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ASPECTS OF THE COMPOSITION, PIGMENTS AND CARBON FIXATION OF MARINE PHYTOPLANKTON

A thesis submitted to the university of Glasgow

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by

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DEDICATED TO MY PARENTS, BROTHER, SISTER AND MY HOMELAND

DECLARATION

I hereby declare that this thesis is composed of work carried out by myself unless otherwise cited or acknowledged and that this thesis is of my own composition. The research was carried out within the period April 1984 - April 1987. This dissertation has not in whole or in any part been previously presented for any other degree.

Signed

ADEL S. BEN OMRAN

DATE: 15.12.1989

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Summary

The seasonal variation of phytoplankton biomass in terms of total number of algal cells, chlorophyll a levels and phytoplankton productivity was investigated in the years 1984, 1985, 1986 and 1987 for samples collected from the photic zone (surface and 5 metres depth) at stations 11 and 9, at the Fairlie Channel in relation to the changes in nutrient levels and weather conditions. The seasonal variation in the phytoplankton composition was assessed using microscopic examination of the samples and the qualitative analysis of the different algal pigments. Also investigated was the contribution of the different phytoplankton size fractions to the total photosynthetic activity, including that of net -, nano - and picophytoplankton.

Although there is a year to year slight variability in weather conditions and nutrient concentrations during the course of this investigation, certain features recurred annually: 1) The spring diatom increase (spring bloom) occurred in March or early April. 2) The phytoplankton biomass during the summer fluctuated about intermediate levels, although on certain occasions they were comparable or higher than those observed during the spring diatom increase and during this period the minimum nutrient levels were recorded. The maximum photosynthetic activities were found during the summer period (1986) in reflection of the favourable weather conditions marking this period. 3) Small to relatively high standing crop levels were recorded during the autumn period with photosynthetic activities comparable to those found during the summer. Relatively high nutrient levels were recorded during the autumn. 4)Low phytoplankton biomass (representing the year minimum) and high nutrient concentrations (representing the year maximum) were found during winter. There was no regular recurring autumnal bloom.

With the exception of the findings on 25 May and 6 June, 1984 when the benthic organisms represented a large part of the total population, these organisms were found to be most numerous during autumn and winter months, coinciding with the prevailing conditions.

Diatoms were the most dominant fraction of the population mainly during the spring diatom increase of which *Skeletonema costatum* and *Thalassiosira nordenskioldii* were the most dominant species; also observed in considerable numbers was *Navicula spp*. The largest levels of contribution by dinoflagellates to the total phytoplankton biomass were recorded during the autumn months; the dinoflagellate fraction was predominantly composed of the genus *Ceratium*. Green flagellates were found in considerable numbers during the summer months although they were common in the autumn and winter months of 1986.

The seasonal variations of the total phytoplankton biomass and nutrient levels were similar to those observed in the past in the Fairlie Channel. The highest chlorophyll a levels were recorded in 1985. The maximum chlorophyll a levels in 1984 were recorded during the spring diatom increase on 11 April (3.9 - 4.1 mg. m^3); the maximum chlorophyll a in 1985 were recorded on 20th and 29th of March (12.4 - 18 mg. m^{-3}); the maximum chlorophyll a levels in 1986 were found on 2nd of April for samples collected from stations 11 and 9 at the surface (9.52 and 10.2 mg. m^{-3} respectively), also comparable levels were found on 4th June (7.5 - 11.5 mg. m^{-3}). In 1987 the maximum chlorophyll values (8.1 - 13.7 mg. m^{-3}) were observed during April.

Based on laboratory incubations the photosynthetic levels (measured with ^{14}C), which were recorded from 10 March, 1986 till 22 April 1987 showed a clear seasonality and close correlation with the changes in chlorophyll levels. Carbon fixation levels were high during the summer period following the spring diatom increase. The maximum primary

productivity values were recorded in 4th June (418 - 766 mg C m^{-3}. h^{-1}), with the exception of samples collected from station 11 at 5 metres depth of which the maximum of 389 and 393 mg C m^{-3}. h^{-1} were recorded on 30th July and 15th August respectively.

During the late summer period and early autumn (15 August and 10 September, 1986) most of the total fixation was carried out by the netplankton fraction (61 - 80.87% of the total photosynthetic activity), whilst on 25 September and 6 October more or less equal levels of contribution by the net and nanophytoplankton to the total photosynthetic output were recorded. On 27 October the nanoplankton size fraction accounted for 58 - 62% of the total ^{14}C fixed. During the winter period on 12th of November and 23rd of December the nanophytoplankton population accounted for all of the photosynthetic activity, of which most was in the ≥5<10 µm size fraction (66.6 - 88.9%); whilst although on 22nd of January and 17th of February there was an increase in the contribution of the net fraction most of the fixation occurred in the <20 µm size fraction (nanophytoplankton). During the spring diatom increase of 1987 the levels of carbon fixed by the nanophytoplankton fraction (50 - 57.6%) exceeded that by the netphytoplankton, with most of the nanophytoplankton production occuring in the ≥10<20 µm size fraction and most of the netphytoplankton production occuring in the ≥100 and ≥20<50 µm size fractions, in the latter of which the were higher.

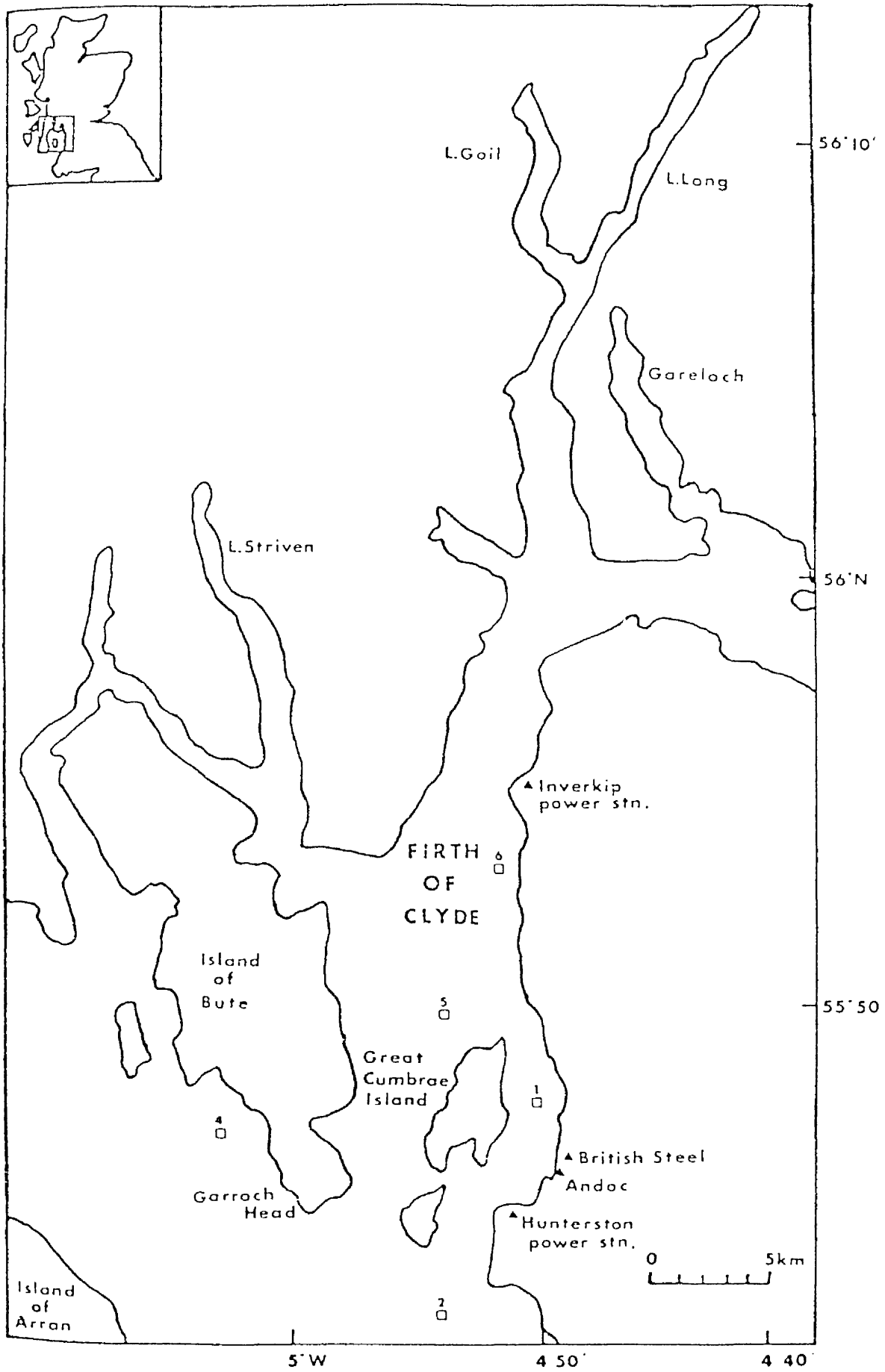
The photosynthetic activity by picoplankton (<1 - >0.2 µm) which was a part of the ≥0.45<5 µm size fraction was variable throughout the different seasons, as well as with stations and depth. Generally picoplankton accounted for significant proportions of the total photosynthetic output. Picoplankton accounted for 5.86 - 11.6%of the summer fixation, for 8.8 - 29.6% of the autumn production, for 11.2 - 32.2% of the winter photosynthetic output and for 17.87 - 20.9% of the spring photosynthetic activity.

1. Introduction

The Clyde Sea area lies between latitudes 55°5' and 56°17' North and longitude 4°30' and 5°40' West and covering an area of about 1160 square miles, or 881 square sea miles, the water surface corresponds to 3350 square miles of land surface slope. The total volume of water in the area at low tide is about 25.5 cubic sea miles, and the average depth is 29 fathoms. At high water the total volume of water is about 26.65 cubic sea miles and the average depth is 30.5 fathoms.

The area has been described in detail by Mill (1889 - 91 and 1901). The Kintyre Peninsula, which forms the western boundary of the area, is separated from Ireland by the North Channel, eleven miles across. The southern boundary of the area stretches from the Mull of Kintyre to Galloway, a distance of twenty three miles. On the south it is divided from the Irish Sea by the Great Plateau which has an average depth of 24 fathoms, this deepening northwords to the Arran Basin. The islands of Arran, Inchmarnock, Bute and the Cumbrae divide this into a number of narrow sounds, continued to the north as a series of lochs. The north west is prolonged into Loch Fyne, which curves off to the north - east, and the north - east into Loch Long. This is joined on the east by the shallow estuary of the Clyde, the only important river entering the area. The Arran Basin into which the Great Plateau descends, is sharp like the latter, the western branch of the Arran Basin forming the Short Leg and the Central and Eastern Basin the Long Leg, which reaches as far north as Otter Sit. The maximum depth is about 107 fathoms, which is the maximum for the area. The Dunoon Basin is a straight trough of a 54 fathoms maximum depth which runs up Loch Long as far as its junction with Loch Goil. The estuary, which joins it at the middle point, shoals off rapidly, the navigable channel being maintained by dredging. On the north the estuary is joind by the Gareloch, which has a maximum depth of 21 fathoms. Loch Long is a continuation to the north of the Dunoon Basin with a maximum depth of 35 fathoms, and Loch Goil, with a maximum depth of 47 fathoms, joins it on the west Loch Striven, which runs almost due north and south, has a maximum depth of 42 fathoms; the Kyles

Figure. 1. 1. Map of the Inner Firth Region of the Clyde Sea Area.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L.Long
56°10'
Gareloch
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FIRTH
OF
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Cumbrae
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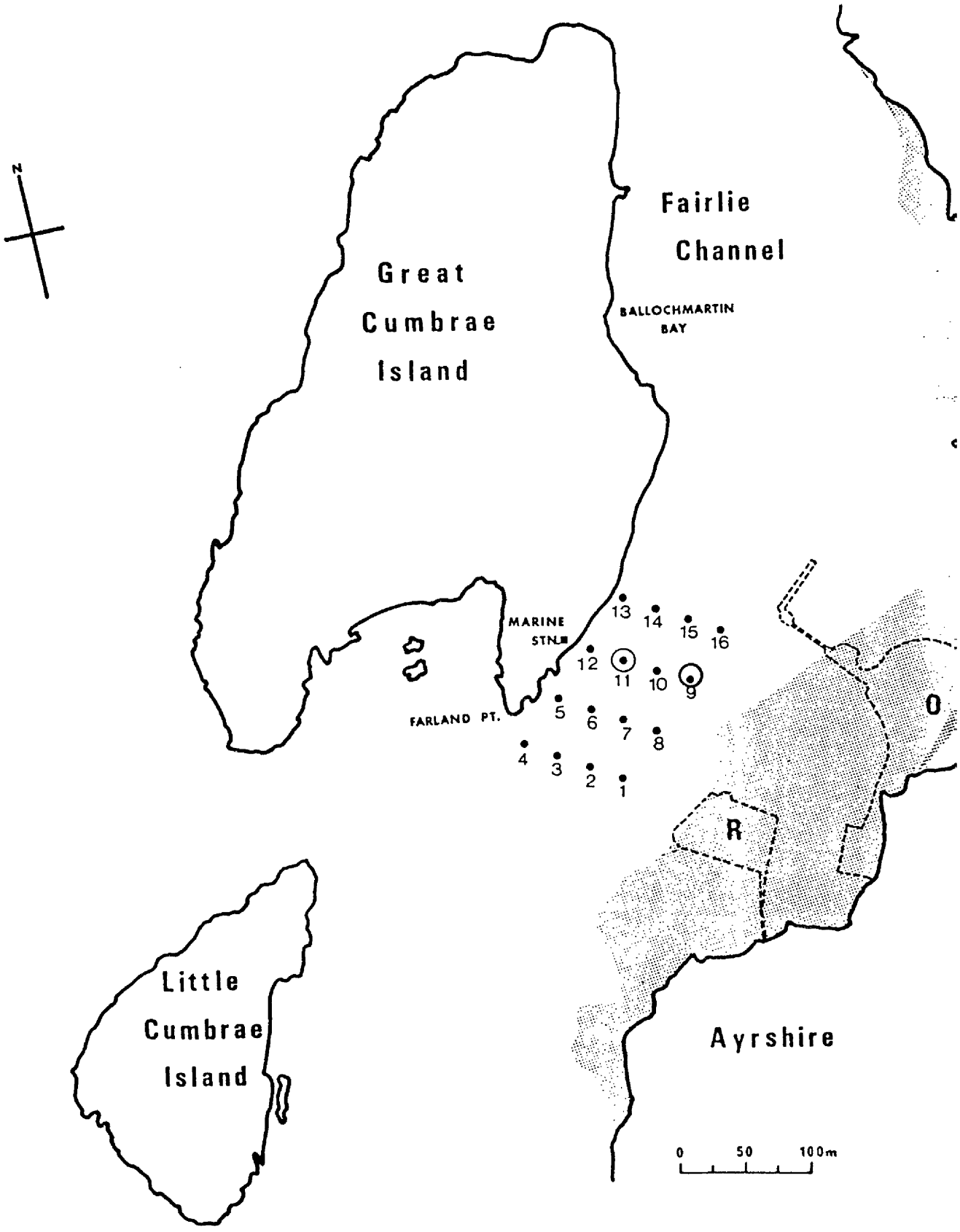
5km
Island
of
Arran
2
5°W
4 50'
4 40'

Figure. 1. 2. A detailed map of the Fairlie Channel showing the position of the main sampling stations (11 and 9) and the position of the grid stations. The stippled area represents Hunterston and Fairlie sands.

(The grid stations were those used by Hannah (1979))


N
Fairlie
Channel
Great
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Little
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of Bute and Loch Ridum are shallower, the maximum depth is 23 fathoms. Loch Fyne is divide into two basins, the Grantans Basin and the upper Loch Fyne Basin, the former with a maximum depth of 36 fathoms and the latter with a maximum depth of 80 fathoms.

The different lochs are separated from the more open water by "thresholds" or bars. Loch Striven is an apparent exception, unless the shallow plateau between it and the Dunoon Basin be counted as such.

Tidal conditions and the general hydrography of the area have been discussed by Mill (1901), Barnes and Goodley (1961), Allen (1966) and Collar (1974). The tidal ranges of the Clyde Sea area are relatively small when compared with that of other estuaries. Because of the depth and the width, the Firth of Clyde is not considered a typical estuary and in many aspects can be regarded as a shallow sea. The tidal conditions are mostly semidiurnal, although a diurnal influence of up to ten percent of the range may be apparent at times (Allen, 1966). The mean spring range at Cumbrae is 2.92 metres and the neap tide range is 1.76 metres. The tidal ranges become amplified as it passes up the Firth reaching a spring range of 4.11 metres in Glasgow. The delay of high water from the outer to inner Firth is only 17 minutes (Mill, 1889).

Mill (1901) mentioned that in the Clyde Sea area the tidal currents are as a rule, generally weak, with the current strength being greatest in the North Channel where the water becomes thoroughly mixed with each ebb and flow. It has been suggested that the spring maximum rate in the Arran Basin is 3 knots, and that generally the ebb stream is opposite the flood and of equal velocity and duration. Barnes and Goodley (1961) gave a revised view of the tidal movements and showed that the currents in the wide outer Firth are weaker than that suggested by Mill, also they found that the spring rate for the main tidal streams ranged from 1.5 to 2.0 knots. Mill (1901) noted that currents increased or decreased to a marked degree according to the direction and

strength of the wind. The same effect was also noted by Dooley and Steele (1969), who found that the surface inshore wind driven currents near the Ayrshire coast moved up to 1.6% of the wind speed and responded rapidly to changes in wind direction. In the case of offshore, they found that the water movement was more complex with the flow being part of the large scale wind induced circulation of the Firth.

The more recent data, obtained from Steele et al. (1973) shows that the estuarine circulation is barely detectable from current measurements. The estuarine inflow was detected along the eastern shores of the Firth where the water appears to originate from the Irish sea. Except in this narrow strip the salinity of the surface water is relatively low and constant over the whole Firth to the estuary. The upper water flows southwards above the depth of the strong pycnocline at about 15 metres, with the amount of fresh water in this layer rarely exceeding 2%. Although currents in the Clyde Sea area are slight , the retention time of water is not long as spatial scales are small and the estimated residence time of water in the area is approximately one month (Steele et al, 1973).

Hinton (1974) mentioned that there are no published data available for the circulatory pattern in the Fairlie Channel, but from private communications and personal observations, it seems probable that there is an anticlockwise circulation of surface water within the channel. This results in a continued southward flow of the water at Keppel Pier throughout the tidal cycle, with the exception of a short period, around low tide, when the direction changes to northward.

The climatology of the area has been reviewed by Mill (1889) and Barnes (1955). The review carried out by the latter author showed that the temperature trends are typical of the north temperate zone and the rainfall is typical of a wet oceanic climate. The measurements of air temperature at the Marine Station, Millport carried out by Barnes(1955) showed an annual maximum monthly mean of 14.1°c in July while the minimum monthly mean of 4.3°c, is recorded in February. The rainfall in the area is

not excessive, being around 45 inches (1143 mm) per year. Generally December is the wettest month with 5.42 inches (137.6 mm) and the driest is May with only 1.82 inches (64.2 mm). Barnes and Goodley (1958) showed that the land rainfall was higher than that at sea with 55.24 inches (1403 mm) per year, supplying 1.162×10^{10} cubic meters. The islands have a rainfall of 47.87 inches (1215.8 mm) supplying 0.07×10^{10} cubic metres, whereas the sea and loch surfaces receive 42.74 inches (1085.6 mm) supplying 0.387×10^{10} cubic metres per annum. The prevailing winds in the Clyde Sea area are usually from the south west quadrant, except for March and May when north - easterlies predominate. The difference in the mean hourly wind speed did not exceed 5 knots between the windiest month, October, and the calmest month, June.

Both Mill (1889) and Barnes (1955) showed a clear reduction in the salinity of surface and bottom waters in the Clyde Sea area during winter months, reaching a minimum level of 31.26°/oo at Millport in January. Mill (1889) found a surface maximum between July and September, while he found a maximum levels of 32.98°/oo in June at Millport. Both authors correlated this change with the pattern of seasonal rain - fall changes. Mill stated that a change in rainfall takes two months to produce its full effect on salinity while Barnes showed a delay of one month; i.e both authors correlated salinity changes with changes in the pattern of seasonal rainfall.

Except in the estuary, where stratified layers of fresh water on top of the salty water often occur (Allen, 1966) temperature and salinity usually vary only gradually, another reason for regarding the Firth of Clyde as a shallow sea and not a typical estuary (Johnston et al, 1971). Mill (1889) attributed the small differences in vertical distribution of salinities to mixing processes; also he stated that fresh water was lost by mixing in each tidal outflow and not by the flowing out of a fresh water layer.

The presence of a well developed thermocline in the outer Firth during the summer has been suggested by Barnes (1955). Mill (1901) investigated the isothermocline

conditions throughout the Clyde Sea area. The North Channel remained isothermal throughout the year, similarly the Arran Basin remained completely mixed till the period of maximum surface temperatures. Even at this time no distinct thermocline occured, a constant gradient of temperature from 12.2^{0}c at the surface to 8.3^{o}c at 110 metres was evident. Strong winds cause complete circulation of the water column at the autumn equinox. The presence of a vertical temperature discontinuity was only demonstrated in Loch Goil and Loch Fyne although Mill suggested that other deep lochs would have a similar thermal regime.

One of the first studies of the chemical nature of the water mass in the Clyde Sea area was carried out by Mill (1889). His study was confined to the changes in the proportions of sulphates and carbonates in relation to the differences in the salinity. He found that the amount of sulphate and carbonate increased in waters of lower salinity.

In 1926, the first annual survey of the area was carried out in Loch Striven , a deep fjordic sea loch, by Marshall and Orr (1927), in which they showed a close relation between diatom increase and changes in pH values, dissolved oxygen saturation and dissolved phosphate. During the winter period, while diatoms were very scarce phosphate values varied between 40 and 50 mg. per cubic metre. During the spring phytoplankton increase the phosphate content of the water declined abruptly from around 40 mg. m^3 on 23 March to 12 mg. m^3 at surface within 2 weeks and from 47 mg. m^3 on 23 March to 17 mg. m^3 on 13 April, at 5 fathoms. During this period the largest levels of decrease were recorded at the surface and 5 fathom layers, in which a considerable increase in the total number of algal cells was found, while at the deeper waters, mainly at the bottom, little change was evident. During this period *Skeletonema costatum* was the predominant species. The regeneration of phosphate in deep waters was shown to occur during late summer and autumn. During the summer period a gradual rise in phosphate was recorded in deep waters which continued till the autumn turnover, while at the surface and 5 fathom layers phosphate levels remained low. The

surface and 5 fathom layers were completely denuded of phosphate on 25 May. The diatom population during the summer period was mixed, *Cerataulina bergoni, Skeletonema costatum, Chaetoceros* spp and *Nitzschia seriata* forming the majority. Also observed in considerable numbers was *Leptocylindrus danicus*. In autumn two species of diatoms became abundant, *Melosira* spp and *Chaetoceros didymum*. Oxygen saturation reached its highest values of more than 135% at the surface in April and August while at the bottom a minimum of 30% was recorded during autumn. The pH values varied within close range and never exceeded 8.45 or fell below 7.75. The lowest values were recorded in the winter. The analysis for silicate (dissolved silica) in the surface and bottom samples showed a distinct lowering in its values during the spring diatom increases at Clapochlar, whilst nitrites in the loch throughout the year showed no obvious relation to the phytoplankton.

The phosphate and total nitrogen content of the muds at 33 stations in the Clyde sea area was studied by Moore (1930). The phosphate values for shallow stations range only from 0.178% to 0.224% by weight. There is no general relation between P_2O_5 or N_2 values and the depth of water, with the following exceptions: 1) The phosphate values in depths of less than 40 metres all lie close together. 2) The phosphate values fall off with increasing depth in the mud, but usually show a rise at the ten - fifteen centimetre level. 3) The nitrogen values usually fall with increasing depth in the mud. 4) Generally the strongest tidal streams, have low phosphate and nitrogen levels.

The background winter nitrate values over most of the Firth of Clyde are about 25% higher than in the northern North Sea (Steele et al, 1973). This is due to nutrient addition from both the Clyde and the Irish Sea. Also they showed that the daily input of soluble nitrogen compounds into the upper estuary is up to 30 tons per day. Johnston et al (1974) studied the nitrate enrichment of the Firth of Clyde around Irvine Bay for a short period during April. Along the eastern coastline of Kintyre the lowest values were found (5 - 9 µg at N. l^{-1}), whilst higher levels were (12 - 14 µg at N. l^{-1}) to the west of

Cumbrae than those found to the east (10.5 - 12 µg at N. l^{-1}). Within Irvine Bay itself, localized nitrate values exceeding 30 µg at N. l^{-1} were found on occasions.

The first seasonal survey of phytoplankton in the Clyde Sea area was carried out by Marshall (1924), by examining the gut contents of *Calanus finmarchicus* which occurs in the Clyde Sea area all the year round and relating them to the changes in the algal population. During the spring diatom increase *Skeletonema costatum* was the predominant species in the gut of *Calanus finmarchicus*, with *Thalassiosira* a close second. The two diatoms changed places in May and June. During April, May and June other diatom species were common including various species of *Navicula* and *Fragilaria* . In July and August *Chaetoceros* spp, and *Rhizosolenia* spp , mainly *Rhizosolenia fragillima* were dominant. A group which is present in considerable numbers during the summer were the dinoflagellates; *Peridinium* (=*Protoperidinium*) itself was most abundant in August. Again, during the autumn diatom increase most of the population was made up of *Skeletonema* and *Thalassiosira*, the latter species continued to be of importance throughout the winter. Also found during the winter months were *Coscinodiscus* spp and *Biddulphia* spp mainly in November. The silicoflagellate *Dictyocha* spp was occasional throughout the winter and its maximum found in September.

Marshall and Orr (1927, 1928 and 1930) studied the phytoplankton composition of Loch Striven and other stations in the Clyde Sea area. Their studies were based on weekly sampling from the different stations, whilst during 1927 and 1928 the spring diatom increase in Loch Striven was studied at shorter time intervals. In 1926 the pattern of changes in the phytoplankton population for Loch Striven was based on weekly visits from the greater part of the year. During the years of sampling there was a well - marked spring diatom maximum which started at the end of March or the beginning of April, which consisted of *Skeletonema* and *Thalassiosira* in varying proportions, but with *Skeletonema* usually predominant. The spring increase of 1926

and 1927 was regular in form, beginning at the surface and sinking gradually into deeper water, with the maximum at 5 fathoms occuring a week after the maximum at the surface, and the maximum at 10 fathoms a week later. The spring increase of 1928 was of quite a different type, being much less regular. It began while a vertical mixing was still going on and the diatoms increased in numbers simultaneously down to a considerable depth instead of only at surface as usual. The maximum total number of algal cells was recorded at the beginning of April on the 10th, and between the 10th and 11th the numbers were doubled at the surface (16.700 to 33 milion cells. l^{-1}) and 5 metres (6.900 to 16.4 million cells. l^{-1}). At the beginning of May a small wave of *Skeletonema* appeared (2.5 million cells. l^{-1}), followed by a second and larger wave of 9 million cells. l^{-1}. The maximum number of *Thalassiosira* cells (500.000) was recorded at the end of May. During early June diatoms were very scarce until the 29 June when there was a sudden appearance of 3 million at the surface. The following week this rich layer was found at 10 fathoms, while at the surface and 5 fathoms diatoms were scarce. The diatoms were mixed, *Cerataulina bergoni, Skeletonema costatum and Chaetoceros* spp forming the majority. From the end of July there followed a series of diatom increases which lasted till the middle of September. During this period a pulse of *Nitzschia seriata* at the end of July was followed by *Leptocylindrus danicus* at the beginning of August. At this time the surface samples contained practically nothing but *Leptocylindrus,* the 5 fathom sample a mixture of *Nitzschia* and *Leptocylindrus*, and the 10 fathoms and samples below only *Nitzschia* was observed. Also observed in numbers during this period was *Eucampia zoodiacus.* At the beginning of October a small number of *Rhizosolenia setigera* was observed, with subsequent peak of *Skeletonema.* Other important diatom species were observed during this period, of which the most important were *Chaetoceros sociale, Thalassiosira nordenskioldii* and *T. gravida.*

The occurrence of dinoflagellates throughout the years was irregular, and they were never numerous except in the surface layer. The larger dinoflagellates, including *Ceratium* spp and some species of *Protoperidinium* had their maxima usually in

August, but the distribution of some of the photosynthetic *Protoperidinium* sp. (e.g *P. triquetra*) was less regular.

The detailed study carried out in the Fairlie Channel by Hinton (1974) for a period of one year, from the beginning of August, 1972 until the end of August, 1973 showed that the maximum nutrient levels were recorded during winter at the time of low algal biomass; Phosphate phosphorus values generally exceeded 1 µg at P. l^{-1} from November till the middle of March, with a maximum of 1.6 in January; For nitrate nitrogen the maximum of 23.7 µg at N. l^{-1} was found at the end of January, 1973, whilst the maximum for dissolved silica was 14.95 µg at Si. l^{-1}. Throughout the period of this study the nutrients showed a similarity in never being reduced to undetectable levels, including the values recorded during the summer minimum and in having a larger winter maximum than other areas. The seasonal cycle of phosphate showed fluctuating levels in August, 1972 rising to a maximum in September followed by a marked reduction in early spring, 1973, associated with the spring diatom increase. During spring and summer the levels fluctuated between 0.25 and 0.6 µg at P. l^{-1}. During the spring of 1972 the phosphate changes were similar but occured about a month later, and the minimum was slightly lower, 0.18 µg at P. l^{-1}.

The seasonal pattern of dissolved silica was regular in the Fairlie Channel, although a much more irregular seasonal distribution was found in the English Channel by Raymont (1963). Low, fluctuating summer levels at the beginning of August, 1972 changed into a period of increase towards the latter half of the month reaching an early autumn maximum of around 6 µg at Si. l^{-1}. Also Cooper (1933) in the English Channel has recorded a marked regeneration of this nutrient in some years in August, which he attributed to the more rapid regeneration and cycling of this nutrient, due to the dissolution of dead diatom values, both in surface and bottom waters. At the end of September a marked fall in silicate levels was recorded, which was short - lived. Similar to phosphate, the winter silicate increase started in October reaching highest

levels from December onwards. A sharp decrease in dissolved silica levels was recorded in early spring (middle of March) caused by the utilization by diatoms which reduced this nutrient to 0.5 µg at Si. l^{-1} within days. During the rest of spring and summer with the exception of the distinctive rise in April, dissolved silica levels remained low (below 4 µg at Si. l^{-1}). In the spring of 1972 dissolved silica utilization began at the same time as in 1973, although the rate of development was much lower with minimum levels (0.21 µg at Si. l^{-1}) not being reached till the end of April.

The nitrate + nitrite nitrogen showed a clear seasonal pattern although short - term fluctuations were considerable. Varying levels in August, 1972 gave way to a steady rise in September along with the increase of phosphate phosphorus and dissolved silica. The depletion of nitrate nitrogen during the latter half of September accompanied the autumnal rise in phytoplankton, after which nitrate levels increased, exceeding 10 µg at N. l^{-1} by the end of November, and the maximum level was not reached till February, which was two months later than when phosphate and silicate approached their maximum levels. Barnes (1957) indicated that nitrate showed a longer regeneration period than phosphate and silicate in temperate coastal waters. Hinton (1974) stated that a remarkable feature of the winter variation of nitrate is its wide range of fluctuations, with extreme values of 6 to 23.7, also he stated that during the winter period (low algal biomass) the changes in nutrients are mainly due to non - biological enviromental factors, whilst during spring and early summer the changes in nutrients were more associated with the rise and fall of phytoplankton populations and other biological activity.

