and displayed on a SONY Trinitron KX-14CP1 colour monitor. The sonar was deployed as a drop sonde and information on depth of recording was obtained by the winch meter wheel and subsequently recorded on videotape by a microphone.

A Photosea 1000 still camera and strobe mounted in a specially designed frame was used to take still photos of zooplankton and mesopelagic fish between 200-0m.

A 120 kHz transportable split beam transducer with 200 m cable was used in a tank borrowed from the University of Bergen, Institute of Fisheries and Marine Biology. The tank was made of 2.5cm thick polyethylene (PEH) with a diameter and height of 70cm and 2.0m respectively. An internal stainless steel frame was designed and built on board the ship to mount individual zooplankton specimens in the center of the tank. Each specimen could be mounted to a Y-shaped socket which made it possible to rotate the animal 360^0 for target strengt experiments.

Water samples

Water samples were collected at selected depths with 5l Niskin water bottles. Samples to be analyzed by the Marine Laboratory, Aberdeen by their field laboratory in Scalloway, were stored on 2.5l bottles for later analysis by a Perkin-Elmer LS-5 Luminiscence Spectrometer. The instrument was measuring fluorescent emission at 356nm while exitation was set to 256nm. Table 1 gives gear types and actual sampling depth for each station.

Water samples to be analyzed by the Institute of Marine Research, Bergen were added 1ml of internal standard and then extracted 3 times in a 3l separating funnel with 40, 20 and 20ml DCM (dichloromethane) respectively. Selected aromatic hydrocarbons were analyzed by a HP 5987A gas chromatography/mass spectrometry system (GC/MS), at the Institute of Marine Research, Bergen. By selected ion monitoring the C_3-C_4 benzene, naphtalene, phenanthrene and dibenzothiophene and their C_1-C_3 alkyl derivatives were determined. Selected samples were analyzed by gas chromatography (GC) which gives the total amount of hydrocarbons in the water. This analysis is comparable to the UV-fluorescence method.

Water samples obtained for the Norwegian oil company Statoil were stored in 2l bottles and preserved with 2.2ml hydrochloric acid.

Biological sampling

Mesozooplankton was sampled by vertical hawls with a 180µm WP2 net from near the bottom to the surface at selected stations. Fish larvae and macrozooplankton were sampled with a Methot Isaacs-Kidd ring trawl (MIK) in a double oblique hawl (0-100-0m). Usually two WP2 hawls were taken at each station.

The first WP2 sample was treated according to standard IMR procedure. Half of the sample was used for biomass determination while the other half was preserved in 4% formalin for species composition. Due to the small size of the sample and low number of individuals the sample was usually preserved undivided.

The second WP2 sample was washed with cooled sea water and gently retrieved and scraped off a 180µm mesh and stored in liquid nitrogen. These samples were brought to the Marine Laboratory, Aberdeen for analysis of gut fluorescence.

The MIK samples were washed into a dish and herring larvae extracted. The larvae were measured to nearest mm below (total length), and preserved in 80% borax buffered ethanol (pH 8-9) for otholit analyses. Some larvae were stored in liquid N_2 for RNA/DNA analyses. The rest of the sample was preserved in 4% formalin for species composition.

INVESTIGATIONS

Due to the extreme weather conditions the first part of the cruise was dedicated to test gear and equipement and gain experience with respect to the application of the Mesotech 971 scaninng sonar, the transportable 120 kHz split beam transducer and the still photocamera.

Mesotech 2 Mhz scanning sonar

The scanning sonar was mounted in a frame originally used to deploy the Photosea 1000 still camera system. It was deployed to approximately 100m depth on two occasions at night. Detection of scatterers like the ephausiid (*Meganyctiphanes norvegica*) and the two species of mesopelagic fish (*Benthosema glaciale* and *Maurolicus muelleri*) seemed to be fully possible. Registrations of scatterers were recorded with the VHS video system connected to the Mesotech 971 display processing unit. However the sonar display of the scatterers seemed to be weaker than during a similar tank experiment on euphausiids (Ona & Knutsen, 1992). This migth be due to a sub-optimal electrical resistance and the need to pre-amplify the sonar signals. A proper housing to protect the scanning sonar is also needed in order to deploy it safely when mounted to a trawl. These problems have to be solved in order to conduct further experiments on avoidance of zooplankton on sampling gear.

Underwater still photography

Six series of pictures were taken during different parts of the day in Jøsenfjorden, western Norway (Table 2). All deck lights were turned off during the nigthtime experiments. Both copepods, krill and mesopelagic fish were detected on several photographs from each series. Even if the density of krill and fish seemed to be low, as evaluated on the basis of each photograph, most registrations of macrozooplankton and

Table 1. Sampling (x) during Shetland cruise with RV M. Sars January 6th to January 24th 1993. HT: Harstadtrawl. 1 and 2: Samples for RNA/DNA analyses on herring larvae and krill respectively. MLAB: Marine Laboratory, Aberdeen. IMR: Institute of Marine Research, Bergen.

Station	Position	Depth (m)	Gear	Date	Time GMT	RNA/DNA	Gut fluorescence	Otholits	Zooplankton Biomass	Zooplankton Species	Water samples IMR	Water samples MLAB	Water samples Statoil
1	5918N, 0621E	100	HT	10.1	13:38				x	x			
1	5918.4N, 0622E	152-137	HT	10.1	15:09				x	x			
1	5917.2N, 0618.2E		CTD	12.1	18:40								
2	6002N, 0106W		CTD	18.1	12:02								
2	6002N, 0106W	80-0	WP2		12:02		x		x	x			
2	6002N, 0106W	0-60-0	MIK		12:02			x	x	x			
2	6002N, 0106W	1	5lNisk		12:02						x		
2	6002N, 0106W	3	5lNisk		12:02						x		
2	6002N, 0106W	5	5lNisk		12:02						x	x	
2	6002N, 0106W	10	5lNisk		12:02						x		
2	6002N, 0106W	20	5lNisk		12:02						x		
2	6002N, 0106W	25	5lNisk		12:02						x	x	
2	6002N, 0106W	30	5lNisk		12:02						x		
2	6002N, 0106W	50	5lNisk		12:02						x		
3	6000N, 0100W		CTD		14:16								
3	6000N, 0100W	110-0	WP2		14:16		x		x	x			
3	6000N, 0100W	0-97-0	MIK		14:16			x	x	x			
3	6000N, 0100W	5	5lNisk		14:16						x	x	
3	6000N, 0100W	25	5lNisk		14:16						x	x	
4	5959N, 0052W		CTD		16:12								
4	5959N, 0052W	110-0	WP2		16:12		x		x	x			
4	5959N, 0052W	0-105-0	MIK		16:12			x	x	x			
4	5959N, 0052W	1	5lNisk		16:12								x
4	5959N, 0052W	5	5lNisk		16:12							x	x
4	5959N, 0052W	10	5lNisk		16:12								x
4	5959N, 0052W	25	5lNisk		16:12								x
5	5958N, 0045W		CTD		18:00								
5	5958N, 0045W	110-0	WP2		18:00		x		x	x			
5	5958N, 0045W	0-100-0	MIK		18:00	1		x	x	x			
5	5958N, 0045W	1	5lNisk		18:00						x		x
5	5958N, 0045W	3	5lNisk		18:00						x		x
5	5958N, 0045W	5	5lNisk		18:00						x	x	x
5	5958N, 0045W	10	5lNisk		18:00						x		x
5	5958N, 0045W	20	5lNisk		18:00						x		x
5	5958N, 0045W	25	5lNisk		18:00						x	x	x
5	5958N, 0045W	30	5lNisk		18:00						x		x
5	5958N, 0045W	50	5lNisk		18:00						x		x
6	5956.5N,0038W		CTD		20:30								
6	5956.5N,0038W	130-0	WP2		20:30		x		x	x			
6	5956.5N,0038W	0-100-0	MIK		20:30			x	x	x			
6	5956.5N,0038W	1	5lNisk		20:30						x		
6	5956.5N,0038W	5	5lNisk		20:30						x	x	
6	5956.5N,0038W	10	5lNisk		20:30						x		
6	5956.5N,0038W	25	5lNisk		20:30						x		
7	5955.5N,0030W		CTD		22:20								
7	5955.5N,0030W	125-0	WP2		22:20		x		x	x			
7	5955.5N,0030W	0-100-0	MIK		22:20			x	x	x			
7	5955.5N,0030W	1	5lNisk		22:20						x		
7	5955.5N,0030W	3	5lNisk		22:20						x		
7	5955.5N,0030W	5	5lNisk		22:20						x	x	
7	5955.5N,0030W	10	5lNisk		22:20						x		
7	5955.5N,0030W	20	5lNisk		22:20						x		
7	5955.5N,0030W	25	5lNisk		22:20						x		
7	5955.5N,0030W	30	5lNisk		22:20						x		
7	5955.5N,0030W	50	5lNisk		22:20						x		
8	5957N,0107W		CTD	19.1	10:15								
8	5957N,0107W	100-0	WP2		10:15		x		x	x			
8	5957N,0107W	0-92-0	MIK		10:15			x	x	x			
8	5957N,0107W	5	5lNisk		10:15						x	x	
8	5957N,0107W	25	5lNisk		10:15						x	x	
9	5955N,0102.5W		CTD		12:00								
9	5955N,0102.5W	5	5lNisk		12:00						x	x	
9	5955N,0102.5W	25	5lNisk		12:00						x	x	
10	5952.5N,0057.5W		CTD		12:43								
10	5952.5N,0057.5W	110-0	WP2		12:43		x		x	x			
10	5952.5N,0057.5W	0-100-0	MIK		12:43		x		x	x			
10	5952.5N,0057.5W	5	5lNisk		12:43						x	x	

