Short Title

Primary and Secondary Production in Malpeque Bay P.E.I.

A B S T R A C T

The Primary Productivity of the Bideford River peaks at the time when oyster larvae and other pelecypod and gastropod larvae are most abundant in the water.

The peak phytoplankton blooms in summer are due to microflagellates which are suitable food for these larvae.

The relatively low production levels in the centre of Malpeque Bay are probably due to the high rate of tidal flushing. This is reflected in the relative paucity of oysters and other molluscs in this area.

Production levels in the centre of Malpeque Bay are not much higher than those found offshore.

TITLE

Primary and Secondary Production in Malpeque Bay, Prince Edward Island compared with one of its tributaries and the nearby Gulf of St. Lawrence.

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Department of Biology

M. Sc. Thesis

Primary and Secondary Production in Malpeque Bay Prince Edward Island Compared with One of its Tributaries and the Nearby Gulf of St. Lawrence.

by

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science.

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To Sigrid

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A B S T R A C T

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Introduction

Studies of the productivity of sea water in relation to nutrient concentrations have been carried out for many years. Pioneers in this field were K. Brandt (1899, 1902) who first suggested that phytoplankton production must depend on the supply of nitrates and phosphates present in natural waters. Proof of this relationship was given by Atkins (1923, 26, 26a) and others. Nathansohn (1906) first pointed out that stability of the water column, associated with the vernal warming of surface waters was intimately correlated with plankton production. A thorough documentation of these and other pioneer work in the field of productivity in relation to nutrients is found in the reports of Ketcham et al (1958), Raymont (1963).

The present study centered around a comparison of the productivity of a semi-enclosed bay, or estuary with the nearby open sea.

An estuary, as defined by Cameron and Pritchard (1963), is a semi-enclosed coastal body of water, having a free connection with the open sea, and within which sea water is measurably diluted with fresh water deriving from land drainage.

Historically, man has tended to establish his settlements around estuaries as these form natural trade centres. They provide ready access equally to inland water ways and the sea, and usually form safe harbours. Estuaries are fed from watersheds which are often enriched by farming activities and usually support a shellfish or crustacean industry. The high concentration of nutrients, due to land run off and other terrestrial sources often results in a high degree of eutrophication.

Estuaries, because of their tidal flushing, form an effective means of removing the wastes of human presence and activities. These wastes may provide yet another source of enrichment for estuarine water (increasingly often, man's presence so overloads the natural equilibrium of estuaries that the existing ecological system breaks down, to be replaced by another, which is usually less desirable or useful to man) (McHugh 1967).

Many factors are known to affect the producitivity of seawater, a large number of these parameters is recorded and methods for their analysis are described by Strickland and Parsons (1968). Of these, the following were investigated in the present study.

1) Temperature, Salinity.

2) Inorganic Micronutrients:

   a) dissolved reactive phosphorus.

   b) dissolved reactive nitrate (and nitrite).

   c) dissolved reactive silicate.

3) Determination of organic particulate materials.

   a) pigment analysis-chlorophyll 'A'.

4) Photosynthetic rate measurements.

   a) uptake of radioactive carbon.

5) Biomass

   a) wet volume of zooplankton.

   b) dry weight of zooplankton.

Aim

The purpose of this study was to compare the rates of primary and secondary production in Malpeque Bay, P. E. I. with the nearby Gulf of St. Lawrence water. The study was extended in the second year to include the Bideford River, a tributary of Malpeque Bay, as this river has been shown to support a large population of bivalve and gastropod molluscs (Thomas 1970). Most notable of these, because of its commercial value, is the oyster Crassostrea virginica (Gmelin).

A further aim of the project was to relate seasonal variation of primary production to the oyster development. The study will also serve as a baseline for further research in this area with regard to pollution of the waters.

Methods

1. Descriptions of study area
2. Field collection and processing

Methods

Description of the study area.

Prince Edward Island lies in the Southern part of the Gulf of St. Lawrence, Canada. A bibliography of the physical oceanography of the Gulf (El Sabh, Forrester and Johannessen 1969) gives the following facts.

Gulf of St. Lawrence	area 214×10^3 sq.Km.
Land area draining into Gulf	1300×10^3 sq.Km.

The principal connection with the Atlantic Ocean is through the Cabot Strait. A more restricted connection is through the Strait of Belle Isle. The Strait of Canso, separating the mainland of Nova Scotia from Cape Breton Island is very narrow, and since 1954 has been closed except for a lock through the causeway. The report also defined the St. Lawrence 'estuary' as the area between Quebec City and Pte. des Monts and the term 'Gulf' as the area eastward from Pte. des Monts and bounded by the mainland, Cape Breton Island and Newfoundland. Figure 1 was drawn from this manuscript.

Malpeque Bay is situated on the North Coast of Prince Edward Island, it encloses a shallow tidal body of water with an average depth of 3 - 5 m. In a study of Malpeque Bay made by the Inland Waters Board of the Department of Mines, Energy, and Resources, the following information on the area was obtained.

Total land area draining to Malpeque Bay	154 mi^2 (398.9 km^2)
Total length of streams to tide	71 mi (114.3 km)
Total length of shore line	135 mi (217.3 km)
Total area of estuaries (Hog Island to mainland)	80 mi^2 (207.2 km^2)

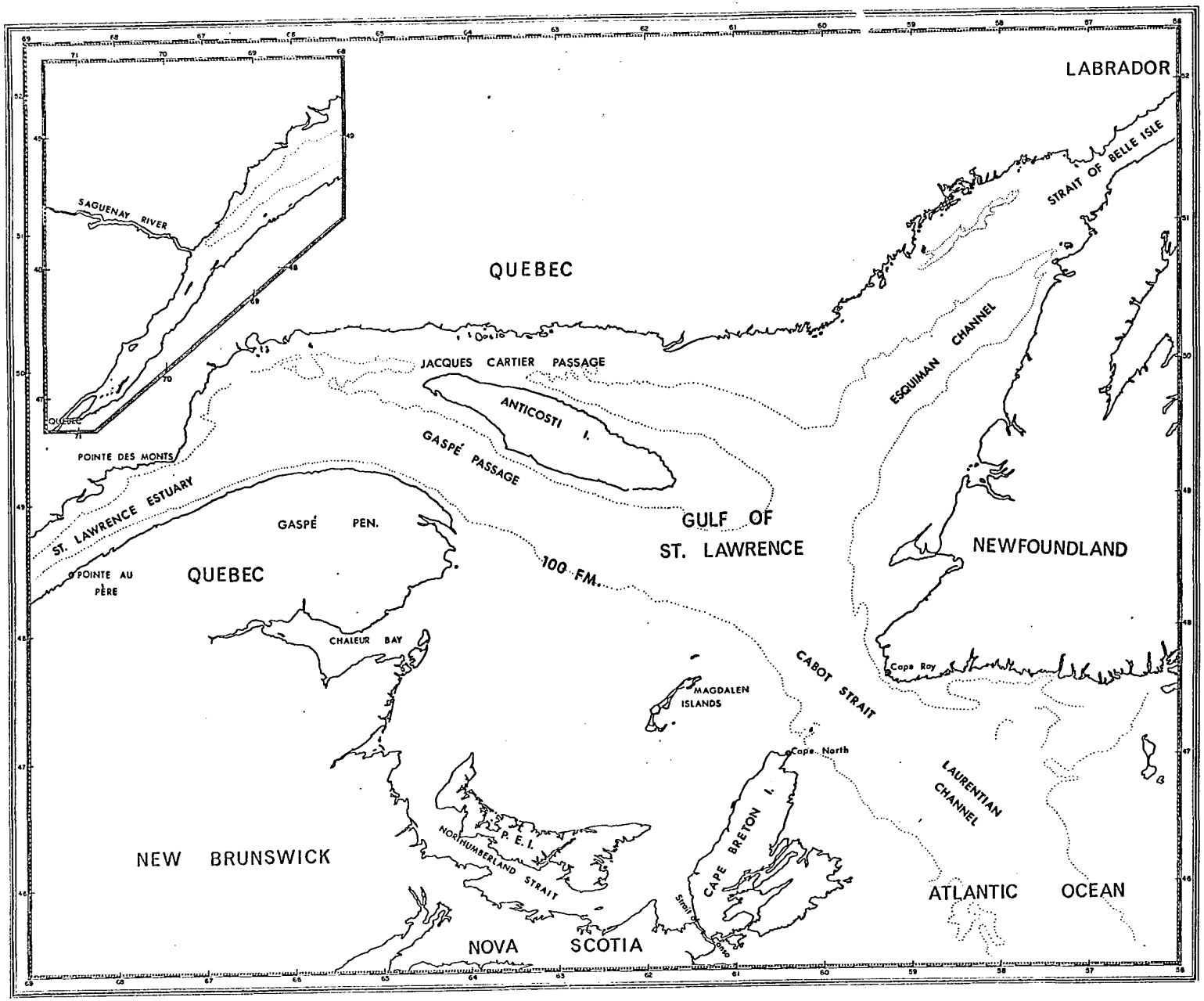
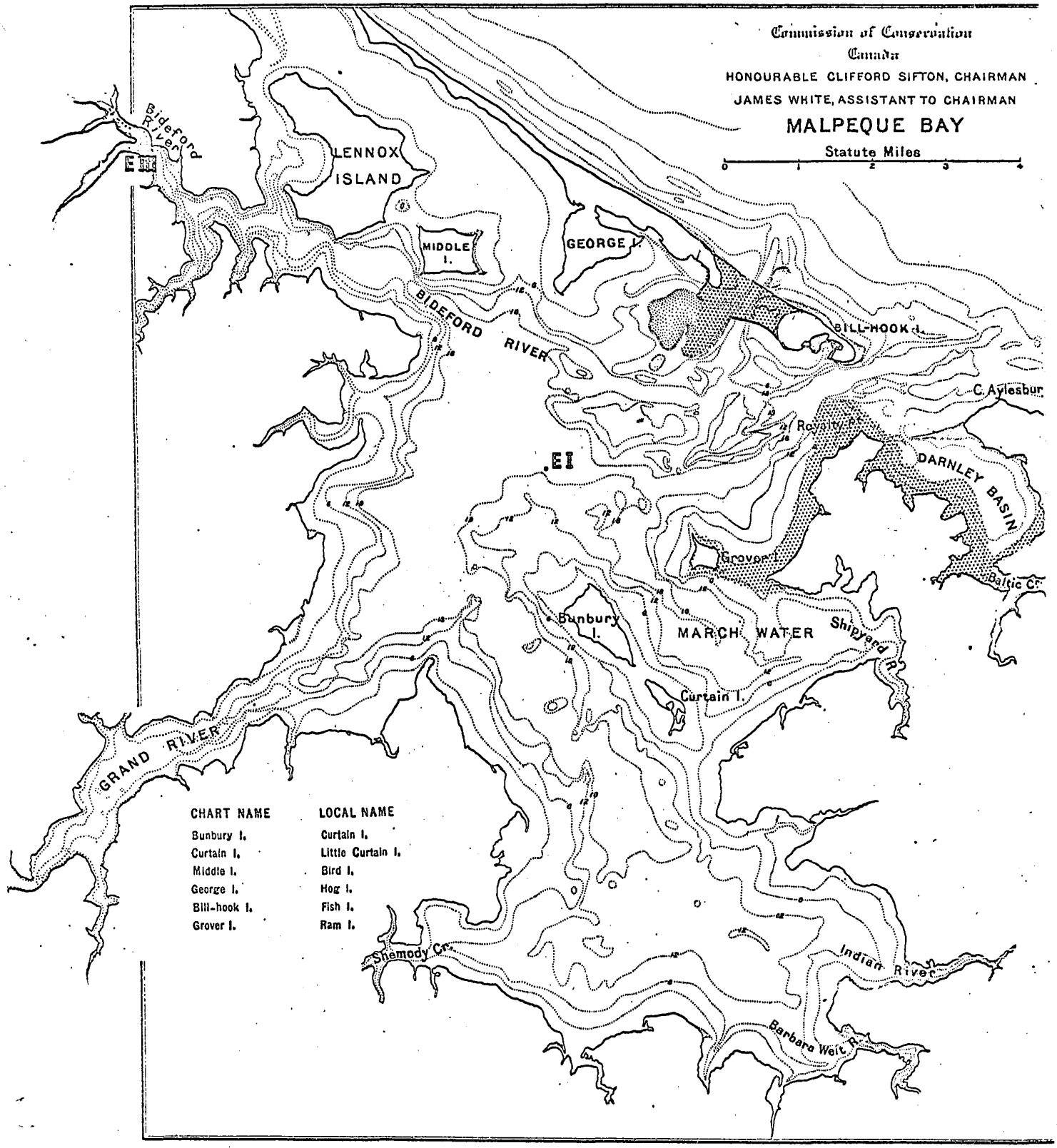


Fig. 1. Gulf of St. Lawrence

The tides propagated into the Gulf of St. Lawrence are of a mixed type and on the north shore of Prince Edward Island, diurnal inequalities dominate. The Canadian Tide and Current Tables (1971) give data on predicted tide elevations and list the tidal amplitudes at Malpeque as 4.2 ft (1.28 m) for a large tide and 2.5 ft. (o.76 m) for a mean tide.

Malpeque Bay has long been famous for its oysters. The history of this industry in the Maritimes has been well documented by J. C. Medcof (1961). An early publication of the Canadian oyster by J. Stafford (1913) also includes a description of the area from which the following map was drawn and modified to up-date (fig. 2).

Fig. 2


Commission of Conservation
Canada
HONOURABLE CLIFFORD SIFTON, CHAIRMAN
JAMES WHITE, ASSISTANT TO CHAIRMAN
MALPEQUE BAY
Statute Miles
0 1 2 3 4
Bideford River
LENNOX ISLAND
MIDDLE I.
GEORGE I.
BIDEFORD RIVER
BILL-HOOK I.
C. Aylesbur
Royalty Pt.
DARNLEY BASIN
EI
Grover I.
Baltic Cr.
Bunbury I.
MARCH WATER
Shipyard R.
Curtain I.
GRAND RIVER
Shemody Cr.
Indian River
Barbara Weit R.
CHART NAME
Bunbury I.
Curtain I.
Middle I.
George I.
Bill-hook I.
Grover I.
LOCAL NAME
Curtain I.
Little Curtain I.
Bird I.
Hog I.
Fish I.
Ram I.

A study of the nutrients and energy cycles was made by F. Uyeno (1966). His study was based on observations made at three shallow water stations (maximum depth 3m) at various times during 1962 in the tributaries of this area.

Positions of Sampling Stations.

Collections were made at four sampling stations throughout the icefree seasons, from April to November in 1969 and 1970. The offshore Station E II 46° 46.6' N lat. 63° 44.5' W long. and E IV 46° 38.9' N lat. 63° 38.6' W long. approximately 12.87 km (8 mi.) NE of Malpeque Bay, were operated as two of a number of stations established for the study of primary production in the I. B. P. Gulf of St. Lawrence Project under the direction of Dr. D. M. Steven of McGill University.

Collections also were made at Station E I 46° 42.3' N. lat. 63° 48.5' W long. near the centre of Malpeque Bay.

After analysis of the first year's data, it became evident that the difference between the bay station and the open sea was not as great as had been anticipated. A third location E III was chosen near the Fisheries Research Board Biological Station and Oyster Hatchery, on the Bideford (Goodwood) River, one of the tributaries of the Malpeque Bay. This was specifically selected in an oyster breeding area. (See Fig. 3) As well as contributing information on estuarine conditions, this station served to link the 1962 data of Uyeno (1966) with the present study, being equivalent to his station 'C'.

The locations, depth, and number of collections are summarized in table 1.

Fig. 3

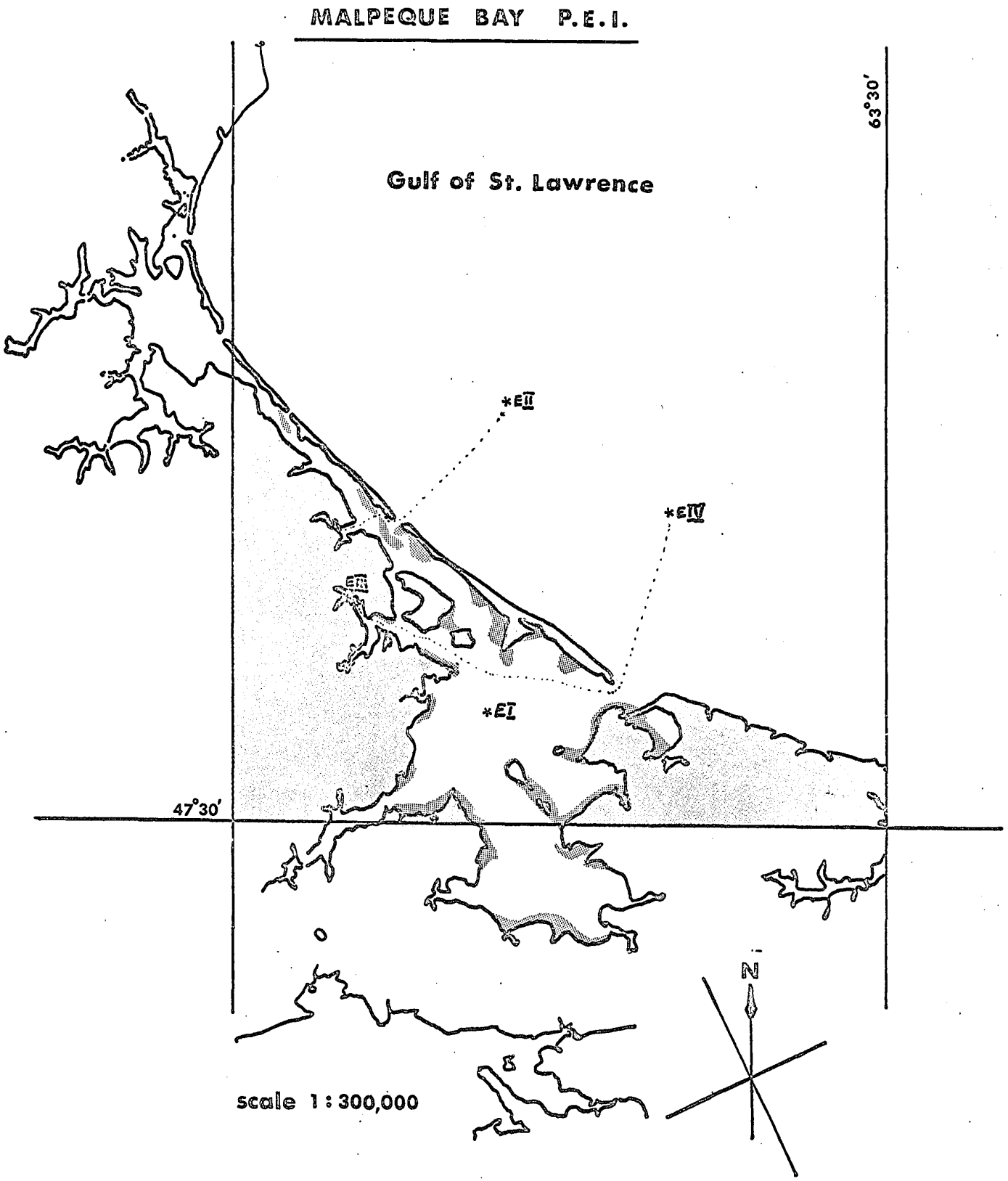

MALPEQUE BAY P.E.I.
Gulf of St. Lawrence
63°30'
47°30'
*EII
*EIV
EIII
*EI
N
scale 1:300,000

Table I

STATION INFORMATION

Stations	Location	Year	Dates	No. of Collections	Max. Depth	Sampling Depth (m)
Biological Stn EIII	(Uyeno Stn. C) 46°37.°05'lat. 63°35' long.	1962 1969 1970	4/4-18/11 none 26/5-7/11	9 15	3m.	0,2½
			Total	24		
Malpeque Bay P. E. I.	46°43.°3'lat. 63°48.°5'long.	1969	9/5-3/11 9/4-5/11	16 19	14m.	0,5,10
			Total	35		
Offshore (N.E.)PEI E II	46°42-5' long. 63°48.°31'long.	1969 1970	14/5-21/8 23/4-12/9	15 17	28m.	0,5,10 15,25
E IV	46°38.°9' lat. 63°38.°6' long.	1969 1970	29/8-6/11 19/9-6/11	5 5	28m.	"
			Total	42		

Two offshore stations were established rather than one, which would have been preferable, due to difficulties in chartering one vessel for the entire season. 50' lobster boats were hired for the work during the lobster season May 1st - 31st., lobster fishing took precedence over the research program and boats were available only in late evening and occasionally on a Sunday.

The routes taken to the Stations E II and E IV are indicated on fig. 3.

Both E II and E IV were located in approximately 28 meters of water. The bottom, at both stations, was sandy with some clumps of rocks. Station E II was chosen originally because of the relative ease of access. Because E IV was only 16 km SE of Station E II and equidistant from the coast, it was

considered to be equally representative of the offshore water as E II. The total time for a round trip was approximately four hours for Station E II and six hours for Station E IV. The time of collections was unavoidably dependant upon various factors such as availability of the ship, fog, winds, and weather, but whenever possible was timed in order that the afternoon was free for processing of samples collected.

The lobster boats were modified to carry a small winch and derrick and a rack to support two full six liter Van Dorn bottles. The boat was anchored while samples were being collected.

The collections at the E I and III were obtained with a 16' whaler similarly equipped. Sampling was generally done in the morning, weather permitting. The depths at these stations were 14 meters and 3 meters respectively and the bottom at both was black mud.

Field Collection and Processing

Water and plankton samples were collected at the sampling stations and were stored on the boat until the return to the Biological Station. Here initial processing was carried out to preserve the samples until they could be sent to Montreal where they were later analysed.

The methods can be dealt with under three headings: a) Shipboard procedures, b) Initial processing at base, c) Analysis at McGill University.

a) Shipboard Procedures in order of collections

General Station Data

The time of arrival at the station, general sea and weather conditions were recorded.

Secchi Disc

A standard, white secchi disc of 30 cm diameter was lowered into the water, and the depth at which it disappeared from view was noted.

Bathythermograph

A temperature/depth profile was taken using a shallow-water bathythermograph (0-75m DF 1090), the surface temperature being verified with a 0-50°C thermometer.

Water sample collecting and dividing

This was followed by the simultaneous collection of sea water samples from preselected depths, measured on a metered block, using a series of six liter Van Dorn bottles. The samples were then sub-divided and treated on deck according to Table 2.

Table 2

Purpose	Bottle Type	Vol. ml	On deck treatment, storage
Nutrients	2 Polythene	125	Refrigerated immediately in ice box.
Salinity	1 Glass	250	Kept in covered wooden box in shade
Phytoplankton	1 Glass	200	Preserved with 5 ml. 40% Formalin
Chlorophylls	1 Polythene	2000	Kept in closed wooden box in shade
Carbon 14 Fixation	2 glass	125	Kept in closed wooden box in shade
		2950	

* All bottles were rinsed 2 or 3 times before filling.

Zooplankton collections

Zooplankton were collected with a .5m diameter conical, #6 mesh plankton net, (30 mesh/cm, aperture size 0.239mm), fitted with a calibrated T. S. K. flowmeter. Two tows were made at the offshore stations each of 15 minutes duration at 2 knots.

1) Surface tow.

2) Oblique tow.

The oblique tow was made with 35m of cable paid out and a 10 kgm lead weight on a 2 meter leader was shacked to the net bridle. The effective maximum towing depth of the net was 12-15 meters. The speed of the boat was varied in order that the net planed at a range of depths, giving an approximate integration of the 0-15 meter water column.

The samples were fixed immediately in 4% formaldehyde solution after collection.

5 to 10 minute surface tows only were made at the Stations E I and E III using the same gear.

Initial processing at base

Nutrient Samples

Immediately on return to the base at the Biological Station, Ellerslie, the nutrient samples were filtered through a 42.5mm glass fibre filter (Whatman GF/C) to remove all planktonic and particulate matter. They were then returned to their polythene bottles and stored in a deep freeze at 20°C.

Carbon 14 Samples

Duplicate samples were collected in 125ml pyrex glass bottles for measurement of carbon fixation and were treated after the general method of Steeman

Nielson (1952), as given in Strickland and Parson (1969). (Each sample was inoculated with 1 ml. of 5 μCurie of $NaHC^{14}O_3$ in an aqueous solution supplied as premeasured aliquotes in sealed vials supplied by New England Nuclear Co. Care was taken to avoid contamination of the laboratory and personnel.) The samples were then incubated under conditions of temperature and light as near as possible to those of the depths from which the samples were taken. This was effected by cooling the bottles in a beige coloured basin of running water, later replaced by a sloping black wooden box with cool water flowing through it after July 1970. (Details of the incubator are given in appendix A). The natural illumination was simulated by placing a bottle from each depth in black nylon mesh bags of known transmissivity to attenuate the light in predetermined amounts, supplied by G.M. Manufacturing Company, New York, so that the illumination received by the phytoplankton in the samples was equivalent to that at the depth from which it was drawn. Bags of 60%, 30%, 16%, and 1% transmissivity were used and the equivalent depths were calculated from the secchi disc reading using the following formula (Sverdrup et al 1958).

$$K = \frac{1.7}{d} \quad \text{----- (1) for coastal waters}$$

Where K - extinction coeffient

d - Secchi disc reading

The extinction coefficient was converted to percentage light transmission per meter. These values were calculated for a range of Secchi disc readings, and tabulated for ease of reference - see appendix B.

One bottle from each set was placed in the filter-bag which most closely approximated the natural transmissivity of the water at the depth from which it was taken.

The other sample bottle drawn from each depth was wrapped in light-proof aluminum foil and subjected to identical conditions.

The incubator containing the samples was placed in direct sunlight for a known period of time, generally four hours. A simultaneous record of solar radiation was obtained with a Belfort recording pyroheliometer in/g cal/cm^2/hr.

Following incubation, samples were filtered immediately through millipore 25mm dia. HAWP membrane filters of 0.45μpore size, dried, and stored on aluminum planchets in an air-tight carbon-dioxide free dessicator (Strickland & Parsons, 1969).

Chlorophyll samples.

Each two liter water sample for chlorophyll analysis was filtered through a 42.5mm glass fibre filter (Whatman GF/C) followed by 1ml. of magnesium carbonate 1% suspension in the last 100 ml of the sample to inhibit acidification of the residue and breakdown of the chlorophyll present to phyophytin. The filter papers were then placed in individual glassine envelopes and stored in a deep freeze at -20°C. (Strickland & Parsons, 1969).

Phytoplankton samples.

The preserved phytoplankton samples were stored in partitioned boxes at room temperature.

Zooplankton samples.

The preserved samples were labelled and stored at room temperature for later sub-division and study.

Summary of Division of Water Sample (See table 3)

Table 3

SUMMARY OF WATER SAMPLE

Purpose	Volume ml	Bottle type	Pre-Storage	Storage
Nutrients	125	2 polythene	cool, filtered	-20°C
Salinity	250	1 glass	wax, sealed	room temp.
Phyto-Plankton	200	1 glass	5 ml, 40% Formalin	room temp.
Chlorophylls	2000	1 polythene	GF/C filtered	filter papers
Carbon 14	125	2 pyrex	Dept. in dark incubator (as soon as possible)	
Total	2950			

Transportation of Samples

Samples were sent frozen to Montreal periodically where they were stored under similar conditions until analyzed. The frozen samples were sent in refrigerated ice boxes and air freighted. The other samples were sent by rail.

The following analyses were carried out at McGill University

Quantitative analysis of the water samples was made by colormetric determination using a Beckman DU-2 spectophotometer modified to take cell paths up to 10cm in length.

Frozen samples were thawed in a water bath at 20°C immediately before analysis. Phosphate and silicate analysis were done the same day from the same sample bottle. Nitrate determinations were made on the other 125ml. sample.

Analyses for nutrient concentrations

Reactive Nitrate Determination

Nitrite was measured as the sum of nitrate plus nitrite, NO_2+NO_3-N by reducing the nitrate to nitrite using a variation of the cadmium - copper amalgam method as described by Morris and Riley (1963). No correction was made for the presence of nitrite in the samples. Details of procedure are given in appendix C1.

Inorganic Phosphorus Determination

Inorganic phosphate PO_4-P was measured by the method of Murphy and Riley (1962).

Reactive Silicate Determination

Reactive Silicate was measured after the modified method of Mullins and Riley (1955).

The details of the above analyses are recorded in appendix C.

Chlorophyll 'A'

Chlorophyll 'A' was measured by the method of Richards with Thompson (1952), as given in Strickland and Parsons (1969) by grinding the glassfibre filter paper bearing the phytoplankton and eluting the chlorophyll in 10 ml of 90% acetone. The following formula was used to calculate the amount of Chlorophyll 'A' present in the sample expressed in mg/m^3.

Chlorophyll 'A' = $11.6 E_{6650} - 1.31 E_{6450} - 0.14 E_{6300}$

Where E stands for the extinction value, at wavelengths indicated by the subscripts, measured in 10cm cells after blank correction.

