Plymouth Marine Laboratory
United Kingdom

CRUISE REPORT - ROSIMER 88

PML 3/88, RVS P12/29/88

VESSEL - RRS CHALLENGER

CRUISE PERIOD - 21 May - 4 June, 1988

PERSONNEL PML - Plymouth

R Williams (Principal Scientist)
I Joint
S Coombs
D V P Conway
M Jordan
N Halliday
I Firkin (Student)

MAFF - Lowestoft

J Nicholls
S Milligan

CNRS - Roscoff and Villefranche-sur-mer

S A Poulet
J C Marty
H Claustre
M A Hapette

RVS - Barry

P Taylor

ITINERARY

20/21 May Loaded equipment onboard.
PM departed Plymouth and set course for the Irish Sea site.

22/23 May Deployed CTD and UOR along diagonal course from North Wales coast to the Irish coast (Fig. 1). Other UOR deployments are given in Table 1 and Fig. 1.

Four sampling sites were selected on the basis of hydrographic and biological conditions. One station in the thermally unstratified coastal zone of the Welsh coast, two in the Central Irish Sea, ie. mixed and stratified conditions and one in the coastal waters of the Irish coast. Between 22 May and 3 June 52 CTD and water bottles profiles were taken (Fig. 2) and the LHPR, Bongo nets, 1 m

ring net and 30" TTN were deployed at the four sites (Fig. 3, Tables 2 to 5). Phytoplankton ^{14}C *in situ* incubations and light meter rigs were deployed at each of these sites.

3 June	19.30	Station programme completed
	22.16	UOR deployed on passage to Troon
4 June	03.40	UOR inboard
	10.00	Dock Troon
5 June		Equipment and personnel to Plymouth

OBJECTIVES

To quantify the rates of primary and secondary production in the Irish Sea and to relate these rates to the biomass and distribution of phytoplankton, zooplankton and fish larvae. The hydrographic origin of differences in regional production will be investigated and its consequences to the feeding of early larval fish examined. The results will be compared with equivalent data available for the North Sea and from the Celtic Sea (ROSIMER 87).

SPECIFIC OBJECTIVES

1. To determine size fractionated rates of phytoplankton production in different light regimes and bacterial production - to relate these to the production and flux of organic matter by various components of the pelagic ecosystem.

2. To relate primary production, phytoplankton biomass and species composition to the vertical structure, behaviour and feeding of the herbivorous zooplankton.

3. To determine the horizontal and vertical distribution of micro and mesozooplankton including fish eggs and larvae, in relation to hydrographic conditions.

4. To assess the quantity, composition (species identification) and quality of the various particle size fractions available as food for fish larvae. Analyses:- dissolved free amino acids, vitamins, polyunsaturated fatty acids, carbon (POC, PC) nitrogen, ash free dry weight and pigments in various size classes of particulates and in fish larvae and eggs.

5. Fish larvae will be collected and stored in liquid nitrogen for determination of gut contents, RNA/DNA and biochemical analysis.

RESULTS

A series of UNDULATOR tows were carried out across the central Irish Sea and through the North Channel (Fig. 1). The main Angelsey to Dundalk Bay transect was sampled twice, on the 23 May and 3 June. The eastern half of the transects showed fully mixed water, at a salinity of ~34.1 °/oo, throughout the water column (Figs. 4, 5c). CTD profiles in the extreme east in Colwyn Bay showed an area of well mixed, low salinity (~32.7 °/oo) coastal water extending to a frontal region of weak temperature and salinity stratification north-east of Angelsey (Figs 5a, b). Further west, over deeper water, thermal stratification was evident extending to the limit of western UOR sampling, (Figs 4, 5d). Stratification was more evident further west, where there was a thermocline of ~2.2°C. This feature became more pronounced on the second transect and

extended further into the Central Irish Sea (Figs 4, 5e). Towards the Irish coast, there was slight stratification in salinity, decreasing to a salinity of ~33.9 °/oo. In all areas and on both transects levels of chlorophyll a were moderate, rarely exceeding 6 mg/m^3, although there was more structure in the distribution of chlorophyll in the mixed, eastern half of the Irish Sea and in the mixed layer above the thermocline in the west.

Particle Size Analysis

Coulter Counter (TA II) particle size analysis was carried out on surface and water bottle samples throughout the survey area (Fig. 6). Two tube analysis was completed on all samples covering the size range 2-256 μm (Fig. 7). Characteristic particle distributions were identified in relation to the different hdyrographic regions. There was relatively little change in the distributions over the duration of the cruise. In the mixed, low salinity, coastal water in Colwyn Bay there was a dominant peak at 5.0 μm equivalent spherical diameter (e.s.d.) with a broader subsidiary peak at 16.0 μm to 64.0 μm. The first peak often reached a maximum of 3 ppm by volume, which reflected a relatively high total particle concentration in this region. There was little change in particle size distribution down the water column, although there was an increase in particle concentration towards the bottom, perhaps due to tidal resuspension.

In the narrow frontal region to the north-east of Anglesey a 16.0 μm to 64.0 μm mode was present throughout the water column. However, the 5.0 μm to 8.0 μm peak became less defined in the underlying high salinity water becoming a broader less concentrated peak of 4.0 μm to 16.0 μm. This peak was characteristic throughout the water column in the mixed, central region. There was a increase in particle concentration towards the bottom due to tidal mixing in the central region although overall particle concentrations were much lower than in the east.

Further west in the stratified region the surface water showed an increase in particle concentration and a particle size mode between 20.2 μm to 64.0 μm, this became more prominent further west in more strongly stratified water. This particle mode was also found throughout the shallow waters of Dundalk Bay. Below the thermocline the 20.2 μm to 64.0 μm mode disappeared and particle concentrations decreased to give a distribution at 4.0 μm to 16.0 μm similar to that found in the central, mixed water.

Phytoplankton biomass and nutrient concentrations

Chlorophyll a concentrations were generally high over the region of the Irish Sea surveyed and typical values were 2.3 μg/l. However, in the near coastal waters off North Wales, a bloom of *Phaeocystis pouchetti* was present and chlorophyll a concentrations increased to greater than 8 μm/l. Nitrate concentrations remained high (> 8 μmol/l) in the mixed waters to the north of the Welsh coast but were undetectable (< 0.2 μmol/l) in the stratified waters in the western region of the Irish Sea.

Phytoplankton production

Phytoplankton production was measured by 24 h *in situ* incubations on 8 days; on one occasion it was necessary to curtail the incubation because of deteriorating weather conditions, and the samples were incubated for only half a day. At all other times, a full *in situ* incubation from dawn to dusk was

possible. In addition to *in situ* incubations, the physiological condition of the phytoplankton assemblages was determined on 9 occasions: photosynthetic parameters were measured by incubations of samples with ^{14}C in artificial light gradients. Values of photosynthetic efficiency (α), maximum rate of photosynthesis (P_m^B) and degree of photoinhibition (I_k) were obtained from these incubations.

Bacterial production

The numbers of bacteria present were determined by eipfluorescence microscopy and the rates of bacterial production were measured in all regions by the incorporation of ^3H thymidine into bacterial DNA. In addition, a detailed study was made at one station on uptake of dissolved free amino acids (DFAA) by bacteria. DFAA incorporation by bacteria was rapid and was shown to be inhibited by the addition of the antibiotic, rifampicin, which inhibits protein synthesis. The importance of protozoa and other grazers on bacteria was established in an experiment where bacteria were separated from the rest of the microbial assemblages by filtering through 1 μm pore-size Nuclepore filters; removal of the grazers resulted in a 10-fold increase in DFAA incorporation rate over a 6 hour period.

Submersible light meter array

The submersible light meter array with thirteen sensors at surface, 0.5, 1.0, 2.0, 3.0, 4.0, 5.0, 7.0, 10.0, 15.0, 20.0, 25.0 and 30.0 m depth was deployed on 7 occasions (example of data - Fig. 8). On three deployments the logger malfunctioned although data were recovered on one of these deployments. A total of 5 days data was obtained successfully. Water samples were taken on 9 days from nine depths for the study of *in situ* absorption parameters ie. dissolved material, detrital particulate and pigment containing material. Samples were also taken from the same depths (1, 2, 5, 7, 10, 15, 20, 25 and 30 m) for pigment analysis by HPLC.

