NRA - North West 93

Less Sensitive Areas and candidate *High Natural Dispersion Areas* in the North West Region

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1. Introduction

Under Article 6 of the Urban Waste Water Treatment directive, member states are permitted to designate waters as *less sensitive*. Discharges into such waters from works serving a population equivalent of <150,000 are permitted to receive only primary treatment. To implement this part of the directive, the U.K. government introduced the concept of High Natural Dispersion Areas (HNDAs). The various regulators were asked to nominate discharges which in their opinion would satisfy the requirements for an HNDA. The underlying principal in the guidance notes from the DoE was that the receiving water would not benefit from the provision of secondary treatment on the discharge.

It is significant that the process was discharge driven; the potential HNDAs, as approved by the DoE, are sea areas around a particular outfall, not entire lengths of coast line. To justify the designation 'HNDA', the government requires that 'comprehensive studies' are carried out to demonstrate that limiting the treatment on qualifying discharges will not have an adverse impact on the receiving waters. The scope of these comprehensive studies is set out in considerable detail in a document published in February 1994 under the auspices of the Marine Pollution Monitoring Management Group. The onus of carrying out the comprehensive studies was placed on the discharger - in this case North West Water Ltd.

Once the regulator is satisfied with the technical merits of an HNDA study, a certificate conferring HNDA status will be issued. In the N.W. Region four candidate HNDAs were approved by the DoE:

- Workington North
- Workington South
- Braystones
- North Wirral

2. Study Definition

The studies being undertaken by North West Water are focused on determining the impact of their discharges on near-field water quality, in particular the complex task of discriminating the differing effects of a primary or secondary treated effluent.

From 1993 onwards, synoptic data has been available for all coastal waters in England & Wales. The spring and summer chlorophyll levels along the coasts of the North West and North Wales suggested high primary productivity when compared with the generality of U.K. coastal waters. This prompted consideration of N.W. coastal waters as an entity. Whilst the comprehensive studies will determine the extent of changes caused by the qualifying discharges, they cannot be expected to consider the status of the north east Irish Sea as a whole. Information from the NRA coastal surveillance programme has been complemented by the results of a joint programme with Port Erin Marine Laboratory which has covered the area between Liverpool Bay, the Solway Firth and the Isle of Man.

3. Irish Sea Hydrography

The hydrography of the region clearly influences water quality. The area is characterised by two basins - the Solway and Irish Sea basins. Both are shallow with water depths less than 50m (see figure 1). The dominant water movement is south to north but, with the bulk of the flow passing to the west of the Isle of Man, flushing is limited with long residence times (figure 2).[1]

4. Factors Affecting Nutrient Distributions

Most of the recently collected data is from near surface samples, but stratification can be present over much of the area. Salinity stratification appears to dominate in winter, whilst thermal stratification is in evidence during summer (figures 3 & 4). Figures 5 & 6 give an indication of the extent and patchiness of stratification.

Nutrient levels are often assumed to show rapid depletion following the main spring plankton bloom and a secondary smaller autumn bloom. This conventional pattern is not encountered in much of the Irish Sea. There *may* be a double chlorophyll peak in the Irish Sea, but in many years there is only a single bloom peak which may persist well into the summer. Figure 7, based on data collected off the Wirral, demonstrates the wide variation from year to year.

The concentrations of both nitrogen and phosphorus have risen inexorably over the past 40 years. Figure 8 shows the pattern at the Cypris station off the west coast of the Isle of Man, well away from localised inputs.

4.1 Nitrogen

A 1988 review gave the following typical values for winter nitrate N in the Irish Sea:

off shore	70- 100 µg/l
in shore	155 µg/l
areas receiving polluting inputs	300 - 450 µg/l

Data from 1995 (figures 9-11) confirms that all our coastal waters are typical of those receiving significant local inputs:

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[1] *Note on thematic maps. Many of these are composites of NRA and PEML surveys not necessarily carried out on the same occasion. There are some consequent discontinuities at the boundary, but it is felt that this form of presentation gives the best overall impression of the seasonal changes.*

- March: nitrate distribution patchy with a marked inshore gradient. Maximum concentrations (>300 µg/l N) north of St. Bees Head.
- April: Similar distribution, but a 15% reduction in levels.
- July: Nitrogen severely depleted. Some inshore patches but levels now typically < 15 µg/l.

4.2 Phosphorus

The 1988 review gives a typical value of 30 µg/l P, rising to 70 µg/l P in regions with significant anthropogenic inputs.

Again the 1995 data is typical of 'polluted' areas, with inshore concentrations > 60 µg/l north of Ravenglass. Levels are significantly depleted by July, with not unexpected 'hot spots' near to A&W at Whitehaven (figures 12-14).

5. Hypernutrification and Potential for Eutrophication

The report of the Combined Studies Task Team (CSTT) suggests summer DAIN levels of > 12 µmol in the presence of >= 0.2 µmol/l DAIP as indicative of hypernutrification. On this basis the stations highlighted in red on figure 15 should be considered hypernutrified.

Recently the CSTT have suggested a molar N:Si ratio of >2 in Winter as indicative of waters liable to become eutrophic. This ratio becomes 0.47 when nitrogen is expressed as µg/l N and silicon as µg/l SiO_2. Figures 16a-d show the measured N:Si ratio for a January 1996 coastal survey.

6. Chlorophyll Distributions

As a first approximation, the CSTT suggest summer chlorophyll levels of >10 µg/l as indicative of adversely affected waters. Figures 17-20 show the significant increase in chlorophyll levels from April and May and the persistence of levels >= 10 µg/l through to July in the West Cumbria Area. The plots are based on available data and may well not reflect actual peak values. The occurrence of chlorophyll patches will be noted. The NRA coastal monitoring data demonstrates the routine occurrence of elevated chlorophyll levels in the North West during the warmer months and the generally higher levels found here compared with the rest of the coast. Only the coast of East Anglia shows a similar pattern. (see figures 21-24).

7. Plankton Distributions

The data set is inadequate to describe the relationship (if any) between nutrient concentration and plankton numbers. However, figure 25 is instructive in showing the patchy nature of phytoplankton, and that the highest numbers are north of St. Bees Head, albeit some distance off shore.

8. Nutrient Inputs

The West Cumbria area is unusual, possibly unique, in having major inputs of both nitrogen and phosphorus direct to coastal waters from industrial sources. Albright & Wilson at Whitehaven remains the largest point source of phosphorus in the U.K. despite significant reductions in recent years.

BNFL Sellafield use large quantities of nitric acid on site; nitrate loads to the sea are currently well below the consent limit but are steadily increasing as THORP approaches full production. There are also two possible developments which would further increase the nitrate discharged:

- solvent treatment
- media regeneration on the SIXEP plant

Table 1 Inputs of nitrate - te N/yr

Thames	4594
BNFL (projected)	4000 - 4500
Mersey	4250
Sludge to Sea (Liverpool Bay)	3970
Eden	3069
BNFL (actual)	2000
Derwent	750

Table 2 Inputs of orthophosphate - te P/yr

Albright & Wilson	1434
Sludge to Sea (Liverpool Bay)	1385
Mersey	1202
Liverpool STW (Sandon Dock)	263
Eden	156

Notes:
The Eden & Derwent dominate West Cumbria riverine inputs.
Thames and Sandon dock are included to put the discharges into context.

In the West Cumbria area sewage discharges are a relatively minor contributor to oxidised N and P, but are significant in respect of ammonia (figures 26-28).

9. Discussion

Interpretation of any data requires care. This axiom seems particularly appropriate in the present case where the underlying rationale behind legislation is often used to suggest a particular conclusion.

Whilst the concept of an HNDA is quite complex, as is apparent from the scope of 'Comprehensive Studies', the fundamental question motivating DoE policy was clearly a quite simple and straightforward question, viz. will the provision of a secondary treatment stage on a particular discharge give a demonstrable environmental benefit. The words are never used but the regulator is being asked to decide *'is the cost of secondary treatment value for money?'* It should again be recalled that the DoE show candidate HNDAs as a zone around the discharge, not a defined geographical area containing *inter alia* the discharge.

All this is quite a long way from the original concept of a Less Sensitive Area. The recent judicial review over the status of the Humber & Severn estuaries has given clear guidance that the regulator should not be influenced by the cost of a particular solution. We are thus left with examining the scientific evidence. Again, definition of the problem is crucial. The HNDA zones on the DoE maps may show very different water quality from immediately adjacent areas, but it is perhaps more pertinent to consider the coastal strip of the NE Irish Sea as a whole and compare this with the generality of UK coastal waters.

It would be quite wrong to suggest that there is direct evidence for increases in unacceptable algal blooms, acute symptoms of eutrophication or a reasonable belief that the general ecosystem is under immediate threat. But.....
The symptoms described above are those which could justify designation as a 'sensitive' area. There is certainly not the data to suggest that this is a necessary option. Our present requirement is to justify HNDA status, and this same data, summarised earlier in this report, does not help underpin the designations.

The evidence to cast doubt on HNDA/less sensitive status for the area as a whole can be summarised as follows:

- saline and thermal stratification in coastal waters
- high industrial inputs of N & P
- consistently high summer chlorophyll-a levels, only the East Anglian coast compares
- summer chlorophyll-a levels above the DoE 10µg/l threshold (see CSTT report)
- summer N & P values which are consistent with the CSTT definition of 'hypernutrified'
- winter N:Si ratios indicative of conditions liable to give rise to eutrophication
- 'patchiness' in nutrient and chlorophyll-a distributions, suggesting imperfect mixing

10. Conclusions

These have to be tentative; the data set is not good enough to be confident. Nevertheless, although incomplete and imperfect the data available to us is as good as in any other region and the differing elements do indicate a common theme.

1. It is difficult to conclude that the provision of secondary treatment, in isolation, on the candidate discharges will provide any meaningful benefit to the regional environment. The one caveat to this conclusion is in ammonia inputs in the West Cumbria region. Here the sewage inputs are a significant contributor to the total and could influence the type of plankton favoured. This must be qualified by saying that the evidence that the nitrate to ammonia ratio has a significant impact is, as yet, slender.

2. Equally, to justify to a judicial review or EU arbiter that the North West coastal waters were 'less sensitive' would be an interesting if not particularly pleasant pastime with the information at our disposal.

11. Acknowledgements

Apart from the usual suspects, the following, have provided help and information:

Janette Allen	Port Erin Marine Laboratory
Peter Head	North West Water Ltd.
Ingrid Jack	Forth River Purification Board
Lindsay Murray	MAFF, Burnham-on-Crouch
Paul Tett	Napier College, Edinburgh

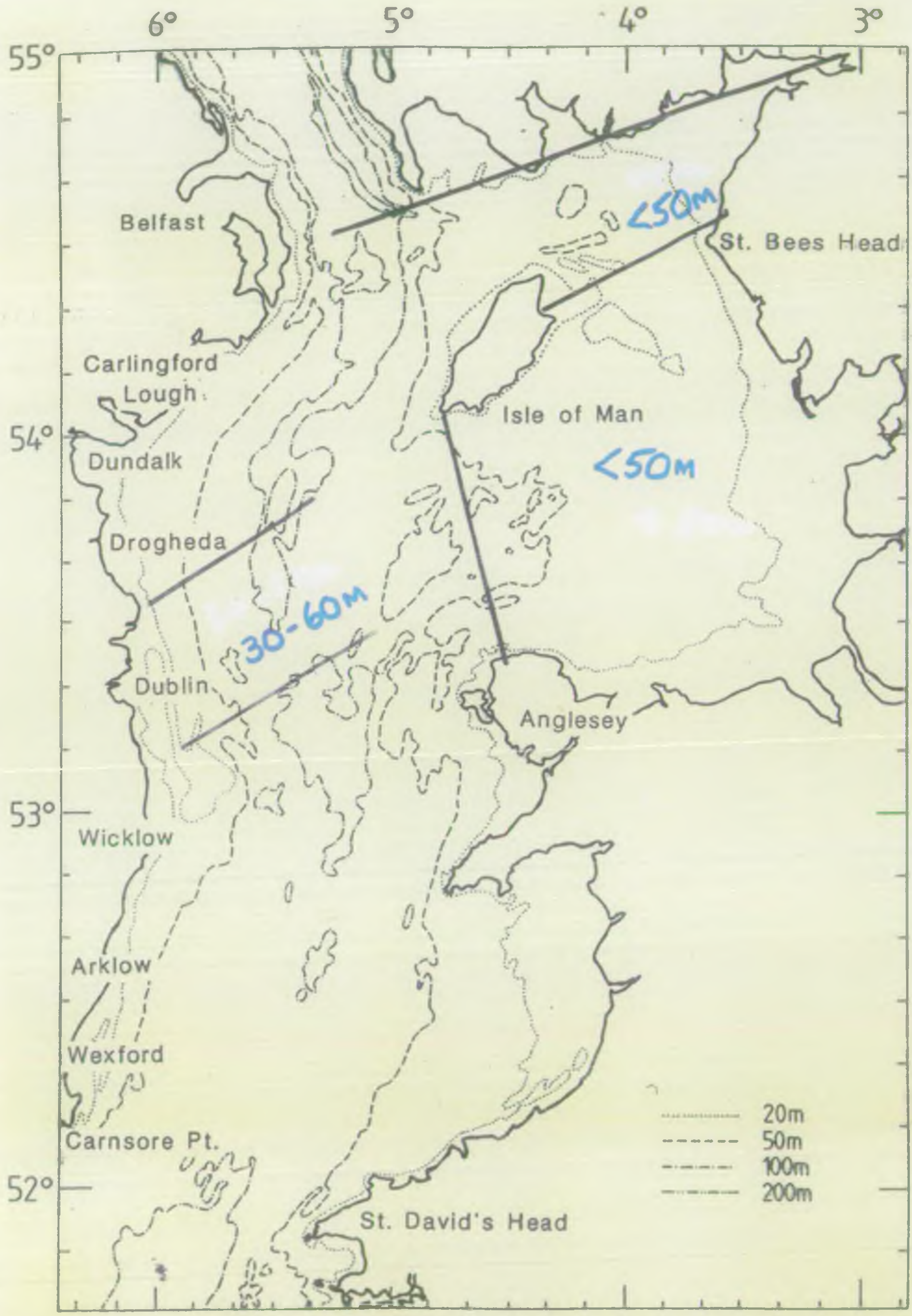


Figure 1 Bathymetry of the Irish Sea.

