Fishery Leaflet 150

Winter Nitrate and Phosphate levels in the Western Irish Sea in 1991

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By

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SUMMARY

This study of nitrate, phosphate and salinity levels in the western Irish Sea indicates that the distribution of nutrient levels can be explained by taking into account the known physical and hydrological features of the area. There is a clear inverse relationship between nitrate and salinity data with nitrate levels decreasing rapidly moving offshore. The distribution of phosphate levels is more complex and appears to be influenced by multiple point source inputs and inflows from the Celtic Sea.

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INTRODUCTION

A knowledge of nutrient (nitrate and phosphate) levels in coastal and marine waters is necessary in order to be able to assess environmental quality and to identify and quantify trends and potential detrimental effects of nutrient inputs, which may lead to a decrease in water quality, algal blooms (nuisance and/or toxic), oxygen depletion following bloom decay, and a subsequent loss of amenity or commercial fishery value.

Nutrient inputs to the Irish Sea come from a variety of sources, including land drainage, sewage discharge, sea dumping, natural oceanic inputs and from the atmosphere. Studies on nutrient inputs (riverine) and ambient levels in the Irish Sea have been numerous (Dickson & Boelens, 1988, ERU, 1989), but have heretofore been geographically limited and often are not comparable. A comprehensive survey of the nutrient status of the Irish Sea, as a whole, has yet to be published.

In 1990, under the auspices of the EC's Northern Seas Action Programme (NORSAP), a number of laboratories involved in routine monitoring of nutrient levels in and around the Irish Sea came together to plan and execute the first co-ordinated

nutrient sampling programme in the Irish Sea. The primary objectives of this initiative were to

(1) establish a network of laboratories involved in nutrient monitoring, and

(2) to combine existing monitoring programmes in order to cover the whole of the Irish Sea in a way that would provide a comprehensive database for future trend monitoring.

While sampling and analysis were carried out as part of existing national or regional monitoring programmes, the overall co-ordination, intercalibration, quality control and establishment of a GIS (Geographical Information System) database on nutrient levels in the Irish Sea was funded by the EC's NORSAP Programme.

This report describes the survey and determination of nutrient levels in the western Irish Sea as carried out by the Fisheries Research Centre (FRC), as part of a national programme, and represents part of the Irish (Republic of Ireland) contribution to the overall NORSAP Project.

METHODS

Sampling and analytical methods for the Irish Sea Programme were discussed and agreed at a number of preparatory workshops held in 1990. This preparatory phase also involved an intercalibration exercise overseen by the MAFF Fisheries Laboratory, Lowestoft (UK) and IFREMER, Brest (France). The intercalibration and the quality control procedures agreed, were designed to assure the compatibility and comparability of the data collected by the different monitoring groups involved in the programme.

Sampling was carried out in the winter months, because this period is characterised by minimal biological activity and a high level of remineralised nutrients in surface waters. This is the sampling period recommended by the ICES Advisory Committee on Marine Pollution (Anon., 1990) for assessment of increasing or decreasing trends in nutrient levels.

Sampling was carried out at 132 open sea sample sites during the period 11 - 24 January 1991 from the RV Lough Beltra (Figure 1). Open sea water samples were taken from 3 metres depth using a 2.5 litre HydroBios sampling bottle.

Subsamples for salinity determination were stored in specially prepared stoppered glass bottles (supplied by MAFF, Lowestoft), and salinities were determined in the laboratory, using a Guildline Portasal 8410 Salinometer.

Subsamples for nutrient analysis were immediately filtered using Whatman GF/C paper and analysed in triplicate on board the RV Lough Beltra, for nitrate and phosphate, using a Technicon II Autoanalyser. Analytical methods used are described by Kirkwood (1989). Standards and quality control samples, as used in the ICES Nutrient Intercalibration (Kirkwood et al., 1991), were analysed after every 10 samples.

The data were then entered into a GIS (PC Arc/Info) database from which contour maps were generated by kriging (Cressie, 1989, Warren, 1991).

RESULTS

The contour and thematic maps produced for this report are subject to a number of "artifacts" produced by the contouring software and the irregularly spread sampling points. The most obvious of these is illustrated by the eastwards extending contours in the northeast areas of the contour plots (Figs 2, 3 and 5). This is caused by a lack of data points offshore. When data collected by the Dept. of Agriculture for Northern Ireland (DANI) are added (as will be reported in the Project Final Report- In prep.), these contours curve back towards the shore as would be expected taking into account the hydrography of the area. Notwithstanding these artifacts the contour and thematic patterns produced are considered to provide a very good representation of actual conditions.

Open-sea data are presented in Annex 1.

Salinity data are presented in Figure 2. With the exception of a narrow strip in the north-western corner of the study area, the salinity was greater than S =33, and over most of the study area greater than S =34. The highest salinity (S = 34.9) was recorded in the south of the sampled area. In general, salinities tend to decrease from south (34.9) to north (33.4) and to increase with distance from the coast (31 to 34.5).

Nitrate concentrations in contour and thematic format are presented in Figures 3 and 4. Nitrate levels varied from 6.8 μmol/l (8 miles off Skerries) to 48.4 μmol/l (off the Boyne Estuary). Carlingford Lough had high concentrations of nitrate (max 43.8 μmol/l) which is considerably higher than the value of 21.5 μmol/l recorded close to the end of the North wall in Dublin Bay. The thematic nitrate plot (Figure 4) indicates that almost all of the sea area covered had nitrate levels less than 20 μmol/l.

Phosphate data are presented in Figures 5 and 6. Phosphate levels were generally less than 1 μmol/l with open-sea levels in the region of 0.8 μmol/l. Many samples in the central offshore area of the sampled area had levels as low as 0.6 μmol/l. Levels tended to be slightly more elevated in inshore areas with a maximum recorded value of 1.3 μmol/l (Dublin Bay). Areas just south of Wexford Harbour, inner Dublin Bay and Dundalk Bay, and Carlingford Lough, had phosphate levels greater than 1 μmol/l.

Nutrient and salinity levels recorded at the seaward ends of the main estuaries and bays are given below.