Phytoplankton

The phytoplankton was superficially studied to determine the predominant forms associated with phytoplankton blooms. The 200 ml samples were allowed to settle for a week and then reduced by very slow syphoning until the volume was 25 ml. They were then transfered to 25 ml settling cells and allowed to settle again for at least eight hours, then examined using a Zeiss Utermöhl plankton microscope. Predominant forms were noted and recorded.

Zooplankton

The zooplankton sample was split twice. See appendix D for details of splitter used. One fourth of the sample was sent to Canadian Oceanographic Identification Center, Ottawa, Ontario, for identification and archiving. Generally a half sample was measured for wet volume (C. Yentch), (see appendix E for modification of the method and equipment) and dry weight (Lovegrove and Tranter, 1962). All volumes and dry weights were expressed per m^3.

Salinity

Salinity was measured with a Beckman Portable Induction Salinometer model RS-7B.

Carbon 14

C^{14} counts were measured from the planchet-mounted filter papers with a gas-filled end window Geiger-Mueller Counter, (Nuclear Chicago Model).

Bathythermograph

The bathythermograph slides processed at the Canadian Oceanographic Data Centre, Ottawa, Ontario, were for computor archiving. Photocopies from these records were used to develop figures 9 and 11.

Calculation Methods and Units

The temperature was recorded for each depth and the salinity in ‰. The concentrations of nutrients in each sample analyzed was expressed in its equivalent concentration in $mg/A/m^3$. The Chlorophyll 'A' pigment was expressed in mg/m^3 and the carbon fixed by photosynthesis was expressed as uncorrected estimates in $mgC/m^3/hr$. Zooplankton wet volume in ml/m^3 and dry weight in mg/m^3.

These values were then averaged over the total water column by first integrating the values estimated for each meter in depth and then averaging over the total water column.

The depth of the offshore stations E II and E IV was taken as 25 meters, Malpeque Bay E I as 10 m and the Biological Station E III as 3 m.

The following formulae were used to integrate the total water column for each parameter.

Offshore - when samples were taken from 0, 5, 10, 15, and 25 m.

$$\sum_{0-25} = \frac{5(v+w)}{2} + \frac{5(w+x)}{2} + \frac{5(x+y)}{2} + \frac{10(y+z)}{2} \quad \text{---------2}$$

Where v, w, x, y, and z are the concentrations of the parameters at 0, 5, 10, 15, and 25 m. respectively.

Malpeque Bay

Where samples were taken from 0, 5, and 10 m.

$$\Sigma_{0-10} = \frac{5(v+w)}{2} + \frac{5(w+x)}{2} \qquad \text{--------} \quad 3$$

depths 0, 5, and 10 m of the parameters being integrated over the total water column.

Biological Station

Where samples were taken from 0 and 2.5 m.

$$\Sigma_{0-3} = \frac{3(v+w)}{2} \qquad \text{---------} \quad 4$$

where v and w are the concentrations.

The integrated values were expressed per m^2 of surface.

These formulae may be simplified mathematically for ease of calculation.

The average concentration per meter in the water column was obtained by dividing by the depth.

e.g. $\bar{x}_{25} = \frac{\text{equation 2}}{25} \qquad \text{--------} \quad 5$

The accuracy of the analytical methods used has been estimated by Strickland and Parsons (1969), and the degrees of confidence determined. The precision of working was also estimated and the methods fell within 95 % confidence limits, which is approximately $\pm 2\sigma$.

The precision P is such that if n determinations are made, the true results will lie in the range :-

Mean of n determinations $\pm \frac{P}{n^{\frac{1}{2}}}$ with 95% confidence.

The precision of integrated values is discussed thoroughly in Pratt and Irwin (MS 1968).

The following tables are a summary of the data for 1969 and 1970 and are average concentrations per m^3. The determined values at each specific depth for each station are recorded chronologically in the major appendix F.

Results Offshore

E II & E IV

TABLE A

1969 Offshore P.E.I. Stn E II - 69

No.	Date	NUTRIENTS			PHYTOPLANKTON		ZOOPLANKTON SURFACE		ZOOPLANKTON OBLIQUE		HYDROGRAPHY			
		Phosphates mg^A/m^3	Nitrates mg^A/m^3	Silicates mg^A/m^3	Chlor 'A' mg/m^3	C ^{14} $mgC/m^3/hr$	Wet Vol ml/m^3	Dry Wt mg/m^3	Wet Vol ml/m^3	Dry Wt mg/m^3	Surf Temp °C	Mean Salinity o/oo	Secchi (d) m	Extinct Coef. $K = \frac{1.7}{d}$
1	14/5	.414	.085	.335	.822	1.05	.112	1.33	—	—	6.4	30.48*	13*	.131
2	23/5	.337	.076	1.349	.234	.041	.110	2.83	—	—	6.6	29.81	9	.189
3	28/5	.279	.214	1.561	.537	1.09	.097	2.12	.272	28.98	7.7	29.45	10.5	.162
4	4/6	.398	.181	1.387	.457	..14	.342	43.04	.477	52.66	8.7	29.41	12	.142
5	11/6	.267	.130	.583	1.405	—	.281	28.19	.723	55.17	11.8	28.85	13*	.131
6	17/6	.179	.109	.640	.630	.56	.820*	102.39*	.796	81.40	14.2	27.82	13*	.131
7	24/6	.190	.216	.746	.482	.38	.731	65.89	.432	45.15	14.4	28.05	11	.155
8	3/7	.256	.150	.950	.660	.33	.371	25.24	1.560*	132.17*	15.6	27.53	9.5	.179
9	9/7	.135	.240	.693	.782	.477	.646	86.12	.719	54.15	13.3	27.35	8.5	.200
10	16/7	.235	.291	.532	.802	.47	.387	45.75	.314	35.88	14.8	27.51	9	.189
11	22/7	.176	.322	.798	.580	.79	.365	37.68	.359	40.79	15.9	27.73	8.25	.206
12	1/8	.259	.408	1.248	.759	.18	.167	18.83	.524	79.83	18.4	27.70	8	.213
13	7/8	.235	.517	1.362	.958	.36	.222	23.23	.474	35.66	19.0	27.65	9	.189
14	13/8	.265	.232	1.693	.716	.43	.017	2.05	.410	43.79	19.5*	27.82	10	.170
15	21/8	.184	.154	1.117	.954	3.22	.491	68.83	.367	24.73	18.2	27.67	7	.243
16	29/8	.234	.356	2.030	.836	2.10	—	—	—	—	17.8	27.28	7.5	.227
17	4/9	.264	.427	1.631	1.011	1.65	.022	1.82	.204	23.08	18.2	27.77	8.5	.200
18	12/9	.495	.994*	2.398	1.667*	1.68*	.171	19.30	.251	23.21	14.7	—	7	.243
19	8/10	.718*	.251	1.891	.829	.79	.315	27.15	.549	56.58	12.7	28.63	5	.340
20	6/11	.501	.908	2.651*	.681	—	.100	8.69	.222	60.47	8.6	28.90	9	.189
	Avg.	.289	.313	1.230	.799	.885	.304	32.13	.509	51.39	13.83	28.36	9.4	.191

* indicates highest recorded value

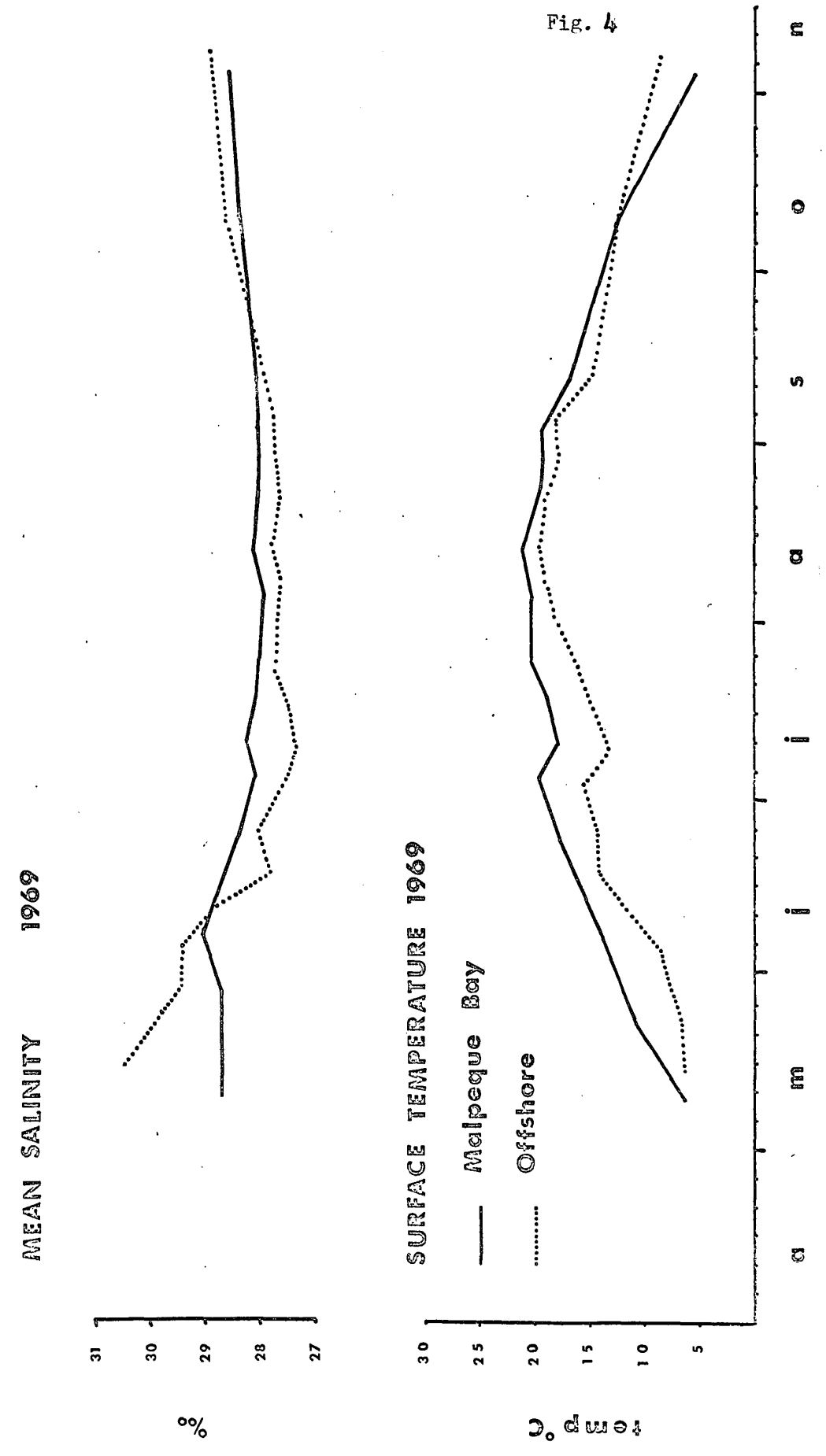
TABLE 5

1970 Offshore P.E.I. Stn E II - 70

No.	Date	NUTRIENTS			PHYTOPLANKTON		ZOOPLANKTON SURFACE		ZOOPLANKTON OBLIQUE		HYDROLOGY			
		Phosphates mg^A/m^3	Nitrates mg^A/m^3	Silicates mg^A/m^3	Chlor 'A' mg/m^3	C^{14} mg^C/m^3hr	Wet Vol ml/m^3	Dry Wt mg/m^3	Wet Vol ml/m^3	Dry Wt mg/m^3	Surf Temp °C	Salinity Mean o/oo	Secchi (d) m	Extinct Coef K=1.7/d
21	23/4	.294	.069	.204	1.027	.29	.030	.25	.249	22.88	2.2	30.19*	5	.340
22	6/5	.454	.112	.261	.228	.09	.025	.71	.292	55.97	5.4	30.17	14	.121
23	12/5	.363	.100	.696	.395	—	.119	18.22	.293	32.03	6.1	22.83	11	.155
24	16/5	.543*	.090	.508	.109	.08	.271	27.62	.216	20.04	7.3	29.54	24	.071
25	6/6	.325	.301	1.621	.484	—	.206	21.50	.210	27.12	9.5	29.31	12	.142
26	14/6	.221	.141	.795	.313	—	.465	47.80	.349	35.92	14.0	29.18	14.5	.117
27	22/6	.195	.163	.912	.452	—	.203	29.35	.320	31.44	—	28.62	11	.155
28	3/7	.229	.213	1.304	.622	.70	.128	9.41	.495	44.74	14.0	28.38	10	.170
29	11/7	.174	.120	1.247	.862	—	.460	43.81	—	—	16.4	28.17	10	.170
30	18/7	.231	.375	1.545	.800	2.82	—	—	—	—	16.1	27.85	8	.213
31	27/7	.35	.3	1.7	.76	2.8	.585	70.41	.664	30.02	18.5	(27.16)	7	.243
32	3/8	.376	.695	3.346	1.076	3.56	.187	37.68	.485	41.01	19.9	27.88	8.5	.200
33	10/8	.307	.366	3.997	.767	1.81	.019	2.28	.288	26.94	20.8*	27.78	7	.243
34	21/8	.313	.789	2.093	.901	—	.534	69.48	.604	70.73	18.3	28.19	10	.170
35	4/9	.217	.480	2.256	1.313	—	.342	46.62	.269	31.94	13.6	28.45	6	.283
36	9/9	.410	1.037	5.403*	1.161	—	.549*	85.24*	.314	37.78	13.3	28.48	4	.425
37	12/9	.440	1.881*	3.481	1.042	3.8*	.298	34.83	.398	42.28	13.5	28.58	5	.340
38	19/9	.249	.923	1.469	1.062	2.22	.130	11.84	.678	62.87	13.0	28.58	10.5	.162
39	23/9	.125	.028	.120	2.079*	—	.360	29.90	.451	68.11	13.0	28.57	8	.213
40	9/10	.182	.115	.488	.640	.86	.091	14.65	.243	56.59	12.5	28.58	11	.155
41	13/10	.230	.975	1.381	1.117	2.14	.061	8.45	.674	83.51	14.0	28.78	10	.170
42	6/11	.270	1.073	2.944	1.207	—	.546	61.25	.789	95.13*	9.0	28.82	9.5	.179
	Avg.	.293	.478	1.718	.837	1.67	.267	31.97	.414	45.89	12.9	28.75	9.8	.202

* indicates highest recorded value

Fig. 4


MEAN SALINITY 1969
‰
31
30
29
28
27
SURFACE TEMPERATURE 1969
Malpeque Bay
Offshore
temp °C
30
25
20
15
10
5
J
F
M
A
M
J
J
A
S
O
N
D

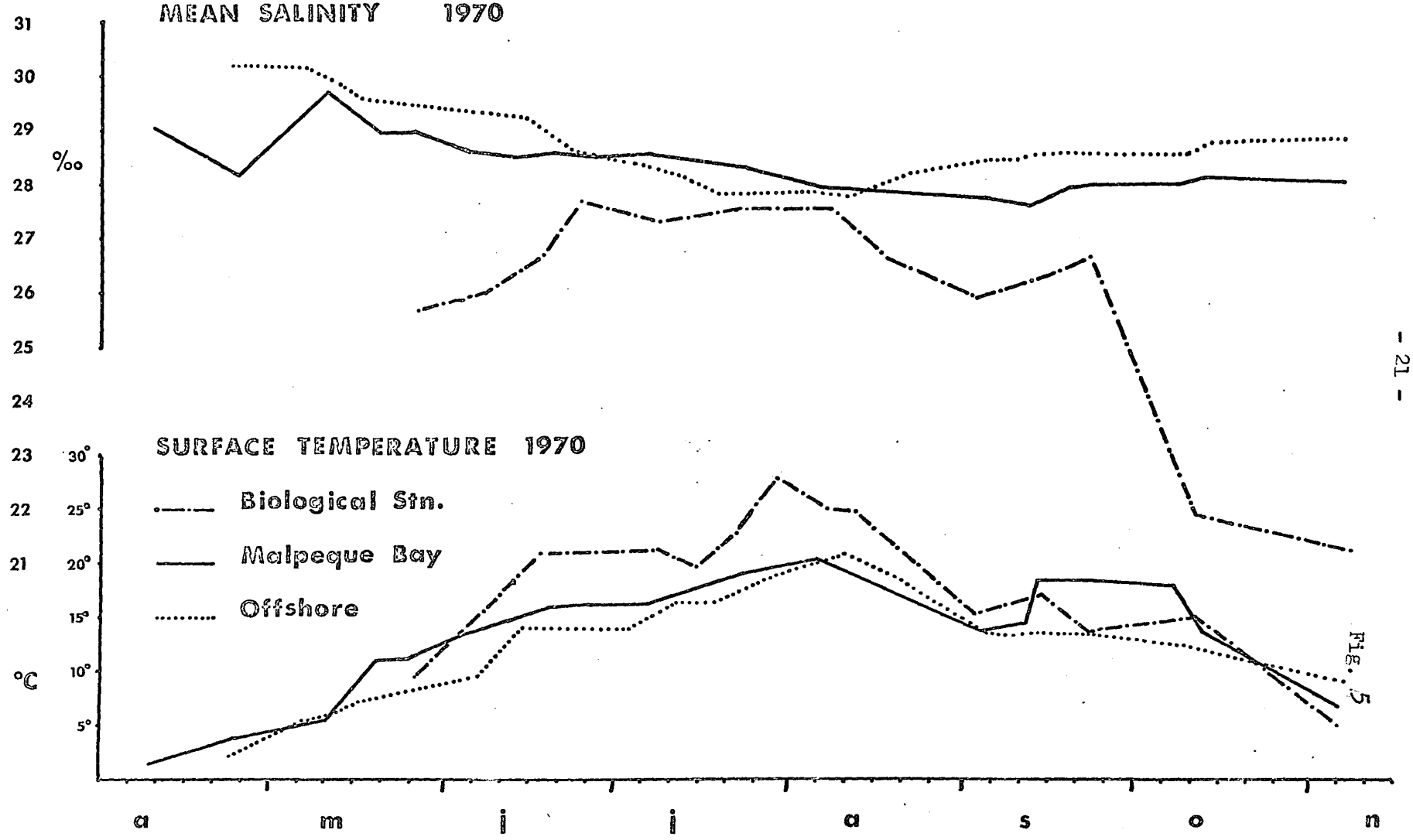

MEAN SALINITY 1970
31
30
29
28
27
26
25
24
‰
SURFACE TEMPERATURE 1970
Biological Stn.
Malpeque Bay
Offshore
30°
25°
20°
15°
10°
5°
°C
23
22
21
a
m
j
j
a
s
o
n

Fig. 5

Results

Tables 4, 5, 8, 9, and 10 summarize the data for 1969 and 1970 expressed as average concentrations per m^3. The determined values at each depth for each station are recorded chronologically in appendix F.

The results obtained in both years are described in three sections:

a) Offshore stations E II and IV

b) Malpeque Bay Station E I

c) Biological Station (Bideford River) Station E III

A) Offshore Stations E II and E IV — Tables 4 and 5

Hydrography and Weather

Winter temperatures were not recorded, the lowest value of 2.2°C being on April 23rd, 1970. The surface water warmed to 19.5°C on August 13th, 1969 and 20.8°C on August 10th, 1970. Air temperatures are subject to large diurnal fluctuations. The monthly mean temperatures from the Meteorological Branch of the Department of Transport, (see Table 6) however, show a January low of 7.5°C and a July high of 19.3°C in a normal year (based on records from 1931 to 1960). 1969 appears to have been cooler than normal, with August being the hottest month averaging 18.5°C.

The temperature-depth profile as recorded in 1970, (see fig. 7), shows a clear development of a thermocline which was especially marked during June, July, and August and September. It also illustrates the progressive warming of the water mass from the surface.

WEATHER INFORMATION - TABLE 6

Summerside — based on monthly averages (calc. from D.O.T. info.)

Temp. converted from °F to °C , ppt. from inches to cm.

Mean air temp °C	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Normal (based on 1931-60)	-7.5	-7.1	-3.1	2.8	9.2	14.6	19.3	18.7	14.7	8.7	2.8	-3.9	
1969 °C	-5.6	-4.2	-2.5	2.1	7.9	15.3	17.9	18.5	14.2	6.9	4.9	-0.9	
1970 °C	-11.1	-7.9	-2.5	2.3	11.8	14.6	19.5	18.9	12.6	9.7	3.6	-6.9	
Total ppt- (cm)													
Normal (1931-60)	9.40	9.59	7.72	6.88	8.23	7.42	7.09	8.36	8.97	8.56	11.66	8.79	102.67
1969 cm	11.40	6.73	4.57	6.99	5.99	7.59	7.92	3.35	7.42	5.99	11.46	10.97	90.38
1970	.86	3.45	4.32	51.05	8.23	9.63	4.70	19.48	9.77	12.37	8.64	21.36	153.86
Wind dir.													
Normal (1931-60)	W	W	N	N	SSW	SW	SW	SSW	SW	WNW	W	W	
1969	NW	NE	NE	N	S	S	S	SSW	SW	SW	S	W	
1970	W	W	N	N	SSW	SSW	SSW	SSW	S	N	WSW	WNW	
Duration bright sunlight													
1969 hrs	88.7	87.3	117.6	176.5	206.9	275.2	272.2	246.4	162.3	139.4	75.4	52.2	1900.1
1970	133.3	112.0	145.7	182.3	197.1	251.4	287.6	221.9	117.8	152.4	104.7	70.2	1876.4
Mean 69/70	111.0	99.7	131.7	179.4	202.0	263.3	279.9	234.2	140.1	140.9	90.1	61.2	1888.3

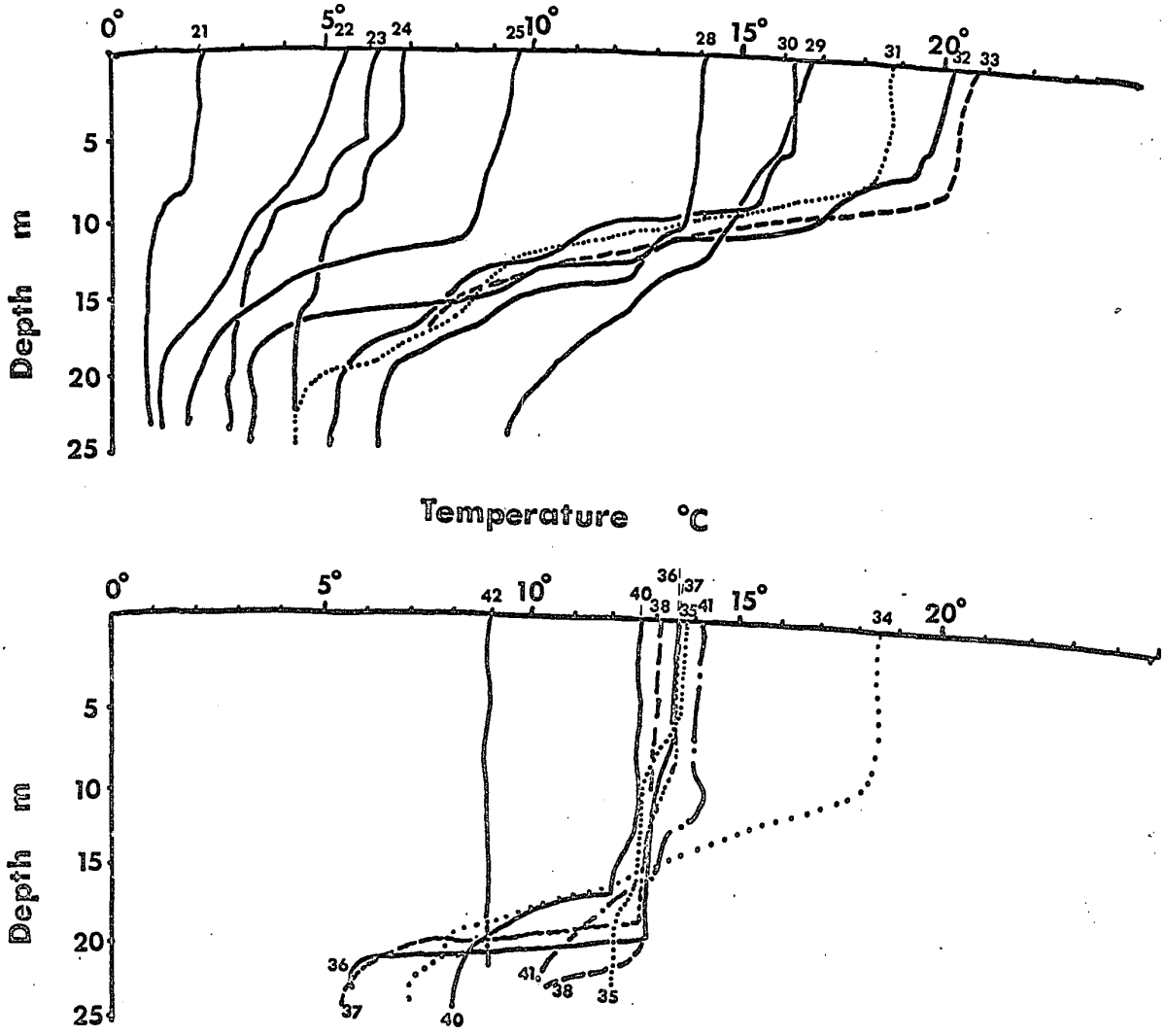
OFFSHORE P. E. I. 1970

Station E II - 70	1970
#	Date
21	23 April
22	6 May
23	12 May
24	16 May
25	6 June
26	14 June
27	22 June
28	3 July
29	11 July
30	18 July
31	27 July
32	3 August
33	10 August
34	21 August
35	4 September
36	9 September
37	12 September
38	19 September
Station E IV - 70	
39	23 September
40	9 October
41	13 October
42	6 November

Fig. 6

OFFSHORE 1970

Seasonal variation in Temperature-Depth profile.



At the beginning of the season there was little variation in temperature from surface to bottom and by November the same condition was re-established, the temperature difference from surface to bottom being 9°C.

The water was most saline at the beginning of the season 30.48% on May 14th, 1969 and 30.19% on April 23rd, 1970 falling to 27.35% on July 9th, 1969 and 27.88% or less between mid July and August 3rd, 1970.

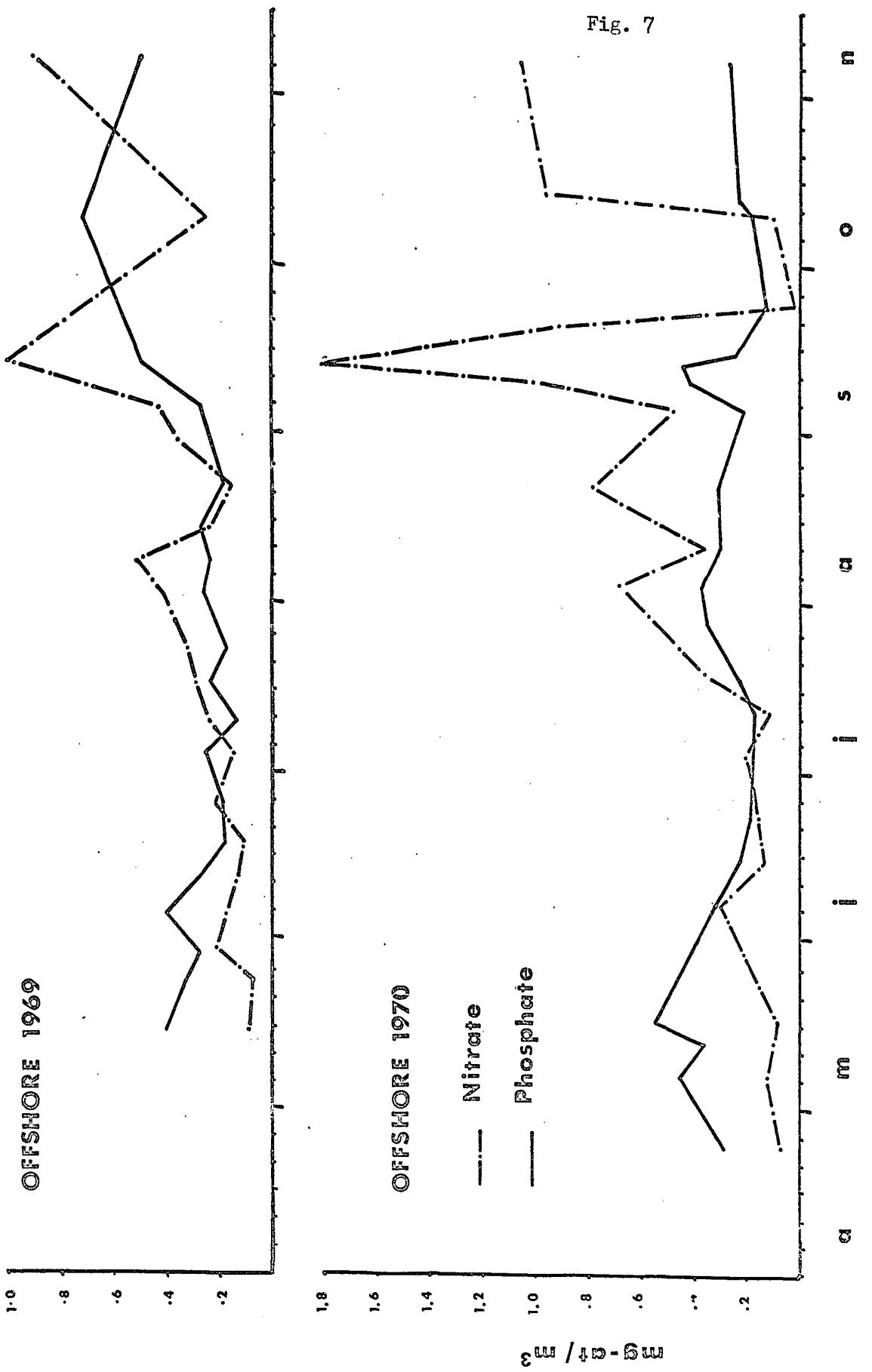
Precipitation over the two years during which the study was made differed in that 1970 was considerably wetter than normal particularly in April. See table 6.

