Firth of Lorne Study:

Grantham, B E

Publication date:
1983

Firth of Lorne Study: Report No. 1.

Introduction and details of programme, with data for the period February 1979 to August 1981.

Brian Grantham

Scottish Marine Biological Association,

Dunstaffnage Marine Research Laboratory,

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

May 1983

S.M.B.A. Internal Report No. 86

Introduction

In February 1979 a programme was set up to investigate long-term changes in temperature, salinity, nutrients and chlorophyll a at selected stations in the Firth of Lorne and its associated sea lochs.

The programme had several aims. Firstly to provide a time-series of data for use in the analysis of long-term trends and the testing of hypotheses relating to the processes governing them. Secondly to provide background information for those engaged in biological studies. Thirdly to stimulate interest in, not only the study and detection of long-term changes in the physics and chemistry of inshore waters, but also in the biological consequences of these changes.

This report presents the background to the work, describes the programme as originally devised and gives details of progress of the programme up to the end of 1981. A detailed analysis and interpretation of the results will be conducted at a later date and published in a separate report.

A representative set of data has been included for general reference.

Background

Since the beginning of this century, and possibly earlier, concern over the fluctuations and apparent decline of some major fisheries has stimulated research workers to investigate their possible causes. The decline and eventual disappearance of the North Sea herring fishery was largely the result of continual

overfishing since the introduction of the steam drifters in the 1880's, but in most other cases, however, fishery fluctuations can be attributed in some degree to climatic change. For instance, the colonisation of the West Greenland continental shelf by cod from Iceland in the 1920's has been linked (by Beverton and Lee, 1965) with the climatic amelioration that occurred in the first half of this century over the North Atlantic and which has now suffered a reversal. The cod fishery peaked in the 1960's and has rapidly declined since, with no recruitment after 1968 (Cushing and Dickson, 1976).

Similarly, the sequence of events termed the Russell cycle in the western English Channel appears linked to the same climatic change, and now seems to be reverting to the conditions originally found in the 1920's (Southward, 1980). Other biological changes which may be associated with this cycle are changes in the North Sea phytoplankton (Reid, 1975), growth of Zostera beds in the Gulf of Morbihan, northern Bay of Biscay (Glemarec, 1979), and changes in the benthos off Spitzbergen (Blacker, 1957).

The cycle of changes in the English Channel came to light as a result of a long-term programme of sampling started in 1924. It was found that between 1930 and 1936 there was a sequence of changes in abundance and species of zooplankton and pelagic fish, accompanied by a fall in the winter maximum of dissolved inorganic phosphate. From 1965 onwards the situation slowly changed back to the original conditions found in the 1920's.

It is generally accepted that this sequence of events, now called the Russell cycle, is linked with climatic change, although

the exact mechanism of this linkage is speculative. However there is no doubt about the economic importance of some aspects of the cycle. The lack of recruitment of young herring in the early 1930's led to the collapse of an important fishery off Plymouth in 1936. On the other hand, in recent years, the return of large mackerel shoals has led to an upsurge in commercial mackerel fishing. The phenomena associated with climatic change seem therefore to be widespread, and in some cases of considerable economic importance. While there is no direct evidence that comparable changes are occurring in the Firth of Lorne, given its importance as a nursery ground for a number of commercial fish (Gordon, 1977 a and b, Cooper, 1979) the mounting of an investigative programme to identify long-term changes and examine their causative processes, seemed worthwhile. Indirect evidence points to the likelihood of long-term changes occurring. Coastal waters to the west of Scotland provide one of the sources of deep water for the Firth of Lorne fjordic system. Changes in the characteristics of this offshore water may therefore be reflected in the circulation patterns or winter nutrient levels of the deep water in the sea lochs.

Long-term changes in the temperature and salinity of the waters to the west of Scotland have been reported by Martin (1972) and Ellett (1977 and 1982). Martin related the surface temperature changes to the flow of the Gulf Stream. Taylor and Stephens (1980) have also correlated latitudinal displacements of the Gulf Stream with changes in sea-surface temperature, salinity and zooplankton abundance in the north-east Atlantic to the west of the British Isles.

In west coast sea lochs the weather pattern (West Coast of Scotland Pilot, Admiralty, 1974) can exert a strong influence on phytoplankton growth and distribution through water column stability, which is affected by freshwater run-off and wind stress, and through illumination which is controlled by the cloud cover (Solorzano and Grantham, 1975, Solorzano and Ehrlich, 1979, Tett and Wallis, 1978, Jones, 1979). Hence fluctuations in the weather pattern may produce significant year to year variations in primary productivity and nutrient distribution, while longer term climatic change may produce less easily detectable secular changes in the environment.

Over the northern hemisphere there has been a change from a "strong" atmospheric circulation pattern predominant during the 50 year period up to the 1960's, to a "weak" circulation pattern, which we are now experiencing (Lamb, 1972). The "strong" circulation gives blander, more predictable and less extreme weather, which in Britain is characterised by a "westerly" weather pattern with a regular succession of Atlantic depressions giving mild weather and regular rainfall. The "weak" circulation allows Britain to receive a greater proportion of "continental" weather with its greater extremes of summer drought and severe winters (Gribbin, 1979).

The sea lochs of the Firth of Lorne system differ widely in their physical characteristics and freshwater input. Consequently each has its own hydrographic features which influence the pattern of phytoplankton growth. Changes in the weather pattern will affect some lochs more than others. For instance, increased

rainfall (and hence run-off) will be detrimental to phytoplankton growth in those lochs which already have high freshwater input since there will be an increase in flushing rate and surface dilution. On the other hand in lochs which receive little run-off an increase in rainfall will tend to increase water column stability and favour phytoplankton growth.

Changes in wind stress will be more apparent in lochs whose axes are aligned with the mean wind direction.

Changes in illumination, particularly in the early spring, will affect the onset and timing of the spring bloom differently in each loch depending on whether the phytoplankton growth is light limited or stability limited (Solorzano and Grantham, 1975).

From previous unpublished work in the Lynn of Lorne and Loch Creran, and Loch Eil (Grantham, 1981) there is evidence of considerable year to year changes in nutrient levels, temperature cycles and phytoplankton production. If any long-term changes in the Firth of Lorne are of the same order of magnitude as those found in the English Channel (Southward, 1980) then they will be masked by the year to year fluctuations that are known to occur. Hence the main emphasis of the work should initially be the study of these year to year fluctuations and their governing processes, while at the same time accumulating a data time-series which may form the basis of the longer term study. Once the year to year noise has been quantified, the analysis of the data for secular changes may be possible. The most important part of the programme however should be the testing of hypotheses concerning the processes

involved in long-term changes. This may in some cases require separate field work from that carried out in this programme, but in general the data acquired for this study will provide the basis for the initial testing.

Previous work

Most of the previous work on hydrography, nutrients and phytoplankton in the Firth of Lorne area consisted of short-term intensive studies of individual lochs. Consequently there are few data covering periods of more than one or two years and little attempt to view the results in terms of the Firth of Lorne system as a whole. Milne (1972) provided a useful introduction to the hydrography of the main lochs since he attempted to classify lochs in terms of the number of sills they have. He also included references to work carried out before 1972.

Since then most of the work in the area has been carried out by staff of the S.M.B.A. Dunstaffnage Laboratory. Lochs Etive, Creran and Eil have been the most intensively studied. The general hydrography of Loch Etive was briefly introduced by Gage (1972) and covered in more detail by Wood, Tett and Edwards (1973), while Edwards and Edelsten (1977) described the process of deep water renewal. The dissolved nutrients in Etive were studied in detail by Solorzano and Ehrlich (1977a and 1977b) who related the changes in deep water nutrients to the inflow of saline water from outside the loch. Solorzano and Grantham (1975) compared the surface nutrients and chlorophyll *a* in Lochs Etive, Creran and Linnhe

and related their distribution to the hydrographic conditions. The hydrography of Loch Creran was presented by Gage (1974), Landless and Edwards (1976), Tett and Wallis (1978) and Jones (1979), the latter including a study of the nutrient levels. Further nutrient studies were carried out by Solorzano and Ehrlich (1979). Phytoplankton studies in Loch Creran were started in 1970 and are still continuing (Tett and Wallis, 1978). The hydrography of Loch Eil was investigated by Edwards, Edelsten, Saunders and Stanley (1980), and the nutrient and chlorophyll a distribution by Grantham (1981).

Details of Programme

The programme was devised with the following points in mind:-

(a) The spread of stations should give a representative cover of the major areas in the Firth of Lorne.

(b) The new stations should be selected to tie in with previous work, where possible by using existing stations.

(c) The number of stations and amount of sampling at each station should be arranged so that all the field work could be comfortably completed in no more than one week.