Estuary/Bay	Salinity (PSU)	Nitrate (μmol/l)	Phosphate (μmol/l)
Carlingford Lough	30.84	43.8	1.2
Boyne	30.3	48.4	0.9
Liffey	33.1	21.5	1.3
Avoca	33.9	16.2	0.7
Slaney	33.86	17.4	0.6

A linear regression of nitrate on salinity is presented in Figure 7 and a linear regression of phosphate on salinity is presented in Figure 8.

A thematic plot of Nitrate:Phosphate ratios in the sample area is presented in Figure 9. This shows that the ratio in offshore areas was less than 15:1. Moving inshore the ratio increases particularly off Wexford, in the Wicklow Head area, Dublin Bay, the mouth of the Boyne, Dundalk Bay and Carlingford.

DISCUSSION

As expected, salinity tended to be lower (S< 33) in those inshore areas strongly influenced by freshwater run-off. The 'island' pattern displayed off the Wexford coast may be an artifact of the contouring software, but was more likely attributable to high salinity 'cells' (S = 34.9) which had detached from the Celtic Sea inflow.

As the most identifiable, and measurable, nutrient gradients are due to freshwater inputs, a linear relationship between salinity and nutrient concentration would be expected (Foster, 1984). This is supported by the linear regression plot of nitrate on salinity (Figure 7), which shows a clear inverse relationship between salinity and nitrate. The nitrate ranges illustrated by the nitrate contour and thematic plot (Figures 3 and 4) also show the localised elevations in nitrate corresponding with freshwater influence.

The pattern of phosphate distribution (Figures 5 & 6) in the survey area correspond closely to nitrate and salinity patterns, reflecting freshwater run-off influences. There is, however, a poor correlation between phosphate and salinity (Figure 8). This may be due to localised non-riverine inputs that may perturb the general pattern. Such an effect may occur in the Waterford estuary, which is known (ERU, 1989) to include a relatively high phosphate source (Annex 2).

A linear regression plot using only data north of the Wicklow Head latitude to remove the influence of the Celtic Sea inflow also showed a poor correlation between phosphate and salinity.

As the ratio of N to P is generally similar in plankton to that in productive seawater at 15:1 (Spencer, 1975), examination of this relationship can give useful information on the availability of nutrients for biological production. Examination of Figure 9 illustrates that the offshore area had ratios less than 15:1 suggesting that nitrate might be limiting for phytoplankton growth. However, a broader database, including measurements between spring and autumn is needed to confirm this preliminary observation.

The mouth of the Boyne had the highest recorded nitrate levels in this survey (48.4µmol/l). This is consistent with the findings of the ERU (1989), which identified high nutrient loadings from this river, of which a significant proportion may be derived from agricultural practices in the catchment.

Dublin Bay has nitrate levels of less than 20 µmol/l and phosphate levels in the region of 1 µmol/l, which are quite typical for inshore waters in the study area. There is an indication of enhanced nitrate levels around Howth Head (16 µmol/l) which probably reflect local sewage inputs.

The area around Wicklow Head shows a slight elevation in nutrient levels (15 µmol/l nitrate and 0.8 µmol/l phosphate and a relatively low salinity (S< 33.9), possibly due to run off from the Wicklow Mountains.

In general, it can be seen that the parameters measured are distributed largely on the basis of known physical and hydrographical differences between water masses. There appears to be a clear inverse relationship between salinity and nitrate, with nitrate levels decreasing rapidly as one moves offshore. The situation with phosphate is different and appears to be complicated in the south west by phosphate inputs from the Celtic Sea and Waterford estuary and possibly other point sources elsewhere in the Irish Sea.

CONCLUSIONS

The database (Annex 1) and the contour and thematic maps provided by this survey, our knowledge of nitrate and phosphate levels in the western Irish Sea. These data when combined and jointly evaluated with similar data sets collected simultaneously in other parts of the Irish Sea by the EOLAS Shannon Laboratory; the Dept. of Agriculture for Northern Ireland's Fisheries Laboratory; the Industrial Science Division Laboratory, Dept. of Economic Development (N.I.); the University of Liverpool, Isle of Man Marine Laboratory; The National Rivers Authority (Welsh and N.W. Regions) and MAFF (U.K.), under the auspices of the EC's NORSAP Programme will provide the first quality assured and synoptic assessment of nutrients in the Irish Sea, which can be used as a baseline for future trend analysis.

A report on the complete NORSAP Irish Sea Nutrient Project is in preparation.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Don Kirkwood (MAFF, Lowestoft) and Dr. Alain Aminot (IFREMER, Brest, France) for their invaluable assistance and advice in the intercalibration and quality control aspects of this Programme. Thanks are also due to Mr. Paul Mills (Trinity College, Dublin) for his assistance in the preparation of the GIS database and the generation of contour and thematic plots. We also wish to thank the skipper and crew of the R.V. L. Beltra.

The financial support provided by the EC's NORSAP Programme (DG XI) for co-ordination, intercalibration, quality control and GIS database of the Irish Sea Project (NORSAP Project No. B6618-89-03) is gratefully acknowledged.