Table 1. Cont.

10	5952.5N,0057.5W	25	5lNisk		12:43						x	x	
11	5952.5N,0101.5W		CTD		14:24								
11	5952.5N,0101.5W	5	5lNisk		14:24						x	x	
11	5952.5N,0101.5W	25	5lNisk		14:24						x	x	
12	5952.5N,0107W		CTD		15:02								
12	5952.5N,0107W	5	5lNisk		15:02						x	x	
12	5952.5N,0107W	25	5lNisk		15:02						x	x	
13	5952.5N,0112.5W		CTD		15:33								
13	5952.5N,0112.5W	90-0	WP2		15:33		x		x	x			
13	5952.5N,0112.5W	0-79-0	MIK		15:33	1		x	x	x			
13	5952.5N,0112.5W	5	5lNisk		15:33						x	x	
13	5952.5N,0112.5W	25	5lNisk		15:33						x	x	
14	5950.3N,0118W		CTD		17:05								
14	5950.3N,0118W	45-0	WP2		17:05		x		x	x			
14	5950.3N,0118W	5	5lNisk		17:05						x	x	
14	5950.3N,0118W	25	5lNisk		17:05						x		
15	5952.5N,0122.5W		CTD		18:25								
15	5952.5N,0122.5W	45-0	WP2		18:25		x		x	x			
15	5952.5N,0122.5W	5	5lNisk		18:25						x	x	x
15	5952.5N,0122.5W	25	5lNisk		18:25						x		x
16	5955N,0131W		CTD		19:55								
16	5955N,0131W	5	5lNisk		19:55						x	x	
16	5955N,0131W	25	5lNisk		19:55						x	x	
17	5955N,0126.5W		CTD		20:25								
17	5955N,0126.5W	5	5lNisk		20:25						x	x	
17	5955N,0126.5W	25	5lNisk		20:25						x		
18	5957.5N,0123.5W		CTD		21:00								
18	5957.5N,0123.5W	5	5lNisk		21:00						x	x	
18	5957.5N,0123.5W	25	5lNisk		21:00						x		
19	5950N,0122.5W		CTD	22.1	14:20								
20	5957.5N,0127.5W	100-0	WP2		15:58		x		x	x			
20	5957.5N,0127.5W	0-100-0	MIK		15:58			x	x	x			
20	5957.5N,0127.5W	5	5lNisk		15:58						x	x	x
20	5957.5N,0127.5W	25	5lNisk		15:58						x	x	x
20	5957.5N,0127.5W	50	5lNisk		15:58						x	x	x
20	5957.5N,0127.5W	90	5lNisk		15:58						x		x
21	5957.5N,0137.5W		CTD		17:55								
21	5957.5N,0137.5W	110-0	WP2		17:55		x		x	x			
21	5957.5N,0137.5W	5	5lNisk		17:55						x	x	
21	5957.5N,0137.5W	25	5lNisk		17:55						x	x	
21	5957.5N,0137.5W	50	5lNisk		17:55						x	x	
21	5957.5N,0137.5W	90	5lNisk		17:55						x		
22	5957.5N,0142.5W		CTD		18:55								
22	5957.5N,0142.5W	100-0	WP2		18:55		x		x	x			
22	5957.5N,0142.5W	0-90-0	MIK		18:55	1		x	x	x			
22	5957.5N,0142.5W	5	5lNisk		18:55						x	x	
22	5957.5N,0142.5W	25	5lNisk		18:55						x	x	
22	5957.5N,0142.5W	50	5lNisk		18:55						x	x	
22	5957.5N,0142.5W	90	5lNisk		18:55						x		
23	5957.5N,0155W		CTD		20:45								
23	5957.5N,0155W	90-0	WP2		20:45		x		x	x			
23	5957.5N,0155W	0-92-0	MIK		20:45	1		x	x	x			
23	5957.5N,0155W	5	5lNisk		20:45						x	x	
23	5957.5N,0155W	25	5lNisk		20:45						x	x	
23	5957.5N,0155W	50	5lNisk		20:45						x	x	
23	5957.5N,0155W	90	5lNisk		20:45						x		
24	6000N,0210W		CTD		22:45								
24	6000N,0210W	85-0	WP2		22:45		x		x	x			
24	6000N,0210W	5	5lNisk		22:45						x	x	
24	6000N,0210W	10	5lNisk		22:45						x		
24	6000N,0210W	25	5lNisk		22:45						x	x	
24	6000N,0210W	50	5lNisk		22:45						x	x	
24	6000N,0210W	75	5lNisk		22:45						x		
25	6002.5N,0205W		CTD	23.1	07:00								
25	6002.5N,0205W	5	5lNisk		07:00						x	x	
25	6002.5N,0205W	25	5lNisk		07:00						x	x	
25	6002.5N,0205W	50	5lNisk		07:00						x	x	
26	6005N,0200W		CTD		07:55								
26	6005N,0200W	5	5lNisk		07:55						x	x	
26	6005N,0200W	25	5lNisk		07:55						x	x	