(d) The sampling techniques and methods of analysis chosen should be the most reliable and well tried of those currently available.

(e) Particular attention should be paid to determining the amount of variance in each parameter due to the various stages in the process of collection and analysis.

Stations

Figure (1) shows the positions of all the stations mentioned in this report.

In the original plan three stations (LL1, LY1 and FL1) were chosen to be representative of the main areas of the central fjord. Three more were subsequently added, stations C3 and C5 in Loch Creran to link up with the nutrient work (Jones, 1979) and the phytoplankton study (Tett and Wallis, 1978) and one in Loch Eil (E70) to link up with the work of the S.M.B.A. Organic Degradation Group.

The final station list of the original programme was as follows:-

(1) Station E70

Located in Loch Eil, lat. $56^{\circ}51'.1$ N, long. $5^{\circ}12'.6$ W, with a depth of 65 metres.

This is an existing station which was one of the regular sampling sites of the Organic Degradation Group. It was intensively sampled for nutrients, temperature, salinity and chlorophyll over the period November 1975 to March 1977. It is possibly affected by effluent from the pulp and paper mill at Corpach.

(2) Station LL1

Located in upper Loch Linnhe, lat. $56^{\circ}45'.3$ N, long. $5^{\circ}12'.5$ W, with a depth of 150 metres.

This station is situated in the deepest part of upper Loch Linnhe (Loch Aber) and will be used to monitor the deep water of the Loch Linnhe fjordic system. The sill depth at the Corran Narrows

is 12 metres. The station receives freshwater runoff from Loch Eil and the river Lochy, and effluent from the pulp mill, British Aluminium Works and the town of Fort William.

(3) Station C3

Located in Loch Creran, lat. 56°31'.0 N, long. 5°22'.4 W, with a depth of 45 metres.

This station has been a regular sampling site for phytoplankton work since 1970.

(4) Station C5

Located in Loch Creran, lat. 56°32'.1 N, long. 5°19'.4 W, with a depth of 20 metres.

This station is situated in mid-loch off the Alginate factory and may therefore be subject to the effluent. It has been a regular sampling site for phytoplankton work since 1970.

(5) Station LY1

Located near the Greag Isles, Lynn of Lorne, lat. 56°28'.9 N, long. 5°30'.1 W, with a depth of 43 m.

This is an existing station, which has been used as a control site for studies in Loch Eil and Loch Creran. There is monthly nutrient, temperature and salinity data for this station covering a period of about 3 years. It is conveniently close to the laboratory and is directly influenced by the outflow from Loch Etive and Loch Creran.

(6) Station FL1

Located in the western end of the Firth of Lorne, 4 miles north-east of the northern tip of Colonsay. Lat. 56°11'N, long. 6°4'.5 W, with a depth of 80 metres.

This station is a good site at which to monitor the influence of offshore water, but it is quite exposed and difficult to work in heavy weather.

As the programme has developed further stations have been added from time to time. They are described below in the Progress Report.

Sampling Schedule

The original proposal was for four sampling trips per year, in February, May, August and November. The spring bloom period was deliberately avoided in order to minimise the chance of sampling at times of rapid change in chlorophyll and nutrients. Sampling was subsequently reduced to twice yearly, because of problems with boats and pressure of time, and is now down to one trip per year, in February. On the other hand the number of stations visited and the number of samples taken at each station has increased, without any increase in effort because of the change from manual chemical methods to automated methods. Details of all these changes are described below in the Progress Report.

Samples for nutrient analysis were taken at the following depths:-

E70	2 m, 10 m, 60 m
LL1	2 m, 10 m, 50 m, 100 m, 150 m
C3	2 m, 10 m, 40 m
C5	2 m, 10 m, 20 m
LY1	2 m, 10 m, 40 m, 80 m

The depth of the deepest sampled varied according to the depth of water found, and was generally within 5 to 10 metres of the bottom. Samples were taken using N.I.O. bottles, the depth being measured to the top of the bottle. For each sample of two litres two bottle casts were required. An additional 2 to 10 metre integrated sample was taken by mixing 500 ml of water from each of the depths 2 m, 4 m, 6 m, 8 m and 10 m. The object of this was to reduce the effect of sharp gradients in the sampling of the near surface water. On selected trips replicate samples were taken at different steps in the sampling, filtration and analytical process in order to assess the degree of variance introduced at each stage.

Temperature/Salinity

At each station a temperature/salinity profile was taken using either an E.I.L. or Braystoke instrument. Reversing thermometers were used for temperature calibrations. Salinity calibration samples were measured on a precision salinometer in the laboratory. At stations with depths exceeding the cable length of the instrument, deeper temperature/salinity readings were taken with reversing thermometers and bottle samples for salinity measurement.

On certain trips temperature/salinity readings were logged directly from the Braystoke instrument by a Hewlett-Packard 9825 computer and stored on magnetic tape, for later plotting.

Filtration and Analysis

About 200 ml of each water sample was filtered through a 5.5 cm GF/C filter for chlorophyll determination. On some trips the chlorophyll was extracted immediately as follows.

The filter was folded and placed in a polythene centrifuge tube which was then filled with 90% acetone up to an engraved mark corresponding to a volume of 10 ml. The sample was then placed in a refrigerator and later measured by the method described by Tett and Wallis (1978). If extraction was not carried out immediately, the filter was folded, wrapped in aluminium foil and stored frozen. At the earliest opportunity the filter was freeze dried and then stored in a deep-freeze until analysis.

The methods of extraction and measurement were similar to those used for the non-freeze dried samples. The filtrate was transferred to polythene bottles and stored deep frozen. Analyses for nutrients were carried out either by manual methods described in Strickland and Parsons (1968), or by using a Technicon Autoanalyzer, sometimes on board ship, otherwise in the laboratory. With the Autoanalyzer on board ship water samples were analysed for nutrients directly after collection, without any filtration. Details of Autoanalyzer methods, and a comparison between them and the corresponding manual methods are given in Grantham (1982). The readings from the Autoanalyzer were sometimes output to the Hewlett-Packard 9825 computer and logged on magnetic tape, for storage and calculation.

Sampling Trips: Progress Report

February 1979

Problems with 'Calanus' delayed some of the sampling work with the result that the whole survey took place over the period 27th February to 26th March. All the proposed sampling was completed.

May 1979

Sampling was carried out over the period 15 - 18th May. In addition to the usual duplication of samples, further replicates were taken after the filtration stage to determine the variance due to storage and analysis only.

August 1979

Sampling was carried out over the period 13 - 17th August. At LY1 a series of samples were taken, each being treated differently from the filtration stage onwards, in order to investigate the changes brought about by freezing.

Set A (taken at 10.10 BST) was treated normally and filtered first. The filtrate was stored in the deep freeze on 'Calanus'. Set B (12.30 BST) was treated like set A but was filtered last. Set C (11.05 BST) was filtered second. Acetone was added to the chlorophyll samples immediately. The filtrate, in polythene bottles, was rapidly frozen in DRI-KOLD. Set D (12.45 BST) was filtered third. The filtrate, in polythene bottles, was returned to the laboratory unfrozen and analysed immediately for nitrate,

phosphate and silicate. An investigation was also started into the effects of long-term storage on nutrient levels in seawater samples. A large (40 l) polythene container was filled with water from a depth of 40 m at LY1. The water was well mixed and a series of samples were withdrawn, filtered and the filtrate placed in the deep-freeze on board 'Calanus'. Care was taken to ensure that all the samples received similar treatment. Some samples were analysed within a few days for nitrate, phosphate and silicate. The rest of the samples were stored frozen and analysed at intervals of a few months to determine the effects of storage. The last series of samples were analysed some 18 months after collection. The results of this investigation will appear in a later report.

November 1979

Sampling was carried out over the period 13 - 15th November. Only the basic programme was completed.

February 1980

Sampling was carried out over the period 11 - 14th February. Medium townet hauls for zooplankton were carried out at stations FL1, LY1 and E70.

May 1980

Basic programme. 13 - 15th May.

August 1980

6 - 11th August. Phosphate and silicate analyses were carried out manually. Nitrate and DON analyses were carried out on an Autoanalyzer using filtered water, which had been stored frozen.

November 1980

Trip cancelled because of mechanical problems with 'Calanus.

February 1981

4 - 10th February. Nitrate and silicate analyses were carried out on board 'Calanus' using an Autoanalyzer. Water was analysed immediately after collection, without filtration. No phosphate analyses were done. Each station was studied in greater detail than on previous trips, with closer sampling depth intervals being used.

Station FL1 was not worked because the weather was not suitable. The following additional stations were worked:-

Station E24, Loch Eil, lat. 56°51'N, long. 5°16'.9W.