The quantitative aspects of the changes in standing crop in terms of total number of algal cells, chlorophyll a levels and total particle volume using a Coulter Counter were also discussed. Hinton (1974) stated that the three estimates closely parallel one another, each showing simultaneous pulses related to increasing biomass. The highest values for all three measurements were recorded in early spring (23 March) when the

total number of algal cells exceeded 11 million cells. l^{-1}, chlorophyll levels reached 0.83 µg. l^{-1} and the total particle volume reached 7.2 x 10^7 cubic micrometres (μm^3) per litre. Similar results were obtained by Butler et al (1970), in the spring outburst of 1969, in which the maximum total number of algal cells was 12.5 million cells. l^{-1} of which the prominent species was *Thalassiosira* and chlorophyll level was 0.6 µg. l^{-1}. Following the spring diatom increase, two peaks of total phytoplankton counts were observed in June, the first at the beginning of the month, with about 3 million cells. l^{-1}, chlorophyll level of 0.5 µg. l^{-1} and total particle volume of 1.3 x 10^7 μ^3. l^{-1}. The second burst occured at the end of the month, in which slightly higher than 2 million cells. l^{-1} were counted, with a total particle volume of 4 x 10^7 μ^3. l^{-1} and a chlorophyll peak, 0.66 µg. l^{-1}, which was greater than that recorded during the first pulse, which may have resulted from the changed species composition of the population. A further pulse was recorded at the end of July, in which the total number of algal cells was 1.4 million cells. l^{-1}. From August onwards the higher magnitude of pulses was recorded, which was clearly shown in 1972, when the total number of algal cells reached a maximum of 2 million cells. l^{-1}. In the autumn pulse recorded in September the total number of algal cells rose to around 3 million cells. l^{-1} with a corresponding total particle volume of 4.3 x 10^7 μ^3. l^{-1}. The pattern of seasonal succession of phytoplankton studied by Hinton (1974) in the Clyde Sea area including the Fairlie Channel showed a clear similarity to that described by Marshall and Orr (1927) for Loch Striven. Hinton (1974) found that during the spring diatom increase in the years 1972 and 1973 the dominant diatom species was *Skeletonema costatum*, accompanied by smaller numbers of *Thalassiosira nordenskioldii*, which constituted one - tenth of the total population in 1972 and one - third in 1973. In the first year the spring outburst occurred at the beginning of April, whilst in the second year the increase was almost over by the end of March. During the spring diatom increase the water temperature was 7°C, Raymont (1963) showed that *Skeletonema* can reach great abundance in nature at a wide range of temperature(between 2 and 9°C) and was not temperature dependent. The accompanying diatoms were generally *Thalassiosira, Nitzschia seriata* and *Nitzschia*

closterium. In all bodies of water examined in spring, 1973, except for Gare Loch, small numbers of *Protoperidinium* spp were present, reaching about 4000 cells. l^{-1}. A visit by Hinton to Loch Striven on 15 March, 1973, a week prior to the spring diatom increase in the Fairlie Channel, showed that the spring outburst had reached its peak; the total number of algal cells exceeded 13 million cells. l^{-1} in the upper 2 metres and a reduction in nutrient levels was recorded, nitrate to 1.61 µg at N. l^{-1}, phosphate to 0.44 µg at P. l^{-1} and silicate to 1.27 µg at Si. l^{-1}. The dominant species was *Thalassiosira nordenskioldii* (80% of the total biomass), instead of *S. costatum* being the dominant organism, which is unusual for Loch Striven. Butler et al (1970) recorded the predominance of *Thalassiosira* in the inner firth during the spring diatom increase of 1969. Hinton (1974) stated that following the early spring diatom increase in the Clyde Sea area *Thalassiosira, Skeletonema* and *Nitzschia seriata* produced another pulse during May, 1973 whilst in 1972 *Skeletonema* and *Thalassiosira* were succeeded by *Chaetoceros cinctum* that became the dominant organism at the beginning of May. Following a third pulse of *Thalassiosira* in June in the Fairlie Channel (1973) the population become dominated by *Chaetoceros cinctum*. The same pattern of succession was described by Hasle and Smayda (1960) who showed that *Chaetoceros* usually succeeded *Thalassiosira* in Oslofjord. The same pattern of succession to 1972 was mentioned by Marshall and Orr (1927) for Loch Striven where the late spring population was made up of *Skeletonema* and *Chaetoceros cinctum*. During the summer the number of flagellates increased and there is more diversity in species composition. The dinoflagellates occurred irregularly throughout the year, mainly the species *Protoperidinium triquetra* with a summer maximum in both years. During August the common species were *Ceratium tripos, C. furca* and *Dinophysis* sp. Increased diversity was obtained during the late summer, mainly of *Chaetoceros* species with the appearance of *C. diadema, C. sociale* and *C. simplex*. During the autumn diatom increase in 1972 the common species were *Leptocylindricus danicus* and *Eucampia zodiacus* while during this period there is no increase in *Skeletonema* or *Thalassiosira* whilst there an increase in *Nitzschia seriata*.

Comparable results were obtained from the studies carried out by Jensen and Sakshaug (1973) in Trondheim fjord and Jones (1979) in Loch Creran. Those results showed that the spring populations were dominated by *Skeletonema costatum* with smaller numbers of *Thalassiosira gravida, T. decipiens* and *Chaetoceros debilis* or *C. sociale.*

The detailed survey carried out by Hannah (1979) in the Fairlie Channel during 1976 and 1977 showed a close similarity with the survey carried out by Hinton (1974) in the same area. The nutrient levels found were similar to those obtained by Hinton (1974), although the minimum values recorded for all three nutrients in 1977 were higher than those found in either the previous year or in 1974. The maximum nutrient levels were recorded during winter of which the highest were those found in 1976; phosphate levels were above 1 µg at P. l^{-1}; for nitrate nitrogen the maximum was 17.9 µg at N. l^{-1}; whilst for dissolved silica the maximum was 13.1 µg at Si. l^{-1}. The seasonal cycles of all three nutrients showed that the minimum values were recorded during late spring and early summer.

The seasonal pattern for dissolved silica showed high levels during the winter months until early March with quantities ranging from 6.9 to 13.1 µg at Si. l^{-1}. During the spring diatom increase the dissolved silica levels decreased rapidly, from around 7 µg at Si. l^{-1} during March 1976 to around 3 µg at Si. l^{-1} during April. After the main period of the spring outburst the levels were further reduced reaching a minimum of 0.21 µg at Si. l^{-1} on 5 May. The levels remained low over summer and then gradually increased from September onwards. In the following year, dissolved silica levels remained high until mid - April when a decline from 6.3 µg at Si. l^{-1} on 21 April to 0.95 µg at Si. l^{-1} was observed within a week.

The seasonal pattern of nitrate nitrogen showed that the decrease during the spring outburst from the high winter values was more gradual than that of dissolved silica. In 1976, the high winter values did not start to decrease until 8 April, declining from 17.9

µg at N. l^{-1} to 4.75 µg at N. l^{-1} in the middle of May. A brief increase in nitrate levels was recorded at the end of May, after which low levels were found, reaching a minimum of 0.75 µg at N. l^{-1} in the middle of July. From September onwards, values increased reaching a maximum level of 21.9 µg at N. l^{-1} on 17 February. In the spring of 1977, nitrate levels decreased from 13.3 µg at N. l^{-1} on 21 April to 4.5 µg at N. l^{-1} on 28 April, succeeded by an increase until 12 May and followed by a gradual decrease to reach a minimum of 1.24 µg at N. l^{-1} on 21 July.

The seasonal cycle of phosphate showed that during the spring diatom increase in early April 1976, there was a drop from 1.78 µg at P. l^{-1} on 8 April to 0.8 µg at P. l^{-1} on 15 April, while the levels continued to decrease until 29 April when there was a slight increase, after which the levels gradually decreased reaching a minimum value of 0.12 µg at P. l^{-1} on 24 June. Levels rose during autumn and remained high over winter. The following decrease during the spring diatom increase of 1977 was not pronounced, with levels dropping from 0.97 µg at P. l^{-1} on 21 April to 0.51 µg at P. l^{-1} on 28 April, with the levels remaining around this value for most of the summer with a recorded minimum of 0.31 µg at P. l^{-1} on 21 July.

Similarly Hannah and Boney (1983)and Boney (1986) stated that the autumn and winter build - up of all nutrients was evident and there was a marked decline in nutrient levels during the spring diatom increase mainly at late March and early April, the decline of dissolved silica being the most striking. Variable levels were obtained during the summer months, with the maximum levels recorded during the winter.

The standing crop levels were discussed by Hannah (1979) in terms of chlorophyll and carbon fixation. The changes in chlorophyll were closely paralleled by the changes in the amounts of carbon fixed. The total chlorophyll levels recorded by Hannah (1979) during the different seasons were of similar magnitude to those found by Hinton (1974). Also discussed by Hannah (1979) was the phytoplankton composition of the algal

population. During the spring diatom increase of 1976 the population was dominated by *Skeletonema costatum* with *Thalassiosira nordenskioldii* and *Nitzschia seriata* being present in large numbers. Chlorophyll and productivity levels began to rise rapidly between 25 March and 31 March. The annual recorded maximum for photosynthetic activity was found on 8 April (44 mg C m^{-3}. h^{-1}) and maximum chlorophyll four days later on 12 April (10.51 mg m^{-3}). After this increase, both the chlorophyll and productivity began to decrease. During the summer an increase in the total number of algal cells was observed, which probably caused the increase in chlorophyll (6.04 mg m^3) and photosynthetic output (47.8 mg C m^{-3}. h^{-1}). *Chaetoceros* spp succeeded *Skeletonema* as the dominant diatom species in the surface samples whist *Skeletonema* remained dominant at 5 and 10 metres depth. *Rhizosolenia deliculata* began to appear in numbers from 24 June, several dinoflagellate species including *Ceratium furca, C. tripos* and *Dinophysis* sp. On 9 July high chlorophyll (7mg m^{-3}) and productivity levels (66.6 mg C m^{-3}. h^{-1}) were recorded, which were caused by a large increase in diatom numbers. The most prominent species were *Thalassiosira* spp., *Chaetoceros* spp., *Rhizosolenia deliculata* and *Guinardia flaccida.* In mid - July, the diatoms were succeeded by dinoflagellates, including *Dinophysis acuta* which was common, *Protoperidinium* spp., *Ceratium fusus* and *C. tripos*. Chlorophyll levels at this time ranged from 0.5 to 1.5 mg m^{-3}. At the end of July diatoms re-established as the dominant fraction of the population, with *Ceratulina pelagica* present in large numbers, also *Chaetoceros* spp., *Thalassiosira* spp., and *Rhizosolenia deliculata;* also observed were non - thecate dinoflagellates. During autumn, in September the algal population was made up mainly of *Leptocylindrus danicus* and *Chaetoceros* spp., with non - thecate dinoflagellates and green flagellates. During the early part of this month reasonably high surface carbon fixation (20.6 mg C m^{-3}. h^{-1}) and chlorophyll levels (2.97 mg -m^3) were recorded on 9 September. By the end of this month and into October the surface chlorophyll level was below 0.5 mg m^{-3}. At this time green flagellates, cryptomonads and non - thecate dinoflagellates were observed. During winter, minimum carbon fixation levels were found (less than 1 mg C m^{-3}. h^{-1} on occasions at the surface) with

lower levels at deeper waters. The average chlorophyll value during November and December was 0.27 mg m^{-3}. The spring diatom increase of 1977 was later in commencing than in 1976, whilst chlorophyll surface levels remained at approximately 0.5 mg m^{-3} until 14 April when the surface quantities rose to 1.25 mg m^{-3} with a further increase to 4.76 mg m^{-3} on 21 April, and with a carbon fixation level of 15.5 mg C m^{-3} h^{-1}. The maximum chlorophyll and photosynthetic activity levels were lower during the spring increase in 1977 than in the previous year and instead of a sharp increase and decline over a short period, the increased levels persisted into May longer than in 1976. *Skeletonema costatum* was the dominant species, followed by *Thalassiosira nordenskioldii* and *Chaetoceros* spp. Also common was *Nitzschia seriata*. Throughout May *Skeletonema* remained dominant with smaller numbers of *Thalassiosira* and *Chaetoceros*. During the summer months a much more mixed population was observed. *Thalassiosira* spp succeeded *Skeletonema* as the dominant species, also found in large numbers was *Chaetoceros* spp. Also observed were *Nitzschia closterium*, *N. seriata*, *Leptocylindrus danicus*, *Protoperidinium* spp and flagellates which included representatives of the classes Prasinophyceae, Chlorophyceae and Prymnesiophyceae. Chlorophyll and carbon fixation levels were generally low ranging from 1 - 2 mg m^{-3} and 5 - 13 mg C m^{-3}. h^{-1} with the exception of a clear increase on 8 June (chlorophyll - 4.83 mg m^{-3}). During July and August productivity and biomass levels were generally high. During this period the most common diatoms were *Chaetoceros* spp and *N. seriata*, *Skeletonema* and *Thalassiosira* spp being of lesser importance. Also observed were a small number of dinoflagellates. During autumn a large increase in the algal population was observed on 22 September, which was reflected into the high chlorophyll (7.8 mg m^{-3}) and high carbon fixation levels (55.7 mg C m^{-3}. h^{-1}). Most of the population was made up of *N. seriata* accompanied by *Skeletonema*, *Thalassiosira*, *Rhizosolenia* and *Eucampia zodiacus*. From October onwards the levels of phytoplankton activity in terms of biomass and productivity decreased.

The phytoplankton community covers a wide range of size and shape. The traditional studies dealt with the phytoplankton community as one unit, emphasizing the role of diatoms and dinoflagellates in the primary production. Most of those studies used net sampling methods to assess populations and biomass. Lohmann (1903) stated that an unknown part of the algal biomass was not retained by the nets, due to the fact that those cells were too small, and he referred to them as the "nanoplankton", whilst the algal cells retained by the nets were the "netplankton". Several schemes have been proposed for the classification of phytoplankton according to size. The system used in this study was that proposed by Dussart (1965), in which the netplankton category includes cells with size ≥20 µm, with no distinction between microplankton ≥20 <200 µm, mesoplankton ≥200<2000 µm and megaplankton ≥2000 µm, whilst the nanoplankton is considered to consist of cells ≥2<20 µm, with no distinction between nanoplankton and ultraplankton. In this study the organisms retained by 100 µm, 50 µm and 20 µm mesh net represented netplankton category; organisms retained by 10 µm, 5 µm mesh net and 0.45 µm millipore filter represented the nanoplankton category, this fraction also including the picoplankton (0.2 - 2 µm).

Steeman Nielsen (1938), Atkins (1945), Harvey (1950), Knight - Jones and Walne (1951) and Davies (1956) demonstrated that a large proportion of the phytoplankton population was too small to be retained by plankton nets.

Ballantine (1953) assessed the six methods available at that time for estimating the nanoplankton component and concluded that cell counts of water samples concentrated by centrifugation gave the most reliable results. The use of chlorophyll determinations provided accurate method of assessing the size fractions of phytoplankton populations (Richards and Thomson, 1952). Since its introduction (Steemann Nielsen 1952) the ^{14}C technique has become a principal method for estimating phytoplankton productivity. From the beginning, experimenters have size - fractionated natural populations to estimate the productivity of the size classes (e.g. Steemann Nielsen and

Jensen 1957). The usefulness of size fractionation depends on two key assumptions: first, that the size classes reflect meaningful floristic, trophodynamic, or physiological groupings; and second, that the mechanics of size fractionation induce no adverse changes in the property or process of interest (i.e. screened cells are or act the same as unscreened cells). The first assumption appears valid. Results from several studies indicate that floristically or ecologically useful separations can be made by careful choice of screen type or pore size (Berman 1975; Sieburth et al. 1978; Furnas 1983). The second assumption is harder to validate. It is generally assumed that gently screened cells behave as unscreened cells and that differences between measured rates of carbon uptake in pre- and post- screened treatments reflect rates of predation (Li 1984) or heterotrophic carbon transfer within aquatic microbial assemblages (Larsson and Hagstrom 1982; Ward 1984). Tests of screening effects on production rates have been limited to parallel comparisons between pre- and post- fractionated samples (McCarthy et al. 1974; Takahashi and Beifang 1983; Smith et al. 1985). Data from experiments done in tropical and subtropical waters generally indicate that prescreening depresses ^{14}C uptake (Herbland and Le Bouteiller 1981; Platt et al. 1983; Takahashi and Beifang 1983), but some results from temperate waters indicate stimulation (McCarthy et al. 1974; Li 1984). In notes published by Furnas (1987), about the effects of prescreening on on productivity of size - fractionated phytoplankton, it is stated that prescreening of natural phytoplankton populations reduced biomass-specific primary productivity, as measured by incorporation of [^{14}C] bicarbonate. Incorporation of ^{14}C by prescreened populations in light bottles decreased relative to unscreened populations while assimilation of ^{14}C increased in dark bottles. These trends were less pronounced in populations collected from the base of the euophotic zone. The magnitude of the screening effect was inversely related to pore size of the screen with ultra- (<5 μm) and picoplankton- (<2 μm) sized algae being effected most strongly. Prescreening through 10 μm nylon netting had relatively minor impact on estimates of chlorophyll - specific productivity.

The ecological significance of net and nanoplankton categories lies in the role of cell size in phytoplankton community dynamics. Typically, small cells have shorter generation times and higher growth rates in a given environment than do larger cells, presumably owing to the high surface area - to - volume ratios of smaller cells (Odum 1956 and Williams 1964). In addition, the relative levels of nanoplankton and netplankton productivity and standing crop should be reflected in the distributions and abundances of herbivores that selectively graze one group or the other (Mullin 1963). The investigations in both temperate (Yentsch and Ryther 1959; Gilmartin 1964; Anderson 1965) and tropical waters (Steemann Nielsen and Jensen 1957; Holmes 1958) have demonstrated that nanoplankton are often responsible for 80 - 99% of the observed phytoplankton productivity. Spatial netplankton - to - nanoplakton transitions can occur in response to transitions in temperature, water - column stability and nutrient availability and significantly impact algal photosynthetic responses (Malone, 1981). The development of phytoplankton communities dominated by nano and picoplankton - sized algae often are accompanied by a floristic shift from diatoms and dinoflagellates towards cyanobacteria and microflagellates (Malone, 1981; Glover et al., 1986). Compared to netplankton, these smaller phytoplankton are reported to have increased assimilation rates, photosynthetic efficiencies and cell - division rates (Malone, 1981; Geider et al. 1986).

The studies carried out by Lund(1961) and Findenegg(1965) of fresh water lakes in England and Switzerland found that in the oligotrophic lakes where the overall production was low the nanoplankton fraction dominated the population. Findennegg(1965) stated that generally the nanoplankton fraction assimilated more carbon per unit biomass than did larger diatoms or blue - green algae. The same findings were stated by Rodhe(1958). In the eutrophic condition, although the nanoplankton population make a significant contribution to the biomass and productivity, it is less important than that in the oligotrophic situation. Kalff(1972) found that in a eutrophic lake in Quebec, Canada, the algal cells <64μm contributed 9[illegible]

99% of the total algal biomass and around 75% of the productivity, while cells <20μm contributed 50%of the productivity. Gelin(1975), found that 50% of the productivity was accounted for by the <20μm fraction of the phytoplankton, in a study of a Swedish lake.

The contribution of the nanoplankton fraction to the photosynthetic output in marine tropical waters has been studied by Steemen Nielsen and Jensen (1957), Teixeria (1963), Saijo (1964), Sumitra Vijayaraghawan, Joseph and Balachandran (1974), Pant, Bhargava and Goswami (1976), Malone (1971a) and Beers, Reid and Stewart (1975). In the temperate waters the contribution of the nanoplankton population to the total photosynthetic activity has been documented by Yentsch and Ryther (1959), Holmes and Anderson (1961), Gilmartin (1964), Malone (1971b), McCarthy, Taylor and Loftus (1974), Garrison (1976) and Revelente and Gilmartin (1976).

The contribution of the nanoplankton population to the total organic productivity in colder waters has been documented by Digby (1953), Kawamura (1960), Reynolds (1973), Fay (1975) and Throndsen and Heindal (1976). The results from these studies are summarised in Table 1. 1.

The comparison between the different studies in Table 1 was difficult, due to the widely different mesh sizes used to separate the netplankton from the nanoplankton (5 - 110μm). Generally the nanoplankton population often accounted for between 50 to 100% of the total algal biomass and total productivity. The netplankton population was dominant in neritic habitats where generally nutrient - rich waters were found (Digby, 1953; Steemann Nielsen and Jensen, 1957; Subrahamanyan and Sarma, 1965; Malone, 1971b). The nanoplankton fraction was dominant in oceanic environments where the nutrient levels were low (Malone, 1971a; Beers et al, 1975). Malone (1971a) noted that the mean photosynthetic activity of the nanoplankton population did not show a significant variation between oceanic and neritic environments whilst in the case of netplankton population a significant increase in productivity levels were found

in neritic areas, therefore the higher productivity levels associated with neritic areas was mainly due to the increase in netplankton.

From the different data it is quite apparent that the nanoplankton fraction represented the more stable component of the phytoplankton population, also it is less effected by the seasonal fluctuations observed with the netplankton (Yentsch and Ryther, 1959; Teixeira et al, 1967). Considerable seasonal variations in the nanoplankton biomass were observed (Kalff, 1972; Sumitra Vijayaraghavan et al, 1974).

The assimilation number (mg C / mg chlorophyll a . h^{-1} at light saturation, as defined by Yentsch and Ryther, 1959) when used as an indicator of growth rates of phytoplankton population indicated that the assimilation number for the nanoplankton size fractions was higher than that for the netplankton fractions (Saiyo and Takasue, 1965; Malone, 1971; Gelin, 1975) indicating higher growth rates. On some occasions there is no significant differences between the mean assimilation numbers of the different size fractions (e.g Durbin et al, 1975).

These higher growth rates for the nanoplankton population can be associated with the higher surface area to volume ratios. Generally the small cells have shorter generation times and higher growth rates (Williams, 1964; Findenegg, 1965; Eppley and Sloan, 1966; Eppley and Thomas, 1969; Eppley et al, 1967; Banse, 1976). Under stratified conditions the high surface area to volume ratios increases the bouyancy which facilitate the suspension of the cells which in turn increases the time spent by the nanoplankton size fractions in the euphotic zone (Munk and Riley, 1952; Smayda and Boleyn, 1966; Eppley et al, 1967; Smayda, 1970).

Table. 1. 1. Contribution of the nanoplankton to the total standing crop and productivity in different localities: values expressed as % of the total phytoplankton.

Locality and latitude	Size range Max (µm)	Nanoplankton as % of total			Reference
		No. of cells	Chlorophyll	C^{14} uptake	
Tropical waters					
Temperate & tropical waters	50			94% oceanic	Steeman, Nielsen & Jensen, 1957
Equatorial Atlantic 0^0	65	77%		90%	Teixeira, 1963
Indian ocean	110			95%	Saijo, 1964
10^0 N - 20^0 S	5			22 - 49%	
Indian costal waters - Cochin 10° N	50	4 - 58%	50 - 93%	36 - 94%	Sumitra Vijayaraghavan et al, 1974
Indian costal waters Porto Novo 12° N	20		33 - 100%		Ramadhas et al, 1975
Goa waters India 15° N	60	>90%	>90%	>90%	Pant et al, 1976
Tropical Pacific 5° N - 25° N	22		66 - 100%	80 - 100%	Malone, 1971b
Peru current 10° S - 10° N	22		80 - 96%	87 - 99%	Malone, 1971b
North Pacific Gyre 28° N	20	99%			Beers et al, 1975
Temperate waters					
Vineyard sound 41° N	65	91%	92%	98%	Yentch & Ryther, 1959
Puget sound 48° N	35			>50 - 90%	Holmes & Anderson, 1961
British Columbian fjord 49° N	56			>90%	Gilmartin, 1964

Table. 1. 1. (cont).

Locality and latitude	Size range Max (μm)	Nanoplankton as % of total: No. of cells	Chlorophyll	C^{14} up take	Reference
Monterey Bay 35° N - 50° N	22		60 - 90%	60 - 90%	Malone, 1971a
35° N - 50° N	22		up to 82% (6% in upwelling period)	up to 95% (7% in upwelling period)	Garrison, 1976
Chesapeake Bay 37° N - 39° N	35 10		93% 81%	100% 94%	McCarthy et al, 1974
Chesapeake Bay 37° N - 39° N	10		81 - 88%	65 - 75%	Van Valkenburg & Flemer, 1974
Narragansett Bay 45° N	20		47%	51%	Durbin et al, 1975
Northern Adriatic 45° N	20	74 - 88%	62 - 76%		Revelante & Gilmartin, 1976
Colder waters					
Ocean Weather station (P) - Pacific 50° N	10		75%		McAllister et al, 1960
North Pacific & Bering Sea 45° N - 60° N	110			44 - 84%	Kawamura, 1960
North Sea - South Bight 51° N - 52° N	50			43%	Mommaerts, 1973
Barents Sea 62° N - 82° N	25		55 - 90%		Reynolds, 1973
Tromso, Norway 60° N	20 5			7% (Summer) 85% (Winter) 6% (Summer) 73% (Winter)	Throndsen & Heindal, 1976
Antarctic Sea 45° S - 79° S	35		73.9%	72.5%	Fay, 1973

The grazing carried out by herbivores was of importance in affecting the size distribution of the phytoplankton. The nanoplankton fraction appears to be grazed mainly by planktonic invertebrate larvae and microzooplankton (Cole, 1936; Bruce et al, 1940; Thorson, 1950; Beers and Stewart, 1969; Parsons and Le Brasseur, 1970). Herbivorous copepods selectively graze on the larger netplankton fraction (Marshall and Orr, 1955; Mullin, 1963; Conover, 1966; Richman and Rogers, 1969; Richman et al, 1977).

The relationship between chlorophyll a specific photosynthesis and light intensity follows saturation kinetics and can be specified in terms of saturated photosynthesis and photosynthetic efficiency at low light intensity (Platt et al, 1977). Although it has been argued that photosynthetic efficiency (Dunstan, 1973; Bannister, 1974) and saturated photosynthesis (Ryther, 1956; Ryther and Yentsch, 1958) can be considered constants independent of species and environmental conditions, it appears that both parameters vary significantly (cf. Platt and Jassby, 1976).

Chlorophyll a concentrations tend to be better correlated with surface area than with either volume or number of cells (Paasche, 1960; Smayda, 1965) so that chlorophyll a volume can be inversely related to cell size (Eppley and Sloan, 1966; Eppley et al, 1969; Taguchi, 1976). Thus, photosynthetic efficiency and saturated photosynthesis have been found to be inversely related to cell size (Taguchi, 1976), and variations in photosynthetic efficiency and saturated photosynthesis for natural assemblages of phytoplankton populations could reflect the size distribution of phytoplankton cells (Eppley, 1972; Platt and Jassby, 1976).

However, the size - dependency of photosynthetic parameters is modified by environmental effects. Platt and Jassby (1976) found that photosynthetic efficiency was correlated with incident solar radiation when averaged over 3 days while saturated photosynthesis was correlated with temperature. Saturated photosynthesis has been

reported to vary with nutrient concentration (Curl and Small, 1965; Thomas, 1970; Malone, 1971a; Takahashi et al, 1973), temperature (Durbin et al, 1975; Malone, 1976, 1977a), light history (Jorgensen, 1969; Beardall and Morris, 1976) and time of day (MacCaull and Platt, 1977).

Size and environmental effects are complicated by the ability of cells to store environmental information. Factors such as temperature, nutrient status of cells and light history can influence photosynthetic efficiency and saturated photosynthesis (their effects on chlorophyll a concentration and concentrations of accessory pigments (Eppley and Sloan, 1966; Halldal, 1970; Thomas and Dodson, 1972; Eppley, 1972; Yoder, 1979). Since chain - length as well as cell size can infuence the environmental history of cells (Malone, 1971b, 1977b; Malone and Chervin, 1979), it follows that chain forming diatoms might exhibit photosynthetic characteristics that are different from those of solitary cells even if cell size is similar.

Malone and Neale (1981), in their study of parameters of light - dependent photosynthesis for phytoplankton size fractions in temperate, estuarine and coastal environments (Hudson Estuary, plume of the Hudson River, and offshore in the region of the shelf - break) reported that the photosynthetic parameters (saturated photosynthesis and photosynthetic efficiency at low light intensity) for netplankton (>22 μm) and nanoplankton (<22μm) varied over similar ranges but exhibited different seasonal and geographic patterns of variation. Nanoplankton photosynthetic efficiency was relatively constant (0.06 mg C [mg Chl. h]$^{-1}$ [μE m^{-2} s^{-1}]$^{-1}$), but saturated photosynthesis (mg C [mg Chl. d]$^{-1}$) was an exponential function of temperature independent of nutrient concentration and vertical stability in the euphotic zone. The temperature function gives a saturated photosynthesis of 24 at 25^{0} c for nanoplankton growing in the estuarine environment characterized by high nutrient concentrations and a shallow stratified euphotic zone. Variations in netplankton photosynthetic efficiency and saturated photosynthesis were less predictable and were not correlated with temperature, nutrients or vertical stability. Chain forming diatoms with small cells

were able to achieve high photosynthetic efficiencies (0.1 to 0.15) and saturated photosynthesis (20 to 24) that were 3 to 5 times higher than large - celled diatoms and dinoflagellates were able to achieve.

A conflicting report on different aspects of the ecology and the factors controlling the distribution of the nanoplankton in many habitats mainly in temperate, estuarine environments were unclear, as mentioned by Durbin et al, (1975). Jones and Spencer (1970) found that most of the phytoplankton population in the Menai Straits, Anglesey was made up of small flagellates and diatoms. During the period of this study the mean contribution value to the total standing crop by the netplankton fraction was 13%. Holligan and Harbour (1977) found that during the summer period at station E 1 in the English Channel, the small flagellates were dominant at surface, whilst dinoflagellates were dominant at sub - surface. During and immediately after the spring diatom increase the <10 μm cells accounted for more than 50% of the total photosynthetic activity. Similar results were obtained by Wood et al, (1973) in Loch Etive, to the north of the Firth of Clyde, where the micro - flagellates made a significant contribution to the total biomass during the spring increase. A larger degree of abundance for the μ - flagellates was recorded during autumn and winter. The seasonal cycles of the larger phytoplankton species in the Firth of Clyde have been well documented in the works of Marshall (1924) and Marshall and Orr (1927, 1930 and 1955) and reviewed in detail by Hinton (1974). The seasonal changes in nanoplankton organisms were studied by Marshall (in Marshall et al, 1934; Nicholls, 1933) by assessing the numbers of μ - flagellates present on several occasions in the Firth of Clyde in connection with the studies on *Calanus finmarchicus* grazing. Although present in large numbers at times, the nanoplankton was found not to be efficiently filtered by *Calanus finmarchicus* or its larval stages (Marshall and Orr, 1955, 1956).

Hannah (1979) and Hannah and Boney (1983) discussed in detail the changes in nanoplankton organisms and their contribution to the chlorophyll a and photosynthetic

activity in the Fairlie Channel. They stated that the nanoplankton fraction was made up predominantly of flagellates of maximum cell size <10 µm, many ranging between 2 - 5 µm. This fraction formed a stable component of the total phytoplankton population, fluctuating in terms of extracted chlorophyll and carbon fixed less dramatically than the netplankton fraction. In late autumn, winter and early spring the nanoplankton was the major component of the phytoplankton, whilst in spring and summer the diatoms were dominant. In the upper 10 metres of the water column the average percentage contribution of the nanoplankton was 50% of the total photosynthetic output and 60% of the chlorophyll during 1976 and 1977. During winter the nanoplankton population accounted for all of the photosynthetic activity.

The reports by Waterbury et al, (1979) and Johnson and Sieburth (1979) of the widespread distribution of small marine cyanobacteria and in freshwater (Paerl, 1977), must be considered as the beginning of the current upsurge of interest and research on small photosynthetic microbes in the sea and fresh water ecosystems. Although these reports were the first to show that cyanobacteria were widely distributed, the presence of small autotrophic algae has been known for many years. Lohmann (1911) described unicellular blue - green algae in marine plankton and Gross (1937) commented on the difficulties of establishing cultures of diatoms because flagellates, some as small as 2 µm, would grow in vast numbers in the enrichment cultures. The early reports by Waterbury et al, (1979) and Johnson and Sieburth (1979) were concerned with cyanobacteria which were readily identified with epifluorescence microscopy by the orange fluorescence due to phycoerythrin. However, it is now known that very small euokaryotic algae (<2 µm) are also present in many regions and are true components of the picoplankton. There have been many reports on the quantitative importance of small phytoplankton cells in various marine provinces, from polar seas to tropics (Gieskes et al, 1979; Krempin and Sullivan, 1981; Joint and Pomroy, 1983; Li et al, 1983; Platt et al, 1983; Takahashi and Bienfang, 1983; Bienfang et al, 1984; Douglas, 1984; Takahashi and Hori, 1984; Murphy and Haugen , 1985; Smith et al,

1985). These small cells have come to be known as picoplankton, which was defined by Sieburth et al, (1978) as microbes between 0.2 and 2 μm.

It is generally accepted that the picoplankton is adapted to growth at low light. If this generalisation is true, the vertical distribution of picoplankton in different sea areas should reflect this adaptation and picoplankton might be expected to be restricted to regions such as the pycnocline, where dispersion is reduced and the cells are less likely to be advected into surface waters where irrediance is high. However, this does not seem to be the case; in their initial report of cyanobacterial picoplankton, Waterbury et al, (1979) found highest numbers in the surface waters. Johnson and Sieburth (1979) reported very similar cell densities at 50 and 100 metres in the Sargasso Sea and Caribbean, but they did comment that a morphologically different cyanobacterium, with more closely spaced thylakoids, was only found in samples collected from 100 metres in oceanic waters. In warm oligotrophic regions of the oceans , seasonal variations in temperature are small and there is a permanent, strong pycnocline; a distinct chlorophyll maximum is usually associated with this pycnocline and chlorophyll concentrations are often an order of magnitude greater in this layer than in the surface mixed layer. Bienfang and Szyper (1981) found that small phytoplankton (<5 μm) accounted for more than 80% of the biomass in the chlorophyll maximum in waters off Hawaii. In a subsequent study, Takahashi and Bienfang (1983) used 3 μm pore size filters and again found 80% of the chlorophyll associated with cells <3 μm. Therefore, the subsurface chlorophyll maximum in these waters appears to be dominated by picoplankton. However, picoplankton was also present in surface waters (Bienfang and Takahashi, 1983) and no information is available to indicate whether there were differences in species composition of the picoplankton from the subsurface chlorophyll maximum and from the surface mixed layer.