26	6005N,0200W	50	5lNisk	07:55						x	x	
27	6005N,0152.5W		CTD	08:30								
27	6005N,0152.5W	5	5lNisk	08:30						x	x	
27	6005N,0152.5W	10	5lNisk	08:30						x		
27	6005N,0152.5W	25	5lNisk	08:30						x	x	
27	6005N,0152.5W	50	5lNisk	08:30						x	x	
27	6005N,0152.5W	75	5lNisk	08:30						x		
28	6006N,0142.5W		CTD	09:40								
28	6006N,0142.5W	75-0	WP2	09:40		x		x	x			
28	6006N,0142.5W	5	5lNisk	09:40						x	x	
28	6006N,0142.5W	10	5lNisk	09:40						x		
28	6006N,0142.5W	25	5lNisk	09:40						x	x	
28	6006N,0142.5W	50	5lNisk	09:40						x	x	
28	6006N,0142.5W	75	5lNisk	09:40						x		
29	6006N,0135W		CTD	10:45								
29	6006N,0135W	90-0	WP2	10:45		x		x	x			
29	6006N,0135W	0-65-0	MIK	10:45			x	x	x			
29	6006N,0135W	5	5lNisk	10:45						x	x	
29	6006N,0135W	25	5lNisk	10:45						x	x	
29	6006N,0135W	50	5lNisk	10:45						x	x	
30	6007N,0130W		CTD	12:05								
30	6007N,0130W	75-0	WP2	12:05		x		x	x			
30	6007N,0130W	0-85-0	MIK	12:05	2		x	x	x			
30	6007N,0130W	1	5lNisk	12:05						x		x
30	6007N,0130W	5	5lNisk	12:05						x	x	
30	6007N,0130W	10	5lNisk	12:05						x		x
30	6007N,0130W	25	5lNisk	12:05						x	x	
30	6007N,0130W	50	5lNisk	12:05						x	x	
30	6007N,0130W	75	5lNisk	12:05						x		
31	6007N,0125W		CTD	14:11								
31	6007N,0125W	75-0	WP2	14:11		x		x	x			
31	6007N,0125W	0-65-0	MIK	14:11			x	x	x			
31	6007N,0125W	1	5lNisk	14:11						x		x
31	6007N,0125W	5	5lNisk	14:11						x	x	
31	6007N,0125W	10	5lNisk	14:11						x		x
31	6007N,0125W	25	5lNisk	14:11						x	x	
31	6007N,0125W	50	5lNisk	14:11						x	x	
31	6007N,0125W	65	5lNisk	14:11						x		
32	6001.8N,0126.3W		CTD	15:40								
32	6001.8N,0126.3W	110-0	WP2	15:40		x		x	x			
32	6001.8N,0126.3W	0-102-0	MIK	15:40	2		-	x	x			
32	6001.8N,0126.3W	5	5lNisk	15:40						x	x	
32	6001.8N,0126.3W	25	5lNisk	15:40						x		
32	6001.8N,0126.3W	50	5lNisk	15:40						x		
33	5952.5N,0127.5W		CTD	17:45								
33	5952.5N,0127.5W	0-90-0	MIK	17:45		x	x	x	x			
33	5952.5N,0127.5W	5	5lNisk	17:45						x		x
33	5952.5N,0127.5W	10	5lNisk	17:45						x		x
33	5952.5N,0127.5W	25	5lNisk	17:45						x		x
33	5952.5N,0127.5W	50	5lNisk	17:45						x		x
33	5952.5N,0127.5W	65	5lNisk	17:45						x		
34	5950N,0122.5W		CTD	19:50								
34	5950N,0122.5W	5	5lNisk	19:50						x		
34	5950N,0122.5W	25	5lNisk	19:50						x		-
34	5950N,0122.5W	50	5lNisk	19:50						x		
34	5950N,0122.5W	70	5lNisk	19:50						x		

Table 2. Still camera photographs taken at selected depths with a Photosea 1000 and strobe.

	Series 1		Series 2		Series 3		Series 4		Series 5		Series 6	
Date	9-Jan-93		10-Jan-93		10-Jan-93		12-Jan-93		12-Jan-93		13-Jan-93	
Time		Kl. 22.00		Kl. 10.45-10.56		Kl. 20.33		Kl. 16.00		Kl. 20.05-2020		Kl. 16.00-16.20
Aperture adjustment (f)		f:8		f:11		f:11		f>8		f:5.6-8		f:8/11
Distance		0.9-1.8m		0.8-2.0m		0.8-1.3m		<0.6-0.8m		1.2-3m		0.5-0.7m
	Depth (m)	# Exposures	Depth (m)	# Exposures	Depth (m)	# Exposures	Depth (m)	# Exposures	Depth (m)	# Exposures	Depth (m)	# Exposures
	0	-	0	-	0	5	100	1	35	1	150	1
	5	3	5	3+3	25	4	105	1	40	1	152	1
	10	3	10	3	65	4	110	1	45	1	154	1
	15	3+1	25	3	100	4	115	1	50	1	156	1
	20	3	50	3	160	4	120	1	55	1	158	1
	25	3	75	3	180	4	125	1	60	1	160	1
	30	3	100	3	100	4	130	1	65	1	162	1
					LAB	3	135	1	70	1	164	1
							140	1	75	1	166	1
							145	1	80	1	168	1
							150	1	85	1	170	1
							155	1	90	1	172	1
							160	1	95	1	175	1
							165	1	100	1	177	1
							170	1	105	1	180	1
							175	1	110	1	182	1
							180	1	115	1	185	1
							185	1	120	1	187	1
							190	1	125	1	190	1
							195	1	130	1	195	1
							200	1	135	1	200	1
									140	1		
									145	1		
									150	1		

fish seemed to be confined to the scattering layers observed by the 38kHz SIMRAD scientific echosounder. During the first 5 experiments the camera and strobe was mounted parallell to each other at a distance of approximately 53cm. In the last experiment (Series 6) the strobe was mounted at an angle of approximately 14^0 to the camera to get a more evenly illuminated field of vision.

Transportable 120 kHz echosounder

Due to the long cable and a low signal to noise ratio it was not possible to run the target strength experiments without shortening the conducting cable. All the necessary preparations to do the experiments were conducted. However, due to improved weather conditions the ship by this time headed for the Shetland islands.

SHETLAND OIL SPILL INVESTIGATIONS

Background

A fishing exclusion zone was established by the Shetland authorities around the southern part of Shetland shortly after the MV Braer incident (Fig. 1). One of our main collaborative goals was to take samples from inside and outside the exclusion zone, to supply the Scottish Office with sufficient data on the dispersion of oil to either uphold or repeal the zone.

The investigations started on the east coast of Shetland 18th of January. Little information was available as to the extent of the oil spill prior to this date. Two air surveys presented in The Shetland Times, Friday Januar 15th, from 12th and 14th of January respectively (Fig. 2) gave us a general view of the situation. Another air survey on January 21th confirmed the data obtained by the January 15th air survey. This information and data received from the Scottish Office and especially the model results from Proudman Oceanographic Laboratory (POL), Liverpool, was the basis for the joint planning of the cruise. The POL model indicated that the main concentration of oil off the east coast of Shetland could be found around 25m depth at 59°58'N,0°45'W (Fig. 3). Due to the importance of verifying the model and trace a possible drift of oil towards the Norwegian coast, samples were collected along a transect (St 2- St 7) (Fig. 4), crossing the predicted center of dispersed oil (see Fig. 3 and 4).

Another aspect to be studied during the cruise was the vertical and horizontal dispersion of the Gullfaks crude oil. Little information was available at the time of the incident to which extent this type of oil would be dispersed in the water column. This information would be of prime importance in any later evaluation of toxicity or sub-lethal effects on the different components of the plankton community in the affected area.