Pump Rig

A submersible pumping system, incorporating three 1 m^3 storage hoppers as reservoirs and a filtration system, was used to sample plankton in the < 22 to > 200 μm size range. This range was assumed to correspond to the size of planktonic organisms potentially being utilised as food by sprat or sole larvae. This pumping and filtration system allowed the partitioning of the particulate food into four size categories (< 22 μm, > 22-100 μm, > 100 μm-200 μm and > 200 μm). Ten deployments were made with this system (Table 6). Samples were filtered onto pre-ashed GFC filters and frozen (-20°C) for subsequent analysis of particulate carbon, particulate nitrogen, particulate organic carbon, proteins, lipids, vitamin C, pigments and dissolved free amino acids. Water samples were also taken from each depth and preserved in DMSO and glutaraldehyde. These samples were initially frozen in liquid nitrogen and refrigerated at 4°C. Samples were also preserved in Lugol's. Analytical flow cytometry will be used to evaluate the best method of sample preservation. The samples will be further analysed to determine the proportion and size range of particles containing photosynthetic pigments and the proportion of living particles in each size category.

Zooplankton

Samples were taken with the UOR, LHPR, Bongo nets, 1 m ring net and Lowestoft

sampler (Fig. 3 and Tables 1-5). All fish eggs and larvae were sorted from the samples and identified onboard ship. The DLHPR was deployed on 7 occasions and collected 87 fine mesh and 118 coarse mesh samples. The 20 μm samples were split immediately on recovery of the sampler, one half was preserved in formaldehyde for taxonomic analysis and the other half was filtered onto pre-ashed GFC glass fibre filters and frozen (-20°C) for subsequent analysis of PC, PN, POC and photosynthetic pigments (HPLC). The samples from the 200 μm mesh net were initially preserved and then sorted into their main taxonomic groups for identification and dry weight determination. The copepod aliquot was analysed using voice recognition techniques. DLHPR1 (IS25) from the central station was analysed onboard ship. Large numbers of *Acartia*, *Oithona*, *Paracalanus*, *Pseudocalanus* and *Temora* were present throughout the water column (0-86 m). *Coscinodiscus* was numerous in the samples throughout the water column (2-7 thousand m^{-3}). A detailed grid was sampled south of Dundalk Bay to determine the distribution of sprat eggs and larvae.

Shipboard Experiments (Zooplankton)

Two types of experiments were carried out in order to collect large quantities of copepod faecal material and nauplii. These particles are a known component of the food of fish larvae. Incubation of natural assemblages of copepod populations collected with Bongo and Lowestoft nets (0-30 m depth) were conducted, in 300-400 litres of seawater which had been filtered through 100 μm mesh netting, at each of the four selected sites. Faecal material was collected after a 12-16 hours incubation period, concentrated in filtered seawater (0.8 μm) and collected on pre-ashed GFC filters. Five samples of faeces were obtained from biochemical analysis for PC, PN, fatty acids, photosynthetic pigments, proteins, amino acids and vitamin C. The sampling of copepod nauplii was carried out on 3 occasions with 80-100 μm mesh nets. The extraction of large quantities of nauplii was unsuccessful, mainly because of the low density of nauplii at this sites and the high biomass of phytoplankton (*Ceratium* and *Phaeocystis*) which interfered with the extraction and separation of nauplii. Samples of zooplankton species (Temora, Sagitta, mixed copepods, Euphausiid) and phytoplankton, (Coscinodiscus, Phaeocystis) were sorted and frozen for biochemical analysis.

From shipboard primary production experiments 200 samples were collected for analysis of dissolved free amino acids absorbed or excreted by microorganisms.

Fish larvae - for biochemical analysis

Sprat larvae (5-17 mm) were preserved from contrasting areas of the Irish Sea for biochemical analysis as an index of condition. These results will be compared with parallel sets of data on food abundance and quality in each area. Gut fullness was low in all areas except at the inshore site north-east of Anglesey where a much wider size range of larvae were found. Few larvae were taken in the central stratified area although they became more numerous towards the Irish coast.

Numbers of samples of larvae taken for biochemical analysis in each area

Area	RNA/DNA	Lipids	Protein	Amino-acids	Vitamin	Pigment	Formalin (for gut content)
Central Stratification	5	4	-	3	-	1	-

NE Anglesey	17	4	1	3	8	4	-
Irish E Coast	35	17	19	17	36	13	13
Central Mixed	10	10	3	11	9	4	3
Sole ground NE of Anglesey	8	5	5	7	5	4	3
NE Anglesey	6	3	2	6	1	-	1

Sole larvae feeding experiments

400 sole larvae were transferred from MAFF Conwy Laboratory to the ship for on-board feeding experiments. five equal sub-sets of larvae were offered the following diets:

- food from "low quality" area at ambient concentration
- food from "high quality" area at 10 x ambient concentration
- food from "high quality" area at ambient concentration
- food from "high quality" area at 10 x ambient concentration
- stored.

The designated "low quality" feeding area was in the central Irish Sea in mixed water south of the Isle of Man where fish larvae were scarce. Depending on where the ship was working the "high quality" area was either in well-stratified water off the Irish east coast or mixed coastal water north-east of Anglesey, in both area fish larvae being relatively abundant.

Natural plankton assemblages were concentrated at intervals from 50 l surface water samples obtained at night from the two area of different food quality. Initially particles in the size range 20-200 μm were offered as the experimental diet, subsequently in view of the larger sized particles being taken by the sole larvae plankton was concentrated in the size range 100 - 500 μm.

Larvae were kept for 9 days during which period mortality rates for all treatments, including starved larvae, were less than 5% overall. Microscope examination of gut contents indicated a higher incidence of feeding in the two concentrated food treatments. Larvae and samples of food were preserved at intervals for subsequent biochemical analysis.

Number of samples preserved for each biochemical analysis

Lipid	Amino-acid	Protein	Vitamin	RNA/DNA(AFC)	RNA/DNA(bulk)
28	27	15	17	25	2

EQUIPMENT FAILURE

Submersible light meter - During the first deployment the logger failed to respond to the stop command but on 'resetting', the correct number of scans, up to the time of the buoy coming inboard, was dumped. The logger apparently stopped on retrieval. The third deployment also failed as did the 5th when the logger stopped prior to launching of the rig. Approximately 30% of data was lost.

DLHPR The fine mesh (20 μ) gauze failed to transport during the first deployment on 25 May.

HPLC Problems arose with the equipment and the system was not used throughout the cruise.

Prepared by: R Williams

Approved by: B Bayne .

Date: November 4 1988

Circulation

Internal

Bayne, Williams, Joint, Coombs, Conway, Jordan, Halliday, Notice Board, File VES 1.1.

External

NERC (Swindon)	D Pugh, S White
D.L. (Wormley)	M Angel + Library
Proudman L.	B S McCartney (Director) + Library
MIAS	P Draper
RVS (BARR)	C Fay (x 2) (Director)
DAFS	A Hawkins (Director)
MAFF	D Garrod, K Brander, J Nichols, S Milligan
SMBA	J L Matthews (Director)
MAFF (Conwy)	S Lockwood (x 3)
CNRS (Roscoff)	S A Poulet (x 2)
CNRS (Villefranche-sur-mer)	J C Marty (x 2)