Because of their extremely small size, algal picoplankton have very rapid nutrient uptake rates (Friebele et al, 1978; Lehman and Sandgren, 1982; Suttle and Harrison,

1986). Although Lehman and Sandgren (1982) reported a short - lived (few minutes) sustainability of the high uptake rate. Suttle and Harrison (1986) using *Synechococcus* from a coastal British Columbia lake showed little or no reduction of the uptake rate per cell in response to increasing cellular-p (permeability) over a period of at least 100 minutes. If the latter observation is found to be widespread, then the ability to sustain high uptake rates while cell quota is rapidly increasing should confer competitive advantage in areas where ephemeral pulses of elevated nutrient concentration exist. Evidence for such pulsing has been reported for oceanic regions (Holligan et al, 1985; Jenkins and Goldman, 1985).

The paper by Gieskes et al, (1979) was one of the first to report significant carbon fixation by cells which passed through a 1 µm pore - size sieve. In their study of primary production in the North Equatorial Current in the tropical Atlantic, they found 20 - 30% of ^{14}C and 43 - 53% of the chlorophyll a passed through a 1µm Unipore filter. These measurements were done in 1977 and 1978, before the first publications of cyanobacterial picoplankton abundance and Gieskes et al, (1979) did not comment on the ecological significance of this fixation. However, it is probable that the ^{14}C fixation which passed through the 1 µm pore filter was the result of picoplankton activity. Therefore, this early work by Gieskes et al. suggests that 20 -30% of the photosynthetic activity in the tropical Atlantic was by cells <1 µm, 16% was by cells <3 µm and 16 - 31% was by cells 3 - 8 µm.

Li et al, (1983) studied two sites in the tropical Pacific and found that the percentage of ^{14}C fixation which passed through a 1 µm Nucleopore filter increased with depth. In experiments with light - attenuated deck incubators, 20% of ^{14}C fixation in the surface waters was by picoplankton <1µm but this proportion increased with depth and was up to 80% of total fixation at the equivalent of 70 metres depth. Field data by other workers have shown that picoplankton photosynthesis saturates at low irradiance, with maximum contributions to primary production at the base of the euphotic zone (Morris

and Glover, 1981 and Iturriaga and Mitchell, 1986). In the subtropical Atlantic, Platt et al, (1983) also found significant picoplankton production and calculated that picoplankton <1 μm was capable of supplying about 60% of the total primary production at this open ocean ecosystem west of the Azores. These estimates were again based on experiments using ^{14}C and were made on water samples taken from the subsurface chlorophyll maximum. Takahashi and Bienfang (1983) found 77 - 82% of the total ^{14}C fixation in waters off Hawaii was by phytoplankton <3 μm. Using a different approach, Bienfang and Takahashi (1983) estimated specific growth rates by following the change in chlorophyll concentration after size fractionation of water samples through 3 μm sieves; the prefiltration was designed to remove grazing organisms and, hence, any change in chlorophyll concentration should be the result of growth of the population on the absence of grazing pressure. The assumptions made in this type of experiment are open to criticism because it is difficult to demonstrate the total absence of grazing organisms; nevertheless, these experiments suggested that picoplankton <3 μm had growth rates equivalent to 1.3 to 2.5 doublings d^{-1}. In contrast the calculated growth rate of picoplankton from the chlorophyll maximum studied by Platt et al. was 0.22 doublings d^{-1} for the picoplankton <1 μm and 0.07 doublings d^{-1} for phytoplankton >1 μm. The differences in the growth rates between these two experiments could be attributed to the different conditions under which these experiments were carried out. The experiments of Bienfang and Takahashi (1983) were carried out on water samples taken from near shore and and incubated at high light (250 $\mu E. m^{-2}. s^{-1}$) and it is difficult to draw any comparison with the estimate of Platt et al, (1983) which indicate a growth rate only 10% of that suggested by Bienfang and Takahashi (1983).

Picoplankton production is also significant in temperate waters. In waters of the European continental shelf, Joint and Pomroy (1983) found that picoplankton (<1 μm) accounted for 20 - 30% of the total productivity in the summer months. Joint et al, (1986) have determined rates of primary production for size - fractionated populations

in waters of the continental shelf and shelf slope of the Celtic sea during all seasons. They found that picoplankton (<1 μm) production was greatest during summer (about 20 to 30% of the primary production), but was always less than that of the small nanoplankton (cells 1 to 5 μm), which accounted for most of the primary production throughout the year. In winter, picoplankton contributed 13% to the primary production, while small nanoplankton contributed 70%. In the eastern Canadian arctic, Smith et al, (1985) found picoplankton responsible for 10 - 25% of the primary production in late summer. Evidence from Joint and Pomroy, (1983), Douglas, (1984) and Joint et al, (1986) indicated that the picoplankton size fraction appears to be less important in temperate high latitude waters than in tropical and subtropical waters, where it may contribute 60 to 80% of the primary production (Li et al, 1983; Platt et al, 1983; Iturriaga and Mitchel, 1986).

Krempin and Sullivan (1981) reported the seasonal abundance of cyanobacteria in coastal waters off southern California; maximum numbers were found in August when the population reached 0.1 x 10^4 cells. ml^{-1} and the population minimum was in February and March when 7 x 10^4 cells. ml^{-1} were present. In their study of the seasonal primary production in the Celtic Sea by different size fractions of phytoplankton, (Joint et al, 1986) reported that the greatest measured monthly production was in the <5 μm fraction in April when the spring diatom increase occurred in the Celtic Sea (Fasham et al, 1983); the production of 18.5 g C. m^{-2}. yr^{-1} in April accounts for almost half of the annual production by phytoplankton >5 μm and occurred before the develpment of maximum copepod biomass in the area. An estimate of total primary production (but excluding dissolved organic carbon production which was about 10 - 15% of the total fixation) shows that small nanoplankton is most significant in the Celtic Sea and fixed about 42 g C. m^{-2}. yr^{-1} (40.7% of the total fixation). Picoplankton (<1 μm) fixed 23.1 g C. m^{-2}. yr^{-1} (22.4% of the total photosynthetic activity) and phytoplankton >5 μm fixed 37.9 g C. m^{-2}. yr^{-1} (36.8% of the total photosynthetic out put). Picoplankton production was highest in spring, immediately after the spring

diatom increase and again in August. At both times, nutrient levels were low (nitrate <0.1 μmol. l^{-1}) and chlorophyll a concentrations in the surface mixed layer were <0.5 mg. m^{-3}. Picoplankton production was low in winter (13 mg C. m^{-2}. d^{-1} by cells <1μm, out of a total daily production of 99 mg. C. m^{-2}. d^{-1}); small nanoplankton (<5 to >1 μm) were the most productive fraction in winter (67.4 mg C. m^{-2}. d^{-1}). Similarly Joint and Pomroy, (1983) reported that a significant proportion of the total primary production in the Celtic Sea (50° 30'N; 07°00'W) has been found to be due to picoplankton and small nanoplankton. In July, August and October, 1982, 20 to 25% of the ^{14}C fixed in primary production was in organisms >5 μm, 35 to 40% was in organisms <5 - >1 μm and 20 to 30% was in organisms <1 μm.

Hannah and Boney (1983) working in the nearshore waters of the Firth of Clyde, also found that small nanoplankton was dominant in winter and commented that all the carbon fixation in the winter could be attributed to the nanoplankton. Therefore, picoplankton production in the temperate waters of the European continental shelf is most significant in the summer months in those regions where a seasonal thermocline results in long periods of stable surface stratification and when ambient nutrient concentrations are low.

Prezelin et al, (1987) have documented the range of variability possible in diurnal patterns of size - fractioned photosynthesis and ilustrated a general view of the size dependency in assimilation rates and diurnal patterns. In July 1985, diurnal patterns of photosynthesis and pigmentation were characterized for whole water (>0.4 μm) and size - fractioned (≥5 μm and 0.4 to 5 μm) communities from three light depths sampled across a coastal thermal front in the southern California Bight. Variations in chlorophyll a and accessory pigment - to - chlorophyll a ratios showed no obvious diurnal trend. Timing of peak photosynthesis potential (P -max) and its coincidence with variations in light limited rates of photosynthesis (alpha), as well as diurnal amplitudes in (P max) and alpha, often differed between size fractions sampled within

the same community. The same was true for identical size fractions collected from different depths and stations transecting the front. Primary productivity was 20 - fold greater on the cold water side, where >5 μm diatoms dominated the mixed layer and accounted for 80% of the day time productivity. Diatoms collected from the top and the bottom of the upper mixed layer displayed nearly identical diurnal patterns in P max and alpha. Above the pycnocline, the 0.4 to 5 μm fraction had lower assimilation rates than the >5 μm fraction and smaller diurnal amplitudes in P max and or alpha. Within the front, the 0.4 to 5 μm fraction accounted for two - thirds of the algal biomass and >90% of primary production.

The work presented in this thesis can be divided into two parts. The first part describes the seasonal variation of phytoplankton biomass and composition and the seasonal changes in the standing crop in terms of chlorophyll a levels and the amount of ^{14}C fixed accompanied by a qualitative analysis of the different algal pigments during the different seasons; all this in relation with the seasonal changes in nutrient levels and weather conditions. The second part was aimed to assess the importance of the different size fractions of algal cells including netplankton, nanoplankton and picoplankton in terms of the contribution of each fraction to the total primary production. The principal aim of this research was to add a further dimension to the well - investigated phytoplankton of the Firth of Clyde.

2. Materials and Methods

2.1. Sampling methods:

Sampling was carried out at two stations, 9 and 11, in the Fairlie Channel in the Firth of Clyde (Figure. 1. 2.). Surface samples were collected by means of a clean plastic bucket, depth samples 1, 5 and 10 meters as required were collected by means of a 5 litre Van Dorn sampler (see Figure. 2. 1.). Samples were filtered through a plankton netting with a pore size of 212 µm to remove zooplankton and other large particulate matter, samples were then transferred to a clean 5 litre polythene container, subsamples from these were taken for different analyses. Samples for productivity measurements were stored in 1 litre dark polythene bottles. The temperature and salinity measurements for the period from 10. 3. 86 till 22. 4. '87 were made at the times of sampling using a combined salinity and temperature probe (Mc5 mark 11) supplied by Electronic Switchgear. For the rest of the sampling period the sea surface temperature and salinity measurements were obtained from the Marine Station at Millport.

2.2. Nutrient analysis:

2.2.1. Determination of reactive phosphorus:

The principal form of dissolved phosphorus in sea water is inorganic orthophosphate which is usually designated as phosphate. In the pH range of sea water orthophosphate ions (PO_4^{-3}) are associated as (HPO_4^{-2}) and usually this analytically defined fraction is described as reactive phosphate.

All the methods for the determination of dissolved phosphate in sea water are based on the reaction of the ions with an acidified molybdate reagent to yield a phosphomolybdate complex, which is then reduced to a highly coloured blue compound. The method used in this study was that described by Strickland and Parsons (1972) which is based on the method of Murphy and Riley (1962).

Figure. 2, 1. 5 litres capacity Van Dorn sampler.

The greatest advantage of using this method in which ascorbic acid used as reductant is that the blue phosphomolybdic complex formed is stable for hours and that the colour intensity is not influenced by variations in salinity.

This method has a range of measurement which lies between (0.03 - 5 µg at. l^{-1}). The following reagents were used for the analysis and were prepared as follows:

1)Ammonium molybdate solution: 15 gm of Analar quality ammonium paramolybdate $(NH_4)_6MO_7O_{24}$. $4H_2O$ were dissolved in a distilled water and diluted to 500 ml and then stored in dark polythene bottle out of direct sun light.

2)Sulphuric acid solution: 140 ml of analytical quality concentrated sulphuric acid was added to 900 ml of distilled water. After cooling this solution was stored in a glass bottle and was stable indefinitely.

3)Ascorbic acid solution: 27 gm of good quality ascorbic acid was dissolved in 500 ml of distilled water. This solution was prepared freshly in small quantities before each analysis.

4)Potassium antimonyl - tartrate solution: 0.34 gm of Analar quality potassium antimonyl - tartrate [K Sb $C_4H_4O_7$. $1/2H_2O$] were dissolved in 250 ml of distilled water. This solution was stored in a polythene bottle and prepared every two or three months.

5)Mixed reagent: This reagent was prepared by mixing 100 ml of ammonium molybdate, 250 ml sulphuric acid, 100 ml ascorbic acid and 50 ml potassium antimonyl - tartrate solutions. This reagent was prepared for immediate use and any excess was discarded.

6)Phosphate standard solution: This solution was prepared by dissolving 0.816 gm of anhydrous potassium dihydrogen phosphate, KH_2PO_4, in 1000 ml of distilled water. This solution was stored in a dark bottle with 1 ml of chloroform; 1 ml of this solution contained 6 µg at. phosphate P. 10 ml of this solution was diluted to 100- ml with distilled water to make the appropriate standard. This solution was prepared for immediate use. Two standards of 5 ml of this diluted solution were prepared in which

the volumewas made up to exactly 100 ml with distilled water in a 100 ml graduated measuring cylinder. This solution has a concentration of 3 µg at P. l^{-1}.

were
Samples after being collected brought back to the laboratory and immediately filtered under slight negative pressure through Whatman glass fibre filter papers after being filtered through a nylon plankton netting with a pore size of 212 µm to remove zooplankton and other large particulate matter. After warming the samples to a temperature of 20 ^{0}C in a water bath 5 ml of mixed reagent was pipetted to each 100 ml of sample and mixed thoroughly. After one hour the extinction was measured for samples, standards against blanks of distilled water in duplicate using SP 600 spectrophotometer at a wavelength of 885 nm using red filter in a Unicam 4 cm glass cells.

The amount of phosphate phosphorus measured in microgram atoms per litre (µg at P. l^{-1}) from the following formula:

$$\mu g \text{ at P. } l^{-1} = \text{Corrected extinction} \times F$$

The corrected extinction was calculated by subtracting the mean extinction of the two blanks from the mean extinction of the two samples and the factor F was calculated from the expression:

$$F = \frac{3}{Es - Eb}$$

Where Es was the mean extinction of the two standards and Eb was the mean extinction of the two blanks.

2.2.2. Determination of reactive silicate (dissolved silica):

Silicon is present in sea water in solution and particulate form. The soluble form of the element is orthosilicic acid (H_4SiO_4) and silicon present in 5% as ionic form. Because the polymeric forms of silicic acid are rapidly depolymerized in sea waters (Burton et

al, 1970), they are unlikely to occur in the sea . Sea waters contain silicon as particulate matter in suspension many of these being by the weathering of rocks on land and transported to the sea by the rivers or by wind and they include quartz and clay minerals and the concentration of suspended matter in the sea varies with geographical location; on average half of it is inorganic. Highest concentrations occur in inshore waters, for example, Armstrong (1958) has found 37 - 410 µg. l^{-1} of suspended silica in waters from the English Channel, in contrast waters from the east North Atlantic contained only 20-60 µg. l^{-1}.

The determination of dissolved silica in sea water depends on the formation of yellow silicomolybdic acid. When the sample is treated with acidic molybdate reagent only silicic acid and its dimer react at a good rate. Therefore by using this method we measure only the reactive form of silicate.

Since the silicomolybdic acid is unstable and has a low molar absorbtion it is reduced to a stable and more absorbent molybdenum blue complex which is measured spectrophotometrically. The reduction was carried out with stannous chloride or metol - sulphite solution. Phosphate and arsenate produce the same blue coloured complex and this is prevented by adding oxalic acid to the reducing agent so any interference from phosphate or arsenate is eliminated. The using of metol - sulphite solution as a reducing reagent provides a less sensitive method than that when stannous chloride is used (Armstrong, 1951). However sensitivity is not of prime importance with silicon which is present in large concentration in sea water in comparison with other elements such as phosphorus. Metol reagent has some advantages over stannous chloride in terms of stability as it is more stable and less temperature and salinity dependent (Strickland and Parsons 1972). The method used in this study was based on the procedure of Mullin and Riley (1955) as described by Strickland and Parsons (1972). This method has a limit of detection between 0.1 - 140 µg at Si. l^{-1}. Samples were

filtered before analysis as described on page 39 excluding the use of glass fibre filters. The following reagents were used for the analysis and were prepared as follows:

1)Molybdate reagent: 4 gm of Analar reagent quality ammonium molybdate $(NH_4)_6MO_7O_{24}.\ 4H_2O$ was dissolved in 300 ml of distilled water. 12 ml of concentrated hydrochloric acid was added with mixing then the solution was made up to 500 ml with distilled water. This solution was freshly prepared every month.

2)Metol - sulphite solution: 3 gm of anhydrous sodium sulphite, Na_2SO_3 was dissolved in 250 ml of distilled water then 5 gm of metol (p - methylaminophenol sulphite) was added. When the metol was dissolved the solution was filtered through No. 1 Whatman filter. The solution was prepared freshly before every analysis.

3)Oxalic acid solution: This saturated oxalic acid solution was prepared by shaking 50 gm of analytical reagent quality oxalic acid dihydrate $(COOH)_2.\ 2H_2O$ with 500 ml of distilled water. This solution was decanted from the crystals before use. This solution was prepared every four months.

4)Sulphuric acid solution: 50% v/v solution was prepared by adding 250 ml of concentrated sulphuric acid to 250 ml of distilled water. After the solution was cooled down the volume was made up to 500 ml with distilled water.

5)Reducing reagent: This solution was prepared by mixing 100 ml of metol - sulphite solution with 60 ml of 50% sulphuric acid solution and the volume was made up to 300 ml with distilled water. This solution was prepared for immediate use.

6)Standard silicate solution: This solution was prepared by dissolving 0.960 gm of dried sodium silicofluoride, Na_2SiF_6, in fine powder form by stirring it with 100 ml of distilled water in a plastic beaker. The solution was transferred to a 100 ml volumetric flask and made up the volume to the mark, then this solution was rapidly transferred to a polythene bottle for storage, as this solution picks up silica rapidly from glass. 1 ml of this solution contains 5 µg at Si. l^{-1}. 10 ml of this concentrated solution was diluted to 500 ml with synthetic sea water. This solution has the concentration of 4 µg at Si. l^{-1}. This diluted solution was prepared for immediate use.

Synthetic sea water: 25 gm of analytical reagent quality sodium chloride and 8 gm of magnesium sulphate - pentahydrate, $MgSo_4 . 7H_2O$ was dissolved in one litre of distilled water.

One day after the sample was collected, the samples were thawed to a temperature of 20 ^0C in a water bath. Even if there is no pronounced temperature effect with this method the samples mainly in the reduction stage should be at a temperature exceeding 18 ^0C but not more than 25 - 30 ^0C to avoid the decomposition of the silicomolybdate complex. 25 ml of sea water sample was added to 10 ml of acid molybdate reagent rather than the reverse to prevent the formation of any undesirable isomeric forms of the silicomolybdate complex and this way because the sea water - molybdate mixture is always above a certain acidity. The mixture was allowed to stand for 10 minutes then the reducing reagent was added rapidly to make the volume exactly 50 ml and mixed. The solution was allowed to stand for two hours to allow the complete reduction of the silicomolybdate complex. After such time the extinction was measured for samples and standards against blanks of distilled water in duplicate using a Unicam SP 600 spectrophotometer with a red filter at a wavelength of 810 nm in a 4 cm glass cell.

The amount of silicate was calculated in microgram atom per litre of Si (µg at Si. l^{-1}) using the following expression:

$$\mu g \text{ at Si. } l^{-1} = \text{corrected extinction} \times F$$

Where the corrected extinction calculated by subtracting the mean extinction of the two blanks from the mean extinction of the samples. The calibration factor, F was calculated using the following expression:

$$F = \frac{100}{Es - Eb}$$

Where Es is the mean extiction of the two standards and Eb is the mean extinction of the two lanks.

2.2.3. Determination of nitrate nitrogen:

The accurate determination of nitrate ion in sea waters has been difficult. One of the procedures for nitrate determination was that by Armstrong (1963) which proved to be satisfactory for samples containing high concentrations of nitrate but lacks sensitivity to measure samples with low nitrate concentrations. There are many other methods used and on the reduction of nitrate into nitrite such that by Mullin and Riley (1955) by using hydrazine in the presence of cupric ion as a catalyst to reduce nitrate but the reduction proved to be time consuming, not quantitative, and highly dependent on external conditions. The method of Morris and Riley (1963) in which a column of amalgamated cadmium filings is used as reducing agent and this method has a negligible salt error and minimal temperature effect. The efficiency of the column decreases with use because of the formation of $Cd(OH)_2$. The process was further refined by Strickland and Parsons (1965) by replacing the ammonium chloride with tetrasodium salt of ethylenediaminetetraacetic acid, EDTA and the washing of cadmium filings with nitric acid before amalgamation is to increase the surface area of cadmium (Cd).

The method used in the present study is based on the reduction of nitrate quantitatively to nitrite and the subsequent colorimetric determination of nitrite by a diazotization method. This procedure, based on the investigations by Wood, Armstrong and Richards (1967), and described by Strickland and Parsons (1972).

Special apparatus:

The reducing column (Figure. 2. 2.) was prepared by joining three pieces of glass tubing end to end. A 10 cm tubing of 5 cm diameter on to 30 cm of tubing 10 mm in internal diameter (which contained the metal filings) which in turn was joined to a 35

cm of tube 2 mm in diameter. The last tube was bent just below this join into a U - shape so that it runs up parallel to the 10 mm diameter tube and then its end was bent over to form an inverted U siphon.

Preparation of the reducing column:

a)Coarse cadmium filings were produced from sticks of cadmium and sifted to obtain the fraction which passed through a 2 mm screen but were retained by 0.5 mm screen.

b)Sixty gm of filings were stirred with 500 ml of 2% v/w solution of copper sulphate pentahydrate, $CuSo_45H_2o$, until the blue colour had left the solution and the semicolloidal copper particles began to enter the supernatant liquid.

c)A small plug of glass wool was placed at the bottom of the column which was then filled with the supernatant liquor from the preparation of the cadmium - copper above.

d)A sufficient amount of the cadmium - copper mixture was poured in to produce a column about 25 - 30 cm in length, tapping the column firmly when necessary to settle the filings.

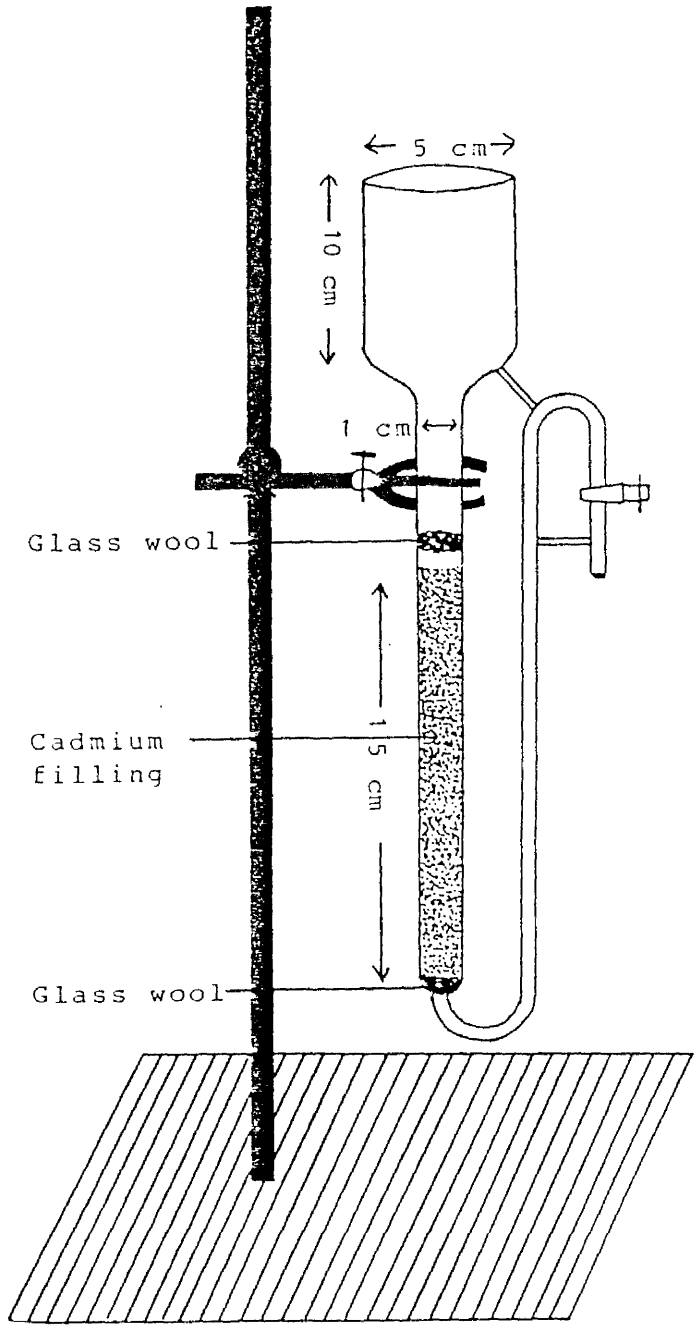
e)The column was washed thoroughly with diluted ammonium chloride solution. The flow rate was fixed so that 100 ml of the solution needed between 8 - 12 minutes to flow completely through the column. This was controlled by loosening or packing the glass wool at the bottom of the column.

f)A small plug of glass wool was placed on the top of the column to prevent cadmium filings being washed into the top chamber when solutions were added to the column.

g)The column was covered with diluted ammonium chloride solution when not in use.

h)when the efficiency of the column was suspected (usually after passing about 100 samples through it) the column was repacked by emptying its contents into a beaker. The filings were washed vigorously twice with 500 ml of 5% v/v hydrochloric acid solution. The acid was decanted and the metal was washed with 300 - 500 ml of distilled water until the water column was no longer acid. The liquid was decanted and the metal was left as dry as possible. Then it was treated with the copper sulphate solution as described above.

Figure. 2. 2. Cadmium - copper column used for the reduction of nitrate to nitrite.


5 cm
10 cm
1 cm
Glass wool
Cadmium filling
15 cm
Glass wool

Special reagents:

1)Concentrated ammonium chloride solution: This solution was prepared by dissolving 125 gm of analytical reagent quality ammonium chloride in 500 ml of distilled water and stored in a glass bottle.

2)Diluted ammonium chloride solution: 25 ml of the concentrated ammonium chloride solution was diluted to 100 ml with distilled water and then stored in a glass bottle.

3)Sulphanilamide solution: This solution was prepared by dissolving 5 gm of sulphanilamide in a mixture of 50 ml of concentrated hydrochloric acid and about 300 ml of distilled water. This solution was renewed every 3 months.

4)N - (1 - Naphthyl) Ethylenediamine dihydrochloride solution: This solution was prepared by dissolving 0.5 gm of the dihydrochloride in 500 ml of distilled water. This solution was stored in dark bottle and renewed once a month.

5)Standard nitrate solution: This solution was prepared by dissolving 1.02 gm of analytical reagent quality potassium nitrate, KNO_3, in 100 ml of distilled water (1ml= 10 µg at N.). This solution was stable indefinitely in the absence of evaporation. Two ml of this concentrated solution was diluted to 1000 ml with synthetic sea water. This solution was prepared freshly before use. The concentraction was 20 µg at N. l^{-1}. Synthetic sea water was prepared by dissolving 75 gm of analytical reagent quality sodium chloride, NaCl, 25 gm of analytical reagent quality magnesium sulphate, $MgSO_4 7H_2O$, and 0.125 gm of sodium bicarbonate, $NaHCO_3 H_2O$ in 2.5 litres of distilled water.

Procedure:

Samples were filtered before analysis as described on page 2 then the samples allowed to freeze within the hour. This procedure ensures satisfactory preservation for many months (Strckland and Parsons, 1972). At the time of analysis samples were allowed to thaw and brought back to room temperature. The analysis starts by placing 100 ml aliquot sample in a graduated cylinder. Two ml of concentrated ammonium chloride solution were added to each sample. After mixing the solution 5 ml was

poured onto the top of the column and allowed to pass through, this small preliminary addition ensures that the liquid in the top part of the column has the composition of the sample. The remainder of the sample was then added and the graduated cylinder was placed under the discharge tap. 40 ml of the sample was allowed to pass through the column and was used for rinsing the cylinder. The further 50 ml of reduced sample was collected and rapidly emptied into a flask. The sample was then treated as nitrite sample. For a full description of the method see nitrite determination. After one hour the extinction for the samples and standards was measured against blanks of distilled water in duplicate using a Unicam SP 600 spectrophotometer at a wavelength of 543 nm using blue filter for 4 cm glass cell. The concentration of nitrate nitrogen was measured in microgram atoms per litre (µg at N. l^{-1}) using the following expression:

$$\mu g \text{ at N. } l^{-1} = (\text{Corrected extinction} \times F) - 0.95\ C$$

Where C is the concentration of nitrite present in the sample in µg at N. l^{-1}, corrected extinction calculated by substracting the mean extinction of the two blanks from the mean extinction of the two samples. The calibration factor, F was determined by the calculation of the expression:

$$F = \frac{20}{Es - Eb}$$

Where Es was the mean extinction of the two standards and Eb was the mean extinction of the two blanks.

2.2.4. Determination of nitrite nitrogen:

All the methods used for the determination of nitrite in natural sea waters are based on the reaction in which nitrous acid is converted into a highly coloured "azo" dye. The method used in the present study is based on the method of Shinn (1941) in which sulphanilamide solution is used as the diazotizing agent and N - (1 - naphthyl) - ethylenediamine dihydrochloride solution as the coupling agent in the determination of

nitrite in fresh water. The following first equation represent the diazotization reaction but the equations (2) and (2a) represent the possibilities of the coupling reaction:

1) $NH_2SO_2C_6H_4NH_2$. HCL + HNO_2 --------> $NH_2SO_2C_6H_4N$=NCL + $2H_2O$;

2) $NH_2SO_2C_6H_4N$ = NCL + $C_{10}H_7NHCH_2CH_2NH_2$. 2HCL --------->

$NH_2SO_2C_6H_4N$ = $NNHC_2CH_2NH(C_{10}H_7)$. 2HCL + HCL

2a) $NH_2SO_2C_6H_4N$ = NCL + $C_{10}H_7NHCH_2CH_2NH_2$. 2HCL --------->

$NH_2SO_2C_6H_4$ = $NC_{10}H_6NHCH_2CH_2NH_2$. 2HCL + HCL

This method was applied to sea water by Bendschneider and Robinson (1952) and described by Strickland and Parsons (1972).

The following special reagents were required for the analysis:

1) Sulphanilamide solution: See nitrate determination.

2) N - (1 - Naphthyl) - ethylenediamine dihydrochloride solution: See nitrate determination.

Procedure:

One ml of sulphanilamide solution was added using an automatic pipette to each 50 ml of sample followed by mixing. After 2 - 8 minutes one ml of naphthyl ethylene diamine solution was added and mixed immediately. After one hour the extinction was measured for samples, standards and blanks of distilled water in duplicate using Unicam Sp 600 spectophotometer at a wavelength of 543nm in a Unicam 4 cm glass cells.

The standard nitrite solution was prepared by dissolving 0.345 gm of anhydrous analytical reagent quality sodium nitrite, $NaNO_2$, which was dried at 110 ^{0}C for one hour in 1000 ml of distilled water. This solution was stored in a dark bottle with 1 ml of chloroform as a preservative, this solution was renewed every two months (1 ml of this solution contained 5 µg at N.). Five ml of this concentrated solution was diluted to 500 ml with distilled water for immediate use.

The concentration of nitrite nitrogen was calculated in microgram atoms of nitrogen per litre (µg at N. l^{-1}) from the following expression:

$$\mu g \text{ at N. } l^{-1} = \text{Corrected extinction} \times F$$

The corrected extinction was calculated by subtracting the mean extinction of the two blanks from the mean extinction of the two samples. The calibration factor F, was determined using the following formula:

$$F = \frac{2}{Es - Eb}$$

Where Es was the mean extinction of the two standards and Eb was the mean extinction of the two blanks.

2.3. Pigment analysis:

2.3.1. Estimation of standing crop - chlorophyll a determination:

The spectrophotometric determination of chlorophyll a is the most frequently used technique for the estimation of standing crop since chlorophyll a is present in all marine algae. Most of the estimations are based on the method described by Richards and Thompson (1952). Considerable modifications have been made. Pigment concentrations of algae can vary widely depending on metabolism, light, temperature, nutrient availability, and many other factors. In addition pigments of certain bacteria, especially those photosynthetic, can interfere with the spectrophotometric or fluorometric determination of chlorophyll. Phaeophytin concentrations, however can be estimated separately on the same samples for which chlorophyll is determined.

Chlorophylls and related pigments are hydrophobic and the choice of extractant is therefore limited to those organic solvents that are miscible with water. Acetone was used in preference to methanol and ethanol because of the possible formation of methyl and ethyl chlorophyllides in the last two solvents. The evidence for this has been questioned by some workers as Marker et al, (1980) who also suggested that methanol

might be a more efficient extractant than acetone but which may only apply to the extraction of pigments from fresh water algae, since they also state that some workers have found acetone to be more efficient than methanol in extracting chlorophyll a from (pelagic ?) diatoms.

The method used in the present study was that given by Richard and Thompson (1952) as described by Parsons and Strickland (1963) and described in Strickland and Parsons (1972).

Apparatus:

a) Millipore filtration apparatus designed to hold 47 mm diameter filters with a two litre volume reservoir.

b) Stoppered graduated glass centrifuge tubes of 15 ml capacity.

c) Mortar and pestle.

Special reagents:

a) 100% analytical reagent grade acetone.

b) 90% acetone: 10 ml of distilled water was pipetted into 100 ml volumetric flask and analytical reagent grade acetone was added to make the volume to exactly 100 ml.

c) Magnesium carbonate suspension: 1 gm of light weight and finely powdered magnesium carbonate of analytical reagent quality was added to 100 ml of distilled water in a stoppered flask.