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Figure 1

FRC Nutrient Sample Sites 1/91

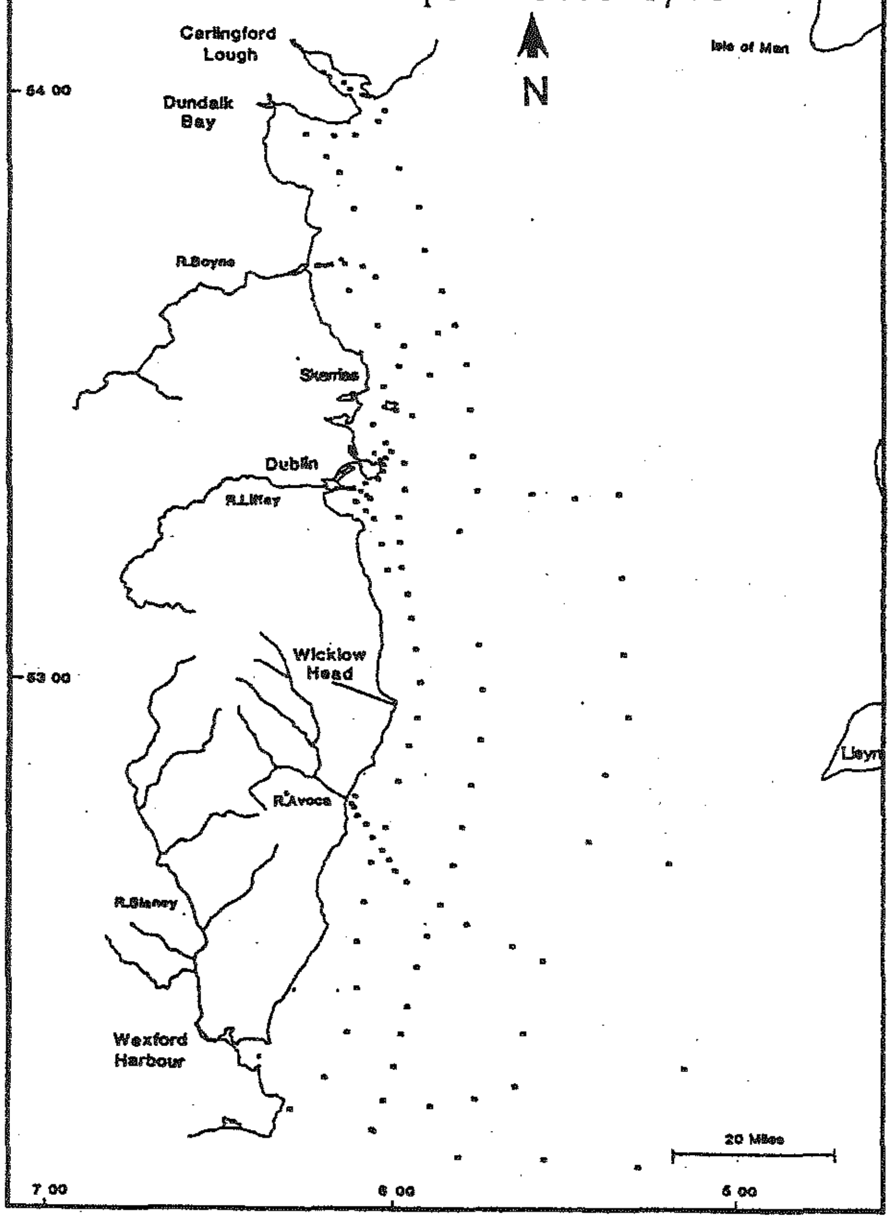


Figure 2

Contour Plot of FRC Salinity Data

