Firth of Lorne Study

Grantham, B E; Boyd, David; Gowen, Richard; Lewis, Jane

Publication date:
1983

Firth of Lorne Study: Report No. 3

Hydrography, nutrients and chlorophyll in the Firth of Lorne and its associated sea lochs, 19th-23rd JULY 1982.

Brian Grantham, D. Boyd, R. Gowen, J. Lewis and A. Weeks.

Scottish Marine Biological Association,

Dunstaffnage Marine Research Laboratory,

P.O. Box 3, Oban, Argyll, Scotland.

November 1983

S.M.B.A. Internal Report No. 97

Introduction

This report is the third in the series on the long term study of nutrients, chlorophyll a and hydrography of the Firth of Lorne started in 1979. It contains results from a cruise of R.V. Calanus carried out between 19th and 21st July 1982.

An additional study on dinoflagellate cysts by Jane Lewis (Royal Holloway College, University of London) was conducted during this cruise and is briefly described.

Methods

Temperature and Salinity

Temperature and salinity profiles were obtained with a Braystoke STM 500 instrument. Calibration measurements were taken with reversing thermometers and by precision salinometer readings on discrete samples. Details of the operation and calibration of the Braystoke instrument are given in Jones (1983).

Nutrients

Analyses for dissolved nutrients (nitrate and silicate) were carried out on board 'Calanus' using a Technicon Autoanalyzer. Samples were collected from standard depths using N.I.O. bottles. The water was analysed immediately, without filtration. The methods used were as described in Grantham (1983).

Chlorophyll a

Water collected for nutrient analysis was also filtered and analysed fluorometrically for chlorophyll a as described in Grantham (1983).

Results & Discussion

Table 1 gives details of the stations sampled. Their positions are shown in figure 1. A full set of tabulated data is given in Appendix B. Longitudinal profiles of temperature (fig. 2) and salinity (fig. 3) show several interesting features. There was a pronounced absence of freshwater influence in the lower Firth of Lorne seawards of the Lady Rock. At the three stations surveyed between the Lady Rock and Colonsay, a distance of 44 km, and maximum depth 200 m, the salinity varied between 33.5 and 33.9‰ throughout the water column. In contrast, landwards of the Lady Rock, in the Lynn of Morvern, a brackish surface layer 20 m deep was found, with salinities between 32.3 and 33.4‰. Below this layer the salinity remained almost constant at 33.6‰. In upper Loch Linnhe and Loch Eil the freshwater surface layer was more pronounced.

Three regions of different hydrographic characteristics were apparent. First, a region of thermal stratification found at station FL1, second, a well mixed region in the Firth of Lorne extending up to the Lady Rock at the seaward end of Lismore, and third a region of salinity stratification extending from the Lady Rock landwards.

The effect of stratification on the phytoplankton standing crop can be seen in figure 4 which shows vertical profiles of chlorophyll concentration at selected stations together with a tabulation of the difference between σt values at 10 m and 2 m at these stations - a simple measure of the stability of the surface water. In general those stations with the greatest stability showed the highest chlorophyll levels in the top 10 m of the water column. Station E70 showed unusual

trends, having higher chlorophyl levels in the deeper water. This may be because of its unusual hydrography (Grantham, 1981). The phytoplankton in the deeper water probably originated outside the loch and were brought in on the flood tide. The presence of colder water (of higher nutrient content) below 80 m in upper Loch Linnhe compared with the well flushed conditions in the Lynn of Morvern and the Firth of Lorne illustrated the longer residence time of water in this basin.

Longitudinal profiles of nitrate (fig. 5) and silicate (fig. 6) showed low values throughout the system, the highest values being found in the deeper water at station LM4 (Loch Linnhe), in upper Loch Linnhe and Loch Eil. These values may indicate localised regeneration of organic matter in the deep basins or may represent remnants of the old winter water which had not been completely replaced by summer water.

In general, nutrient concentrations would be expected to have reached their minimum values for the summer although in the semi-isolated deep basins minima would be reached some two or three months later.

References

Grantham, B. (1981). The Loch Eil project: chlorophyll a and nutrients in the water column of Loch Eil. J. exp. mar. Biol. Ecol., 55 : 283-297.

Grantham, B. (1983). Firth of Lorne Study: Report No. 1. Introduction and details of programme, with data for the period February 1979 to August 1981. S.M.B.A. Internal Report No. 86.

Jones, K. (1983).

List of Figures and Tables

Table 1 Station List

Station E24

Loch Eil, lat. 56°51'N, long. 5°16'.9 W, depth 40 m.

Station E70

Loch Eil, lat. 56°51'.1N, long. 5°12'.6 W, depth 65 m.

Station LL2

Upper Loch Linnhe, lat. 56°47'.7N, long. 5°9'.1 W, depth 110 m.

Station LL1

Upper Loch Linnhe, lat. 56°40'.8N, long. 5°12'.5 W, depth 150 m.

Station LM4

Loch Linnhe, lat. 56°38'.2N, long. 5°22'.3W, depth 95 m.

Station LM3

Loch Linnhe, lat. 56°34'.6N, long. 5°28'.6W, depth 100 m.

Station LM1

Lynn of Morvern, lat. 56°29'.6N, long. 5°38'.4W, depth 200 m.

Station C3

Loch Creran, lat. 56°31'N, long. 5°22'.4 W, depth 45 m.

Station LY1

Lynn of Lorne, lat. 56°28'.9N, long. 5°30'.1 W, depth 43 m.

Station FL3

Firth of Lorne, lat. 56°19'.4N, long. 5°43'.2 W, depth 210 m.