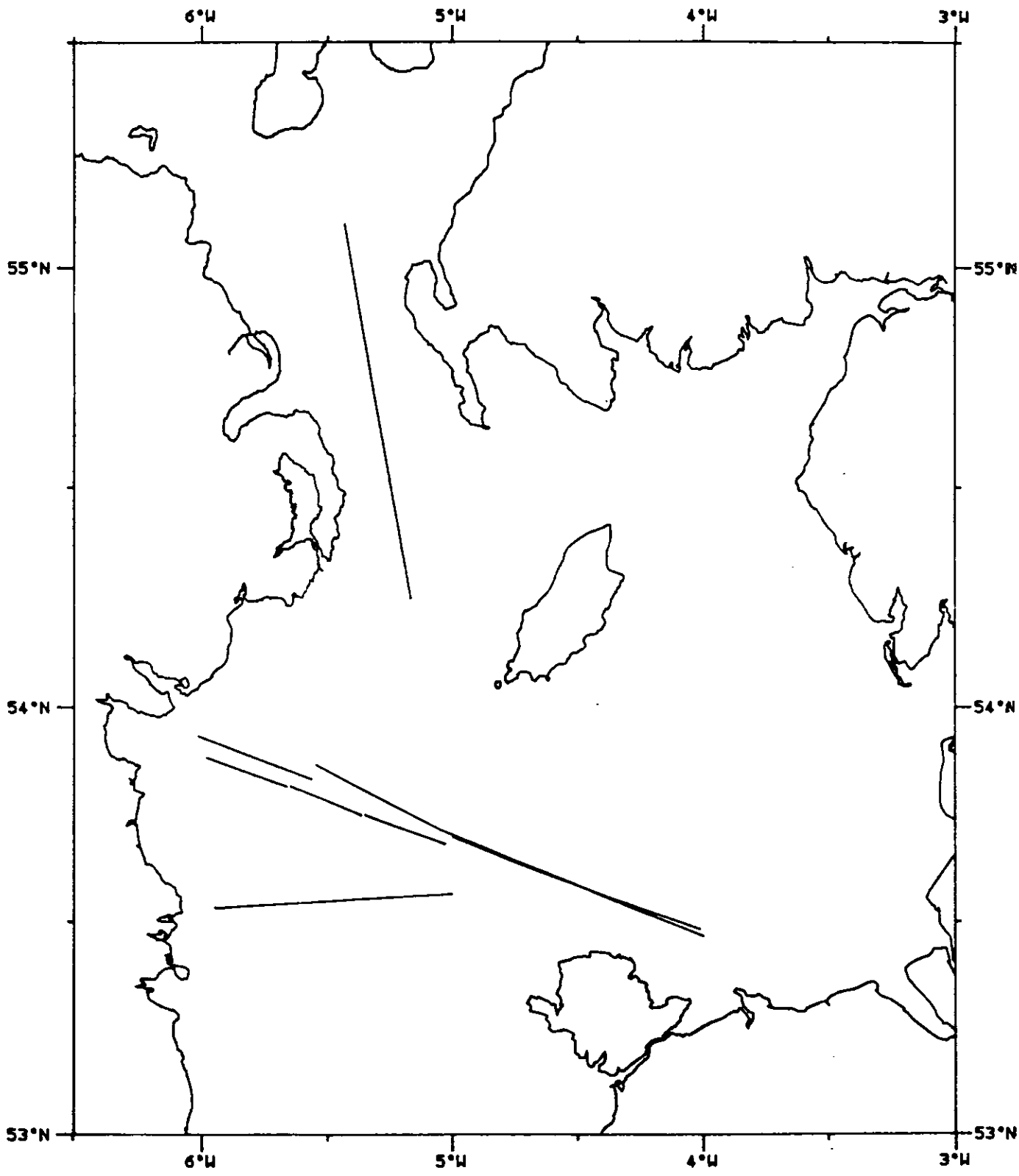


Fig. 1. UNDULATOR tows in May/June 1988. The diagonal transect was sampled twice on 23 May and 3 June.

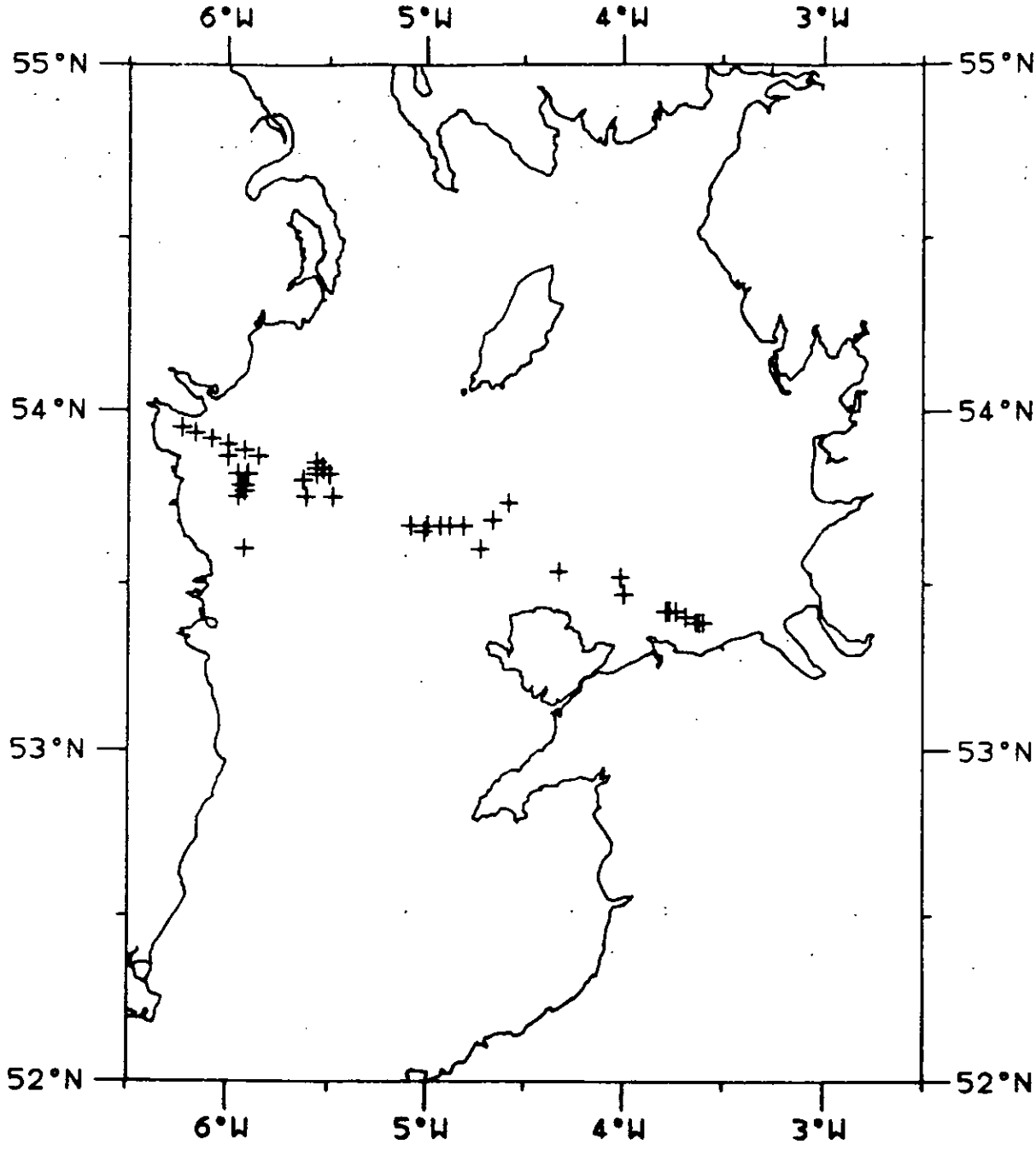
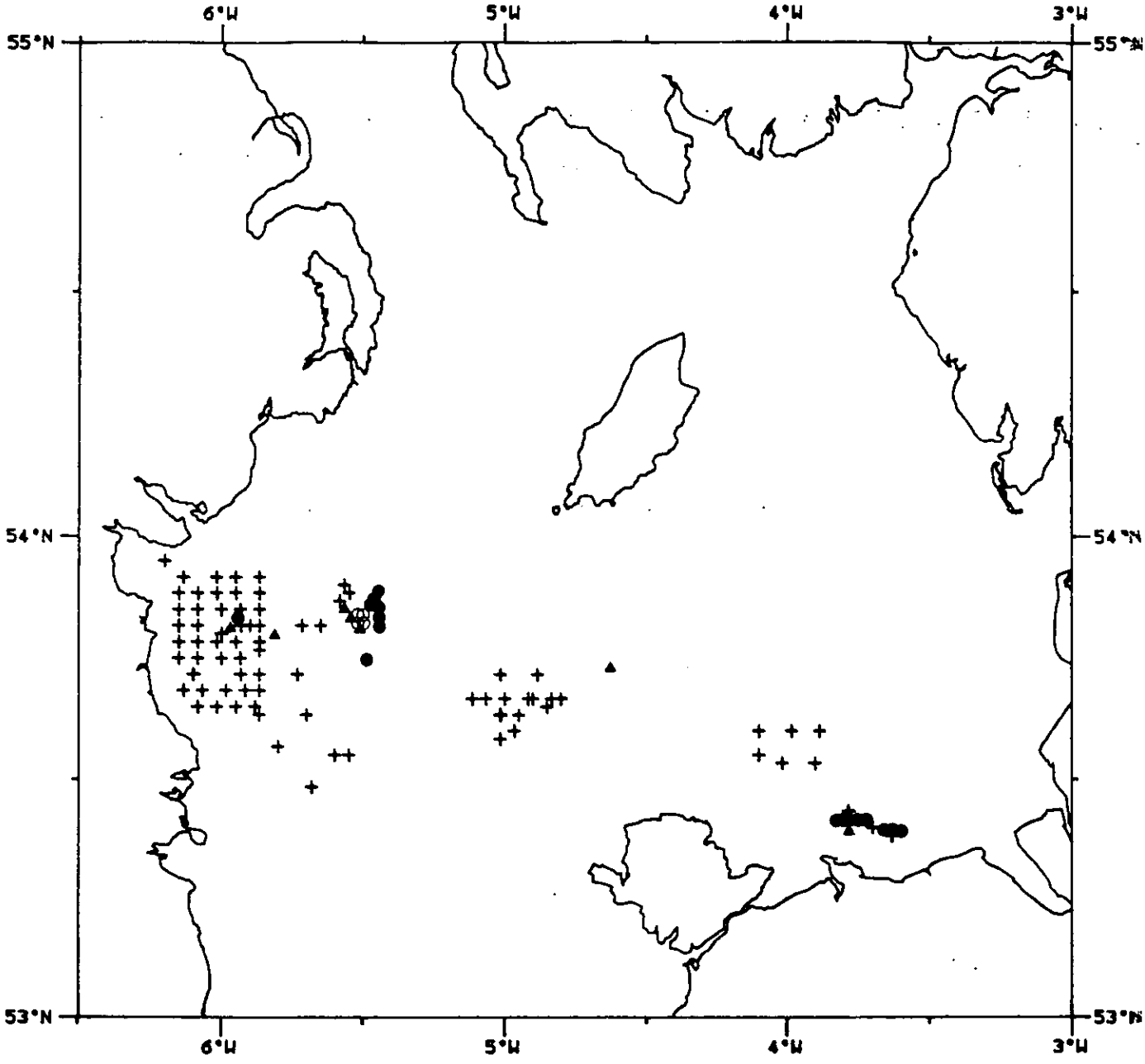