The weather during 1969-1970 was monitored in the general area of Malpeque Bay by the Department of Transport at the Armed Forces Base, Summerside, P. E. I., and at the Biological Station Ellerslie. The results from the Armed Forces Base are summarized by month in table 6, after having been converted to metric units.

Nutrients

The results for phosphate concentration in both seasons are shown in figure 12 and show a general decline from 0.398 mgA/m^3 on May 14th, 1969, and 0.543 mgA/m^3 on May 16th, 1970, to lower levels of 0.1 mgA/m^3 to 0.25 mgA/m^3 in June and July with a rise again in September. The two years did not appear identical in the fall, as phosphate levels continued to rise in 1969 to a peak of 0.718 mgA/m^3 on October 8th, whereas in 1970, the rise in early September was followed by a sharp decline to a low of 0.125 mgA/m^3 on September 23rd. A gradual recovery was seen until early November, when collection ceased.

Fig. 7


OFFSHORE 1969
OFFSHORE 1970
Nitrate
Phosphate
mg-at/ m³
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
J
F
M
A
M
J
J
A
S
O
N
D

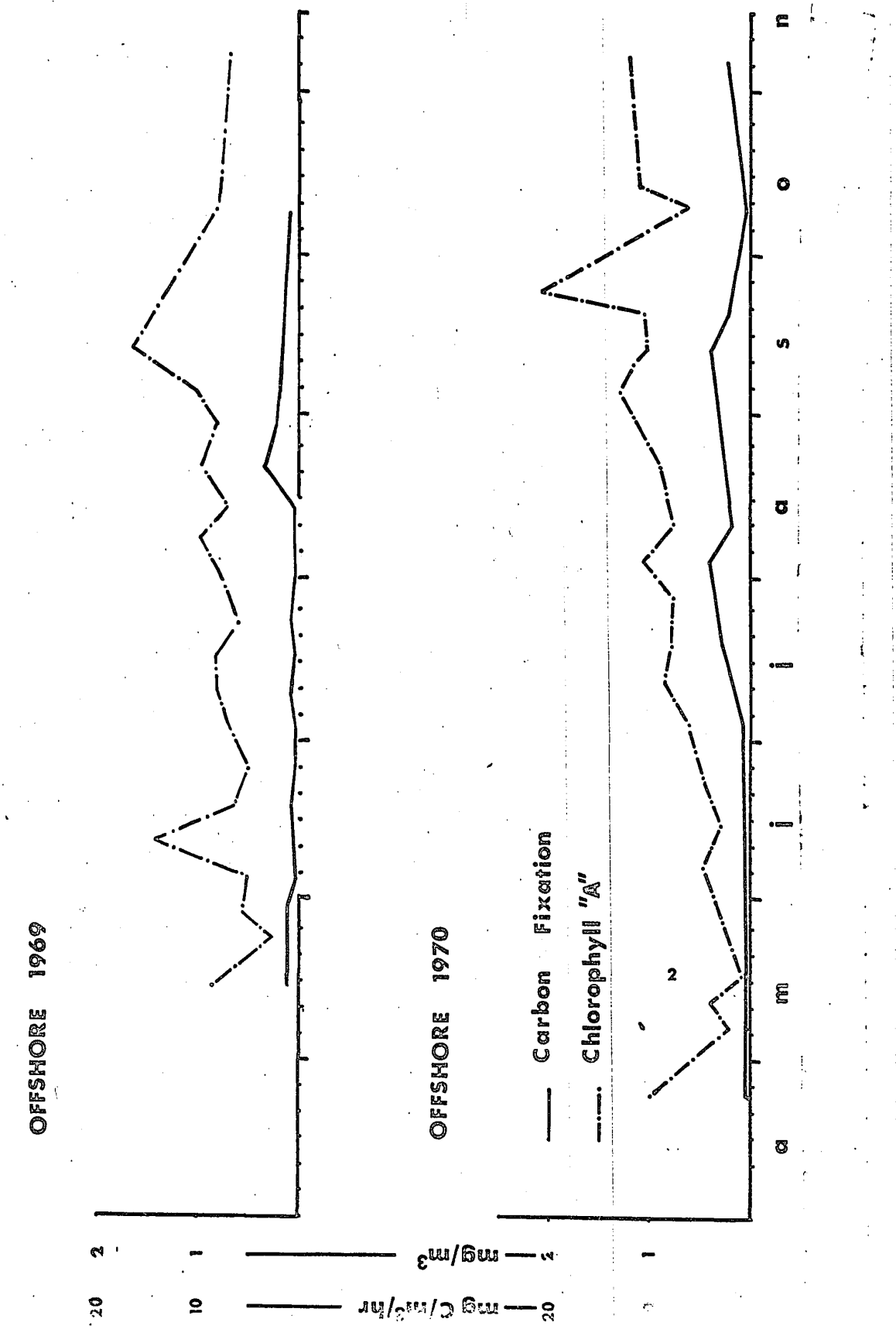
Nitrate concentration showed a clear picture of a general rise from a low value in April and May of 0.076 mgA/m^3 on May 23rd, 1969 and 0.069 mgA/m^3 on April 23rd, 1970. A peak occured around the beginning of August in both years and another very marked increase in early September. Analysis of the raw data shows this to be due mainly to large increases of about one order of magnitude in the bottom 10 meters. ,When compared with the hydrographic data, this indicates that water samples were taken on either side of a marked thermocline at around 20 m.

This was followed by a marked decrease in both years, the frequency of sampling in September 1969 did not allow a very close analysis of what happened, in 1970, however, it is apparent that there was a decline in the concentration of nitrates at all depths. By November 6th, in both years, the levels had built up again to around 1.0 mgA/m^3 : the 1970 results would indicate that the rate of increase in nitrate concentrations was reduced after mid October.

The silicate concentrations in both seasons are tabulated in tables 4 and 5. They show a slight rise over the year in 1969 with an early minimum of 0.335 mgA/m^3 on May 14th. There was an increase during the latter part of May and early June, rising to 1.561 mgA/m^3 on May 28th.

Average concentrations per m during June and July after June 4th did not rise above 1.0 mgA/m^3, but they increased irregularly during August until the maximum of 2.651 mgA/m^3 was recorded for the season on November 6th. During 1970, there was a more marked progressional increase in silicate concentrations from 0.204 mgA/m^3 recorded on April 23rd. There was a general rise until

Fig. 8


OFFSHORE 1969
OFFSHORE 1970
Carbon Fixation
Chlorophyll "A"
mg C/m³/hr
mg/m³
20
10
2
1
J
F
M
A
M
J
J
A
S
O
N
D

September 9th, when an average concentration of 5.403 mgA/m^3 was found. This was followed by a pronounced decline in concentration to the mimimum recorded for the year of 0.120 mgA/m^3 by September 23rd. By November 6th, the level had risen again to 2.944 mgA/m^3. The two years thus show rather different patterns.

Plant Biomass and Primary Production

Chlorophyll 'A'

The results of the indirect measurement of plant biomass by chlorophyll 'A' analysis are shown in Fig. 8. These graphs illustrate the increase of plant biomass over the season with periodic larger increases marking phytoplankton blooms of limited duration. In both years, there is indication of a higher level of chlorophyll at the start of the sampling season, (0.822 mgA/m^3 on May 14th, 1969, and 1.027 mgA/m^3 on April 23rd, 1970). In 1969, this was followed by an increase on June 11th to 1.405 mg/m^3. A similar increase at this time in 1970 was not recorded but could have occured between collections, which were not as frequent as desirable at this time due to poor weather. In both years, a peak occured in the fall. In 1969, it was apparent during the first two weeks in September, with a maximum recorded for the season of 1.667 mg/m^3. In 1970, the increase occured slightly later, peaking about September 23rd, at 2.079 mg/m^3. In general, 1970 seems to have been very similar to 1969.

Carbon Fixation

The data on carbon fixation rates are shown in fig. 8. They do not show as clear a pattern as the chlorophyll 'A' results. Not too much significance is attached to the first seven results of 1969, as these were from samples that had been incubated on the day after their collection, however, they are in the same order of magnitude as those of the following year. There was surprisingly no evidence of a spring bloom. Production was generally higher in the months of July, August, and September. Levels of production of 3.22 $mgC/m^3/hr$ were reached on August 21, 1969. In 1970 a level of 3.56 $mgC/m^3/hr$ was measured on August 3 and 3.80 $mgC/m^3/hr$ on September 12.

When looked at as production under a square meter of surface area, i.e., integrating values 0 to 25 m depth per m^2, a clearer picture emerges.

TABLE 7

Stations E II and E IV

Carbon Fixation $mgC/m^2/hr$ (integrated uncorrected values)

YEAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT
1969	-	33,27	3,13 9.	18,10 11,20	49,10 80,52	41,42	17
1970	7.	2.	17.	70.	89,45	95,55	21,53
MEAN	7	17	11	44	54	58	27

(Table 6 shows the duration of bright sunlight for 1960 and 1970)

The above table 7 shows an increasing rate of carbon fixation during July, August, and September.

Zooplankton Biomass

The determinations of zooplankton biomass were made from surface and oblique tows. The results from the surface tows are shown graphically in fig. 9 and 10.

The results show a high degree of variability in wet volumes and dry weights within each year, but do show some consistency in the fluctuations when the 1969 results are compared with those of 1970.

Generally the surface plankton net tows and the oblique tows gave similar results, the notable exception being in the fall when oblique tows gave consistently higher results, indicating a greater number of animals in the deeper water.

A detailed analysis of the composition of the zooplankton will be made by C.O.I.C. Ottawa.

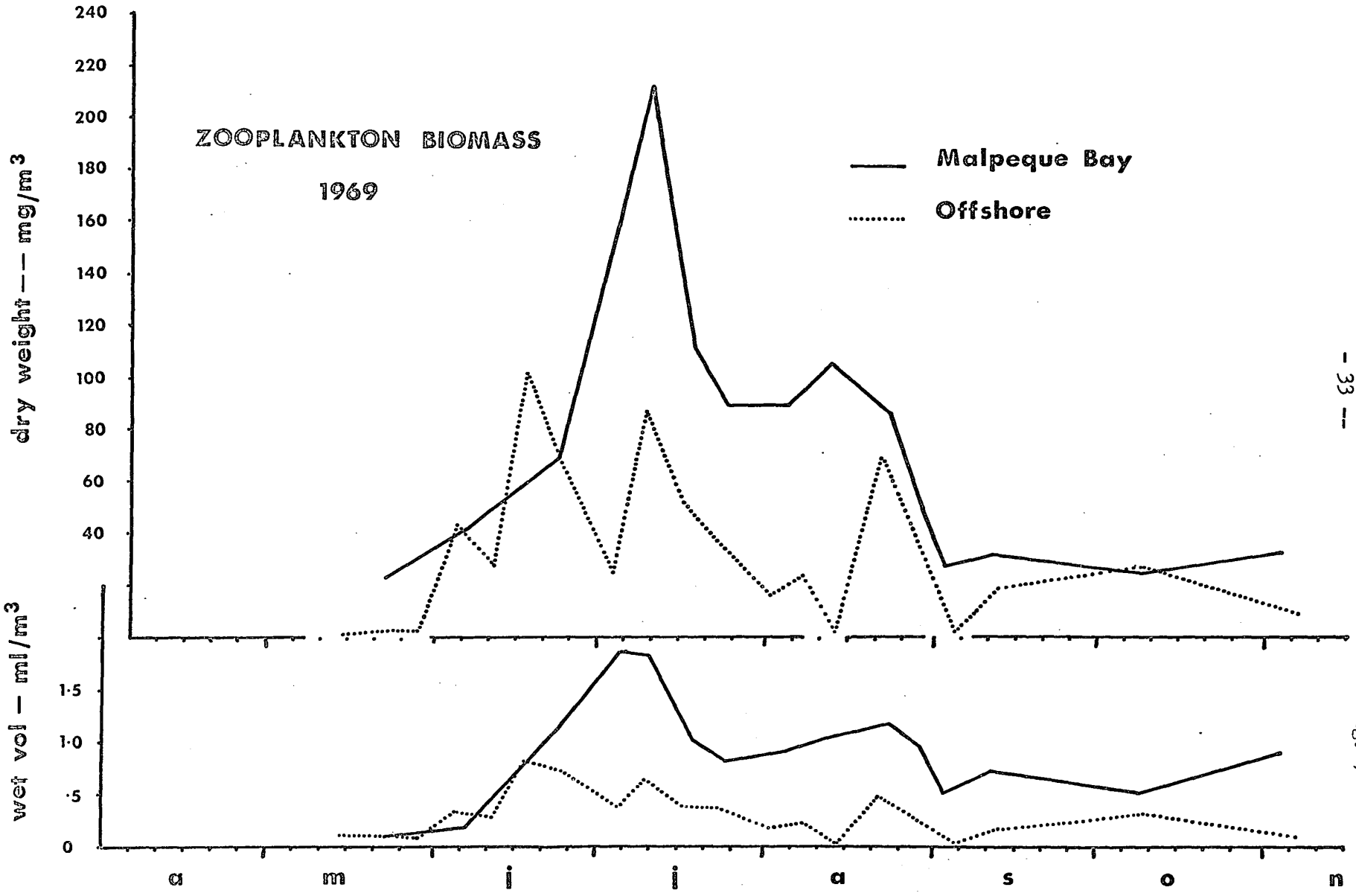

ZOOPLANKTON BIOMASS
1969
Malpeque Bay
Offshore
dry weight — mg/m3
wet vol — ml/m3
240
220
200
180
160
140
120
100
80
60
40
1·5
1·0
·5
0
a
m
j
j
a
s
o
n

Fig. 9

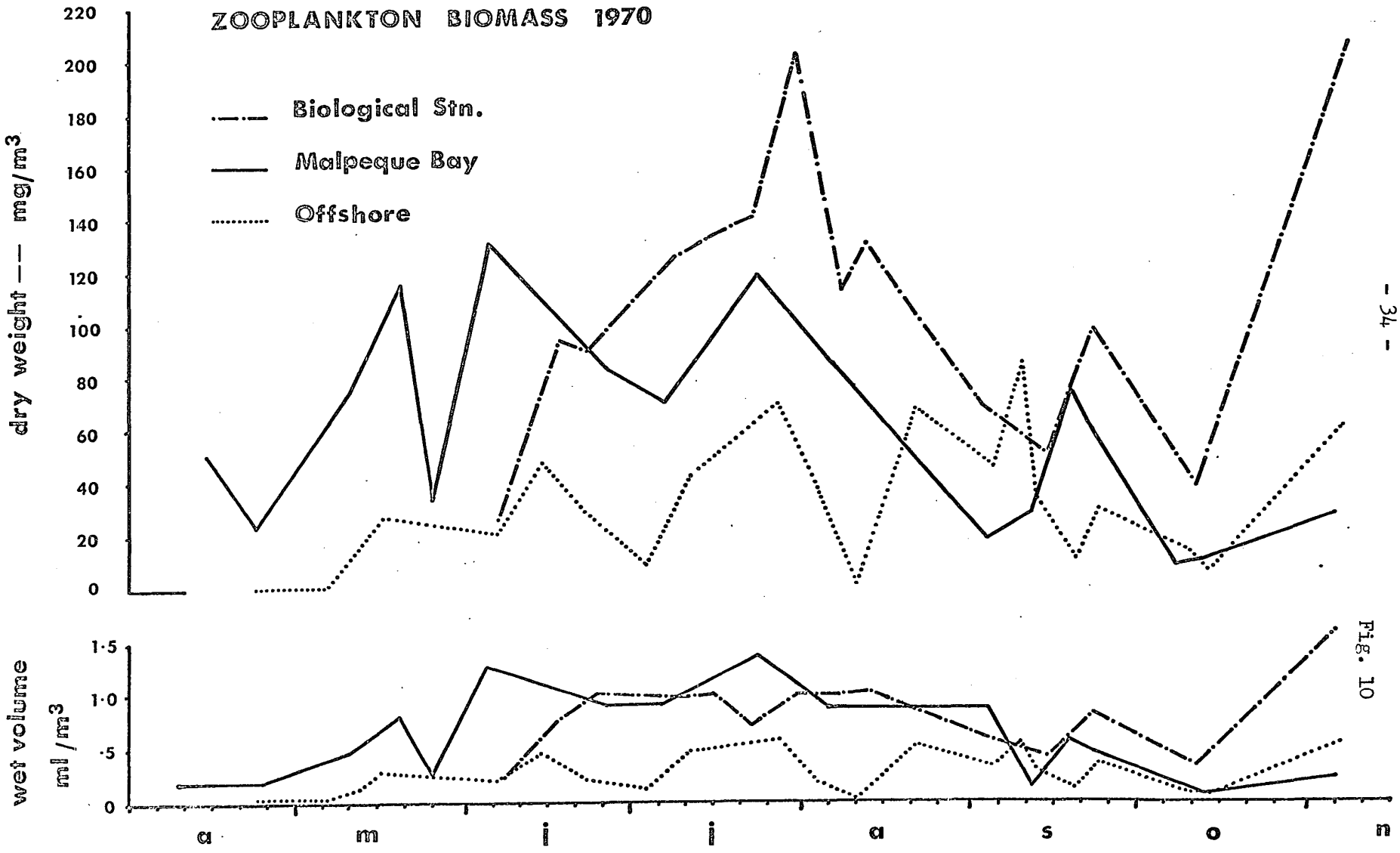

ZOOPLANKTON BIOMASS 1970
Biological Stn.
Malpeque Bay
Offshore
dry weight — mg/m³
220
200
180
160
140
120
100
80
60
40
20
0
wet volume
ml / m³
1·5
1·0
·5
0
a
m
j
j
a
s
o
n

Fig. 10

R E S U L T S

M A L P E Q U E E I

MALPEQUE BAY STN.E I - 69 TABLE 8

		NUTRIENTS			PHYTOPLANKTON		ZOOPLANKTON Surface		HYDROLOGY			
	DATE	PHOSPHATES mgA/m³	NITRATES mgA/m³	SILICATES mgA/m³	CHLORO 'A' mg/m³	C^{14} mgC/m³/hr	WET VOL ml/m³	DRY WT mg/m³	SURF T °C	EXTINCT Coef K-1.7/d	MEAN Sali-nity	SECCHI (d) m
1	1/5	.315	.182	.543	.727	—	---	---	6.4	.378	28.72	4.5
2.	22/5	.222	.219	.467	.615	.27	.100	22.6	10.7	.425	28.76	4
3.	6/6	.139	.238	.506	.812	1.47	.197	41.8	13.9	.296	29.05*	5.75*
4.	23/6	.238	.339	1.735	1.299	7.07	1.127	68.9	17.7	.486	28.42	3.5
5.	4/7	.195	.177	1.136	1.150	1.08	1.852*	158.0	19.6	.425	28.11	4
6.	10/7	.217	.141	1.274	1.323	8.18	1.829	211.9*	17.9	.523	28.28	3.25
7.	18/7	.181	.096	1.227	1.275	5.79	1.010	113.9	18.9	.340	28.09	5
8.	24/7	.203	.090	1.575	2.405	4.58	.836	88.5	20.4	.400	28.03	4.25
9.	4/8	.147	.200	.781	1.465	1.79	.914	88.7	20.3	.340	27.96	5
10.	12/8	.242	.134	1.675	1.924	2.53	1.047	105.0	21.0*	.425	28.16	4
11.	23/8	.250	.121	2.174	2.455	3.88	1.165	85.9	19.4	.425	28.04	4
12.	28/8	.276	.112	1.321	2.025	7.33	.950	48.2	19.3	.425	28.03	4
13.	2/9	.354	.149	1.947	2.294	10.75	.503	26.9	19.4	.486	28.06	3.5
14.	11/9	.526	.349*	4.147*	3.959*	16.11*	.740	31.5	16.7	---	28.10	—
15.	9/10	.382	.202	1.305	2.693	5.58	.517	24.2	12.4	.486	28.41	3.5
16.	3/11	.390*	.191	.625	.880	1.60	.589	32.1	5.3	.486	28.62	3.5
	AV.	.267	.184	1.402	1.706	5.87	.892	76.5	18.5	.423	28.30	4.1

*Indicates highest recorded value

1970 MALPEQUE BAY STN E I - 70 TABLE 9

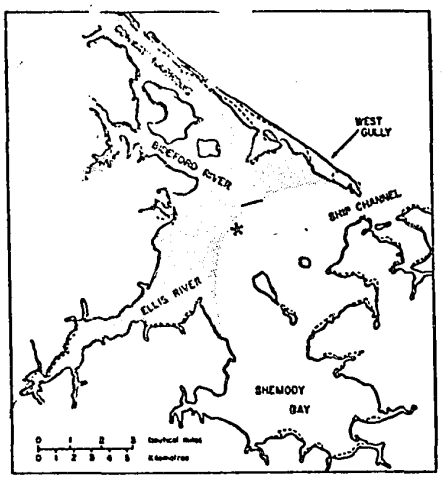
		NUTRIENTS			PHYTOPLANKTON		ZOOPLANKTON SURFACE		HYDROLOGY			
	DATE	PHOSPHATES mgA/m^3	NITRATES mgA/m^3	SILICATES mgA/m^3	CHLOR 'A' mg/m^3	C^{14} mgC/m^3 hr	WET VOL ml/m^3	DRY WT mg/m^3	SURF TEMP °C	EXTINCT COEF K-1.7/d	MEAN SALI-nity	SECCHI (d) m
17	9/4	.225	.224	.336	.625	---	.169	50.138	1.2	.340	29.08	5
18	24/4	.184	.238	.412	.555	---	.182	23.665	3.8	.425	28.20	4
19	10/5	.338	.228	.685	.375	.99	.461	75.256	5.6	.243	29.73*	7*
20	19/5	.279	.055	1.028	.708	.88	.817	115.920	11.0	.378	28.98	4.5
21	25/5	.269	.386	.876	.613	---	.270	34.692	11.3	.378	28.96	4.5
22	4/6	.208	.304	1.509	.893	---	1.296	132.153*	13.5	.425	28.60	4
23	12/6	.209	.211	1.916	1.140	2.30	---	---	14.8	.486	28.50	3.5
24	19/6	.251	.127	1.040	.789	---	---	---	16.0	.425	28.63	4
25.	26/6	.211	.140	1.604	1.203	3.30	.936	82.936	16.4	.567	28.51	3
26	6/7	.285	.167	2.418	1.465	6.17	.937	71.166	16.4	.567	28.54	3
27	23/7	.349	.418	2.777	1.730	10.58	.390	119.756	19.1	.567	28.31	3
28	5/8	.281	.031	4.237*	2.686	8.63	.877	87.124	20.3*	.425	27.95	4
29	3/9	.391	.104	2.407	2.945	11.07*	.147	19.250	13.9	.486	27.76	3,5
30	11/9	.304	.022	2.325	3.198*	---	.280	28.692	14.5	.425	27.60	4
31	18/9	.903	.034	2.279	2.326	---	.565	75.143	13.5	.425	27.93	4
32	22/9	.215	.052	1.425	1.816	---	.479	59.769	13.4	.425	27.97	4
33	7/10	.216	.354	1.880	2.483	8.28	.067	8.890	13.0	.378	27.53	4.5
34	12/10	.248	.266	1.307	2.062	4.92	.085	10.371	13.8	.378	27.62	4.5
35	5/11	.217	.666*	1.279	2.537	4.58	.227	28.411	6.8	.567	27.53	3
	AV.	.294	.212	1.675	1.640	5.61	.540	60.190	13.6	.437	28.31	4.4

*Indicates highest recorded value

b) Malpeque Bay E I (Tables 9 & 8)

Hydrography and Weather

The lowest surface temperature recorded during the two seasons was 1.2°C. at E I on April 9th, 1970, at the edge of the ice, which at that time half filled Malpeque Bay. See fig. 11.



(Fig. 11)

The highest temperatures recorded were 21.0°C on August 12th, 1969 and 20.3°C on August 5th, 1970. The temperatures in 1970 may have risen higher in August 1970, but more frequent sampling in that month would be needed to demonstrate this.

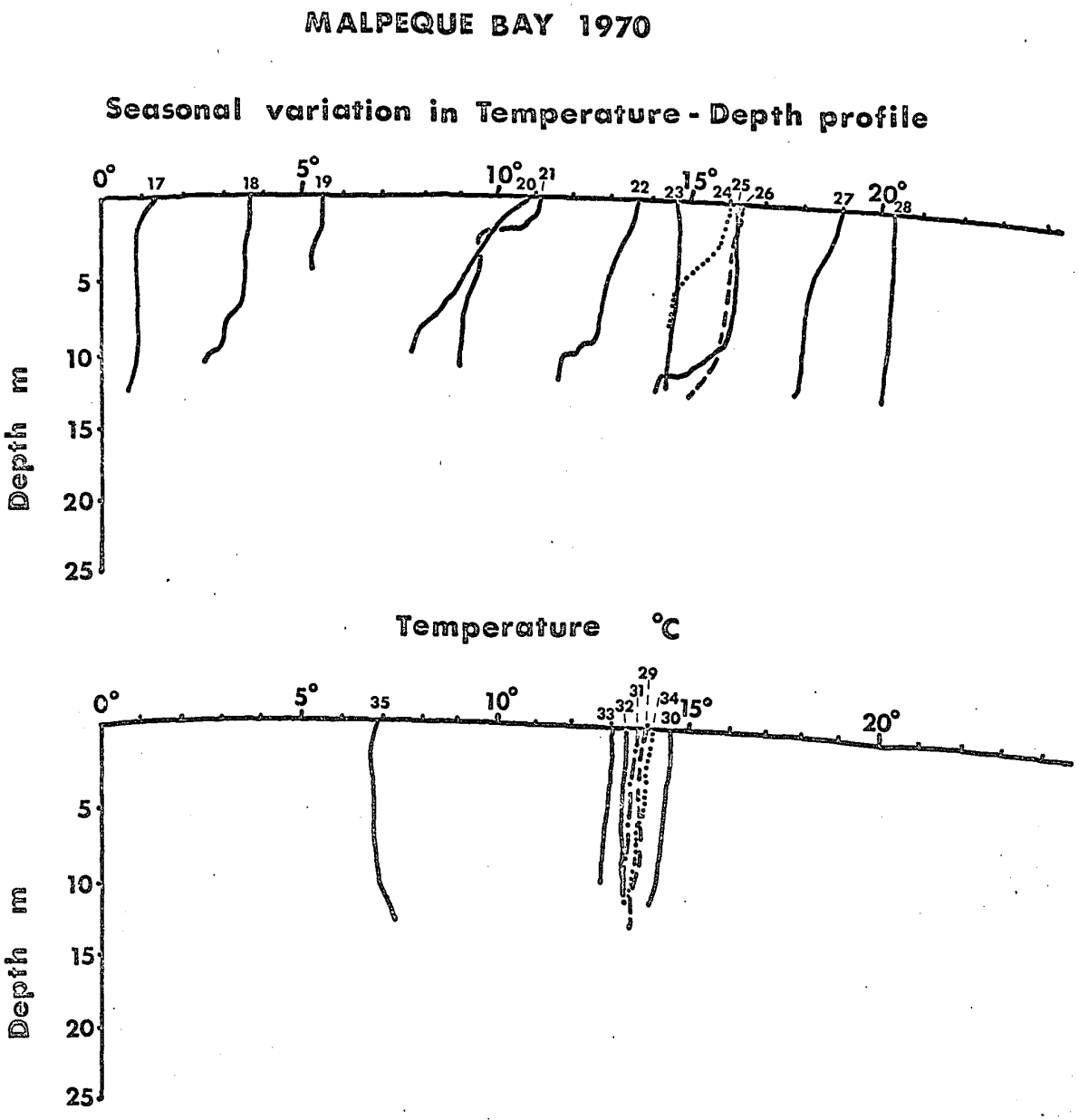
The temperature depth profile of E I in 1970 (see fig. 12) shows that the bay was generally holomictic. A short lived thermocline appeared in late May to disappear by June 12th, only to reappear in late June. From July until the last collection on November 5th, the water column was nearly isothermal. A similar pattern was observed in 1969; The raw data of which is given in appendix F.