Procedure:

Samples filtered through a nylon plankton netting with a pore size of 212 µm to remove zooplankton and other large particulate matter, brought back to laboratory within two hours of collection, were immediately filtered under slight negative pressure on to Whatman glass - fibre filters (0.45 µ pore size) containing one ml of magnesium carbonate suspension to act as a filter aid and to prevent acidity from developing during extraction. About 14 litres of sample was filtered, often more than one filter was used so

often due to rapid blockage by a hight percentage of the suspended mater in the sample. The filter was then removed from the apparatus and the excess glass fibre was trimmed with a clean pair of scissors. The filters was carefully folded in half with their inner surfaces coming against each other, placed into labelled, folded foil pads and immediately frozen (-20 °C). Half the amount filtered (7 litres) was used for the determination of chlorophyll a while the other half used for the qualitative analysis of different pigments using thin - layer chromatography. Within 2 - 3 days the filters containing the golden - brown films of phytoplankton were ground using pestle and mortar with a small volume (2 - 3 ml) of 100% acetone, this solvent rather than the 90% acetone being recommended (Score - Unesco, 1966), was always used as the first extractant on order to inactivate the highly active chlorophyllase present in many diatoms (Barrett and Jeffrey, 1964, 1971 and Jeffrey, 1974). The enzyme is slightly active in 90% acetone but not in 100% acetone. After this first extraction in 100% acetone, the filters and homogenizer were rinsed with 8 ml of 90% acetone, to make the over all volume of acetone 10 ml, all operations being carried out in dim light to minimize the harmful photo - oxidation reactions. The combined green - yellow acetone extracts were transferred quantitatively into 15 ml centrifuge tube, the tubes were then covered with a double layer of aluminium foil for light prevention. The acetone extracts were centrifuged at 5000 r. p. m for 10 minutes, then the clear supernatant liquid was decanted into a Unicam glass 1 cm spectrophotometer cell, the extinction of which was measured against a cell containing 90% acetone at 630, 645 and 665 m using SP 600 spectrophotometer. The concentration of chlorophyll a was calculated from the equation:

$$\text{mg pigments} / m^{-3} = C \left(\frac{v}{V \times L} \right)$$

Where (C) is a value obtained from the following equation of Parsons and Strickland, (v) the volume of acetone used for extraction, (V) is the volume of sea water filtered in litres and (L) the path length of the cuvette (1 cm).

$$C \text{ (chlorophyll a)} = 11.6\, E_{665} - 1.31\, E_{645} - 0.14\, E_{630}$$

Where E_{665}, E_{645} and E_{630} being the extinction values measured at wavelengths 665, 645 and 630 nm respectively.

2.3.2. Phaeopigment determination:

Even if the previous method describes the measurement of pigment referred to as chlorophyll, it in fact represents chlorophyll a and chlorophyllide a. The presence of chlorophyllide will go undetected and this will be reported as an equivalent of chlorophyll. Some idea of the amounts of phaeopigments present in a sample may be obtained by measuring extinctions before and after acidification of extracts.

The method used in this study to measure the ammount of non - active chlorophyll a in terms of quantity of phaeopigments was that described by Parsons and Strickland (1972) which was similar to other two procedures described by Moss (1967) and Lorenzen (1967a) and the equation employed here was that of Lorenzen (1967a).

To measure the phaeopigment level the samples were carried through the above procedure for chlorophyll a analysis. The extinction values were measured against a cell containing 90% acetone at 665 nm. To each sample two drops of 50% hydrochloric acid (HCL) were added, after mixing the samples were allowed to stand for between 4 - 5 minutes, the extinction were measured again at the same wavelengths. All readings were corrected for cell to cell blanks. The concentration of phaeo - pigments in the samples was calculated from the expression:

$$\text{Phaeopigments (mg/m}^{-3}) = \frac{26.7\,(1.7[665_a] - 665_o)\,v}{V \times L}$$

Where 665_0 was the extinction at 665 nm before acidification, 665_a the extinction at 665 nm after acidification, (v) the volume of acetone used for extraction, (V) the volume of sea water filtered in litres and (L) the path length of the cuvette.

2.3.3. Qualitative determination of photosynthetic pigments using thin - layer chromatography:

In the process of the qualitative determination of different chlorophyll pigments using thin layer chromatography the low concentration of phytoplankton population, mainly in late summer and early winter, even if large quantities of water samples were filtered, was a problem. To overcome this problem the samples were aggregated togather in terms of seasons corresponding to each sampling date. According to that samples were aggregated in the following sequance:

1) Spring 1984 include samples collected at 11/4, 11/5 and 25/5.

2) Early summer 1984 include samples collected at 6/6, 20/6 and 11/7.

3) Late summer 1984 include samples collected at 23/7, 15/8 and 29/8.

4) Autumn 1984 include samples collected at 19/9, 17/10 and 31/10.

5) Early winter 1984 - 1985 include samples collected at 7/11, 21/11, 5/12 and 3/1.

6) Late winter 1985 include samples collected at 30/1 and 20/2.

7) Spring 1985 include samples collected at 6/3, 13/3, 20/3, 29/3 and 3/4.

8) Autumn 1985 include samples collected at 19/9, 9/10 and 30/10.

9) Early winter 1985 - 1986 include samples collected at 11/11, 25/11 and 9/12.

10) Late winter 1985 - 1986 include samples collected at 6/1 and 12/2.

11) Early spring 1986 include samples collected at 10/3, 19/3 and 26/3.

12) Late spring 1986 include samples collected at 2/4, 9/4 and 23/4.

13) Early summer 1986 include samples collected at 7/5, 4/6 and 18/6.

14) Late summer 1986 include samples collected at 2/7, 16/7, 30/7 and 15/8.

15) Autumn 1986 include samples collected at 10/9, 6/10 and 27/10.

16) Early winter 1986 - 1987 include samples collected at 12/11 and 23/12.

17) Late winter 1986 - 1987 include samples collected at 22/1 and 17/2.

18) Spring 1987 include samples collected at 11/3, 18/3, 25/3, 8/4, 15/4, 22/4 and 29/4. The method used in the present investigation was taken from Jeffrey (1974) with some modifications in terms of the actual system used. Instead of using two - dimensional chromatography one dimension was used and the pigments were separated with 50% ethyl - acetate in light petroleum ether (60 ^{0}C - 80 ^{0}C) instead of using 25% chloroform in light petroleum (60 ^{0}C - 80 ^{0}C) for the first dimension and 2% n - propanol in light petroleum for the second dimension. This way more satisfactory results were obtained. The extraction of pigments for chromatography were carried out in the same way as the above procedure for chlorophyll analysis. After extraction the acetone pigment extract (10 - 12 ml) was immediately prepared for chromatography by adding an equal volume of redistilled diethyl ether followed by 20 volumes of cold 10% NaCl, solution in a separatory funnel. After inverting the mixture gently several times, the phases were allowed to separate for 5 minutes. The pigments migrated to the ether hyper phase, and acetone and water soluble impurities were removed in the aqueous hypophase. The ether layer containing pigments was collected and concentrated to a small volume of (1 ml) for chromatography under a stream of nitrogen. Condensation water was removed by centrifugation. Pigments were separated on silica gel thin layer plates by one dimensional chromatography with 50% ethyl acetate in light petroleum (60 ^{0}C - 80^{0}C). Solvents were placed in a small tank, lined with filter paper and allowed to equilibrate for few hours. All the previous procedures were carried out in a dim light. The plates were spotted and the one dimensional development in a dim light was completed in 12 minutes. Pigments were identified by R_f values and the sequence in which colours developed.

2.4. Estimation of standing crop - Enumeration of phytoplankton:

Even if the standing crop (biomass) of phytoplankton can be obtained from the measurement of chlorophyll a concentration previously described, still the direct microscopic examination, identification and enumeration of individual species in

numbers is of great importance. For this purpose algae concentration was necessary which can be done by filtration, sedimentation or centrifugation.

A technique for the direct enumeration of fresh water phytoplankton concentrated on a molecular filter was given by McNabb (1960) in which algae were found to be distributed at random on the filter.

In the present investigation this method was used with a few modifications. Lugol's iodine solution (100 gm potasium iodide in 1000 ml of distilled water + 50 gm iodine + 100 gm glacial acetic acid) was used as preservative instead of formalin. Algae were counted as numbers of individuals per field of species instead of presence or absence of individuals of that species.

After collection sea water samples were filtered through a fine mesh net with pore size of 212 µm to remove zooplankton and other large particulate mater. Five hundred ml of sample was placed in a graduated measuring cylinder and 2 ml of Lugol's iodine solution were added. The sample was left to stand for sedimentation for 5 days (Furet and Benson - Evans, 1982). The 400 ml of supernatant water was pipetted and between 50 - 75 ml of the sample left was filtered through twenty - five mm diameter Millipore HA filter with 0.45 µm pore size. The membrane filter was removed carefully from the filtration unit and the edges were trimmed. The membrane filter was placed on a clean microscope slide, filtered surface uppermost, three drops of Univert immersion oil were added to the filter which acts as clearing agent by replacing the water in the filter in 24 hours at room temperature in the dark. The clear filters were then covered with a clean cover glass. The excess oil was removed with a tissue and the mount was sealed with clear nail varnish. A Leitz Ortholux microscope was used throughout the investigation for the identification and the enumeration of organisms on the filters. A x 40 objective bright field was used for counting and identification and oil immersion objectives were

used when necessary for identification. Thirty random fields were viewed. The number of algal cells per litre were calculated from the following equation:

$$\text{No. of algal cells. } l^{-1} = \frac{\text{Area of filter x Total count in 30 fields}}{\text{Total area of 30 fields x volume of sample in litres}}$$

2.5. Measurements of carbon fixation:

2.5.1. C^{14} light and dark bottles technique for measuring the carbon fixation by phytoplankton:

The most commonly used approach is to make measurements on samples of a natural community that have been isolated in some sort of container. Changes in oxygen evolution or CO_2 uptake are then measured after the sample have been incubated either in situ or under conditions of light and temperature simulated for the depth from which the samples were collected. The most commonly used method is to add a tracer amount of $^{14}CO_2$ as labelled bicarbonate (e.g. $NaH^{14}CO_3$) to the water sample. If the total CO_2 content of the sample is known and the C^{14} of the phytoplankton is measured after a period of incubation, the total amount of carbon assimilated can be calculated by the proportional relationship (Steeman Nielsen, 1952).

$$\frac{C^{14} \text{ available}}{C^{14} \text{ assimilated}} = \frac{C^{12} \text{ available}}{C^{14} \text{assimilated}}$$

In practice a known amount of radioactive bicarbonate, $HC^{14}O_3$ was added to a sample of a known total CO_2 content, the amount of CO_2 added along with the tracer is usually negligible in relation to the total in the water. After photosynthesis by the phytoplankton has proceeded for a suitable time, the algae are filtered onto a membrane filter, treated and assayed for the amount of radioactivity incorporated. This technique has excellent sensitivity. The subject of measuring primary productivity

using C^{14} light and dark bottle techniques was reviewed by Strickland (1960) in which he mentioned that the value of productivity measured between gross and net and this value is probably nearer to the net productivity value than the gross. In the present investigation measurements were made for samples collected from 10/3/86 till 25/3/87 from surface and 5 metres at stations 11 and 9 in which the incubation was carried out under laboratory conditions. For samples collected on 8/4/87 and 22/4/87 from surface, 1 metre, 5 metres and 10 metres at station 11 incubations were carried out in situ and in culture cabinets.

Equipment and reagents used:

1) 150 ml capacity (BOD) bottles light glass bottles and dark bottles which were prepared by covering the bottle surfaces by a double layer of black scotch tape with aluminium foil on top of that.

2) Millipore filtration apparatus which holds filters of 4.5 cm in diameter and 0.45 µm pore size.

3) Liquid scintillation counter (LKB Wallac model 1211 Minibeta).

4) Plastic (20 ml) vials.

Reagents:

1) Good quality 40% formaldehyde solution.

2) Filtered sea water: collected at the same time as the samples, filtered through a Millipore filter which was used as a washing liquid.

3) Solution (C^{14}) bicarbonate aqueous solution, batch 69, in sterile vials containing 1 ml of 50 µ Ci radioactive concentration.

4) Triton scintillant which was prepared by mixing 5 gm ppo (2, 5, diphenyl oxazole) + 0.3 gm dimethyl - popop - 1, 4 - Di - [2 - (4 - methyl - 5 - phenyloxazolyl)] - benzene + 150 ml triton. The volume was made up to 1 litre with toluene.

Before inoculation sodium (C^{14}) bicarbonate were diluted to the required concentration with a sodium chloride solution (5% w/v Analar NaCl in distilled water with 0.3 gm

anhydrous sodium carbonate (Na_2Co_3) and 0.2 gm sodium hydroxide (NaOH) added per litre.

Procedure:

The method used in the present investigation was that of Steeman Nielsen (1952) as described by Strickland and Parsons (1972). 1) Water sample collected for C^{14} up take measurement was put in a 1 litre dark bottle and more water sample was put in 500 ml amber bottle for pH and alkalinity measurement from which the total CO_2 content of sea water was measured (see pH and total CO_2 content measurement). 2) In the field the temperature and salinity was measured at each sampling depth using a combined salinity and temperature probe (see sampling methods). 3) In the laboratory two light and one dark 145 ml biochemical oxygen demand (BOD) bottles of actual volume 150 ml were filled with water from each depth sampled in each station and placed inside a dark wooden box. 4) The samples were inoculated with 1 ml of 1 µCi labelled sodium bicarbonate using a disposable syringe and mixed. 5) Immediately the bottles were transferred to a growth room for incubation and placed under fluorescent strip lights at 5 Wm^{-2} at 11^0C.

* For those samples in which C^{14} up take was measured in situ the above steps were carried out in the following way:

1) Shading the bottles, first one dark bottle and then two light 150 ml capacity stoppered biochemical oxygen demand (BOD)bottles were filled with 145 ml sea water from each depth sampled and then immediately placed into a light - proof wooden box, taking care to maintain them in order of collection. Next, 500 ml screw - cap amber polythene bottles was filled to the brim with water samples for alkalinity and pH measurement in the laboratory which was carried out as soon as possible. 2) The temperature and salinity was measured at each sampling depth using a combined salinity and temperature probe (see sampling methods). 3) Each productivity bottle in the dark - wooden box was opened and each bottle inoculated with 1 ml of 1 µCi labelled sodium bicarbonate using a disposable syringe. Immediately the bottles were

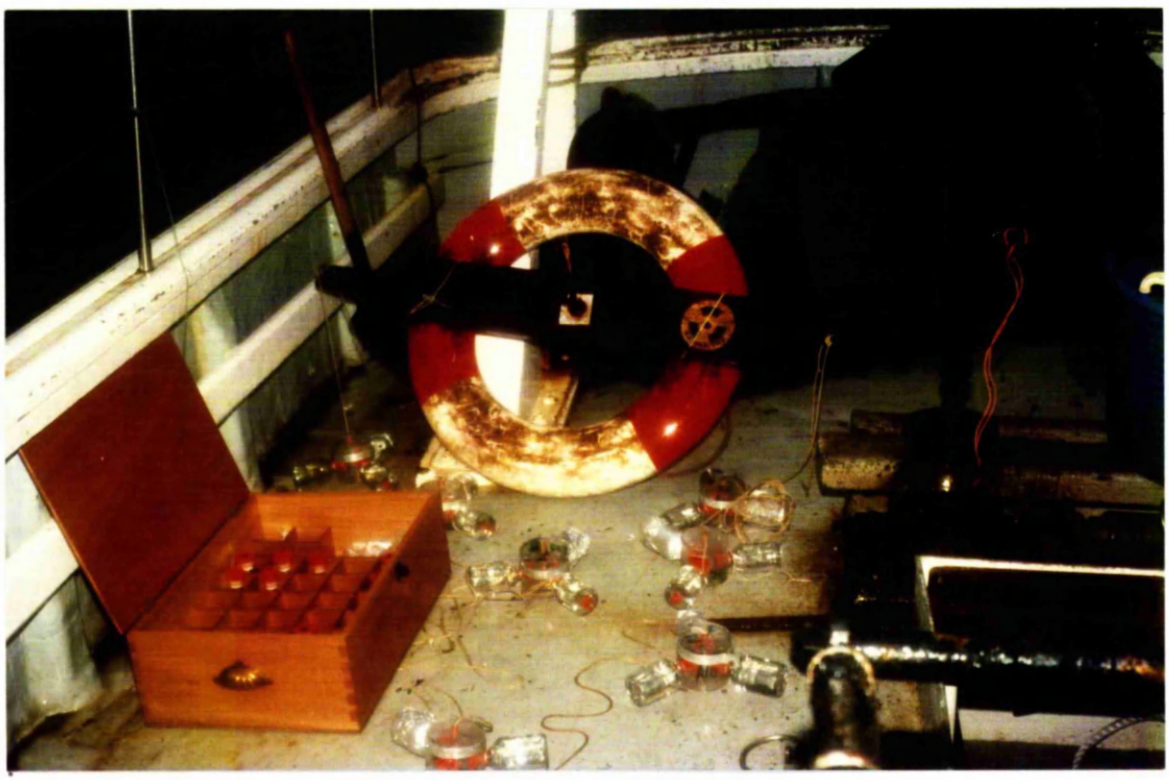
stoppered and after making certain that each bottle was tightly sealed each was gently mixed by repeated inversion and the dark bottles were caped with aluminium foil to ensure that no light leaks through the stoppers joints. To suspend the samples in situ a float consisting of a life buoy with a wooden spar strapped across it was moored on station.

Two lines were attached to either end of the spar, away from the possible shading effect of the buoy, and these had attached at the required depths perspex holders each designed to hold three sampling bottles in a horizontal position to allow maximum exposure of the bottles to the available light at each depth (see Figure. 2.3).

4) Samples were incubated under natural light and temperature conditions for 5 hours.

The following steps were carried out in the same way for samples incubated in the lab and samples incubated in the field. After incubation the samples were placed in a dark, wooden box and 1 ml of formaldehyde solution was added to each bottle to prevent any further fixation. Samples incubated in the field were immediately returned to the laboratory for processing. Immediately samples were filtered through Millipore filters with a pore size of 0.45 µm using pressure less than 380 mm Hg to reduce the possibility of rupturing more fragile cells as they aggregate on the filter. Filtration preformed in a semi - darkend area to minimize further photosynthesis. Amount of sample filtered was governed by the observed density of the phytoplankton. Normally between 50 - 100 ml was filtered. After filtration the filters were exposed to fumes of hydrochloric acid (HCL) to remove residual inorganic C^{14} and carbonates that may have precipitated as a result of photosynthetic activity (Wetzel, 1965). The samples were then transferred to the scintilation vials containing 10 ml of scintillant and stoppered. The vials with the samples were then left in the dark for 24 hours at a low temperature to allow the filters to become dissolved. Finally the vials were transferred into the scintillant ion counter and the activities were expressed as counts per minute (cpm). The amount of C^{14} fixed was calculated using the following formula :

Figure. 2. 3. Illustrates the perspex bottle holders and the buoy used in the "in situ" fixation experiment.



$$P = \frac{C^{14}\text{ up take} \times C^{12}\text{ availability} \times 146 \times 1.06}{C^{14}\text{ added} \times E \times V \times T}$$

P = Photosynthetic production in mg C m^{-3}. hr^{-1}.

C^{14} up take = mean of light bottles - dark bottle values (in cpm).

146 = Volume of incubation bottles (ml).

1.06 = Isotope correction factor (put in to allow for the fact that the C^{14} isotope behaves differently from C^{12} isotop found in nature).

C^{12} availability = total Co_2 content of sea water sample. (mg C m^{-3})

E = Scintillation counting efficiency, was determined as described by Hannah (1979), and was found to be 80 - 85%.

V = Volume of sample filtered from incubation bottle (ml).

T = Time of incubation (in hours).

C^{14} added = Concentration of C^{14} bicarbonate solution inoculated into samples (in - μci).

2.5.2. pH determination:

The pH of the water samples was determined with a Howe pH meter model (6030) immediately on return to the laboratory. The electrode was standardized using commercially available pH buffer tablets having pH values of 4 and 7. The electrode was washed with distilled water and dried with tissue before immersion in any sample. Two to three minutes were allowed for equilibration once the electrode was immersed in the sample.

2.5.3. Determination of the total CO_2 content of the sea water:

The total inorganic carbon of sea water is commonly estimated from measurements of total alkalinity, pH and temperature. The total alkalinity of the samples was measured by the method outlined in Strickland and Parsons (1972).

100 ml of sea water was added into a polyethylene screw cap bottle with 25 ml of standard 0.01 N Hydrochloric acid, then the solution was mixed thoroughly and the pH

was measured as described before. The pH of the buffer used to standardize the pH meter was 4. The total alkalinity was calculated from the equation:

$$\text{Total alkalinity} = 2.5 - (1250\ aH / f)$$

aH value corresponding to the measured pH value was determined from standard data, and value f can be similarly obtained from salinity and pH value. From total alkalinity measurements and several other measurements (salinity, pH and temperature at which the pH was measured, and initial temperature) the total CO_2 content of the sea water was calculated from the following equations:

1) Carbonate alkalinity = Total alkalinity - A (milliequivalents l^{-1}).

2) Total CO_2 = Carbonate alkalinity x 12 x Ft (mg C^{12} available l^{-1}).

Where A and Ft are factors which are temperature and pH dependent and determined from the standard tables.

2. 6. 4. Separation of the samples into a different fractions:

To obtain different fractions of samples for productivity determinations, water samples were passed successively through a series of nylon mesh nets with the following pore sizes:

1) 100 µm to retain phytoplankton organisms larger in size than 100 µm.

2) 50 µm to retain phytoplankton organisms larger in size than 50 µm.

3) 20 µm to retain phytoplankton organisms larger in size than 20 µm.

4) 10 µm to retain phytoplankton organisms larger in size than 10 µm.

5) 5 µm to retain phytoplankton organisms larger in size than 5 µm.

Finally the sample was passed through a Millipore membrane filter of 0.45 µm pore size to retain phytoplankton organisms larger in size than 0.45 µm.

According to their size the phytoplankton organisms retained were classified into the following categories:

Organisms retained by 100 µm, 50 µm and 20 µm mesh net represented Netplankton category; organisms retained by 10 µm, 5 µm mesh net and 0.45 Millipore membrane

filter represented Nanoplankton category, this fraction also including the picoplankton (0.2 - 2 μm).

From this fractionation of water samples measurements were made of the contribution of the different size groups of phytoplankton organisms to primary productivity. Prior to fractionation the water samples were filtered through 212 μm nylon mesh to remove any zooplankton and any other large particulate matter. The amounts of water sample used for fractionation ranged between 1 - 2 litres. Phytoplankton organisms retained by each net was resuspended in a 145 ml of prefiltered sea water, obtained by filtration through Whatman No 1 filter papers and next through 0.45 μm Millipore filters. Primary productivity was measured in the same way as described previously.

3. Physico - Chemical Data and Standing Crop Measurements:

3. 1. Sea Temperature and Meteorological data:

3. 1. 1. Sea surface temperature and salinity:

The local sea surface temperatures at Keppel Pier were obtained from the Biological Marine Station, at Millport. The actual measurements are summarized in Table. 3. 1. 1. In 1984 the minimum sea surface temperature of 7^0C was recorded in 11 April, after which sea surface temperature increased progressively reaching a maximum of 15.1^0C in 23 July. During the rest of sampling period the minimum sea surface temperatures were recorded in March (around 6^0C) and the maximum were found in July (around 14^0C). Throughout the present study the pattern for temperature changes were similar to that found by Hinton (1974) and Hannah (1979).

The levels for surface salinities varied between 29.2°/oo and 32.95°/oo depending on the time of the year.

Table. 3. 1. 1. Sea surface temperature recorded on the different dates of sampling.

Date	Temperature in ^{0}C	Date	Temperature in ^{0}C
1984			
11.04	7.0	17.10	12.9
11.05	8.2	7.11	11.3
25.05	9.2	21.11	11.2
6.06	10.0	5.12	10.0
20.06	11.4	1985	
11.07	14.8	3.01	7.8
23.07	15.1	31.01	8.2
15.08	15.0	6.03	7.5
29.08	13.6	20.03	6.0
19.09	13.8	29.03	6.0
3.10	12.9	8.04	6.0

Table. 3. 1. 1. (Contiued)

Date	Temperature in ^{0}C	Date	Temperature in ^{0}C
1985		16.07	12.4
19.09	13.2	30.07	12.4
11.11	9.8	27.08	11.0
25.11	9.0	23.09	12.0
9.12	8.7	6.10	12.1
1986		27.10	11.0
6.01	6.5	12.11	9.5
12.02	5.3	23.12	8.2
10.03	5.2	1987	
19.03	5.8	24.01	7.1
26.03	5.8	18.02	4.9
2.04	6.0	11.03	6.0
9.04	5.9	18.03	5.8
23.04	6.1	25.03	5.5
7.05	8.0	8.04	6.0
4.06	8.3	15.04	6.2
18.06	11.0	22.04	8.8
2.07	14.8		

3. 1. 2. Wind speed and sunshine hours data:

The data for wind speed and sunshine hours are discussed in detail in the comparative discussion of the physico - chemical and biological data (pp. 329). The actual data are given in Appendices 1 and 2.

3. 2. Nutrient analysis:

3. 2. 1. Reactive silicate (dissolved silica):

During the course of this study seasonal fluctuations in dissolved silica concentration were observed, with values ranging between trace quantities and a maximum of 22.45 µg at Si. l^{-1}. Significant variations were observed at different seasons, at different stations, and at different depths (Table. 3. 2. 1.), (Figs. from 3. 2. 1. to 3. 2. 4).

At the time of the beginning of this investigation during the spring of 1984, low levels of dissolved silica were recorded on 11 April, at both stations, at both depths, with values ranging from 1.3 to 2.2 µg at Si. l^{-1}. On 11 May, although there was a slight increase in the dissolved silica levels recorded for samples collected from surface at both stations, the values remained low ranging from 1.3 to 1.8 µg at Si. l^{-1}. The dissolved silica levels remained low over summer with minimal trace quantities recorded on 6 th of June, at both stations, at both depths.

From 20 June onwards the dissolved silica values increased gradually reaching a maximum summer level of 8.2 µg at Si. l^{-1} for samples collected from station 11 (surface) on 15 August and 6.2 µg at Si. l^{-1} for samples collected from the same station at 5 metres depth on 29 August, while maximum levels of 2.2 and 3.6 µg at Si. l^{-1} were recorded on 23 July for samples collected from station 9 at surface and 5 metres depth respectively. Levels rose during autumn and remained high over winter. Maximum values for the year were recorded on 5 December, in which the levels ranged from 15.2 to 19.4 µg at Si. l^{-1}.

In 1985, dissolved silica remained high until the end of March when it declined from 6.2 µg at Si. l^{-1} station 11 (surface), 6.8 µg at Si. l^{-1} station 11 (5 metres), 6.4 µg at Si. l^{-1} station 9 (surface) and 5.2 µg at Si. l^{-1} station 9 (5 metres) on 6 March to 0.4 µg at Si. l^{-1} station 11 at (surface and 5 metres depth), 0.3 µg at Si. l^{-1} station 9 (surface) and 0.4 µg at Si. l^{-1} on 29 March.

Minimum values as measured for the year were recorded on 3 April, in which the levels ranged from 0.16 to 0.2 µg at Si. l^{-1}.

When the investigation was recommenced on 19 September the levels of dissolved silica started to increase as autumn and winter months proceeded from 9.7 µg at Si. l^{-1}at station 11 (surface), 8.0 µg at Si. l^{-1} at station 11 (5 metres), 6.6 µg at Si. l^{-1} at station 9 (surface) and 6.2 µg at Si. l^{-1} at station 9 (5 metres) on 19 th of September reaching 20.5 µg at Si. l^{-1} at station 11 (surface), 18.8 µg at Si. l^{-1} at station 11 (5 metres), 21.9 µg at Si. l^{-1} at station 9 (surface) and 19.5 µg at Si. l^{-1} at station 9 (5 metres) on 9 December, which represented the maximum levels for the year, for each depth at each station.

In 1986, maximum values measured for the year were recorded on 6 January, in which the levels ranged from 19.95 to 22.45 µg at Si. l^{-1}. A sharp decrease in dissolved silica values was recorded on 12 February, in which the levels ranged from 2.8 to 5 µg at Si. l^{-1}.

During the spring, dissolved silica levels remained high until 9 April when it declined from 12.8 µg at Si. l^{-1} at station 11 (surface), 10.5 µg at Si. l^{-1} at station 11 (5 metres), 17.7 µg at Si. l^{-1} at station 9 (surface) and 11.5 µg at Si. l^{-1} at station 9 (5 - metres) (2 April) to 1.6 µg at Si. l^{-1} at station 11 (surface and 5 metres depth), 1.8 µg at Si. l^{-1} at station 9 (surface) and 1.6 µg at Si. l^{-1} at station 9 (5 metres) within a week. The levels recorded on 23 April were similar to those recorded on 9 April. Minimum values for the year were recorded on 7 May, with levels ranging from 0.16 to 1 µg at Si. l^{-1}. The levels remained low through summer, steadily increasing from 10 th of September on wards and reaching a highest values on 23 December, in which the levels ranged from 19 to 20 µg at Si. l^{-1}.

In 1987, maximum values for the year were recorded on 22 January, in which the levels

ranged from 20 to 21.5 µg at Si. l^{-1}. A sharp decrease was recorded on 17 February (7 - 11 µg at Si. l^{-1}).

During the time of the spring diatom increase the dissolved silica values declined gradually reaching minimum levels on 22 April (1 - 1.2 µg at Si. l^{-1}).

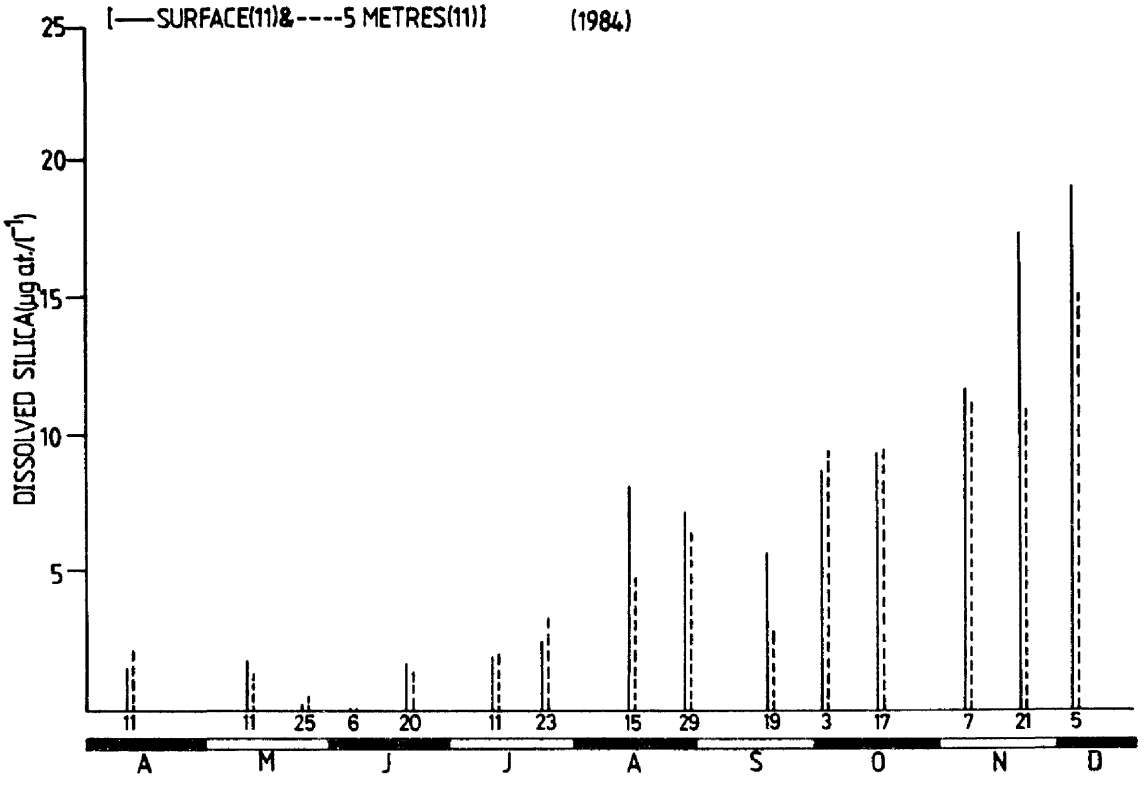
Table 3. 2. 1. Dissolved silica levels (µg at Si. l^{-1}) recorded in the Fairlie channel at stations 11 and 9 during the period of this study. (T = trace)

	Station 11		Station 9	
Date	S	5m	S	5m
1984				
11.04	1.60	2.20	1.30	1.50
11.05	1.70	1.30	1.80	1.60
25.05	0.30	0.50	0.55	0.50
6.06	T	T	T	T
20.06	1.60	1.50	0.90	1.10
11.07	2.00	2.10	1.90	1.50
23.07	2.60	3.40	2.20	3.60
15.08	8.20	5.00	1.00	2.00
29.08	7.00	6.50	2.00	2.60
19.09	5.80	3.30	1.77	2.00
3.10	8.70	9.40	7.50	7.50
17.10	9.50	9.60	9.50	8.00
7.11	11.7	11.0	11.0	11.4
21.11	17.4	11.7	14.3	12.6
5.12	19.0	15.2	18.0	19.4
1985				
3.01	22.0	16.6	19.0	19.8
31.01	16.0	15.6	15.2	13.0
20.02	17.00	9.600	13.70	13.40
6.03	6.400	5.200	6.200	6.800
13.03	5.000	5.000	5.200	5.400
20.03	4.300	4.600	4.000	4.200
29.03	0.300	0.400	0.400	0.400
3.04	0.160	0.160	0.200	0.180
19.09	9.700	8.000	6.600	6.200
9.10	13.00	13.00	12.30	11.70
30.10	13.90	13.20	14.30	12.30
11.11	16.00	14.70	16.00	13.70
25.11	18.80	15.30	16.00	14.60
9.12	20.50	18.80	22.00	19.50
1986				
6.01	22.45	19.95	22.35	20.00

Table. 3. 2. 1. (Continued)

	Station 11		Station 9	
Date	S	5m	S	5m
1986				
12.02	5.000	4.600	5.000	2.800
10.03	12.20	18.40	16.60	17.78
19.03	16.50	15.80	14.30	15.50
26.03	19.00	17.00	21.80	12.80
2.04	17.70	11.50	12.80	10.50
9.04	1.800	1.600	1.600	1.600
23.04	1.800	1.600	1.600	1.600
7.05	1.000	0.400	0.160	0.300
4.06	4.000	3.600	3.600	5.000
18.06	3.000	2.600	3.000	2.500
2.07	2.000	1.300	2.000	1.000
16.07	1.260	1.200	1.000	1.500
30.07	2.000	2.200	1.700	2.500
10.09	7.760	5.600	4.100	4.200
6.10	11.00	11.30	9.600	10.00
27.10	11.70	11.40	12.00	10.00
12.11	13.80	13.00	13.40	12.50
23.12	19.00	19.20	20.00	19.40
1987				
22.01	21.50	20.00	21.00	20.00
17.02	11.00	7.000	9.400	8.000
1.03	10.00	7.000	9.000	7.800
18.03	9.000	6.000	8.400	6.500
25.03	8.000	6.000	8.000	6.000
8.04	4.000	3.000	3.000	3.000
15.04	2.000	2.000	2.000	2.000
22.04	1.000	1.000	1.200	1.100

Figure. 3. 2. 1. Seasonal changes in the dissolved silica (µg at Si. l^{-1}) levels at the surface and 5 metres depth. Station 11, from 11 April 1984 to 9 December 1985.