Station LY2, north of Shuna Island (Port Appin), lat. 56°37'N, long. 5°24'W.

Station LL2, upper Loch Linnhe, lat. 56°47'.7N, long. 5°9'.1W.

Temperature/Salinity measurements were taken with a Braystoke instrument.

May 1981

Trip cancelled.

August 1981

The full survey was carried out between 10th and 13th August, except that station FL1 was omitted.

Additional stations were worked:-

Station E24, Loch Eil.

Station 1, Firth of Lorne (off Seil), lat. 56°20'.3N, long. 5°40'.7W, depth 200 m.

Station 2, Lynn of Morven, lat. 56°29'.6N, long. 5°38'.4W, depth 200 m.

Nitrate and silicate were measured on board 'Calanus' using an Autoanalyzer. Phosphate was not analysed.

November 1981

Trip cancelled.

From now on trips are only twice-yearly.

References

Admiralty (1974). West coast of Scotland pilot. 11th edition.

Beverton, R.J.H. and A.J. Lee (1965). Hydrographic fluctuations in the North Atlantic Ocean and some biological consequences. Symp. Inst. Biol. 14: 79-107.

Blacker, R.W. (1957). Benthic animals as indicators of hydrographic conditions and climatic change in Svalbard waters. Fish. Invest. Ser. II, 20 (no. 10): 1-49.

Cooper, A. (1979). Aspects of the ecology of gadoid fish of the west coast of Scotland. Ph.D. thesis, University of Stirling. 139 pp + Appendix.

Cushing, D.H. and R.R. Dickson (1976). The biological response in the sea to climatic changes. Adv. mar. Biol. 14: 1-122.

Edwards, A. and D. Edelsten (1977). Deep water renewal of Loch Etive: a three basin Scottish fjord. Estuar. coast. mar. Sci. 5: 575-595.

Edwards, A., D.J. Edelsten, M.A. Saunders and S.O. Stanley (1980). Renewal and entrainment in Loch Eil; a periodically ventilated Scottish fjord. In "Fjord Oceanography", ed. Freeland, Farmer and Levings, Plenum Press, N.Y., pp. 523-530.

Ellett, D.J. (1977). Long-term oceanographic changes in the Rockall Channel. Jasin News No. 2: 1-3.

Ellett, D.J. (1982). Long-term water-mass changes to the west of Britain. In "Time Series of Ocean Measurements". World Climate Report WCP21, pp. 245-254.

Gage, J. (1972). A preliminary survey of the benthic macro-fauna and sediments in Lochs Etive and Creran, sea lochs along the west coast of Scotland. J. mar. biol. Ass. U.K., 52: 237-276.

Gage, J. (1974). Shallow-water zonation of sea-loch benthos and its relation to hydrographic and other physical features. J. mar. biol. Ass. U.K., 54: 223-249.

Glemarec, M. (1979). Les fluctuations temporelles des peuplements benthiques liees aux fluctuations climatiques. Oceanologica Acta, 2: 365-371.

Gordon, J.D.M. (1977a). The fish populations in inshore waters of the west of Scotland. The biology of the Norway pout (Trisopterus esmarkii). J. Fish. Biol. 10: 417-430.

Gordon, J.D.M. (1977b). The fish populations in inshore waters of the West Coast of Scotland. The distribution abundance and growth of the whiting (Merlangius merlangus L.). J. Fish. Biol. 10: 587-596.

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. (1982). The use of an Autoanalyzer with data logging for the analysis of nutrients in seawater. SMBA Internal Report No. 69.

Gribbin, J. (1979). Eighteenth century climate may indicate future patterns. New Scientist, 83 (No. 1173): 891-893.

Jones, K.J. (1979). Studies on nutrient levels and phytoplankton growth in a Scottish sea loch. Ph.D. Thesis, University of Strathclyde, Glasgow.

Lamb, H.H. (1972). Climate: Present, past and future. I. Fundamentals and climate now. Methuen, London.

Landless, P.J. and A. Edwards (1976). Economical ways of assessing hydrography for fish farms. Aquaculture, 8: 29-43.

Martin, J.H.A. (1972). Marine climate changes in the north-east Atlantic, 1900-1966. Rapp. P.V. Reun. cons. Int. Explor. Mer. 162: 213-219.

Milne, P.H. (1972). Hydrography of Scottish west coast sea lochs. DAFS Marine Res. 3. H.M. Stationery Office, Edinburgh.

Reid, P.C. (1975). Large scale changes in North Sea phytoplankton. Nature, Lond., 257: 217-219.

Solorzano, L. and B. Ehrlich (1977a). Chemical investigations of Loch Etive, Scotland. I. Inorganic nutrients and pigments. J. exp. mar. Biol. Ecol. 29: 45-64.

Solorzano, L. and B. Ehrlich (1977b). Chemical investigations of Loch Etive, Scotland. II. Dissolved organic compounds. J. exp. mar. Biol. Ecol. 29: 65-79.

Solorzano, L. and B. Ehrlich (1979). Chemical investigations of Loch Creran, Scotland. I. Inorganic nutrients, dissolved organic compounds and pigments. J. exp. mar. Biol. Ecol. 40: 1-25.

Solorzano, L. and B. Grantham (1975). Surface nutrients, chlorophyll *a* and phaeopigment in some Scottish sea lochs. J. exp. mar. Biol. Ecol. 20: 63-76.

Southward, A.J. (1980). The Western English Channel - an inconstant ecosystem? Nature, Lond., 285: 361-366.

Strickland, J.D.H. and T.R. Parsons (1968). A practical handbook of seawater analysis. Fisheries Research Board of Canada, Bulletin 167.

Taylor, A.H. and J.A. Stephens (1980). Latitudinal displacements of the Gulf Stream (1966 to 1977) and their relation to changes in temperature and zooplankton abundance in the NE Atlantic. Oceanologica Acta, 3 (No. 2): 145-149.

Tett, P. and A. Wallis (1978). The general annual cycle of chlorophyll standing crop in Loch Creran. J. Ecol., 66: 227-239.

Wood, B.J.B., P. Tett and A. Edwards (1973). An introduction to the phytoplankton, primary production and relevant hydrography of Loch Etive. J. Ecol., 61: 569-585.

Figures

Figure 1. Map of area showing station positions.

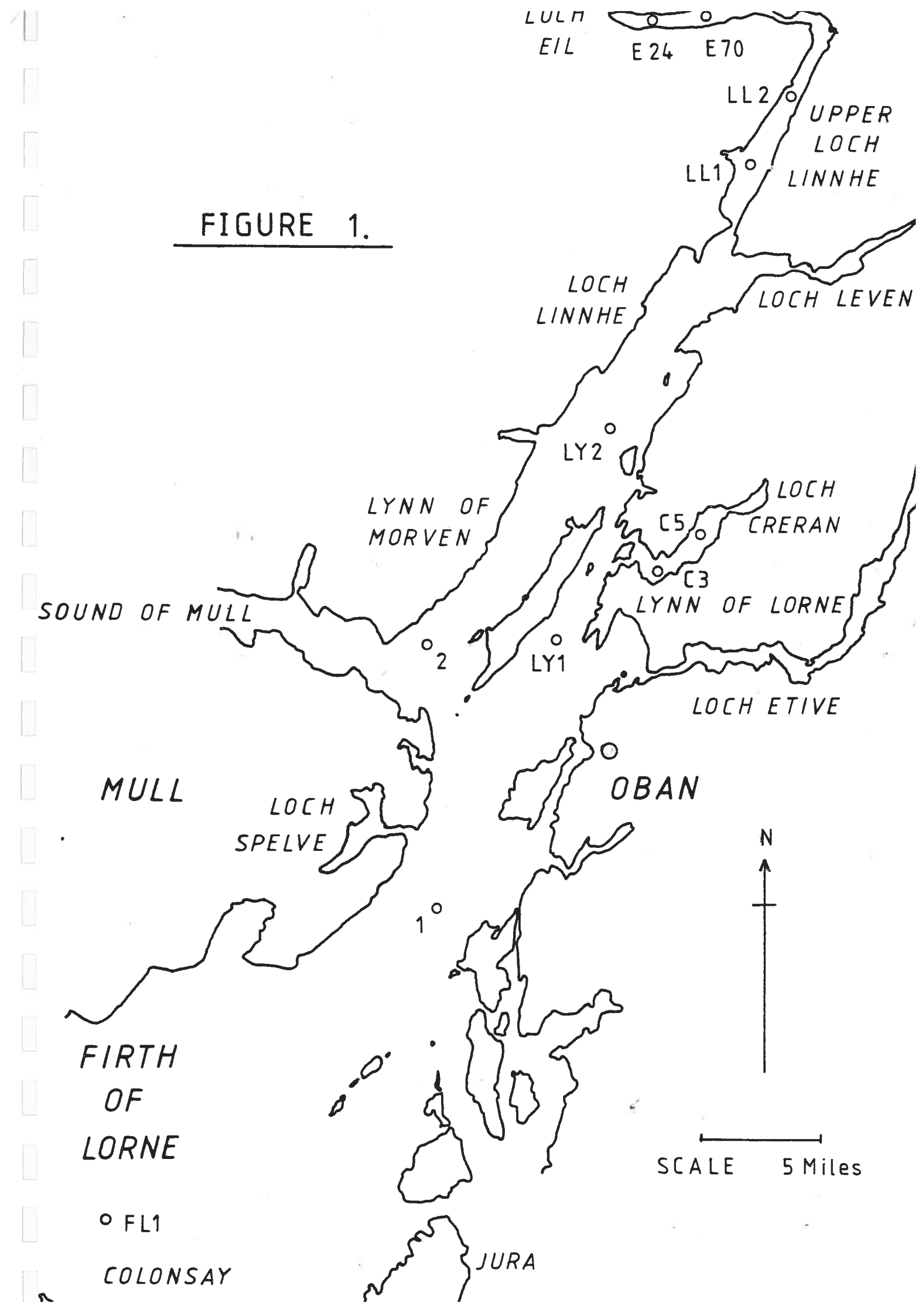
LOCH EIL
E24
E70
LL2
UPPER LOCH LINNHE
LL1
LOCH LINNHE
LOCH LEVEN
LY2
LYNN OF MORVEN
LOCH CRERAN
C5
C3
LYNN OF LORNE
SOUND OF MULL
2
LY1
LOCH ETIVE
MULL
OBAN
LOCH SPELVE
1
N
FIRTH OF LORNE
FL1
COLONSAY
JURA
SCALE 5 Miles