Fig. 2. CHALLENGER 1988 CTD STATIONS

Fig. 3. CHALLENGER 1988 PLANKTON TOWS



+ T.T.NET HAULS

○ 1M RING NET HAULS

▲ L.H.P.R. NET HAULS

● BONGO NET HAULS

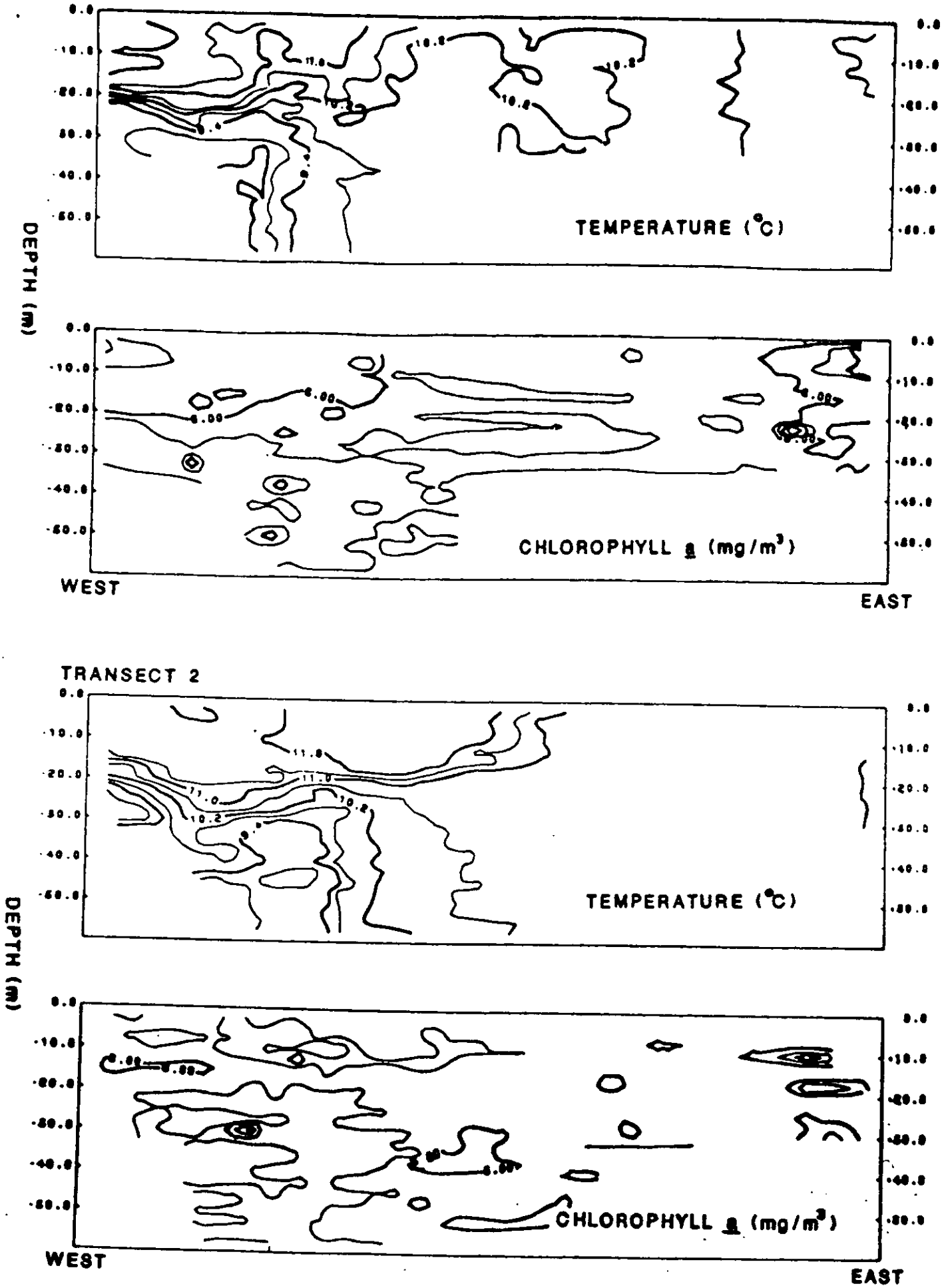


Fig. 4. Temperature and chlorophyll contour plots (temperature plotted at intervals of 0.4 C and chlorophyll at intervals of 4.0 mg/m) for the main diagonal transect sampled on 23 May and 3 June.