[—SURFACE(11)&----5 METRES(11)]
(1984)
DISSOLVED SILICA(µg at./l⁻¹)
25
20
15
10
5
11
11
25
6
20
11
23
15
29
19
3
17
7
21
5
A
M
J
J
A
S
O
N
D

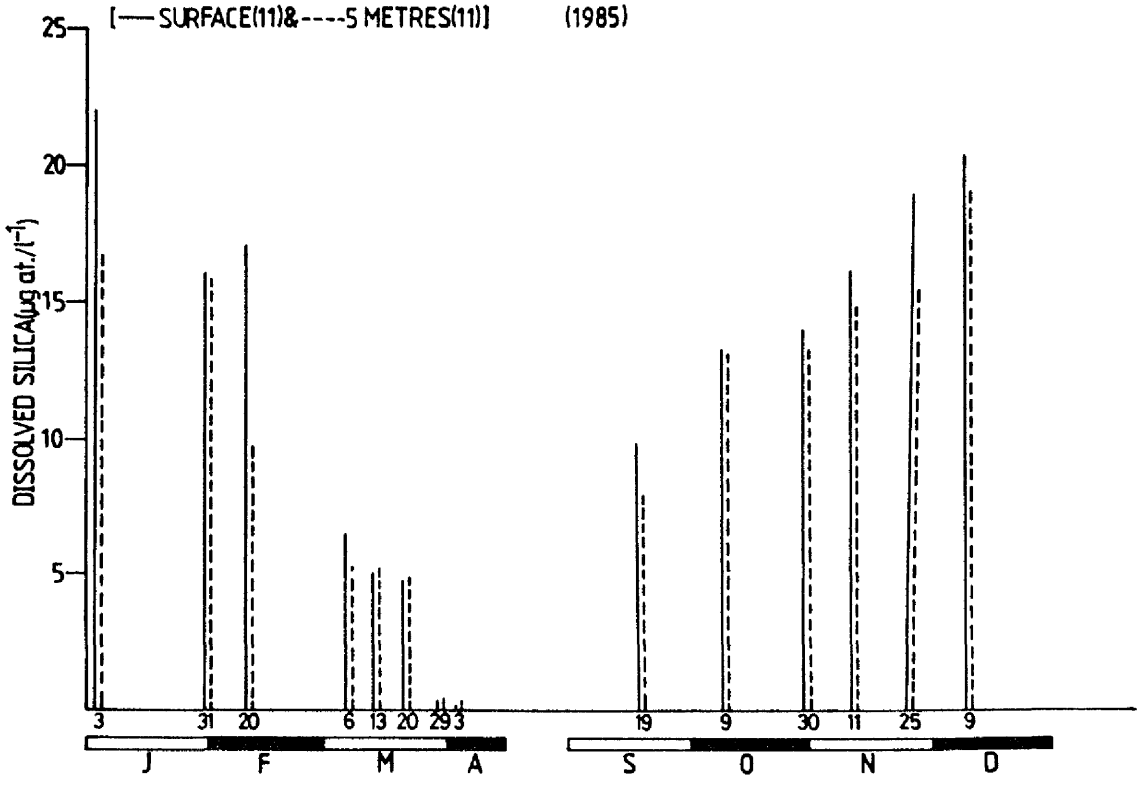
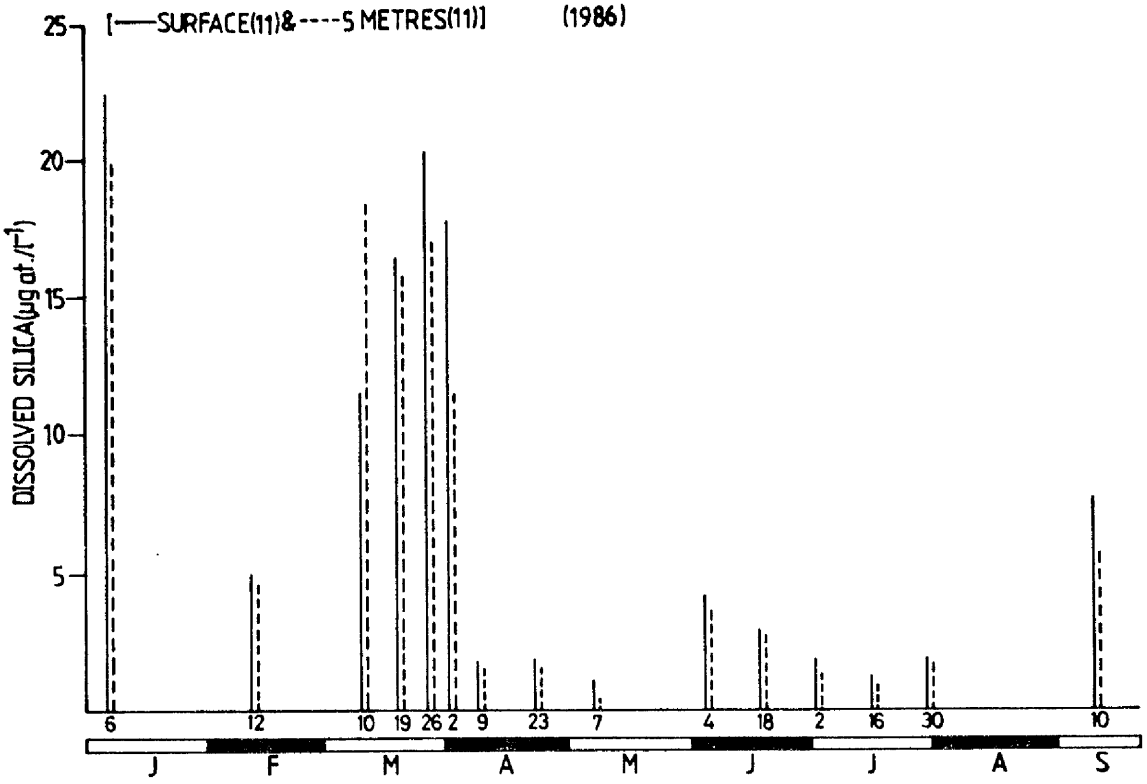

[—SURFACE(11)&----5 METRES(11)]
(1985)
DISSOLVED SILICA(µg at./l⁻¹)
25
20
15
10
5
3
31
20
6
13
20
29
3
19
9
30
11
25
9
J
F
M
A
S
O
N
D

Figure. 3. 2. 2. Seasonal changes in the dissolved silica (µg at Si. l^{-1}) levels at the surface and 5 metres depth. Station 11, from 6 January 1986 to 22 April 1987.


[——SURFACE(11)&----5 METRES(11)]
(1986)
DISSOLVED SILICA(µg at./l⁻¹)
25
20
15
10
5
6
12
10
19
26
2
9
23
7
4
18
2
16
30
10
J
F
M
A
M
J
J
A
S

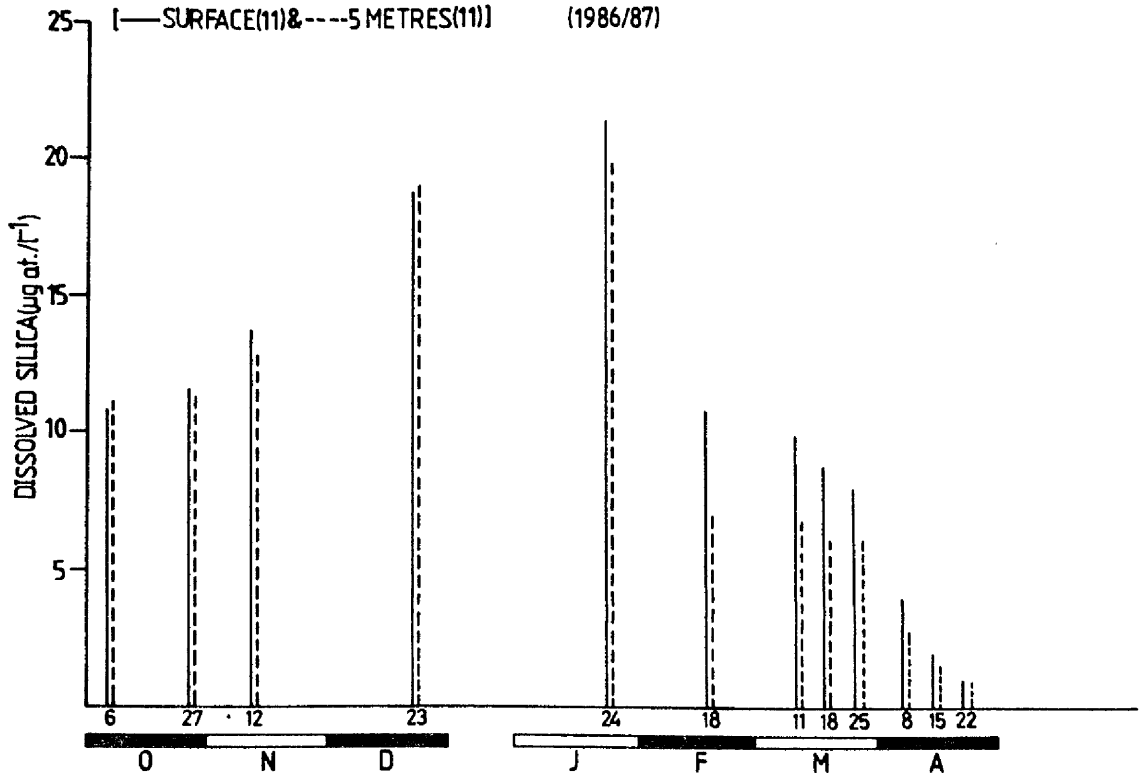
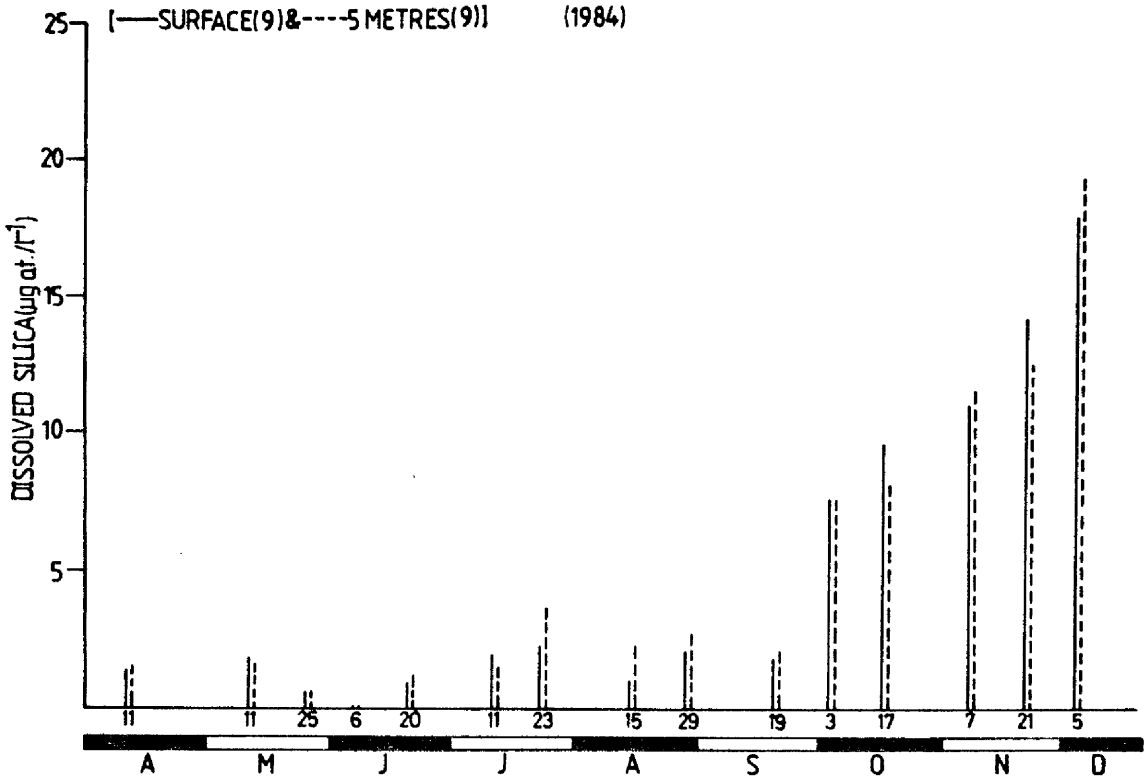

[——SURFACE(11)&----5 METRES(11)]
(1986/87)
DISSOLVED SILICA(µg at./l⁻¹)
25
20
15
10
5
6
27
12
23
24
18
11
18
25
8
15
22
O
N
D
J
F
M
A

Figure. 3. 2. 3. Seasonal changes in the dissolved silica (µg at Si. l^{-1}) levels at the surface and 5 metres depth. Station 9, from 11 April 1984 to 9 December 1985.


[—SURFACE(9)&----5 METRES(9)]
(1984)
DISSOLVED SILICA(ug at./l⁻¹)
25
20
15
10
5
11
11
25
6
20
11
23
15
29
19
3
17
7
21
5
A
M
J
J
A
S
O
N
D

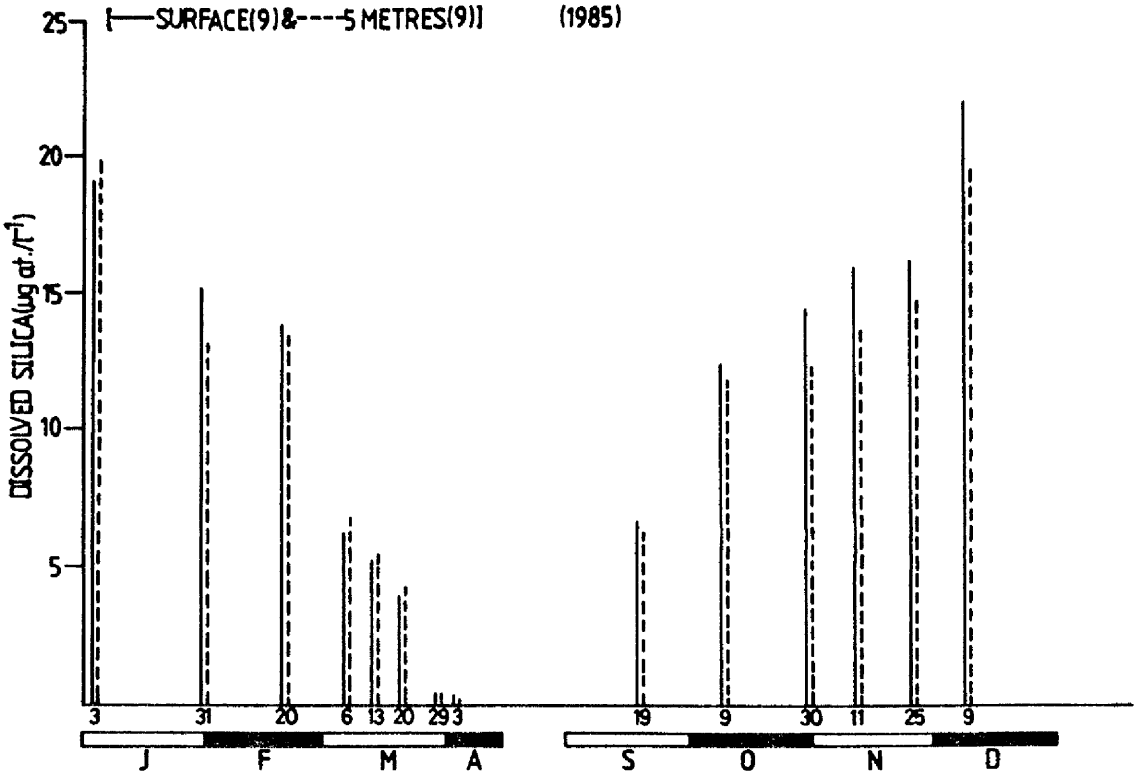
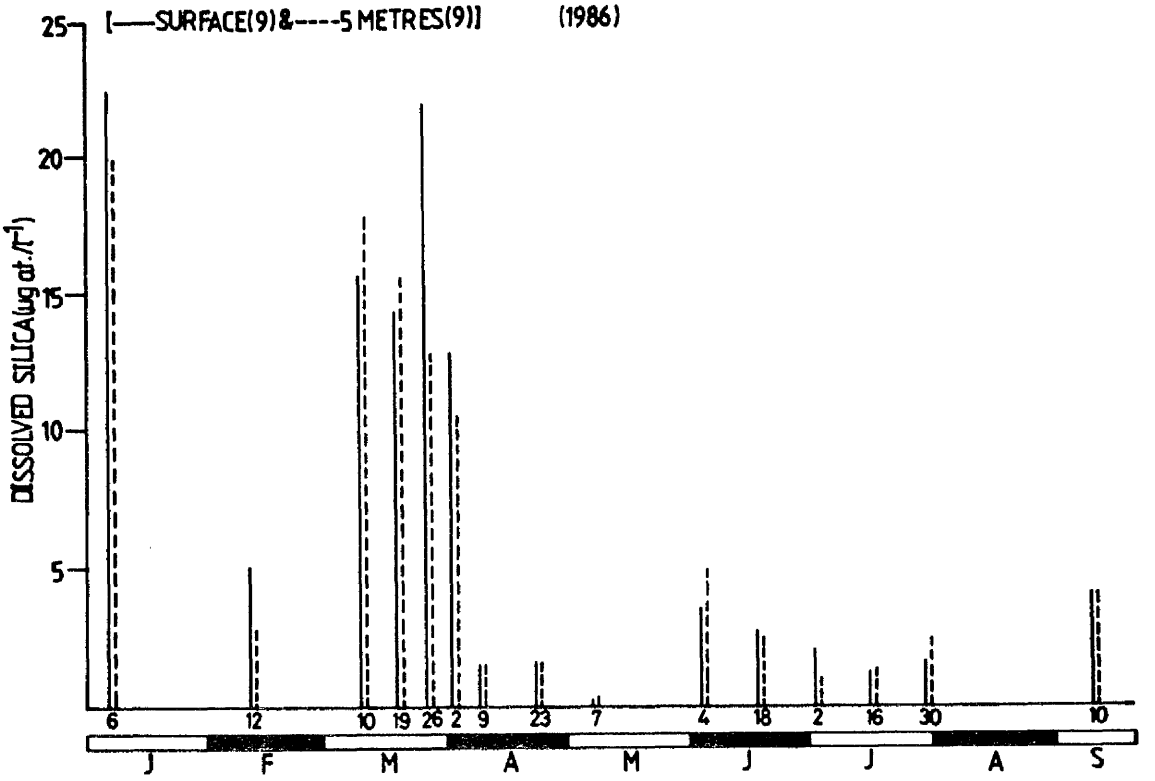
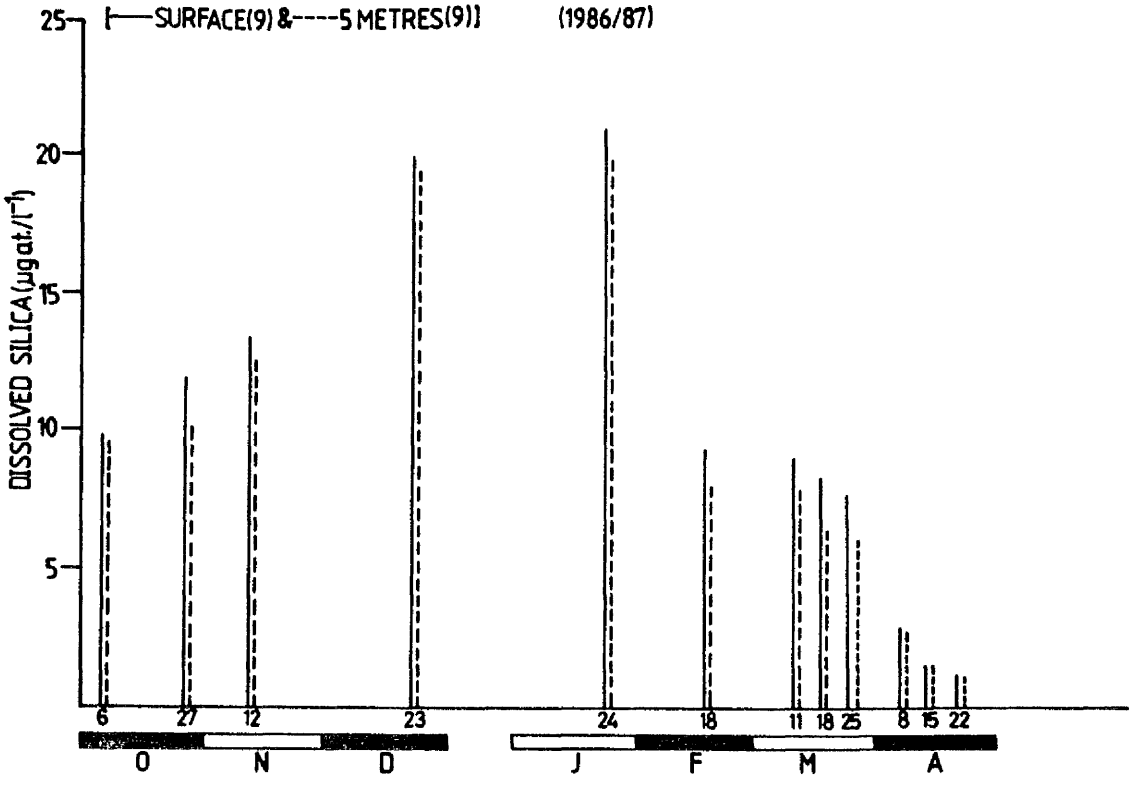

[—SURFACE(9)&----5 METRES(9)]
(1985)
DISSOLVED SILICA(ug at./l⁻¹)
25
20
15
10
5
3
31
20
6
13
20
29
3
19
9
30
11
25
9
J
F
M
A
S
O
N
D

Figure. 3. 2. 4. Seasonal changes in the dissolved silica (µg at Si. l^{-1}) levels at the surface and 5 metres depth. Station 9, from 6 January 1986 to 22 April 1987.


[—SURFACE(9)&----5 METRES(9)]
(1986)
DISSOLVED SILICA(µg at./l⁻¹)
25
20
15
10
5
6
12
10
19
26
2
9
23
7
4
18
2
16
30
10
J
F
M
A
M
J
J
A
S


[—SURFACE(9)&----5 METRES(9)]
(1986/87)
DISSOLVED SILICA(µg at./l⁻¹)
25
20
15
10
5
6
27
12
23
24
18
11
18
25
8
15
22
O
N
D
J
F
M
A

3. 2. 2. Nitrate + Nitrite nitrogen:

The total nitrate + nitrite Nitrogen levels (Table. 3. 2. 2.) which were recorded through out this study varied between low and high values, with significant variations seasonally and with stations and depth (Table. 3. 2. 2.). The values observed ranged between trace quantities and a maximum of 15.7 µg at N. l^{-1}.

Figs. from 3. 2. 5. to 3. 2. 9. show the seasonal variations in the total nitrate + nitrite N content at both stations, at both depths.

On 11 April, 1984, low levels of nitrate were recorded, ranging from 1.6 to 2 µg at N. l^{-1}. On 11 May the levels remained low (1.7 - 2.1 µg at N. l^{-1}). The nitrate levels remained low over summer, with the minimal values for the year recorded on 23 July, at both stations, at both depths (trace - 0.1 µg at N. l^{-1}).

On the 15 th and 29 th of August an increase in the nitrate levels was recorded for samples collected from both stations, at both depths. Maximum summer level for samples collected from station 11 at 5 metres depth was recorded on the 15 August (3 µg at N. l^{-1}), whilst the maximum surface level of 5.4 µg at N. l^{-1} was recorded on the 29 August at both stations, with the maximum for 5 metres levels at station 9 (3.87 µg at N. l^{-1}).

A sharp autumn decrease was recorded on 19 September (0.1 - 0.14 µg at N. l^{-1}). The levels rose from 3 rd of October and remained high over winter.

Maximum values for the year were recorded on 5 December, with quantities ranging fom 11.75 to 14.2 µg at N. l^{-1}.

In 1985, nitrate nitrogen levels remained high until 13 March when the values declined from 10 µg at N. l^{-1} at station 11 (surface), 8.8 µg at N. l^{-1} at station 11 (5 metres), 8.5 µg at N. l^{-1} at station 9 (surface)and 7.65 µg at N. l^{-1} at station 9 (5 metres)on 6 th of March to 5.6 and 3.3 µg at N. l^{-1} at station 11, at surface and 5 metres depth

respectively, and to 4 and 3.8 µg at N. l^{-1} at station 9, at surface and 5 metres depth respectively within a week. On 20 and 29 of March the levels remained low, with quantities ranging from 3.1 to 6.75 µg at N. l^{-1}, the higher values recorded on the latter date.

Minimum values for the year were recorded when the investigation was recommenced on 19 September, with quantities ranging from 0.4 to 0.55 µg at N. l^{-1}. From the 9 October onwards the nitrate nitrogen levels increased gradually reaching highest quantities on the 9 December, of which those recorded for samples collected from station 11, at both depths represented the maximum values for the year (Table. 3. 2. 2.).

In 1986, maximum levels for the year were recorded on 6 January, with quantities ranging from 14 to 15.7 µg at N. l^{-1}. Although a decrease in the nitrate nitrogen levels was recorded on 12 th of February, the values remained high ranging from 10.4 to 12.4 µg at N. l^{-1}. The levels decreased sharply to quantities ranging from 5 to 5.4 µg at N. l^{-1} on 10 March, after which the values continued to decrease gradually during the spring months of March, April and early May, reaching minimum values for the year on the 7 May (0.6 - 1.2 µg at N. l^{-1}). The levels continued to decrease during the summer months, reaching minimum values for the year on the 2 nd of July (trace quantities - 0.2 µg at N. l^{-1}). On the 16 and 30 July the levels were of the same order of magnitude as those recorded on 2 July (Table. 3. 2. 2.). On the 10 th of September nitrate values remained low (0.27 - 0.3 µg at N. l^{-1}). From 6 th of October and through out the rest of the winter months the levels increased steadily reaching maximum winter levels as measured on 23 December (13- 14 µg at N. l^{-1}).

In 1987, maximum values for the year were recorded on 22 January, with quantities ranging from 14 to 15 µg at N. l^{-1}. Equally high levels were recorded on 17 February (11.7 - 12.3 µg at N. l^{-1}).

During the time of the spring diatom increase the nitrate nitrogen levels declined gradually reaching minimum quantities on 22 April (2 - 4 µg at N. l^{-1}).

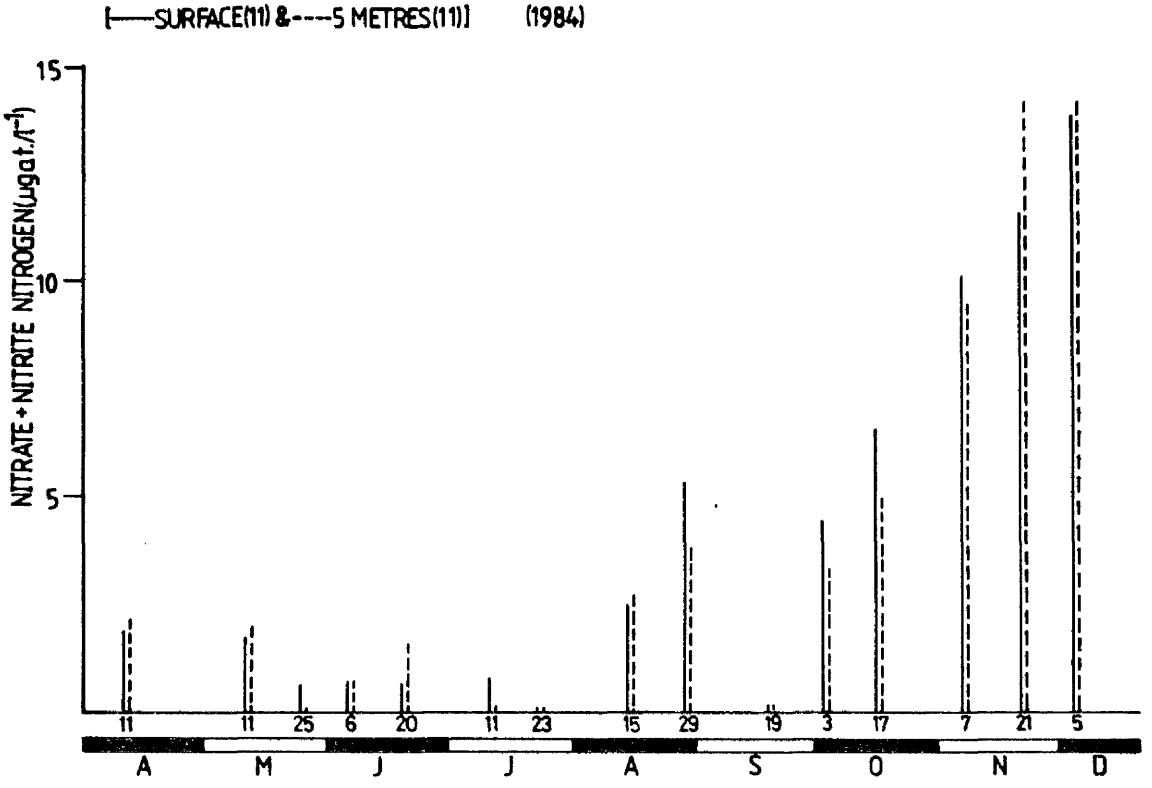
Table. 3. 2. 2. Nitrate + Nitrite levels (µg at . l^{-1}) recorded in the Fairlie Channel at stations 11 and 9 during the period of this study. (T = trace)

	Station 11		Station 9	
Date	S	5m	S	5m
1984				
11.04	2.000	2.000	1.800	1.600
11.05	1.700	2.000	1.700	2.100
25.05	0.640	0.030	0.050	0.050
6.06	0.800	0.800	0.800	0.900
20.06	0.700	1.600	0.400	0.100
11.07	0.800	0.100	0.050	0.050
23.07	0.050	0.100	T	T
15.08	2.600	2.800	2.600	3.000
29.08	5.400	3.870	5.400	0.900
19.9	0.100	0.100	0.100	0.100
3.10	4.500	3.370	3.000	4.200
17.10	6.600	5.000	7.000	4.000
7.11	10.20	9.500	10.56	11.20
21.11	11.66	14.00	10.60	8.750
5.12	14.00	14.20	11.75	12.00
1985				
3.01	15.30	14.85	12.00	12.56
31.01	14.50	14.00	11.20	12.40
20.02	14.00	11.78	10.30	12.27
6.03	8.500	7.650	10.00	8.800
13.03	4.000	3.800	5.600	3.300
20.03	4.200	3.400	3.100	5.200
29.03	6.500	5.600	6.750	6.700
19.09	0.450	0.550	0.400	0.450
9.10	5.000	4.600	5.000	4.000
30.10	7.000	5.000	7.700	5.000
11.11	10.8	9.70	11.0	10.0
25.11	13.3	14.2	12.4	10.5
9.12	14.6	14.4	13.5	13.8
1986				
6.01	15.7	15.0	14.0	14.2
12.02	11.6	12.4	10.4	11.5
10.03	5.20	5.40	5.00	5.40
19.03	5.00	5.00	4.86	5.50
26.03	3.70	5.00	3.60	3.90
2.04	5.00	5.30	4.70	5.00
9.04	4.30	2.00	2.40	2.50
23.04	4.00	2.20	2.30	2.40
7.05	1.20	0.60	0.90	1.00
4.06	0.30	0.30	0.36	0.30
2.07	T	0.10	T	0.20
16.07	0.05	0.10	0.01	0.10

Table. 3. 2. 2. (Continued)

	Station 11		Station 9	
Date	S	5m	S	5m
1986				
30.07	0.05	0.10	0.01	0.10
10.09	0.28	0.30	0.27	0.28
6.10	5.00	4.00	4.00	4.00
27.10	7.00	5.20	7.30	4.50
12.11	10.5	9.60	11.3	10.6
23.12	14.0	13.6	13.2	13.0
1987				
22.01	15.0	14.2	14.3	14.0
17.02	12.3	11.7	12.0	12.0
11.03	9.90	9.00	9.70	9.50
18.03	8.80	7.80	8.60	8.00
25.03	8.00	7.00	8.00	7.00
8.04	4.20	2.00	2.80	2.50
15.04	4.00	3.00	2.40	2.00
22.04	4.00	2.30	2.30	2.00

Figure. 3. 2. 5. Seasonal changes in the combined nitrate + nitrite nitrogen (µg at N. l^{-1}) levels at the surface and 5 metres depth. Station 11.
From 11 April 1984 to 9 December 1985.