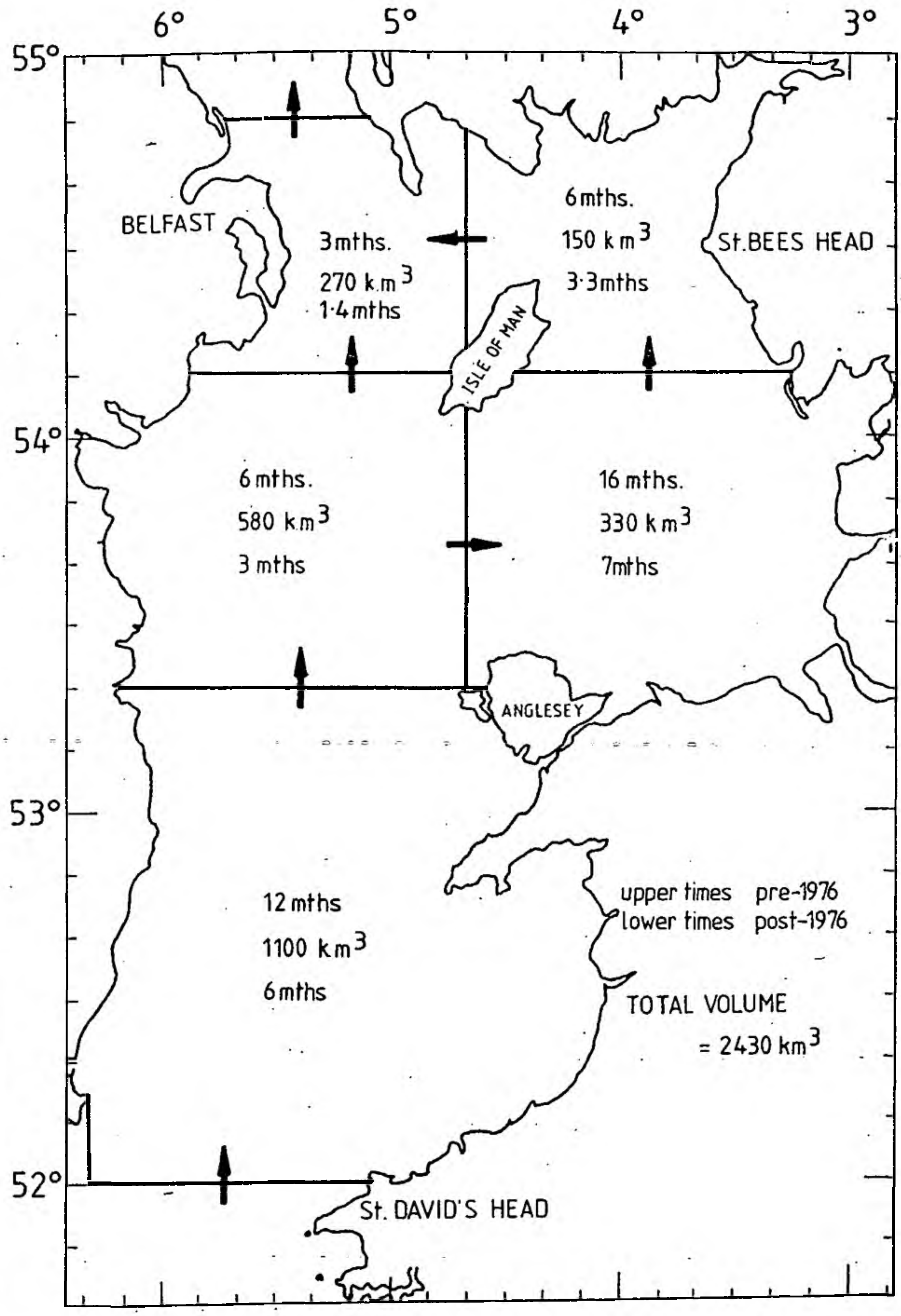


Figure 2 Residence times and volumes for sub-areas of the Irish Sea

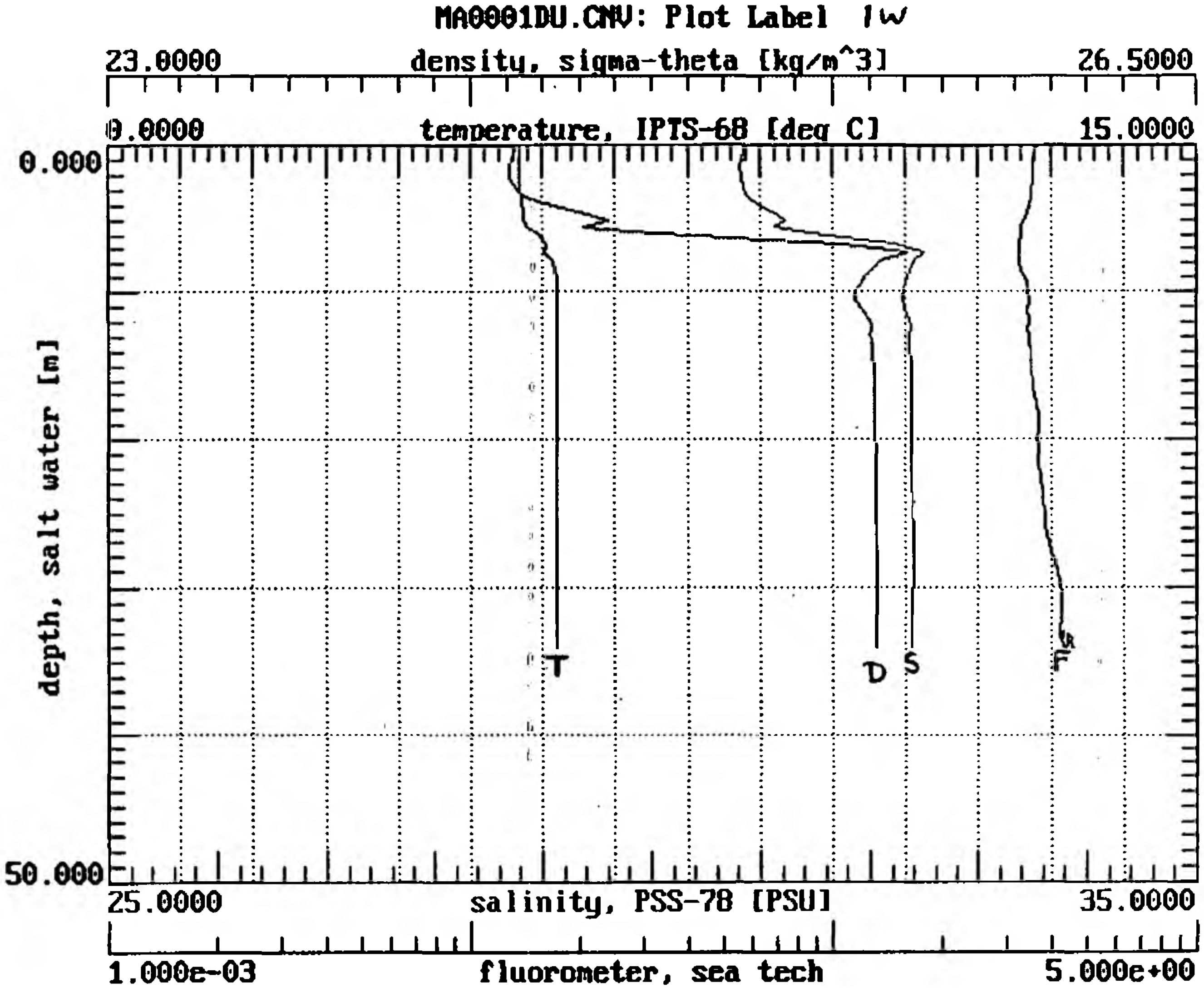


Fig.3
Vertical structure of the water column in northern stratified region, March 1995, showing salinity stratification. Temperature, salinity, density and fluorescence from ctd cast (site 1W).

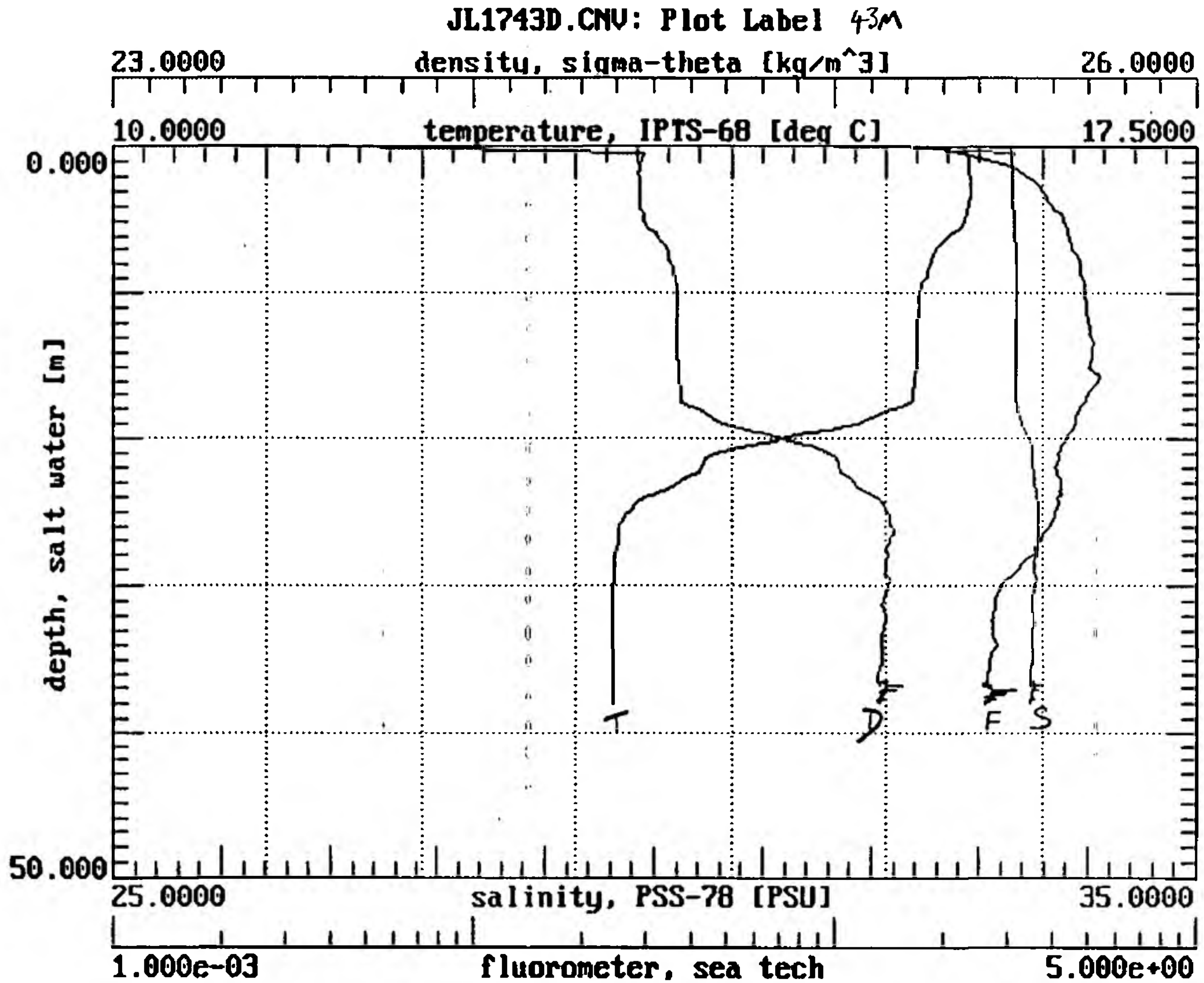


Fig. 4
Vertical structure of the water column in southern stratified region, July 1995, showing thermal stratification. Temperature, salinity, density and fluorescence from ctd cast (site 43M).

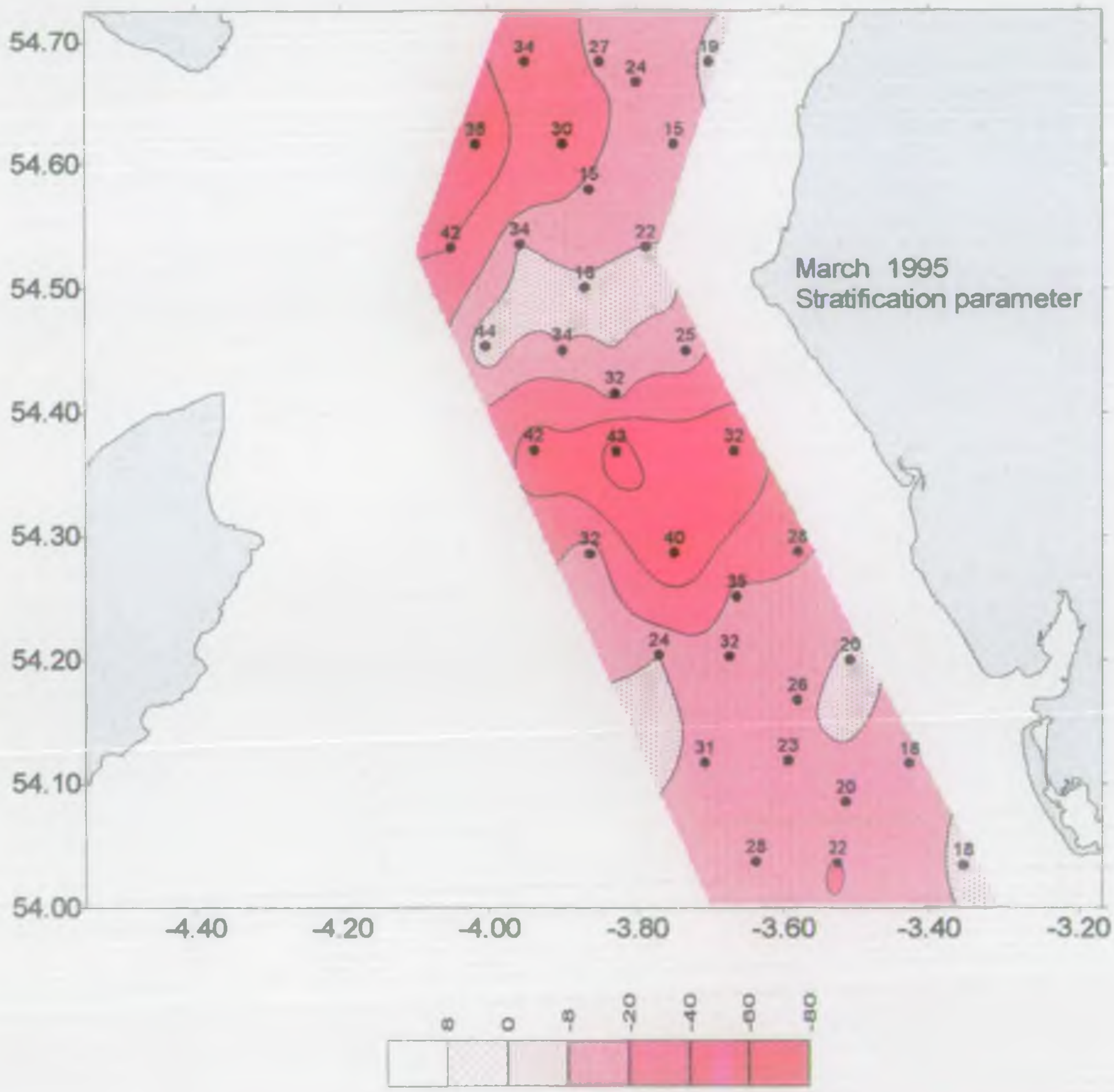


Fig. 5 Simpson's stratification parameter calculated from ctd data, 2nd March 1995. Position and depth (m) of casts are indicated.