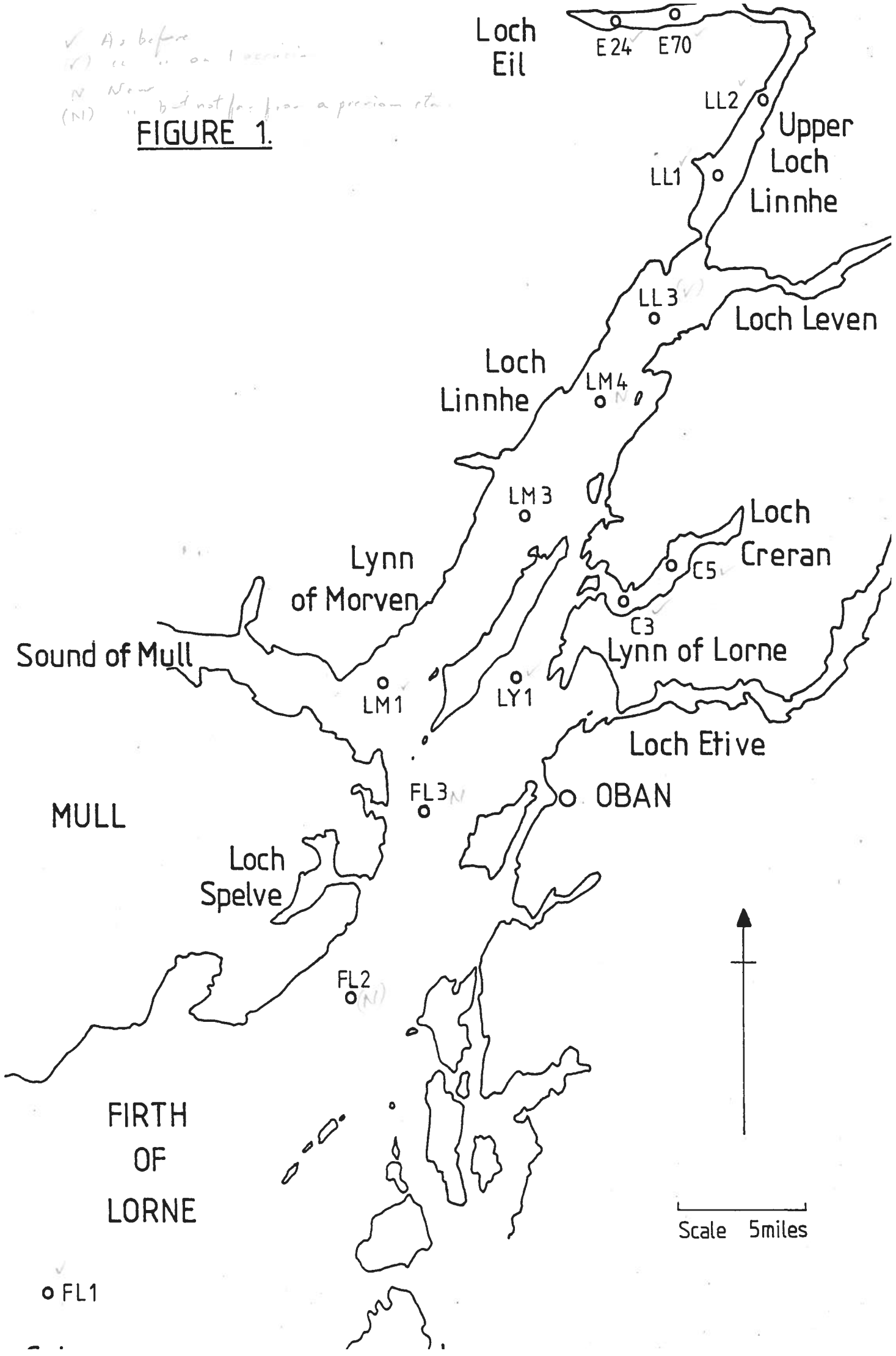
Station FL2

Firth of Lorne, lat. 56°24'.7N, long. 5°36'.5W, depth 210 m.

Station FL1

Off Colonsay, lat. 56°11'N, long. 6°4'.5 W, depth 80 m.

FIGURE 1.


Loch Eil
E24
E70
LL2
Upper Loch Linnhe
LL1
LL3
Loch Leven
Loch Linnhe
LM4
LM3
Loch Creran
C5
Lynn of Morven
C3
Lynn of Lorne
Sound of Mull
LM1
LY1
Loch Etive
FL3
OBAN
MULL
Loch Spelve
FL2
FIRTH OF LORNE
FL1
Scale 5miles

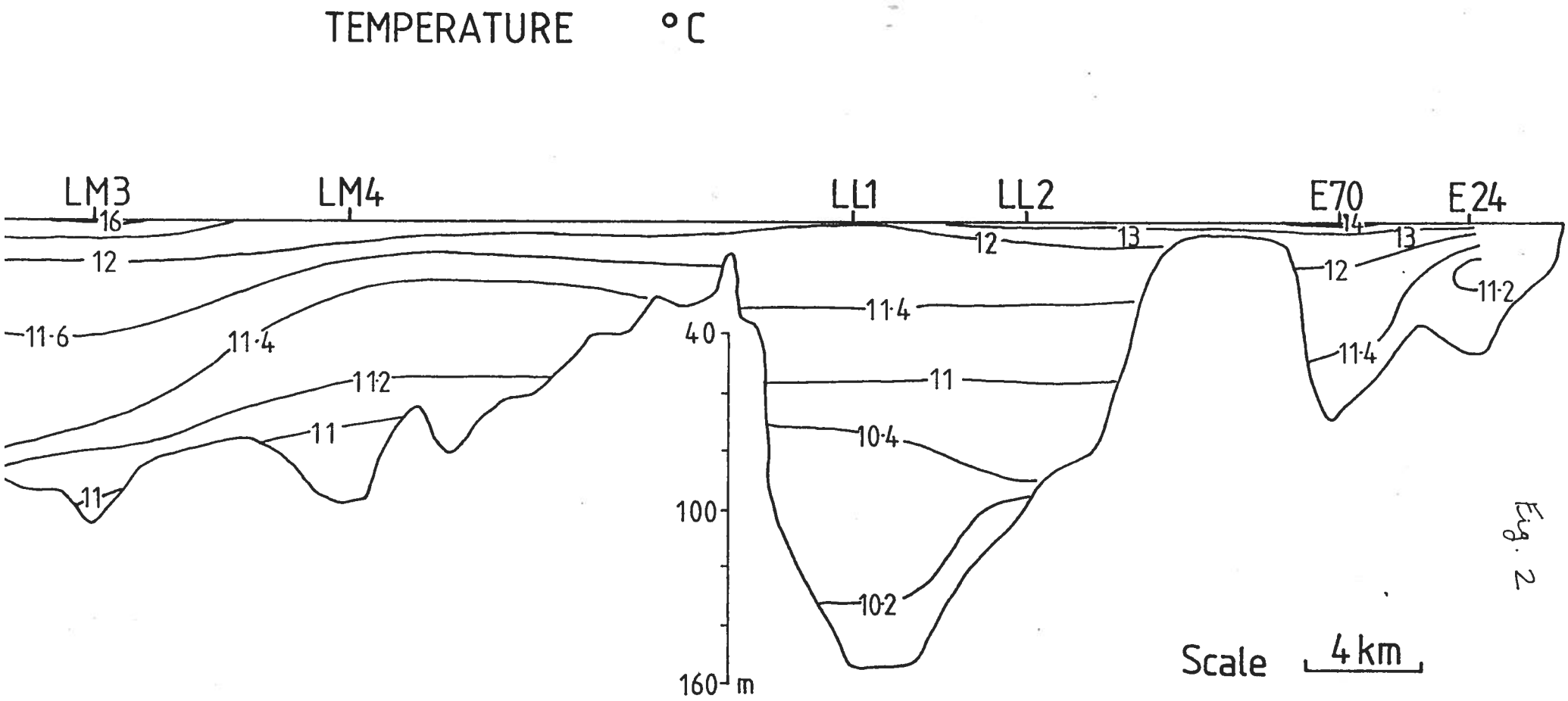
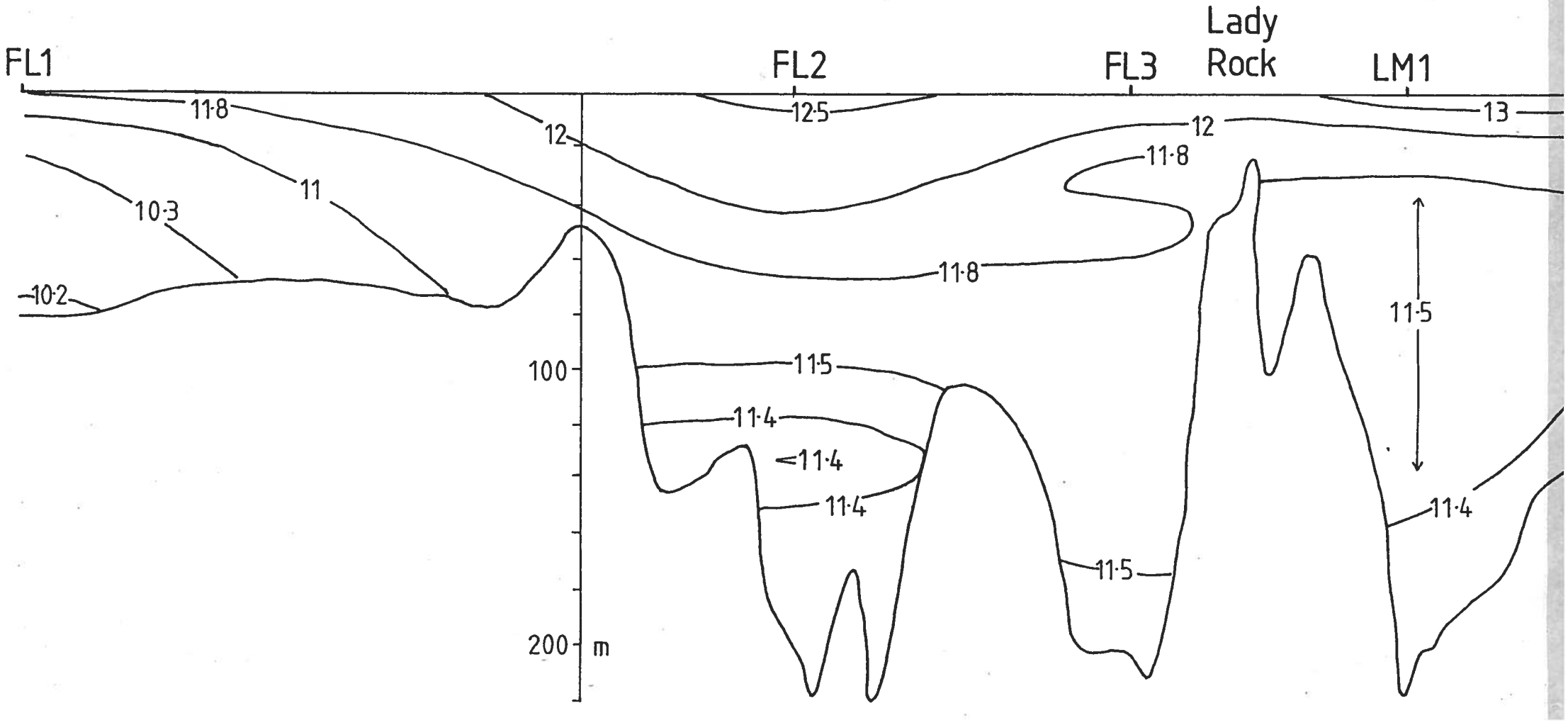