[——SURFACE(11) &----5 METRES(11)] (1984)
NITRATE + NITRITE NITROGEN(µgat./l⁻¹)
15
10
5
11
11
25
6
20
11
23
15
29
19
3
17
7
21
5
A
M
J
J
A
S
O
N
D

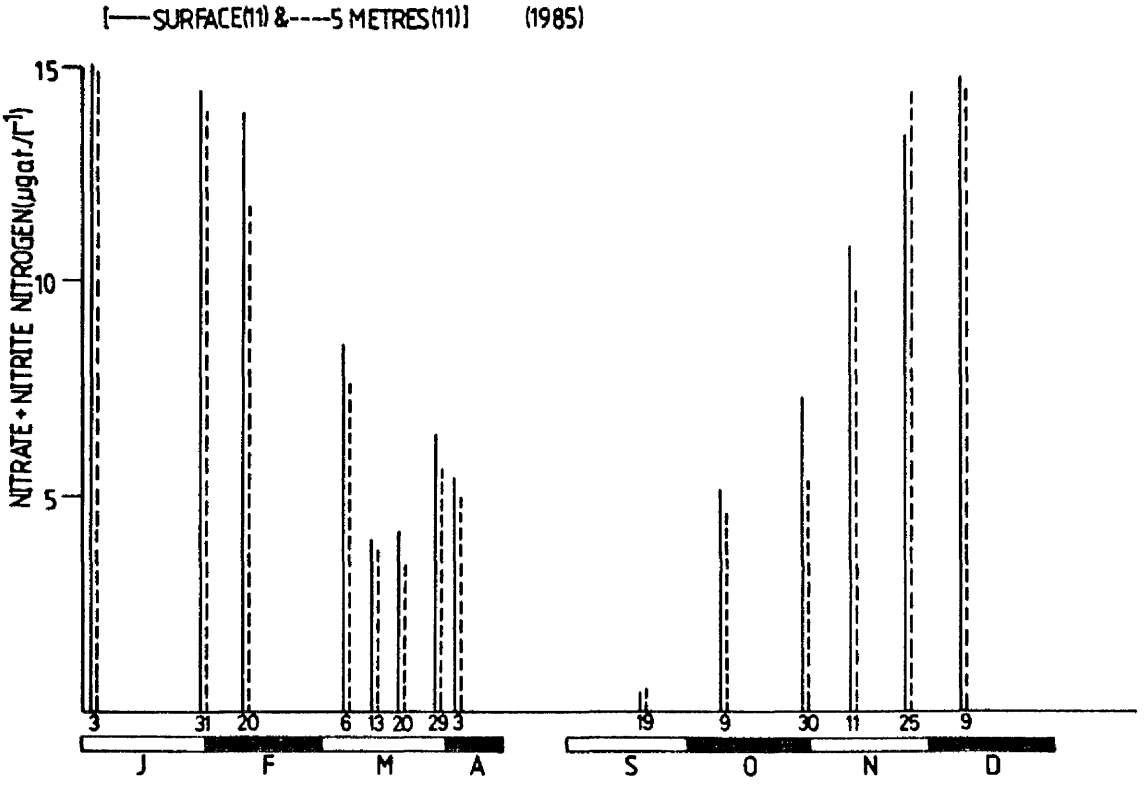
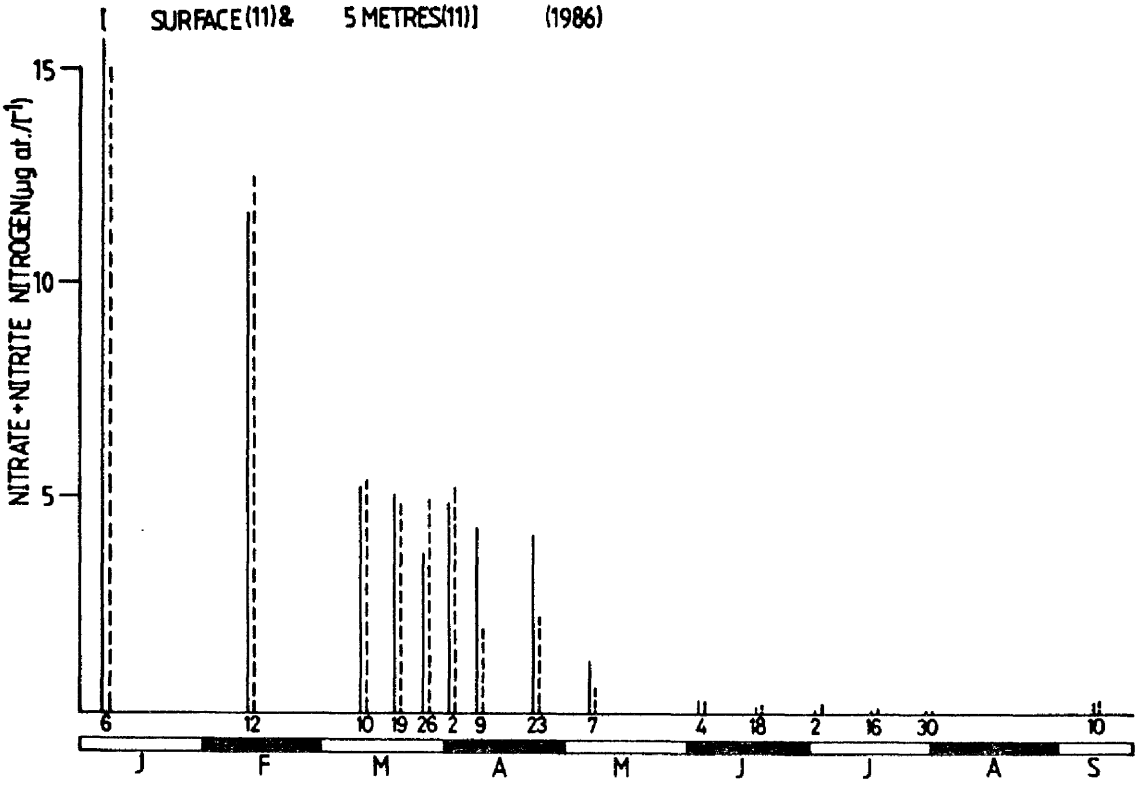

[——SURFACE(11) &----5 METRES(11)] (1985)
NITRATE + NITRITE NITROGEN(µgat./l⁻¹)
15
10
5
3
31
20
6
13
20
29
3
19
9
30
11
25
9
J
F
M
A
S
O
N
D

Figure. 2. 3. 6. Seasonal changes in the combined nitrate + nitrite nitrogen (µg at N. l^{-1}) levels at the surface and 5 metres depth. Station 11.
From 6 January 1986 to 22 April 1987.


[SURFACE (11) & 5 METRES (11)] (1986)
NITRATE + NITRITE NITROGEN (µg at./l⁻¹)
15
10
5
6
12
10 19 26 2 9 23 7
4 18 2 16 30 10
J F M A M J J A S

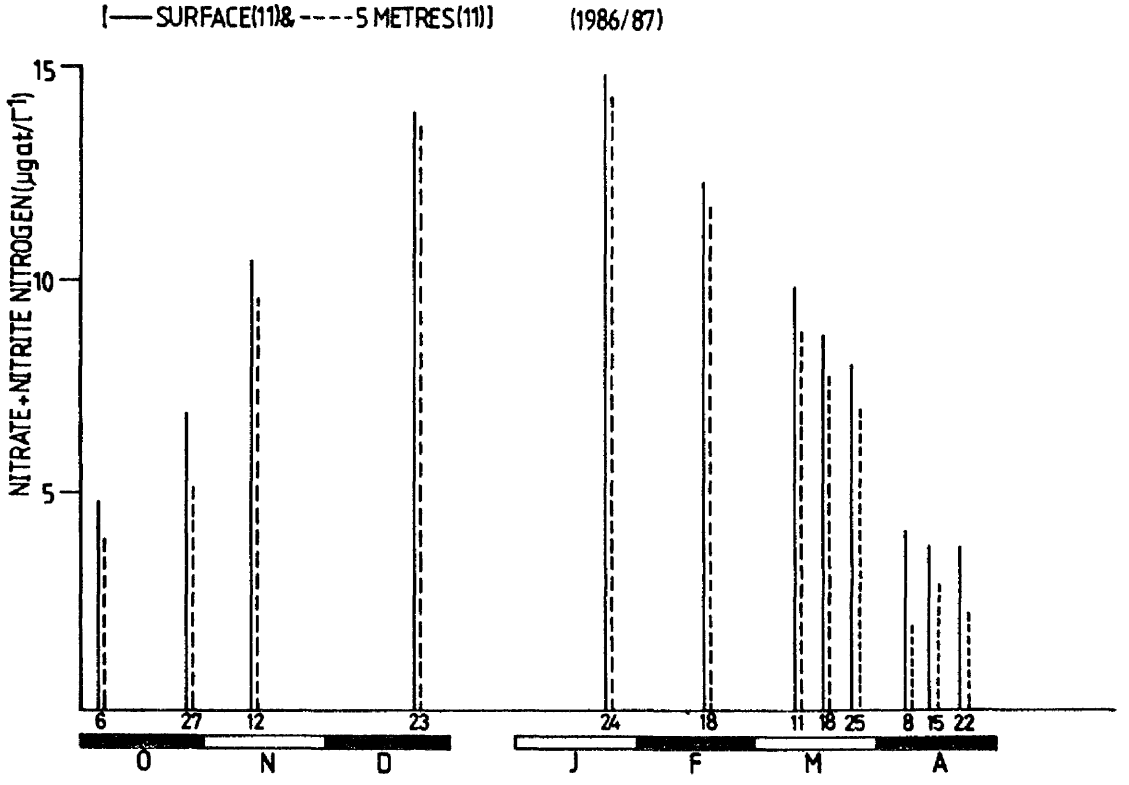
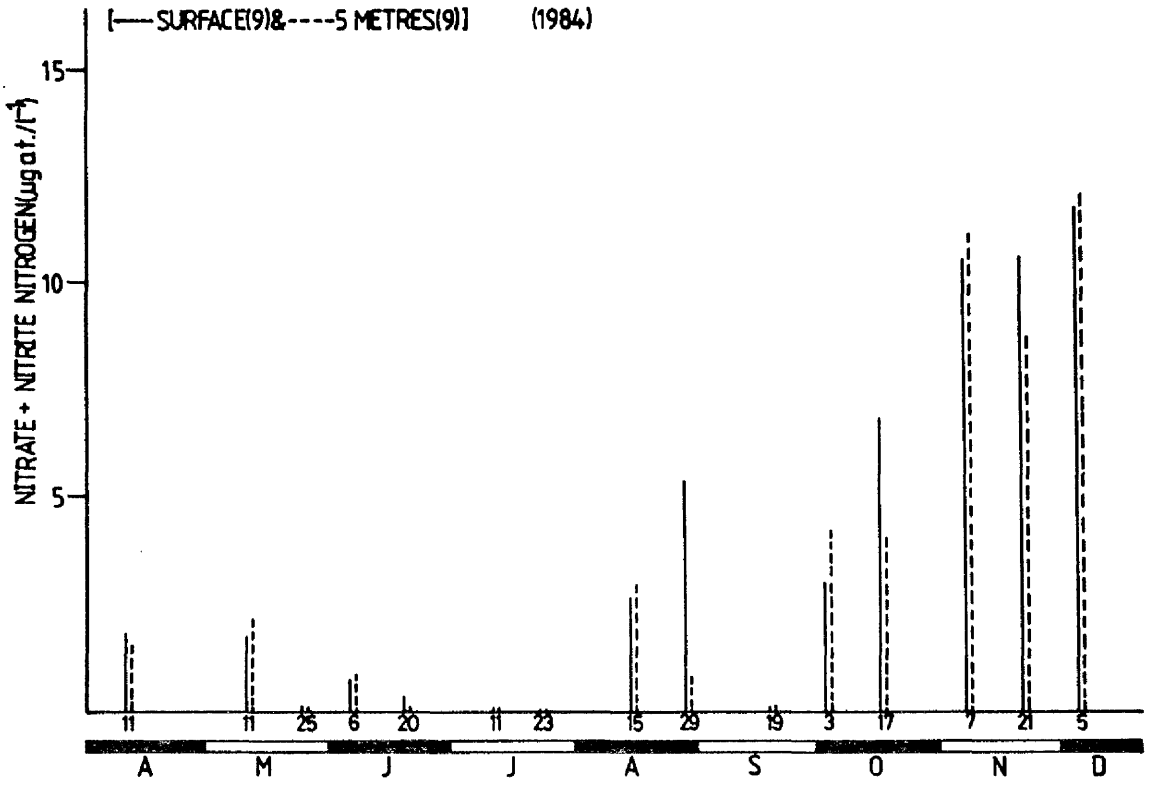

[—— SURFACE (11) & ---- 5 METRES (11)] (1986/87)
NITRATE + NITRITE NITROGEN (µg at/l⁻¹)
15
10
5
6 27 12 23
24 18 11 18 25 8 15 22
O N D J F M A

Figure. 3. 2. 7. Seasonal changes in the combined nitrate + nitrite nitrogen (µg at N. l^{-1}) levels at the surface and 5 metres depth. Station 9.
From 11 April 1984 to 9 December 1985.


[—— SURFACE(9)&----5 METRES(9)] (1984)
NITRATE + NITRITE NITROGEN(µg at./l⁻¹)
15
10
5
11
11
25
6
20
11
23
15
29
19
3
17
7
21
5
A
M
J
J
A
S
O
N
D

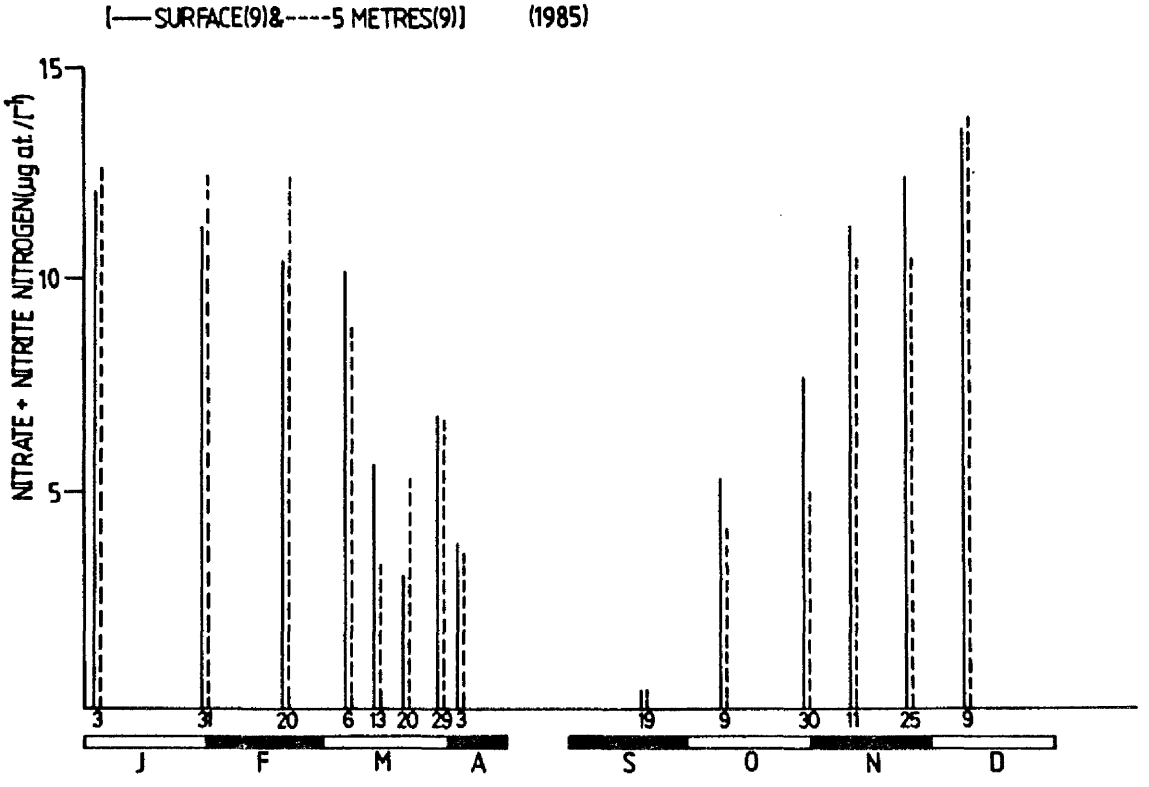
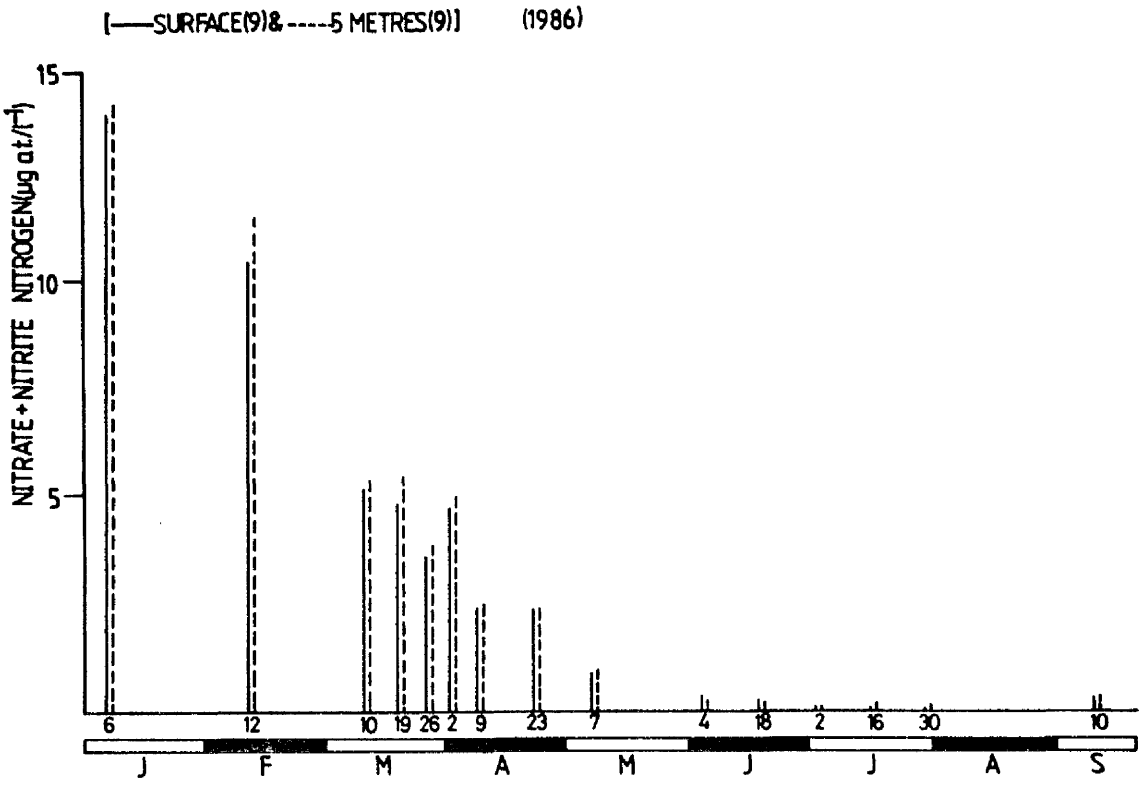
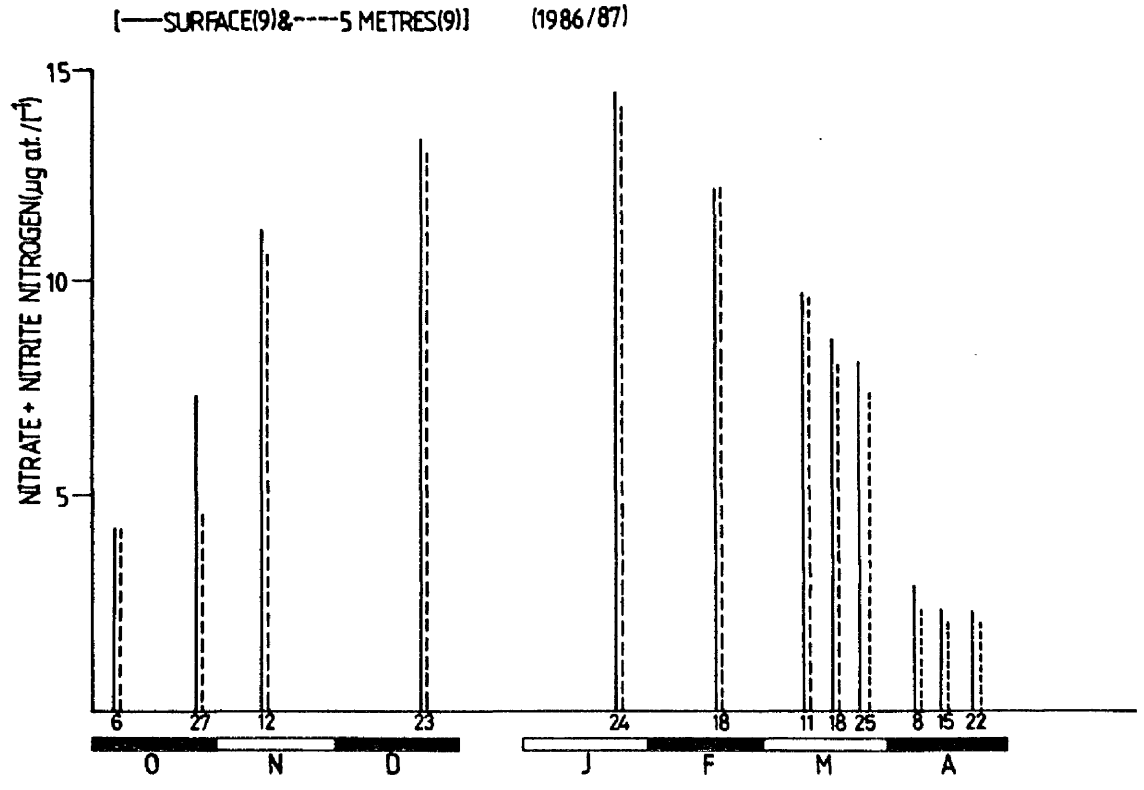

[—— SURFACE(9)&----5 METRES(9)] (1985)
NITRATE + NITRITE NITROGEN(µg at./l⁻¹)
15
10
5
3
31
20
6
13
20
29
3
19
9
30
11
25
9
J
F
M
A
S
O
N
D

Figure. 3. 2. 8. Seasonal changes in the combined nitrate + nitrite nitrogen (µg at N. l^{-1}) levels at the surface and 5 metres depth. Station 9.
From 6 January 1986 to 22 April 1987.


[——SURFACE(9)& ----5 METRES(9)] (1986)
NITRATE + NITRITE NITROGEN(µg at./l⁻¹)
15
10
5
6
12
10
19
26
2
9
23
7
4
18
2
16
30
10
J
F
M
A
M
J
J
A
S


[——SURFACE(9)&----5 METRES(9)] (1986/87)
NITRATE + NITRITE NITROGEN(µg at./l⁻¹)
15
10
5
6
27
12
23
24
18
11
18
25
8
15
22
O
N
D
J
F
M
A

3. 2. 3. Reactive Phosphate:

Phosphate phosphorus levels were lower than the other nutrients throughout the course of this investigation. Values ranged between trace quantities to 1.45 µg at P. l^{-1} (Table. 3. 2. 3.). The minimum trace quantities was recorded at station 11 (surface) on the 11 May, 1984, while the maximum of 1.45 µg at P. l^{-1} were recorded for samples collected from the same station, at the same depth on the 9 December, 1985.

Marked variations were observed at the different seasons, at different stations (Table. 3. 2. 3.). Figs. from 3. 2. 9. to 3. 2. 12. show a clear seasonal pattern for reactive phosphate at both stations.

The recorded levels of phosphate during the spring of 1984 and at the time of the beginning of this study on 11 April were low ranging from 0.45 to 0.6 µg at P. l^{-1}. On 11 May, after the main period of the diatom spring increase, a decrease in phosphate levels was recorded with values ranging from trace quantities - 0.3 µg at P. l^{-1}.

Levels remained low over summer, with quantities ranging from 0.1 to 0.6 µg at P. l^{-1}, with the exception of values recorded for samples collected from station 11 (surface) on the 15 and 29 August, on which 0.9 and 0.8 µg at P. l^{-1} were recorded respectively.
Levels rose during autumn and remained high over winter, with the maximum quantities for the year observed on 5 December (1.3 µg at P. l^{-1}).
In 1985, phosphate levels remained around 1 µg at P. l^{-1} until 6 March in when lower levels ranging from 0.35 to 0.6 µg at p.l^{-1} were recorded. On the 13 th of March, with the exception of levels recorded for samples collected from station 9 at surface (0.06 µg at P. l^{-1}) which represented the minimum quantities ranging from 0.8 to 1 µg at P. l^{-1}. Slightly lower levels were recorded on the 20 and 29 March, and on 3 April with quantities ranging from 0.46 to 0.68 µg at P. l^{-1}. When the investigation was recommenced on 19 September phosphate were found to have the following values, 0.8 µg at P. l^{-1} at station 11 (surface), 0.5 µg at P. l^{-1} at station 11 (5 metres), 0.77 µg at P.

l^{-1} at station 9 (surface) and 0.75 µg at P. l^{-1} at station 9 (5 metres). The levels increased gradually throughout the winter months reaching maximum values for the year on 9 December, with quantities ranging from 1.35 to 1.45 µg at P. l^{-1}.

In 1986, on 6 January and 12 February, the levels remained high ranging from 0.87 to 1.4 µg at P. l^{-1}, with the highest quantities observed on the former date, which represented the maximum values for the year.

Spring values fluctuated between quantities slightly higher or equal to 1 µg at P. l^{-1} and levels lower than 1 µg at P. l^{-1} (not below 0.65 µg at P. l^{-1}) until 2 April after which the levels recorded ranged between 0.64 and 0.9 µg at P. l^{-1}.

Phosphate values were low over summer, with the minimum levels for the year recorded on the 2 July (0.07 - 0.15 µg at P. l^{-1}).

High autumn and winter levels were recorded from the 10 September. During this period phosphate values increased gradually reaching maximum quantities on the 23 December (1.2 - 1.4 µg at P. l^{-1}).

The 1987 phosphate levels remained high until 25 March when a decrease from quantities ranging from 1.1 to 1.2 µg at P. l^{-1} on 22 January to levels ranging from 0.6 to 0.64 µg at P. l^{-1} within two months and two days was recorded. From the 8 April onwards phosphate levels decreased gradually reaching quantities ranging from 0.45 to 0.53 µg at P. l^{-1} on 22 April.

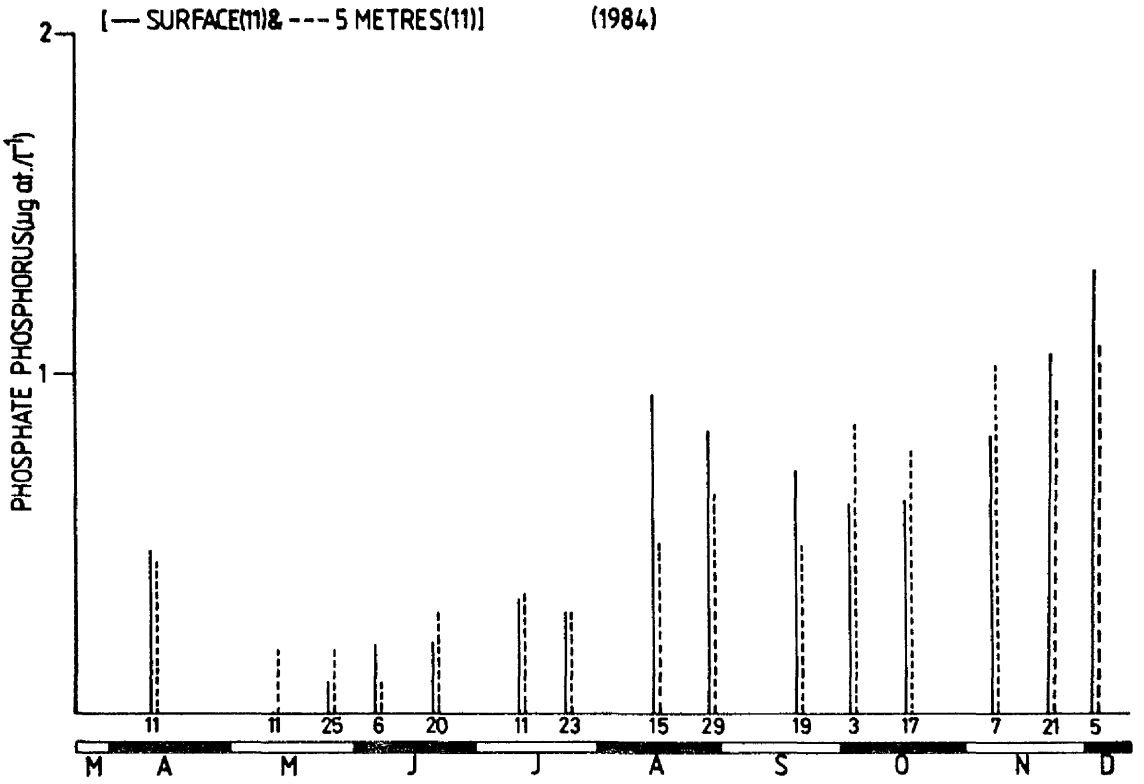
Table. 3. 2. 3. Phosphate phosphorus levels (µg at. l^{-1}) recorded in the Fairlie Channel at stations 11 and 9 during the period of this study.

	Station 11		Station 9	
Date	S	5m	S	5m
1984				
11.04	0.50	0.45	0.50	0.60
11.05	T	0.20	0.10	0.30
25.05	0.10	0.10	0.40	0.20
6.06	0.20	0.10	0.24	0.20
20.06	0.20	0.30	0.20	0.20
11.07	0.34	0.36	0.35	0.30
23.07	0.30	0.30	0.37	0.25
15.08	0.90	0.50	0.20	0.40
29.08	0.80	0.65	0.36	0.40
19.09	0.72	0.50	0.54	0.57
3.10	0.60	0.85	0.50	0.60
17.10	0.60	0.80	0.60	0.70
7.11	0.80	1.00	0.87	0.80
21.11	1.00	0.90	1.00	1.00
5.12	1.30	1.10	1.30	1.24
1985				
3.01	1.30	0.80	1.25	0.90
31.01	0.87	0.55	0.87	0.87
20.02	0.90	1.00	0.80	0.80
6.03	0.60	0.50	0.35	0.40
13.03	1.00	1.00	0.06	0.80
20.03	0.67	0.68	0.60	0.70
29.03	0.56	0.65	0.50	0.60
3.04	0.60	0.60	0.46	0.60
19.09	0.80	0.50	0.77	0.75
9.10	0.70	0.90	0.70	0.80
30.10	0.70	0.95	0.80	0.90
11.11	1.00	0.97	1.00	1.00
25.11	1.20	1.20	1.20	1.00
9.12	1.45	1.35	1.42	1.40
1986				
6.01	1.40	1.30	1.40	1.30
12.02	1.26	0.87	1.00	1.00
10.03	1.00	1.30	0.95	0.90
19.03	1.00	0.96	0.65	0.65
26.03	0.60	1.20	1.10	1.10
2.04	0.74	0.80	1.10	1.10
9.04	0.65	0.66	0.90	0.90
23.04	0.64	0.64	0.90	0.90
7.05	0.65	0.54	0.43	0.85
4.06	0.74	0.65	0.74	0.60
18.06	0.25	0.20	0.25	0.20

Table. 3. 2. 3. (Continued)

	Station 11		Station 9	
Date	S	5m	S	5m
1986				
2.07	0.09	0.07	0.15	0.08
16.07	0.22	0.22	0.20	0.20
30.07	0.23	0.26	0.28	0.22
10.09	0.76	0.50	0.66	0.66
6.10	0.67	0.87	0.60	0.70
27.10	0.70	0.86	0.70	0.80
12.11	0.90	1.00	0.95	0.93
23.12	1.30	1.30	1.20	1.40
1987				
22.01	1.20	1.20	1.20	1.20
17.02	1.00	1.10	1.00	1.00
11.03	1.00	1.00	1.00	1.00
18.03	0.90	0.80	0.80	0.80
25.03	0.64	0.62	0.62	0.60
8.04	0.60	0.60	0.60	0.60
15.04	0.55	0.53	0.53	0.50
22.04	0.53	0.53	0.47	0.45

Figure. 3. 2. 9. Seasonal changes in the phosphate phosphorus levels (µg at P. l^{-1}). Station 11, at surface and 5 metres depth. From 11 April 1984 to 9 December 1985.