FIGURE 1.

Appendix

Units

The units used throughout the report are as follows:-

Depth	-	metres	m
Temperature	-	degrees Celcius	^{o}C
Salinity	-	parts per thousand	‰
Dissolved Inorganic Phosphate	-	microgram-atoms per litre	µg-at/ℓ
Dissolved Organic Phosphate	-	microgram-atoms per litre	µg-at/ℓ
Dissolved Inorganic Nitrate	-	microgram-atoms per litre	µg-at/ℓ
Dissolved Organic Nitrogen	-	microgram-atoms per litre	µg-at/ℓ
Silicate	-	microgram-atoms per litre	µg-at/ℓ
Chlorophyll *a*	-	milligrams per cubic metre	mg/m^3
Phaeopigment	-	milligrams per cubic metre	mg/m^3
Acid Ratio	-	ratio (dimensionless)	

Station LY1 (Lynn of Lorne) 28 February 1979. 16.00 G.M.T. Sunny periods, heavy show showers. Wind SW x S 4.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	5.4	32.5	0.67 d	0.11 d	7.92 d	7.87 d	13.07 d	0.25 ld	0.18 ld	1.58 d
10 m	5.4	33.1	0.69 d	0.12 d	7.72 d	6.14 d	12.29 d	0.22 ld	0.19 ld	1.53 d
40 m	5.6	33.6	0.71 d	0.12 d	8.10 d	5.93 d	12.44 d	0.09 ld	0.20 ld	1.34 d
2-10 m Mix.			0.68	0.12	7.16	10.09	11.62	0.22	0.16	1.57

Station FL1 (off Colonsay) 26 March 1979. 14.00 B.S.T. Sunny, Calm.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	6.0	34.1	0.66 d	0.14 d	7.61 d	6.20 d	5.55 d	-	-	-
10 m	5.9	34.1	0.63 d	0.11 d	6.55 d	6.39 d	5.44 d	-	-	-
40 m	5.9	34.2	0.68 d	0.15 d	8.33 d	6.01 d	5.91 d	-	-	-
80 m	6.0	34.5	0.63 d	0.19 d	8.28 d	7.90 d	5.60 d	-	-	-
2-10 m Mix.			0.68 d	0.22 d	7.05 d	6.96 d	4.20 d	-	-	-

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station C3 (Loch Creran) 27 February 1979. 11.00 G.M.T. Overcast, rain. Wind SW 5, moderating.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	5.3	32.89	0.59 d	0.14 d	4.84 d	6.86 d	10.63 d	0.49 ld	0.27 ld	1.64 d
10 m	5.3	32.90	0.55 d	0.10 d	4.39 d	6.23 d	9.90 d	0.48 ld	0.29 ld	1.63 d
40 m	5.3	33.00	0.58 d	0.16 d	5.14 d	8.90 d	10.47 d	0.42 ld	0.23 ld	1.64 d
2-10 m Mix.			0.47 d	0.18 d	4.55 d	8.70 d	9.28 d	1.38 ld	0.47 ld	1.74 d

Station C5 (Loch Creran) 28 February 1979. 11.00 G.M.T. Sunny periods, squally snow showers. Wind WSW 3.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	4.7	30.1	0.59 d	0.22 d	4.12 d	8.28 d	11.09 d	2.32 ld	0.55 ld	1.80 d
10 m	5.2	32.63	0.60 d	0.17 d	5.67 d	7.83 d	10.79 d	0.82 ld	0.38 ld	1.68 d
20 m	4.8	32.86	0.54 d	0.19 d	5.20 d	6.61 d	10.16 d	1.15 ld	0.59 ld	1.66 d
2-10 m Mix.			0.58	0.23	6.83	6.60	11.62	2.16	5.68	1.28

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station E70 (Loch Eil) 22 March 1979. 09.00 B.S.T. Bright sun, snow showers. Wind NW 3.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	4.5	26.5	0.45 d	0.25 d	5.65 d	8.83 d	12.34 d	-	-	-
10 m	5.0	27.1	0.42 d	0.20 d	6.07 d	8.48 d	10.22 d	-	-	-
60 m	5.3	29.5	0.47 d	0.22 d	5.64 d	12.69 d	12.76 d	-	-	-
2-10 m Mix.			0.43 d	0.24 d	5.94 d	8.71 d	12.81 d	-	-	-

Station LL1 (Upper Loch Linnhe) 22 March 1979. 13.00 B.S.T. Sunny periods, snow showers. Wind W 3.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	4.9	27.5	0.45 d	0.16 d	6.21 d	7.31 d	13.59 d	-	-	-
10 m	5.3	30.9	0.57 d	0.13 d	7.82 d	7.13 d	12.91 d	-	-	-
50 m	5.4	31.8	0.67 d	0.13 d	6.84 d	6.59 d	10.84 d	-	-	-
100 m	5.59	-	0.63 d	0.10 d	5.92 d	6.47 d	9.44 d	-	-	-
145 m	5.67	-	0.60	0.11	7.98	6.79	11.93	-	-	-
2-10 m Mix.			0.52 d	0.13 d	6.43 d	7.74 d	13.22 d	-	-	-

d denotes mean of duplicates

Station LY1 (Lynn of Lorne) 18 May 1979. 10.00 B.S.T. Sunny periods. Wind NW 3.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	7.0	32.81	0.47 d	0.17 d	4.01 d	8.71 d	0.93 d	0.15 ld	0.44 ld	1.26 d
10 m	6.9	33.24	0.46 d	0.18 d	3.93 d	8.23 d	0.94 d	0.18 ld	0.55 ld	1.25 d
40 m	6.9	33.72	0.51	0.18 d	4.84 d	8.12 d	0.95	0.15 ld	0.69 ld	1.18 d
2-10 m Mix.			0.46 d	0.20 d	3.94 d	8.39 d	0.85 d	0.20 ld	0.53 ld	1.28 d

Station FL1 (off Colonsay) 15 May 1979. 12.45 B.S.T. Cloudy, hazy sun, cold. Calm, moderate swell.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	7.2	33.88	0.56 d	0.14 d	5.61 d	6.97 d	0.79 d	0.30 ld	0.45 ld	1.39 d
10 m	6.9	33.90	0.52 d	0.19 d	5.20 d	8.52 d	0.76 d	0.20 ld	0.60 ld	1.25 d
50 m	6.9	33.93	0.53 d	0.13 d	5.39 d	7.47 d	0.73 d	0.23 ld	0.64 ld	1.27 d
80 m	6.9	33.99	0.54 d	0.17 d	4.48 d	6.22 d	0.86 d	0.25 ld	0.70 ld	1.26 d
2-10 m Mix.			0.52 d	0.19 d	5.80 d	7.12 d	0.76 d	0.21 ld	0.59 ld	1.26 d