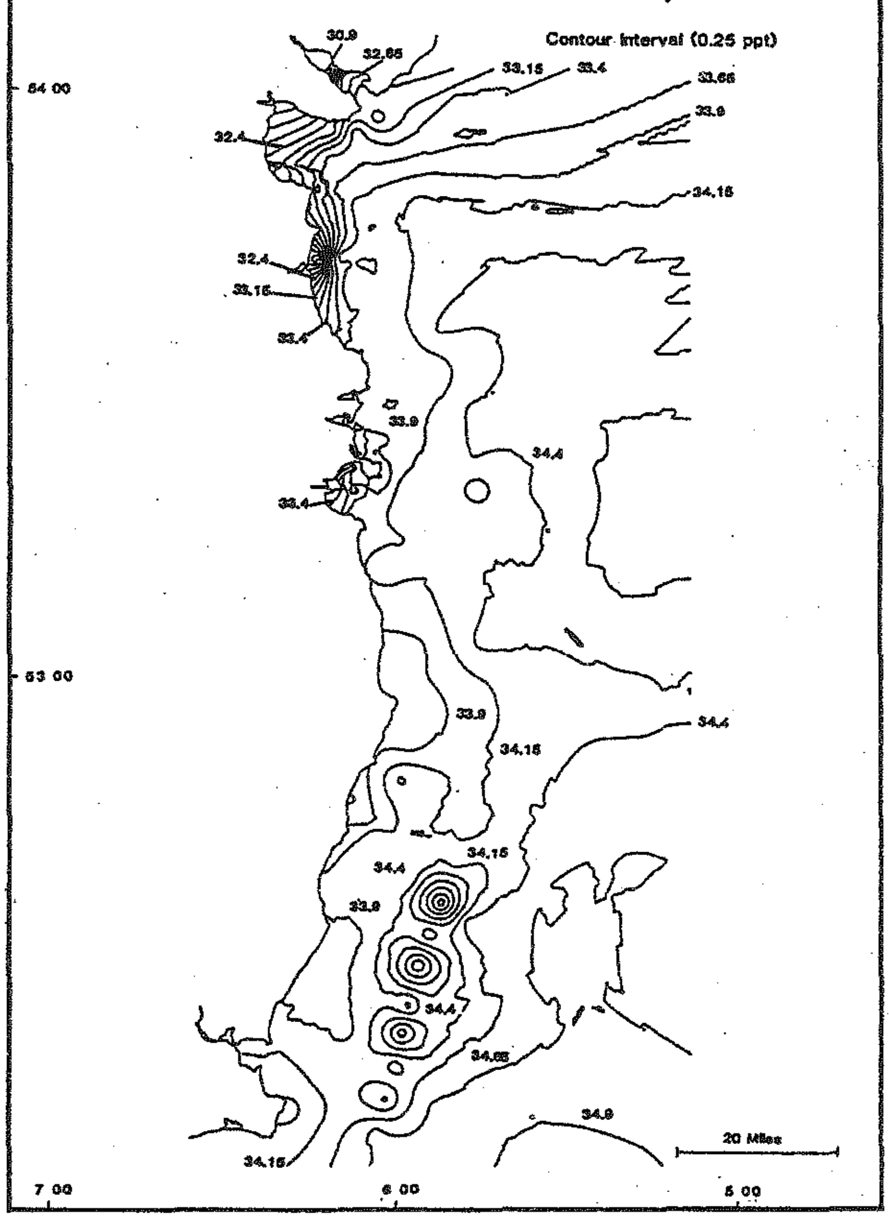


Figure 3

Contour Plot of FRC Nitrate Data

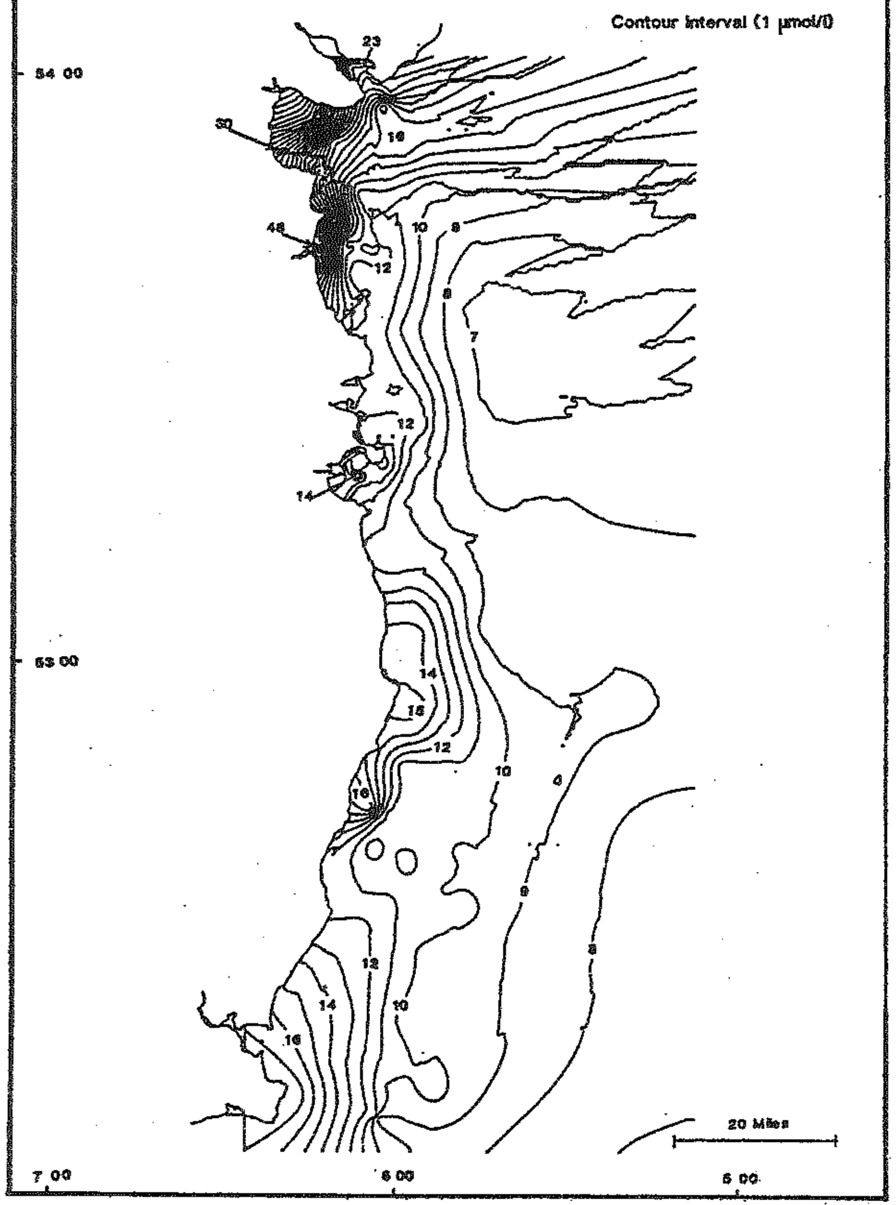


Figure 4

Thematic Plot of FRC Nitrate Data