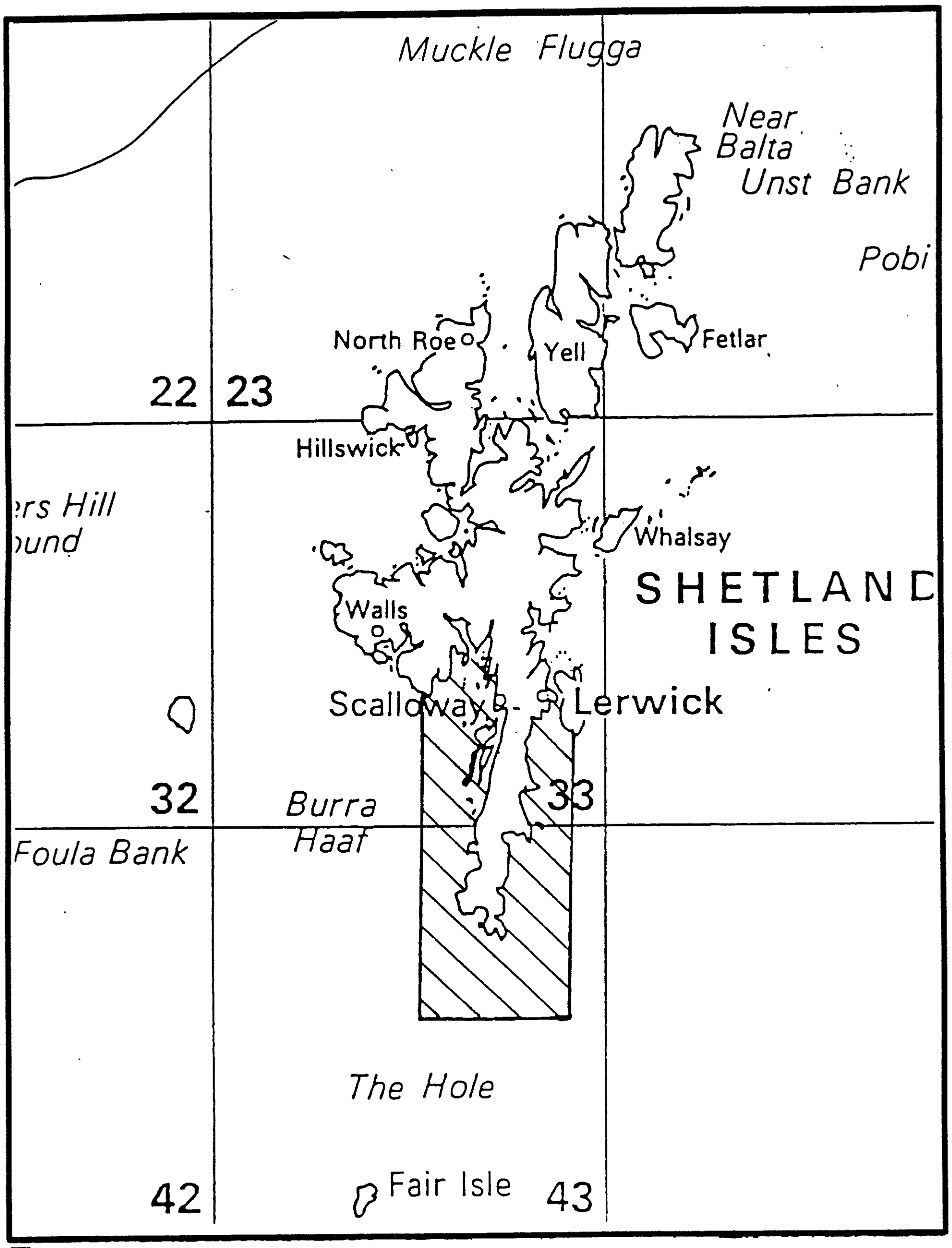

Figure 1. The exclusion zone as announced by the British Government on Friday 8th January. From the Shetland Fishing News no. 87, January 1993.

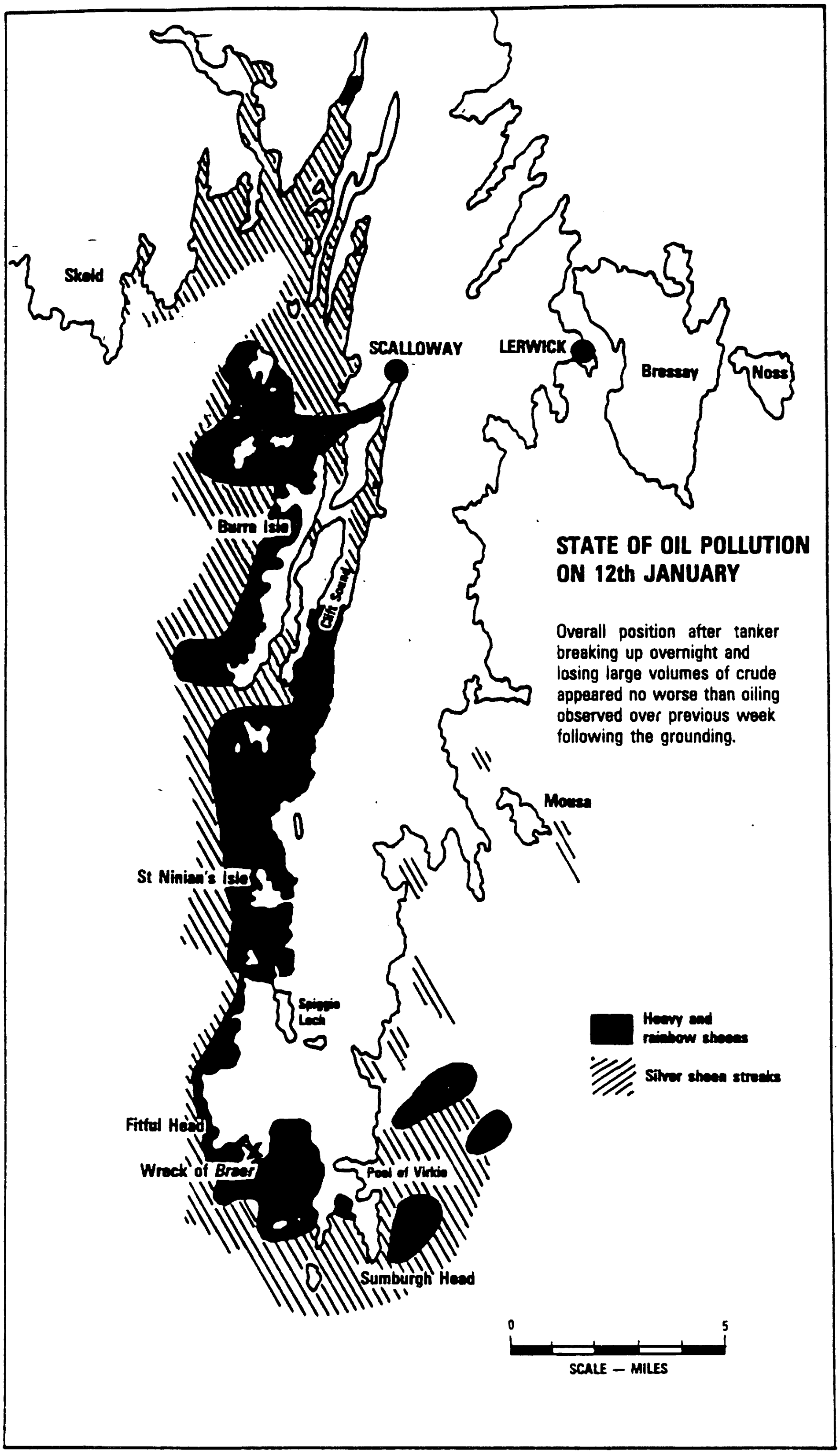

Figure 2. State of oil pollution based on airial surveys published by the Shetland Times, Friday January 15th and 22nd 1993. a) 12th January, b) 14th January and c) 21st January.