MALPEQUE BAY 1970

Station E I - 70

Number	Date
17	9 April
18	24 April
19	10 May
20	19 May
21	25 May
22	4 June
23	12 June
24	19 June
25	26 June
26	6 July
27	23 July
28	5 August
29	3 September
30	11 September
31	18 September
32	22 September
33	7 October
34	12 October
35	5 November

Fig. 12


MALPEQUE BAY 1970
Seasonal variation in Temperature - Depth profile
0°
5°
10°
15°
20°
17
18
19
20
21
22
23
24
25
26
27
28
Depth m
5
10
15
20
25
Temperature °C
0°
5°
10°
15°
20°
35
29
31
32
33
34
30
Depth m
5
10
15
20
25

The salinity of Malpeque Bay was fairly constant throughout the season varying in 1969 between 29.05‰ on June 6th and 27.96‰ on August 4th.

It is interesting to note that the high salinity coincided with maximum clarity of the water for the season with a Secchi disc reading of 5.75 m.

In 1970 the picture was very similar, again the high salinity and water clarity coincided, this time on May 10th, salinity 29.73‰ and Secchi disc reading of 7 m. The lowest salinities were in October and November when it dropped to 27.53‰. Again this was a relatively small range of approximately 2‰.

Nutrients

The results for phosphate in both years are shown graphically in fig. 13. Concentration varied from .1390 mgA/m^3 on June 6th to .390 on November 3rd in 1969 and from .184 on April 24th to a peak of .903 on September 18th in 1970. The pronounced peak in September was due to a surface phenomenon of undetermined cause. In general, both years showed a consistent level of an average of .281 mgA/m^3. There is indication of a slight increase during the early part of May and a somewhat large and more sustained increase in the fall particularly during late August and September. During 1969, the September level was sustained through November while in 1970 a slight decrease was evidenced.

The nitrate values are shown in figure 13. In 1969 two peaks were observed, the first on June 23rd of .339 mgA/m^3 , the second on September 11th 2.349 mgA/m^3. The concentration was generally lowest during July and August,

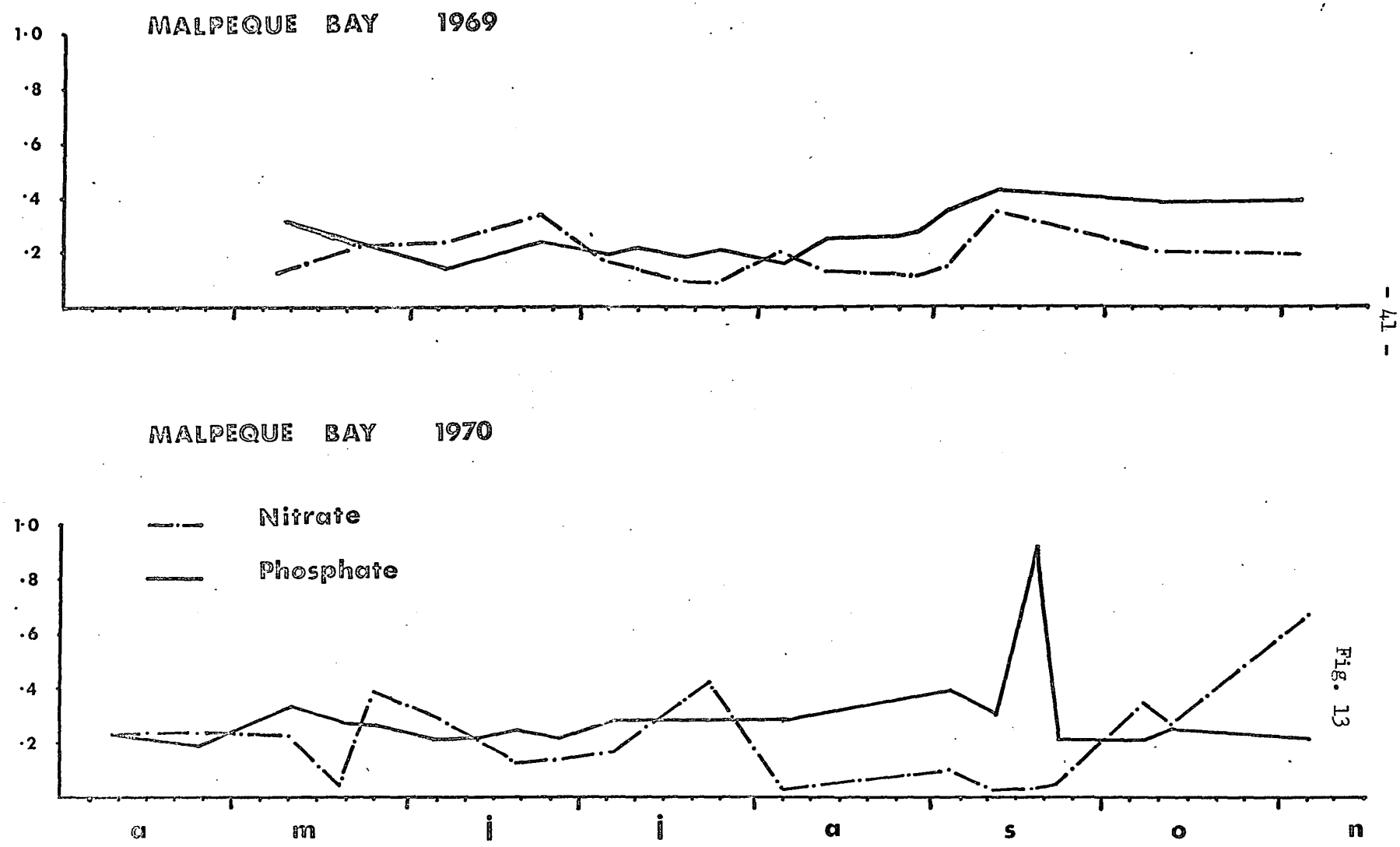

MALPEQUE BAY 1969
1·0
·8
·6
·4
·2
MALPEQUE BAY 1970
Nitrate
Phosphate
1·0
·8
·6
·4
·2
a
m
j
j
a
s
o
n

Fig. 13

the minimum being .090 mgA/m^3 on July 24, 1969.

The average concentration of nitrate in 1970 was similar to that found in 1969, around 0.2 mgA/m^3. The level was less consistent with concentrations dropping as low as .022 mgA/m^3 in August and September, a pronounced increase in nitrate concentration occurred in the late fall, October and November with the maximum concentration for the year occuring on November 5, 1970. Lesser peaks also occured in May 25th (.386 mgA/m^3) and July 23rd (.418 mgA/m^3).

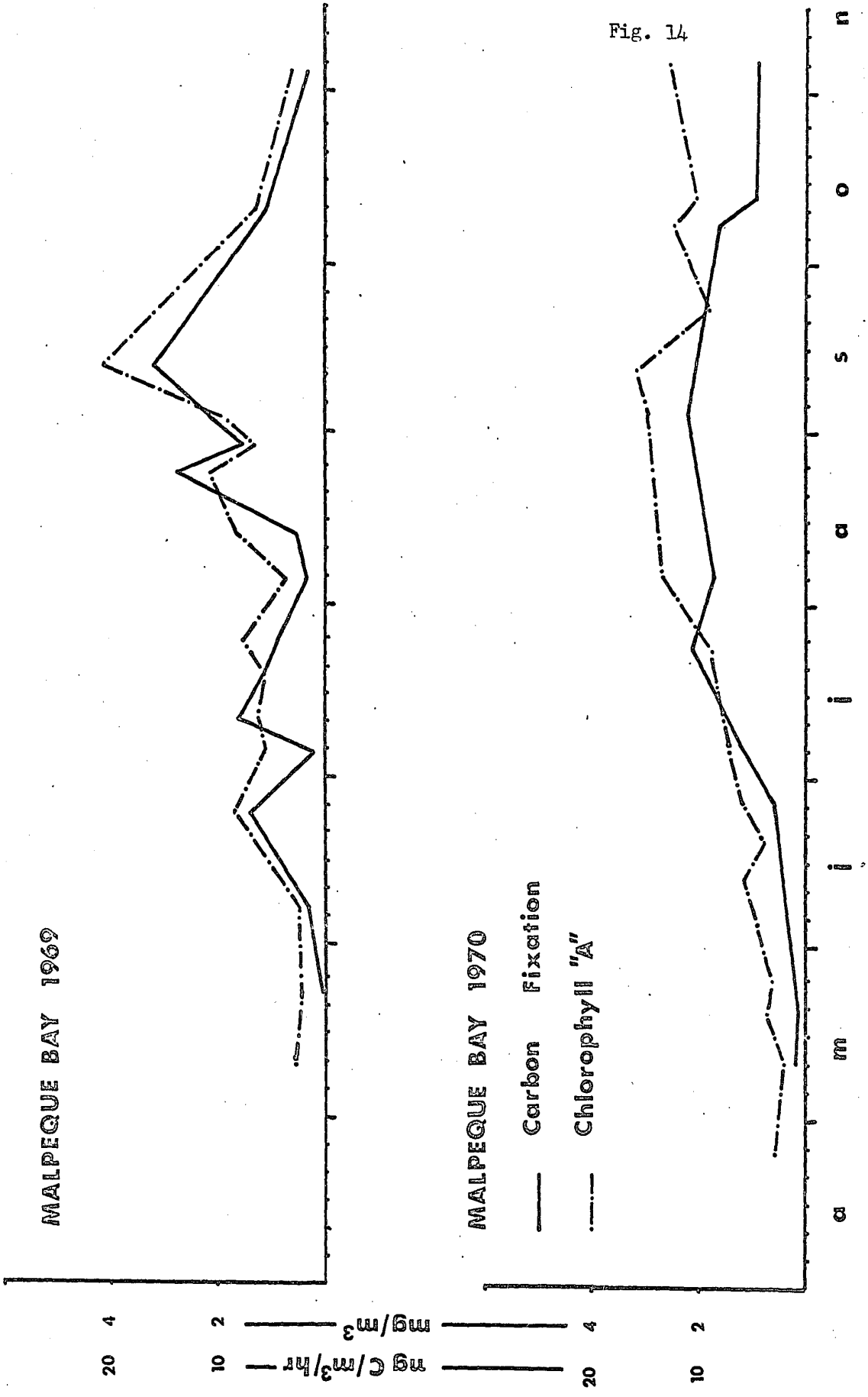
Silicate concentrations are given for 1969 and 1970 in tables 7 and 8 and show a general increase during the season from .463 mgA/m^3 on May 22, 1969 to a concentration of 4.147 mgA/m^3 on September 11, 1969, declining again to .625 mgA/m^3 by November 3, 1969. Similarly in 1970, there was a general increase from a low of .336 mgA/m^3 on April 9, to a maximum of 4.237 mgA/m^3 on August 5th, declining again by November 5th to 1.279 mgA/m^3.

Phytoplankton Biomass and Primary Production

The results of Chlorophyll 'A' and carbon fixation rates for 1969 and 1970 are shown in fig. 14.

The chlorophyll results show a general rise from .615 mg/m^3 on May 22, 1969 and .375 on May 10, 1969 to a maximum in September of 3.959 mg/m^3 on September 11, 1969 and 3.198 on the same date in 1970.

Fig. 14


MALPEQUE BAY 1969
MALPEQUE BAY 1970
Carbon Fixation
Chlorophyll "A"
mg C/m3/hr
mg/m3
20
10
4
2
a m j j a s o n

Thereafter, a decline in the concentration was noted. This was much more pronounced in 1969, when the concentration on November 3rd fell to 0.880 mg/m^3, while the concentration in 1970 after falling to 1.816 mg/m^3 on September 22nd, the level rose again and by November 5th, it was 2.537 mg/m^3.

The fluctuation in Chlorophyll 'A' concentration was quite closely paralleled by fluctuations in carbon fixation. There was a gradual increase in production rates particularly in 1970. A sustained fixation rate greater than 6 $mgC/m^3/hr$ was found during July, August, and September, the maximum recorded being 11.07 $mgC/m^3/hr$ on September 3, 1970, the minimum fixation rates each year were recorded at the beginning of the season; 0.27 $mgC/m^3/hr$ on May 22, 1969 and 0.88 $mgC/m^3/hr$ on May 19, 1970. By November of both years, the production rates had fallen again so that by November 3, 1969 the carbon fixation rate was 0.589 $mgC/m^3/hr$ and by November 5, 1970 the level was 4.58 $mgC/m^3/hr$. In 1969 a less regular development showed, although the production levels throughout the season were of the same order of magnitude. High production was most pronounced during late August and September.

In order that the primary production rates can be compared with those determined in different areas by other investigators the data have been converted to mg of carbon fixed per m^2 of surface, rather than per m^3 as was used in the graphical representation of the data. This is summarized in the following table 10.

TABLE 10

Carbon Fixation per m^2 in Malpeque Bay E I

	1969	1970	Average
May	3	10, 9	7
June	15, 70	23, 33	37
July	11, 81, 58, 46	62, 106	61
August	18, 25, 39, 73	86	48
September	108, 161	111	127
October	56	83, 50	63
November	16	46	31

Zooplankton Biomass

The zooplankton biomass results were difficult to analyse as they appeared to differ in 1969 and 1970. A more detailed investigation than was planned for this broader study would probably explain some of the apparent anomalies.

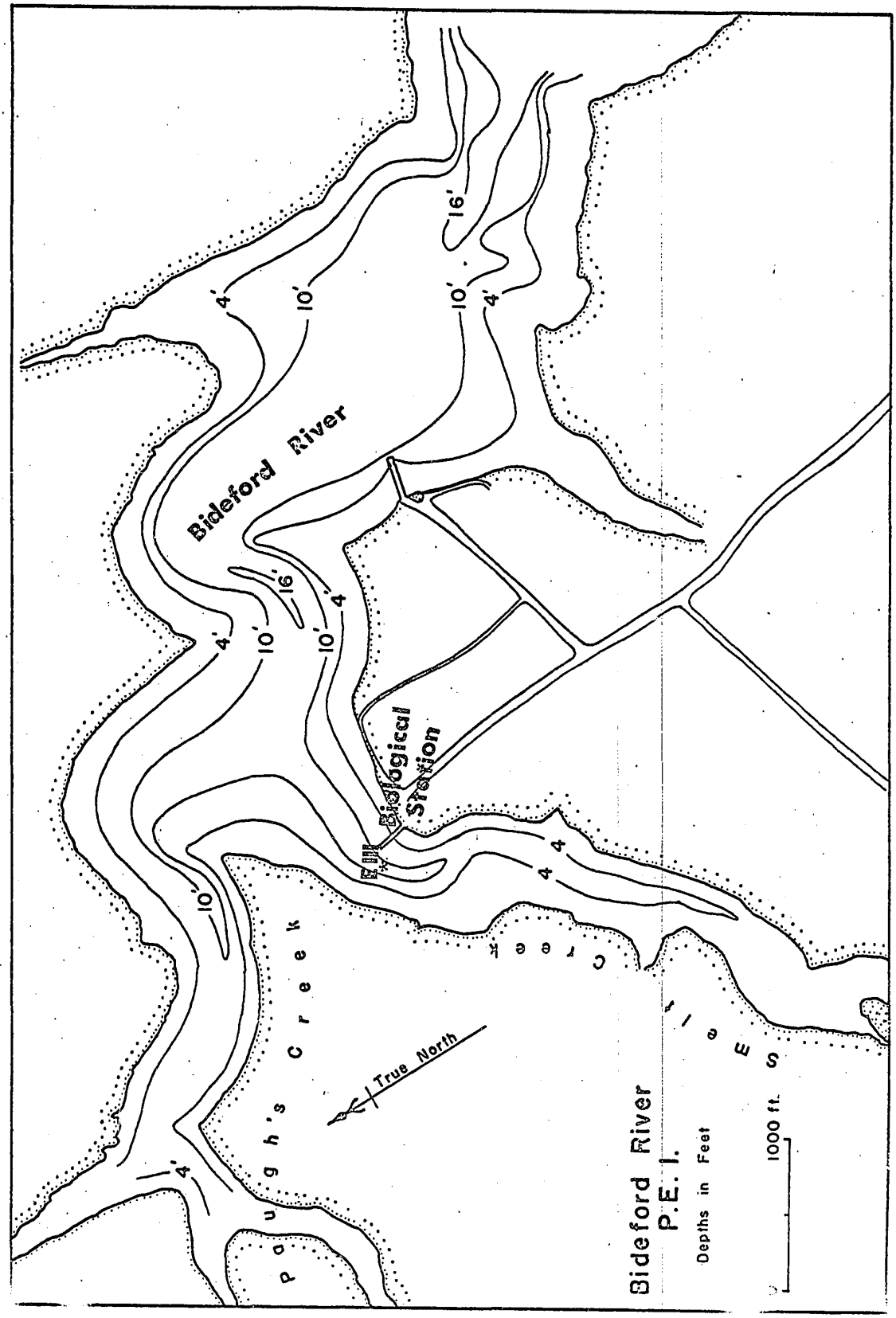
In 1969, the maximum recorded was on July 10th when a vast amount of plankton was caught in the nets within five minutes. The dominant organisms were copepods. The spring and fall concentrations of zooplankton were around 30 to 40 mg/m^3 dry weight, while during the summer the level was generally about 80 to 100 mg/m^3.

In 1970 the zooplankton biomass results showed a fluctuating summer population of zooplankton, starting from a relatively low mass of about 20 mg/m^3 in April, with a maximum of approximately .30 mg/m^3 in May and June, graduâlly declining to less than 10 mg/m^3 by October. The zooplankton was generally dominated by copepods. Acartia sp. and Temora sp. were the most abundant species in the samples collected.

B I O L O G I C A L S T A T I O N E I I I

(Bideford River)

fig. 15.


Bideford River
Biological Station
Pugh's Creek
Creek
True North
Bideford River
P.E.I.
Depths in Feet
1000 ft.
4'
10'
16'

1970 - Biological Stn. EIII-70 TABLE II

		NUTRIENTS			PHYTOPLANKTON		ZOOPLANKTON		HYDROGRAPHY			
No.	Date	Phosphates mgA/m^3	Nitrates mgA/m^3	Silicates mgA/m^3	Chlor 'A' mg/m^3	C^{14} $mgC/m^3/hr$	Wet Vol ml/m^3	Dry Vol mg/m^3	Temp °C	Salinity mean o/oo	Secchi m	Extinct Coef K 1.7/d
1	26/5	.171	.251	1.603	2.525	-----	----	----	---	25.68	3.5*	.486
2	07/6	.241	.003	6.132	1.690	3.49	.222	26.795	15.5	26.0	2	.850
3	17/6	.406	nil	3.071	2.150	2.10	.766	95.992	19.5	26.73	3	.567
4	24/6	.759	nil	2.208	2.895	5.77	1.074	90.950	20.8	27.70	2.5	.680
5	08/7	.428	nil	2.055	3.357	34.83	.989	126.483	21.3	27.31	3	.486
6	15/7	.759	nil	4.401	10.306*	47.38	1.170	134.603	19.8	27.38	3	.486
7	22/7	1.046	.071	1.536	6.556	43.10	.731	140.948	22.9	27.55*	2	.850
8	30/7	2.216	.459	7.536	4.998	30.08	1.031	203.575	28.0*	27.54	2	.850
9	07/8	1.256	.018	4.300	10.273	66.89*	1.008	114.072	25.0	27.54	2	.850
10	12/8	3.256*	.975	7.978	3.339	----	1.183	130.763	24.8	26.5	1	1.70*
11	02/9	.375	.280	3.183	4.152	----	.616	69.092	14.8	25.91	2	.850
12	14/9	.213	.288	1.934	3.022	----	.423	51.142	17.0	26.33	2	.850
13	22/9	.435	.226	1.435	4.267	----	.822	98.290	13.6	26.68	2.5	.680
14	11/10	.196	.209	8.531*	6.399	45.02	.331	37.985	15.0	22.89	2	.850
15	7/11	.179	1.371*	6.072	2.413	9.48	1.591*	205.815*	5.0	21.26	3	.567
	Av	.796	.277	4.131	4.557	30.29	.854	109.036	18.17	26.21	2.4	.773

* indicates highest recorded value

Biological Station E III (Bideford River) see table 11

Hydrography and Weather

Surface temperatures only were recorded at this station, but information from the Biological Station records indicate that bottom temperatures rarely vary more than ± 1.0°C from thos found at the surface, and most frequently are about 0.5°C less. Ice did not move out of the river until mid April. The highest surface temperature recorded was 28.0°C on July 30, 1970. This coincided with the warmest day on which samples were collected, the mean temperature of which was 24.1°C (76.0°F). Warming of the water began early in this tributary, with surface temperatures as high as 19.5°C by June 17th, 1970. The lowest temperature recorded on a collection day was 5.0°C around mid-day. On the previous day a thin film of ice had appeared on the surface before dawn, the air temperature overnight having dropped to -1.0°C (30°F). There was a fairly large diurnal fluctuation in surface temperature, more pronounced than at the other stations.

The salinity in the tributary, as would be expected, was significantly lower than that of the bay or off-shore. It was also much more variable, particularly at the beginning and end of the collecting season. The highest salinity recorded was on the 22nd of July and remained at about the same level until the 12th of August when a heavy rainstorm (2.04 cm ppt.) altered conditions. Surface salinities were highly variable, depending on the weather, the bottom salinities (see data in appendix F) were much more stable reaching a maximum of 28.06 o/oo on July 30, 1970. The lowest bottom salinity was recorded on the first collection May 26, 1970.

On three occasions during 1970 the surface water appeared a peaty brown colour and of a very low salinity. 1.04 o/oo on June 7, 18.40 o/oo on October 11, and 16.35 o/oo on November 7. The source of this water was traced to nearby Paugh's Creek, see fig. 15. After a heavy rainfall the water became turbid, with much fine red silt suspended in it, this was accompanied by a lowering of the surface salinity.

The tidal effect is still noticeable at this level of the estuary, with mean fluctuations in amplitude of about $\pm$0.3 meters.

Nutrients

The results of phosphate analyses in 1970 are shown in figure 12. They show that the phosphate concentration increased from 0. 171 mg/A/m^3 on May 26, until mid-August when pronounced decline in concentration levels was apparent. These lower concentrations were sustained until November 7, when 0.179 mgA/m^3 was recorded. The maximum of 3.256 mgA/m^3 occurred on August 12.

Nitrate concentrations are also shown in fig. 12. After an average concentration of 0.251 mgA/m^3 was recorded on May 26, the nitrates were completely exhausted until a reappearance on July 22 which coincided with a marked increase in phosphates. The nitrate concentration level dropped again by August 7, increasing by August 12 to 0.975 mgA/m^3. A plateau was reached until the November sampling showed a pronounced rise to 1.371 mgA/m^3.

When sampling was first started, on May 26, 1970, the concentration of silicate was 1.603 mgA/m^3. The level at the end of the collecting season on November 7 was 6.072 mgA/m^3. The concentration was highly variable but the genral picture is of an increasing concentration over the months from May to November.

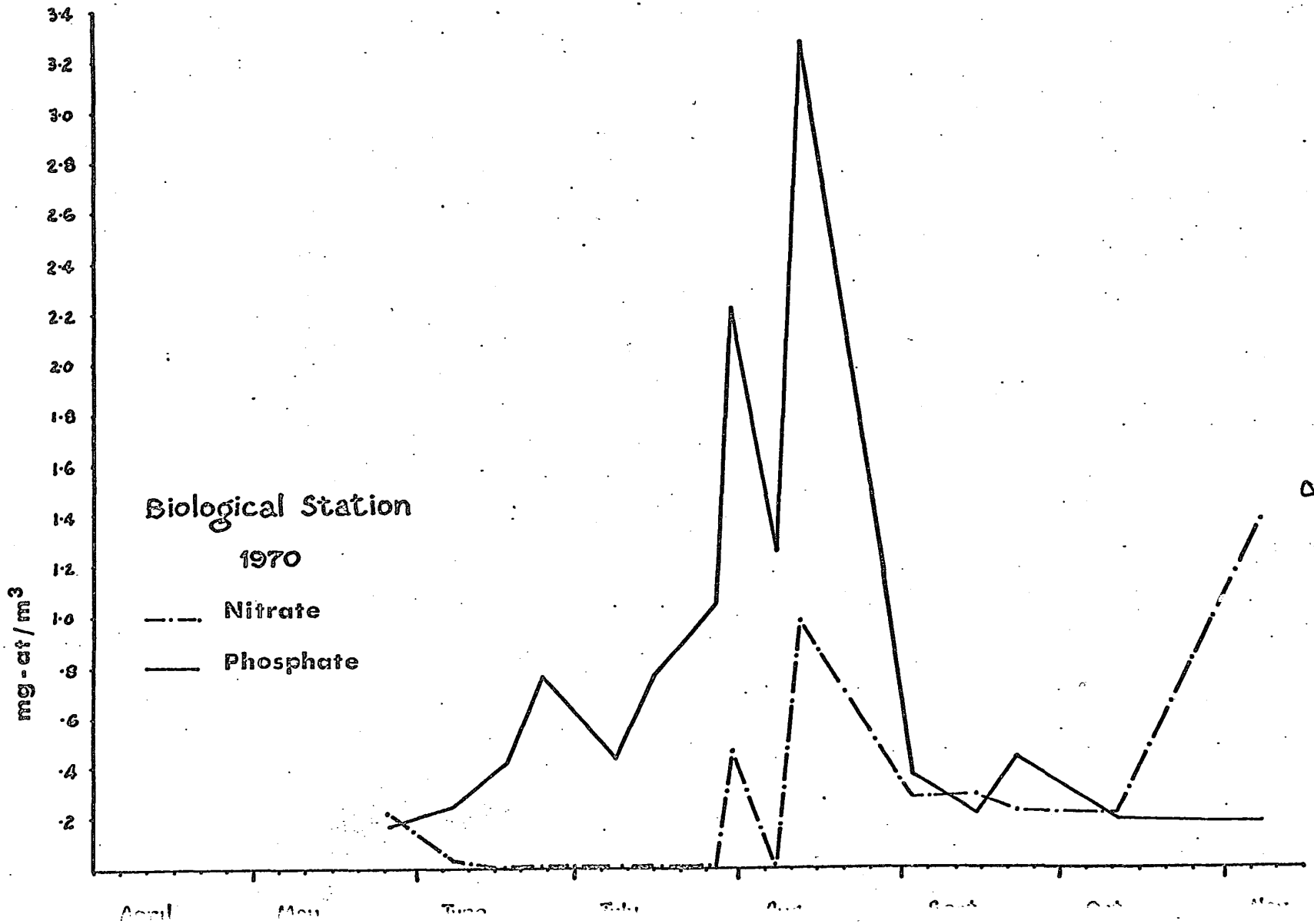

3·4
3·2
3·0
2·8
2·6
2·4
2·2
2·0
1·8
1·6
1·4
1·2
1·0
·8
·6
·4
·2
mg-at/m3
Biological Station
1970
Nitrate
Phosphate
April
May
June
July
Aug
Sept
Oct
Nov

Fig. 15a

50 A

Four major peaks occured on June 7 - 6.132 mgA/m^3; July 30 - 7.536 mgA/m^3; August 12 - 7.978 mgA/m^3; October 11 - 8.531 mgA/m^3.