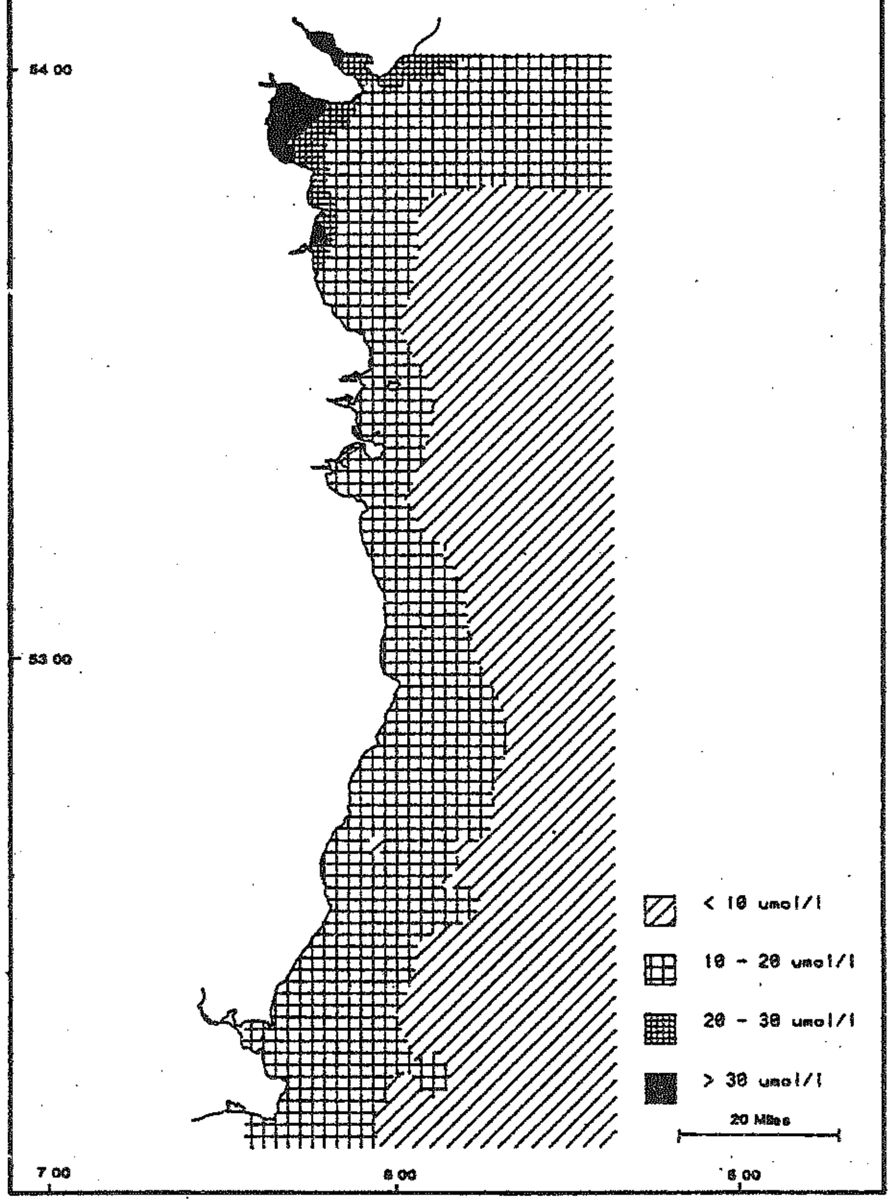


Figure 5

Contour Plot of FRC Phosphate Data

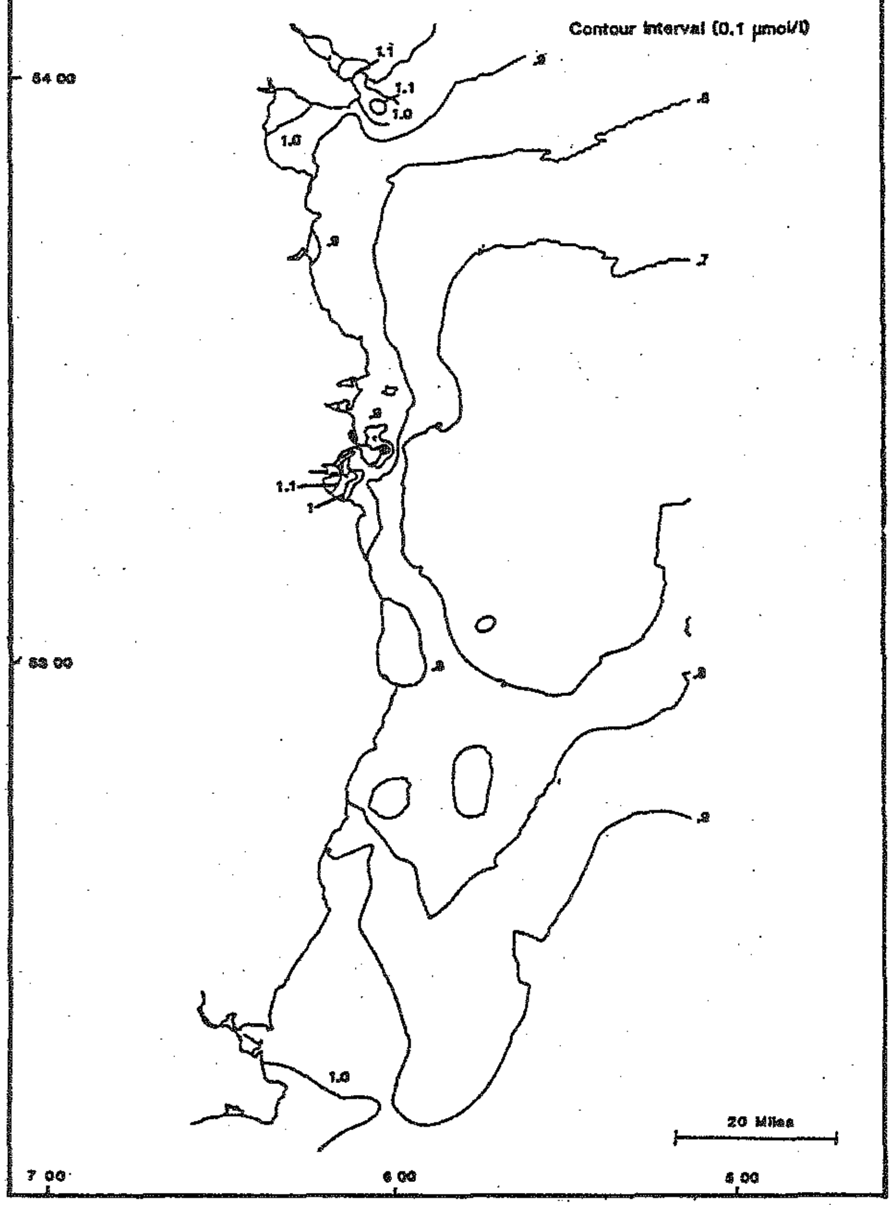


Figure 6

Thematic Plot of FRC Phosphate Data

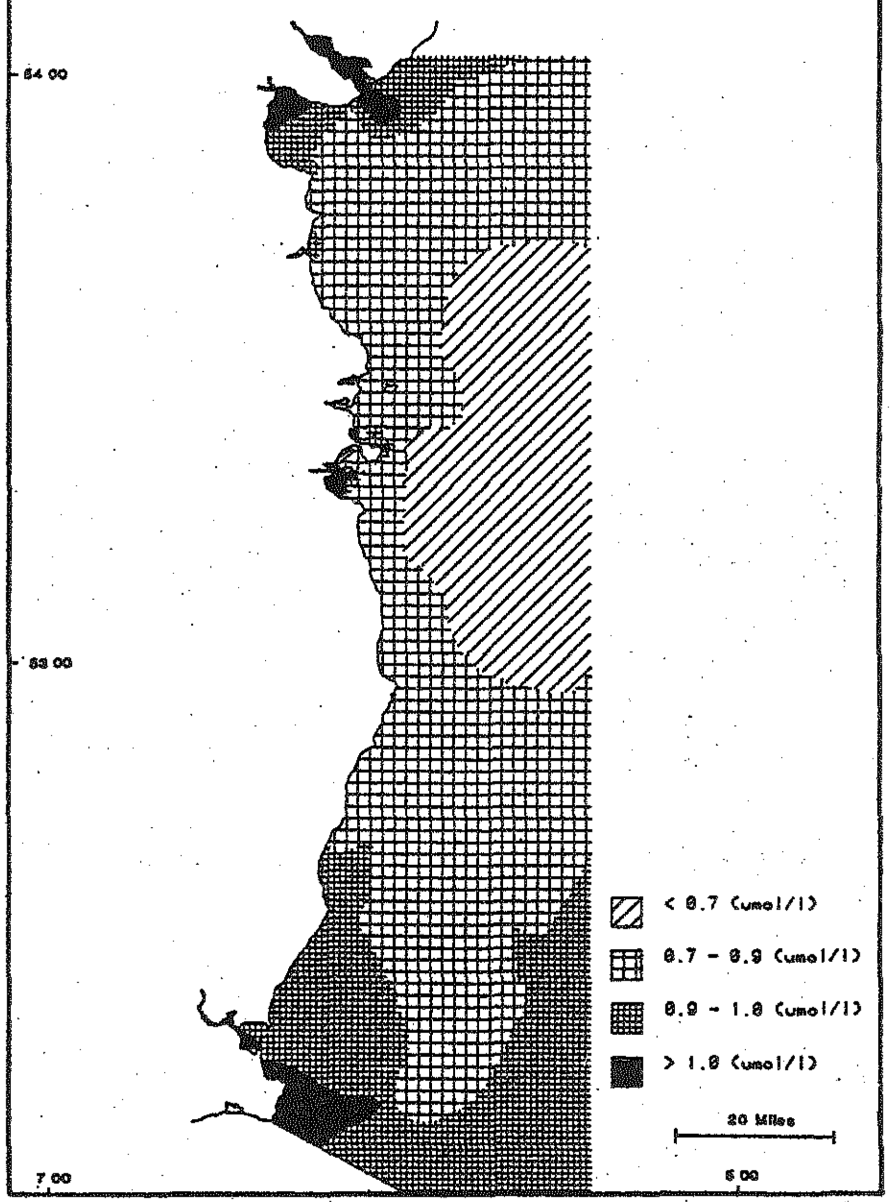