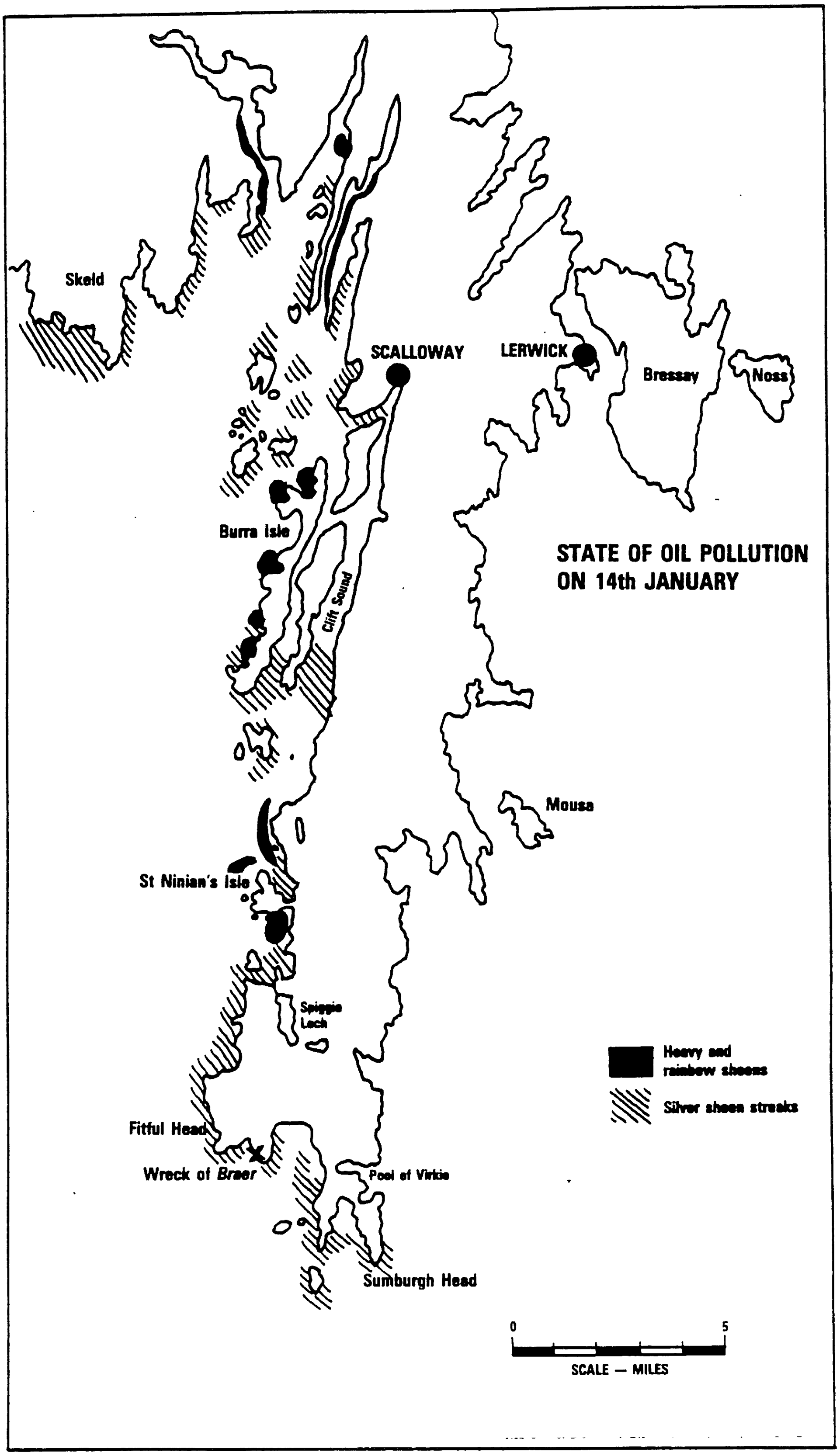

Figure 2. Cont.

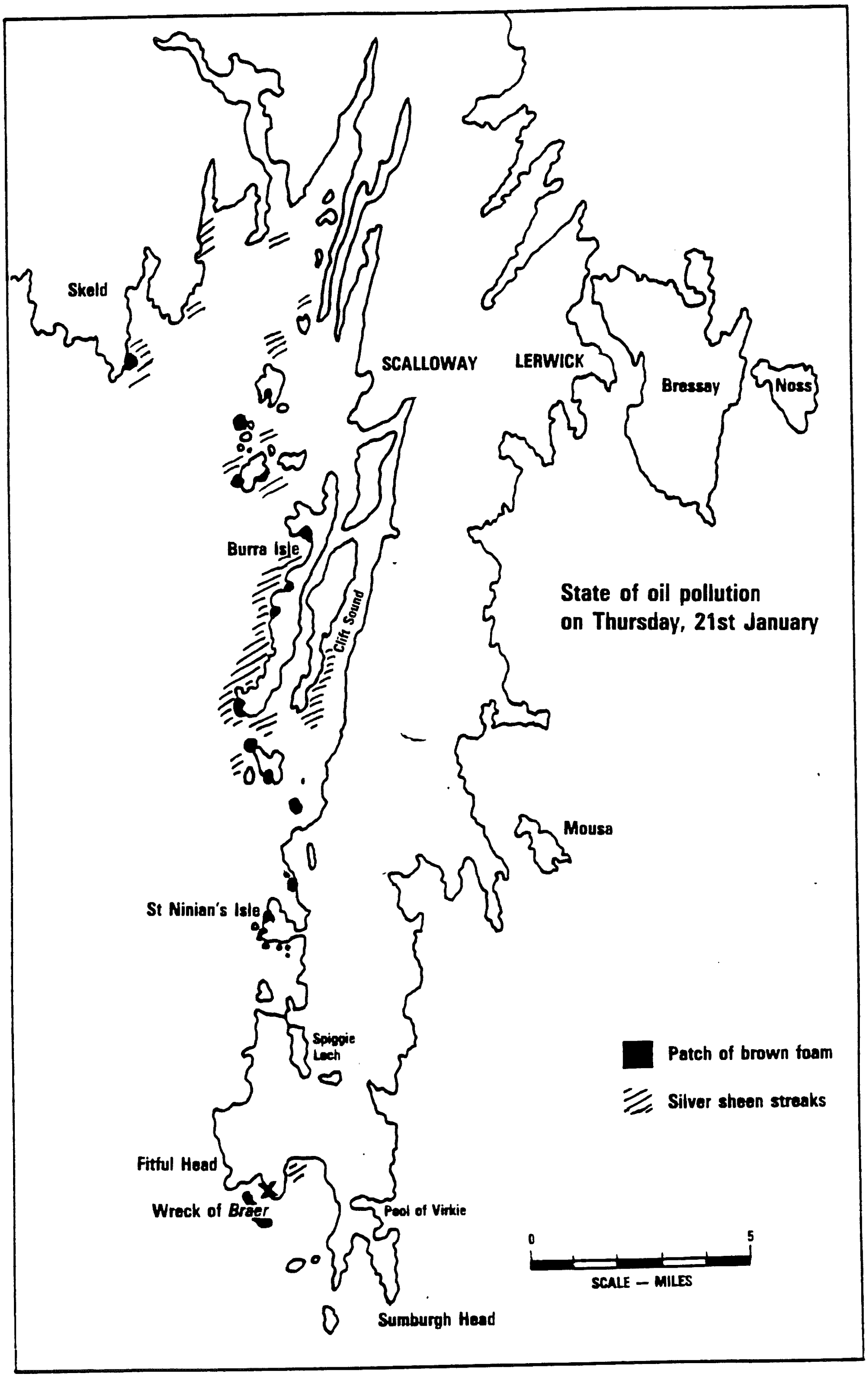

Figure 2. Cont.