TEMPERATURE °C
LM3
LM4
LL1
LL2
E70
E24
16
12
11·6
11·4
11·2
11
11
14
13
12
13
12
11·2
11·4
11·4
11
10·4
10·2
40
100
160 m
Scale 4 km

Fig. 2


FL1
FL2
FL3
Lady Rock
LM1
11·8
12
12·5
12
13
11·8
11
10·3
10·2
11·8
11·5
100
11·5
11·4
<11·4
11·4
11·5
11·4
200
m

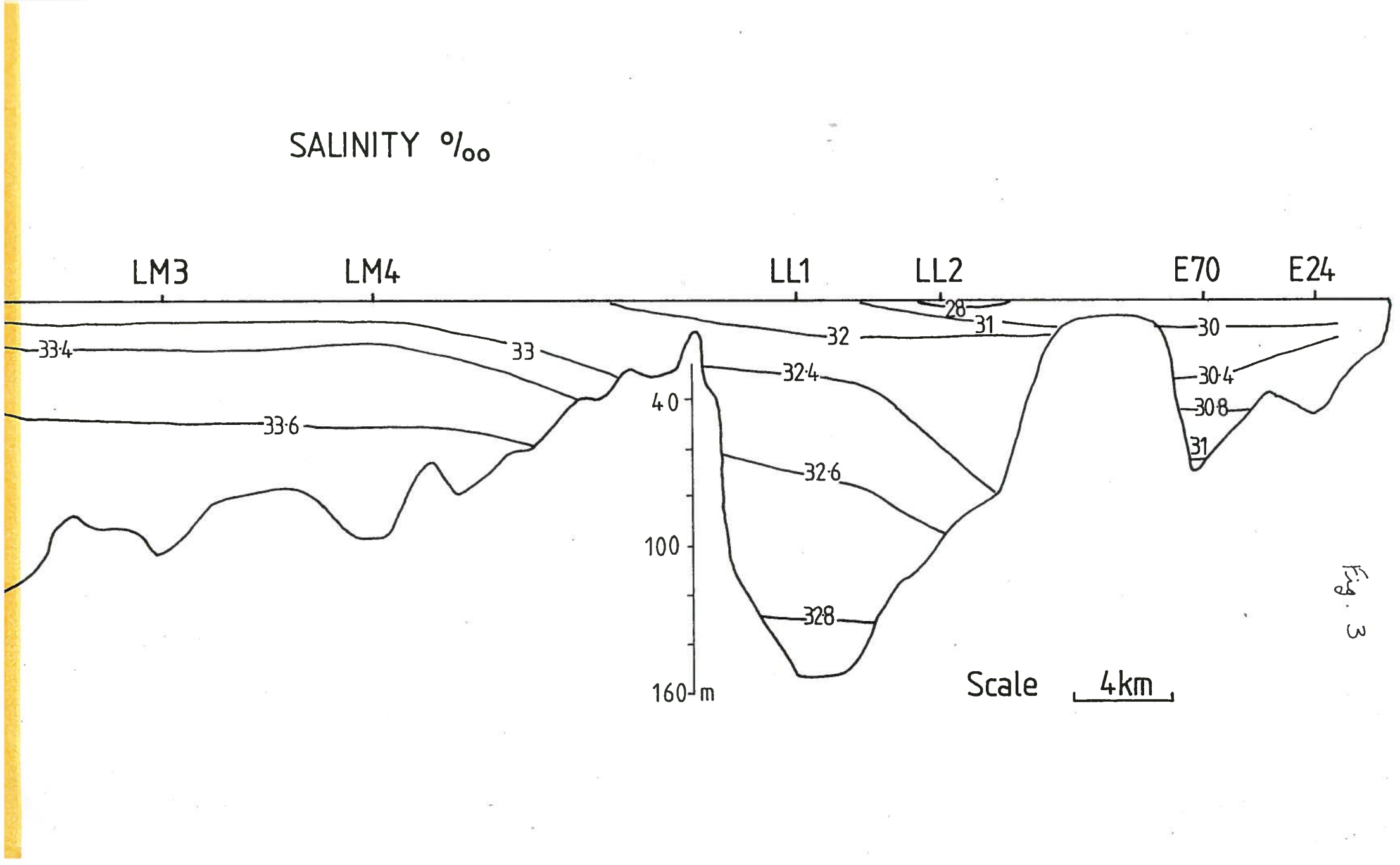
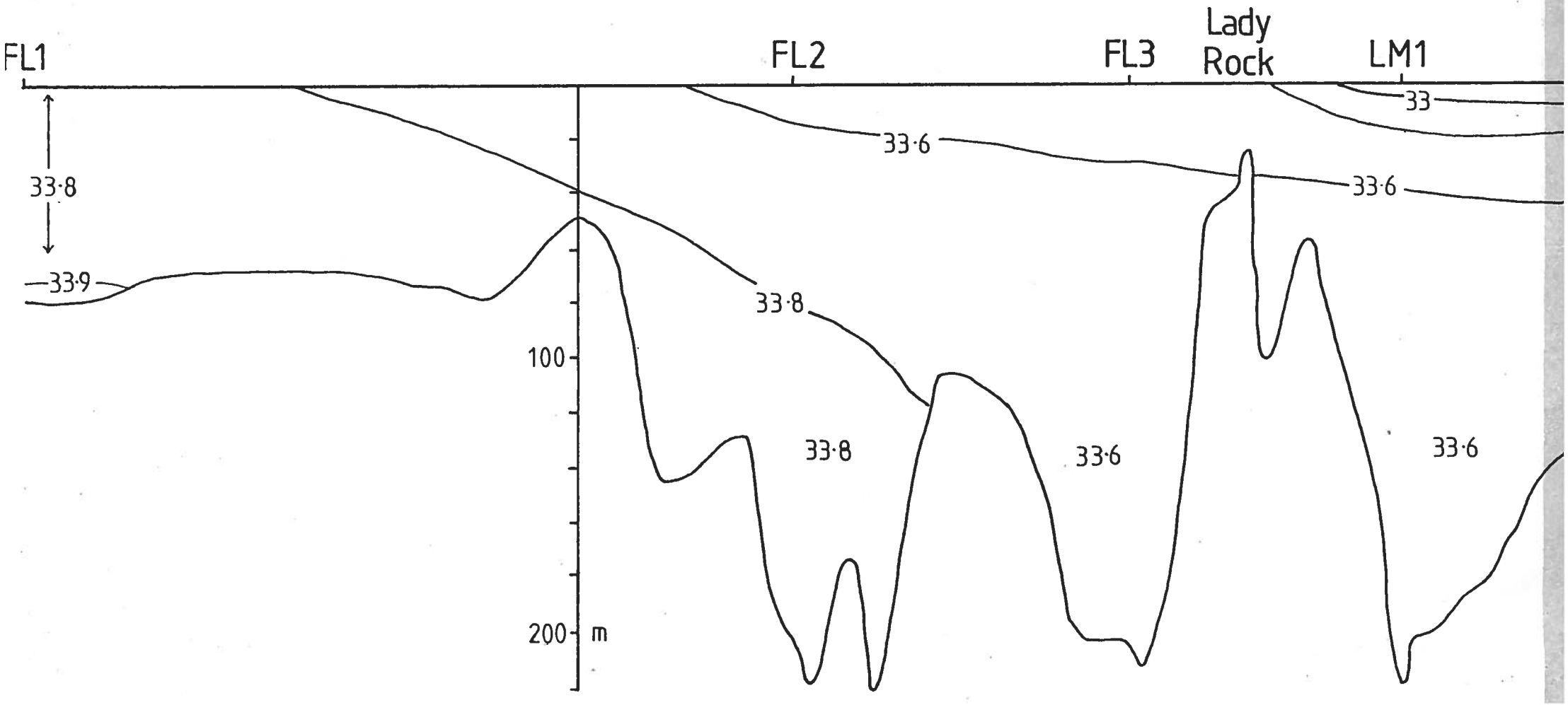