Figure 9

Thematic Plot of FRC NO3:PO4 Values

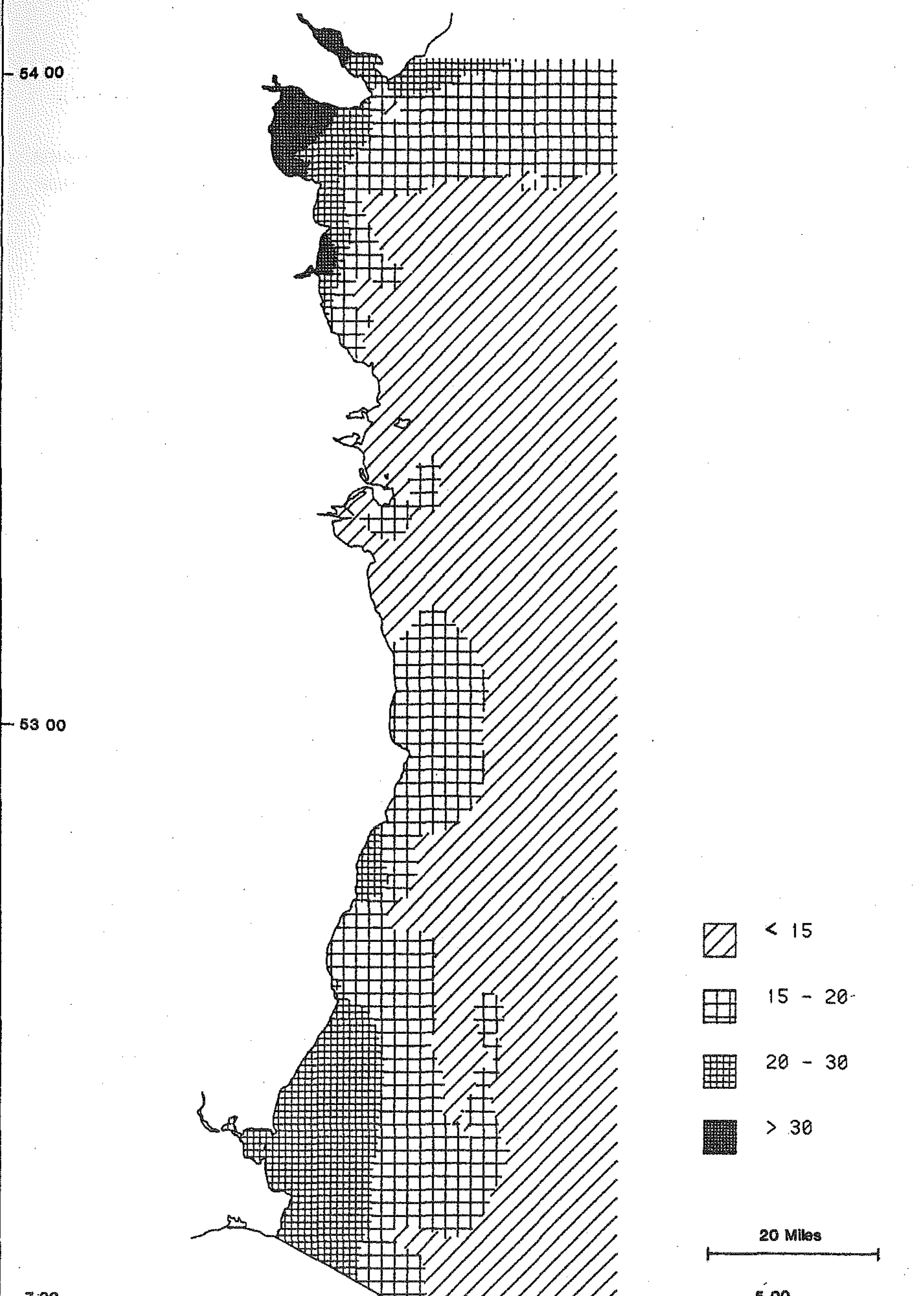
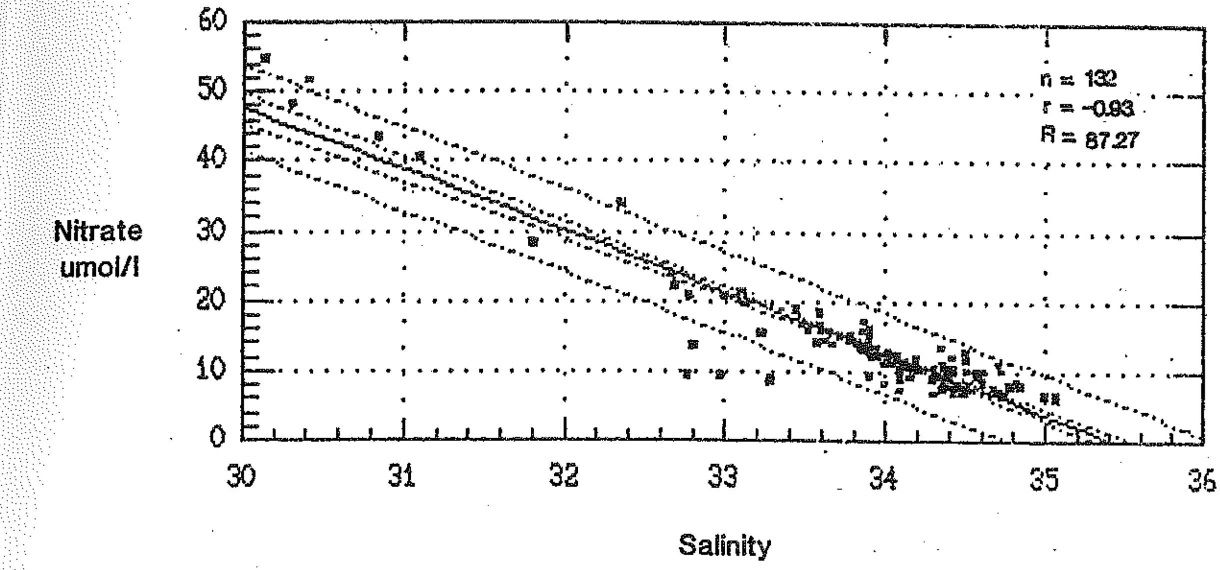
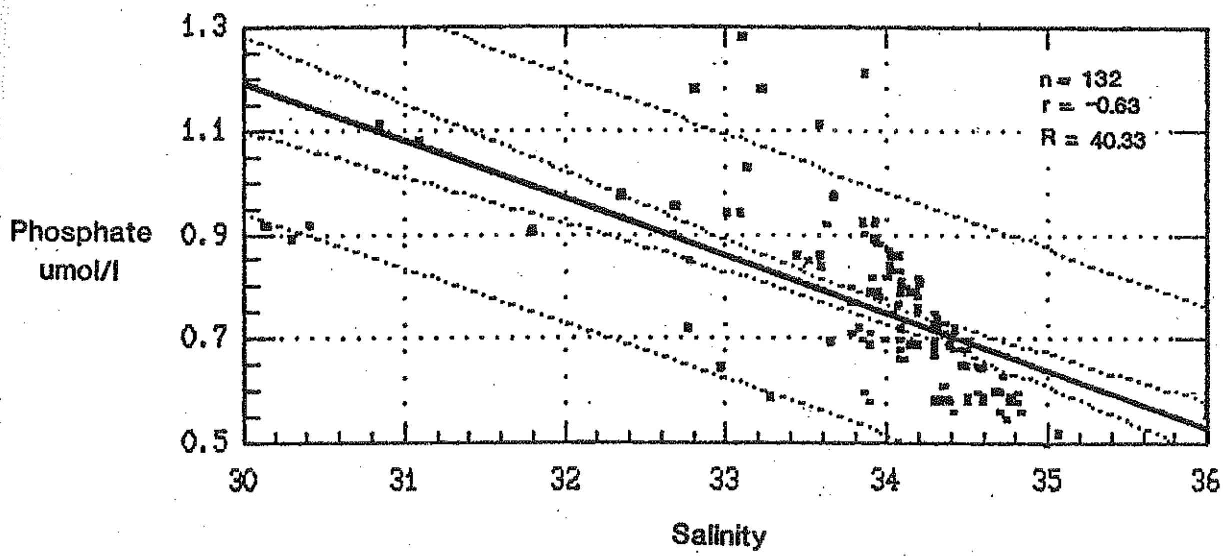