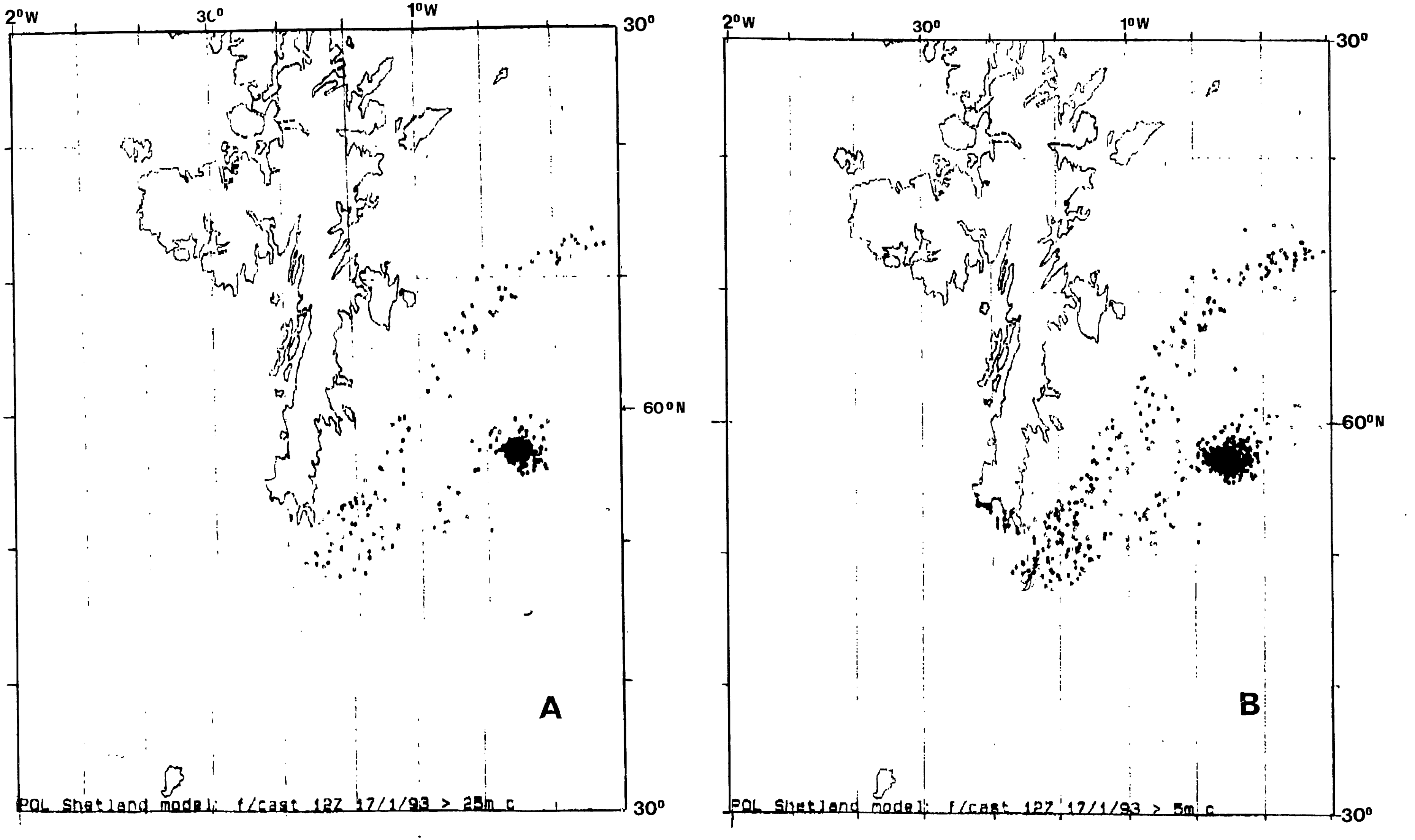

Figure 3. POL model results. a) Forecast for 17 January 1993, 5m depth, b) Forecast for 17 January 1993, 25m depth.

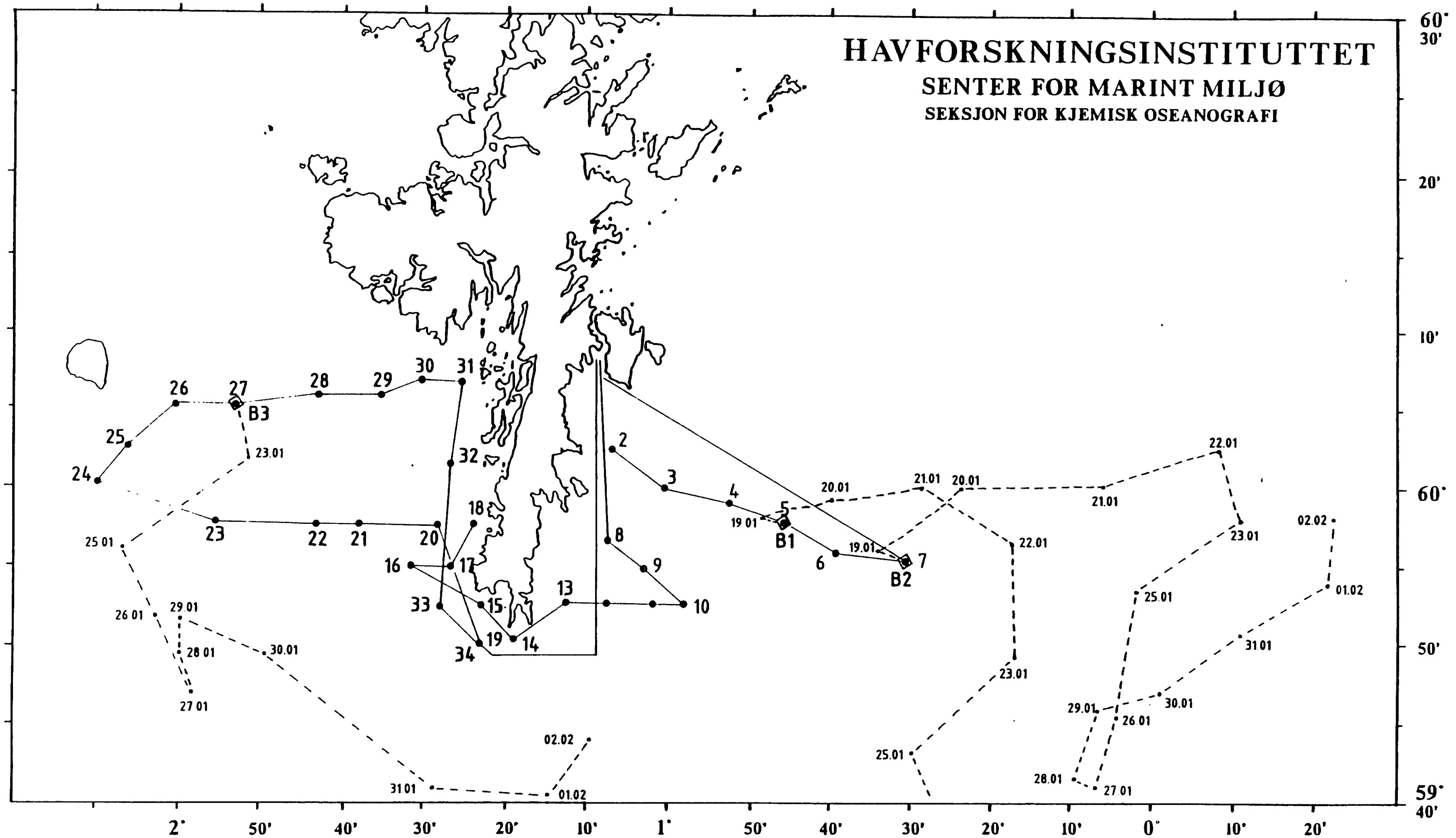

Figure 4. Map of surveyed area. • : Sampling stations. ◇ : Argos drifters deployed.
------ : Drift of Argos buoys.

Hydrography and current regime

Two Argos-drifters were deployed along the transect (St 2 -7) on the east coast of Shetland (Fig. 4). One was deployed at the position predicted by the POL-model to be the center of dispersed oil, while the second buoy was deployed at the easternmost St 7. Both buoys, with $11m^2$ droughs situated at a mean depth of 5m, showed an easterly drift during the first 5 days, probably caused by strong south-westerly wind. The mean drift of the buoys was approximately 7nm/day. The wind pattern changed however on January 22nd resulting in a drift of both buoys to the south. The drift of the Argos buoys were most probable governed by the prevailing winds. However it seems probable that the southward drift of the buoys from January 22nd partly were governed by a soutward flow approximately 25nm off the eastcoast of Shetland.

Temperature, salinity and density distribution along the transect (Fig. 5) reveal a completely mixed water column typical of a shallow shelf winter situation.