SALINITY ‰
LM3
LM4
LL1
LL2
E70
E24
28
31
32
33
33·4
33·6
32·4
32·6
328
30
30·4
30·8
31
40
100
160 m
Scale 4km

Fig. 3


FL1
FL2
FL3
Lady Rock
LM1
33·8
33·9
33·8
33·6
33·6
33
100
200
m
33·8
33·6
33·6

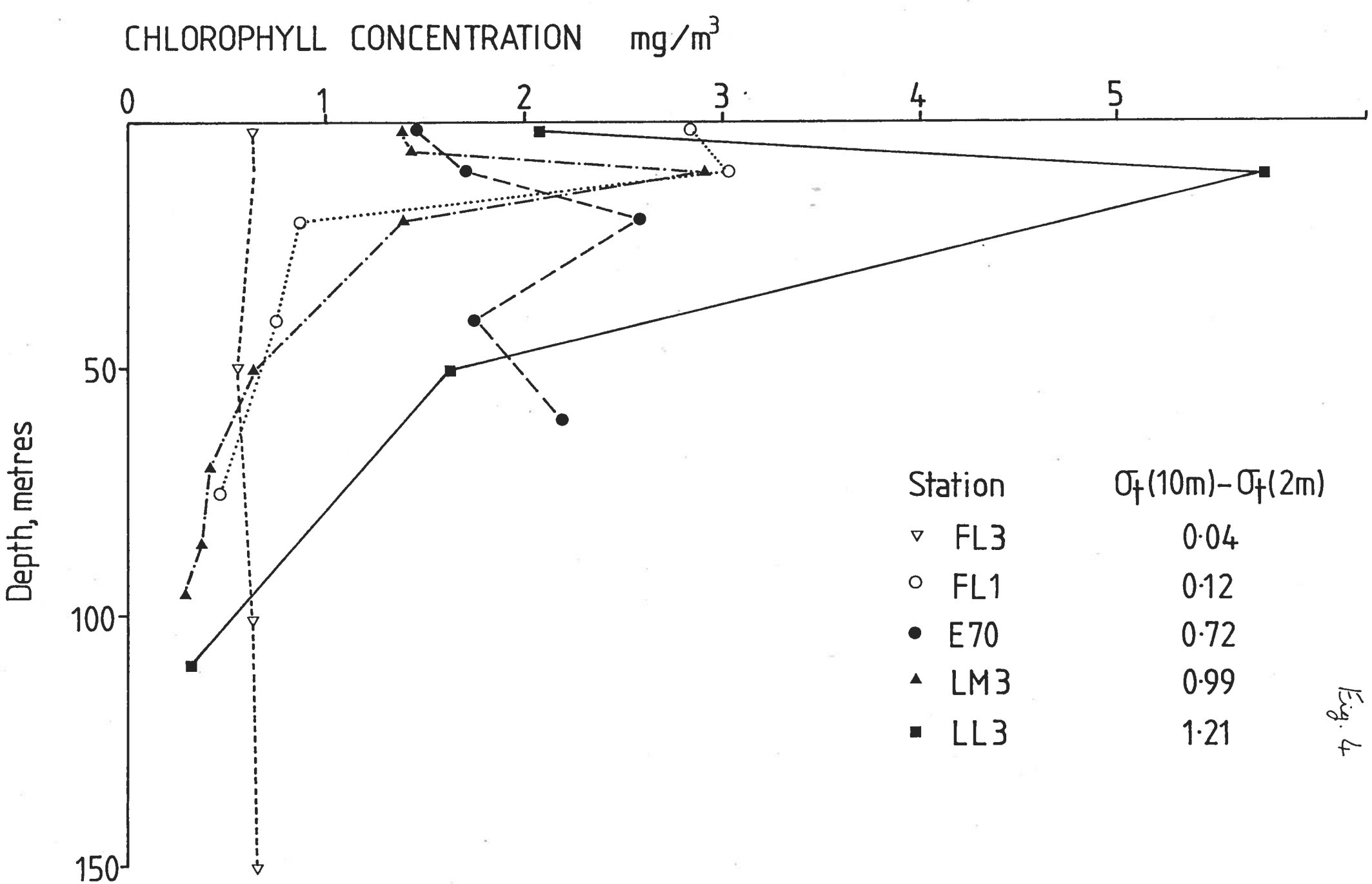

CHLOROPHYLL CONCENTRATION mg/m3
0
1
2
3
4
5
50
100
150
Depth, metres
Station
σt(10m)–σt(2m)
FL3
0·04
FL1
0·12
E70
0·72
LM3
0·99
LL3
1·21