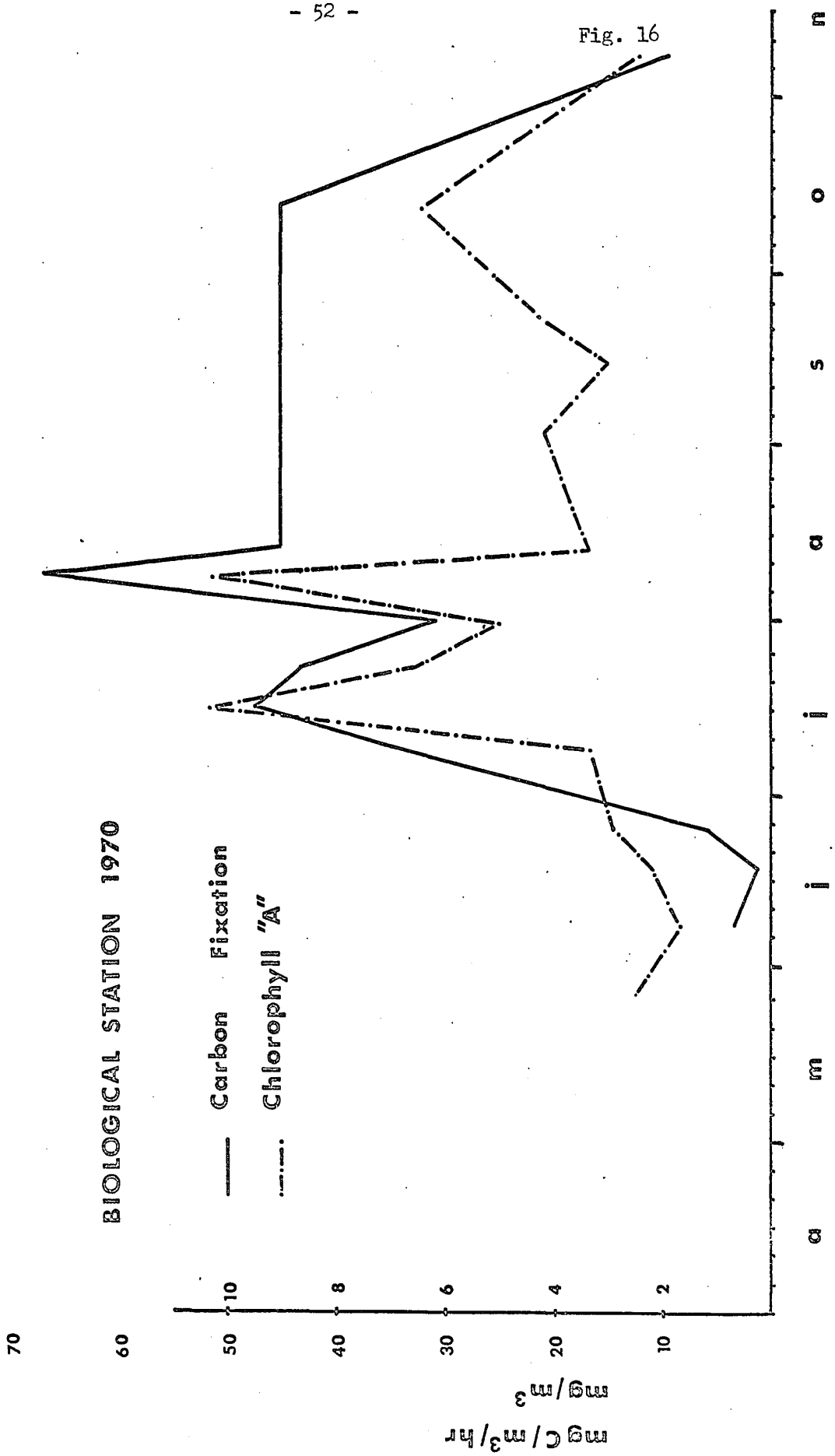
Phytoplankton Biomass and Primary Production

Results of chlorophyll 'A' and carbon fixation experiments are shown in fig. 16.

The first measurement of chlorophyll 'A' concentration was 2.525 mg/m^3 on May 26. The concentration fell to the minimum recorded for the year on June 7 of 1.690 mg/m^3. The period from June 7 until October 11 showed a general rise in chlorophyll concentration with marked peaks on July 15 - 10.306 mg/m^3 and August 7 - 10.273 mg/m^3. Microscopic examination showed that the dominant plant organisms at these times were microflagellates and bacteria ranging in size from 2 to 5μ and present in concentrations of greater than 10^6 per liter. Diatoms made up most of the other phytoplankton present but did not exceed 4000 to 5000 per litre. The high concentration of chlorophyll on October 11 of 6.399 mg/m^3 was due mainly to microflagellates and bacteria.

Results of carbon fixation correlated significantly with the chlorophyll results for the dates on which both analyses were made (see fig. 17). A low level of 2.10 mgC/m^3/hr was found on June 17, followed by a marked rise to 47.38 mgC/m^3/hr corresponding to a fall in chlorophyll 'A' present in the samples collected on July 22,1970. The maximum rate of fixation observed during the year was 66.89 mgC/m^3/hr on August 7, 1970. No carbon fixation experiments were carried out during September, but on October 11 a rate of fixation of 45.02 mgC/m^3/hr was observed. By November 7 the rate had decreased to the general level observed at the beginning of the season.

Fig. 16


BIOLOGICAL STATION 1970
Carbon Fixation
Chlorophyll "A"
mg C / m3/ hr
mg/m3
70
60
50
40
30
20
10
10
8
6
4
2
a
m
j
j
a
s
o
n

Regression of Carbon Fixation and Chlorophyll 'A' at Biological Stn. 1970

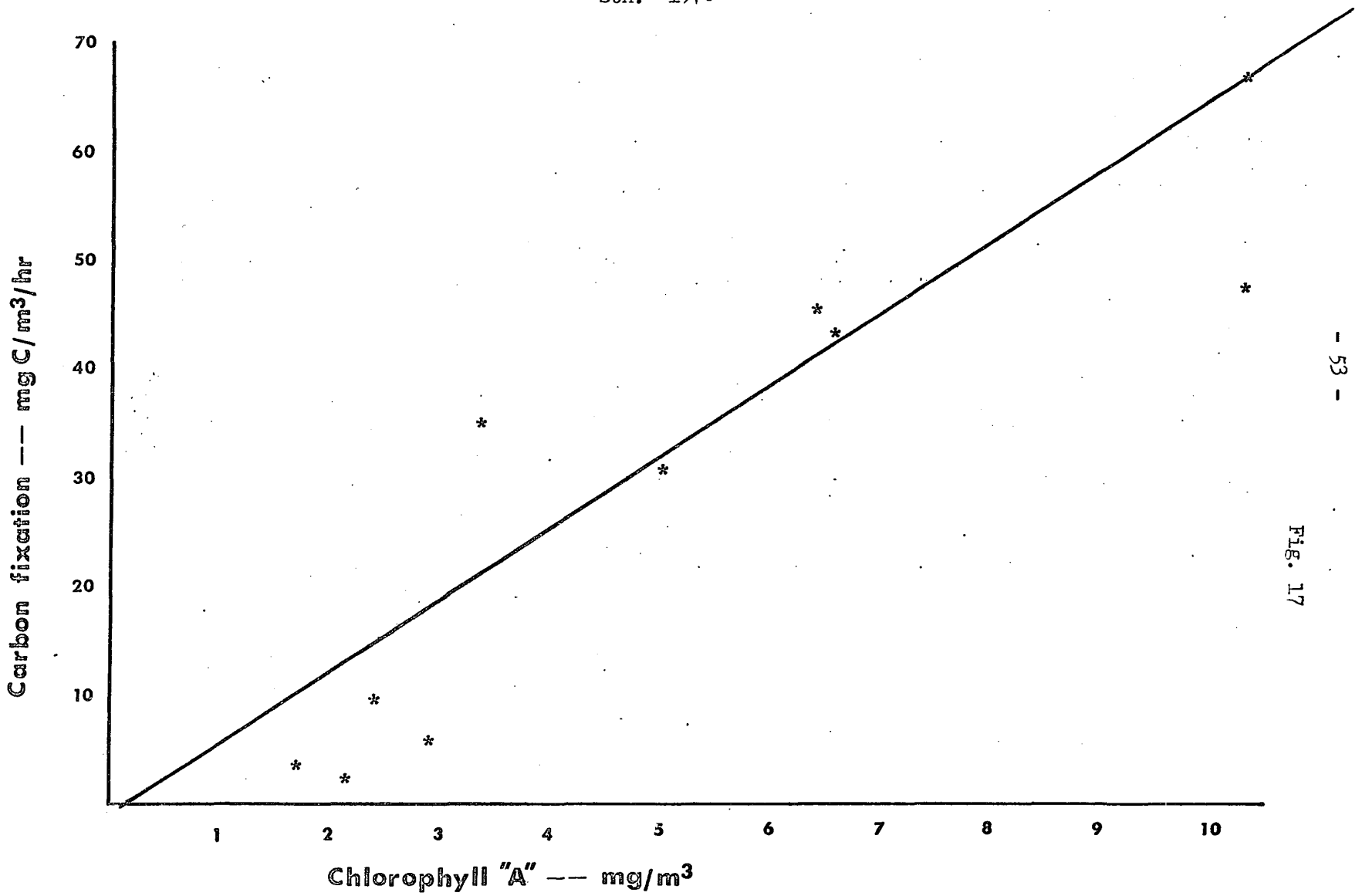


Fig. 17

The carbon fixation rates when converted to production per m^2 appear in the following table 12.

TABLE 12

Carbon Fixation per m^2 at Biological Station E III (Bideford River)

	1970	Average
May	-	-
June	11, 6, 17	11
July	134, 142, 129, 120	131
August	200	200
September	-	-
October	135	135
November	29	29

Phytoplankton Identification

Phytoplankton identification was not a planned objective of this study, but since Station EIII is in a major oyster rearing area, a closer look was taken at the organisms responsible for the phytoplankton blooms here than was made at the other stations.

Formalin fixed samples were studied for the following dates; July 15, July 30, August 7, and October 11, 1970. The numbers of organisms present were estimated and a summary of the results is recorded below.

PHYTOPLANKTON DATA

1. July 15 - surface sample

   (a) Nannoplankton - microflagellates and bacteria, size 10 microns
   - very abundant 1,000,000/liter

   (b) Diatoms - especially pennate forms
   - common approx. 4,000 - 5,000/liter

2. July 30 - surface sample

   (a) Nannoplankton -
   - very abundant 1,000,000/liter

   (b) Diatoms - pennate - especially Nitschia, Closterium
   - common approx. 5,000/liter
   - unidentified triangular form
   - common

   (c) Filamentous algae
   - few

3. August 7 - surface sample

   (a) Nannoplankton - abundant approx. 500,000/liter

   (b) Diatoms - pinnate
   - few 1,000/liter
   - triangular form
   - very abundant approx. 500,000/liter

4. October 11 - surface sample, water brownish and of low salinity

   (a) Nannoplankton - various types 100,000/liter

   (b) Diatoms - pennate - various types 4,000 - 5,000/liter

   (c) unidentified micro organisms 4,000 - 5,000/liter

(d) Protozoa - some eg. Stylonychia

October 11 - 3 meter sample (more typical)

(a) Nannoplankton - various types

- abundant approx. 1,000,000/liter

(b) Diatoms - pennate

- common approx. 200,000/liter

(c) Dinoflagellates e.g. Ceratium fusus

- few

In all samples, much detritus was present, mainly of plant origin.

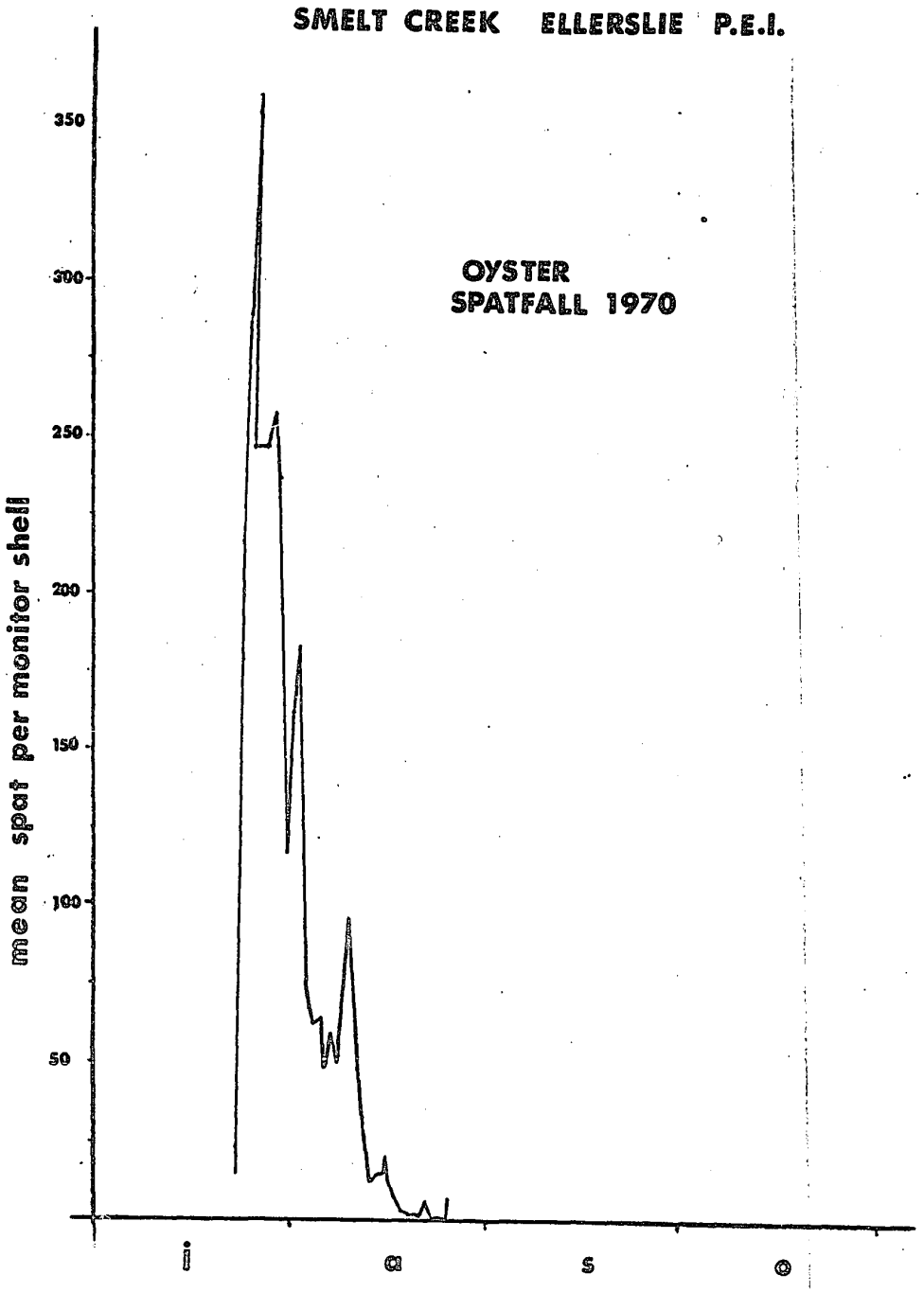
Zooplankton Biomass

Some difficulty was experienced in collecting the zooplankton especially at this station due to the clogging of the nets by phytoplankton and medusae.

The biomass results show that there was a steady increase in the zooplankton with a summer peak at the end of July of approximately 200 mg/m^3 dry weight. This, however, is a little deceptive as this was due to the additional weight of the tests of a large number of small gastropods found in the sample. The mass of zooplankton decreased irregularly until the fall, but the last collection of the year on November 7 showed a marked increase in the zooplankton population with the highest concentration of the season of 205 mg/m^3.

Particular interest was paid to the occurrence of planktonic molluscan larvae, especially oyster larvae. These were too small to be captured by the plankton net used, but their presence may be inferred from secondary indications of their abundance, for example, by spat monitoring. Oyster spatfall is routinely monitored by the Department of Environment. Fig. 18

Fig. 18


SMELT CREEK ELLERSLIE P.E.I.
OYSTER
SPATFALL 1970
mean spat per monitor shell
350
300
250
200
150
100
50
i
a
s
o

records the average daily spatfall on monitor scallop shells in Paugh's Creek, a small tributary of the Bideford about a hundred yards from Station E III, and was calculated from Department of the Environment data (with permission). The motile life of Crassostrea virginica (Gmelin) in this latitude is approximately 21 days prior to setting (Galstaff 1964).

D I S C U S S I O N

Comparison of Offshore Stations E II and E IV and Malpeque Bay E I

When this study was proposed, it was anticipated that there would be a considerable difference between the water of Malpeque Bay and that immediately offshore, particularly since Malpeque Bay has the general appearance of an almost completely enclosed lagoon. There was, however, less difference than was expected.

The surface temperature at stations E II, E IV, and E I showed the same pattern of seasonal warming and cooling. The Bay water was generally 2 - 3°C warmer than the offshore water in the spring-time*, paralleling the offshore water closely in the summer and generally cooling more rapidly in the fall. This is the pattern to be expected in a shallow body of water, where rapid diurnal warming, especially along the shore, can take place. At times during the summer, the salinity at Malpeque Bay E I was slightly higher than that offshore which could be accounted for by the effect of evaporation from this partially enclosed estuary-lagoon complex. The effect of the inflowing 'rivers' is small even during the spring run-off because of the very small drainage area of the streams (Sheldon et al, 1969) (Needler, 1931). See also fig. 19, drawn from data supplied by the Inland Waters Branch of the Department of Energy, Mines, and Resources.

The Offshore temperature and salinity data show that the water column remains fairly stable throughout the months of sampling, April to September. During September, October, and November there was intermittent complete mixing coinciding with a rejuvenation of the nitrogen/phosphate levels.

*Note: Winter - December 21 - March 21; Spring - March 22 - June 21
Summer - June 22 - September 21; Fall - September 22 - December 21

The thermocline was seldom distinct and varied considerably in depth from collection to collection. This might indicate that fairly rapid heat exchange from surface waters was taking place and/or the presence of internal waves of some magnitude (15 - 20 m). A third possibility is that wind driven wave action in this coastal location has a marked effect on mixing. Particularly strong offshore winds occur in October and November, which could induce upwelling along the coast. (Sverdrup, Johnson and Fleming 1942, p 501).

In Malpeque Bay E I, when the earliest temperature/depth profile was taken with the bathythermograph on April 9, 1970, the water column was found to be practically uniform in temperature at 0.3°C. (The limit of error of the bathythermograph was 0.5°C). The water became progressively stratified as the surface warming spread through the water mass. By mid-June the water column was thermally mixed, and remained generally so for the remainder of the year. Most of the time the waters were holomictic.

The salinity of Malpeque Bay E I was relatively high in the early spring, possibly due to the cessation of land drainage because of below freezing conditions and the existing ice on the surface. After the melting of the ice, the salinity was relatively uniform throughout the water column.

Apart from the spring thaw when rapid land drainage had a marked temporary effect on the salinity of Malpeque Bay, the variation in salinity between the offshore and the water of the Bay was never more than 1 o/oo.

The silicate results for both the Offshore stations and Malpeque Bay showed considerable variation throughout the season, the significance of which was hard to determine. The source could well be varied amounts of land drainage.

The pattern of phosphate availability at the Offshore stations E II and E IV during 1969 and 1970 was quite similar. It would appear that the early abundance which sustains the spring bloom of phytoplankton in many temperate areas may possibly have been absent or could have occurred before sampling was started in the spring. The relatively low levels of phosphate found at the beginning of the season were generally maintained until the fall, when marked increases coinciding with the breakdown of the thermocline, and the instability of the water column promoted the recirculation of bottom nutrients. These were quickly depleted by phytoplankton which bloomed with this enrichment.

In Malpeque Bay, the increases in phosphate in the fall may be explained in part by the influx of enriched water from the coast, and increased land drainage due to an increase in precipitation. Since the water column had been thermally mixed for the greater part of the year, there would be no special recruitment of nutrients from the bottom. The biological factors in this system must not be discounted as significant environmental influences. The phosphate peak in the fall of 1970 (Sept. 18) coincided with a zooplankton bloom and could have been augmented by fecal wastes from these organisms.

The general characteristic of the Offshore stations E I and E I V was of a paucity of nitrates. Judging from the way that phytoplankton blooms followed closely the relative abundance of available nitrogen it seems that nitrate was the primary limiting factor in phytoplankton production. Recycling of nitrates during periods of water column instability, particularly in September, resulted in increases of nitrate to the order of 10 times the summer level.

The nitrate level of concentration at the Offshore stations and Malpeque Bay E I were quite similar up to July 18, 1970, but showed a marked difference on August 7, 1970, with the nitrate concentration in the Bay much lower than that offshore. This difference became increasingly pronounced until by September 23 it was in the order of one magnitude greater. This is attributed to the fact that at that time the thermocline at the Offshore stations was very close to the bottom, allowing the regeneration of nitrate from below the thermocline to take place. A similar, though less pronounced pattern was observed in 1969.

An indication of general levels of phytoplankton biomass was obtained from pigment analysis and interpreted as an indirect indication of phytoplankton production, taking into consideration the effect of grazing by zooplankton.

At E II in both 1969 and 1970 there was an initial fall in the level of chlorophyll concentration followed by a steady increase. This was not reflected, however, in the carbon fixation rates. This could indicate that the offshore sampling, particularly in 1970, just caught the end of a spring bloom. Weather and boat availability prevented the actual documentation if such an event did occur. (Studies in St. Margaret's Bay by Platt and Irwin (1968) showed a marked spring increase in chlorophyll 'A', peaking to 100 times the general level for the year). The steady rise in chlorophyll concentration peaked in late September when, sustained by the increased phosphate and nitrate concentrations induced by the recycling of bottom water, there was a pronounced fall bloom.

The carbon fixation experiments, particularly for Stations E I I and E I V were not as satisfactory as could be wished for the following reasons:-

1. Irregularity in the times of sampling due to unavoidable variation in boat hiring arrangements.
2. Light inhibition by the incubator used (from an experiment conducted, light inhibition due to the use of the buff coloured incubator rather than a black one reduced the production measured by approximately one third. This was reduced on June 15, 1970 with some improvement in results.).
3. Length of time between collection and incubation, due to the necessity of returning to the base station to incubate samples. At the beginning of the 1969 season samples were kept in the dark overnight and cooled in a water bath, then incubated the next day. These results are not considered to be as reliable as the others, but were included in the statistics as they are probably in the correct order of magnitude. These comprise the first five results of that year.

Inspite of these limitations, the general pattern of production follows the same pattern as the chlorophyll concentration. Together these indicate that the plant production is at a low level throughout the greater part of the season due mainly to a nutrient deficiency, notably nitrate.

The annual primary production cycle at the Offshore Stations and in Malpeque Bay do not follow the classical pattern for temperate latitudes, that is a dominant spring bloom and a lesser fall bloom, with little phytoplankton production in between as found, for example, by Hart (1942) in the English Channel. (Raymont 1963). It appears that the phytoplankton production in this area is median between that found somewhat to the south (Platt and Irwin, 1968) and that seen for example in Scoresby Sound, Greenland, as reported by Digby (1953) (Raymont 1963, p. 191). The suppression of the spring bloom

with a greater summer and fall production could be a characteristic of a more northern region where the late dissipation of ice retards the vernal warming of the water and inhibits the phytoplankton. This is speculative and could bear further investigation by a thorough sampling during the break-up of the ice to verify that the absence was not due to a failure of the data due to infrequent sampling at this time. This was technically not possible in the present study.

The zooplankton biomass results of the Offshore stations E II and E IV show a certain inverse relationship to the minor fluctuations in the chlorophyll 'A' concentrations, as would be expected where zooplankton grazing has a secondary effect on the phytoplankton population.

The zooplankton biomass results of Malpeque Bay E I, show that by weight and by volume the zooplankton in the bay is almost double that of the Offshore stations. This reflects the higher plant biomass which was also approximately double. In both areas the zooplankton was generally dominated by copepods.

The variations in the zooplankton biomass results, even between successive years at the same station may have been due to natural fluctuations in the zooplankton populations dependant on available food sources, breeding cycles, etc., or may have been in past errors introduced during sampling.

Possible sources of error include:-

1. Variability in the time of collection of the sample, thus, a surface sample might not be representive of the plankton population due to diurnal movement by vertical migration in the water column.
2. Error introduced during the towing and metering of the volume filtered, clogging of the net and some loss of plankton during the transfer from the net to the storage container.

3. Loss during drying or loss of oils etc. during the storage of the sample.
4. Loss of all zooplankton smaller than the mesh of the sampling net.
5. Misleading results due to the presence of medusae, slime, fucus or tests of gastropods, all of which may contribute to inaccuracies in measurement either by their removal or by their presence in the sample.
6. Limitations in the accuracy of the methods of measurement.

In spite of these possible sources of error, the measurements are considered to be a fair indication of the zooplanktonic biomass and a good indication of secondary production.

The most logical explanation of the unexpected similarity of the Offshore Stations E II and E IV to Malpeque Bay E I would be that rapid tidal flushing is taking place, this in spite of the fact that the bay appears to be semi-lagoonal and fairly enclosed. 'Ship Channel', the main opening between Malpeque Bay and the Gulf of St. Lawrence, is about 460m wide and 15m deep, which would permit a considerable exchange of water over a tidal cycle. Actual rates have not been measured, but direct observation of the rapid influx and outflow of water through this channel support the secondary evidence of the unexpectedly low production level of the Bay. Drift bottles released by M. J. Thomas in the Bay also indicate a rapid turnover of the water (unpublished data). One bottle when released in the Bay appeared one week later in the Magdalen Islands! The tidal pattern within the bay is also quite complex and strong.

Thus it would appear that the build-up of nutrients in the bay is prevented by its effective tidal flushing even though the tributaries leading into the Bay must contribute to the enrichment of the water by carrying run-off from the surrounding fertilized farmlands at least in the spring and fall.

This is reflected in the general paucity of fauna particularly molluscan which one would expect to find in quantity, but which in fact are uncommon in the central areas of the Bay.

Station E III revealed a much higher level of biological production.

Biological Station E III (Bideford River)

A much wider range of temperatures was experienced in the shallower waters of the river, often with a marked difference between the surface and the bottom temperatures. The surface temperature rose to a maximum of 28°C on July 30, 1970 compared with a maximum of 20.3°C on August 5, 1970 in the Bay and 20.8°C Offshore on August 10 of the same year.

The salinity likewise varied considerably depending on the season and the rainfall. Conditions of layering or stratification appeared from time to time, but readily broke down. Two occasions in the fall fresh water originating from nearby Paugh's Creek and high in humic content, layered over the more saline waters of Smelt Creek, the headwaters of the Bideford River (see fig. 19) (modified after Thomas 1970). Salinity in the River was lower at all times than in the Bay.

Rapid run-off produced large quantities of particulate matter, especially of a silicious origin. At times the water was red with the soil of the Island. The summary of run-off from Smelt Creek shows this to be particularly marked in the Spring and the Fall. (fig. 20) The graph was drawn from raw data supplied by the Inland Waters Branch.

Nitrate exhaustion appears to be the limiting factor in photoplankton production in the River particularly at the time of the heavy blooms in June and July when it was totally depleted. This is probably because all the

available nitrate was being used to support a burgeoning microflagellate population. It accumulated somewhat in August and seems to have been building up again in the Fall. It is possible that its recruitment is linked with periods of rapid land drainage, although runoff is considered to be small even in the springtime because of the small drainage areas of the streams (Needler 1931).

Compared with the Offshore Stations and the Bay, the phosphates at the Biological Station E III were abundant throughout the season, especially in July and August and September. They do not appear to be the limiting factor of phytoplankton production and are probably overabundant due to the leaching of commercial fertilizer from adjacent farm lands.

The actual phytoplankton per unit volume of water was of the order ten times that at the other stations monitored. This was found to consist largely of microflagellates and bacteria in the order of 2 - 5μ during the July and August peaks. There is an interesting inverse corelation between the phytoplankton biomass and the zooplankton biomass. The summer maximum of 200mg/m^3 of zooplankton dry weight on July 22 falls between the two summer phytoplankton maxima, and would indicate a grazing effect. The high zooplankton value was due to an abundance of gastropod larvae present in the water. This also coincided with the presence of large numbers of oyster larvae (fig. 18) and other molluscan larvae which were reaching setting size and were reaching their peak in nutrient requirements. (The spatfall is a critical time in their development at which there are extremely high mortalities). (Galstoff 1964) (Yonge 1960 p.67). Generally, however, the zooplankton was dominated by copepods.