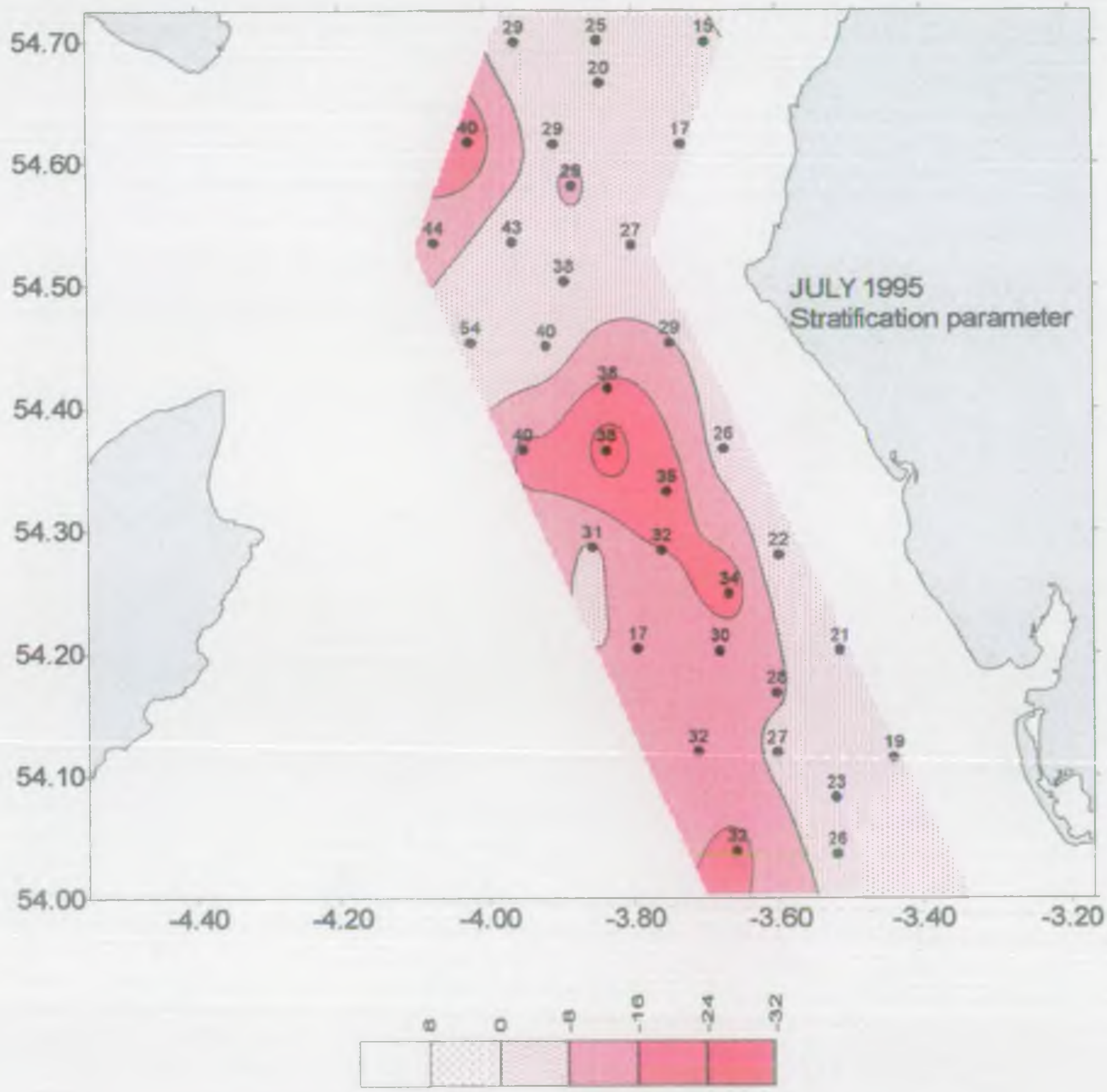
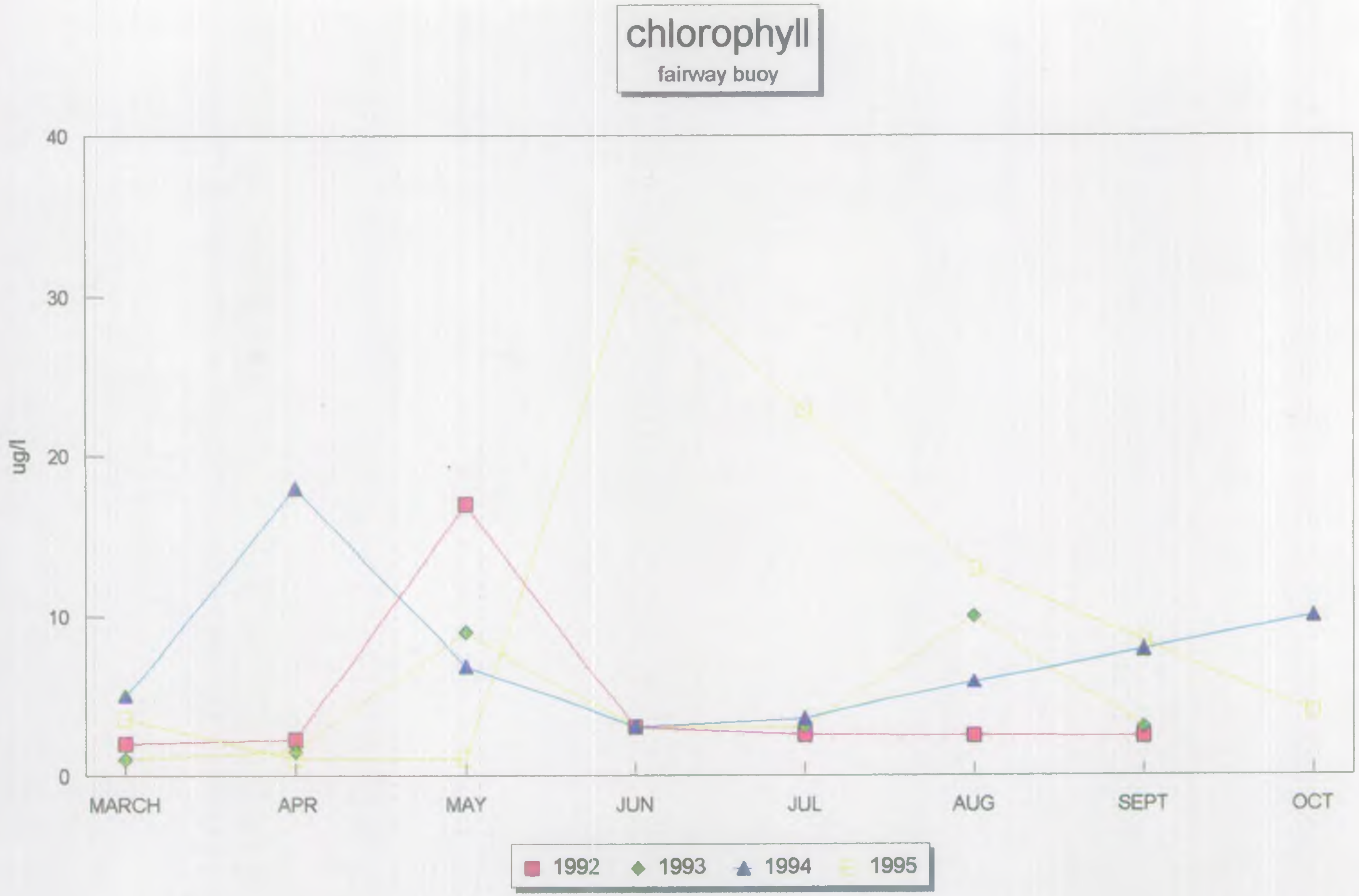


Fig. 6 Simpson's stratification parameter calculated from ctd data, 24th July 1995. Position and depth (m) of casts are indicated.


chlorophyll
fairway buoy
ug/l
0
10
20
30
40
MARCH
APR
MAY
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JUL
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1993
1994
1995

figure7

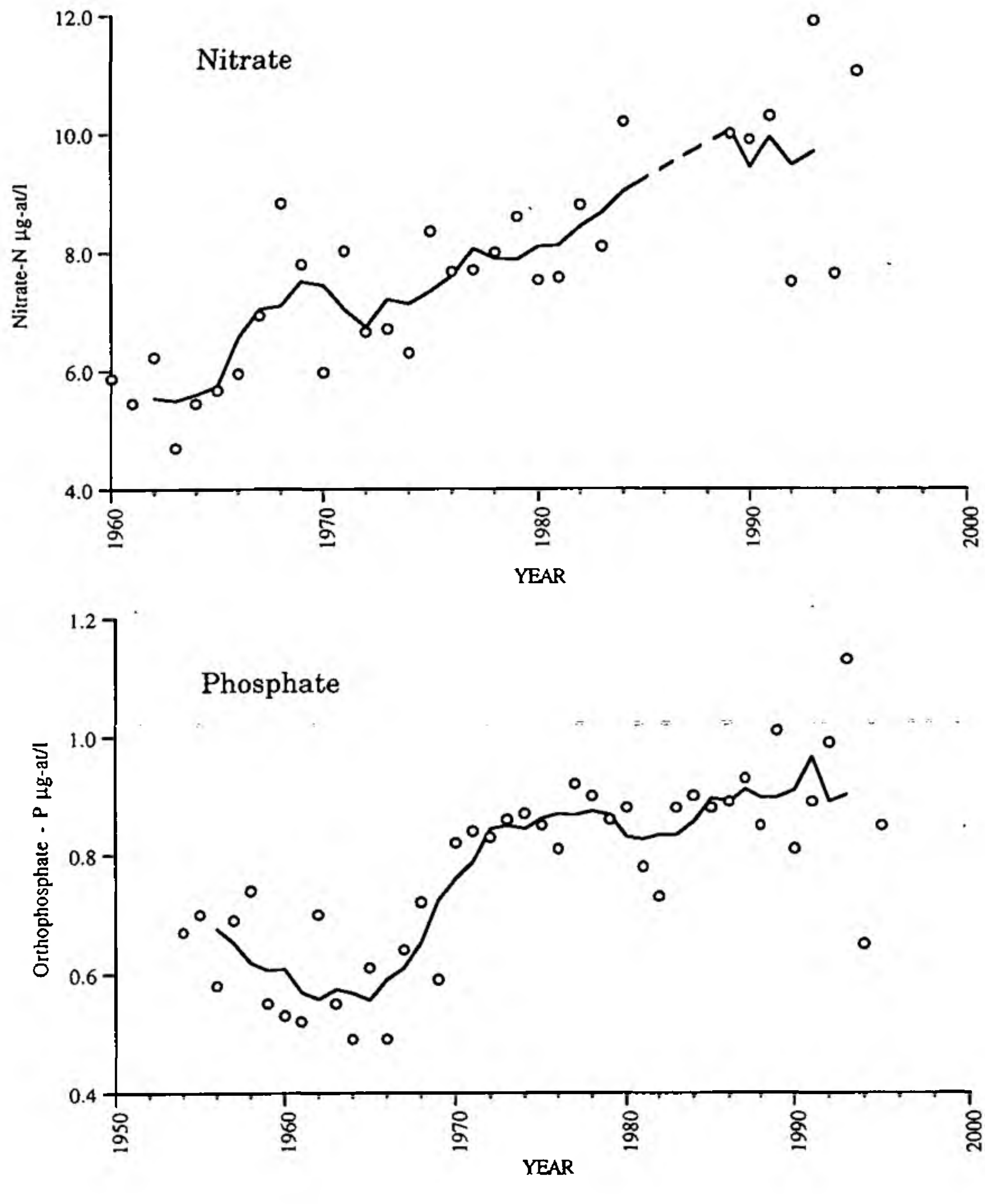


Fig. 8 Annual winter (Dec. to March incl.) maximum concentrations of nitrate (1960 to 1995) and phosphate (1954 to 1995), in surface water at the Cypris Station (open circles), with five year running means (line).