Fig. 4

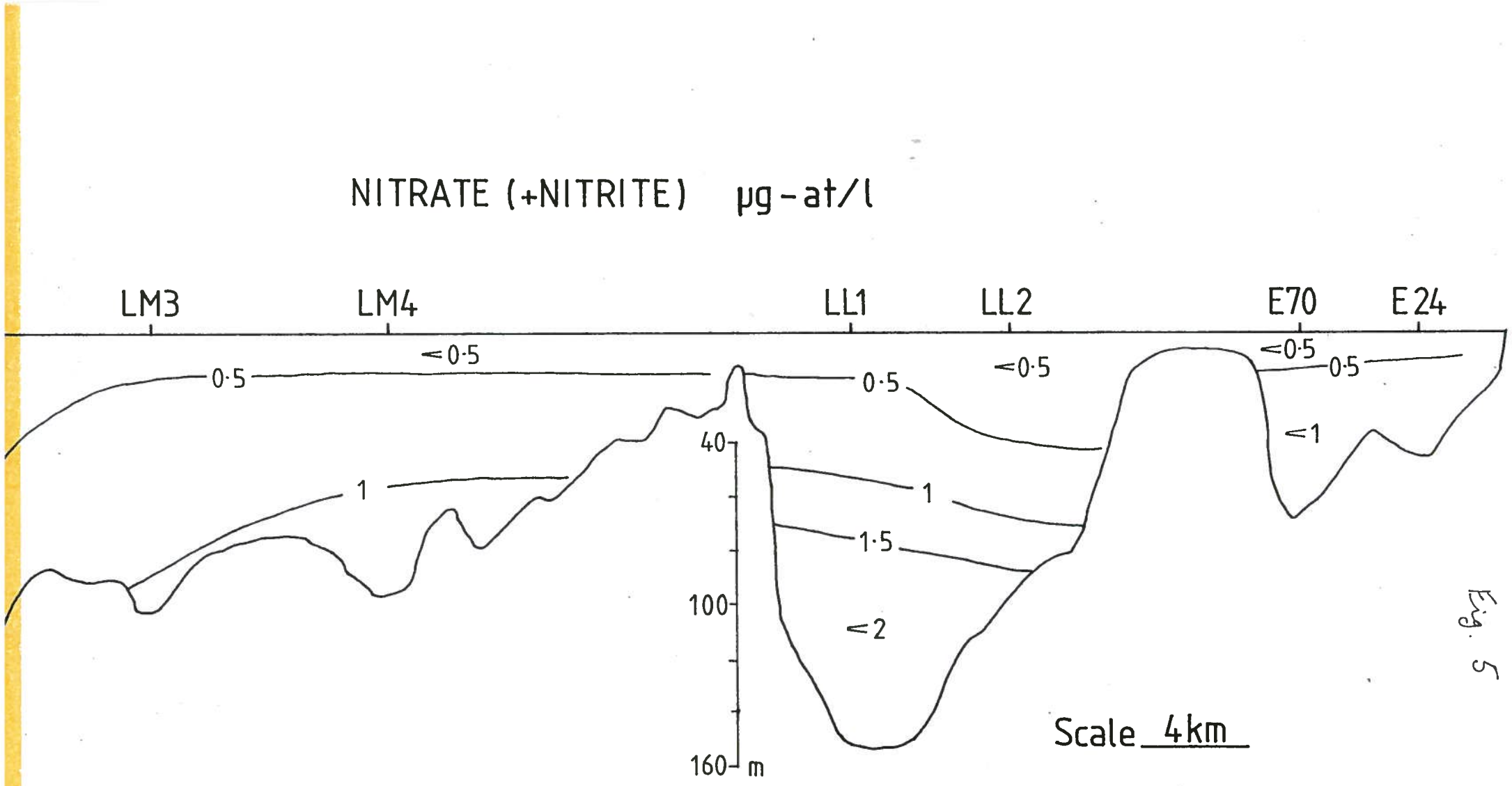
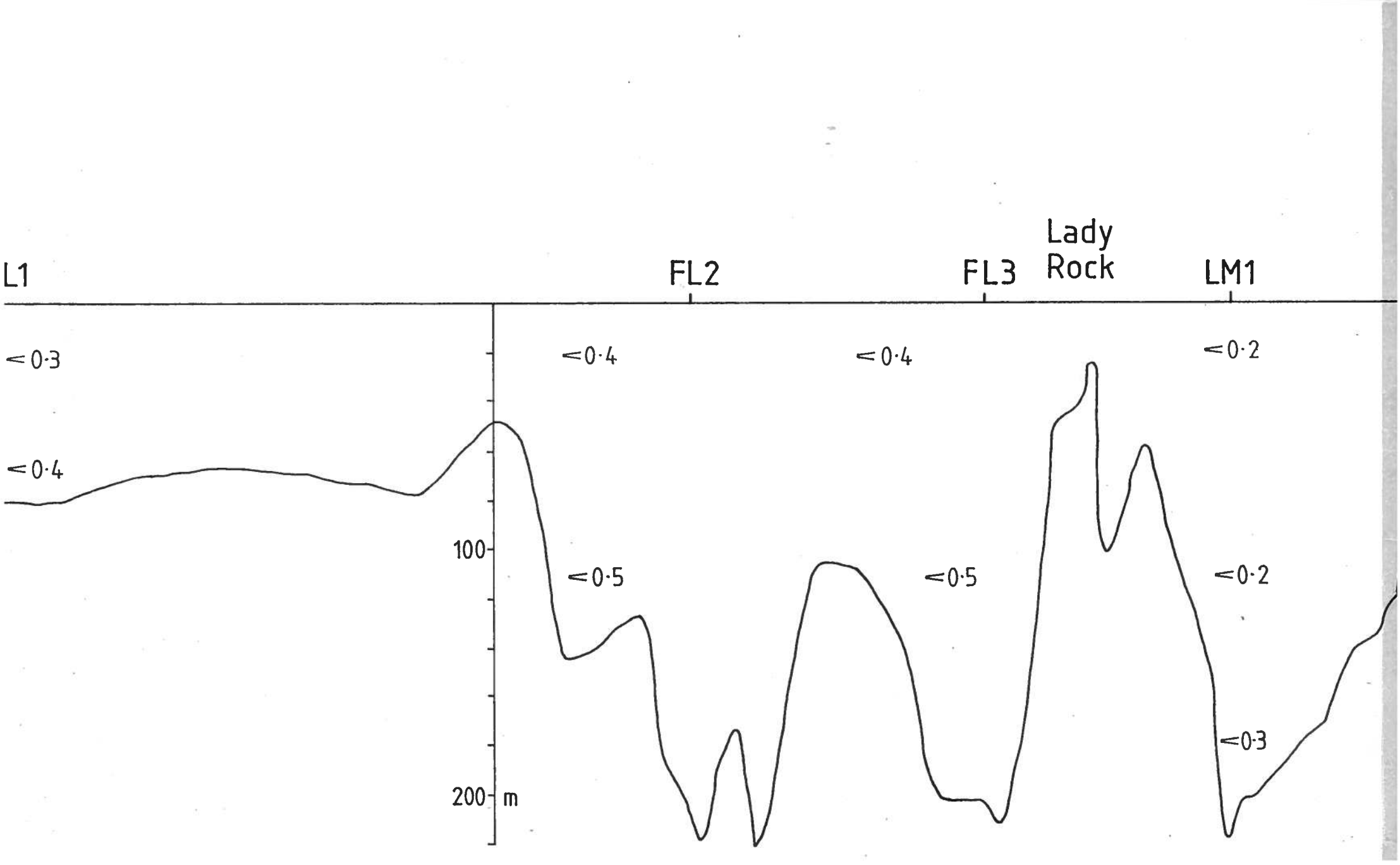