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station C3 (Loch Creran) 17 May 1979. 10.45 B.S.T. Dull, overcast, heavy rain. Wind SW 1.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	7.8	31.1	0.30 d	0.30 d	2.27 d	8.70 d	0.66 d	0.37 ld	0.47 ld	1.44 d
10 m	7.4	32.5	0.38 d	0.27 d	2.27 d	7.28 d	0.60 d	0.32 ld	0.55 ld	1.37 d
40 m	7.3	33.0	0.39 d	0.20 d	3.03 d	7.58 d	0.59 d	0.20 ld	0.60 ld	1.24 d
2-10 m Mix.			0.33 d	0.14 d	2.37 d	8.54 d	0.60 d	0.39 ld	0.52 ld	1.43 d

Station C5 (Loch Creran) 17 May 1979. 13.30 B.S.T. Dull, overcast, rain. Calm.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	7.7	31.1	0.21 d	0.35 d	1.20 d	8.11 d	0.75 d	6.48 ld	0.82 ld	1.88 d
10 m	7.4	32.72	0.36 d	0.28 d	2.74 d	10.85 d	0.66 d	0.24 ld	0.54 ld	1.31 d
16 m	7.4	32.84	0.41 d	0.26 d	2.05 d	9.39 d	0.87 d	0.14 ld	0.55 ld	1.20 d
2-10 m Mix.			0.29 d	0.42 d	1.57 d	7.52 d	0.67 d	1.81 ld	0.52 ld	1.77 d

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station E70 (Loch Eil) 16 May 1979. 13.30 B.S.T. Overcast, drizzle. Calm.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	7.4	27.1	0.07 d	0.34 d	0.27 d	8.90 d	0.85 d	3.95 ld	2.31 ld	1.63 d
10 m	6.8	28.4	0.23 d	0.35 d	2.08 d	8.46 d	1.06 d	2.29 ld	1.25 ld	1.65 d
40 m	6.6	29.4	0.30 d	0.33 d	3.35 d	8.95 d	4.81 d	1.53 ld	1.50 ld	1.50 d
60 m	6.6	29.7	0.32 d	0.29 d	3.41 d	8.60 d	1.70 d	1.72 ld	1.80 ld	1.48 d
2-10 m Mix.			0.15 d	0.38 d	1.44 d	8.41 d	0.93 d	3.08 ld	1.48 ld	1.67 d

Station LL1 (upper Loch Linnhe) 16 May 1979. 16.00 B.S.T. Overcast, occasional drizzle. Wind NE 2.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	7.1	28.4	0.19 d	0.29 d	1.89 d	8.05 d	0.80 d	2.55 ld	1.57 ld	1.61 d
10 m	6.7	31.2	0.34 d	0.26 d	3.54 d	7.19 d	0.56 d	1.90 ld	1.21 ld	1.61 d
50 m	6.4	32.2	0.46 d	0.22 d	4.86 d	7.83 d	0.57 d	0.54 ld	1.19 ld	1.31 d
100 m	6.38	32.35	0.48 d	0.14 d	5.13 d	7.34 d	0.72 d	0.38 ld	1.00 ld	1.28 d
145 m	6.7	32.38	0.51 d	0.23 d	5.37 d	7.87 d	0.74 d	0.40 ld	1.03 ld	1.28 d
2-10 m Mix.			0.26 d	0.22 d	2.97 d	7.80 d	0.69 d	2.16 ld	1.34 ld	1.62 d

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station LY1 (Lynn of Lorne) 16 August 1979. 10.30 B.S.T. Sunny periods, showers. Wind SW 3.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	12.3	29.6	0.27 d	0.26 d	0.38 d	8.87 d	2.88 d	3.22 ld	0.91 ld	1.78 d
10 m	11.8	32.87	0.26 d	0.25 d	0.28 d	8.05 d	2.21 d	3.45 ld	0.78 ld	1.81 d
40 m	11.4	33.51	0.46 d	0.17 d	1.13 d	9.28 d	4.01 d	0.59 ld	0.37 ld	1.61 d
2-10 m Mix.			0.27 d	0.23 d	0.25 d	8.57 d	2.96 d	3.49 ld	0.99 ld	1.77 d

Station FL1 (off Colonsay) 13 August 1979. 13.30 B.S.T. Sunny. Wind SW 2.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	11.8	33.82	0.40 d	0.09 d	1.07 d	8.55 d	3.29 d	0.75 ld	0.27 ld	1.74 d
10 m	11.6	33.83	0.41 d	0.08 d	1.14 d	8.49 d	3.27 d	0.55 ld	0.26 ld	1.67 d
40 m	11.5	33.88	0.36 d	0.10 d	1.11 d	7.86 d	3.29 d	0.44 ld	0.33 ld	1.57 d
80 m	12.5	34.31	0.37 d	0.11 d	1.06 d	8.03 d	3.06 d	0.41 ld	0.32 ld	1.56 d
2-10 m Mix.			0.39 d	0.10 d	1.07 d	8.78 d	3.20 d	0.69 ld	0.20 ld	1.77 d

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station C3 (Loch Creran) 14 August 1979. 11.00 B.S.T. Calm, continuous rain, dull.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	12.6	31.0	0.29 d	0.24 d	0.43 d	8.40 d	4.05 d	2.65 ld	0.60 ld	1.81 d
10 m	11.9	32.23	0.35 d	0.26 d	0.69 d	8.90 d	3.63 d	1.87 ld	0.49 ld	1.79 d
40 m	11.8	32.48	0.37 d	0.22 d	0.85 d	8.74 d	3.74 d	1.73 ld	0.62 ld	1.73 d
2-10 m Mix.			0.32 d	0.25 d	0.65 d	8.37 d	3.62 d	2.18 ld	0.69 ld	1.76 d

Station C5 (Loch Creran) 14 August 1979. 13.15 B.S.T. Calm, dull.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acic Ratio
2 m	12.3	30.2	0.23 d	0.32 d	0.16 d	10.83 d	4.04 d	4.81 ld	0.98 ld	1.83 d
10 m	11.7	32.24	0.39 d	0.21 d	0.81 d	10.13 d	4.31 d	2.15 ld	0.67 ld	1.76 d
16 m	11.8	32.43	0.40 d	0.31 d	0.86 d	10.38 d	4.25 d	1.74 ld	0.61 ld	1.74 d
2-10 m Mix.			0.30 d	0.23 d	0.48 d	10.29 d	3.75 d	3.08 ld	0.69 ld	1.81 d

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station E70 (Loch Eil) 15 August 1979. 13.00 B.S.T. Sunny periods, showers. Wind SW 3.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	11.3	27.0	0.48 d	4.44 d	1.54 d	8.87 d	8.15 d	1.07 ld	0.55 ld	1.66 d
10 m	11.1	28.7	0.51 d	4.40 d	1.75 d	9.11 d	7.00 d	0.49 ld	0.36 ld	1.57 d
40 m	10.9	29.8	0.68 d	3.80 d	1.86 d	10.0 d	6.74 d	0.20 ld	0.28 ld	1.42 d
60 m	10.9	30.5	0.66 d	3.02 d	2.02 d	9.25 d	6.98 d	0.20 ld	0.29 ld	1.41 d
2-10 m Mix.			0.49 d	3.56 d	1.69 d	8.51 d	7.14 d	0.55 ld	0.43 ld	1.56 d

STATION LL1 (Upper Loch Linnhe) 15 August 1979. 16.00 B.S.T. Sunny, showers. Wind SW 4.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	11.7	29.7	0.37 d	0.26 d	1.60 d	9.38 d	5.72 d	1.10 ld	0.48 ld	1.69 d
10 m	11.2	31.1	0.40 d	0.27 d	1.59 d	8.49 d	4.70 d	0.47 ld	0.33 ld	1.59 d
50 m	10.8	31.8	0.46 d	0.22 d	1.74 d	9.94 d	4.48 d	0.25 ld	0.28 ld	1.46 d
100 m	10.8	31.98	0.48 d	0.24 d	1.79 d	9.79 d	4.54 d	0.27 ld	0.26 ld	1.51 d
140 m	10.87	32.05	0.45 d	0.16 d	1.46 d	8.85 d	4.50 d	0.29 ld	0.30 ld	1.49 d
2-10 m Mix.			0.39 d	0.25 d	1.51 d	9.16 d	5.24 d	0.65 ld	0.33 ld	1.65 d