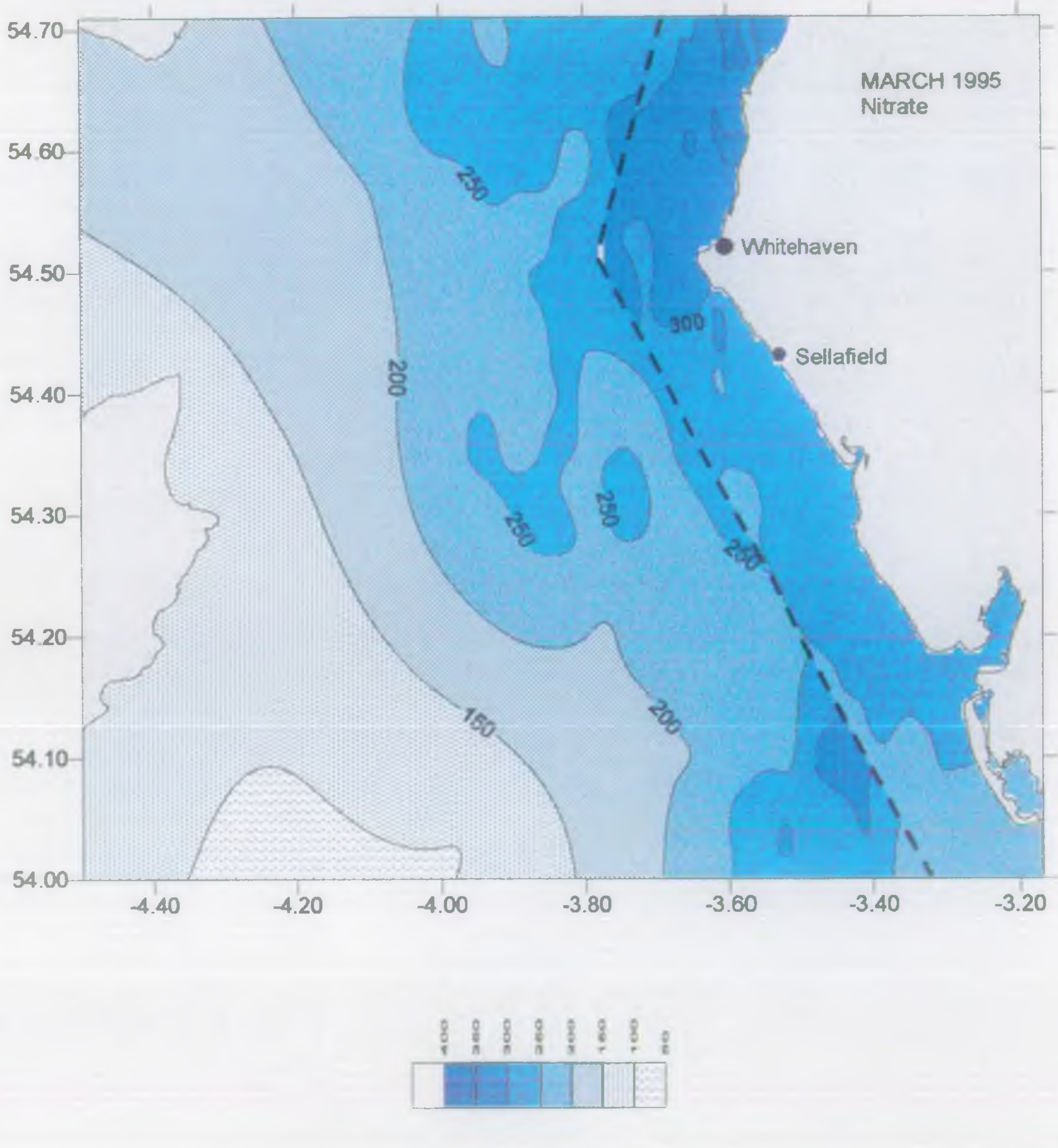


Fig. 9
Nitrate-N µg/l in the eastern Irish Sea March 1995.
Contours west of the dashed line are derived from PEML samples (02/03/95).
Contours east of the dashed line are derived from NRA samples (20/03/95).

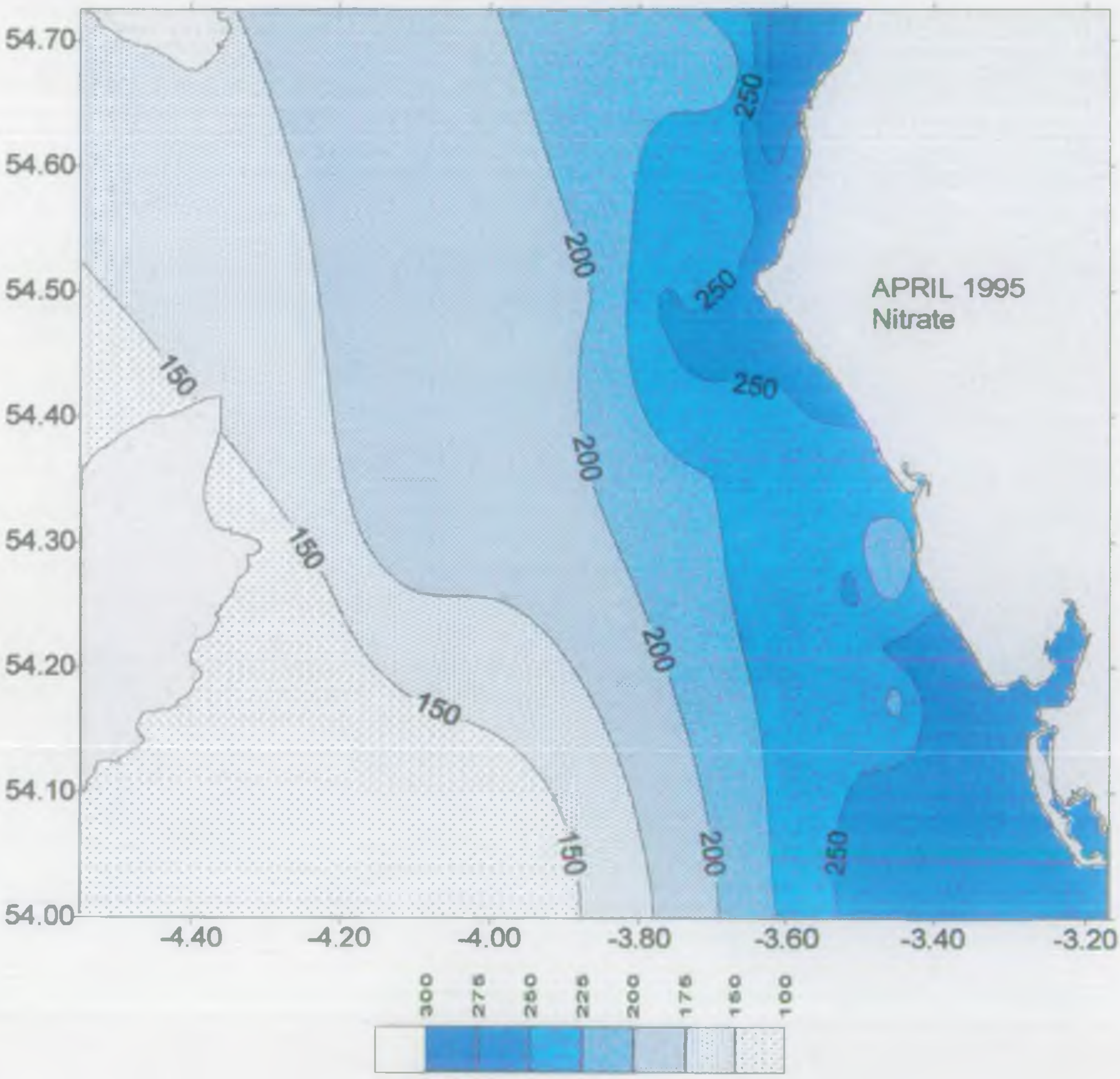


Fig. 10
Nitrate-N µg/l in the north east Irish Sea 3rd April 1995 (from PEML samples).

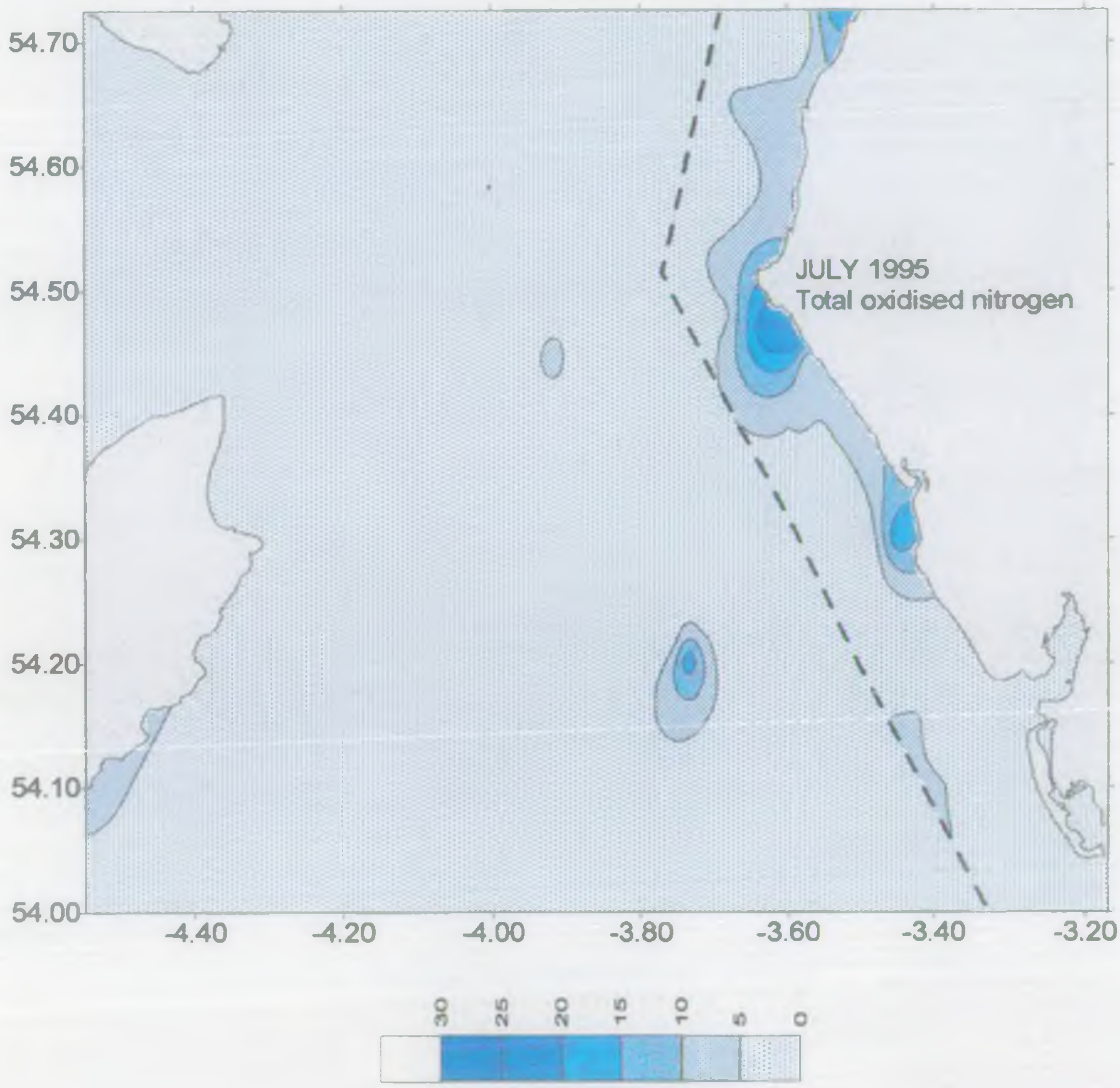


Fig. 11
Nitrate-N in the north east Irish Sea July 1995.
Contours west of the dashed line are derived from PEML samples (24/07/95).
Contours east of the dashed line are derived from NRA samples (24/07/95).

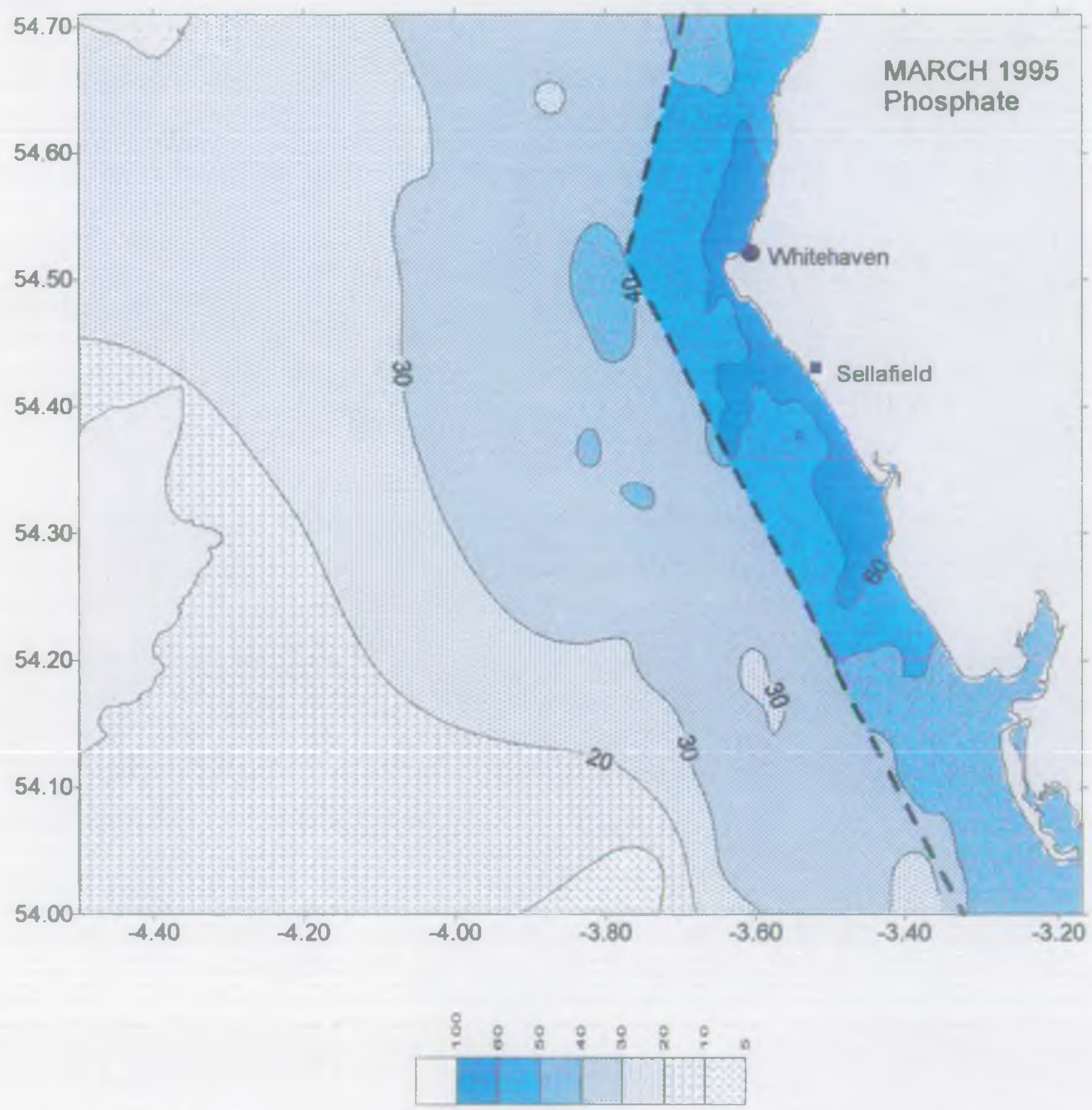


Fig. 12 Orthophosphate-P µg/l in the north east Irish Sea March 1995.
Contours west of the dashed line are derived from PEML samples (02/03/95).
Contours east of the dashed line are derived from NRA samples (20/03/95).