NITRATE (+NITRITE) µg-at/l
LM3
LM4
LL1
LL2
E70
E24
<0·5
0·5
<0·5
0·5
<0·5
0·5
<1
1
1
1·5
<2
40
100
160
m
Scale 4km

Fig. 5


L1
FL2
FL3
Lady Rock
LM1
<0·3
<0·4
<0·4
<0·4
<0·2
100
<0·5
<0·5
<0·2
<0·3
200
m

SILICATE µg-at/l

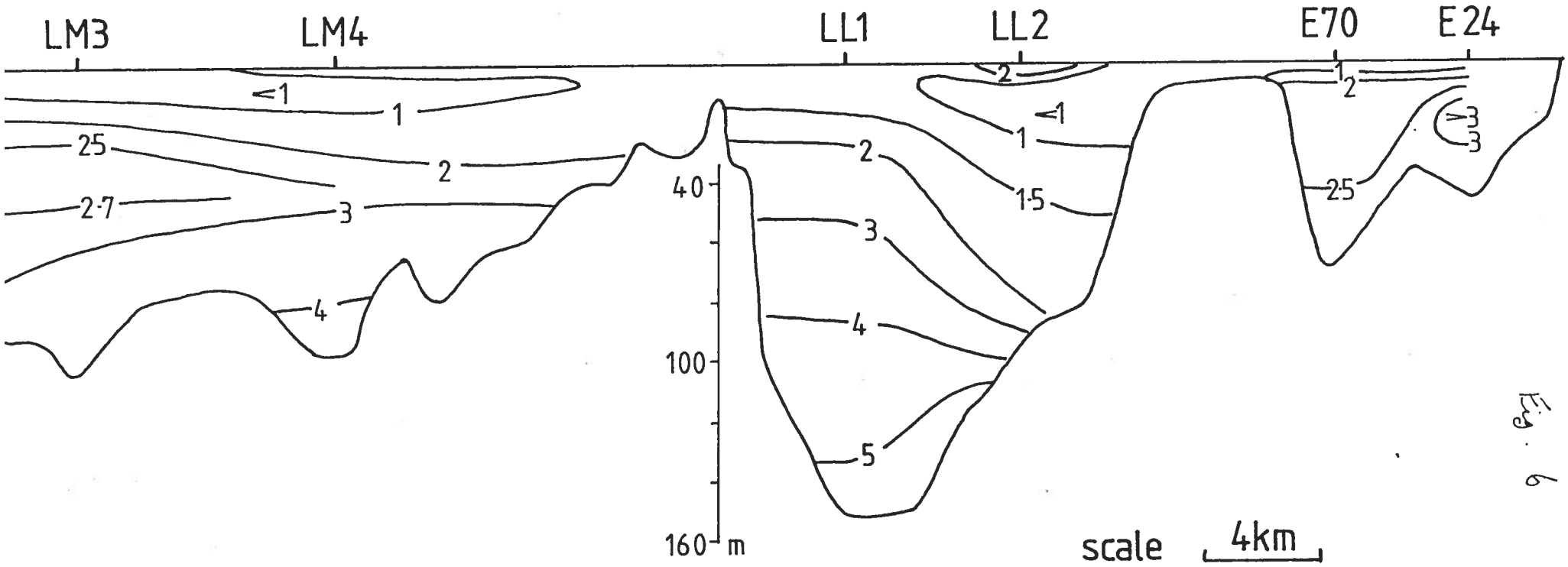
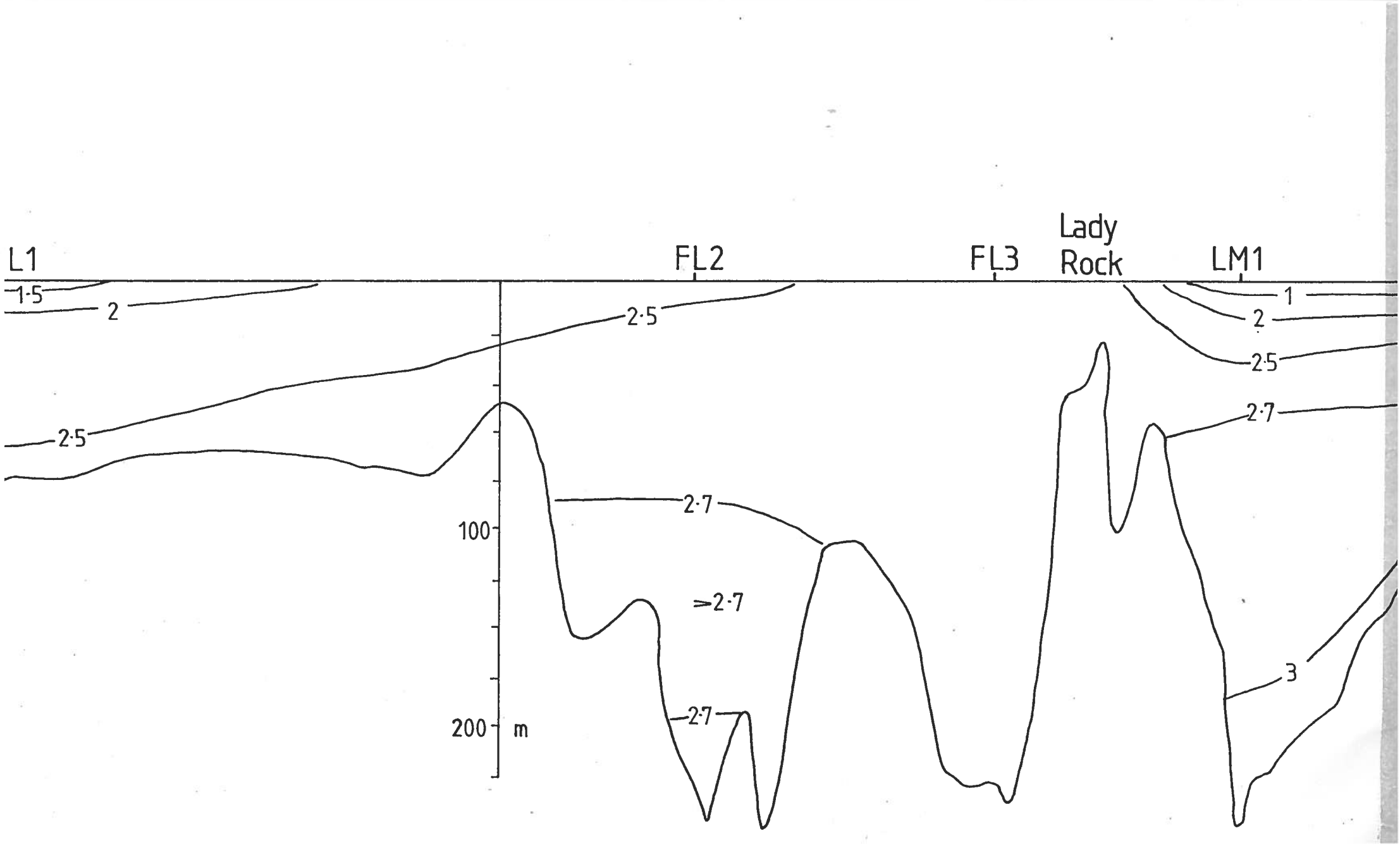