Fig. 19

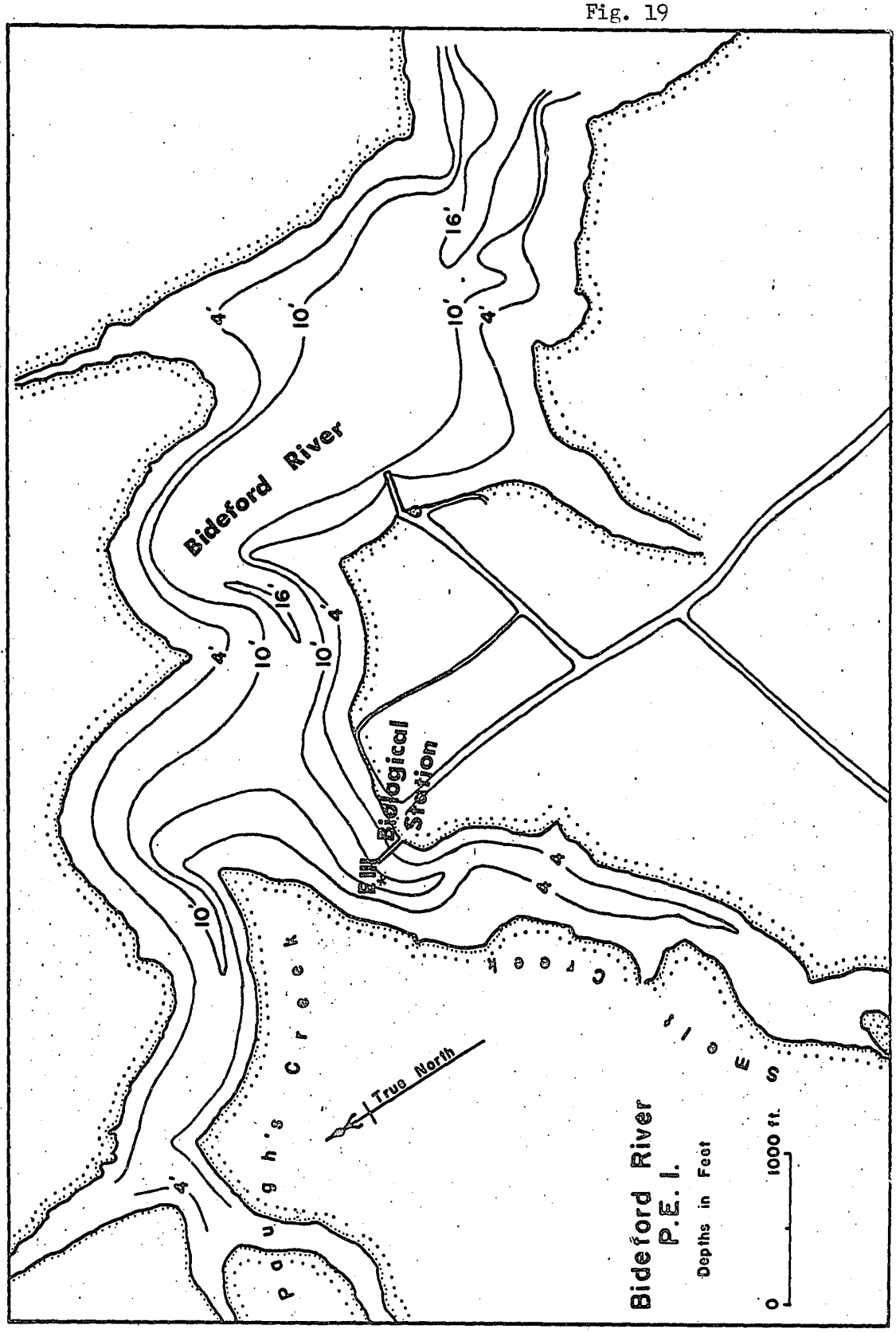
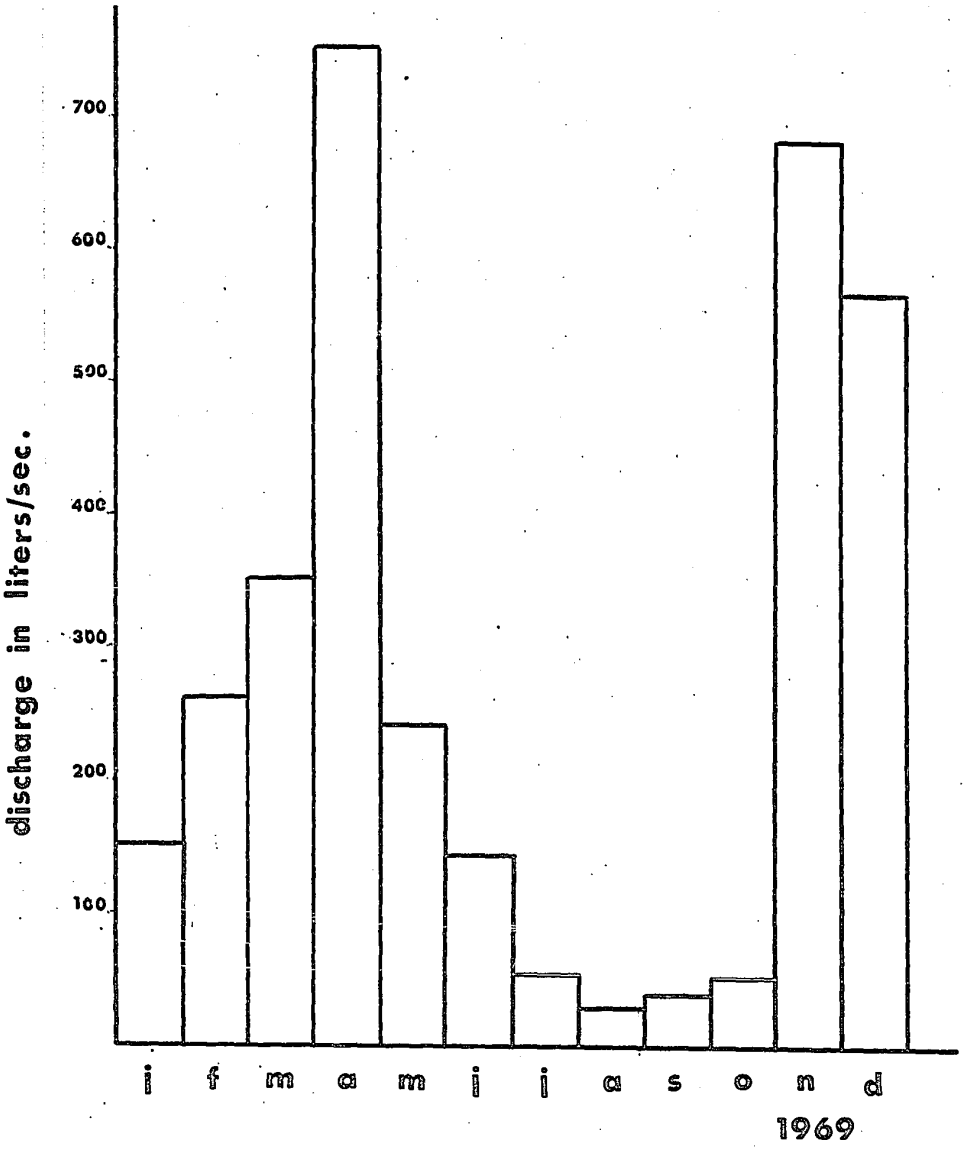

Bideford River
Biological Station
Pugh's Creek
Creek
True North
Bideford River
P.E.I.
Depths in Feet
0
1000 ft.
4'
10'
16'

Fig 19

Fig. 20.

SMELT CREEK
a tributary of the Bideford River

ANNUAL FLOW



Periodically, surface water rich in humic substances was observed at the Biological Station E III, particularly after heavy rains. The greater part of this emanated from Paugh's Creek (see fig. 19) which originates in a swampy area. Prakash and Rashid (1968) postulate that humic substances in small amounts exert a stimulatory effect on marine dinoflagellates which is reflected in increased yields, growth rate, and C^{14} uptake. This is for the most part independent of nutrient concentration and can not be attributed entirely to chelation processes. They suggest that humic substances may be regarded as a significant entity influencing planktonic production. This may partially explain the abundance of phytoplankton in the Bideford River.

A study of an oyster growing area, similar in many ways to this study, was carried out at Goose Creek, Long Island, N. Y. (Alexander 1968). Nitrate nitrogen seemed to be the factor controlling the primary production in the region. Alexander did not suggest any specific parameters studied as directly linked with oyster growth. Butler (1962) in Santa Rosa, Florida, monitored pH, nutrient salts, dissolved copper, chlorophyll and certain plankton pigments, total plankton, turbidity, and currents without identifying any causal relationships between these and oyster growth.

Comparison of the productivity of the study areas with other North-Eastern areas.

In all productivity studies it is of value to compare the productivity of the study area with that of other areas. It is acknowledged that it is difficult to compare the productivity of two bodies of water when there is a difference in one of the parameters, and this is apparent in this study. In comparing a body of water 10 meters deep with one 25 meters deep there must inevitably be some compromise. Annual plant production rates are usually given in grams of carbon fixed per meter^2 of surface (gC/m^2) rather than per meter^3 of water (gC/m^3).

Since the sampling was done during the open water months only, the winter levels of production have been estimated, based on the first and last collections of the season and also on the general winter levels found in St. Margaret's Bay, N. S. (Platt and Irwin 1968). The length of day and energy fraction were also drawn from this paper since the duration and timing of the carbon fixation experiments were fairly homologous. Uncorrected data were used, since these are estimates only, but the resulting values are thought to be quite realistic, certainly in terms of magnitude. (see table 14) From these daily estimates an annual production rate was derived.

An immediate observation is that the annual primary production due to phytoplankton at station E III in the upper reaches of the Bideford River is twice that of Malpeque Bay and almost three times that of the immediate offshore waters. At 59 $gC/m^2/yr$, the offshore water does not appear to be very productive when compared with other coastal areas (Odum 1958) (Raymont 1963). Legendre (1968) found that the production levels around the Bay of

TABLE 13

Average Primary Production

	$mgC/m^2/hr$ Offshore	$mgC/m^2/hr$ Malpeque Bay	$mgC/m^2/hr$ Biological Stn.
April	7		
May	17	7	
June	11	37.0	11
July	44	61	131
August	54	48	200
September	58	127	(250)*
October	27	63	135
November	--	31	29

* figure in brackets is theoretical.

TABLE 14

Estimates of monthly averages of daily primary production per m^2 of surface. Based on uncorrected data. Duration of experiments - 4 hrs.

Month	(hr)** Day length	F ** Energy fraction	mgC/m^2/day Offshore	Malpeque	Biol. Stn.
Jan.	9.15	.75	(50)*	(50)*	(50)*
Feb.	10.38	.69	(20)*	(20)*	(20)*
Mar.	11.93	.62	(30)*	(30)*	(30)*
Apr.	13.48	.56	50	(50)*	(50)*
May	14.85	.51	133	55	(50)*
June	15.58	.49	90	302	90
July	15.23	.50	352	488	1040
Aug.	14.18	.53	408	362	1509
Sept.	12.28	.60	387	847	1667
Oct.	10.90	.66	164	382	818
Nov.	9.53	.73	(150)*	170	151
Dec.	8.78	.77	(100)*	100	(100)*
mean daily production			161	238	465
total annual production - mean x $\frac{365}{1000}$ in $gC/m^2/yr$			59	87	170

* figures in brackets are speculative
** values taken from Pratt and Irwin (1968)

** Fraction of daily radiation during which experimental exposure took place.

Chaleur, also in the Gulf of St. Lawrence, was in the order of 120 $gC/m^2/yr$ which was similar to that observed by Ryther (1963) for Northern Atlantic waters in the temperate zone. Pratt and Irwin (1968) observed that in St. Margaret's Bay, N. S. in 1967, the annual cycle of primary production differed in some respects from the classical type for temperate latitudes (as recorded in Raymont 1963). Usually the cycle is strongly bimodal, with a dominant peak in the spring, and a smaller peak in the fall and little production at other times. In St. Margaret's Bay, the annual production was spread more evenly throughout the year. The highest production was observed in the spring, but after an initial drop, was sustained at a relatively high level until November. The maximum daily rate was about 500-700 mgC/m^2; minimum about 40 - 60 mgC/m^2 (in February), and averaging around 400 $mgC/m^2/day$. He estimated the annual production at between 125 and 150 gC/m /yr., which is consistent with other measurements in other areas of approximately latitude 45°N (Raymont 1963).

An interesting similarity was found in the primary production level of 55 $gC/m^2/yr$ in the Bras d'Or Lake, N. S. (Geen 1965) and the Offshore Stations E II and E IV with an estimated annual average of 59 gC/m^2. This would indicate a relatively low rate of carbon fixation in these areas and low primary production. In the same study, Geen estimated the carbon production of Morrison Pond, a small embayment of the Bras d'Or Lake to be 170 $gC/m^2/yr$. This compared closely with 179 $gC/m^2/yr$ estimated for the annual production in the Bideford River at Station E III. This would indicate that the microcosm in which the oysters flourish is quite productive. Uyeno (1966) estimated

the mean primary production due to phytoplankton carbon assimilation at his Station A at 38 $mgC/m^2/day$. This, however, is an average based on the measurements made between May and November and is therefore not a true average for the year, which would be expected to be lower since the winter months are generally less productive. Even at 38 $mgC/m^2/day$, this would only give an annual production of 14 $gmC/m^2/yr$, which seems to be excessively low. Similarly the carbon assimilated by phytoplankton at his Station C in the Bideford River which was equivalent, if not identical to, the station E III of this study, was estimated at 73 $mgC/m^2/day$ or 27 $gC/m^2/yr$. This widely differed from the level of 170 $gC/m^2/yr$ estimated in this paper. The area would appear from the present study to be much more productive than was concluded by Uyeno. This is substantiated by the ability of the area to support a considerable population of secondary producers such as molluscs and crustacea, both benthic and planktonic. There is also a fairly large number of estuarine fish. This is reflected in the zooplankton biomass and also in the study of the benthos of the Bideford River made by Thomas (1970).

The particular interest of the productivity of Station E III, off the Biological Station in the Bideford River.

The particular interest of the productivity of Station E III is that it is located on a Federal Shellfish Reserve, the predominant commercial molluscs being the Atlantic oyster, Crassostrea virginica (Gmelin). Other molluscs abundant in this area are Mytilus edulis, Mya arenaria and Macoma baltica. Together these comprise most of the benthic fauna (Thomas 1970).

A summary of investigations into the feeding habits of molluscs and molluscan larvae, especially oyster was made by Galstoff (1964). Although there is some disagreement on what constitutes 'food' for the adult oyster, whether it be phytoplankton, organic detritus or even dissolved nutrients, it is generally agreed that these molluscs are herbivorous filter feeders and that phytoplankton form a substantial part of the diet of adult molluscs mentioned. It has been better demonstrated that nannoplankton, especially naked flagellates of the Chrysophyta, and bacteria are the basic diet of planktonic oyster larvae. It is highly significant that an abundance of these forms are present inthe water when the oyster larvae are liberated, the timing of which was calculated by extrapolation from the oyster spat monitoring data (fig 18) allowing 15 to 21 days of free swimming larval life prior to the settlement of the spat (Galstoff 1964). The larvae of the other molluscs, which are the predominant benthic organisms of the area are also liberated during the period of nannoplankton abundance.

Further Studies

Further studies would call for a detailed analysis of the phytoplankton and zooplankton of these areas especially on the oyster beds of the Bideford River. A thorough understanding of the feeding habits, and diet of the indigenous molluscs is also necessary and only when this is properly understood would predictions on the suitability of growing areas and potential growth rates of oysters and other shellfish be possible. This would be of very great practical value in the development of mariculture, especially the oyster farming industry.

The effect of incidental and intentional fertilization of the waters should be investigated, and the significance of other organic substances such as humic substances, vitamins, and organo-metallics should be studied. Industrial pollutants and chlorinated hydro-carbons should also be monitored for their effect on the phytoplankton and secondary producers. The measurement of the parameters measured in this study should also be repeated after a period of time to determine whether any changes or deterioration of the environment has taken place.

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A P P E N D I C E S

APPENDIX A

INCUBATOR USED FOR C^{14} EXPERIMENTS * 1970.

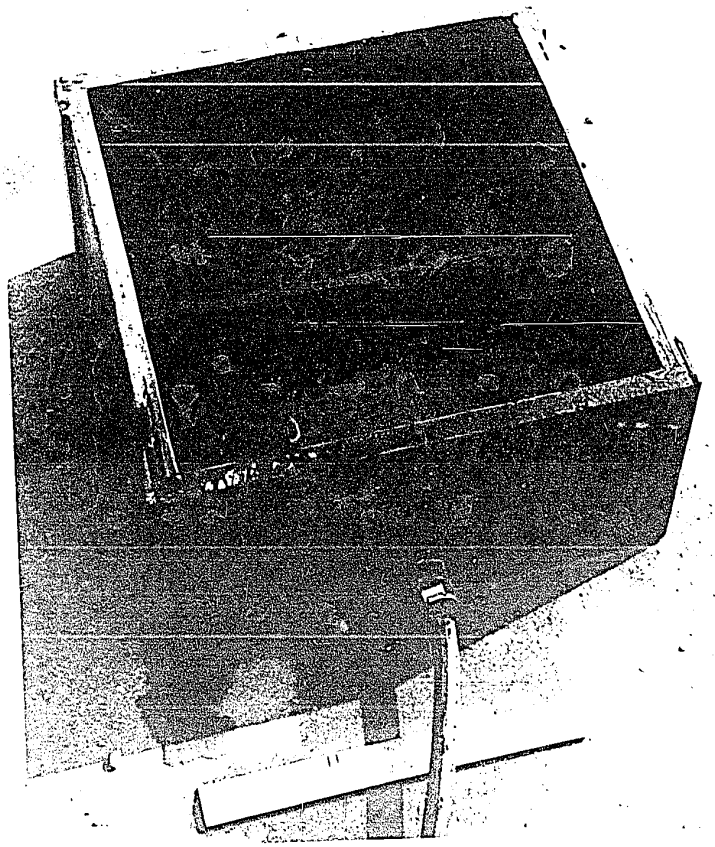
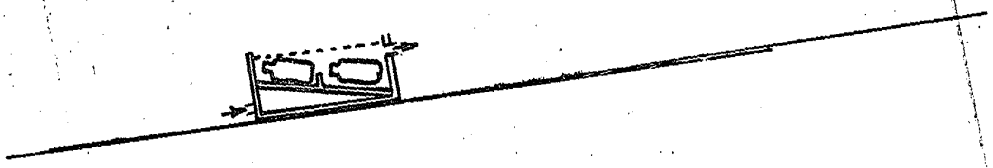


Fig i

Dimensions 14" x 14" x 9" I.D.

APPENDIX A

C^{14} Incubator



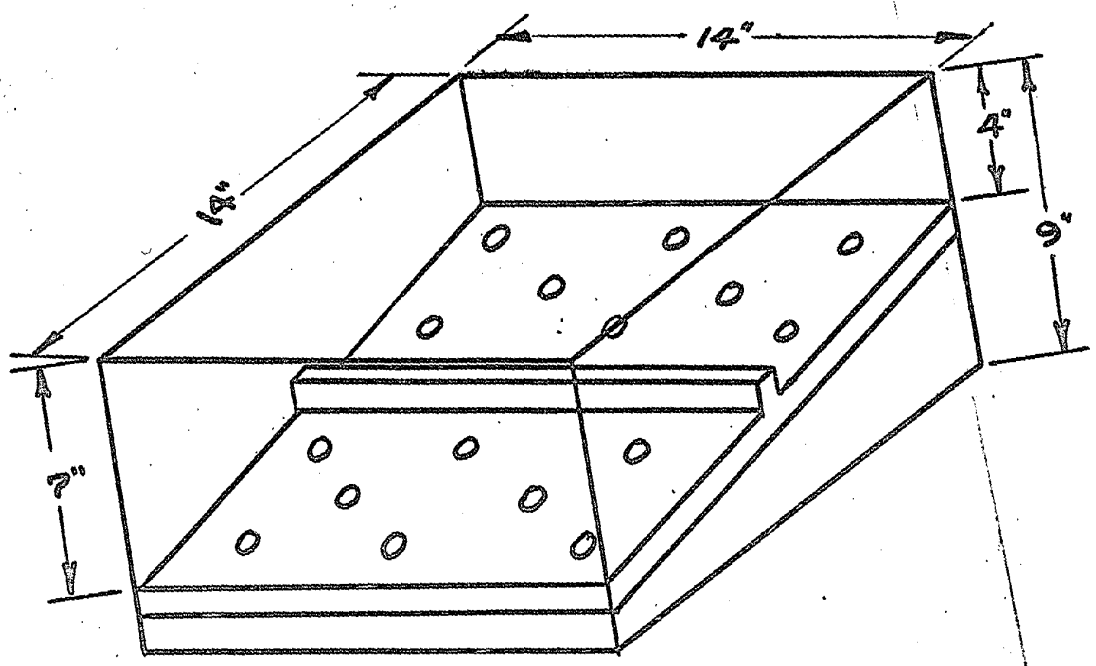


Fig ii

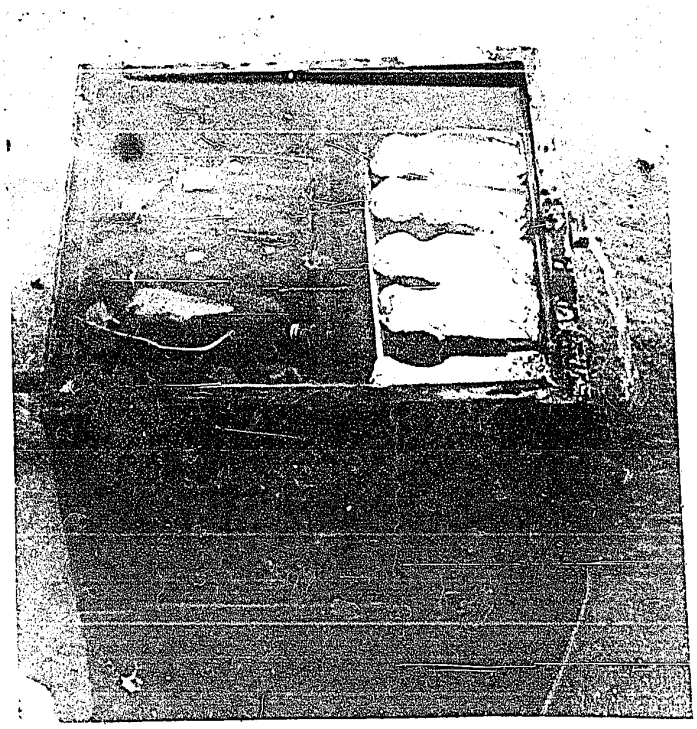


Fig iii

Left side.

Filtered bottles to simulate light intensity at depths from which samples were taken.

Right side.

Foil wrapped control samples and thermometer.

APPENDIX B

SECCHI DISC READINGS

Secchi (m)	K (= extinction coefficient)	% Trans.	neutral density filters: 100%	60%	30%	16%	1%
5	.340	71	0 m	1½ m	3 m	6 m	16 m
6	.284	75	0	2	4	7	18
7	.243	78	0	2	4	7	19
8	.212	80.5	0	2¾	6	8	21
9	.188	82.5	0	3	6½	10	23
10	.170	84.5	0	3½	7	12	26
11	.154	86	0	3½	8	13	29
12	.142	86.8	0	4	8½	14	30½
13	.131	88	0	4½	9	14	32½
14	.121	88.5	0	4½	9½	15	34
15	.113	89.5	0	4¾	11½	17	39
16	.106	90	0	4¾	11½	17	42
17	.100	90.5	0	5	13	17½	43
18	.095	91	0	6	15	18	45
19	.089	91.5	0	5	13	19	48
20	.085	91.8	0	6	14	20	50
21	.081	92	0	6	15	22½	54
22	.077	92.5	0	6	16	24	60
23	.074	92.8	0	7	18	25	65
24	.070	93	0	7	20	28	70
25	.068	93.5	0	8	22	30	75

(e.g. for a Secchi disc reading of 9 m: Van Dorn bottles will be lowered at the following depths: 0 m(surface); 3 m; 6½ m; 10 m; and 23 m.)

A P P E N D I X C

NUTRIENT CONCENTRATION DETERMINATIONS

METHODS

APPENDIX C

REACTIVE NITRATE DETERMINATION

Ref. Morris and Riley (Anal. Chim. Acta 29: 272, 1963.)

Reagents

1. Concentrated Ammonium Chloride Solution (STOCK)

Dissolve 300 g of analytical reagent quality ammonium chloride in 1000 ml of distilled water and store in a glass or plastic bottle. (or: 240 g to 800 ml of distilled water)

2. Ammonium chloride final I solution

50 ml of the stock NH_4Cl in 1 litre D.W.

3. Ammonium chloride final II solution

100 ml of final I in 2 litres D.W.

4. Sulphanilamide solution

Dissolve 5 g of sulphanilamide in a mixture of 50 ml of concentrated hydrochloric acid (sp. gr. 1.18) and about 300 ml distilled water. Dilute to 500 ml with D.W.: the solution is stable several months.

5. N - (1 - Naphthyl) - Ethylenediamine Dihydrochloride

Dissolve 0.50 g of the dihydrochloride in 500 ml D.W. Store the solution in a dark brown bottle. This solution deteriorates rapidly and should be prepared fresh at least every two weeks or as soon as a strong brown coloration develops.

6. Cadmium - Copper filings

Finely divided cadmium was obtained by placing a cadmium stick in a lathe, using a coarse machine file to obtain the filings caught in a pan underneath. Collect filings passing a sieve with 2 mm openings but retained on a sieve with 0.5 mm openings. Stir about 100 g of filings at a time (enough for two columns) with 500 ml of a 2% w/v solution of copper sulphate pentahydrate $CuSO_4 . 5H_2O$ until all blue colour has left the solution and semi-colloidal copper particles begin to enter the supernatant liquid. Make a plug either of very fine copper turnings or glass wool and push this into the bottom of the reductor column. Fill the column with final II ammonium chloride solution and pour in sufficient copper cadmium mixture to fill the column. Add the filings a little at a time, tapping the column hard after each addition to make sure they are well settled. Wash the column thoroughly with final II solution. The flow rate must be such that 100 ml of solution takes between 8 and 12 minutes to flow completely through the column. If it is less than 8 minutes slow it by restricting the outlet of the syphon or by packing more glass wool at the base of the column. When not in use the columns must be left with the metal filings completely covered by a solution of NH_4Cl final I.

When the efficiency of the reduction is suspect (approx. 90% recovery should be obtained normally) the columns should be emptied into a beaker and the filings from four columns should be washed by stirring vigorously with 300 ml of 5% v/v hydrochloric acid solution, decanting the acid and repeating the procedure once more. Finally wash the metal with 200 - 300 ml portions of distilled water until the wash is no longer acid (pH > 5) and decant the liquid to leave the metal as dry as possible. Re-treat the metal with copper sulphate solution as described above. The regenerated cadmium copper mixture should be sufficient for 3 columns.

Procedure

Begin by rinsing the columns with about 50 ml final II NH_4Cl solution. Then determine distilled water blank, sea water blank and standards. If the factors obtained from the standards show that the columns are functioning properly, then analyze the samples.

1) To a 100 ml sample add 2.0 ml of the NH_4Cl stock solution and mix. Pour about 5 - 10 ml into upper reservoir. Allow to pass through. Then add remainder of the sample and allow about 40 ml to pass through. Collect the last 50 ml in a measuring tube. This applies to Distilled water blank, sea water blank, standards and routine samples.

2) Add 1 ml of sulphanilamide reagent. Shake gently; wait 2 minutes, not more than 5 minutes.

3) Add 1 ml of N-1-Naphthyl-Ethylenediamine dihydrochloride reagent. Shake.

4) After 15 minutes read samples at 543 μ in 1 cm or 10 cm cells. The colour is stable for at least two hours.

Standards

Primary Dissolve 0.2528 g of Potassium Nitrate (KNO_3) in 500 ml of distilled water. This solution contains 5 μgA/ml and is stable indefinitely.

Secondary Dilute 10 ml of primary to 100 ml D.W. (0.5 μgA/ml). Mke fresh every 3 - 4 weeks.

Tertiary (Make fresh daily.)

2 ml	of secondary std. (0.5 μgA/ml)	in 500 ml	= 2.0 μgA/l.	
4 ml	"	in 500 ml	= 4.0	(Concn. used daily for standard.)
6 ml	"	in 500 ml	= 6.0	
8 ml	"	in 500 ml	= 8.0	
10 ml	"	in 500 ml	= 10.0	
20 ml	"	in 500 ml	= 20.0	

etc.

The tertiary standards should be made with sea water as there is a slight salt effect in this method. The concentration - extinction relationship

is strictly linear and the factor need be obtained at only one level of nitrate concentration. As a safeguard against column deactivation a standard should be put through each column at the commencement of each day's work. There should be no significant difference between the factors obtained for each column. Should there be differences, the mean may be used, or the columns may be suspect of deterioration. The factors obtained should be between 21 and 25 when determined from the expression:

$$F = \frac{\mu gA\ N - NO_3/l}{O.D. - B}$$ (where B is sea water blank)

Initially the determination of factors should be made in triplicate for each column but a single determination daily is sufficient.

Concentration of samples may be determined from the expression:

$$\mu gA\ N - NO_3/litre = \text{corrected extinction} \times F$$

$$(O.D.\ sample - b)$$ where b is distilled water blank.

This may be corrected for nitrite, if desired, by making a separate determination of nitrite and subtracting this amount multiplied by 0.95 from the initial concentration which includes N in both nitrate and nitrite forms.

Distilled water blanks may give trouble, yielding a high extinction. The blank extinction corrected by a cell-to-cell blank should not exceed about 0.1 using a 10 cm cell. You may need to redistill the D.W. from a little alkaline permanganate, rejecting the first few millilitres of distillate. This may be necessary when determining small amounts of nitrate.

Notes:

Columns should be rinsed with a reservoir full of the NH_4 final II solution at the beginning and the end of a day's work, and when columns are not in use for a period of 1 hour or longer. At the end of the day a further rinsing and storage using the NH_4Cl final I is recommended. Idle columns should be stored with NH_4Cl final I solution.

INORGANIC PHOSPHORUS DETERMINATION

Ref: J. Murphy and J. P. Riley (Anal. Chim. Acta 27: 31, 1962.)

Reagents

1) 5N Sulphuric Acid

140 ml conc. H_2SO_4.

Dilute to 1000 ml with distilled H_2O.

2) 4% Ammonium Molybdate

40 g Ammonium Molybdate in 1000 ml distilled H_2O.

Store in pyrex or plax bottle out of direct sunlight.
Discard if white precipitate forms.
Stable about one month.

3) 0.1 m Ascorbic Acid

Ascorbic acid	1.32 g	1.98 g	2.64 g
Distilled H_2O	75 ml	112 ml	150 ml

Prepare immediately before use.