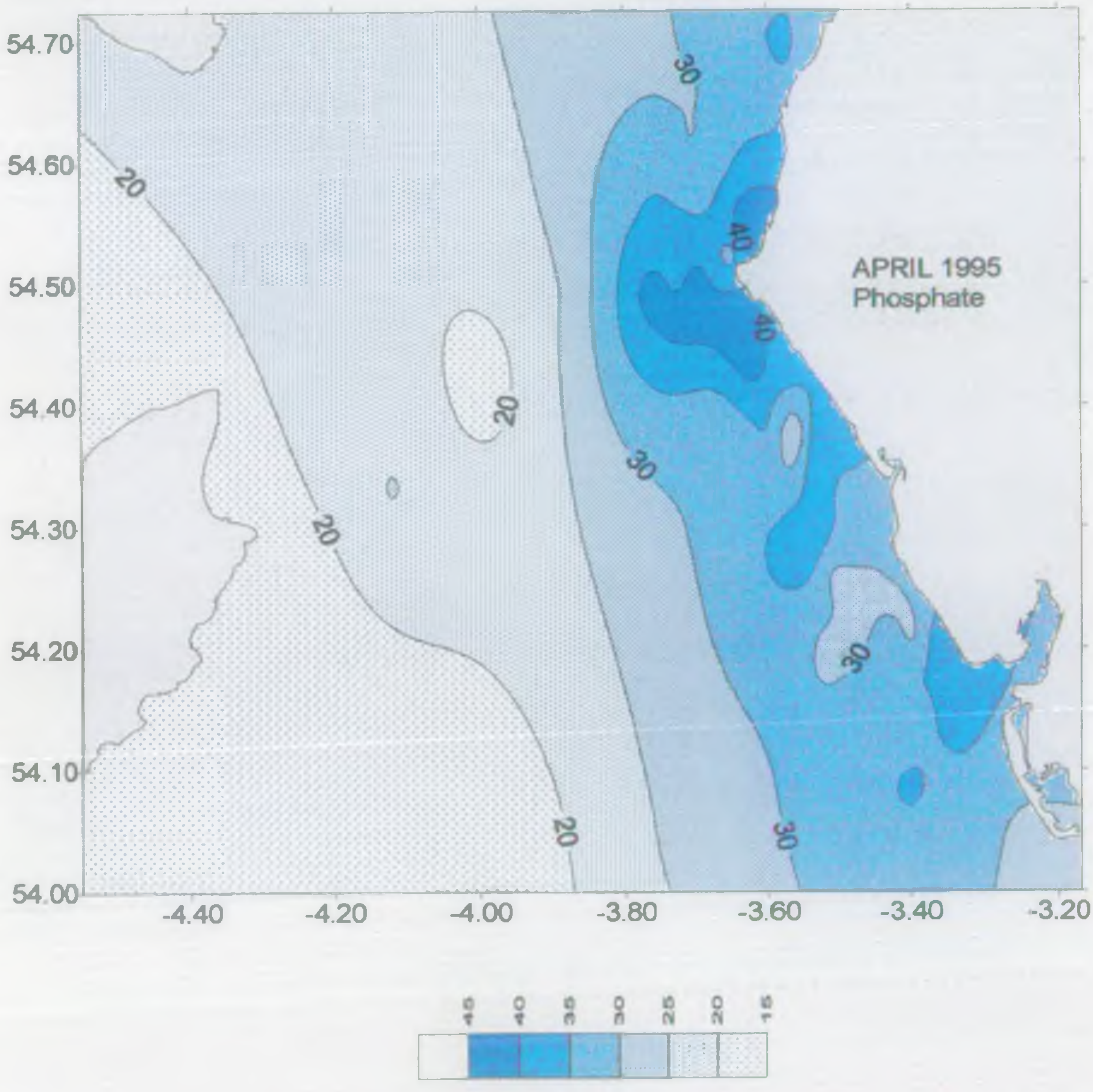


Fig. 13
Orthophosphate µg/l in the north east Irish Sea 3rd April 1995 (PEML samples).

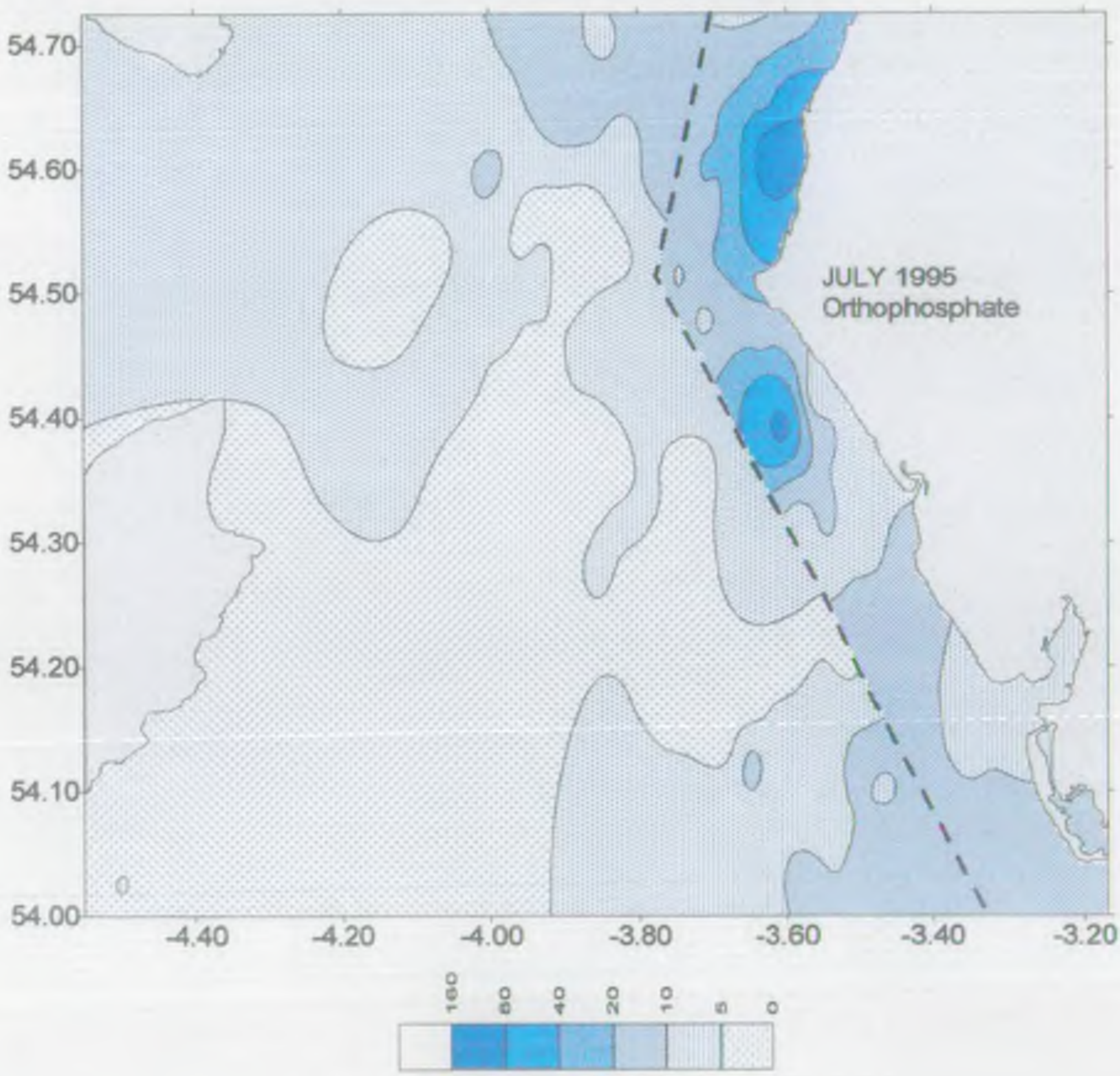
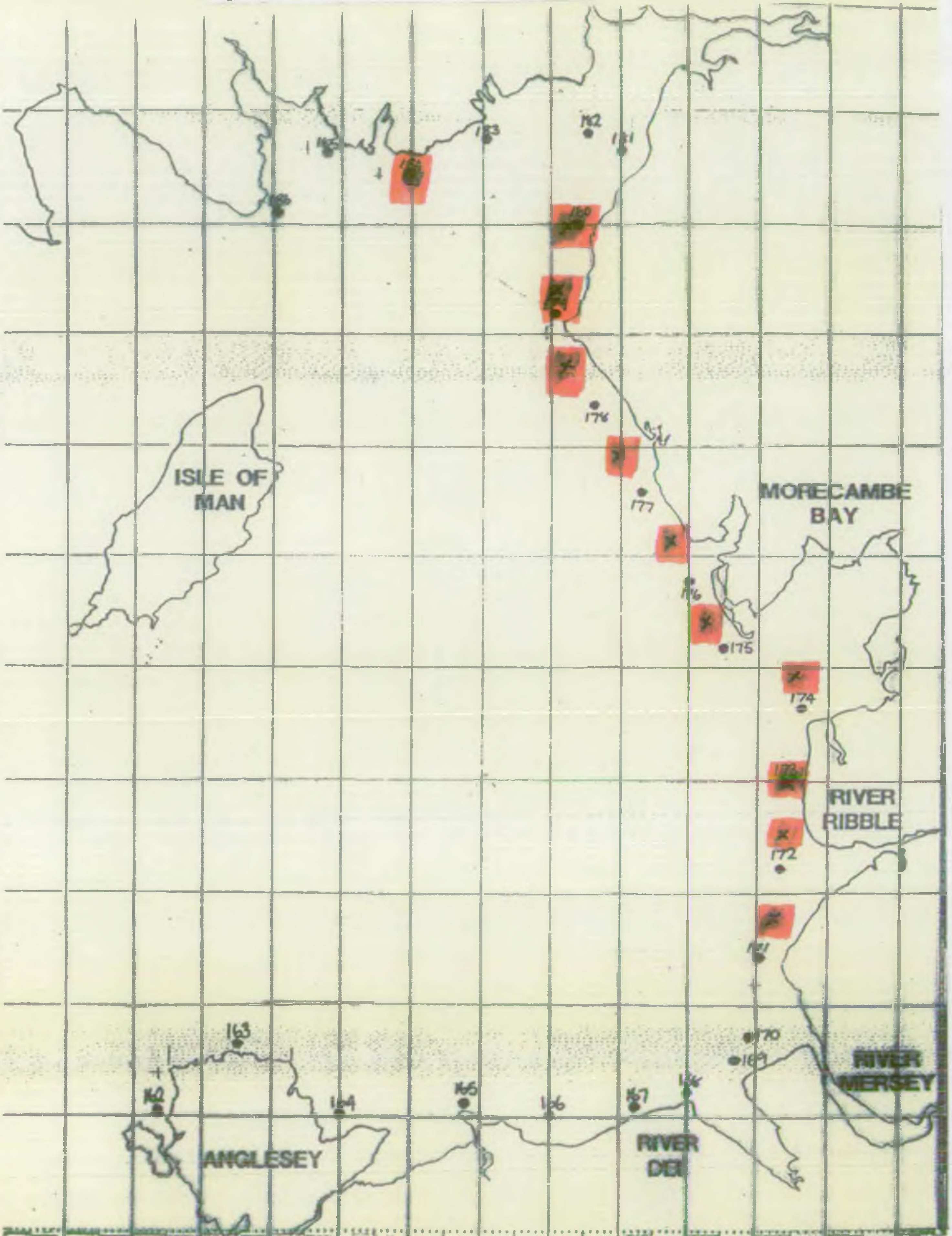


Fig. 14
Orthophosphate-P µg/l in the north east Irish Sea July 1995.
Contours west of the dashed line are derived from PEML samples (24/07/95).
Contours east of the dashed line are derived from NRA samples (24/07/95).

Figure 15 Hypernutrified sampling stations

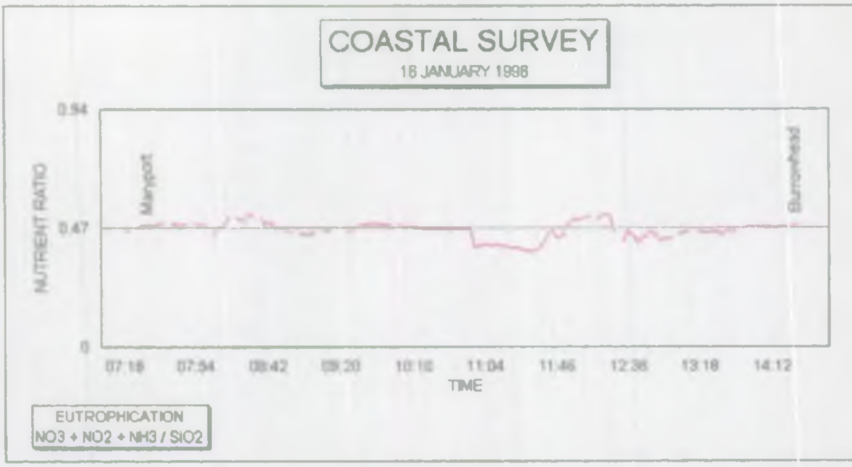


2nd June 94.