Fig. 9


L1
FL2
FL3
Lady Rock
LM1
1·5
2
2·5
2·5
2·7
2·7
2·7
2·7
1
2
2·5
2·7
3
100
200
m

Appendix A

Study on Dinoflagellate Cysts : J. Lewis

Aims

To assess the suitability of a site near the Greag Isles (Lynn of Lorne) for regular sediment sampling to look at dinoflagellate cysts in 1983.

Sampling

Phytoplankton sampling was carried out at the following stations:- E24, E70, LL2, LL1, LM4, LM3, LM1, C3, LY1, FL3, FL2 and FL1. Sediment sampling was carried out at LY1.

Results

Only a limited number of dinoflagellate cysts were found in the sediment at LY1. Consequently this site will not be used for regular sediment sampling in 1983.

Appendix B : Data List

Station E24 (Loch Eil) 21 JULY 1982. 16.45 B.S.T. Hot and sunny. Wind W 3.

Depth	Temperature	Salinity	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
2 m	13.8*	29.4*	0.05	0.87	1.14	0.56	1.68
5 m.	11.7	29.9					
10 m	11.4	29.9	0.69	2.20	3.81	0.70	1.86
15 m	11.2	30.3					
20 m	11.2	30.5	0.96	3.65	1.88	0.82	1.71
25 m	11.2	-					
35 m	11.4	30.7	0.72	2.64	1.74	0.96	1.66
2-10 m Mix.			0.18	1.05	6.69	0.99	1.89

* taken at 1 m

Station E70 (Loch Eil) 21 JULY 1982. 18.00 B.S.T. Fine and sunny. Wind W 2.

Depth	Temperature	Salinity	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
0 m	14.6	29.3					
2 m.	13.6	29.4	0.07	0.95	1.45	0.59	1.73
5 m	12.7	30.0					
10 m	12.2	30.0	0.47	2.21	1.70	0.62	1.75
15 m	12.1	30.0					
20 m	11.8	30.2	0.57	2.21	2.57	0.67	1.81
25 m	11.2	30.2					
35 m	11.6	30.6					
40 m	-	-	0.71	2.49.	1.77	0.47	1.81
45 m	11.5	30.8					
55 m	11.4	30.9					
60 m	-	-	0.75	2.58	2.20	0.96	1.71
65 m	11.4	31.0					
2-10 m Mix.			0.33	1.78	1.76	0.67	1.74

Station LL2 (Upper Loch Linnhe) 21 JULY 1982. 13.00 B.S.T. Fine and sunny. Wind NW 1.

Depth	Temperature	Salinity	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
0 m	13.2	27.8					
2 m.	12.4	30.4	0.26	2.01	2.07	0.39	1.86
5 m	12.4	30.9					
10 m	11.7	31.8	0.09	0.76	5.74	1.28	1.83
15 m	11.7	32.0					
20 m	11.5	32.1					
30 m	11.4	32.2					
40 m	11.1	32.3					
50 m	11.1	32.3	0.61	1.70	1.62	0.51	1.78
60 m	10.9	32.4					
70 m	10.8	32.4					
80 m	10.6	32.5					
90 m	10.4	32.6					
100 m	10.2	32.7					
110 m	10.2	32.7	1.94	5.15	0.34	0.56	1.39
2-10 m Mix.			0.11	1.14	4.03	0.81	1.85

Station LL1 (Upper Loch Linnhe) 21 JULY 1982. 11.00 B.S.T. Fine and sunny, calm.

Depth	Temperature	Salinity	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
2 m	12.0*	31.2*	0.13	1.16	2.47	0.38	1.89
5 m	11.8	31.7					
10 m	11.8	31.9	0.34	1.30	3.29	0.84	1.81
15 m	11.8	32.0					
20 m	11.6	32.3	0.53	1.85	2.29	0.89	1.74
30 m	11.4	32.4					
40 m	11.3	32.5					
50 m	11.1	32.5	0.96	2.65	1.14	0.51	1.70
60 m	10.9	32.5					
70 m	10.4	32.6					
80 m	10.3	32.7					
90 m	10.4	32.7					
100 m	10.3	32.7	1.77	4,49	0.28	0.37	1.44
110 m	10.4	32.7					
120 m	10.3	32.7					
130 m	10.3	32.8	1.91	4.99	0.22	0.41	1.36
2-10 m Mix.			0.14	1.14	3.99	0.89	1.83

* taken at 1 m

Station LM4 (Loch Linnhe, off Eilean Balnagowan) 22 JULY 1982. 11.15 B.S.T. Fine and sunny

Depth	Temperature	Salinity	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
0 m	12.6	32.3					
2 m	12.3	32.3	0.08	1.22	3.31	0.51	1.88
4 m	12.4	32.5					
6 m	12.8	32.6	0.04	0.70	2.21	0.57	1.81
8 m	12.4	33.1					
10 m	11.8	33.2	0.04	0.85	4.02	0.63	1.88
12 m	11.6	33.2					
15 m	11.5	33.4					
20 m	11.5	33.5	0.56	1.03.	4.57	0.94	1.85
25 m	11.4	33.5					
30 m	11.4	33.5					
40 m	11.4	33.5					
50 m	11.3	33.6	0.92	3.04	0.33	0.25	1.58
60 m	11.1	33.6					
70 m	11.0	33.6					
80 m	11.0	33.6					
90 m	10.9	33.6	1.25	4.66	0.26	0.27	1.50
2-10 m Mix.			0.06	0.91	2.39	0.53	1.83

Station LM3 (Lynn of Morven, North of Lismore) 22 JULY 1982. 12.30 B.S.T. Fine and sunny, calm.