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station LY1 (Lynn of Lorne) 12 November 1979. 13.00 G.M.T. Clear and sunny, cold. Wind NW 2.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	10.1	31.87	0.51	0.17	5.22	6.75	6.52	0.28	0.10	1.73
10 m	11.5	33.21	0.53	0.16	5.29	6.95	6.15	0.14	0.10	1.58
40 m	11.5	33.64	0.51	0.16	5.20	6.51	5.33	0.15	0.11	1.57
2-10 m Mix.			0.51	0.20	5.29	7.15	5.99	0.17	0.09	1.65

Station FL1 (off Colonsay) 13 November 1979. 12.55 G.M.T. Cloudy, cold, rough. Wind SE 5.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	11.1	33.89	0.50	0.17	5.33	8.26	4.75	0.18	0.11	1.63
10 m	11.1	33.91	0.51	0.14	4.98	8.07	4.40	0.17	0.12	1.58
40 m	11.2	33.96	0.51	0.19	5.20	7.06	4.55	0.15	0.13	1.55
80 m	11.2	34.53	0.45	0.14	5.27	6.35	3.34	0.20	0.18	1.52
2-10 m Mix.			0.50	0.15	5.33	8.40	4.77	0.16	0.10	1.62

Station C3 (Loch Creran) 14 November 1979. 10.20 G.M.T. Calm, overcast, cold.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	9.1	30.1	0.49	0.22	5.07	7.35	9.10	0.28	0.21	1.58
10 m	9.6	30.7	0.51	0.17	5.29	7.09	7.48	0.22	0.14	1.60
40 m	10.2	31.7	0.52	0.16	5.52	7.05	6.94	0.10	0.15	1.40
2-10 m Mix.			0.49	0.18	5.16	6.79	8.38	0.22	0.15	1.59

Station C5 (Loch Creran) 14 November 1979. 11.30 G.M.T. Calm, overcast, cold.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	10.0	30.6	0.51	0.24	5.20	7.13	8.81	0.56	0.14	1.80
10 m	10.7	31.1	0.51	0.15	5.61	7.56	7.30	0.12	0.13	1.48
20 m	10.6	31.3	0.54	0.14	5.29	7.99	7.21	0.08	0.18	1.30
2-10 m Mix.			0.53	0.18	5.54	7.27	7.90	0.22	0.18	1.55

Station E70 (Loch Eil) 15 November 1979. 13.00 G.M.T. Calm, misty sun, cold.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	8.7	23.9	0.27	0.26	3.21	8.21	13.40	0.23	0.10	1.70
10 m	10.2	25.6	0.29	0.29	2.79	8.77	12.55	0.08	0.09	1.47
40 m	11.1	27.8	0.57	0.20	5.60	8.29	12.55	0.03	0.09	1.26
60 m	11.3	28.2	0.75	0.25	5.61	11.22	13.61	0.06	0.11	1.33
2-10 m Mix.			0.28	0.30	2.98	8.51	12.87	0.11	0.11	1.51

Station LL1 (Upper Loch Linnhe) 15 November 1979. 15.00 G.M.T. Misty sun, cold. Wind NE 2.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	9.4	23.1	0.36	0.22	4.26	8.44	13.92	0.26	0.11	1.70
10 m	11.4	29.8	0.52	0.22	5.36	6.70	9.81	0.05	0.08	1.38
50 m	11.4	31.7	0.51	0.19	5.38	5.99	7.28	0.08	0.10	1.43
100 m	11.60	31.92	0.57	0.20	5.60	6.67	8.23	0.05	0.10	1.33
145 m	11.78	32.00	0.56	0.20	5.60	6.64	8.97	0.05	0.10	1.34
2-10 m Mix.			0.46	0.25	4.74	7.53	10.76	0.14	0.09	1.61

Station LY1 (Lynn of Lorne) 11 February 1980. 13.40 G,M.T. Sunny periods, very mild. Wind S 1-2.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	6.5	31.0	0.62 d	0.12 d	8.64 d	4.98 d	7.84 d	0.16 ld	0.08 ld	1.67 d
10 m	6,8	33.33	0.64 d	0.11 d	8.73 d	4.52 d	6,52 d	0.09 ld	0.08 ld	1.53 d
40 m	6.9	33.63	0.66 d	0.10 d	8.89 d	4.60 d	6.42 d	0.09 ld	0.05 ld	1.62 d
2-10 m Mix.			0.64 d	0.09 d	8.70 d	4.28 d	7.06 d	0.10 ld	0.08 ld	1.56 d

STATION FL1 (off Colonsay) 12 February 1980. 14.30 G.M.T. Overcast, rain, heavy SW swell. Wind S2-3.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	7.2	33.8	0.76 d	0.09 d	8.29 d	5.83 d	6.14 d	0.12 ld	0.09 ld	1.56 d
10 m	7.0	33.85	0.68 d	0.11 d	8.27 d	3.99 d	5.58 d	0.11 ld	0.09 ld	1.55 d
40 m	7.0	33.90	0,65 d	0.12 d	7.38 d	4,57 d	5.82 d	0.07 ld	0.09 ld	1.45 d
80 m	7.0	33.97	0.66 d	0.10 d	8.29 d	4.43 d	5.53 d	0.08 ld	0.11 ld	1.42 d
2-10 m Mix.			0.73 d	0.10 d	8.38 d	5.43 d	5.77 d	0.10 ld	0.10 ld	1.51 d

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station C3 (Loch Creran) 13 February 1980. 11.40 G.M.T. Overcast. Wind SW 2.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	6.5	31.87	0.61 d	0.12 d	8.19 d	5.15 d	7.64 d	0.19 ld	0.10 ld	1.66 d
10 m	6.4	32.49	0.62 d	0.11 d	7.87 d	5.30 d	6.70 d	0.08 ld	0.07 ld	1.53 d
40 m	6.3	33.14	0.66 d	0.14 d	8.20 d	4.99 d	7.22 d	0.05 ld	0.09 ld	1.38 d
2-10 m Mix.			0.62 d	0.11 d	8.32 d	5.06 d	6.89 d	0.09 ld	0.08 ld	1.54 d

Station C5 (Loch Creran) 13 February 1980. 14.05 G.M.T. Sunny periods, drizzle. Wind SW 2-3.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	6.4	31.71	0.58 d	0.16 d	7.54 d	4.90 d	7.60 d	0.26 ld	0.14 ld	1.64 d
10 m	6.2	32.64	0.62 d	0.13 d	7.23 d	4.43 d	7.13 d	0.09 ld	0.09 ld	1.55 d
16 m	6.3	33.00	0.63 d	0.13 d	7.51 d	3.75 d	7.17 ld	0.05 ld	0.07 ld	1.42 d
2-10 m Mix.			0.61	0.14 d	7.52 d	4.74 d	7.03 d	0.17 ld	0.10 ld	1.61 d

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station E70 (Loch Eil) 14 February 1980. 13.30 G.M.T. Dull, rain. Wind S 1.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	6.8	22.0	0.26 d	0.19 d	5.00 d	5.98 d	12.57 d	0.07 ld	0.09 ld	1.44 d
10 m	7.2	28.8	0.41 d	0.16 d	6.66 d	3.93 d	9.75 d	0.04 ld	0.06 ld	1.38 d
40 m	-	-	0.63	0.14	6.96	4.28	9.69	0.02 ld	0.05 ld	1.33 d
55 m	7.4	31.2	0.59	0.17	6.75	5.22	8.89	-	-	-
60 m	-	-	0.62	0.15	6.93	3.80	9.31	0.02 ld	0.04 ld	1.31 d
2-10 m Mix.			0.32 d	0.19 d	5.42 d	4.80 d	11.25 d	0.04 ld	0.08 ld	1.36 d

Station LL1 (Upper Loch Linnhe) 14 February 1980. 17.30 G.M.T. Dull, wet. Wind SW 2.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	6.8	25.8	0.43 d	0.11 d	7.17 d	4.86 d	10.33 d	0.12 ld	0.09 ld	1.56 d
10 m	7.0	30.1	0.55 d	0.10 d	7.96 d	5.08 d	7.64 d	0.08 ld	0.08 ld	1.49 d
50 m	7.2	32.43	0.58 d	0.11 d	8.28 d	3.39 d	6.63 d	0.03 ld	0.05 ld	1.41 d
100 m	7.39	32.58	0.59 d	0.09 d	8.63 d	2.78 d	7.07 d	0.04 ld	0.04 ld	1.53 d
150 m	7.20	32.61	0.59 d	0.12 d	8.48 d	2.78 d	6.68 d	0.04	0.07	1.36
2.10 m Mix.			-	-	7.88	3.39	-	0.12 ld	0.06 ld	1.67 d