TIN >168 + PHOSPHATE > 6·2

COASTAL SURVEY

JUNE 94



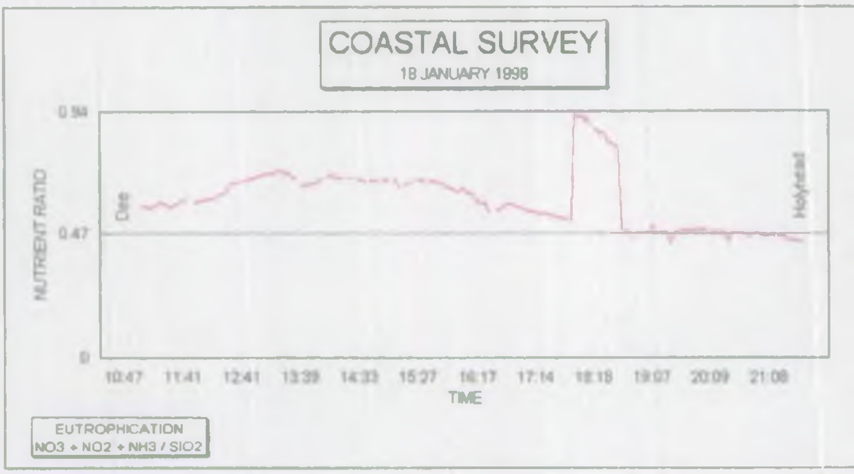
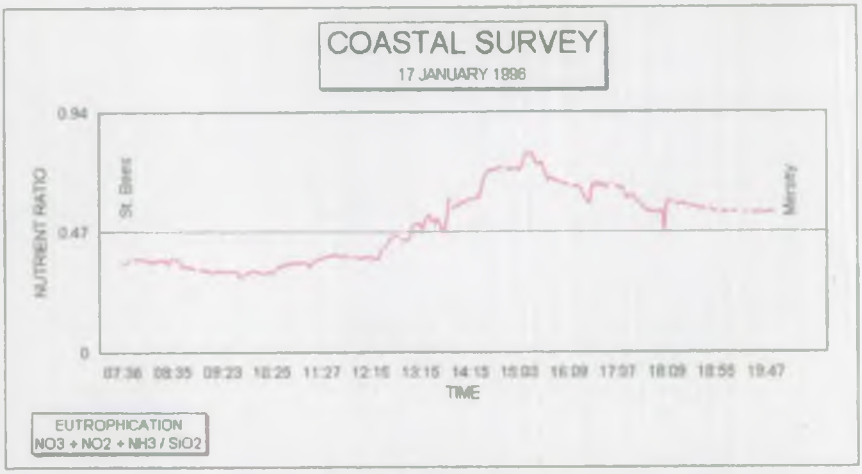
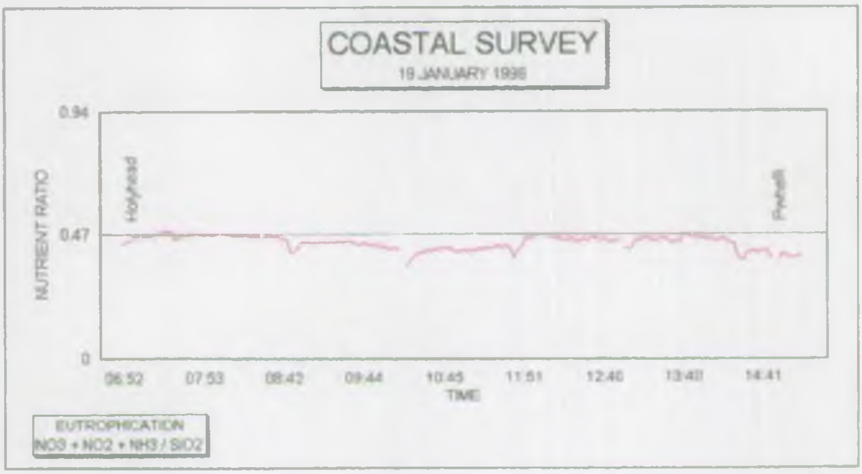


Figure 16 N:Si ratios


COASTAL SURVEY
17 JANUARY 1996
0.94
0.47
0
NUTRIENT RATIO
St. Bees
Mersey
07:36 08:35 09:23 10:25 11:27 12:16 13:15 14:15 15:03 16:09 17:07 18:09 18:55 19:47
TIME
EUTROPHICATION
NO3 + NO2 + NH3 / SiO2


COASTAL SURVEY
19 JANUARY 1996
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NUTRIENT RATIO
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TIME
EUTROPHICATION
NO3 + NO2 + NH3 / SiO2

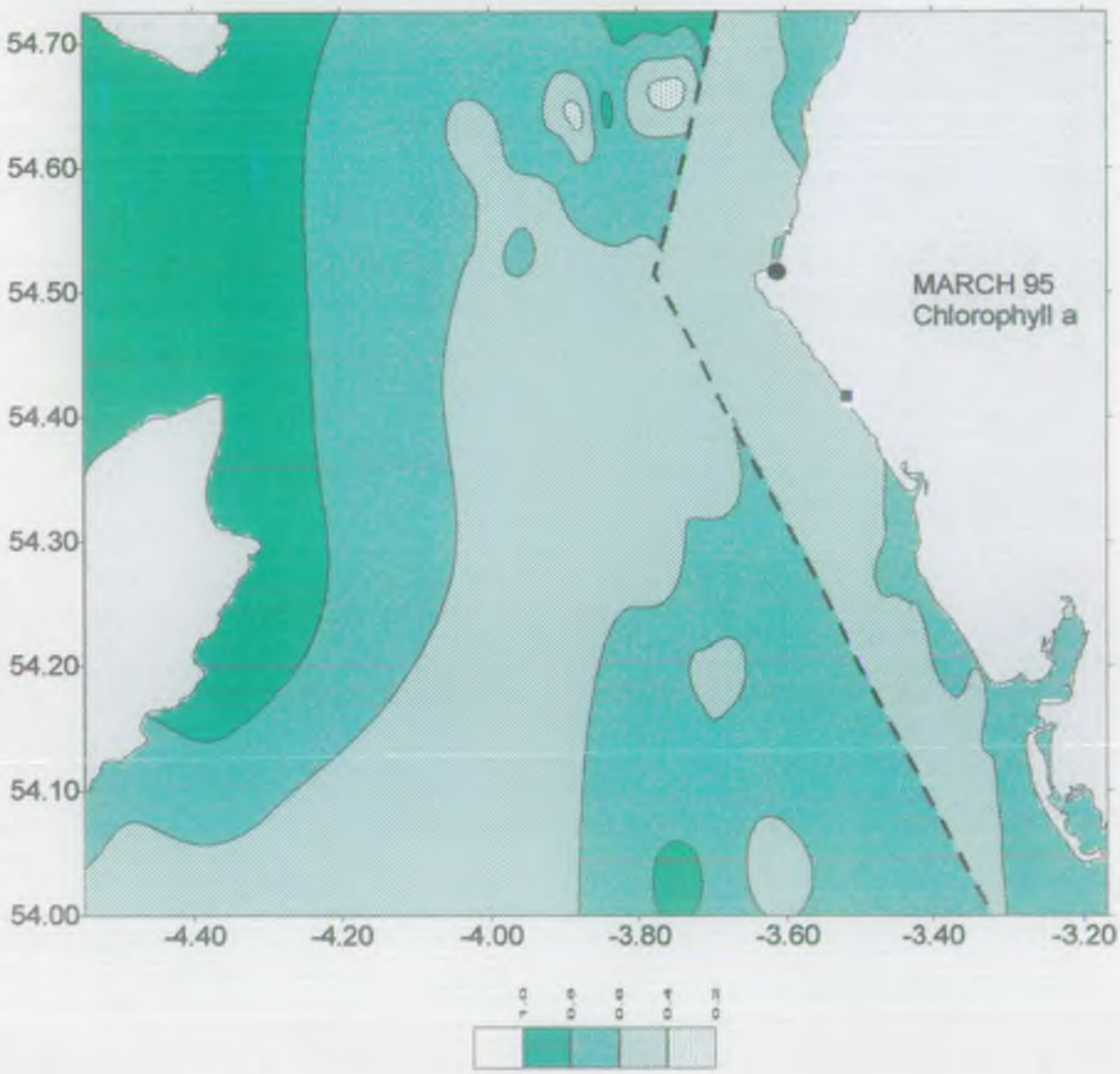

Fig. 17

Chlorophyll a µg/l in the north east Irish Sea March 1995 (fluorimeter readings, surface water).
Contours west of the dashed line are derived from PEML readings (02/03/95).
Contours east of the dashed line are derived from NRA readings (20/03/95).

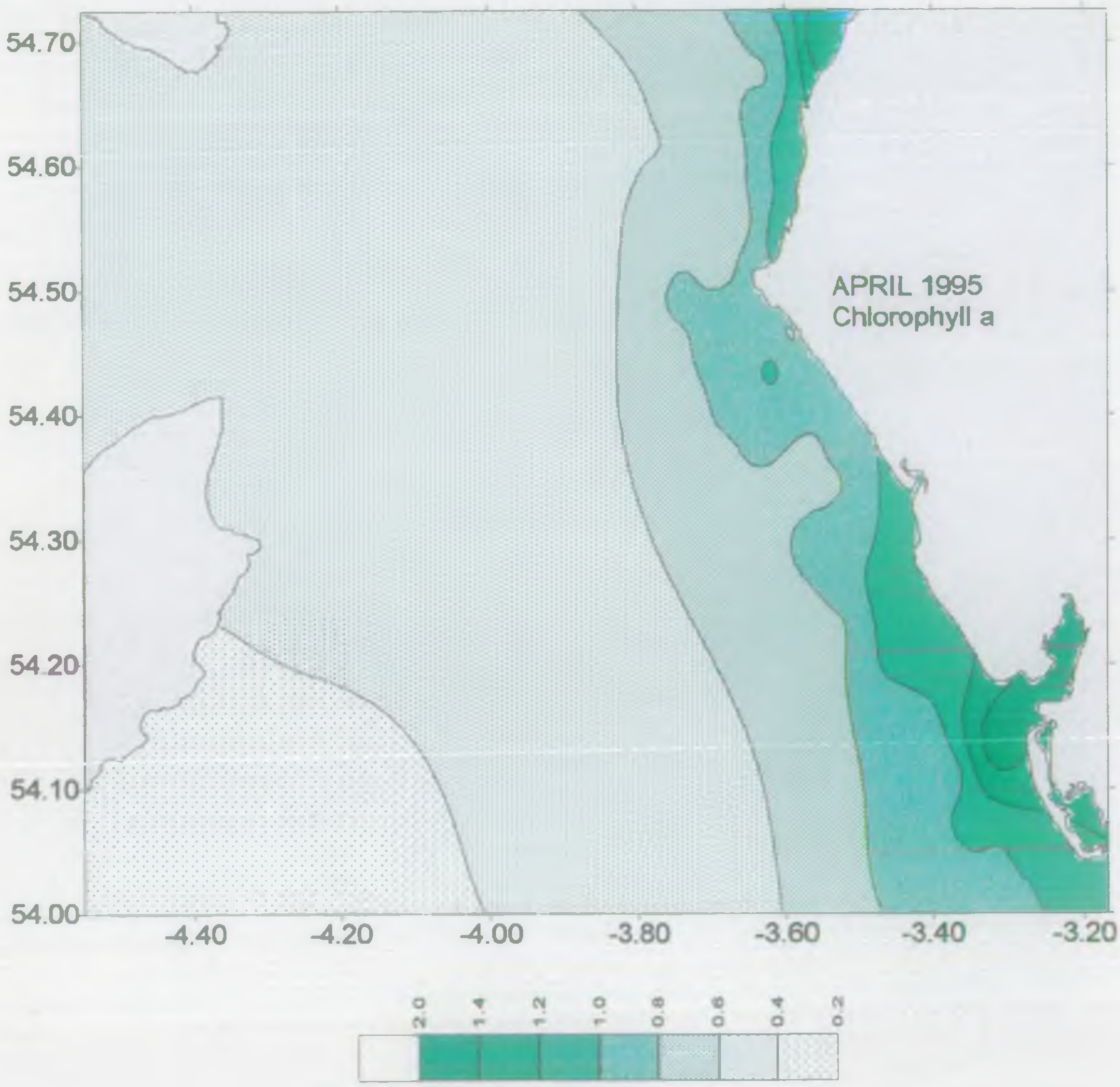

Fig. 18
Chlorophyll a µg/l (fluorescence) in the north east Irish Sea, 3rd April 1995 (PEML samples).

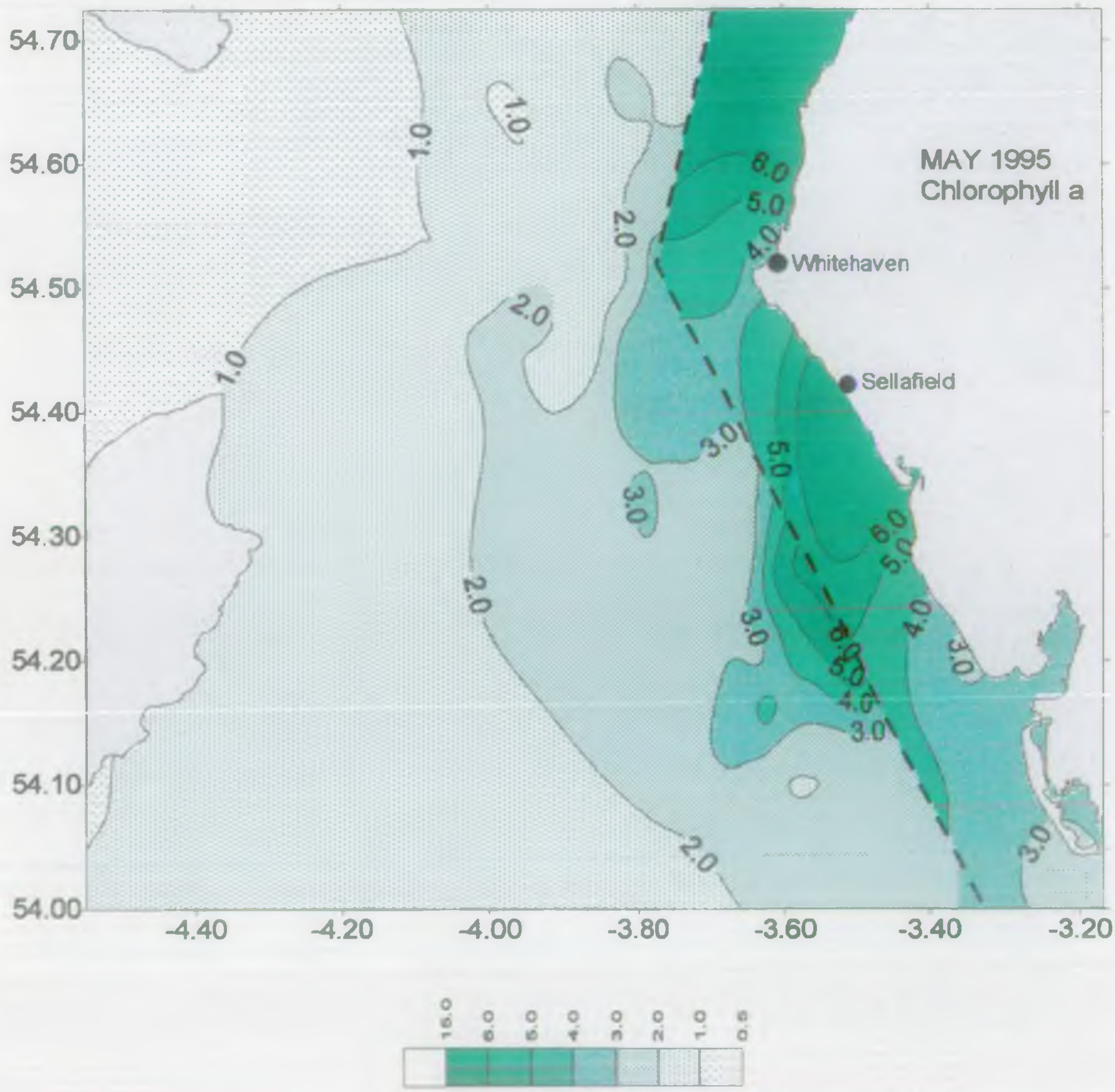

Fig. 19
Chlorophyll a µg/l in the east Irish Sea May 1995.
Contours west of the dashed line are derived from PEML readings (fluorimeter readings, 24/5/95)
Contours east of the dashed line are derived from NRA samples (acetone extraction, 31/5/95)