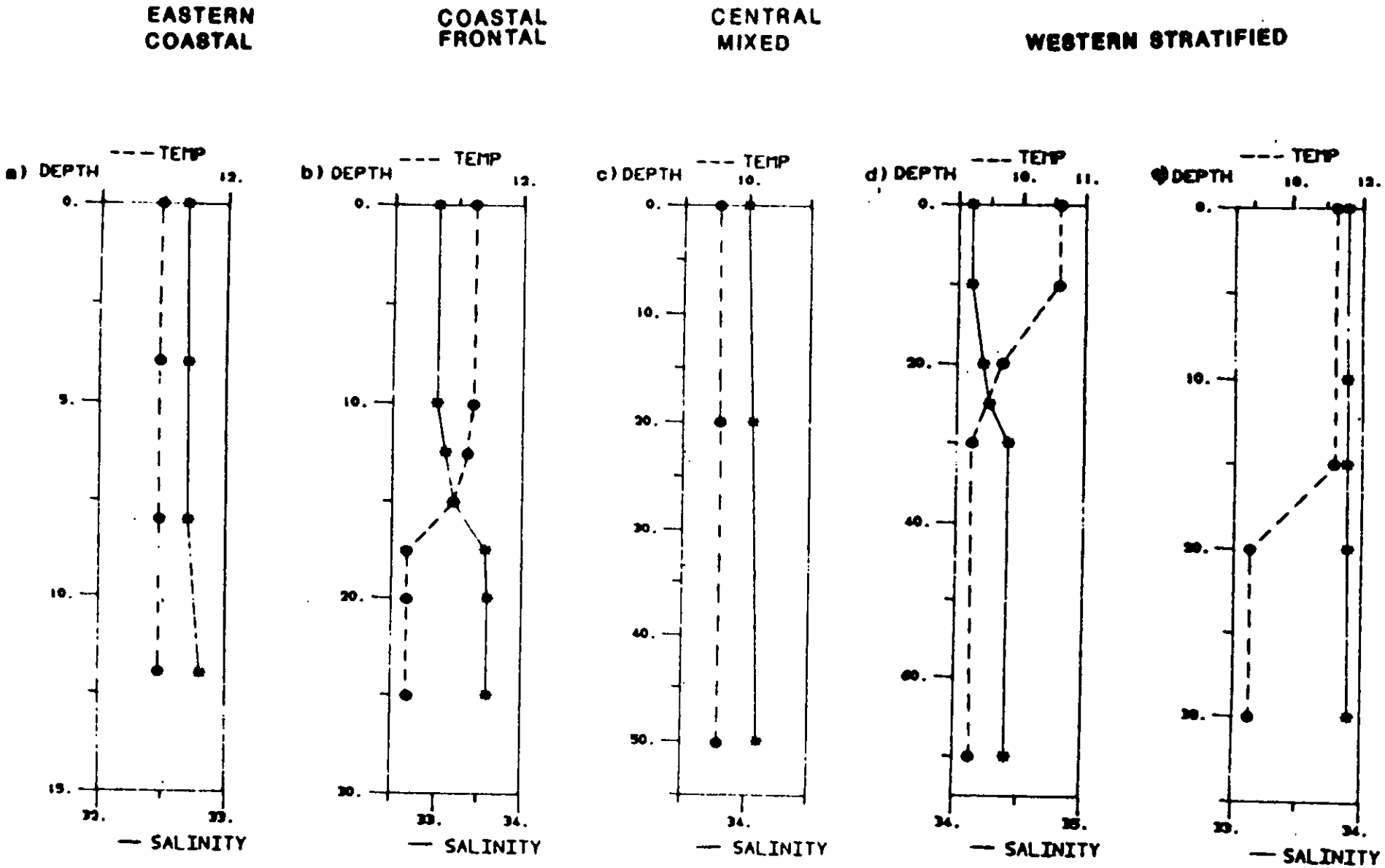
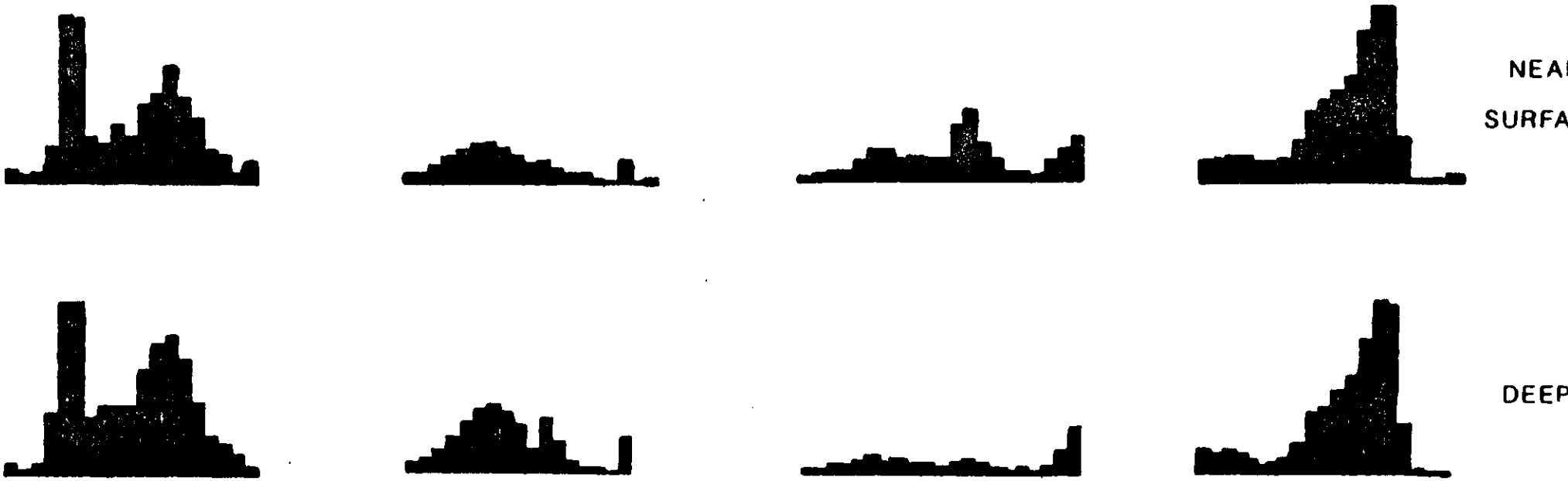


Fig. 5. Salinity and temperature profiles across the central Irish Sea.

Fig. 6.

PARTICLE DISTRIBUTIONS ACROSS THE IRISH SEA



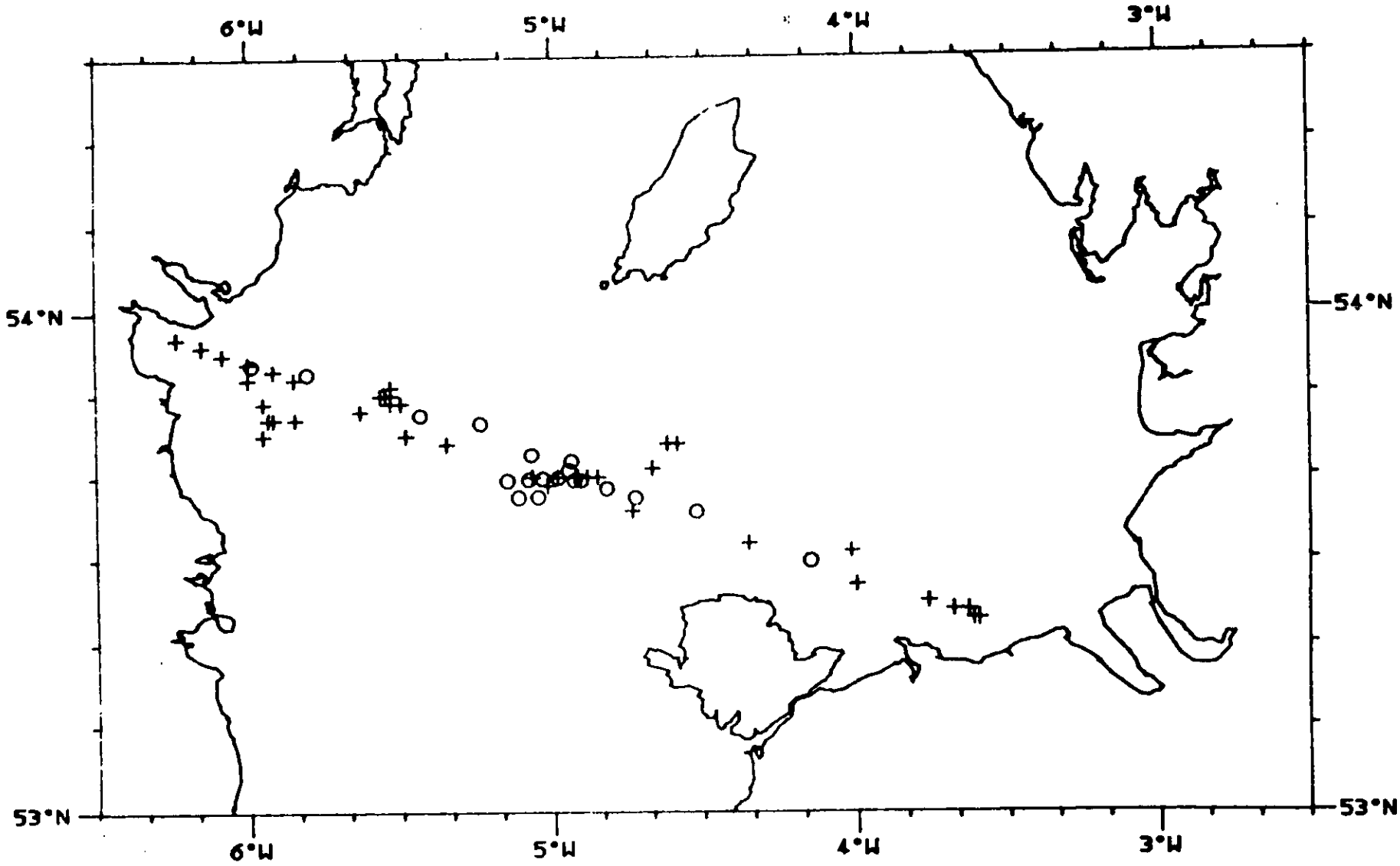
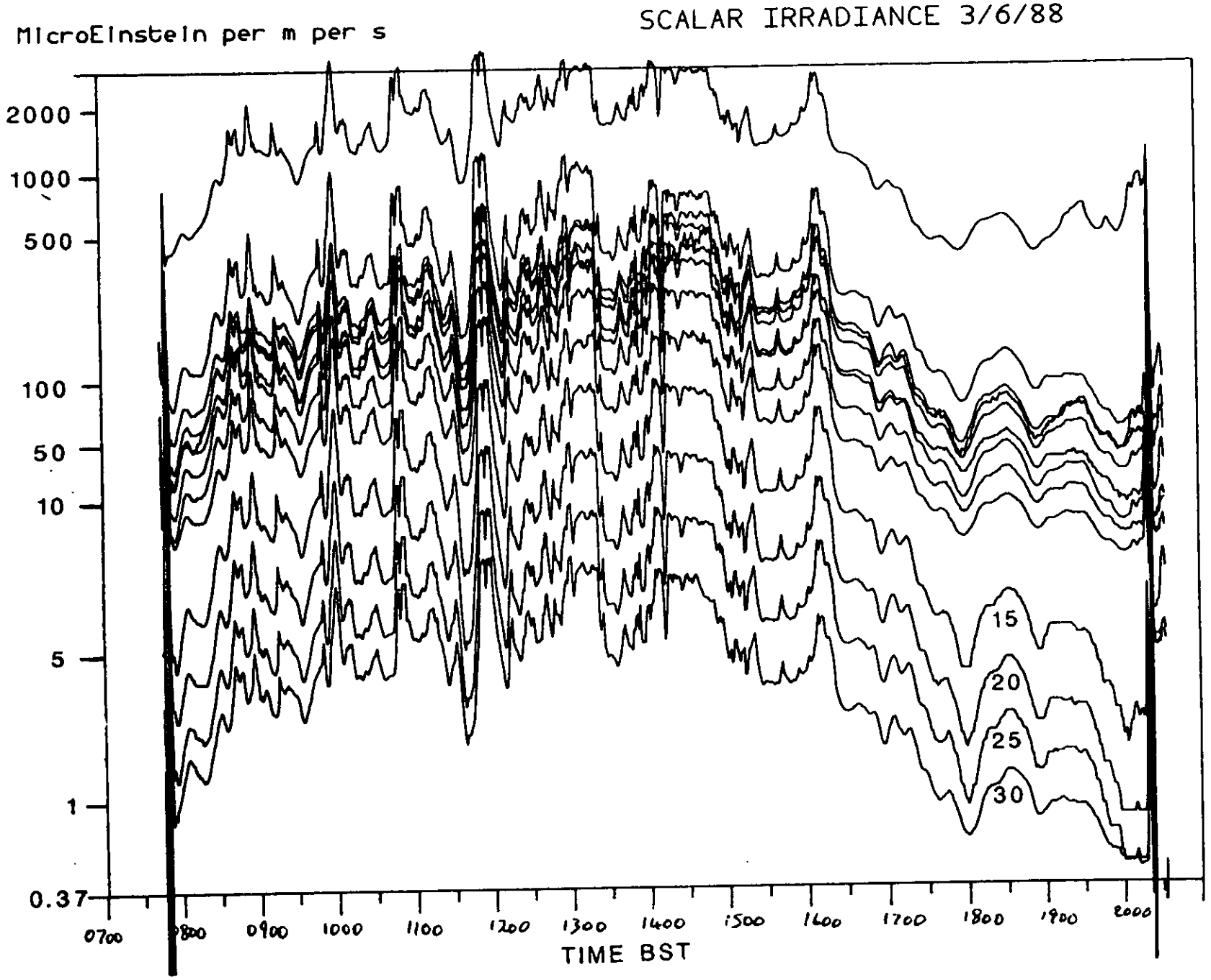