[— SURFACE(11)& --- 5 METRES(11)]
(1984)
PHOSPHATE PHOSPHORUS(ug at./l⁻¹)
2
1
11
11
25
6
20
11
23
15
29
19
3
17
7
21
5
M
A
M
J
J
A
S
O
N
D

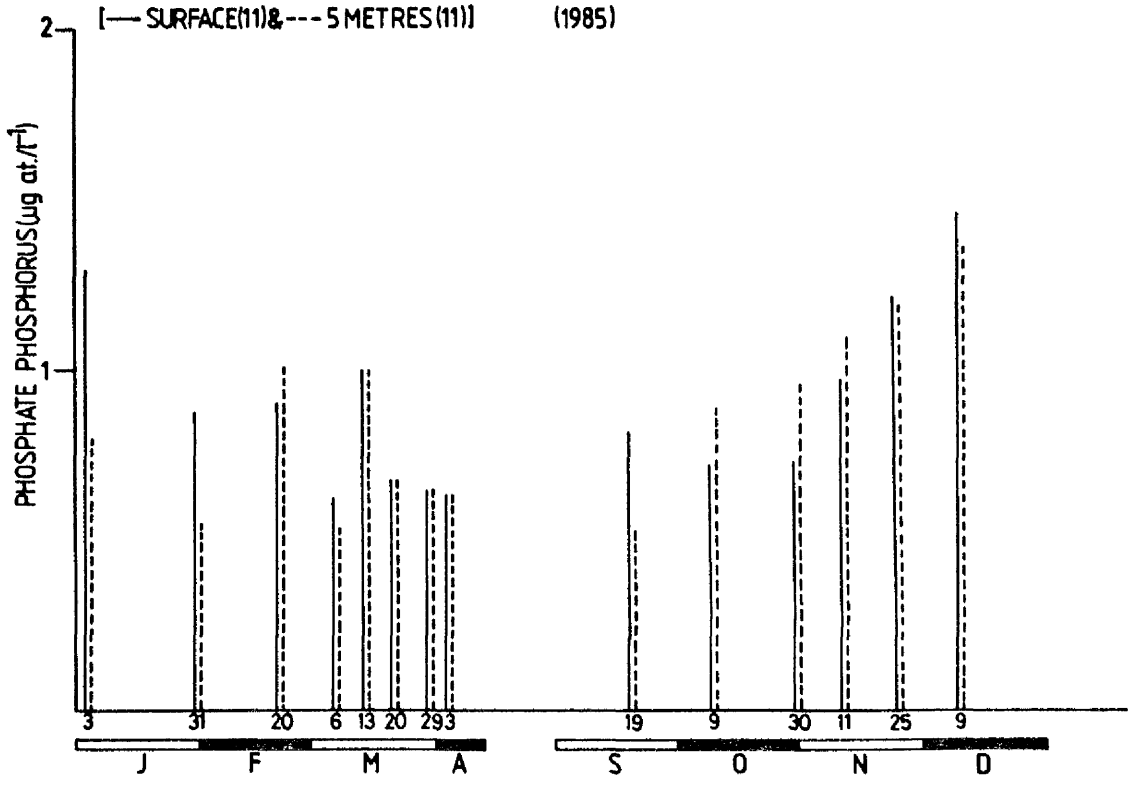
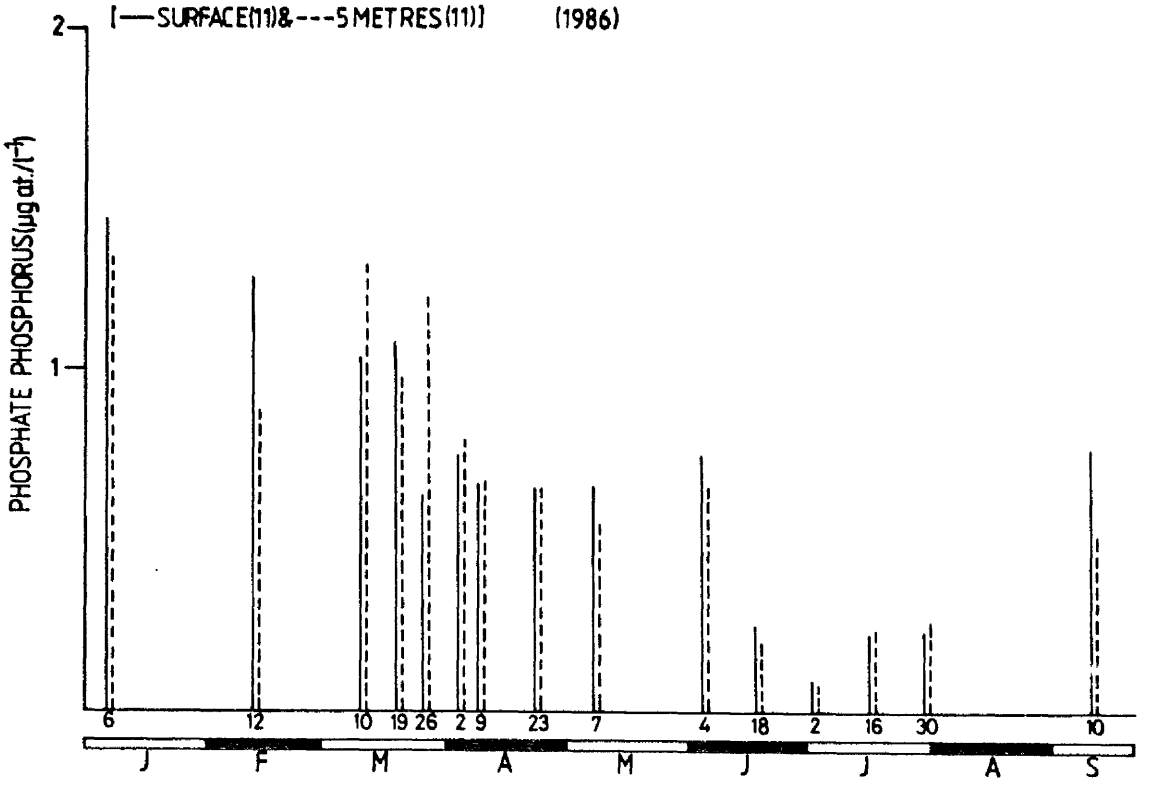

[— SURFACE(11)& --- 5 METRES(11)]
(1985)
PHOSPHATE PHOSPHORUS(ug at./l⁻¹)
2
1
3
31
20
6
13
20
29
3
19
9
30
11
25
9
J
F
M
A
S
O
N
D

Figure. 3. 2. 10. Seasonal changes in the phosphate phosphorus levels (µg at P. l^{-1}). Station 11, at surface and 5 metres depth. From 6 January 1986 to 22 April 1987.


[— SURFACE(11)& --- 5 METRES(11)]
(1986)
PHOSPHATE PHOSPHORUS(µg at./l⁻¹)
2
1
6
12
10
19
26
2
9
23
7
4
18
2
16
30
10
J
F
M
A
M
J
J
A
S

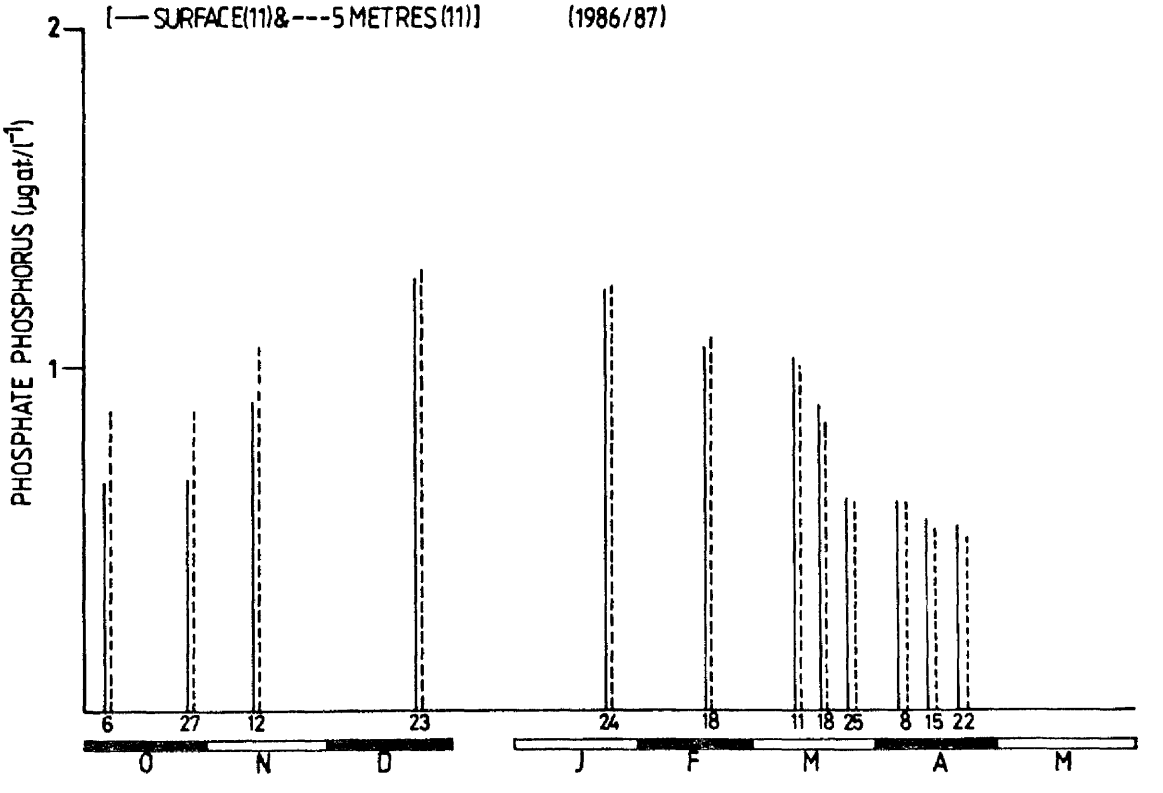
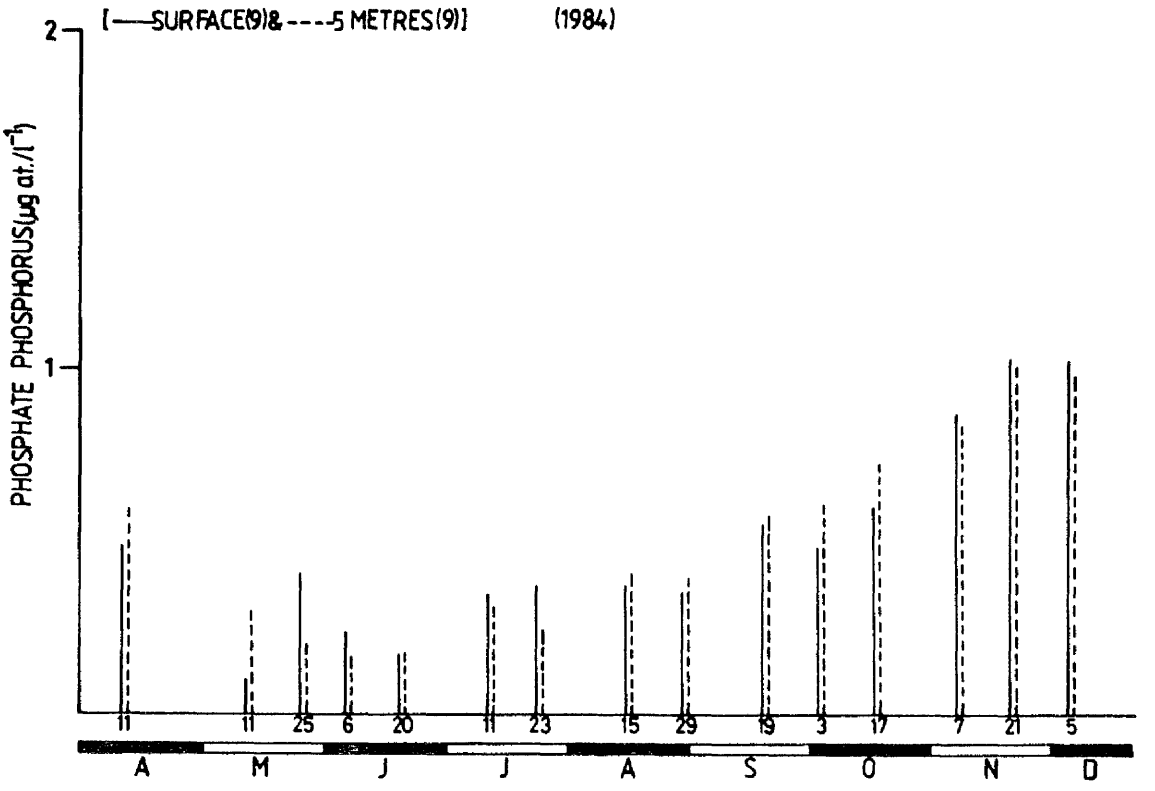

[— SURFACE(11)& --- 5 METRES(11)]
(1986/87)
PHOSPHATE PHOSPHORUS (µg at./l⁻¹)
2
1
6
27
12
23
24
18
11
18
25
8
15
22
O
N
D
J
F
M
A
M

Figure. 3. 2. 11. Seasonal changes in the phosphate phosphorus levels (µg at P. l^{-1}). Station 9, at surface and 5 metres depth. From 11 April 1984 to 9 December 1985.


[——SURFACE(9)& ----5 METRES(9)]
(1984)
PHOSPHATE PHOSPHORUS(µg at./l⁻¹)
2
1
11
11
25
6
20
11
23
15
29
19
3
17
7
21
5
A
M
J
J
A
S
O
N
D

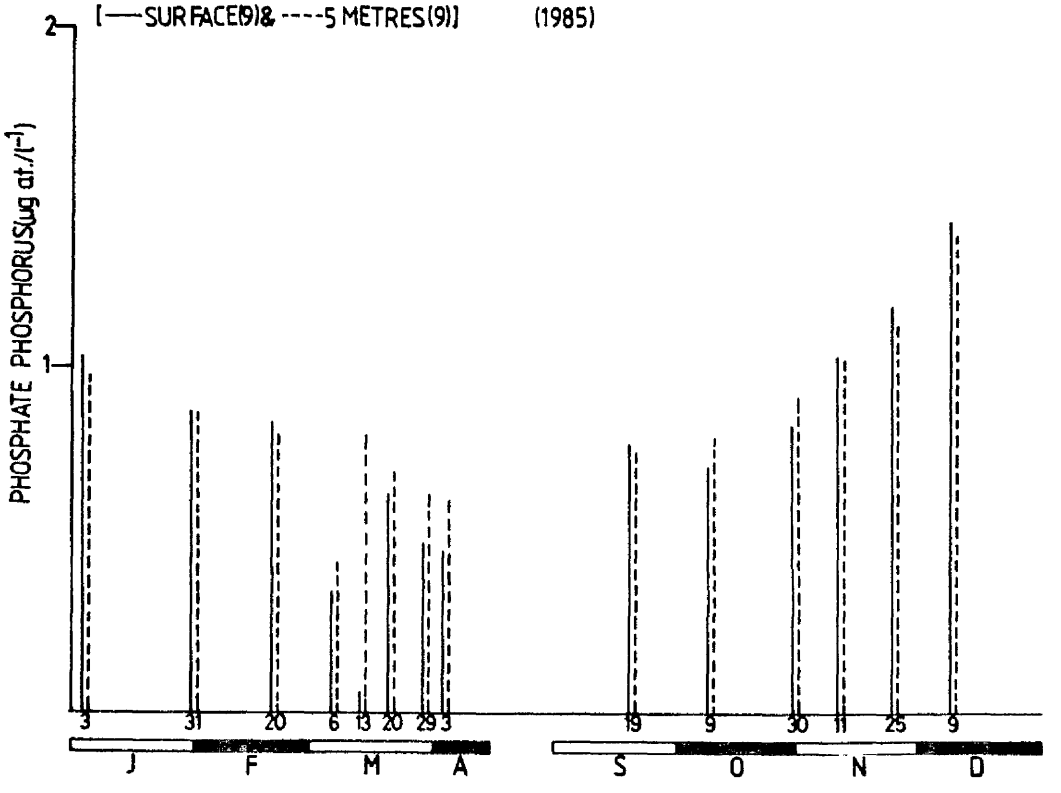
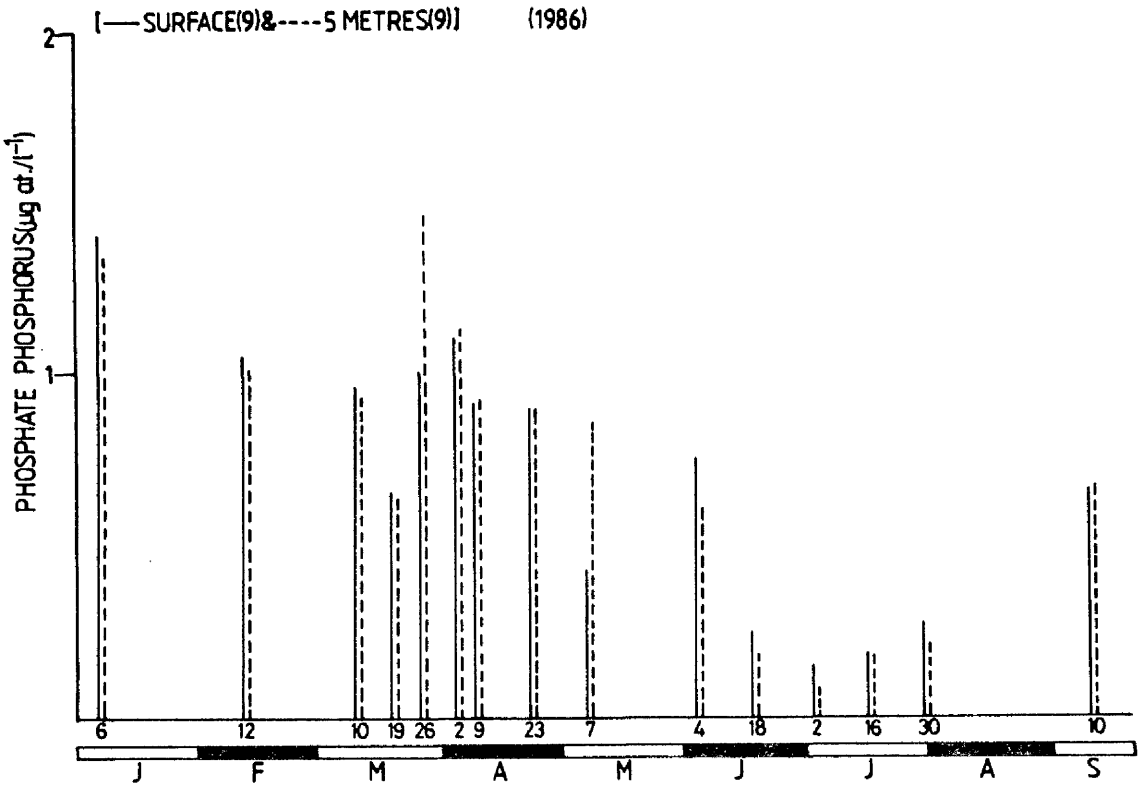
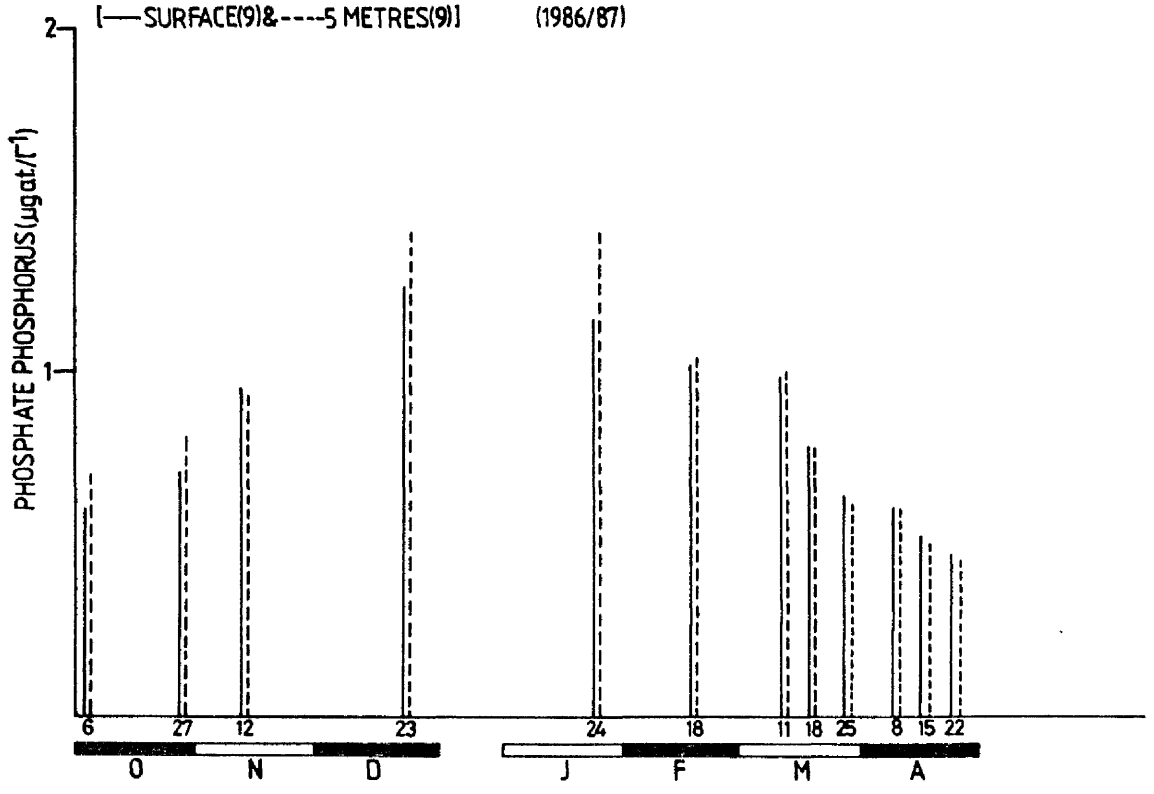

[——SURFACE(9)& ----5 METRES(9)]
(1985)
PHOSPHATE PHOSPHORUS(µg at./l⁻¹)
2
1
3
31
20
6
13
20
29
3
19
9
30
11
25
9
J
F
M
A
S
O
N
D

Figure. 3. 2. 12. Seasonal changes in the phosphate phosphorus levels (µg at P. l^{-1}). Station 9, at surface and 5 metres depth. From 6 January 1986 to 22 April 1987.


[—SURFACE(9)&----5 METRES(9)] (1986)
PHOSPHATE PHOSPHORUS(µg at./l⁻¹)
2
1
6 12 10 19 26 2 9 23 7 4 18 2 16 30 10
J F M A M J J A S


[—SURFACE(9)&----5 METRES(9)] (1986/87)
PHOSPHATE PHOSPHORUS(µgat/l⁻¹)
2
1
6 27 12 23 24 18 11 18 25 8 15 22
O N D J F M A

3. 2. 4. Discussion:

The minimum and maximum recorded nutrient levels during this study are tabulated in Table. 3. 2. 4. and compared with those found by Hinton, (1974) and Hannah, (1979) (Table. 3. 2. 5.).

Table. 3. 2. 4. Maximum and minimum recorded nutrient values during this study (µg at. l^{-1}).

	1984		1985		1986		1987	
	Max	Min	Max	Min	Max	Min	Max	Min
Silica	19.4	T	21.95	0.3	22.45	0.94	21.6	1.0
Nitrate	14.2	0.03	15.3	0.4	15.7	T	14.9	2.0
Phosphate	1.3	T	1.45	0.35	1.43	0.07	1.24	0.45

T = Trace

Table. 3. 2. 5. Maximum and minimum recorded nutrient values recorded by Hinton, (1974) in 1973 and Hannah, (1979) in 1976 and 1977 (µg at. l^{-1}).

	1973		1976		1977	
	Max	Min	Max	Min	Max	Min
Silica	13.4	0.4	11.5	0.26	12.33	0.8
Nitrate	23.7	4.0	20.0	0.75	21.9	1.24
Phosphate	1.60	0.2	1.76	0.12	1.32	0.31

Higher maximum dissolved silica levels and lower maximum nitrate nitrogen levels were found during this study in comparison to those found by Hinton, (1974) and Hannah, (1979). The maximum phosphate phosphorus quantities and the minimum values recorded for all three nutrients observed during the course of this study were similar to those found in 1973 by Hinton and to those found by Hannah in 1976 and 1977.

The seasonal variations of the nutrient levels closely correlated to the changes in the algal biomass, with the decrease in nutrient quantities following the spring diatom increase and the following summer. The maximum nutrient values were recorded during winter at the time of low algal biomass.

During this study the decrease in the nutrient levels following the spring diatom increase was not dramatic. The same was mentioned by Hinton, (1974) and Hannah, (1979).

3. 3. Standing crop:

The quantitative aspects of changes in standing crop were examined in terms of the seasonal changes in total chlorophyll a levels with phaeopigment levels and total number of phytoplankton cells.

3. 3. 1. Seasonal changes in chlorophyll a and phaeopigments levels:

The changes in the levels of chlorophyll and phaeopigments for the surface and 5 metres depth at stations 11 and 9 in the Fairlie channel are shown in Figs. 3. 3. 1. to 3. 3. 8.

The cycles observed at stations 11 and 9 during the period of this study were in general similar (Tables. 3.3.1. and 3. 3. 2), the outstanding feature being the spring increase in phytoplankton biomass, typical of temperate seas. Peaks in chlorophyll concentrations also occured during the summer and autumn. Winter levels of chlorophyll were low.

Maximum chlorophyll levels recorded during the spring of 1984 were low for this time of the year, but phaeopigment levels at the time were high, even higher than chlorophyll levels mainly during 11 April and 11 May which suggests that the peak of the spring diatom increase occured prior to the beginning of this investigation and the effects of zooplankton grazing were prominent.

During the late spring chlorophyll levels remained relatively high, ranging from 3.60 and 3.90 mg m^{-3} on 11 April to 3.30 and 3 mg m^{-3} on the 25 of May at the surface for stations 11 and 9 respectively and from 3.44 and 4.10 mg m^{-3} on 11 April to 3.94 and 4 mg m^{-3} on 25 May at 5 metres depth.

On the 11 May chlorophyll levels at station 11 were 3.40 and 2.5 mg m^{-3} at surface and 5 metres depth, and 3.20 and 3.45 mg m^{-3} at station 9.

Figure. 3. 3. 1. Seasonal changes in the chlorophyll a and phaeopigment (mg / m^3) levels at the surface and 5 metres depth. Station 11, from 11 April to 5 December 1984.

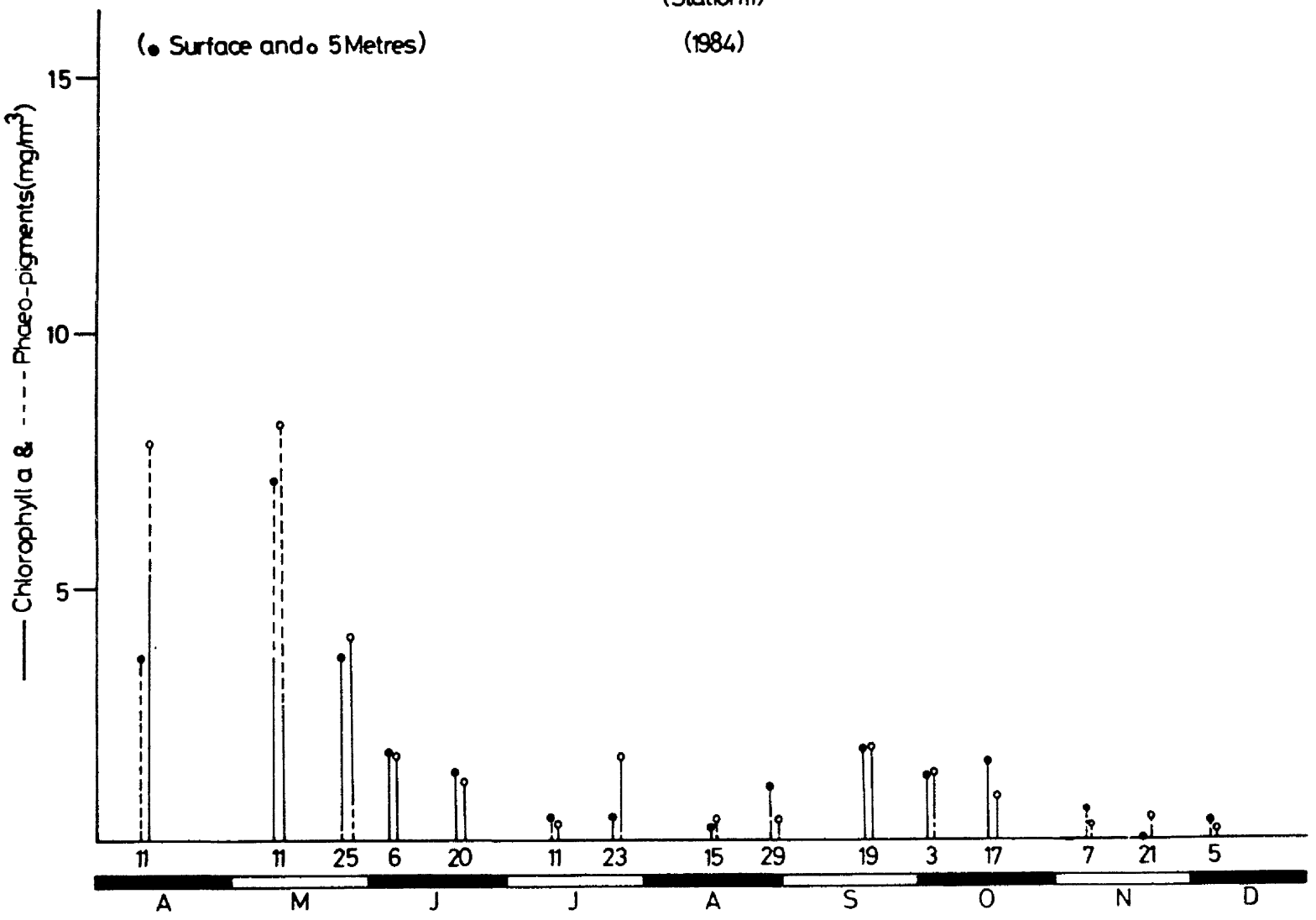

(Station11)
(1984)
(● Surface and ○ 5 Metres)
Chlorophyll a & ---- Phaeo-pigments(mg/m³)
15
10
5
11
11
25
6
20
11
23
15
29
19
3
17
7
21
5
A
M
J
J
A
S
O
N
D

Figure. 3. 3. 2. Seasonal changes in the chlorophyll a and phaeopigment (mg / m^3) levels at the surface and 5 metres depth. Station 11, from 3 January 1985 to 6 January 1986.