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station LY1 (Lynn of Lorne) 13 May 1980. 11.00 B.S.T. Part cloudy. Wind E 2.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	8.8	32.51	0.23 d	0.18 d	0.27 d	5.80 d	1.80 d	-	-	-
10 m	8.5	32.62	0.24 d	0.19 d	0.41 d	5.43 d	1.62 d	-	-	-
40 m	7.9	33.48	0.58 d	0.13 d	4.65 d	5.20 d	4.44 d	-	-	-
2-10 m Mix.			0.23 d	0.20 d	0.35 d	5.35 d	1.56 d	-	-	-

Station FL1 (off Colonsay) 14 May 1980. 13.30 B.S.T. Bright sun, clear. Wind SE 1.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	8.9	33.91	0.52 d	0.16 d	4.55 d	4.83 d	4.55 d	-	-	-
10 m	8.5	33.90	0.51 d	0.16 d	4.19 d	5.14 d	5.69 d	-	-	-
40 m	8.6	34.02	0.44 d	0.18 d	3.27 d	5.57 d	3.06 d	-	-	-
80 m	8.7	34.25	0.45 d	0.16 d	3.01 d	5.40 d	2.58 d	-	-	-
2-10 m Mix.			0.51 d	0.14 d	4.33 d	5.51 d	3.75 d	-	-	-

d denotes mean of duplicates

Station C3 (Loch Creran) 13 May 1980. 14.00 B.S.T. Overcast, hazy sun. Wind SW 2.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	9.4	32.76	0.28 d	0.21 d	0.20 d	6.35 d	2.41 d	-	-	-
10 m	8.9	32.93	0.32 d	0.17 d	1.10 d	6.22 d	2.59 d	-	-	-
40 m	8.9	33.23	0.35 d	0.17 d	1.39 d	5.80 d	3.20 d	-	-	-
2-10 m Mix.			0.30 d	0.19 d	0.62 d	5.95 d	2.63 d	-	-	-

Station C5 (Loch Creran) 13 May 1980. 15.15 B.S.T. Sunny periods, hazy. Wind W 2-3.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	9.7	33.01	0.28 d	0.22 d	0.11 d	5.95 d	2.65 d	-	-	-
10 m	9.1	33.09	0.32 d	0.22 d	0.41 d	5.58 d	3.63 d	-	-	-
16 m	8.9	33.18	0.39 d	0.22 d	1.02 d	6.92 d	4.05 d	-	-	-
2-10 m Mix.			0.30 d	0.23 d	0.27 d	6.60 d	2.81 d	-	-	-

d denotes mean of duplicates.

Station E70 (Loch Eil) 15 May 1980. 14.00 B.S.T. Clear and sunny. Wind SE 1.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	8.6	30.6	0.02 d	0.27 d	0.23 d	6.47 d	1.85 d	-	-	-
10 m	8.0	31.1	0.22 d	0.19 d	1.97 d	8.46 d	1.92 d	-	-	-
40 m	8.0	31.5	0.26 d	0.18 d	2.01 d	5.31 d	2.27 d	-	-	-
60 m	8.0	32.1 f	0.29 d	0.21 d	2.42 d	6.22 d	2.39 d	-	-	-
2-10 m Mix.			0.14 d	0.22 d	1.13 d	6.68 d	2.07 d	-	-	-

Station LL1 (Upper Loch Linnhe) 15 May 1980. 17.00 B.S.T. Clear and sunny. Wind SW 2.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	9.2	30.9	0.27 d	0.19 d	1.78 d	5.92 d	1.31 d	-	-	-
10 m	8.0	31.84	0.31 d	0.18 d	2.07 d	5.65 d	2.52 d	-	-	-
50 m	7.9	32.60	0.38 d	0.15 d	2.68 d	5.80 d	1.67 d	-	-	-
100 m	7.87	32.63	0.40 d	0.15 d	3.26 d	6.38 d	1.63 d	-	-	-
135 m	7.54	32.59	0.52 d	0.15 d	3.61 d	6.59 d	2.72 d	-	-	-
2-10 m Mix.			0.27 d	0.16 d	1.67 d	5.19 d	0.90 d	-	-	-

f denotes fluctuation d denotes mean of duplicates

Station LY1 (Lynn of Lorne) 7 August 1980. 10.00 B.S.T. Overcast. Wind NE 2.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	13.1	31.64	0.19 d	0.22 d	0.11 d	5.49 d	0.55 d	2.50 ld	0.74 ld	1.77 d
10 m	12.3	33.25	0.38 d	0.19 d	0.85 d	6.94 d	2.50 d	1.70 ld	0.57 ld	1.75 d
40 m	12.1	33.59	0.51 d	0.16 d	1.22 d	7.48 d	4.55 d	0.38 ld	0.34 ld	1.52 d
2-10 m Mix.			0.32 d	0.20 d	0.47 d	6.04 d	1.85 d	2.23 ld	0.82 ld	1.73 d

Station FL1 (off Colonsay) 6 August 1980. 13.00 B.S.T. Sunny. Wind SW 1.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	13.2	33.74	0.25 d	0.15 d	0.33 d	3.89 d	2.15 d	1.60 ld	0.42 ld	1.79 d
10 m	12.5	33.82	0.40 d	0.18 d	1.19 d	6.81	2.20 d	1.13 ld	0.45 ld	1.71 d
40 m	12.3	33.84	0.42 d	0.18 d	0.91 d	6.26 d	3.05 d	0.32 ld	0.29 ld	1.53 d
80 m	12.2	33.89	0.44 d	0.15 d	0.92 d	6.27 d	2.80 d	0.33 ld	0.28 ld	1.55 d
2-10 m Mix.			0.33 d	0.17 d	0.84 d	5.57 d	2.15 d	1.59 ld	0.48 ld	1.77 d

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station C3 (Loch Creran) 8 August 1980. 11.00 B.S.T. Sunny periods. Wind NE 1.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	13.3	31.90	0.22 d	0.25 d	0.09 d	5.90 d	0.50 d	1.56 ld	0.78 ld	1.66 d
10 m	12.7	32.57	0.38 d	0.19 d	0.62 d	6.54 d	2.40 d	1.47 ld	0.59 ld	1.71 d
37 m	12.6	33.03	0.45 d	0.18 d	0.78 d	6.16 d	3.30 d	0.74 ld	0.60 ld	1.55 d
2-10 m Mix.			0.31 d	0.20 d	0.40 d	6.92 d	1.90 d	1.83 ld	0.75 ld	1.71 d

Station C5 (Loch Creran) 8 August 1980. 13.30 B.S.T. Sunny periods. Wind SW 1.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	13.3	31.79	0.20 d	0.20 d	0.08 d	5.91 d	0.15 d	1.58 ld	0.90 ld	1.63 d
10 m	12.8	32.54	0.30 d	0.18 d	0.10 d	5.14 d	0.75 d	4.45 ld	0.11 ld	1.90 d
16 m	12.6	32.77	0.70 d	0.20 d	0.89 d	9.53 d	7.20 d	1.97 ld	1.02 ld	1.66 d
2-10 m Mix.			0.22 d	0.44 d	0.11 d	7.38 d	4.95 d	3.90 ld	1.40 ld	1.73 d

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station E70 (Loch Eil). 11 August 1980. 15.30 B.S.T. Overcast, rain. Wind NE 1.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	12.7	28.6	0.15 d	0.22 d	0.11 d	6.24 d	1.40 d	3.42 ld	1.68 ld	1.67 d
10 m	12.2	29.3	0.29 d	0.21 d	0.87 d	6.62 d	3.55 d	0.63 ld	0.54 ld	1.54 d
40 m	11.8	30.2	0.42 d	0.18 d	1.01 d	7.17 d	4.95 d	0.27 ld	0.40 ld	1.40 d
60 m	11.8	30.6	0.43 d	0.17 d	1.01 d	6.35 d	4.80 d	0.25 ld	0.52 ld	1.33 d
2-10 m Mix.			0.25 d	0.20 d	0.81 d	7.36 d	2.85 d	1.08 ld	0.86 ld	1.56 d

Station LL1 (Upper Loch Linnhe) 11 August 1980. 12.30 B.S.T. Overcast, rain. Calm.