Fig. 7. Positions of samples taken for Coulter Counter particle size analysis. Vertical profiles are indicated by a cross and surface samples by a circle.

Fig. 8.


SCALAR IRRADIANCE 3/6/88
MicroEinstein per m per s
2000
1000
500
100
50
10
5
1
0.37
0700
0800
0900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
TIME BST
15
20
25
30

CHALLENGER

MAY/JUNE 88 TABLE 1

TIME:- BST

UOR TOWS

DATE	TIME		POSITION			
22/5	1902	OB	52	23.6N	05	24.5W
	2050	IB	52	35.8N	05	17.9W
23/5	1129	OB	53	28.6N	04	01.0W
	1251	IB	53	32.2N	04	19.3W
	1335	OB	53	32.4N	04	19.5W
	1517	IB	53	36.1N	04	38.9W
	1555	OB	53	36.7N	04	39.0W
	1737	IB	53	40.1N	04	59.5W
	1909	OB	53	49,5N	05	01.3W
	2037	IB	53	44.4N	05	20.7W
	2110	OB	53	44.1N	05	21.3W
	2229	IB	53	48.1N	05	38.6W
	2301	OB	53	48.1N	05	39.5W
24/5	0027	IB	53	52.4N	05	58.8W
31/5	0350	OB	53	31.7N	05	56.4W
	0730	IB	53	34.0N	04	59.1W
02/6	2400	OB	53	27.8N	03	59.1W
	0417	IB	53	42.6N	05	02.7W
	0430	OB	53	42.8N	05	03.0W
	0631	IB	53	50.1N	05	32.8W
	0808	OB	53	49.8N	05	33.5W
	0948	IB	53	55.1N	06	00.1W
03/6	2316	OB	54	15.0N	05	09.7W
04/6	0440	IB	55	06.0N	05	25.9W

CHALLENGER

MAY/JUNE 88

TIME:- BST

TABLE 2

LHPR TOWS

DATE	TIME		POSITION				MAX DEPTH (m)	NO OF SAMPLES 20μm	200 μm
25/5	0113	OB	53	49.3N	05	32.9W	86	-	24
	0210	IB	53	45.7N	05	37.0W			
	1347	OB	53	49.0N	05	30.1W	100	25	20
	1430	IB	53	46.0N	05	30.0W			
26/5	1551	OB	53	24.5N	03	43.2W	25	5	4
	1559	IB	53	24.5N	03	43.9W			
30/5	0041	OB	53	47.5N	05	48.8W	40	8	12
	0100	IB	53	48.8N	05	54.5W			
	1355	OB	53	48.2N	05	56.0W	40	12	13
	1415	IB	53	46.6N	05	55.4W			
01/6	1312	OB	53	43.1N	04	37.1W	60	18	18
	1341	IB	53	41.3N	04	39.8W			
03/6	1247	OB	53	50.5N	05	33.0W	100	19	27
	1328	IB	53	48.8N	05	34.3W			

CHALLENGER

MAY/JUNE 88

TIME:- BST

TABLE 3

BONGO NETS

DATE	TIME		POSITION			
25/5	1540	OB	53	45.0N	05	29.8W
	1549	IB	53	44.9N	05	29.8W
	1552	OB	53	44.6N	05	29.8W
	1607	IB	53	44.7N	05	29.7W
	1902	OB	53	51.2N	05	29.0W
	1921	OB	53	52.3N	05	27.9W
	1928	OB	53	53.4N	05	27.0W
	2102	OB	53	51.3N	05	26.5W
	2129	OB	53	50.3N	05	26.3W
	2205	OB	53	48.9N	05	26.3W
26/5	1212	OB	53	25.0N	03	47.6W
	1242	OB	53	24.8N	03	46.3W
	1305	OB	53	24.7N	03	45.3W
	1319	OB	53	24.6N	03	44.8W
	1654	OB	53	24.3N	03	43.2W
	1807	OB	53	23.8N	03	39.1W
	1830	OB	53	23.6N	03	37.6W
	1855	OB	53	23.7N	03	38.6W
29/5	2115	OB	53	49.0N	05	55.7W

CHALLENGER

MAY/JUNE 88

TIME:- BST

TABLE 4

1 m RING NET

DATE	TIME		POSITION			
24/5	2218	OB	53	49.8N	05	32.1W
	2235	IB	53	49.3N	05	32.3W
	2254	OB	53	48.8N	05	32.5W
	2342	IB	53	47.5N	05	33.7W
25/5	1045	OB	53	49.5N	05	30.9W
	1102	IB	53	48.9N	05	30.9W
	1121	OB	53	49.8N	05	30.9W
	1131	IB	53	49.5N	05	30.6W