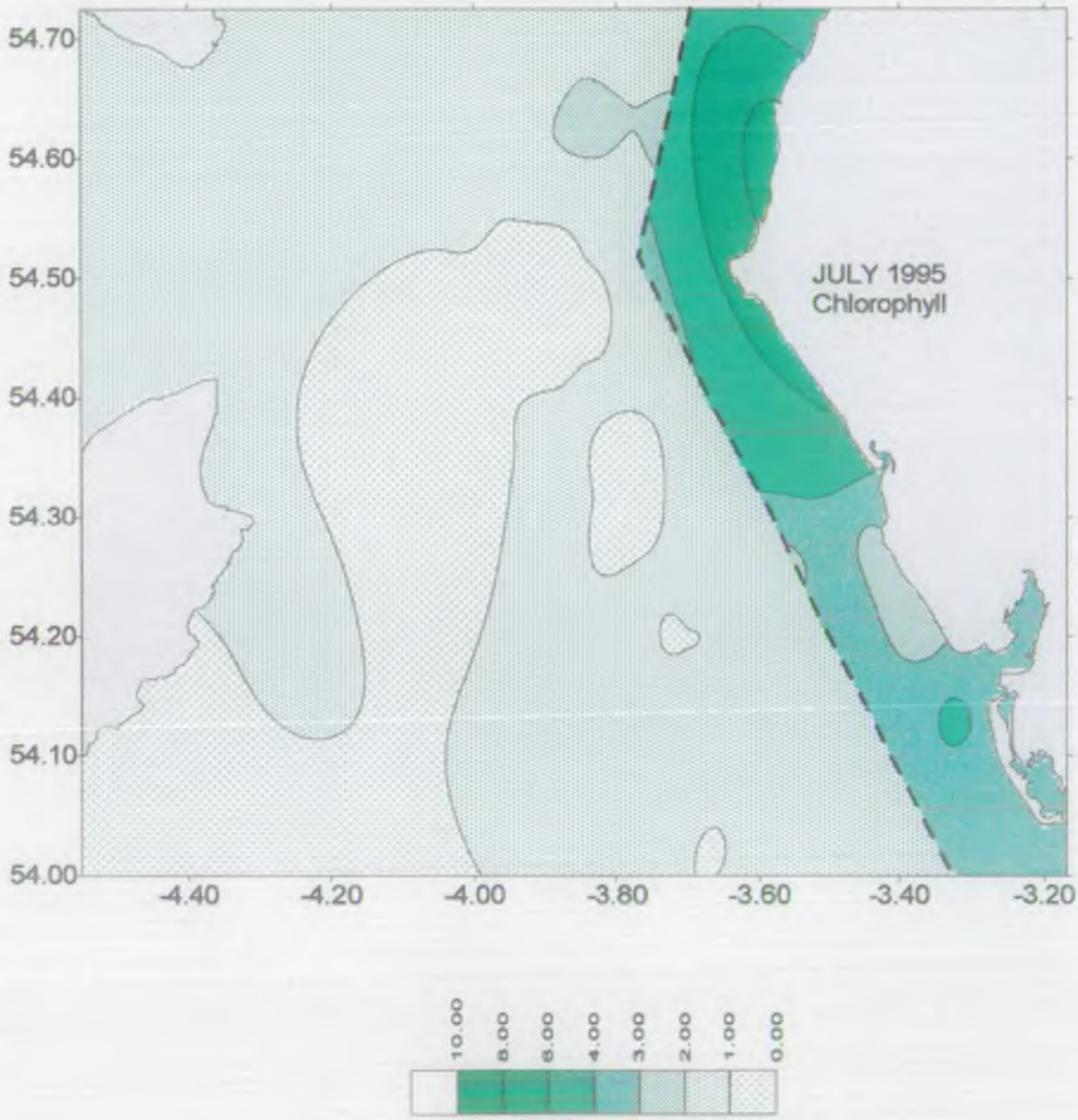

Fig. 20
Chlorophyll a µg/l in the north east Irish Sea July 1995.
Contours west of the dashed line are derived from PEML readings (fluorimeter readings 24/07/95).
Contours east of the dashed line are derived from NRA samples (acetone extraction 24/07/95).

Chlorophyll a Levels, National Baseline Survey, Spring 1993.

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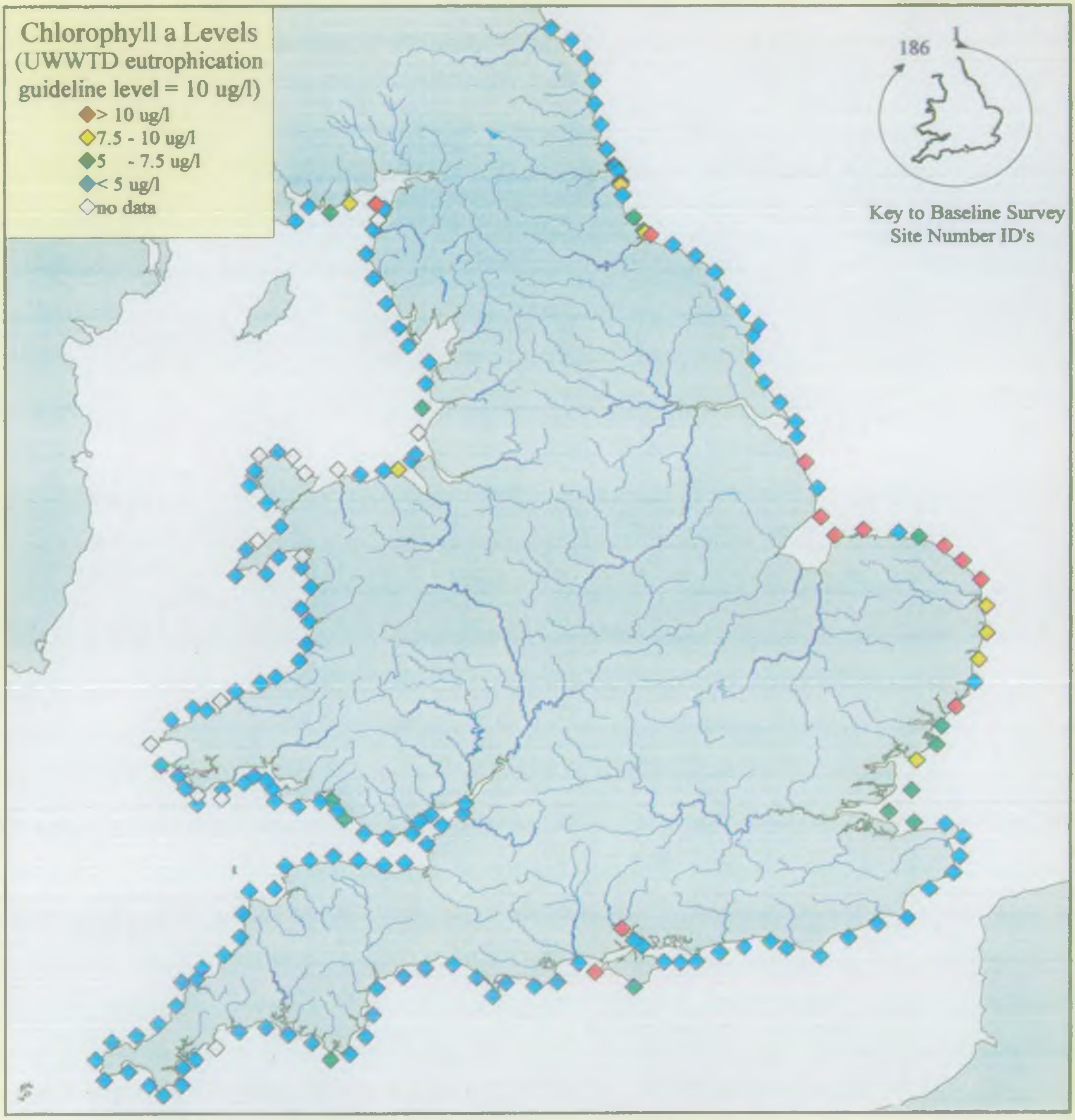

Chlorophyll a Levels, Spring 1993.

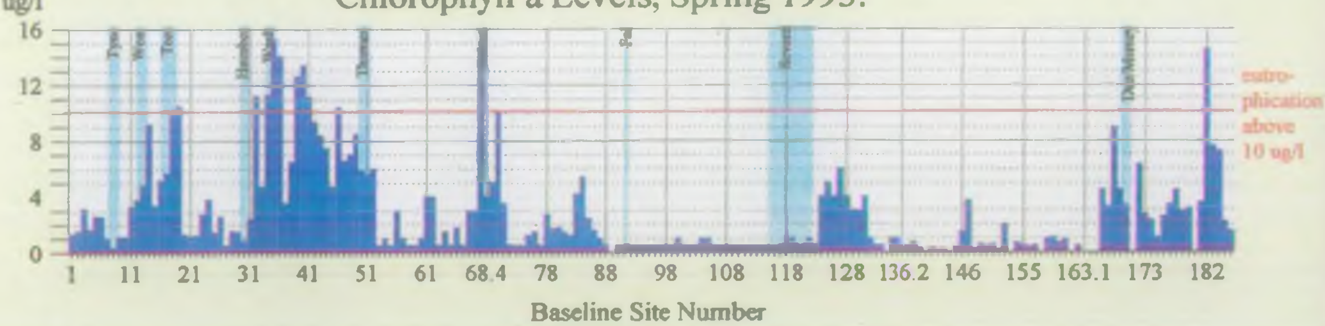

Figure 21

Chlorophyll a Levels, National Baseline Survey, Spring 1994.

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National Centre for Instrumentation and Marine Surveillance

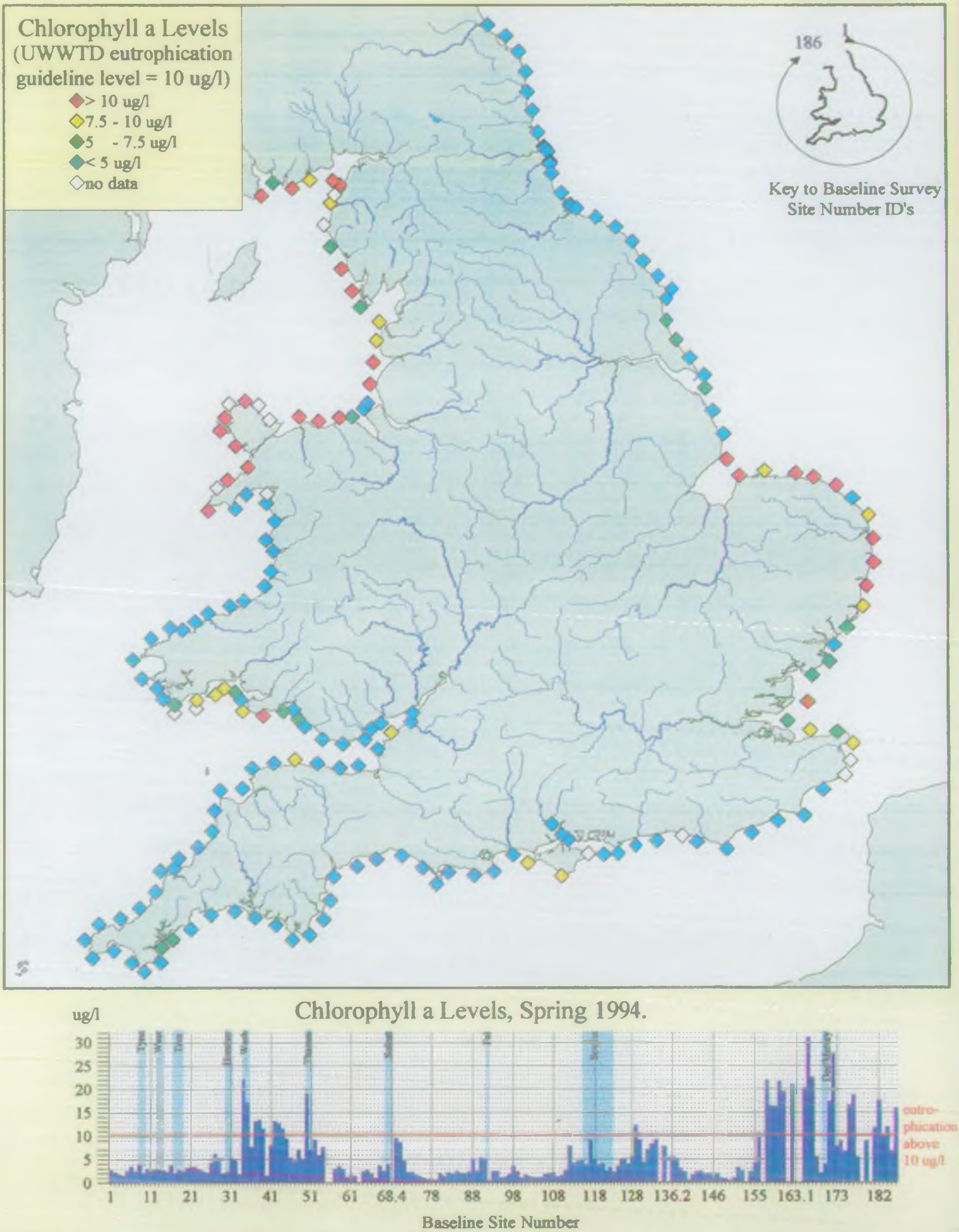

Figure 22

Chlorophyll a Levels, National Baseline Survey, Autumn 1994.