Figure 7



Regression of W. Irish Sea Nitrate values on Salinity values

Figure 8



Regression of W. Irish Sea Phosphate values on Salinity values

Annex 1: Western Irish Sea Stations Sampled 11 to 24 January 1991

Station	Latitude North	Longitude West	Temp. C	Salinity pss	Phosphate umol/l	Nitrate umol/l
1	532303	55806	7	34.11	.66	10.7
2	532027	55807	7.4	34.4	.69	10
3	531738	55907	7.7	34.3	.7	9.7
4	531484	55947	7.5	34.19	.69	10.1
5	531223	55915	7.9	34.3	.69	10.2
6	530905	55800	7.4	34.09	.7	11
7	530700	55736	6.9	34.08	.77	12.6
8	530387	55658	6.4	33.89	.79	13.8
9	530036	55588	6.3	33.94	.79	13.5
10	525666	55641	5.8	33.78	.77	14.7
11	525306	55778	5.8	33.82	.72	14.1
12	525000	55955	7	34.5	.7	10.1
13	524516	60184	6.6	34.09	.66	10.4
14	524148	60433	6.9	34.4	.58	8.9
15	523723	60547	6.8	34.3	.58	10.4
16	523300	60663	6.9	34.5	.59	11.9
17	522805	60683	7.4	34.42	.56	12.1
18	522335	60845	7.4	34.5	.58	12.8
19	521849	61224	7.5	34.34	.58	13.6
20	521511	61810	6.7	33.86	.6	17.4
21	521279	60378	8.2	34.76	.58	8.4
22	521610	60222	8.1	33.89	.58	9.6
23	521969	60049	8	34.59	.58	10
24	522317	55936	8.2	33.27	.59	9.2
25	522604	55828	8.1	34.56	.6	9.6
26	523036	55644	8.1	32.96	.65	9.5
27	523365	55471	7.9	34.4	.69	10
28	523696	55248	8.2	32.76	.72	9.6
29	524122	55035	8.3	34.31	.72	9.6
30	524526	54884	7.9	34.09	.79	10
31	524962	54713	7.5	34.2	.81	10.2
32	525434	54560	7.1	34.19	.76	10.4
33	525961	54530	6.9	34.15	.69	9.4
34	530424	54583	7.7	34.5	.58	8.4
42	532061	60758		33.1	1.28	21.5
43	532036	61366		33.85	.92	13.7
44	531992	50868		34	.82	12.5
45	531963	45869		34.03	.75	12.6
46	531604	54934	8.5	34.43	.68	8.06
47	532015	54633	8.5	34.09	.68	7.54
48	532378	54690	8.8	34.48	.68	7.18
49	532858	54748	8.9	34.49	.68	6.88
50	533333	54814	9	34.3	.67	6.83
51	533741	55017	8.7	34.48	.68	6.82
52	534088	55226	8.6	34.4	.7	7.91
53	533653	55302	8.7	34.47	.7	7.91
54	533222	55442	8.2	33.99	.7	8.4
55	532795	55739	6.6	34.14	.79	10.91
56	532424	60091	6.3	34.02	.86	12.62
57	532357	60178	6.5	34.07	.86	12.55
58	532511	60189	6.5	33.93	.89	12.3