On the west coast of Shetland two transects were sampled (St 18-23 and St 24-31) (Fig. 4) in addition to sampling inside the fishing exclusion zone.
Due to the higher concentrations of oil on the west coast close to shore it was also important to reveal the horisontal and vertical dispersion of oil in these areas. The prevailing strong south-westerly winds would possibly force watermasses to build up against the west Shetland mainland and generate an alongshore northward flowing current. The distribution of oil on the west coast as shown by the air surveys (Fig. 2) supports this interpretion. Downwelling of water along the coast could also have taken place, moving water westward below the surface layers.

However a possible northward flowing current along the west coast of Shetland might have brought polluted water into the Atlantic current running north-west of the Shetland mainland. A current pattern as outlined might thus have been a potential mechanism for transport of oil polluted water towards the Norwegian coast. To verify the current pattern on the west coast of Shetland an Argos buoy was deployed at St 27 between the island of Foula and the Shetland mainland on 23rd of January (Fig. 4). The buoy drifted southwards, and on the 27th of January it was found on the entrance to the Fair Island- Shetland channel, having crossed the channel by February 2nd. The drift of the buoy was probably governed by the dominating wind field. However the drift indicates that there were no major flux of water between the island of Foula and the Shetland mainland. This shallow area may thus act as a barrier towards the north-western part of Shetland restricting the northward transport of polluted water on the west coast. The temperature, salinity and density distribution along the transect (St 24-St 31) are shown in Figure 6 and shows a well mixed water column typical of a winter situation. However, a less saline core of water is observed in the surface layer 10-15 km off the west Shetland mainland and can also be traced about 40km off the coast. This might be due to a westward displacement of coastal water due to a change in wind pattern and a retroflection of water caused by the shallow shelf area between the island of Foula and the west Shetland mainland.

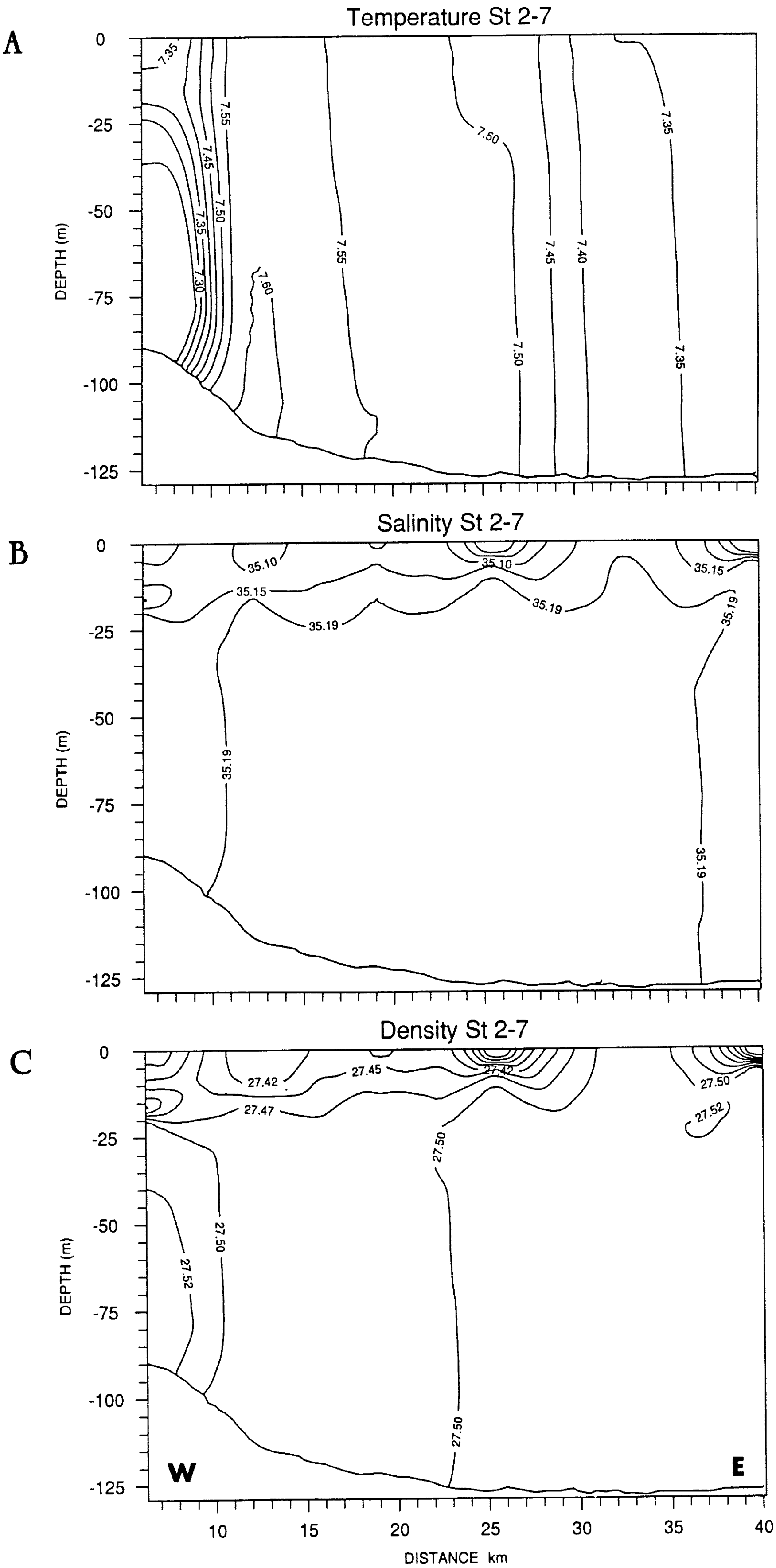

Figure 5. A. Temperature (^{0}C), B. Salinity ($^o/_{oo}$), C. Density (σ_t) along a transect on the east coast of Shetland (St2 - St7), January 18th 1993. W: West. E: East.