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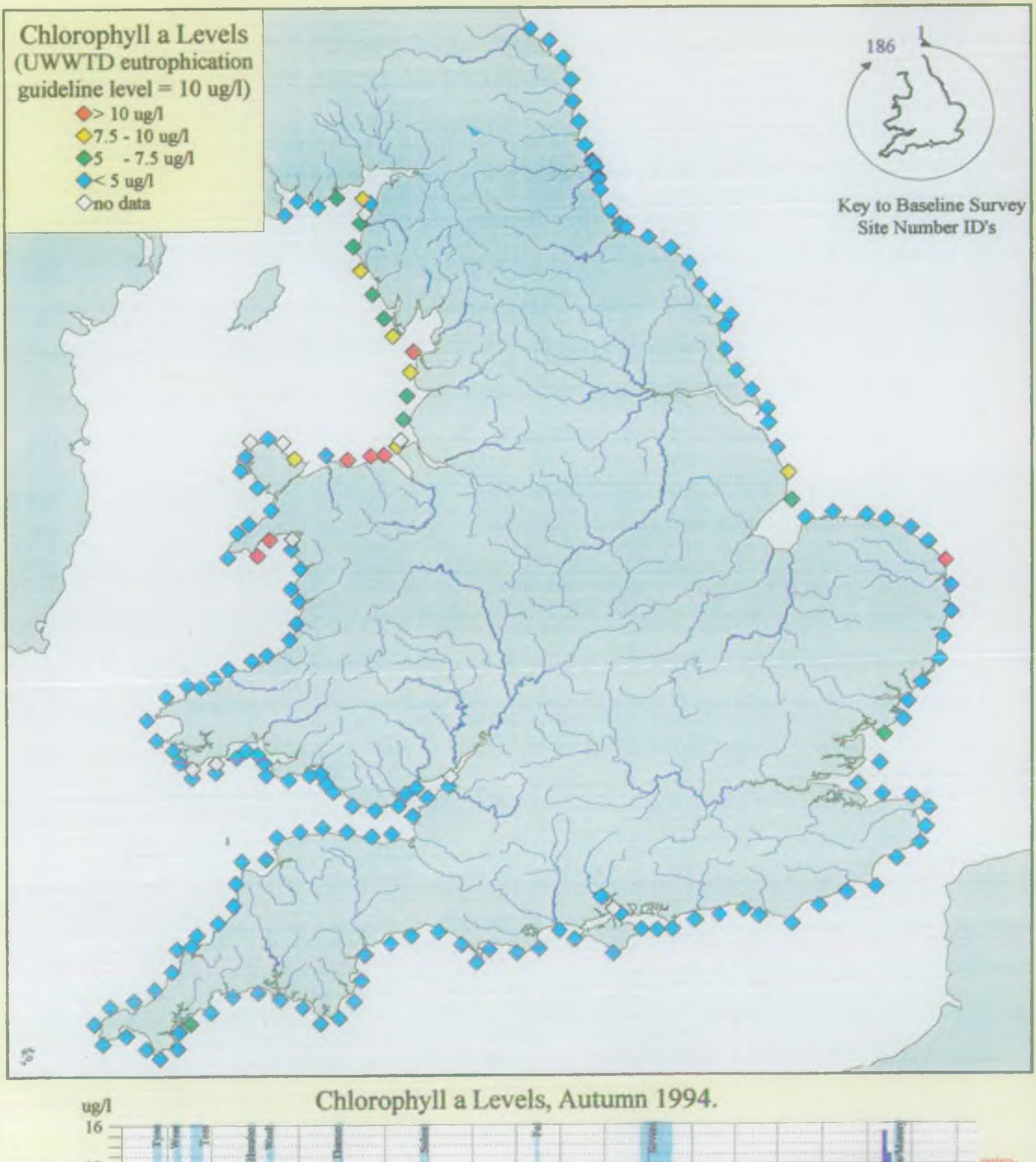


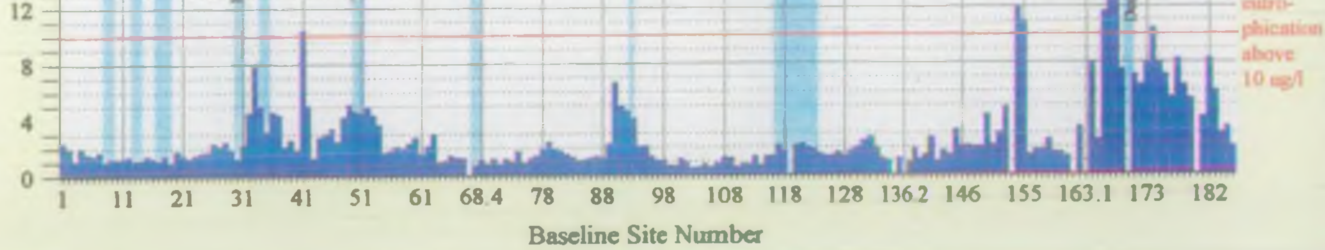
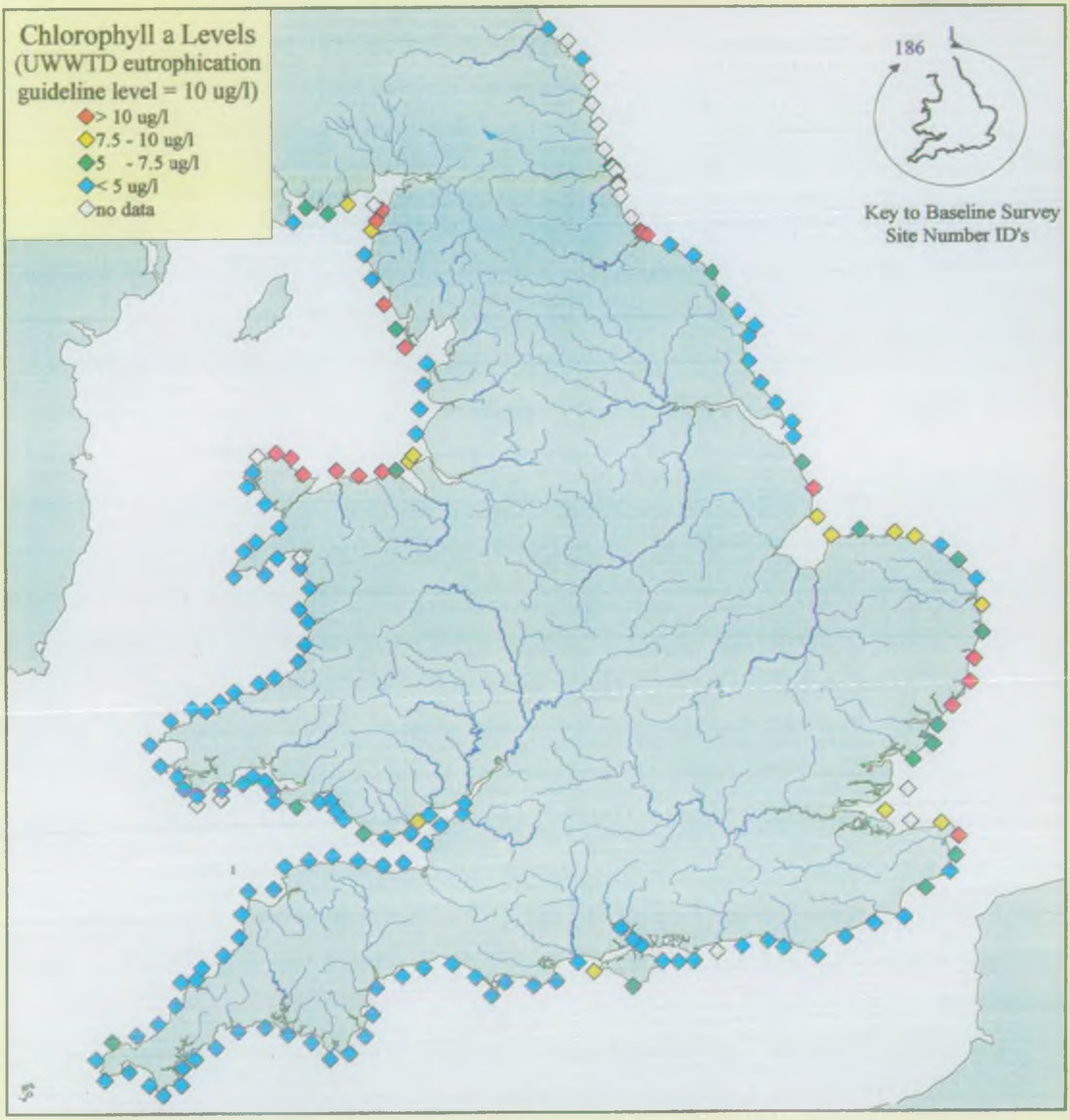


Figure 23

Chlorophyll a Levels, National Baseline Survey, Spring 1995.

NRA
National Centre for Instrumentation and Marine Surveillance



Chlorophyll a Levels, Spring 1995.

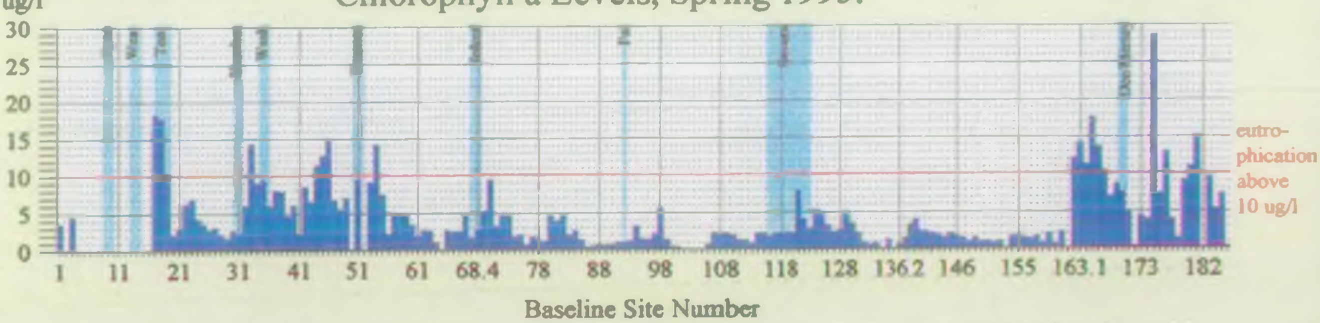


Figure 24

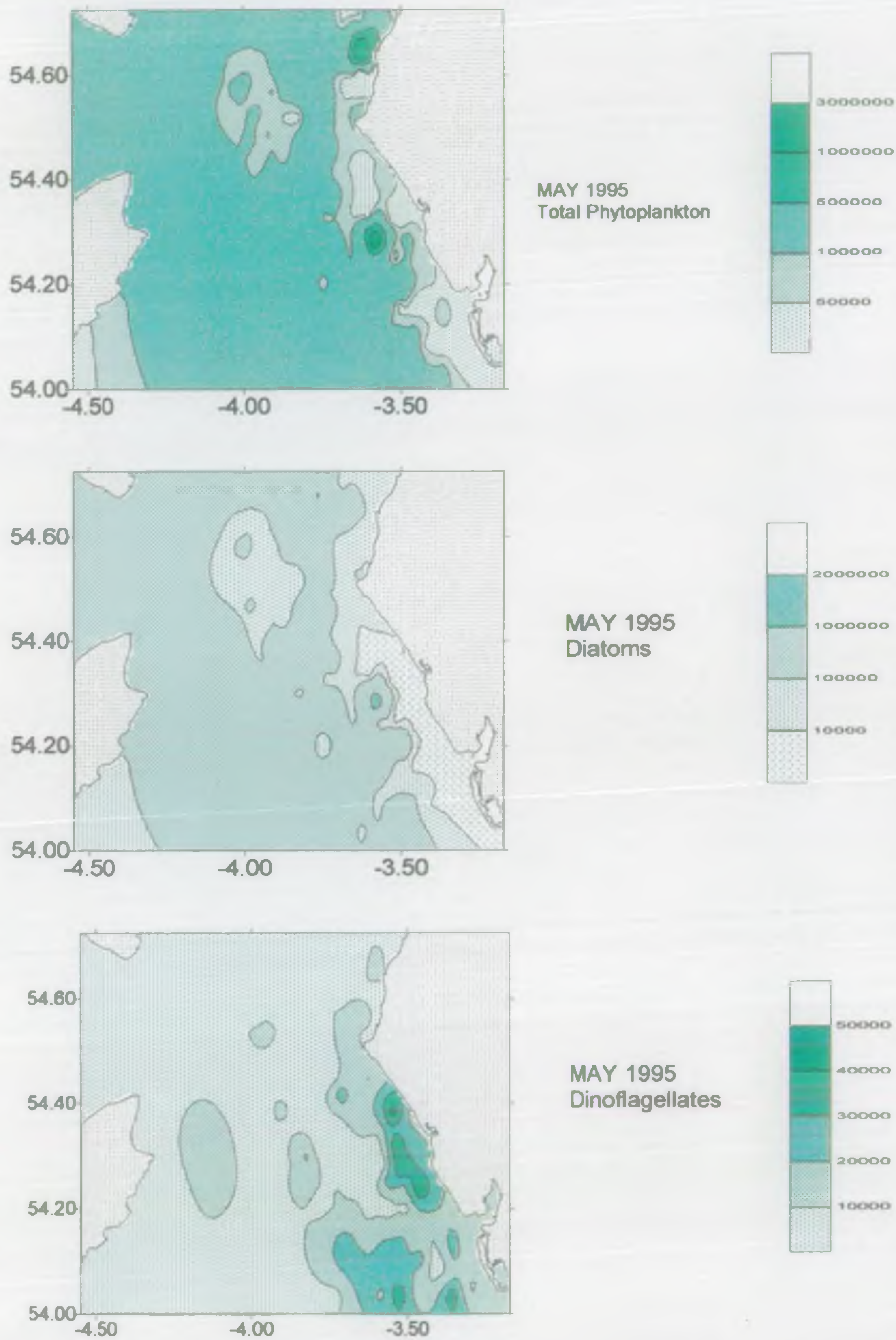


Fig 25
Total phytoplankton, diatom and dinoflagellate cell counts in the north east Irish Sea, surface water, May 23rd (offshore sites) and 31st (inshore sites).

Figure 26: Nitrate-N Inputs
West Cumbria

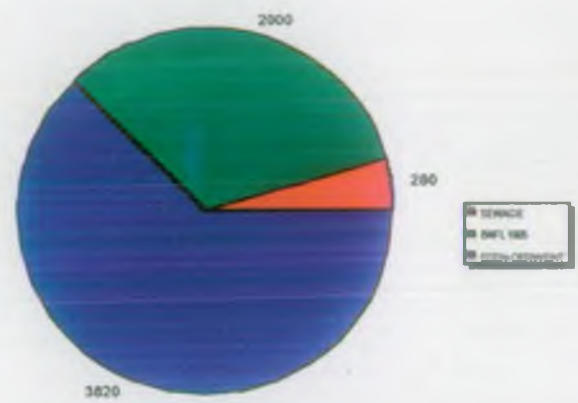


Figure 27: Phosphorous Inputs
West Cumbria

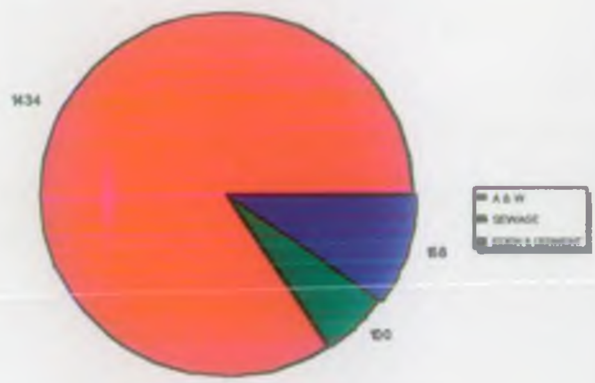


Figure 28: Ammonia Inputs
West Cumbria