Depth	Temp.	Sal.	D.I.P.	D.O.P.	D.I.N.	D.O.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m	12.2	29.4	0.33 d	0.18 d	0.84 d	7.07 d	3.50 d	1.26 ld	0.60 ld	1.68 d
10 m	12.2	31.98	0.41 d	0.15 d	0.77 d	6.48 d	2.80 d	0.46 ld	0.60 ld	1.43 d
50 m	11.9	32.41	0.47 d	0.16 d	1.00 d	6.71 d	3.20 d	0.27 ld	0.50 ld	1.35 d
100 m	11.7	32.44	0.44 d	0.10 d	1.25 d	7.27 d	2.00 d	0.18 ld	0.37 ld	1.33 d
135 m	11.2	32.39	0.54 d	0.16 d	1.54 d	6.72 d	5.30 d	0.09 ld	0.33 ld	1.21 d
2-10 m Mix.			0.41 d	0.20 d	0.87 d	6.81 d	3.35 d	0.65 ld	0.54 ld	1.54 d

d denotes mean of duplicates ld denotes logarithmic mean of duplicates

Station LY1 (Lynn of Lorne) 4 February 1981. 10.00 G,M.T. Sunny periods. Wind NW 3.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
0 m			6.5		-	-	-
2 m			6.5		0.13	0.10	1.58
4 m			6.7		-	-	-
6 m			6.7		0.09	0.11	1.46
8 m			6.8		-	-	-
10 m			6.9		0.09	0.09	1.51
12 m			7.0		0.10	0.12	1.48
16 m			7.0		-	-	-
20 m			7.0		0.09	0.08	1.54
30 m			7.0		0.10	0.08	1.58
40 m			7.1		0.10	0.10	1.51

T/S data not available.

Station LY2 (North of Shuna Island, Port Appin) 5 February 1981. 13.45 G.M.T. Overcast. Wind W 3.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
2 m			6.30		0.11	0.06	1.68
8 m			6.61		0.10	0.05	1.67
14 m			6.52		0.06	0.04	1.61
20 m			6.56		0.05	0.05	1.51
40 m			6.61		0.06	0.04	1.61
70 m			6.75		0.06	0.06	1.53

T/S data not available.

Station LL1 (Upper Loch Linnhe) 4 February 1981. 15.00 G.M.T. Snow showers, sunny periods. Wind NW 2.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
0 m			5.65		0.05	0.16	1.23
2 m			5.96		0.06	0.14	1.30
4 m			6.35		0.05	0.09	1.37
6 m			6.41		0.09	0.13	1.43
8 m			6.46		-	-	-
10 m			6.60		0.07	0.11	1.39
20 m			6.73		0.04	0.06	1.39
50 m			6.91		0.02	0.06	1.31
100 m			6.97		0.03	0.06	1.39
146 m			7.01		0.03	0.07	1.31

T/S data not available.

Station LL2 (Upper Loch Linnhe) 4 February 1981. 17.30 G.M.T. Dark. Wind NW 3-4.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
1 m			5.83		0.05	0.14	1.26
4 m			6.46		0.06	0.10	1.38
10 m			6.71		0.05	0.08	1.42
20 m			6.88		0.04	0.07	1.35
30 m			6.98		0.03	0.06	1.35
60 m			7.07		0.03	0.03	1.50
100 m			7.05		-	-	-

T/S data not available

Station E70 (Loch Eil) 5 February 1981. 10.20 G.M.T. Overcast, calm.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
0 m			4.68		0.12	0.09	1.60
2 m			4.72		0.07	0.11	1.41
5 m			4.83		0.05	0.13	1.26
7 m			5.24		-	-	-
9 m			5.40		0.04	0.12	1.26
19 m			5.99		0.02	0.09	1.20
39 m			6.24		0.02	0.04	1.33
59 m			6.31		0.02	0.06	1.28

T/S data not available.

Station E24 (Loch Eil) 5 February 1981. 09.00 G.M.T. Overcast, rain. Wind W 1.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeopigment	Acid Ratio
1 m			5.61		0.05	0.12	1.30
4 m			6.14		0.07	0.11	1.38
10 m			6.42		0.04	0.10	1.30
20 m			6.74		0.03	0.07	1.28
35 m			7.12		0.04	0.08	1.31

T/S data not available.

Station 1 (Firth of Lorne, S. of Loch Spelve mouth) 10 August 1981. 11.00 B.S.T. Cloudy. Wind SSE 3.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
0 m	12.8	33.23	1.24	2.53	-	-	-
2 m	12.8	33.22	1.21	2.62	-	-	-
10 m	12.6	33.39	1.75	3.28	0.62	0.19	1.76
50 m	12.4	33.55	1.95	3.29	0.74	0.18	1.80
80 m	12.4	33.64	2.21	3.70	-	-	-
120 m	12.35	33.80	2.40	3.82	0.30	0.23	1.56
165 m	12.41	33.93	2.34	4.41	0.28	0.21	1.57
2-10 m Mix			1.52	2.98	0.89	0.30	1.74

Station 2 (Lynn of Morven) 10 August 1981. 14.10 B.S.T. Rain. Wind SSE 2.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
0 m	13.6	32.4	0.14	0.48	-	-	-
2 m	13.3	32.6	0.11	0.45	-	-	-
10 m	12.6	33.28	0.38	1.62	2.24	-0.15	2.07
50 m	12.4	33.37	1.31	3.35	0.22	0.14	1.61
80 m	12.26	33.40	1.39	3.69	-	-	-
100 m	-	-	1.38	3.38	-	-	-
130 m	12.21	33.43	1.53	4.58	0.16	0.09	1.63
150 m	-	-	1.55	3.88	-	-	-
185 m	12.42	33.55	1.85	4.70	0.19	0.13	1.58
2-10 m Mix			0.18	1.06	1.47	-0.03	2.02

Station LY1 (Lynn of Lorne) 13 August 1981. Low Cloud.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
0 m	14.2	30.4	0.12	0.93	-	-	-
2 m	13.6	32.4	0.19	1.24	-	-	-
10 m	12.7	33.19	1.37	3.02	0.83	0.06	1.94
20 m	12.3	33.40	1.85	3.96	-	-	-
40 m	12.2	33.46	2.30	5.42	0.85	0.21	1.80
2-10 m Mix.			0.66	1.88	1.60	0.31	1.84

Station LL1 (Upper Loch Linnhe) 13 August 1981. 12.00 B.S.T. Misty, calm.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
0 m	13.9	26.6	0.18	4.26	-	-	-
2 m	13.1	30.9	0.17	1.32	-	-	-
4 m	12.7	31.7	0.35	1.05	-	-	-
10 m	12.5	31.8	0.66	1.53	0.98	0.08	1.93
20 m	12.2	31.9	0.84	1.86	-	-	-
50 m	11.8	32.1	1.24	3.17	0.22	0.40	1.36
80 m	11.8	32.2	1.24	2.96	-	-	-
100 m	11.80	32.26	1.26	3.15	0.27	0.34	1.45
135 m	11.81	32.29	1.29	3.32	0.21	0.27	1.44
2-10 m Mix.			0.44	1.39	2.40	0.40	1.86

Station LL2 (Upper Loch Linnhe) 11 August 1981. 15.25 B.S.T. Overcast, drizzle. Wind SW 3-4.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
0 m	14.2	30.2	0.10	0.83	-	-	-
2 m	14.2	30.2	0.09	0.99	2.02	0.01	1.99
5 m	13.8	31.7	0.12	0.79	-	-	-
10 m	12.9	31.9	0.11	0.72	2.37	0.43	1.85
20 m	12.4	32.1	1.08	3.20	-	-	-
50 m	12.2	32.0	1.26	4.08	0.19	0.22	1.46
80 m	12.4	32.2	1.15	3.43	-	-	-
120 m	-	-	1.17	3.65	0.29	0.38	1.43

Station E70 (Loch Eil) 11 August 1981. 13.50 B.S.T. Overcast, drizzle.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
0 m	13.8	28.9	0.45	3.47	-	-	-
2 m	13.5	29.4	0.41	3.45	-	-	-
10 m	12.8	30.1	0.16	1.71	0.70	0.22	1.76
20 m	12.3	30.2	0.41	1.65	-	-	-
30 m	12.3	30.4	0.83	3.36	0.35	0.36	1.50
40 m	12.2	30.4	0.80	3.27	-	-	-
50 m	12.2	30.4	0.92	4.40	-	-	-
60 m	12.1	30.5	0.89	4.51	0.18	0.30	1.38
2-10 m Mix.			0.26	2.34	1.24	0.33	1.79

Station E24 (Loch Eil) 11 August 1981. 13.00 B.S.T. Overcast, low cloud, drizzle.

Depth	Temp.	Sal.	D.I.N.	Silicate	Chlorophyll	Phaeo.	Acid Ratio
0 m	13.5	29.4	0.31	2.58	-	-	-
2 m	13.4	29.3	0.20	2.58	3.0	0.45	1.87
5 m	13.2	29.9	0.10	1.33	-	-	-
10 m	12.8	29.9	0.13	0.98	3.59	0.44	1.89
20 m	12.2	30.1	0.96	3.94	-	-	-
30 m	12.1	30.3	1.14	5.52	0.31	0.45	1.40
35 m	12.0	30.1	1.21	5.35	-	-	-