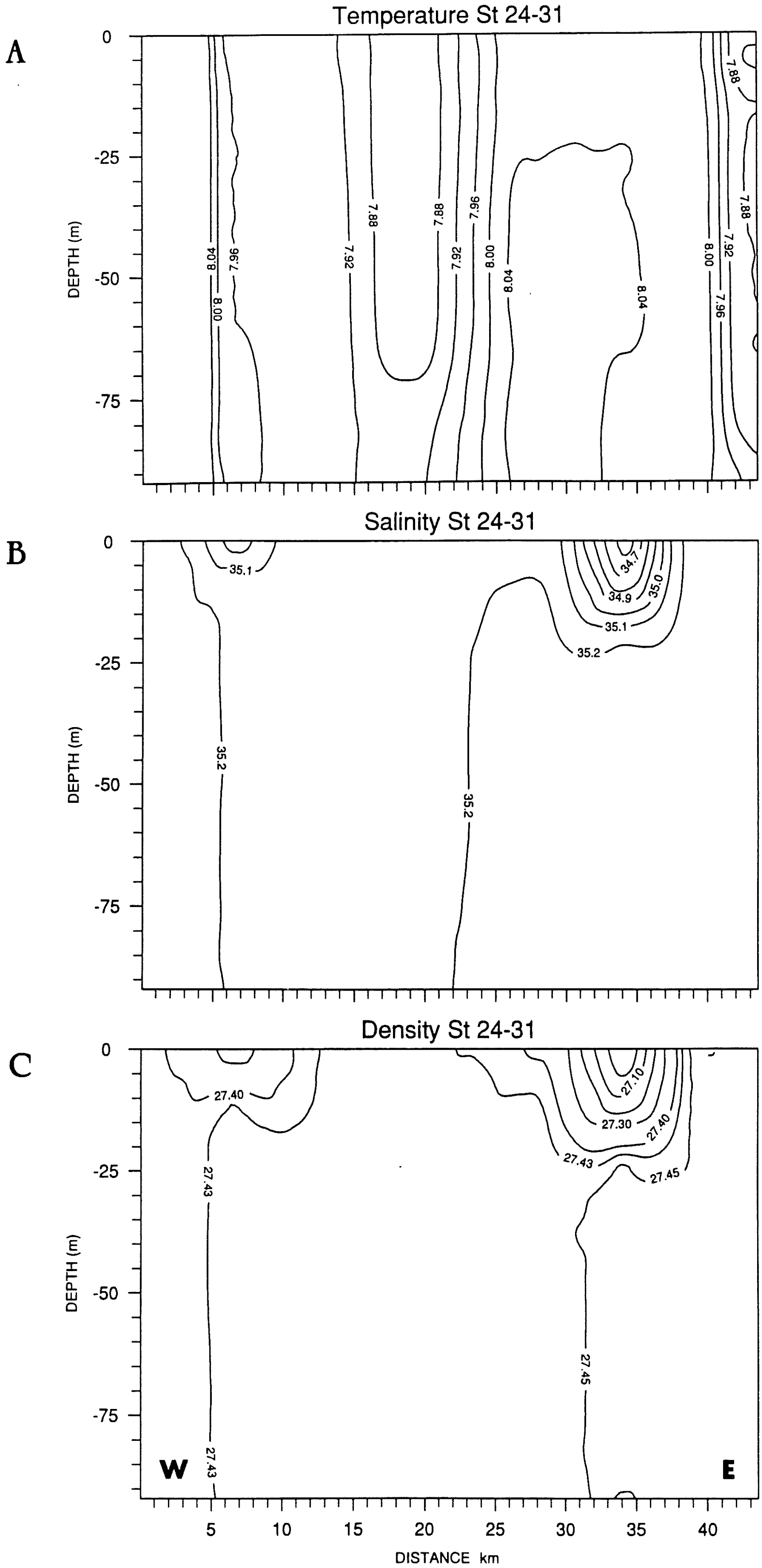

Figure 6. A. Temperature (^{0}C), B. Salinity ($^o/_{oo}$), C. Density (σ_t) along a transect on the east coast of Shetland (St24 - S31), January 22-23rd 1993. W: West. E: East.

Oil investigations

The concentrations of total oil as measured by UV-fluorescence were in general very low and the oil seemed to be well distributed through the water column. On the east coast values in the range 1-11 ppb (µgl^{-1}) were found. To the west values ranged from 2-30 ppb with highest levels inshore in the northern part of the surveyed area (Table 3).

Table 3. Concentrations of total oil in ppb (µgl^{-1}) as measured by UV-fluorescence on a Perkin-Elmer LS-5 Luminiscence Spectrometer. Data from Marine Laboratory, Aberdeen, Field Laboratory, Scalloway. *: Norwegian samples to be analyzed by GC/MS. For the complete set of water samples see Table 1.

		Depth sampled (m)							
Stn.no.	Lat/Long	1	3	5	10	20	25	30	50
2	6002N, 0106W	*	*	4.0	*	*	3.0	*	*
3	6000N, 0100W			0.9			1.5		
4	5959N, 0052W	*		5.9	*		0.7		
5	5958N, 0045W	*	*	1.1	*	*	2.0	*	*
6	5956.5N,0038W	*		10.1	*		0.4		
7	5955.5N,0030W	*	*	1.4	*	*	1.2	*	*
8	5957N,0107W			3.9			4.8		
9	5955N,0102.5W			4.9			5.0		
10	5952.5N,0057.5W			4.8			4.1		
11	5952.5N,0101.5W			5.6			4.4		
12	5952.5N,0107W			3.8			4.6		
13	5952.5N,0112.5W			3.5			4.6		
14	5950.3N,0118W			18.0			26.7		
15	5952.5N,0122.5W			36.8			37.3		
16	5955N,0131W			12.5			11.3		
17	5955N,0126.5W			18.5			*		
18	5957.5N,0123.5W			30.7			*		
19	5950N,0122.5W								
20	5957.5N,0127.5W			34.4			17.4		41.2
21	5957.5N,0137.5W			7.2			4.0		4.6
22	5957.5N,0142.5W			3.6			2.6		1.8
23	5957.5N,0155W			3.8			5.5		1.5
24	6000N,0210W			19.0	*		4.9		4.0
25	6002.5N,0205W			4.3			3.4		2.5
26	6005N,0200W			3.4			4.8		4.6
27	6005N,0152.5W			4.0	*		2.3		4.0
28	6006N,0142.5W			4.1	*		5.2		5.0
29	6006N,0135W			8.5			0.4		10.4
30	6007N,0130W	29.0		11.3	*		10.5		20.4
31	6007N,0125W	*		8.2	*		11.5		10.2
32	6001.8N,0126.3W			23.6			*		*
33	5952.5N,0127.5W			2.7			*		*
34	5950N,0122.5W			*	*		*		*

At stations 30, 31 and 32 (Fig. 4) a "blue shine" surface film of oil was observed, and frequently oil droplets rose to the surface from deeper parts of the water column when the waves were calmer.

A considerable amount of fine grained sand in suspension was observed at several stations on the west coast of Shetland, appearing in the 180µm WP2 plankton net samples. This suspended sand may be of interest as oil may adhere to it. During calmer conditions the sand will be deposited on the sea bottom and thus contribute to the removal of oil from the water column. Analysis of sand size distribution and composition will be performed both at the Institute of Marine Research, Bergen and Marine Laboratory, Aberdeen.

Biology

Biological samples of herring larvae, meso- and macrozooplankton was obtained both from relatively clean, low and high oil concentration areas. The zooplankton mainly consisted of copepods, euphausiids, chaetognaths and pelagic amphipods typical of mixed coastal and boreal Atlantic ocean waters. No obvious effects of oil pollution was observed on the herring larvae and zooplankton sampled. Both herring larvae and zooplankton seemed to be in good condition and euphausiids were frequently observed with filled guts. Live specimens seemed to behave normally.

However a more detailed analysis of herring growth is needed and is presently done at the Marine Laboratory, Aberdeen. Analysis of zooplankton gut fluorescence may also contribute to our general knowledge of feeding activity and to possible effects of oil pollution on feeding and behaviour of the plankton community.

Due to the extreme weather conditions and limited time at sea no bottom or pelagic trawling for commercial fish were performed during the cruise. Bottom sediments were not sampled as this part of the investigation was to be performed from RV Clupea in more inshore areas.

Evaluation of equipement and gear

Originally it was our intention to measure total oil by UV-fluorescence on board RV Michael Sars with a Q-fluorometer. However it turned out that it was impossible to obtain proper lamps and filters for this instrument before departure.

When studying emulsified crude oil or very heavy oils, lamps and filters providing exitation at 350nm and measuring fluorescent emission in the range 410-550nm is recommended. For a situation where emulsion is not present exitation at 254nm and emission at 350nm is recommended.

Both our Turner design fluorometers and our Perkin-Elmer LS-5B Luminiscence Spectrometer could be used in a field situation equipped with a continuous-flow cuvette system measuring total oil along the cruise track. Vertical profiles could be obtained either with point sampling at descrete depths or with a Q-fluorometer giving a continuous profile of dispersed oil. However it is a prerequisite that the above mentioned instruments are equipped with the appropriate lamps and filters to be able to measure total emulsified crude oil or dissolved oil in water.

It is highly recommended and of major importance that this type of instrumentation is operational and available on short notice if an accident similar to the MV Braer incident should occur in Norwegian waters.

Acknowledgements

Thanks are due to the British Government, the Scottish Office and the Marine Laboratory, Aberdeen to allow the Norwegian scientist and research vessel RV Michael Sars to take part in the investigations. Special thanks to the Aberdeen Laboratory representative Steve Hay for his enthusiasm, warm concern and detailed knowledge of the ecology of the Shetland seas. The visit to the Scalloway laboratory to discuss the situation with the coordinator (R. Johnstone) and exchange information and samples concerning calibration materials for oil analysis with their chemist (A. Macintosh), is greatly appreciated. Thanks are also due to the scientific staff, captain, officers and crew of RV Michael Sars who made great efforts in extremely trying weather conditions.

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Tor Knutsen
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