4) 0.2743% Potassium Antimonyl Tartrate (or: Antimony Potassium Tartrate)

1.3715 g in 500 ml distilled H_2O.

Store in glass or plastic.
Stable indefinitely.

5) Mixed Reagent

Do not store more than 6 hours.

5N H_2SO_4	125 ml	187.5 ml	250 ml
Ammonium Molybdate	37.5 ml	56.25 ml	75 ml
Ascorbic Acid	75 ml	112.5 ml	150 ml
Antimony Potassium Tartrate	12.5 ml	18.75 ml	25 ml
	250 ml	375 ml	500 ml

Standard

Primary Standard = 10 µgA PO_4-P/ml

a) 1.3609 g Potassium Dihydrogen Phosphate (KH_2PO_4)
1000 ml distilled water
Add 3 drops chloroform as a preservative.
Store in a dark glass bottle in refrigerator.
Stable many months.

b) Secondary Standard = 10 µgA PO_4-P/l

Dilute Primary Standard 1 in 1000 ml distilled H_2O
Store in dark glass bottle
Stable for several ~~XXXXXX~~ weeks but for surety should be made fresh every 10 days.

Method

1. Allow all samples to come to room temperature. (Use a water bath if samples frozen.)

2. Pipette using an automatic pipette hooked up to a source of vacuum.
Grease stopcock with silicone grease.
Rinse pipette 4 - 5 times with distilled water after using.
Pipette blanks, then standards, then sample.
Keep pipette filled with distilled water when not in use.

3. Add 10 ml mixed reagent to each sample using a Tipet. Mix well.

4. Leave standing at room temperature for at least 10 minutes. Colour developed is stable for many hours. For very precise measurements read within 2 - 3 hours.

5. Read optical density using 10 cm cells at 882 µ. Record.

Reagent Blank

Determine the reagent blank using at least three 50 ml samples of distilled water. Treat exactly as above.

Standardization

Make the following dilutions of the Secondary Solution in aged seawater:

2nd standard	Total volume	µgA PO_4-P/l
200 ml	1000 ml	2.0 µgA
150 ml	100 ml	1.5 µgA
20 ml	200 ml	1.0 µgA
~~XX~~ 10 ml	200 ml	0.5 µgA
4 ml	200 ml	0.2 µgA
1 ml	200 ml	0.05 µgA

Transfer x4 50-ml of each of the above to an emulsion tube.

For Standardization blanks use:

x3 50-ml distilled water
x3 50-ml aged sea water.

Treat as previously described.

CALCULATION

Standardization

$$F = \frac{\mu gA\ PO_4\text{-}P/l}{O.B.(Std)-B}$$

where B is the optical density of the sea water blank.

F should be between 5.0 and 5.5.

Test

$$\mu gA\ PO_4\text{-}P/l \quad (O.D.(test) - b) \times F$$

where b is the optical density of the distilled water blank.

Notes

Salt error: negligible less than 1%.

Beers' Law: obeyed over range 1 - 10 µg

Colour stability: more than 24 hours.

Interference: negative with Cu, Fe, Si, As.

REACTIVE SILICATE DETERMINATION

Ref: Mullin and Riley (Anal. Chim. Acta 12: 162, 1955.)

REAGENTS

1. **Ammonium Molybdate** - Keep in stock.

   10 g Ammonium Molybdate

   470 ml distilled water.

   When dissolved add
   30 ml conc. Hydrochloric acid.

   Store in plax.

   Stable if kept out of direct sunlight.

2. **Oxalic Acid 10%** - Keep in stock.

   in distilled water.

   Store in plax.

3. **Sulphuric Acid 25% v:v** - Keep in stock.

   in distilled water.

   Store in plax.

4. **Metol-Sulphite Solution** - Make up before use. Important to dissolve the sulphite before adding the metol.

   2.4 g Sodium Sulphite (Na_2SO_3)

   200 ml distilled water.

   Dissolve; add

   4 g Metol.

   Dissolve and filter.

/.....

5. Mixed Reagent - Prepare within one hour of use.

Sulphuric Acid 200 ml

Oxalic Acid 100 ml

Metol-Sulphite Solution 167 ml

Dilute to 500 ml with distilled water.

6. Standards

a) Primary standard: 20 µgA SiO_3-Si/ml. - Keep in stock.

0.5685 g Sodium Meta-Silicate ($Na_2SiO_3.9H_2O$)

100 ml distilled water.

Store in plax.

Stable.

b) Secondary standard: - Dilute to (b) before use.

Dilute primary standard

1 in 100 with distilled water.

SAMPLING Collect water from reversing bottle into twice rinsed plax sample bottle.

METHOD

1. Allow samples to come to room temperature.

2. All chemistry is carried out in 125 ml plax bottles.

3. Pipette, using an automatic pipette (N.B. no silicone grease on stopper), 15 ml of sample and 5 ml distilled water, into a plax bottle.

When concentrations over 70 µgA/l are encountered,

pipette

5 ml of sample and 15 ml distilled water.

/.....

4. Add 3 ml Ammonium Molybdate.

   Mix. Leave 10 minutes. - but not more than 20 minutes.

5. Add 15 ml mixed reagent, using Tipet-mix.

6. Stand at room temperature for at least 2½ hours.

7. Read O.D. using large 5 cm cell at 812 µ.

   Use 1 cm cell for concentrations above 12 µgA/l.

   Record.

Reagent Blank — Determine blanks on 3 20-ml samples of distilled water.

Treat as previously described.

STANDARDIZATION

Make the following dilutions of Secondary Standard in distilled water:

Secondary standard	Total Volume (D.W.)	µgA SiO_3-Si/l	
1 ml	100 ml	2.0 µgA	- use for
5 ml	250 ml	4.0 µgA	low
3 ml	100 ml	6.0 µgA	values
10 ml	250 ml	8.0 µgA	of SiO.

Take x3 15-ml of each of the above.

Add 5 ml distilled water and proceed as previously described.

To standardiae for high concentrations of silicate when using 5 ml sample and 15 ml distilled water, make the following dilutions of secondary standard:

Secondary standard	Total volume (D.W.)	µgA SiO_3-Si/l
1.0 ml	5.0 ml	40 µgA
2.0 ml	5.0 ml	80 µgA
3.0 ml	5.0 ml	120 µgA
4.0 ml	5.0 ml	160 µgA

Take x3 5-ml of each of the above.

Add 15 ml distilled water and proceed as previously described.

For standardization blanks use x3 20-ml distilled water; treat as previously described.

N.B. When perfomming test on low values of silicate, estimations must be made

/.....

on: x3 4.0 ugA SiO_3-Si/l standard

and when performing test on high values of silicate, estimations must be made on: x3 the value of the standard expected to be nearest the value of the test.

CALCULATION

1. Standardization

$$f = \frac{\text{ugA } SiO_3\text{-Si/l (standard)}}{\text{O.D. standard - B}}$$

where B is distilled water blank.

F should lie between 20 and 22.

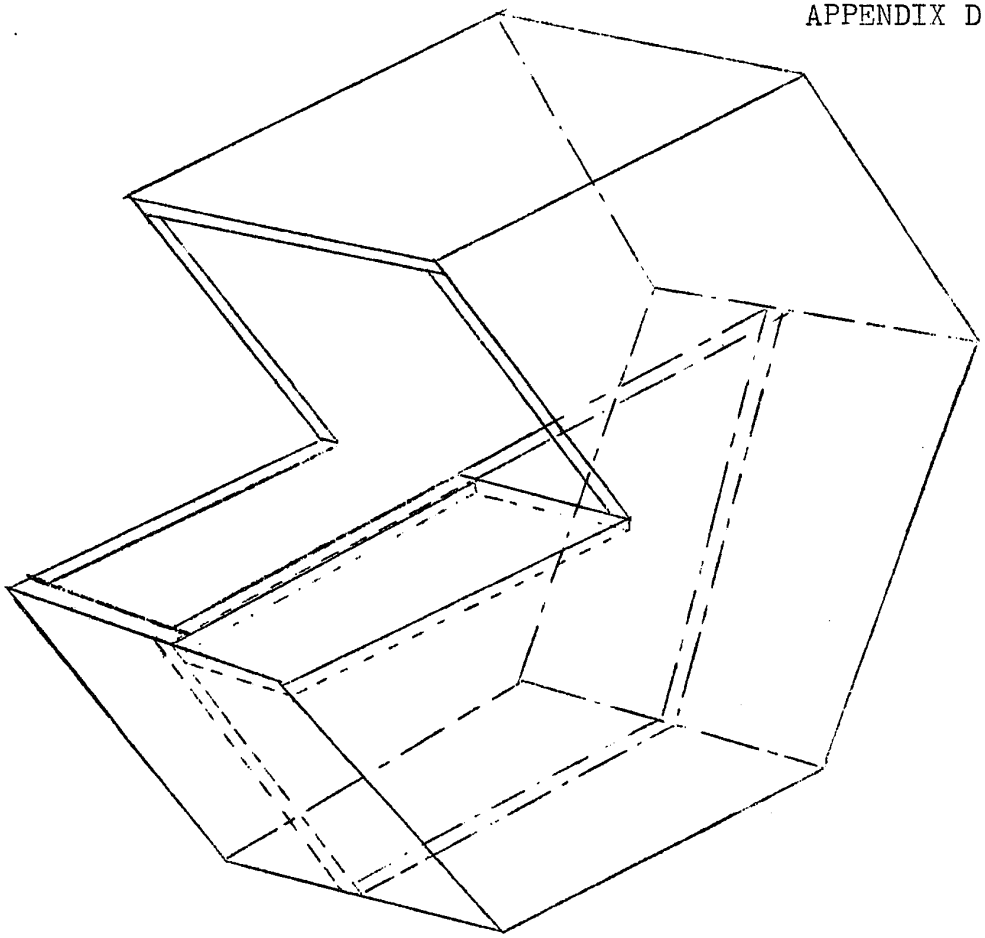
Test

ugA SiO_3-Si/l = O.D. (test) - B x f

where B is distilled water blank.

Do not use soap in washing plax bottles.

Rinse well under tap water, then three times in distilled water.



Plankton Splitter

The zooplankton sample is collected and preserved with 5% formalin in a 500 cc (approx. 1 lb) screw cap jar. The sample may be divided into aliquots by means of the plankton splitter, using the method described:

i) Place the splitter on a flat, level surface and pour the plankton and preservative (about 300 cc) into the undivided section.

ii) Stir or otherwise agitate the sample to ensure even distribution within the section.

iii) When settled, rotate the splitter about its central axis until the section is subdivided by the central divide, maintaining contact with the table or level surface at all times.

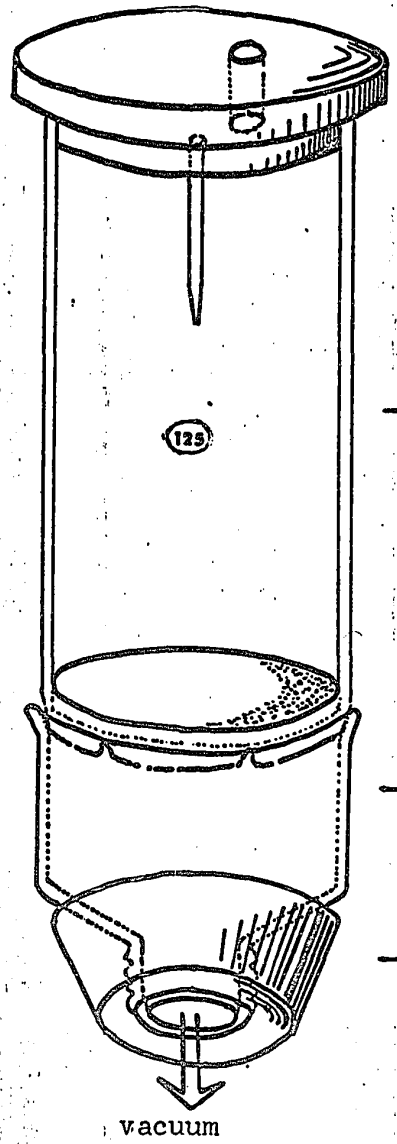
iv) Pour out the open section into a container for wet volume determination by Yentsch method and for drying.

v) Reverse the splitter, and pour out the other side into a vial or jar for storage and later identification. (Note: Always use the fractions from the same sides for the same purposes each time, to minimize errors introduced by inaccuracies in the splitter's construction.)

vi) Further splitting may be done to either aliquot by a repeat of this procedure.

APPENDIX E

Modified Yentsch Apparatus for Wet Volume Determination of Plankton



TOP brass
position of opening for buret, and indicator reversed for greater accuracy than original design.

THIMBLE glass
with coarse sintered glass sieve plate.

ADAPTOR plastic
made from 125ml bottle

BUNG rubber
to fit vacuum flask

APPENDIX F

STATION DATA

OFFSHORE

STATIONS EII & EIV

DATA

Chronological Data Appendix F

OFFSHORE P.E.I. EII & EIV 1969-70

Stn. # & infor.	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P_3 mgA/m^3	NO_3-N_3 mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} $mg/m^3/hr$
EII-69-01	14/05	0	6.4	30.432	.337	.066	.578	.174	.061
		5	6.25	30.444	.288	.088	.347	.492	.122
		10	5.9	30.559	.442	.134	.231	1.045	2.58
		15	--	-----	----	----	-----	---	---
		20	3.5	30.533	.480	.023	.393	1.963	1.22
		25	--	-----	----	----	-----	---	---
		Σ_{0-10}			3.438	.940	3.700	5.508	7.21
		Σ_{0-20}			8.048	1.725	6.820	15.040	26.21
	extrapolated	Σ_{0-25}			10.353	2.118	8.380	20.548	33.8
		$\bar{x}_{25}$	6.18	30.478	.414	.085	.335	.822	1.31
EII-60-02	20/05	0	6.6	29.784	.324	.091	1.536	.426	.28
		5	---	29.811	.319	.155	1.739	.266	.03
		10	---	29.819	.307	.022	1.017	.320	.05
		15	---	------	----	----	-----	----	---
		20	---	30.295	.393	.090	1.468	.209	.04
		25	---	------	----	----	-----	----	---
		Σ_{0-10}			3.173	1.058	15.078	2.945	.97
		Σ_{0-20}			6.673	1.618	27.503	5.840	1.01
	extrapolated	Σ_{0-25}			8.423	1.898	33.716	6.800	1.27
		$\bar{x}_{25}$		29.805	.3369	.076	1.349	.292	.051
EII-69-03	28/05	0	7.7	29.449	.239	1.143	1.536	.211	.378
		5	6.95	29.458	.330	.086	1.220	.245	3.40
		10	6.7	29.453	.296	.088	1.604	.697	1.67
		15	6.8	29.522	.216	.132	1.559	.666	.084
		25	4.9	29.701	.324	.227	1.875	.636	.072
		Σ_{0-10}			2.988	3.508	13.950	3.495	22.12
		Σ_{0-25}			6.968	5.353	39.028	13.413	27.29
		$\bar{x}_{25}$	7.12	29.453	.279	.214	1.561	.537	1.092

Stn.#& infor.	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C ^{14} mg/m^3/hr
EII-69-04	04/06	0	8.65	29.174	.284	.341	1.263	.283	.02
		5	8.5	29.257	.228	.088	1.263	.299	.24
		10	7.8	29.793	.250	.270	1.895	.272	.21
		15	6.2		.178	.131	.457	.415	--
		25	4.0	30.014	.462	.180	2.461	.951	.07
		Σ_{0-10}			2.475	1.968	14.210	2.883	1.77
		Σ_{0-25}			9.945	4.525	34.680	11.430	3.49
		$\bar{x}_{25}$	8.32	29.408	.398	.181	1.387	.457	.146
EII-69-05	11/06	0	11.8	28.835	.165	.090	0.589	.365	0
		5	11.1	28.824	.159	.129	0.587	.351	0
		10	10.3	28.888	.239	.132	0.452	.607	.06
		15	8.7	29.143	.410	.153	0.745	.422	.04
		25	3.3	30.076	.239	.113	0.452	.252	0
		Σ_{0-10}			1.805	1.200	5.533	4.185	
		Σ_{0-25}			6.673	3.243	14.570	10.130	
		$\bar{x}_{25}$	11.07	28.849	.267	.130	.583	.405	
EII-69-06	17/06	0	14.2	27.592	.091	.133	.203	.72	.04
		5	13.0	27.935	.097	.045	.384	.88	.29
		10	12.7	27.936	.125	.110	.384	.93	.95
		15	8.6	28.246	.159	.023	.180	.49	.97
		25	4.6	29.814	.387	.287	2.06	.26	.07
		Σ_{0-10}			1.025	.833	3.388	8.5	3.93
		Σ_{0-25}			4.465	2.715	15.998	15.80	13.9
		$\bar{x}_{25}$	13.30	27.821	.179	.109	.640	.63	.56
EII-69-07	24/06	0	14.4	27.825	.077	.047	.231	.252	.20
		5	14.3	28.045	.121	.091	.670	.540	.59
		10	10.7	28.291	.132	.088	.508	.606	.27
		15	6.8	28.791	.215	.331	.578	.608	.59
		25	3.8	28.795	.337	.381	1.571	.224	.07
		Σ_{0-10}			1.128	.793	5.198	4.845	4.14
		Σ_{0-25}			4.755	5.400	18.658	12.040	9.58
		$\bar{x}_{25}$	13.13	28.054	.190	.216	.746	.482	.38

Stn. # & inform.	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} mg/m^3/hr
EII-69-08	03/07	0	15.6	27.522	.204	.117	.832	.311	0
		5	15.0	27.526	.155	.091	.439	.775	1.08
		10	14.8	27.531	.199	.022	.277	.800	.25
		15	12.3	27.785	.149	.088	1.432	.824	---
		25	4.7	29.615	.602	.445	1.478	.335	.031
		Σ_{0-10}			1.783	.803	4.968	6.653	6.04
		Σ_{0-25}			6.408	3.758	23.746	16.508	8.17
		$\bar{x}_{25}$	15.13	27.526	.256	.150	.950	.660	.327
EII-69-09	09/07	0	13.25	27.344	.114	.500	.549	.778	.08
		5	13.4	27.336	.141	.384	.549	.783	1.26
		10	13.4	27.362	.082	.067	.422	.840	1.00
		15	13.3	27.381	.076	.065	.718	.848	.37
		25	6.7	28.592	.282	.399	1.141	.626	1.01
		Σ_{0-10}			1.195	3.338	5.173	7.960	8.99
		Σ_{0-25}			3.380	5.988	17.318	19.550	19.32
		$\bar{x}_{25}$	13.35	27.347	.135	.240	.693	.782	.773
EII-69-10	16/07	0	14.75	27.511	.076	.273	.465	.633	0
		5	14.5	27.508	.071	.171	.444	.714	.13
		10	14.0	27.513	.092	.044	.317	1.022	1.48
		15	13.0	27.546	.228	.411	.253	1.100	.38
		25	4.5	29.789	.630	.488	1.288	.311	.02
		Σ_{0-10}			.775	1.648	4.175	7.710	8.68
		Σ_{0-25}			5.865	7.280	13.305	20.070	11.67
		$\bar{x}_{25}$	14.42	27.511	.235	.291	.532	.802	.47
EII-69-11	22/07	0	15.9	27.754	.103	.205	.676	.412	.01
		5	15.8	27.753	.087	.469	.634	.481	.85
		10	15.0	27.667	.103	.377	.697	.829	1.38
		15	13.0	27.799	.114	.087	.422	.743	.29
		25	4.6	27.606	.467	.532	1.690	.392	---
		Σ_{0-10}			.950	3.800	6.603	5.588	7.72
		Σ_{0-25}			4.398	8.055	19.96	14.506	20.25
		$\bar{x}_{25}$	15.57	27.725	.176	.322	.798	.580	.79

Stn.# & infor.	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} mg/m^3/hr
EIV-69-12	01/08	0	18.4	27.592	.092	.159	.486	.522	.10
		5	18.0	27.692	.098	.064	.760	.745	.14
		10	16.5	27.802	.082	.355	.549	.912	.33
		15	6.8	28.722	.368	.260	1.056	1.008	---
		25	--	29.805	.516	1.152	3.105	(.365)	.03
		Σ_{0-10}			.925	1.605	6.387	7.310	1.69
		Σ_{0-25}			6.470	10.203	31.205	18.975	4.41
		$\bar{x}_{25}$	17.63	27.695	.259	.408	1.248	.759	.18
EIV-69-13	07/08	0	19.0	27.541	.076	.250	.676	.439	---
		5	16.5	27.520	.071	.683	.718	1.013	.32
		10	16.0	27.882	.092	.155	.908	1.324	.63
		15	11	28.604	.228	.151	1.119	1.167	---
		25	---	29.844	.630	1.396	3.168	.304	.100
		Σ_{0-10}			.775	4.428	7.550	9.473	3.50
		Σ_{0-25}			5.865	12.928	34.053	23.055	8.97
		$\bar{x}_{25}$	17.17	27.648	.235	.517	1.362	.922	.36
EIV-69-14	13/08	0	19.4	27.773	.086	.112	1.121	.454	.18
		5	19.0	27.826	.103	.108	1.275	.429	.50
		10	18.4	27.872	.103	.153	1.275	.769	.69
		15	11.0	28.530	.235	.153	1.780	1.162	---
		25	5.8	29.723	.721	.612	2.682	.412	.23
		Σ_{0-10}			.988	1.203	12.365	4.827	3.80
		Σ_{0-25}			6.613	5.793	42.313	17.900	10.65
		$\bar{x}_{25}$	18.93	27.824	.265	.232	1.693	.716	.43
EIV-69-15	21/08	0	18.2	27.686	.143	.269	1.319	.984	1.12
		5	18.1	27.673	.103	.151	1.055	1.112	2.70
		10	18.1		.200	.197	1.457	.747	6.11
		15	18.0	27.628	.223	.132	.572	.681	--
		25	11.1	27.703	.212	.091	1.561	1.397	.42
		Σ_{0-10}			1.373	1.920	12.200	9.888	31.58
		Σ_{0-25}			4.605	3.858	27.923	23.848	80.52
		$\bar{x}_{25}$	18.13	27.670	.184	.154	1.117	.954	3.22

Stn.# & infor.	Date da.mo	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} mg/m^3/hr
EIV-69-15	21/08	0	18.2	27.686	.143	.269	1.319	.984	1.12
		5	18.1	27.673	.103	.151	1.055	1.112	2.70
		10	18.1		.200	.197	1.457	.747	6.11
		15	18.0	27.628	.223	.132	.572	.681	---
		25	11.1	27.703	.212	.091	1.561	1.397	.42
		Σ_{0-10}			1.373	1.920	12.200	9.888	31.58
		Σ_{0-25}			4.605	3.858	27.923	23.848	80.52
		$\bar{x}_{25}$	18.13	27.670	.184	.154	1.117	.954	3.22
EIV-69-16	29/08	0	17.8	27.777	.195	.318	2.242	.945	.69
		5	17.6	27.794	.097	.154	.484	1.039	4.72
		10	17.75	27.770	.063	.067	.615	1.286	2.59
		15	17.7	27.791	.097	.153	.725	.716	
		25	6.4	29.776	.767	1.169	6.836	.307	.16
		Σ_{0-10}			1.130	1.733	9.563	10.773	31.81
		Σ_{0-25}			5.850	8.893	50.718	20.893	52.45
		$\bar{x}_{25}$	17.72	27.780	.234	.356	2.03	.836	2.10
EIV-69-17	04/09	0	18.2	27.759	.172	.364	.615	1.064	.14
		5	18.1	27.745	.097	.132	.286	1.164	.38
		10	18.0	27.803	.080	.112	.154	1.053	3.64
		15	16.8	27.848	.103	.044	.088	1.214	
		25	6.7	29.384	.904	1.641	7.275	.485	.35
		Σ_{0-10}			1.115	1.850	3.353	11.113	11.36
		Σ_{0-25}			6.608	10.665	40.773	25.275	41.30
		$\bar{x}_{25}$	18.1	27.769	.264	.427	1.631	1.011	1.65
EIV-69-18	12/09	0	14.7		.161	.114	.370	1.727	3.69
		5	14.7		.217	.132	.327	1.874	.74
		10	13.9	28.531	.328	.562	1.350	2.964	2.70
		15	10.5	28.893	.584	.940	2.439	1.421	
		25	5.2	31.108	.973	2.810	6.469	.501	.19
					2.308	2.350	5.935	21.098	20.27
					12.373	24.855	59.948	14.670	41.92
		$\bar{x}_{25}$	14.43	18.531	.495	.994	2.398	1.667	1.68

Stn. # & infor.	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	No_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C ^{14} mg/m^3/hr
EIV-69-19	08/10	0	12.7		.706	.341	1.917	.957	
		5	12.7	28.613	.856	.309	2.439	.732	.81
		10	12.7	28.651	1.023	.292	2.309	.862	.42
		15	12.7	28.597	.462	.219	1.481	.988	.72
		25	10.5	28.737	.467	.157	1.525	.588	.20
		Σ_{0-10}			8.602	3.128	22.760	8.208	10.15
		Σ_{0-25}			17.960	6.285	47.265	20.713	17.15
		$\bar{x}_{25}$	12.7	28.626	.718	.251	1.891	.829	.702
EIV-69-20	06/11	0	8.6	28.897	.767	.750	2.156	.835	---
		5	8.5	28.907	.517	.838	2.548	1.065	---
		10	8.45	28.905	.523	.809	2.505	.847	---
		15	8.35	29.053	.339	.896	2.766	.525	---
		25	8.0	29.482	.573	1.191	2.984	.286	---
		Σ_{0-10}			5.810	8.008	24.393	9.530	0
		Σ_{0-25}			12.525	22.700	66.320	17.015	---
		$\bar{x}_{25}$	8.52	28.903	.501	.908	2.651	.681	---
EII-70-21	23/04	0	2.75	30.053	.281	.084	.217	.36	.205
		5	2.5	30.006	.271	.151	.260	---	.578
		10	1.6	30.229	.319	.043	.152	.58	.214
		15	1.45	30.323	.238	.043	.217	.87	.159
		25	1.4	30.265	.384	.043	.174	2.76	.324
		Σ_{0-10}			2.86	1.07	2.22	4.7	---
		Σ_{0-25}			7.358	1.718	5.100	26.48	7.28
		$\bar{x}_{25}$		30.191	.294	.069	.204	1.059	.29
EII-70-22	06/05	0	5.3	30.094	.461	.108	.253	.29	.20
		5	4.7	30.102	.456	.044	.295	.22	.24
		10	3.7	30.134	.450	.221	.253	.12	.10
		15	2.5	30.194	.423	.087	.232	.15	---
		25	0.9	30.365	.500	.110	.527	.40	---
		Σ_{0-10}			4.56	1.04	2.74	2.125	
		Σ_{0-25}			11.355	2.800	6.535	5.550	2.32
		$\bar{x}_{25}$		30.165	.454	.112	.261	.222	.09

Stn.# & INFOR.	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} mg/m^3/hr
EII-70-23	12/05	0	6.1	29.587	.357	.066	1.308	.75	---
		5	6.0	29.621	.467	.196	.485	.56	---
		10	4.5	29.755	.220	.088	.464	.13	---
		15	3.1	30.084	.395	.065	.464	.13	---
		25	2.8	30.149	.357	.087	1.181	.48	---
		Σ_{0-10}			3.78	1.37	6.86	5.000	----
		Σ_{0-25}			9.075	2.508	17.400	8.70	---
		$\bar{x}_{25}$		29.832	.363	.100	.696	.348	---
EII-70-24	16/05	0	7.2	29.288	.412	.177	..506	.13	.31
		5	6.6	29.339	.675	.065	.358	.04	.09
		10	5.6	29.500	.653	.088	.527	.05	---
		15	4.9	29.699	.434	.065	.316	.08	.02
		25	4.1	29.977	.532	.109	.928	.14	.11
		Σ_{0-10}			6.04	.99	4.37	.650	---
		Σ_{0-25}			13.585	2.240	12.70	2.725	2.20
		$\bar{x}_{25}$		29.543	.543	.090	.508	.109	.08
EII-70-25	06/06	0	9.5	28.811	.307	.279	1.280	.60	---
		5	9.1	28.944	.252	.197	1.324	.53	---
		10	8.7	29.1352	.257	.217	1.172	.48	---
		15	3.8	29.570	.235	.138	.477	.52	---
		25	2.4	30.329	.609	.743	4.253	.33	---
		Σ_{0-10}			2.67	2.23	12.75	5.35	---
		Σ_{0-25}			8.12	7.518	40.523	12.10	----
		$\bar{x}_{25}$		29.305	.325	.301	1.621	.484	---
EII-70-26	14/06	0	14.0	28.443	.093	.199	.866	.474	---
		5	11.6	28.907	.181	.000	.542	.242	---
		10	10.7	29.219	.154	.043	.585	.258	---
		15	7.0	29.290	.192	.022	.715	.385	---
		25	5.0	30.160	.434	.530	2.058	.249	---
		Σ_{0-10}			1.52	.61	6.34	3.04	---
		Σ_{0-25}			5.518	3.528	19.878	7.818	---
		$\bar{x}_{25}$		29.179	.221	.141	.795	.3127	---