Annex 1: Western Irish Sea Stations Sampled 11 to 24 January 1991

Station	Latitude North	Longitude West	Temp. C	Salinity pss	Phosphate umol/l	Nitrate umol/l
59	532852	60013	6.6	34.09	.81	11.3
60	533311	55973	6.6	34.2	.78	10.1
61	533724	60338	6.8	34.09	.81	11.4
62	534087	60812	6.6	34.19	.79	10.8
63	534406	60943	6.5	34.19	.82	11.9
64	534906	60738	6.2	34.02	.83	11.3
65	535299	60986	5.7	33.58	.86	16.9
66	535406	61192	5.1	33.44	.86	18.9
67	535689	61548	4.5	32.35	.97	34.1
68	535676	61063	4.7	32.67	.9	23.9
69	535689	60699	5.8	33.58	.84	18.4
70	535346	55962	6.4	33.77	.8	14.9
71	534945	55625	7	34.3	.75	10.1
72	534508	55522	7.3	34.28	.73	9
73	533522	55883	7.3	34.09	.72	9.1
74	533095	60228	6.5	34.04	.83	11.3
75	532702	60407	6.5	33.99	.82	11.3
76	535887	60292	4.9	32.8	1.18	13.8
77	535998	60187	5.2	33.08	.94	20.2
78	540140	60467	5.1	33	.94	20.8
79	540157	60562	5.3	33.12	1.03	19.9
80	540182	60887	4.9	32.68	.95	22.2
81	540343	61136	4.3	31.08	1.08	40.5
82	540382	61234	4.3	30.84	1.11	43.8
83	540218	60781	4.9	32.67	.95	22.1
91	534334	61361	6.3	31.79	.9	28.6
92	534342	61333	6.4	30.3	.89	48.4
93	534339	61220	6.4	32.76	.85	21.1
94	534349	61125	6.5	33.51	.85	16
95	534362	60882	6.6	33.9	.82	12.9
96	534335	60580	6.7	33.91	.79	12.9
97	534223	60360	6.7	33.94	.78	12.4
98	531984	53697	8.9	34.46	.65	7.6
99	531944	52950	9	34.49	.65	7.6
100	531986	52200	8.7	34.42	.68	7
101	531126	52143	8.7	34.43	.68	8.2
102	530334	52112	8.8	34.5	.68	8.2
103	525680	52029	8.2	34.36	.73	9.1
104	525081	52413	8.5	34.6	.65	8.3
105	524372	52710	8.7	34.66	.6	8
106	524144	51345	9	34.71	.56	7.1
107	523973	45985	7.6	34.35	.61	7.7
108	522969	50378	7.9	34.5	.58	7.4
109	521953	51084	8.4	34.73	.55	7
110	520914	51885	9	34.99	.5	6.7
111	520985	53492	9.1	35.06	.52	7
112	521010	54959	8.7	34.83	.56	8.1
113	521294	60405	7.8	34.71	.6	11.2
114	521551	55424	8	34.72	.63	10.1
115	521629	54664	8.3	34.81	.6	8.9
116	521758	53973	8.7	34.81	.58	8.4

Annex 1: Western Irish Sea Stations Sampled 11 to 24 January 1991

Station	Latitude North	Longitude West	Temp. C	Salinity pss	Phosphate umol/l	Nitrate umol/l
117	522324	53840	8.7	34.6	.59	8.5
118	523100	53483	8.8	34.77	.59	8
119	523255	54014	8.6	34.6	.59	8.5
120	523494	54795	7.8	34.56	.65	9.9
121	523934	55827	7.4	34.41	.68	10.8
122	524058	60019	7.3	34.39	.7	10.8
123	524178	60128	7.5	34.41	.71	10.3
124	524276	60241	7.6	34.42	.72	10.2
125	524412	60406	7.2	34.36	.71	11
126	524551	60519	6.2	33.89	.69	16.2
127	524636	60647	6.5	33.84	.7	15.8
128	524725	60704	6.6	33.89	.71	15.1
129	524765	60746	6.6	33.64	.7	15.9
135	524839	60690	6.7	33.77	.71	15.5
136	531202	60152	7.9	34.31	.74	9.6
137	531464	60259	7.5	34.19	.78	10.6
138	531722	60395	7.3	34.11	.8	11.4
139	531807	60530	7.2	34.07	.83	11.8
140	531932	60695	7.2	34	.84	12.4
141	532060	60807	7.2	33.95	.88	12.7
142	532069	60917	7	33.66	.97	14
143	532065	61023	6.9	33.22	1.18	15.5
144	532061	60940	7.1	33.57	1.11	14.2
145	532061	60839	7.1	33.94	.88	12.5
146	532076	60741	7.1	34.01	.84	12.2
147	532115	60522	7.1	34.01	.87	12.9
148	532166	60604	7	33.62	.92	14.4
149	532221	60226	7.1	33.86	.9	13.2
150	532284	60216	7.1	33.85	1.21	13.1
151	532337	60262	7.1	33.91	.92	12.4

Annex 2 - Total Phosphate and Oxidised Nitrogen (Nitrate + Nitrite) loads per annum in rivers discharging into the Irish Sea - Mean of 1986 and 1987 (Adapted from 'Riverine Inputs To The Irish Sea', ERU, 1989).

River	NO_3+NO_2 (tonnes/annum)	PO_4 (tonnes/annum)
Fane	349	8.6
Glyde	463	12.5
Dee	370	13.0
Boyne	2851	94.5
Tolka	140	10.6
Liffey	1054	46.0
Dodder	196	12.3
Avoca	2814	19.0
Slaney	3810	53.5
Barrow	3341	102.0
Nore	2746	92.0
Suir	4777	155.0