Depth	Temperature	Salinity	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
0 m	16.0	32.3					
2 m.	13.6	32.2	0.02	0.57	1.38	0.33	1.82
4 m	13.1	32.3					
6 m	12.5	32.6	0.01	0.53	1.43	0.57	1.73
8 m	12.6	33.0					
10 m	12.5	33.2	0.05	0.82	2.91	0.55	1.86
12 m	12.1	33.3					
15 m	11.8	33.3					
20 m	11.8	33.4	0.60	2.45	1.40	0.27	1.86
30 m	11.7	33.5					
40 m	11.6	33.5					
50 m	11.6	33.6	0.76	2.79	0.65	0.21	1.77
60 m	11.5	33.6					
70 m	11.4	33.6	0.84	3.19	0.43	0.18	1.71
80 m	11.2	33.6					
85 m	11.2	33.6	0.94	3.43	0.39	0.18	1.71
90 m	11.2	33.6					
95 m	10.8	33.6	1.09	3.76	0.30	0.19	1.62
2-10 m Mix.			0.04	-	1.88	0.63	1.76

Station LM1 (Lynn of Morven) 19 JULY 1982. 15.00 B.S.T. Bright sun, wind SW 3.

Depth	Temperature	Salinity	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
0 m	13.2	32.4					
2 m	13.2	32.4	0.09	0.51	0.80	0.23	1.79
4 m	12.5	32.4					
6 m	12.4	33.1					
8 m	12.3	33.1					
10 m	12.4	33.2	0.11	1.44	1.18	0.42	1.75
15 m	11.9	33.4					
20 m	11.8	33.5	0.17	2.31	1.17	0.33	1.80
30 m	11.6	33.5					
40 m	11.6	33.6					
50 m	11.6	33.6	0.18	2.69	0.68	0.28	1.72
60 m	11.5	33.6					
70 m	11.5	33.6					
80 m	11.5	33.6					
90 m	11.5	33.6					
100 m	11.5	33.6	0.18	2.71	0.86	0.29	1.76
110 m	11.5	33.6					
120 m	11.5	33.7					
150 m	-	33.6	-	2.80	0.64	0.29	1.78
180 m	11.28	33.6	0.26	3.27	0.47	0.25	1.66
2-10 m Mix.			0.10	1.04	0.96	0.31	1.77

Station C3 (Loch Creran) 23 JULY 1982. 09.30 B.S.T. Fine and sunny. Wind NW 1.

Depth	Temperature	Salinity	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
2 m	13.5*	33.0*	0.07	1.24	2.57	0.67	1.81
5 m	13.2	33.1					
10 m	13.1	33.1	0.15	1.36	2.65	0.75	1.80
15 m	13.0	33.1					
20 m	12.9	33.1	0.19	1.49	2.57	0.82	1.77
30 m	12.9	33.1					
40 m	12.9	33.2	0.19	1.51	2.50	0.88	1.75
2-10 m Mix.			0.09	1.25	2.36	0.58	1.82

* taken at 1 m

Station LY1 (Lynn of Lorne) 19 JULY 1982. 13.30 B.S.T. Fine and sunny. Wind SW 2.

Depth	Temperature	Salinity	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
0 m	13.1	32.4					
1 m	12.4	32.9					
2 m	12.2	33.1	0.10	1.05	1.70	0.77	1.70
4 m	12.2	33.1					
6 m	12.2	33.1					
8 m	12.2	33.1					
10 m	12.2	33.2	0.11	1.32	3.37	0.53	1.88
12 m	11.9	33.3					
14 m	11.7	33.4	0.14	2.81	2.68	0.48	1.86
16 m	11.4	33.5					
18 m	11.4	33.5					
20 m	11.4	33.5					
25 m	11.3	33.6					
30 m	11.2	33.6					
35 m	11.1	33.6					
40 m	11.2	33.7	0.20	4.27	0.87	0.48	1.70
2-10 m Mix.			0.11	1.08	3.15	0.54	1.87

Station FL3 (Firth of Lorne, off Grasspoint, Mull) 20 JULY 1982. 16.00 B.S.T. Fine and sunny. Wind variable.

Depth	Temperature	Salinity	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
0 m	12.1	33.5					
2 m	12.1	33.5	0.34	2.61	0.63	0.25	1.73
4 m	12.0	33.5					
6 m	12.0	33.5					
8 m	12.1	33.5					
10 m	11.9	33.5	0.37	2.60	0.64	0.25	1.74
15 m	11.9	33.5					
20 m	11.9	33.5					
30 m	11.7	33.6					
40 m	11.8	33.6					
50 m	11.8	33.6	0.42	2.66	0.56	0.22	1.73
60 m	11.8	33.6					
70 m	11.7	33.6					
80 m	11.7	33.6					
90 m	11.7	33.6					
100 m	11.7	33.6	0.43	2.65	0.64	0.28	1.71
120 m	11.7	33.7					
150 m	-	33.58	0.44	2.61	0.67	0.35	1.67
200 m	11.52*	33.59*	0.47	2.66	0.55	0.35	1.63
2-10 m Mix.			0.44	2.59	0.77	0.40	1.67

* taken at 175 m

Station FL2 (Firth of Lorne, off Easdale) 20 JULY 1982. 14.00 B.S.T. Fine and sunny, calm.

Depth	Temperature	Salinity	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
1 m	12.9	33.6	0.16*	2.07*	1.71*	0.38*	1.83*
5 m	12.5	33.6					
10 m	12.3	33.6	0.26	2.51	1.42	0.24	1.87
15 m	12.3	33.6					
20 m	12.2	33.7					
30 m	12.2	33.7					
40 m	12.1	33.7					
50 m	11.9	33.7	0.36	2.51	0.82	0.27	1.77
60 m	11.9	33.7					
70 m	11.8	33.7					
80 m	11.7	33.8					
90 m	11.6	33.8					
100 m	11.5	33.8	0.44	2.74	0.35	0.28	1.57
105 m	11.5	33.8					
115 m	11.4	33.8					
125 m	11.3	33.8					
150 m	11.40	33.74	0.46	2.73	0.41	0.35	1.55
200 m	-	33.77	0.44	2.67	0.37	0.53	1.42
2-10 m Mix.			0.24	2.13	1.91	0.51	1.81

* samples taken at 2 m

Station FL1 (off Colonsay) 20 JULY 1982. 11.15 B.S.T. Fine, bright sun, calm.

Depth	Temperature	Salinity	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
0 m	11.8	33.9					
2 m	11.3	33.8	0.10	1.49	2.85	0.31	1.92
4 m	11.3	33.8					
6 m	11.2	33.8					
8 m	10.8	33.8					
10 m	10.6	33.8	0.12	1.83	3.02	0.52	1.87
12 m	10.6	33.8					
15 m	10.5	33.8					
20 m	10.4	33.8	0.25	2.24	0.87	0.35	1.73
25 m	10.3	33.8					
30 m	10.3	33.8					
40 m	10.3	33.8	0.26	2.24	0.76	0.36	1.70
50 m	10.3	33.8					
60 m	10.3	33.8					
70 m	10.3	33.8					
75 m	10.2	33.9	0.32	2.63	0.47	0.41	1.54
2-10 m Mix.			0.11	1.56	3.45	0.34	1.93