Stn. # & infor.	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} mg/m^3/hr
EII-70-27	22/06	0	---	27.851	.252	.110	1.194	.292	---
		5	---	27.832	.168	.043	.608	.462	---
		10	---	28.563	.145	.043	.868	.569	---
		15	---	29.373	.156	.243	.629	.540	---
		25	---	29.534	.302	.309	1.541	.272	---
		Σ_{0-10}			1.83	1.10	8.20	4.463	---
		Σ_{0-25}			4.873	4.073	22.788	11.296	---
		$\bar{x}_{25}$	---	28.615	.195	.163	.912	.452	---
EII-70-28	03/07	0	13.9	28.181	.140	.086	.911	.620	.19
		5	13.9	28.182	.123	.043	.890	.643	.63
		10	13.8	28.191	.134	.000	.608	.596	.81
		15	10.8	28.335	.229	.044	.629	.788	1.15
		25	6.2	29.452	.475	.753	2.387	.390	.23
		Σ_{0-10}			1.30	.43	8.25	.620	---
		Σ_{0-25}			5.725	5.322	32.605	15.55	17.45
		$\bar{x}_{25}$	---	28.381	.229	.213	1.304	.622	.70
EII-70-29	11/07	0	15.9	27.954	.151	.025	1.823	.561	---
		5	15.2	27.975	.106	.024	.955	.593	---
		10	14.3	28.074	.089	.023	.825	1.240	---
		15	12.1	28.242	.235	.162	1.541	1.072	---
		25	8.6	28.849	.246	.295	1.234	.588	---
		Σ_{0-10}			1.113	.24	11.40	7.468	---
		Σ_{0-25}			4.345	2.988	31.185	21.548	---
	–	$\bar{x}_{25}$	---	28.173	.174	.120	1.247	.862	---
EII-70-30	18/07	0	16.0	26.963	.078	.169	1.215	.745	.96
		5	16.0	26.951	.084	.046	.868	.878	4.59
		10	15.2	27.333	.084	.023	1.410	.929	4.25
		15	8.1	28.788	.246	.295	.564	.917	---
		25	7.7	29.685	.581	1.280	3.993	.446	.36
		Σ_{0-10}			.83	.71	10.90	8.575	---
		Σ_{0-25}			5.785	9.380	38.622	20.005	70.55
		$\bar{x}_{25}$	---	27.849	.231	.375	1.545	.800	2.82

Stn. # & inform.	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} mg/m^3/hr
EII-70-31	27/07	0	18.9	27.164	.151	.260	1.541	.758	1.18
		5	18.9	------	----	----	-----	----	----
		10	17.2	------	----	----	-----	----	----
		15	9.1	------	----	----	-----	----	----
		25	7.5	------	----	----	-----	----	----
							1.7	21.224	.70
		$\bar{x}$	---	27.164	----	-----	-----	.758	2.8
EII-70-32	03/08	0	20.4	26.936	.111	.046	3.027	1.169	4.14
		5	20.1	26.949	.117	.000	2.810	1.645	7.29
		10	15.0	27.443	.262	.000	3.071	1.380	4.20
		15	9.2	28.692	.546	.531	4.204	.877	----
		25	4.7	29.909	.624	2.586	3.027	.456	.04
		Σ_{0-10}			1.52	.12	29.30	14.598	----
		Σ_{0-25}			9.388	17.373	83.638	26.905	89.10
		$\bar{x}_{25}$	----	27.876	.376	.695	3.346	1.076	3.56
EII-70-33	10/08	0	21.3	27.140	.050	.142	1.220	.367	2.08
		5	21.0	27.142	.067	.096	2.026	.635	2.25
		10	17.0	27.128	.067	.136	1.176	1.736	5.28
		15	10.0	28.188	.368	.166	3.027	1.608	.99
		25	3.4	30.205	.824	1.278	7.427	.475	----
		Σ_{0-10}			.63	1.18	16.12	8.433	----
		Σ_{0-25}			7.675	9.150	99.913	19.168	45.32
		$\bar{x}_{25}$	----	27.783	.307	.366	3.997	.767	1.81
EII-70-34	21/08	0	18.9	27.615	.111	.359	2.178	1.072	----
		5	18.7	27.613	.139	.182	1.067	1.194	----
		10	18.6	27.621	.111	.118	.915	1.003	----
		15	14.0	29.246	.501	1.799	2.156	.673	----
		25	7.6	28.960	.507	.766	4.160	.763	----
		Σ_{0-10}			1.25	2.10	13.07	11.158	----
		Σ_{0-25}			7.820	19.720	52.325	22.528	----
		$\bar{x}_{25}$	----	28.192	.313	.789	2.093	.901	----

Stn. # & infor.	Date da.mo	Dep m	Temp C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} mg/m^3/hr
EII-70-35	04/09	0	13.6	28.310	.333	.415	3.028	1.994	----
		5	13.5	28.314	.199	.391	2.373	1.161	----
		10	12.6	28.482	.251	.630	3.096	1.463	----
		15	12.5	28.524	.167	.311	1.612	1.354	----
		25	12.0	28.647	.217	.705	1.873	.913	----
		Σ_{0-10}			2.46	4.57	27.18	14.448	----
		$\Sigma_{0-\underline{25}}$			5.420	12.00	56.41	32.825	----
		$\bar{x}_{25}$	----	28.450	.217	.480	2.256	1.313	----
EII-70-36	09/09	0	13.2	28.243	.267	.639	2.047	2.068	----
		5	13.1	28.226	.390	.639	2.396	1.695	----
		10	12.9	28.298	.473	1.054	3.550	.942	----
		15	12.8	28.422	.401	.796	3.114	.707	----
		25	5.6	29.689	.975	3.314	8.712	1.072	----
		Σ_{0-10}			1.18	7.43	25.97	16.00	----
		$\Sigma_{0-\underline{25}}$			10.248	25.918	135.083	29.018	----
		$\bar{x}_{25}$	----	28.479	.410	1.037	5.403	1.161	----
EII-70-37	12/09	0	13.7	28.295	.194	1.349	1.268	1.289	5.70
		5	13.7	28.290	.372	1.557	2.864	1.255	8.40
		10	13.5	28.345	.194	1.932	1.618	1.568	----
		15	13.0	28.564	.283	.781	1.640	.840	1.20
		25	5.7	29.926	1.110	4.071	8.941	.481	1.17
		Σ_{0-10}			2.83	15.99	21.54	13.418	----
		$\Sigma_{0-\underline{25}}$			10.988	47.030	87.023	26.043	95.00
		$\bar{x}_{25}$	----	28.577	.440	1.881	3.481	1.042	3.80
EII-70-38	19/09	0	13.0	28.547	.150	.790	.656	1.209	2.65
		5	13.0	28.546	.233	.227	1.574	1.298	2.68
		10	13.0	28.546	.222	.852	.896	1.342	2.40
		15	13.0	28.689	.194	1.041	1.574	1.399	3.00
		25	10.4	28.543	.422	1.581	2.186	.665	0.21
		Σ_{0-10}			2.10	5.24	11.75	12.868	----
		Σ_{0-25}			6.215	23.003	36.725	26.543	55.57
		$\bar{x}_{25}$	----	28.582	.249	.923	1.469	1.062	2.22

Stn. # & infor.	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} mg/m^3/hr
EIV-70-39	23/09	0	13.1	28.515	.067	.068	.262	2.288	-----
		5	13.0	28.514	.067	.047	.066	2.393	-----
		10	12.9	28.598	.189	.024	.044	2.167	-----
		15	12.7	28.615	.150	.024	.153	1.689	-----
		25	10.5	28.604	.111	.000	.131	2.156	-----
		Σ_{0-10}			.98	.47	1.10	23.103	-----
		Σ_{0-25}			3.128	.705	3.008	51.968	-----
		$\bar{x}_{25}$	-----	28.572	.125	.028	.120	2.079	-----
EIV-70-40	08/10	0	12.8	28.572	.200	.071	.415	.685	.51
		5	12.8	28.573	.200	.095	.656	.613	1.90
		10	12.8	28.573	.166	.000	.525	.666	3.19
		15	12.5	28.575	.166	.045	.350	.567	1.08
		25	8.3	28.583	.194	.379	.525	.728	---
		Σ_{0-10}			1.92	.65	5.63	6.44	---
		Σ_{0-25}			4.545	2.885	12.192	16.00	21.45
		$\bar{x}_{25}$	---	28.575	.182	.115	.488	.640	.86
EIV-70-41	13/10	0	12.9	28.576	.272	.118	1.180	.735	1.00
		5	12.9	28.576	.139	.072	1.006	.807	2.32
		10	12.8	28.580	.222	.068	.940	.914	1.45
		15	11.9	28.827	.150	1.681	.874	.877	3.81
		25	8.9	29.709	.427	2.154	3.060	.391	.24
		Σ_{0-10}			1.93	.83	10.33	8.16	---
		Σ_{0-25}			5.745	24.373	34.535	27.930	53.62
		$\bar{x}_{25}$	---	28.781	.230	.975	1.381	1.117	2.14
EIV-70-42	06/11	0	9.4	29.074	.333	.814	3.760	1.185	---
		5	9.3	29.067	.366	1.046	3.192	1.229	---
		10	9.3	29.068	.350	.923	2.754	1.187	---
		15	9.3	29.072	.377	1.054	3.038	1.233	---
		25	9.2	29.082	.222	1.409	2.339	1.178	---
		Σ_{0-10}			2.50	9.57	32.25	12.08	---
		Σ_{0-25}			6.743	26.828	73.61	30.180	---
		$\bar{x}_{25}$	---	28.821	.270	1.073	2.944	1.207	---

M A L P E Q U E B A Y

E I

D A T A

Stn. # & infor.	Date da.mo	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} mg/m^3/hr
EI-69-01	09/05	0	6.5	27.829	.243	.114	.531	.450	0
		5	5.4	29.131	.342	.224	.647	.465	.603
		10	4.8	29.210	.337	.164	.347	1.527	---
		Σ_{0-10}			3.150	1.815	5.430	7.268	---
		$\bar{x}_{10}$	5.57	28.723	.315	.182	.543	.727	---
EI-69-02	22/05	0	10.4	28.654	.189	.137	.383	.581	0
		5	10.6	28.644	.194	.177	.270	.775	.130
		10	8.0	28.994	.311	.198	.473	.327	.798
		12	7.5						
		Σ_{0-10}			2.22	1.723	4.673	6.145	2.65
		$\bar{x}_{10}$	9.67	28.764	,222	.219	.467	.615	.265
EI-69-03	06/06	0	14.0	28.840	.094	.157	.289	.670	2.21
		5	12.1	29.111	.132	.140	.334	.885	1.32
		10	11.45	29.203	.198	.114	1.068	.809	1.04
		Σ_{0-10}			1.390	1.378	5.063	8.123	14.65
		$\bar{x}_{10}$	12.52	29.051	.139	.238	.506	.812	1.465
EI-69-04	23/06	0	17.75	28.402	.229	.561	1.746	1.099	.263
		5	17.4	28.431	.246	.374	1.724	1.322	8.95
		10	17.05	28.429	.229	.374	1.746	1.451	10.11
		14	16.45						
		Σ_{0-10}			2.375	4.208	17.350	12.985	70.68
		$\bar{x}_{10}$	17.16	28.421	.238	.339	1.735	1.299	7.07
EI-69-05	04/07	0	19.7	28.200	.159	.281	1.062	.885	.489
		5	18.3	28.099	.159	.091	.768	1.044	1.39
		10	17.75	28.039	.302	.243	1.943	1.627	1.23
		Σ_{0-10}			1.948	1.765	11.355	11.500	10.83
		$\bar{x}_{10}$	18.58	28.113	.195	.177	1.136	1.150	1.083
EI-69-06	10/07	0	18.0	------	.254	.043	1.917	.971	5.54
		5	17.35	28.275	.199	.179	1.053	1.496	13.80
		10	17.1	28.288	.216	.161	1.074	1.328	1.84
		Σ_{0-10}			2.17	1.405	12.743	13.228	81.76
		$\bar{x}_{10}$	17.48	28.282	.217	.141	1.274	1.323	8.176

Stn. # & infor	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} mg/m^3/hr
EI-69-07	18/07	0	19.0	27.953	.138	.110	2.907	.971	.275
		5	17.5	28.238	.155	.090	.548	1.496	1.42
		10	17.3	28.078	.277	.094	.906	1.328	1.39
		14	17.3						
		Σ_{0-10}			1.813	.960	12.273	12.735	57.91
		$\bar{x}_{10}$	17.93	28.089	.181	.960	1.227	1.274	5.79
EI-69-08	24/07	0	20.5	28.015	.199	.000	1.706	.916	2.91
		5	19.6	28.026	.171	.067	1.285	2.815	7.03
		10	19.3	28.048	.271	.224	2.022	3.074	2.82
		15	18.95						
		Σ_{0-10}			2.030	.895	15.745	24.050	45.84
		$\bar{x}_{10}$	19.80	28.030	.203	.085	1.575	2.405	4.58
EI-69-09	04/08	0	20.65	28.016	.166	.047	.448	1.407	.095
		5	20.55	27.984	.194	.332	.948	1.461	3.09
		10	20.51	27.971	.083	.088	.779	1.529	.863
		Σ_{0-10}			1.468	1.998	7.808	14.645	17.85
		$\bar{x}_{10}$	20.57	27.957	.147	.200	.781	1.465	1.79
EI-69-10	12/08	0	21.1	28.061	.265	.114	.969	1.441	.153
		5	20.5	28.069	.260	.133	1.622	2.253	3.51
		10	17.5	28.350	.182	.154	2.485	1.747	2.95
		12	17.25						
		Σ_{0-10}			2.418	1.335	16.745	19.235	25.31
		$\bar{x}_{10}$	19.70	28.16	.242	.134	1.675	1.924	2.53
EI-69-11	23/08	0	19.48	28.050	.243	.090	2.127	1.905	.783
		5	19.00	------	.243	.140	2.000	2.804	25.2
		10	18.95	28.035	.271	.114	2.569	2.306	4.35
		Σ_{0-10}			2.500	1.210	21.741	24.548	138.83
		$\bar{x}_{10}$	19.14	28.043	.250	.121	.217	.245	13.88
EI-69-12	28/08	0	19.90	28.164	.350	.221	1.618	1.994	5.30
		5	18.75	27.973	.266	.088	1.445	2.037	10.10
		10	18.6	27.957	.222	.045	.820	2.030	3.80
		Σ_{0-10}			2.76	1.1150	13.205	20.245	73.25
		$\bar{x}_{10}$	19.08	28.031	.276	.112	1.321	2.025	7.33

Stn. # &	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} mg/m^3/hr
EI-69-13	02/09	0	19.5	-----	.244	.094	2.157	2.297	8.05
		5	19.40	28.045	.377	.251	1.510	2.222	16.82
		10	19.3	28.088	.416	.000	2.502	2.433	4.53
		Σ_{0-10}			3.535	1.490	19.468	22.935	107.46
		$\bar{x}_{10}$	19.4	28.059	.354	.149	1.947	2.294	10.75
EI-69-14	11/09	0	16.75	-----	.427	.354	5.306	2.617	12.0
		5	16.7	27.968	.522	.264	3.796	3.869	9.62
		10	13.5	28.367	.633	.515	3.689	4.481	38.2
		Σ_{0-10}			5.260	3.493	41.468	39.590	161.05
		$\bar{x}_{10}$	15.65	28.101	.526	.349	4.147	3.959	16.11
EI-69-15	09/10	0	12.45	28.359	.394	.388	2.265	2.521	5.21
		5	12.4	28.405	.383	.155	0.777	2.720	7.94
		10	12.25	28.467	.366	.110	1.402	2.812	1.24
		Σ_{0-10}			3.815	2.021	13.053	26.933	55.83
		$\bar{x}_{10}$	12.37	28.410	.382	.202	1.305	2.693	5.58
EI-69-16	03/11	0	----	28.597	.216	.157	.388	0.884	2.81
		5	----	28.605	.455	.211	.431	0.781	1.33
		10	----	28.651	.433	.183	1.079	1.072	.859
		Σ_{0-10}			3.898	1.905	6.250	8.795	16.00
		$\bar{x}_{10}$	5.4	28.618	.390	.191	.625	.880	1.600
EI-70-17	09/04	0	0.4	28.493	.238	.640	.461	.655	----
		5	0.2	29.197	.221	.085	.272	.489	----
		10	0.1	29.431	.221	.086	.209	.867	----
		Σ_{0-10}			2.251	2.240	3.360	6.249	----
		$\bar{x}_{10}$	----	29.08	.2251	.224	.336	.625	----
EI-70-18	24/04	0	3.5	28.003	.135	.716	.152	.560	----
		5	3.25	28.115	.184	.086	.629	.530	----
		10	2.75	28.570	.233	.065	..239	.610	----
		Σ_{0-10}			1.84	2.383	4.123	5.550	----
		$\bar{x}_{10}$	----	28.201	.184	.238	.412	.555	----

Stn. #&	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C ^{14} mg/m^3/hr
EI-70-19	10/05	0	5.2	29.683	.285	.303	.548	.38	1.21
		5	5.1	29.778	.390	.153	.822	.37	.770
		Σ_{0-10}	Extrapolated		3.38	2.280	6.85	3.75	9.90
		$\bar{x}_{10}$	----	29.730	.338	.228	.685	.375	.990
EI-70-20	19/05	0	11.1	24.498	.214	.000	.844	.63	2.24
		5	9.6	29.223	.302	.109	1.012	.65	.48
		10	8.3	28.985	.296	.000	1.244	.90	.30
		Σ_{0-10}			2.785	.545	10.280	7.075	8.75
		$\bar{x}_{10}$	----	28.982	.279	.055	1.028	.708	.875
EI-70-21	25/05	0	11.3	28.763	.176	.216	.970	.58	
		5	9.7	29.041	.252	.066	.844	.63	
		10	9.4	29.006	.379	1.193	.844	.61	
		Σ_{0-10}			2.648	3.855	8.755	6.125	
		$\bar{x}_{10}$	----	28.963	.265	.386	.876	.613	
EI-70-22	04/06	0	13.7	28.600	.246	.246	2.215	.860	
		5	13.2	28.595	.210	.329	1.198	.720	
		10	12.8	28.631	.164	.313	1.424	1.270	
		Σ_{0-10}			2.075	3.043	15.088	8.925	
		$\bar{x}_{10}$	----	28.605	.208	.304	1.509	.893	
EI-70-23	12/06	0	14.9	28.514	.251	.258	2.170	1.15	2.44
		5	14.8	28.496	.117	.251	1.808	1.16	3.05
		10	14.6	28.497	.351	.082	1.876	1.09	.64
		Σ_{0-10}			2.090	2.105	19.155	11.40	22.95
		$\bar{x}_{10}$	----	28.501	.209	.211	1.916	1.14	2.30
EI-70-24	19/06	0	16.2	28.582	.292	.057	.927	.978	
		5	14.9	28.640	.216	.162	.927	.800	
		10	14.4	28.651	.281	.125	1.379	.576	
		Σ_{0-10}			2.513	1.265	10.400	7.885	
		$\bar{x}_{10}$	----	28.628	.251	.127	1.040	.789	

Stn. # & inform.	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C ^{14} mg/m ^{3}/hr
EI-70-25	26/06	0	16.6	28.509	.275	.238	2.011	.397	2.33
		5	116.6	28.509	.193	.095	1.107	1.583	4.78
		10	16.0	28.498	.181	.130	2.192	1.248	1.31
		Σ_{0-10}			2.105	1.395	16.043	12.028	33.00
		$\bar{x}_{10}$	----	28.506	.211	.140	1.604	1.203	3.30
EI-70-26	06/07	0	16.5	28.530	.251	.250	2.802	1.603	5.01
		5	16.2	28.541	.374	.186	2.396	1.539	8.92
		10	16.0	28.561	.140	.044	2.079	1.180	1.84
		Σ_{0-10}			2.848	1.665	24.183	14.653	61.725
		$\bar{x}_{10}$	----	28.543	.285	.167	2.418	1.465	6.17
EI-70-27	23/07	0	19.2	28.312	.254	.257	2.718	1.588	12.84
		5	18.2	28.312	.406	.087	2.630	1.950	12.93
		10	17.8	28.293	.330	.361	3.131	1.430	3.194
		Σ_{0-10}			3.490	4.178	27.773	17.295	105.787
		$\bar{x}_{10}$	----	28.307	.349	.418	2.777	1.730	10.58
EI-70-28	05/08	0	14.9	27.947	.322	.051	2.350	2.447	3.98
		5	14.9	27.942	.263	.016	5.627	2.280	14.05
		10	14.5	27.957	.275	.039	3.345	3.735	16.48
		Σ_{0-10}			2.808	.305	42.370	26.855	86.275
		$\bar{x}_{10}$	----	27.947	.281	.031	4.237	2.686	8.63
EI-70-29	03/09	0	14.9	27.769	.440	.227	3.180	2.789	12.60
		5	14.9	27.751	.395	.071	2.265	3.078	13.66
		10	14.5	27.761	.334	.047	1.917	2.835	4.352
		Σ_{0-10}			3.91	1.04	24.068	29.450	110.69
		$\bar{x}_{10}$	----	27.758	.391	.104	2.407	2.945	11.07
EI-70-30	11/09	0	14.0	27.593	.240	.051	2.186	3.138	
		5	14.0	27.578	.263	.042	2.463	3.330	
		10	13.8	27.631	.450	.080	2.186	2.995	
		Σ_{0-10}			3.040	.215	23.247	31.983	
		$\bar{x}_{10}$	----	27.595	.304	.022	2.325	3.198	

Stn. # & Inform.	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m3	NO_3-N mgA/m 3	SiO 3-Si mgA/m3	Chl mg/m3	C 14 mg/m 3hr
EI-70-31	18/09	0	13.6	27.925	2.290	.088	6.405	2.345	
		5	13.6	27.937	.500	.021	1.027	2.374	
		10	13.6	27.937	.335	.007	0.656	2.211	
		Σ_{0-10}			9.063	.343	22.787	23.260	
		$\bar{x}_{10}$	----	27.934	.906	.034	2.279	2.326	
EI-70-32	22/09	0	13.5	27.960	.140	.041	1.469	0.994	
		5	13.5	27.967	.216	.172	1.559	2.173	
		10	13.5	27.999	.287	.130	.791	2.105	
		Σ_{0-10}			2.148	.515	13.445	18.613	
		$\bar{x}_{10}$	----	27.973	0.215	.052	1.345	1.861	
EI-70-33	07/10	0	13.10	27.408	.167	.232	3.519	1.426	10.01
		5	13.0	27.564	.230	.369	1.640	2.898	10.21
		10	12.9	27.586	.236	.446	2.601	2.709	2.69
		Σ_{0-10}			2.158	3.540	18.80	24.828	82.80
		$\bar{x}_{10}$	----	27.531	.216	.354	1.880	2.483	8.28
EI-70-34	12/10	0	13.9	27.5766	.333	.346	.874	1.856	6.56
		5	13.8	27.6305	.195	.181	2.186	2.208	5.48
		10	13.5	27.6247	.270	.354	1.290	1.976	2.37
		Σ_{0-10}			2.483	2.655	13.072	20.620	49.20
		$\bar{x}_{10}$	----	27.616	.248	.266	1.307	2.062	4.92
EI-70-35	05/11	0	6.4	27.366	.149	.222	.765	2.485	10.33
		5	6.5	27.484	.207	.696	1.268	2.625	3.59
		10	6.7	27.772	.305	1.048	1.814	2.413	.83
		Σ_{0-10}			2.17	6.655	12.79	25.370	45.81
		$\bar{x}_{10}$	----	27.527	.217	.666	1.279	2.537	4.58

B I O L O G I C A L S T A T I O N

E I I I

D A T A

BIOLOGICAL STATION EIII 1970

Stn # &	Date	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} $mg/m^3/hr$
EIII-70-01	26/05	0	9.5	25.309	.176	.480	2.025	2.42	---
		2.5	---	26.057	.165	.022	1.181	2.63	---
		Σ_{0-3}			.512	.753	4.809	7.575	---
		$\bar{x}_3$	---	25.683	.171	.251	1.603	2.525	---
EIII-70-02	07/06	0	15.5	1.035	.218	---	10.843	.850	2.04
		2.5	--	26.857	.264	---	1.421	2.530	4.94
		Σ_{0-3}			.723	---	18.400	5.070	10.46
		$\bar{x}_3$	--	13.946	.241	.003	6.132	1.690	3.49
EIII-70-03	17/06	0	19.5	26.691	.552	0	3.126	1.99	2.03
		2.5	--	26.775	.259	0	3.017	2.31	2.175
		Σ_{0-3}			1.217	--	9.214	6.45	6.31
		$\bar{x}_3$	--	26.733	.406	0	3.071	2.150	2.10
EIII-70-04	24/06	0	20.8	26.632	.810	0	2.361	2.700	7.08
		2.5	--	27.569	.707	0	2.055	3.090	4.46
		Σ_{0-3}			2.276	0	6.624	8.685	17.31
		$\bar{x}_3$	--	27.101	.759	0	2.208	2.895	5.77
EIII-70-05	08/07	0	21.3	26.838	.471	0	1.967	2.394	30.78
		2.5	--	27.790	.385	0	2.142	4.320	38.87
		Σ_{0-3}			1.284	0	6.164	10.071	104.48
		$\bar{x}_3$	--	27.314	.428	0	2.055	3.357	34.83
EIII-70-06	15/07	0	19.8	27.330	.551	0	3.034	5.272	59.34
		2.5	--	27.434	.966	0	5.768	15.340	35.41
		Σ_{0-3}			2.277	0	13.203	30.918	142.13
		$\bar{x}_3$	--	27.382	.759	0	4.401	10.306	47.38
EIII-70-07	22/07	0	22.9	27.547	.801	.156	1.525	6.266	32.96
		2.5	--	27.561	1.290	.085	1.547	6.846	10.14
		Σ_{0-3}			3.137	.212	4.608	19.668	129.31
		$\bar{x}_3$	--	27.554	1.046	.071	1.536	6.556	43.10

Stn # & infor.	Date da.mo.	Dep m	Temp °C	Sal o/oo	PO_4-P mgA/m^3	NO_3-N mgA/m^3	SiO_3-Si mgA/m^3	Chl mg/m^3	C^{14} mg/m^3/hr
EIII-70-08	30/07	0	28.0	27.023	1.903	.521	6.984	3.318	36.81
		2.5	--	28.060	2.528	.396	8.089	6.677	23.35
		Σ_{0-3}			6.647	1.376	22.609	14.993	90.23
		$\bar{x}_3$	--	27.542	2.216	.459	7.536	4.998	30.08
EIII-70-09	07/08	0	25.0	27.354	.261	0	1.017	12.806	36.81
		2.5	--	27.743	2.250	.037	7.580	7.739	96.97
		Σ_{0-3}			3.767	.055	12.900	30.818	200.60
		$\bar{x}_3$	--	27.549	1.256	.018	4.300	10.273	66.89
EIII-70-10	12/08	0	24.8	20.442	1.682	1.860	7.956	2.912	---
		2.5	23.5	27.001	4.830	.089	8.000	3.765	---
		Σ_{0-3}			9.768	2.924	23.934	10.016	---
		$\bar{x}_3$	--	23.722	3.256	.975	7.978	3.339	---
EIII-70-11	02/09	0	14.8	25.967	.364	.301	2.895	3.496	---
		2.5	--	25.848	.386	.258	3.470	4.808	---
		Σ_{0-3}			1.125	.839	9.548	12.456	---
		$\bar{x}_3$	--	25.908	.375	.280	3.183	4.152	---
EIII-70-12	14/09	0	17.02	25.993	.165	.391	1.945	4.764	---
		2.5	15.8	26.662	.261	.185	1.923	1.280	---
		Σ_{0-3}			.639	.864	5.802	9.066	---
		$\bar{x}_3$	--	26.328	.213	.288	1.934	3.022	---
EIII-70-13	22/09	0	13.6	26.670	.557	.323	1.414	3.414	---
		2.5	--	26.693	.313	.129	1.437	5.119	---
		Σ_{0-3}			1.305	.678	4.276	12.800	---
		$\bar{x}_3$	--	26.682	.435	.226	1.425	4.267	---
EIII-70-14	11/10	0	15.0	18.402	.119	.410	8.575	9.128	86.30
		2.5	--	27.381	.273	.007	3.486	3.669	3.75
		Σ_{0-3}			.588	.626	25.592	19.200	135.07
		$\bar{x}_3$	--	22.892	.196	.209	8.531	6.399	45.02
EIII-70-15	07/11	0	5.0	16.350	.182	2.395	9.017	2.215	14.07
		2.5	--	26.174	.176	.346	2.718	2.611	4.89
		Σ_{0-3}			.537	4.112	18.215	7.239	28.43
		$\bar{x}_3$	--	21.262	.179	1.371	6.072	2.413	9.48