CHALLENGER

MAY/JUNE 88

TIME:- BST

TABLE 5

30 LOWESTOFT SAMPLER

T.T.NET

DATE	TIME		POSITION				FLOWMETER READING m^3 FILTERED
27/5	1342	OB	53	56.4N	06	11.6W	357/36.8
	1400	IB	53	55.9N	06	10.0W	
	1446	OB	53	54.6N	06	07.2W	492/50.7
	1509	IB	53	54.7N	06	05.5W	
	1546	OB	53	54.6N	06	01.0W	1518/156.5
	1617	IB	53	54.7N	05	59.0W	
	1646	OB	53	54.6N	05	56.1W	468/48.2
	1702	IB	53	54.7N	05	55.0W	
	1730	OB	53	54.3N	05	51.7W	3775/398.2
	1800	IB	53	52.3N	05	51.3W	
	1845	OB	53	52.4N	05	51.7W	589/60.7
	1858	IB	53	52.8N	05	52.5W	
	2011	OB	53	52.7N	05	56.1W	1781/183.6
	2028	IB	53	52.8N	05	58.0W	
	2044	OB	53	52.6N	06	00.6W	2126/219.2
	2107	IB	53	52.7N	06	03.1W	
	2118	OB	53	52.6N	06	04.5W	951/98.0
	2130	IB	53	52.6N	06	05.8W	
	2154	OB	53	52.6N	06	08.5W	1406/144.9
	2207	IB	53	51.7N	06	08.4W	
	2227	OB	53	50.7N	06	08.1W	1559/160.7
	2243	IB	53	50.7N	06	06.2W	
	3201	OB	53	50.7N	06	04.1W	2438/251.3
	2324	IB	53	50.7N	06	01.2W	
	2338	OB	53	50.6N	05	59.6W	1932/199.2
	2356	IB	53	50.8N	05	57.1W	
28/5	0012	OB	53	50.3N	05	55.2W	2490/256.7
	0032	IB	53	50.6N	05	52.6W	
	0046	OB	53	50.1N	05	51.5W	1960/202.1
	0108	IB	53	48.8N	05	51.5W	
	0117	OB	53	48.7N	05	52.0W	1185/122.2
	0130	IB	53	48.7N	05	53.4W	
	0159	OB	53	48.7N	05	56.0W	1693/174.5
	0218	IB	53	48.7N	05	58.1W	
	0242	OB	53	48.7N	06	00.0W	1579/162.8
	0301	IB	53	48.7N	06	02.8W	
	0319	OB	53	48.7N	06	04.7W	1415/145.9
	0337	IB	53	48.8N	06	06.8W	
	0950	OB	53	37.2N	05	51.5W	3098/319.4
	1023	IB	53	40.0N	05	51.8W	
	1110	OB	53	38.6N	05	52.8W	1395/143.8
	1123	IB	53	38.7N	05	54.0W	

	1144	OB	53	38.6N	05	56.3W	3259/336.0
	1212	IB	53	38.6N	05	59.4W	
	1223	OB	53	38.5N	06	00.4W	1488/153.4
	1238	IB	53	38.6N	06	02.0W	
	1300	OB	53	38.8N	06	04.8W	1328/136.9
	1315	IB	53	39.4N	06	06.0W	
	1350	OB	53	40.7N	06	07.5W	2086/215.1
	1405	IB	53	40.7N	06	06.0W	
	1423	OB	53	40.6N	06	03.8W	1858/191.6
	1443	IB	53	40.6N	06	00.9W	
	1458	OB	53	40.6N	05	59.0W	2632/271.3
	1518	IB	53	40.6N	05	56.8W	
	1534	OB	53	40.6N	05	55.4W	2454/253.0
	1555	IB	53	40.6N	05	52.9W	
	1612	OB	53	40.9N	05	51.6W	1646/169.7
	1628	IB	53	42.2N	05	51.7W	
	1638	OB	53	42.7N	05	51.8W	1554/160.2
	1654	IB	53	42.7N	05	53.5W	
	1754	OB	53	42.5N	05	55.6W	1924/198.3
	1808	IB	53	42.7N	05	57.2W	
	1824	OB	53	42.6N	06	00.0W	1396/143.9
	1839	IB	53	42.7N	06	01.7W	
	1853	OB	53	42.6N	06	05.7W	951/98.0
	1905	IB	53	42.7N	06	05.7W	
	1921	OB					1965/202.6
	1941	IB	53	44.5N	06	08.7W	
	1952	OB	53	44.7N	06	08.3W	1466/151.1
	2011	IB	53	44.6N	06	06.2W	
	2025	OB	53	44.6N	06	04.2W	2312/238.3
	2045	IB	53	44.7N	06	01.8W	
	2059	OB	53	44.6N	06	00.0W	1912/197.1
	2115	IB	53	44.8N	05	57.8W	
	2133	OB	53	44.7N	05	55.5W	1843/190.0
	2151	IB	53	44.7N	05	53.5W	
	0839	OB	53	45.4N	05	51.4W	3060/315.5
29/5	0907	IB	53	47.8N	05	51.6W	
	0925	OB	53	46.6N	05	51.7W	1500/154.6
	0944	IB	53	46.8N	05	54.1W	
	0957	OB	53	46.7N	05	56.1W	3700/381.4
	1024	IB	53	46.6N	05	59.4W	
	1032	OB	53	46.7N	06	00.4W	1825/188.1
	1046	IB	53	46.7N	06	02.0W	
	1104	OB	53	46.6N	06	04.6W	1476/152.2
	1121	IB	53	46.6N	06	06.2W	
	1144	OB	53	46.8N	06	08.5W	1194/123.1
	1157	IB	53	47.6N	06	08.5W	
	1210	OB	53	48.7N	06	08.2W	1313/135.4
	1227	IB	53	48.7N	06	06.7W	
30/5	0927	OB	53	48.7N	05	53.3W	2581/266.1
	0952	IB	53	48.7N	05	50.7W	
	1105	OB	53	48.4N	05	39.0W	2141/220.7
	1124	IB	53	48.5N	05	41.2W	
	1141	OB	53	48.1N	05	43.0W	2910/300.0
	1207	IB	53	48.2N	05	46.1W	
	2202	OB	53	42.6N	05	43.2W	2229/229.8
	2220	IB	53	41.4N	05	43.1W	

	2255	OB	53	37.9N	05	41.7W	3040/313.4
31/5	0012	OB	53	32.7N	05	35.4W	3337/344.0
	0038	IB	53	30.9N	05	37.0W	
	0114	OB	53	28.2N	05	40.6W	2566/264.5
	0135	IB	53	29.0N	05	41.6W	
	0229	OB	53	33.7N	05	47.6W	1517/156.4
	0243	IB	53	33.6N	05	49.0W	
	0258	OB	53	32.7N	05	52.5W	1317/135.8
	0312	IB	53	32.4N	05	54.0W	
	1334	OB	53	39.9N	04	53.6W	1586/163.5
	1349	IB	53	39.9N	04	52.5W	
	1420	OB	53	40.0N	04	50.0W	1666/171.7
	1434	IB	53	40.0N	04	48.7W	
	1528	OB	53	39.2N	04	48.0W	1426/147.0
	1541	IB	53	38.6N	04	50.0W	
	1550	OB	53	38.4N	04	50.9W	3100/319.6
	1618	IB	53	36.7N	04	54.2W	
	1704	OB	53	35.3N	04	57.2W	1992/205.4
	1732	IB	53	34.6N	05	00.0W	
	1812	OB	53	35.0N	05	00.2W	2539/261.7
	1834	IB	53	36.1N	04	58.8W	
	1852	OB	53	37.5N	04	57.0W	2755/284.0
	1915	IB	53	38.9N	04	55.0W	
	2125	OB	53	40.0N	04	54.2W	2254/232.4
	2145	IB	53	39.6N	04	54.9W	
	2249	OB	53	37.6N	05	00.4W	1330/137.1
	2310	IB	53	37.7N	05	02.1W	
	2327	OB	53	37.5N	05	04.0W	2340/241.2
	2351	IB	53	37.7N	05	06.3W	
01/6	0012	OB	53	37.8N	05	08.0W	1186/122.3
	0036	IB	53	39.7N	05	08.0N	
	0053	OB	53	40.0N	05	06.4W	1322/136.3
	0113	IB	53	40.0N	05	05.0W	
	0122	OB	53	40.0N	05	03.1W	2342/241.4
	0142	IB	53	40.0N	05	00.6W	
	0154	OB	53	40.0N	04	59.5W	1759/181.3
	0214	IB	53	40.0N	04	57.8W	
	0337	OB	53	42.2N	04	52.4W	2914/300.4
	0400	IB	53	42.4N	04	55.9W	
	0424	OB	53	42.3N	05	00.2W	2005/206.7
	0439	IB	53	42.3N	05	02.7W	
02/6	0902	OB	53	32.8N	04	05.5W	2095/216.0
	0919	IB	53	33.9N	04	05.2W	
	0943	OB	53	35.7N	04	06.0W	1626/167.6
	0958	IB	53	35.5N	04	03.2W	
	1017	OB	53	35.5N	03	58.9W	2356/242.9
	1038	IB	53	35.4N	03	55.1W	
	1053	OB	53	35.1N	03	52.8W	1927/198.7
	1110	IB	53	33.9N	03	52.4W	
	1132	OB	53	31.4N	03	53.2W	2043/210.6
	1155	IB	53	31.3N	03	55.4W	
	1227	OB	53	31.5N	04	01.0W	2266/233.6
	1245	IB	53	31.5N	04	02.7W	
	1632	OB	53	25.21	03	46.3W	211/21.7
	1649	IB	53	24.8N	03	45.1W	
	1733	OB	53	24.0N	03	41.5W	148/15.2

	1737	IB	53	23.9N	03	41.1W	
	1803	OB	53	23.0N	03	37.4W	70/7.2
	1810	IB	53	23.0N	03	36.8W	
03/6	1825	OB	53	52.6N	05	33.0W	1462/150.7
	1840	IB	53	53.6N	05	33.0W	
	1852	OB	53	53.3N	05	33.1W	1400/144.3
	1908	IB	53	52.1N	05	33.1W	
	1918	OB	53	51.9N	05	34.4N	1364/140.6
	1935	IB	53	51.8N	05	36.3N	

TABLE 6

Pump and filtration Rig

Station	Date 1988	Time GMT	Position	Container volume (litres)	Depth of sampling (m)	Filter size (µm)	Volume filtered (litre)	Code	Measurements
ISP1	24.05	12.08	53°49.2'N	500	5	>200	500	D2479)	PC,PN, POC
			05°32.2'W			> 80	500	D2481)	Proteins
						> 22	500	D2482)	DFAA Vit C
						22	3	D2478)	Photo. pigments lipids
						22	3		Lipids
						22	3		pigments
						22	3		Vit. C
ISP2	24.05	18.18	53°48.3'N	900	5	>200	900	D2491)	As
			05°27.7'N			>100	900	D2484)	above
						> 22	450	D2486)	
						> 22	450	D2485)	
						22	3	D2483)	
						22	3		Lipids
						22	3		pigments
ISP3	25.05	17.00	53°43.5'N	500	10	>200	500	D2556)	As
			05°28.7'W			>100	500	D2554)	above
						> 22	500	D2552)	
						22	3	D2550)	
						22	3		lipids
						22	3		pigment
						22	3		Vit. C
					30	>200	500	D2546)	As
						>100	500	D2541)	above
						> 22	500	D2540)	
						22	3	D2536)	
						22	3		lipids
						22	3		pigments
						22	3		Vit. C
					47	>200	500	D1124)	As
						>100	500	D1123)	above
						> 22	500	D1125)	
						22	3	D1122)	

						22	3		lipids
						22	3		pigments
						22	3		Vit. C
ISP4	26.05	09.30	53°25.1'N	300	2	>200	150	D2588)	As
			03°48.1'W			>200	150	D2575)	above
						>100	100	D2586)	
						>100	100	D2573)	
						> 22	50	D2584)	
						> 22	50	D2571)	
						22	1	D2569)	
						22	1		lipids
						22	1		pigments
						22	1		Vit. C
					9	>200	100	D2581)	As
						>200	100	D2567)	above
						>100	100	D2577)	
						>100	100	D2564)	
						> 22	100	D2563)	
						22	1	D2561)	
						22	1	)	As
						22	1	)	above
						22	1	)	
ISP5	29.05	15.36	53°46.8'N	300	4	>200	300	D3194)	As
			05°55.2'W			>100	150	D3192)	above
						>100	150	D3186)	
						> 22	50	D3185)	
						> 22	50	D3184)	
						22	1	D3183)	
						22	1	)	As
						22	1	)	above
						22	2	)	
					14	>200	150	D3182)	As
						>200	150	D3181)	above
						>100	100	D3180)	
						>100	100	D3179)	
						> 22	50	D3177)	
						> 22	50	D3175)	
						22	1	D3165)	
						22	1	)	As
						22	1	)	above
						22	1	)	

					34	>200	150	D3174)	As
						<200	150	D3171)	above
						>100	100	D3170)	
						>100	100	D3168)	
						> 22	100	D3167)	
						> 22	100	D3166)	
						22	1	D3163	
						22	1	)	As
						22	1	)	above
						22	1	)	
ISP6	30.05	02.00	53°48.3'N	200	4	>200	200	D3215)	As
			05°54.2'W			>100	100	D3214)	above
						<100	100	D3213)	
						> 22	50	D3212)	
						> 22	50	D3211)	
						22	2	D3205)	
						22	2	)	As
						22	1	)	above
						22	2	)	
					16	>200	200	D3210)	As
						>100	100	D3209)	above
						>100	100	D3208)	
						> 22	50	D3207)	
						> 22	50	D3206)	
						22	2	D3204	
						22	2	)	As
						22	1	)	above
						22	1	)	
					34	>200	100	D3203)	As
						>200	100	D3201)	above
						>100	100	D3200)	
						>100	100	D3199)	
						> 22	50	D3198)	
						> 22	50	D3197)	
						22	1	D3196)	
						22	1	)	As
						22	1	)	above
						22	1	)	
ISP7	30.05	15.00	53°45.1'N	200	4	>200	200	D2924	As
			05°54.5'W			>100	100	D2919)	above
						>100	100	D2917)	
						> 22	50	D2916)	
						> 22	50	D2915)	

						22	2	D2913)	
						22	1	)	As
						22	1	)	Above
						22	2	)	
					15	>200	QUAL	D2911)	As
						>100	100	D2909)	above
						>100	100	D2904)	
						> 22	50	D2901)	
						> 22	50	D2598)	
						22	1	D2594)	
						22	1	)	As
						22	1	)	above
						22	2	)	
					34	>200	100	D3222)	As
						>200	100	D3221)	above
						>100	50	D3220)	
						>100	100	D3219)	
						> 22	50	D3218)	
						> 22	50	D3217)	
						22	1	D3216)	
						22	1	)	As above
						22	1	)	
						22	1	)	
ISP8	01.06	13.30	53°40.5'N	300	4	>200	300	D343)	As
			04°40.4'W			>100	300	D342)	above
						> 22	100	D341)	
						> 22	100	D340)	
						22	1	D339)	
						22	1	)	As
						22	1	)	above
						22	2	)	
					14	>200	300	D338)	As
						>100	300	D337)	above
						> 22	100	D336)	
						> 22	100	D335)	
						22	1	D334)	
						22	1	)	As
						22	1	)	above
						22	2	)	

					35	>200	300	D333)	As
						>100	300	D332)	above
						> 22	100	D331)	
						> 22	100	D329)	
						22	1	D330)	
						22	1	)	As
						22	1	)	above
						22	2	)	
ISP9	02.06	15.11	53°24.9'N	1000	4	>200COPE	1000	D506)	As
			03°45.9'W			>200PHAE	51.3	D507)	above
						>100	40	D501)	
						>100	40	D500)	
						> 22	40	D499)	
						> 22	40	D498)	
						22	0.5	D497)	
						22	0.5	)	As
						22	0.5	)	above
						22	0.5	)	
					14	>200COPE	1000	D503)	As
						>200PHAE	50	D504)	above
						>100	10	D496)	
						> 22	10	D493)	
						> 22	10	D503)	
						22	0.5	D504)	
						22	0.6	)	As
						22	0.6	)	above
						22	0.5	)	
ISP10	03.06	16.10	53°47.8'N	500	10	>200	500	D425)	As
			05°32.4'W			>100	500	D429)	above
						> 22	500	D423)	
						22	3	D422)	
						22	3	)	As
						22	3	)	above
						22	3	)	
					30	>200	500	D421)	As
						>100	500	D594)	above
						> 22	500	D529)	
						22	3	D528)	
						22	3	)	As
						2	3	)	above
						2	3	)	

52	>200	500	D527)	As
	>100	500	D526)	above
	> 22	125	D525)	
	> 22	125	D524)	
	22	3	D453)	
	22	3	)	As
	22	3	)	above
	22	3	)	

Coded samples are GFC filters which will be 'punched' for specific determinations.