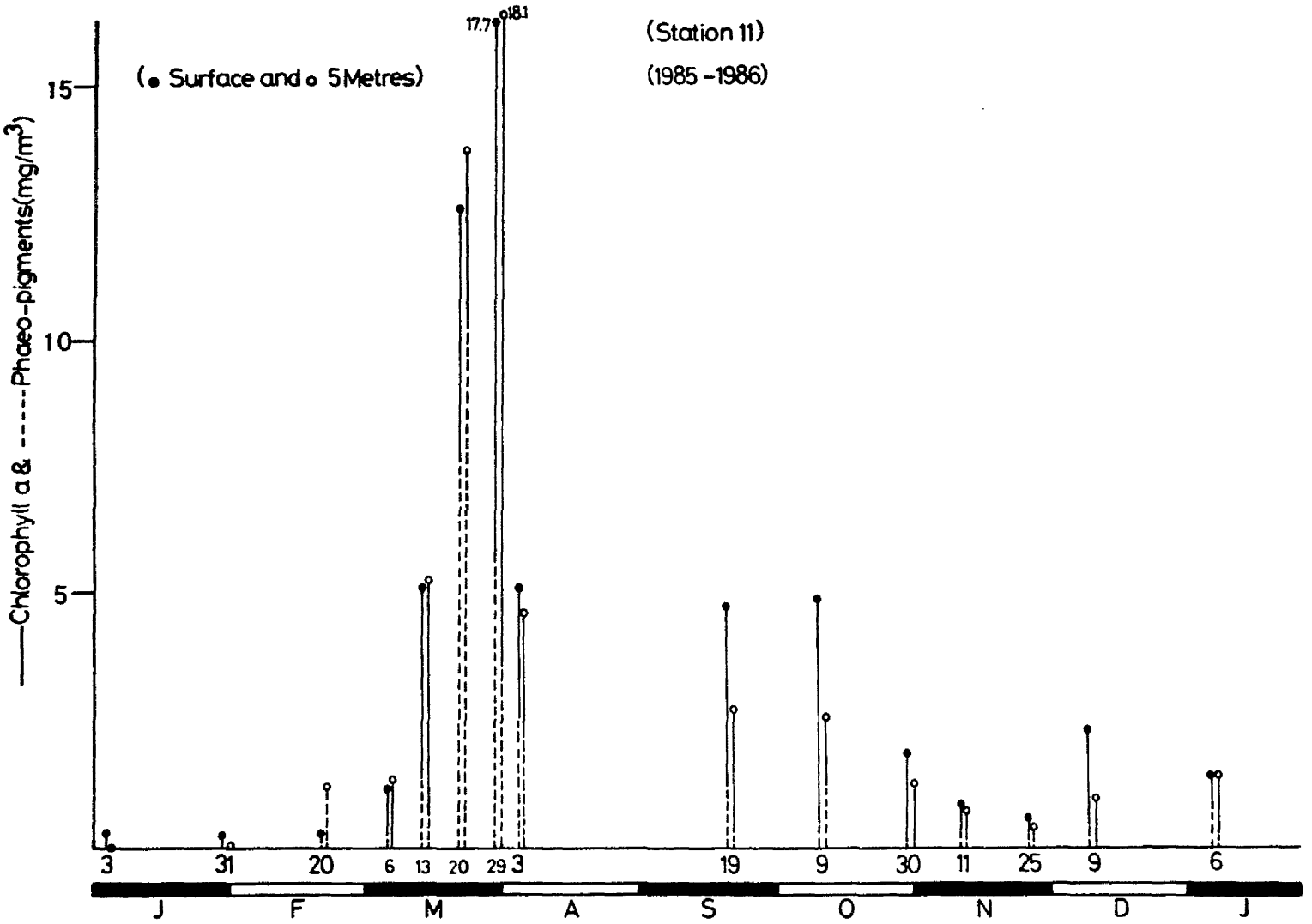

(Station 11)
(1985 -1986)
(• Surface and o 5 Metres)
17.7
18.1
15
10
5
——Chlorophyll a & -----Phaeo-pigments(mg/m3)
3
31
20
6
13
20
29
3
19
9
30
11
25
9
6
J
F
M
A
S
O
N
D
J

Figure. 3. 3. 3. Seasonal changes in the chlorophyll a and phaeopigment (mg / m^3) levels at the surface and 5 metres depth. Station 11, from 12 February to 6 October 1986.

station 11

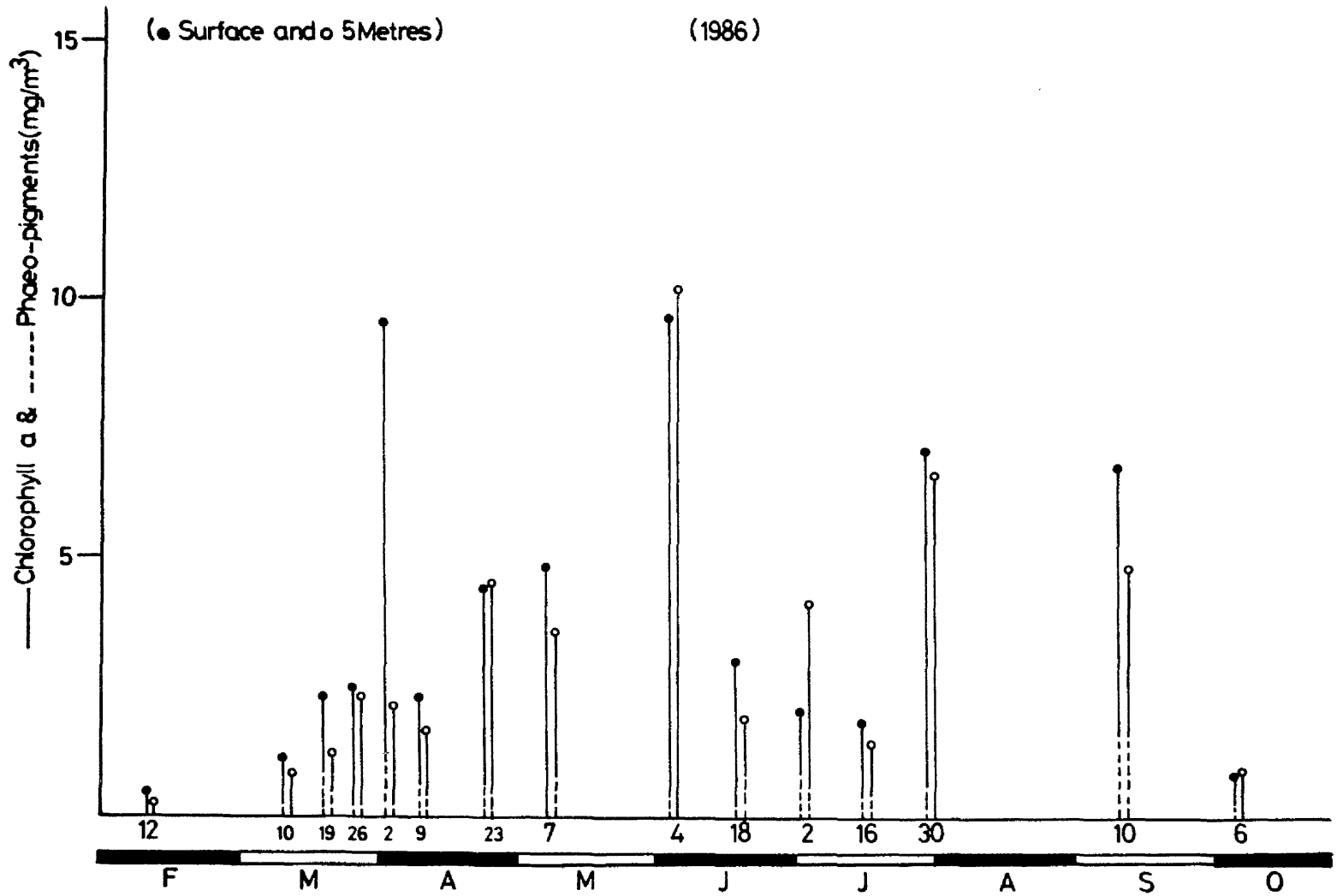

(● Surface and o 5Metres)
(1986)
——Chlorophyll a & ----- Phaeo-pigments(mg/m³)
15
10
5
12
10
19
26
2
9
23
7
4
18
2
16
30
10
6
F
M
A
M
J
J
A
S
O

Figure. 3. 3. 4. Seasonal changes in the chlorophyll a and phaeopigment (mg / m^3) levels at the surface and 5 metres depth. Station 11, from 27 October 1986 to 22 April 1987.

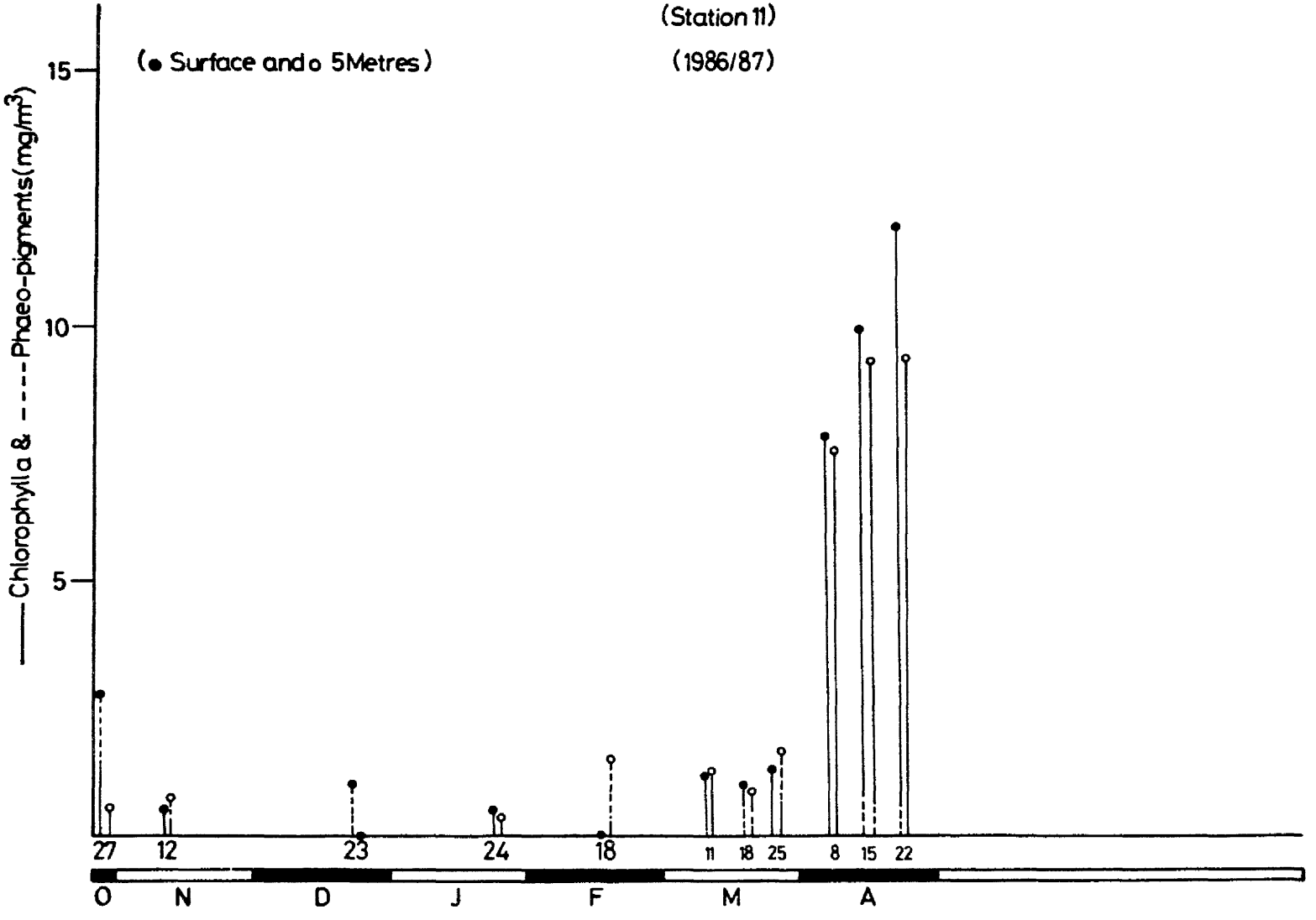

(Station 11)
(● Surface and o 5Metres)
(1986/87)
——Chlorophyll a & ----Phaeo-pigments(mg/m³)
15
10
5
27
12
23
24
18
11
18
25
8
15
22
O
N
D
J
F
M
A

Figure. 3. 3. 5. Seasonal changes in the chlorophyll a and phaeopigment (mg / m^3) levels at the surface and 5 metres depth. Station 9, from 11 April to 5 December 1984.

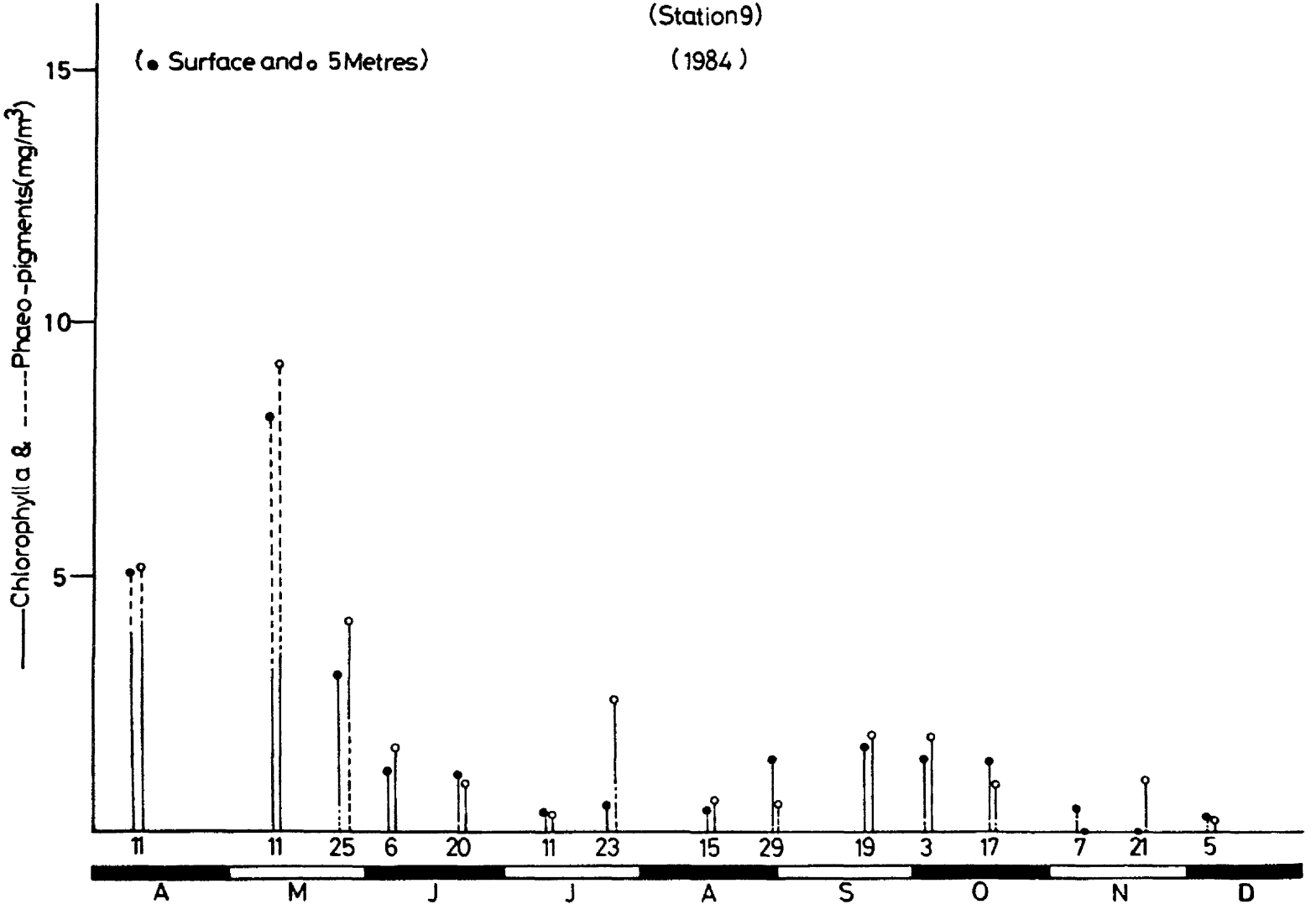

(Station 9)
(1984)
(• Surface and ○ 5 Metres)
——Chlorophyll a & ----Phaeo-pigments(mg/m³)
15
10
5
11
11
25
6
20
11
23
15
29
19
3
17
7
21
5
A
M
J
J
A
S
O
N
D

Figure. 3. 3. 6. Seasonal changes in the chlorophyll a and phaeopigment (mg / m^3) levels at the surface and 5 metres depth. Station 9, from 3 January 1985 to 6 January 1986.

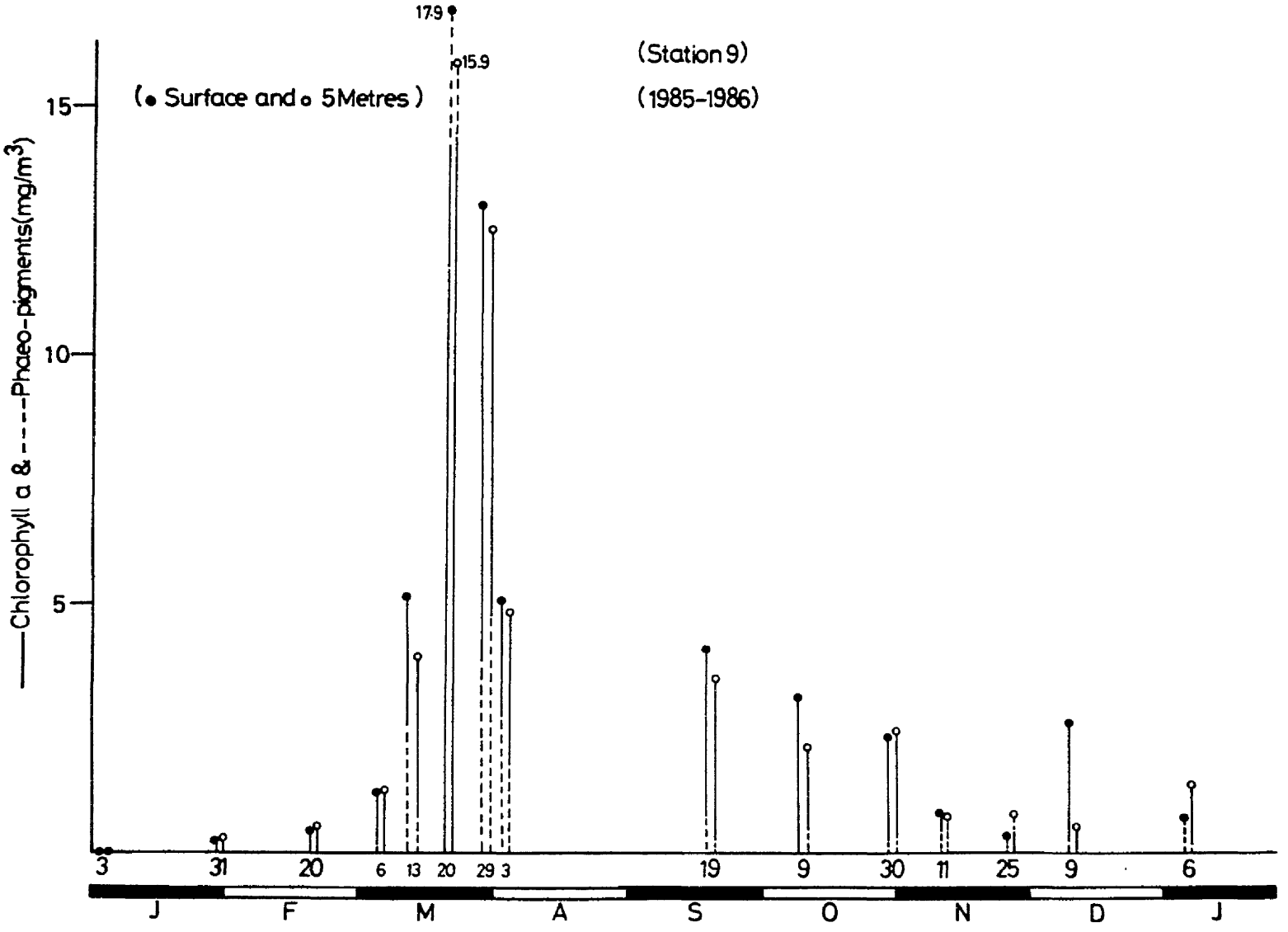

17.9
15.9
(Station 9)
(1985-1986)
(● Surface and ○ 5 Metres)
15
10
5
——Chlorophyll a & - - - -Phaeo-pigments(mg/m³)
3
31
20
6
13
20
29
3
19
9
30
11
25
9
6
J
F
M
A
S
O
N
D
J

Figure. 3. 3. 7. Seasonal changes in the chlorophyll a and phaeopigment (mg / m^3) levels at the surface and 5 metres depth. Station 9, from 12 February to 6 October 1986.

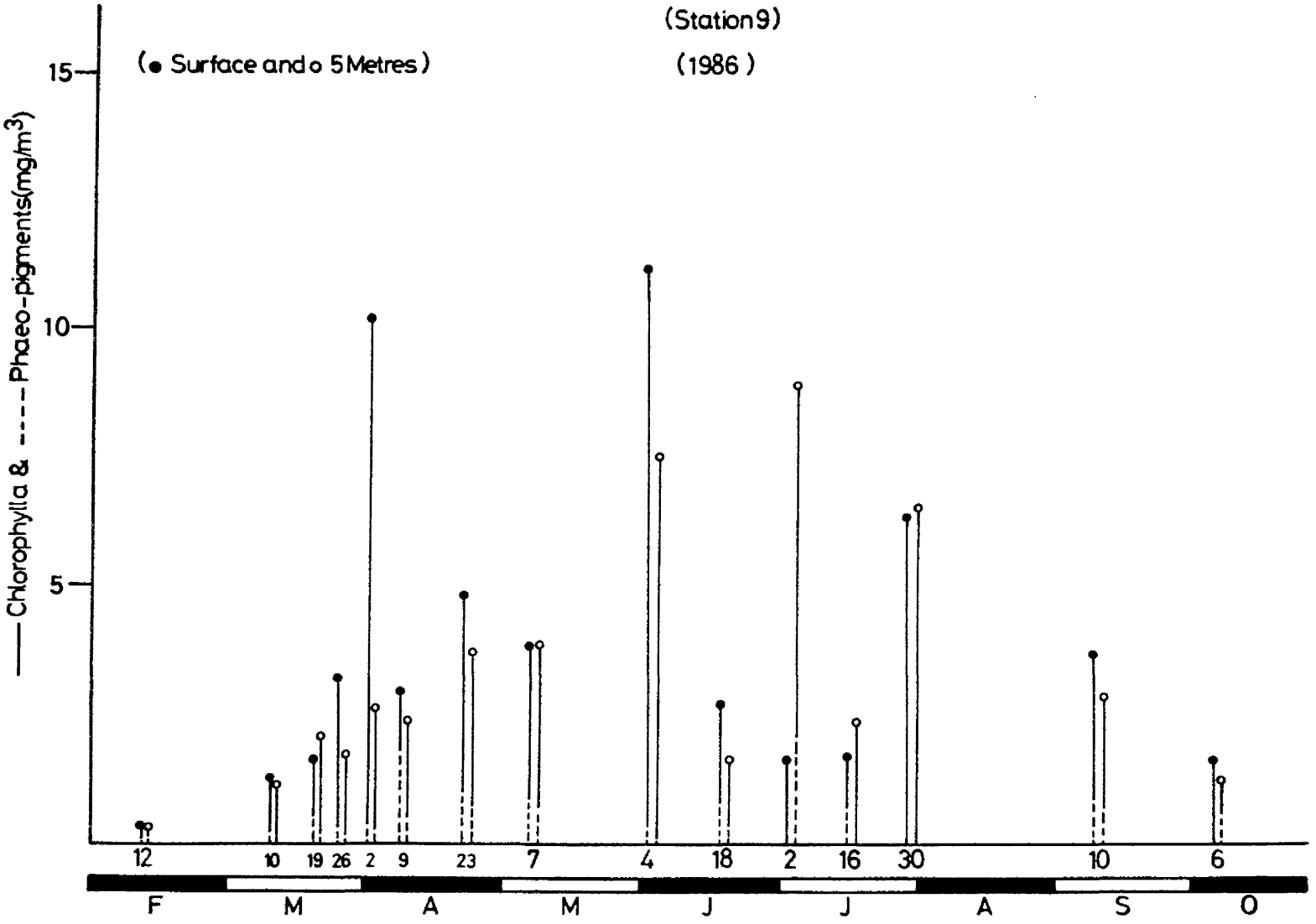
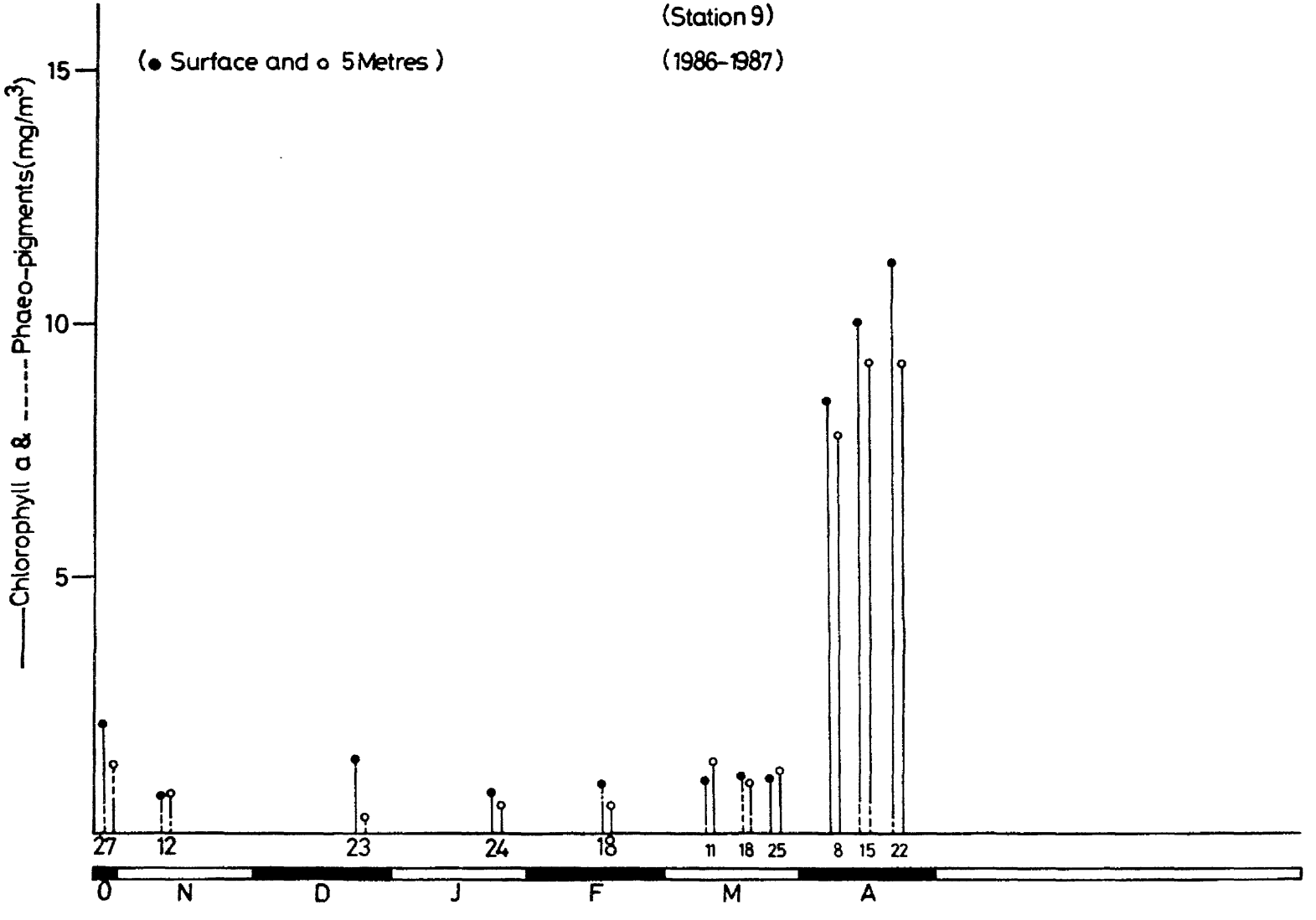

(Station 9)
(● Surface and o 5 Metres)
(1986)
15
10
5
—— Chlorophylla & ---- Phaeo-pigments(mg/m3)
12
10
19
26
2
9
23
7
4
18
2
16
30
10
6
F
M
A
M
J
J
A
S
O

Figure. 3. 3. 8. Seasonal changes in the chlorophyll a and phaeopigment (mg / m^3) levels at the surface and 5 metres depth. Station 9, from 27 October 1986 to 22 April 1987.


(Station 9)
(1986-1987)
(● Surface and o 5 Metres)
——Chlorophyll a & -----Phaeo-pigments(mg/m³)
15
10
5
27
12
23
24
18
11
18
25
8
15
22
O
N
D
J
F
M
A

High phaeopigment values were recorded on 11 April and 11 May, with quantities ranging from 5 - 7.88 mg m^{-3} on the former date and 7 - 9 mg m^{-3} on the latter, much lower levels were recorded on 25 May (0.26 - 2.2 mg m^{-3}).

During the summer months chlorophyll values fluctuated between relatively high and low levels. During early June chlorophyll levels remained slightly high, ranging from 1.75, 1.61 mg m^{-3} on 6 June to 1.3, 0.98 mg m^{-3} on 20 June at the surface for stations 11 and 9 respectively and from 1.64, 1.6 mg m^{-3} on 6 June to 0.93, 0.87 mg m^{-3} on 20 June at 5 metres depth.

On the 6 th and 20 th of June phaeopigments levels were unmeasurable.

During the rest of the summer months chlorophyll levels remained low with the exception of those recorded on 23 July at 5 metres depth which were 1.6 and 2.47 mg m^{-3} at stations 11 and 9 respectively. This compares with the low surface levels recorded at the same time (0.5 mg m^{-3} at station 11 and 0.35 mg m^{-3} at station 9), and with the quantities measured on 11 July which were 0.33 and 0.25 mg m^{-3} at the surface and 5 metres depth at station 11, and 0.24 and 0.3 mg m^{-3} at station 9.

Similar to the previous 5 metres levels recorded on 23 July slightly higher surface readings were found on 29 August reaching 1.06 mg m^{-3} at station 11 and 1.34 mg m^{-3} at station 9, as compared with the low 5 metres readings recorded at that time which were 0.22 and 0.05 mg m^{-3} at station 9. From 11 July onwards phaeopigment levels were low ranging from trace quantities to 0.9 mg m^{-3}.

An increase in chlorophyll concentrations were recorded during autumn, which ranged from 1.24 to 1.76 mg m^{-3} at the surface for stations 11 and 9and from 0.78 to 1.86 mg m^{-3} for 5 metres depth.

Although there was an increase in chlorophyll concentration during autumn, there was no distinctive autumnal peak in September and there after the quantities of extracted pigments were low through the winter months. These were in the range analytical zero - 0.38 mg chlorophyll a m^{-3} at both depths, at both stations.

Again low phaeopigments levels were recorded during autumn and winter (Trace quantities - 0.6 mg m^{-3}).

In 1985, a similar over all seasonal pattern was observed although the maximum recorded levels were higher than those found in the previous year (Figs. 3. 3. 2. and 3. 3. 6.).

From the data recorded in 1985 the diatom increase was gradual starting on 6 March at both stations 11 and 9 in when chlorophyll levels increased from 0.07 and 0.35 mg m^{-3} on 20 February to 1 and 1.15 mg m^{-3} on 6 March at the surface for stations 11 and 9 respectively and from 0.09 and 0.45 mg m^{-3} on 20 February into 1.3 and 1.13 mg m^{-3} on 6 March at 5 metres depth for stations 11 and 9 respectively.

Phytoplankton biomass levels at the peak of the spring growth were more or less similar at stations 11 and 9. The peak in biomass quantity at station 11 was observed on 29 March in which chlorophyll levels recorded at this time were 18 mg m^{-3} at the surface and 17.7 mg m^{-3} at 5 metres depth. The peak at station 9 was recorded on 20 March in which chlorophyll levels were 18 and 16 mg m^{-3} at surface and 5 metres depth respectively.

A sharp and rapid decline in phytoplankton biomass then occured at both stations. Minimum post-peak levels were recorded on 3 April at both stations (4.73 and 4.51 mg m^{-3} at surface and 5 metres depth for station 11, 4.9 and 4.7 mg m^{-3} at station 9).

Also observed during the spring was an increase in phaeopigment levels by which the maximum quantities were recorded on 20 March (7.65 - 17.9 mg m^{-3}).

Although a decrease was observed on 29 March and 3 April phaeopigment levels remained relatively high with quantities ranging from 3.3 to 5.7 mg m^{-3} on the former date and from 1.7 to 2.5 mg m^{-3} on the latter date.

When the investigation was recomenced on 19 of September high autumnal chlorophyll levels were observed which represented the maximum for samples collected from station 9 (4.7 and 3.1 mg m^{-3} from station 11 and 5 metres depth respectively) and for samples collected from station 11 at 5 metres depth (4.8 mg m^{-3}). A surface maximum of 4.8 mg m^{-3} at station 11 was measured on 10 October.

Phaeopigment levels during autumn and winter were low ranging from trace quantities to 1.4 mg m^{-3}.

In the spring of 1986 chlorophyll concentrations first exceeded 1 mg m^{-3} in the surface waters on 10 March (1.1 mg m^{-3}at station 11 and 1.2 mg m^{-3} at station9) and in 5 metres depth by 19 March, some two weeks later than in the previous year.

Maximum surface levels were recorded at both stations on 2 April and they were 9.5 and 10.2 mg m^{-3} at stations 11 and 9 respectively whilst second major peaks in chlorophyll concentration at the surface of both stations were recorded on 23 April (4.4 and 4.9 mg m^{-3} at stations 11 and 9 respectively).

A slight increase in phaeopigment values was recorded during this period (trace quantities - 1.7 mg m^{-3}), which were lower than those found in the previous year for the same period, coinciding with the lower chlorophyll quantities.

Table 3. 3. 1. Chlorophyll a and phaeopigments levels recorded for samples collected from station 11 (mg m^{-3}). (T = trace)

	Chlorophyll a		Phaeopigments	
Date	S	5m	S	5m
1984				
11.04	3.60	3.44	5.27	7.88
11.05	3.40	2.50	7.00	8.00
25.05	3.30	3.94	7.00	8.00
6.06	1.75	1.64	T	T
20.06	1.30	0.93	T	T
11.07	0.30	0.25	0.20	T
23.07	0.50	1.60	0.40	0.34
15.08	0.20	0.05	0.30	0.10
29.08	1.00	0.46	0.40	0.20
19.09	1.76	1.70	T	T
3.10	1.30	1.30	0.37	T
17.10	1.50	0.80	T	T
7.11	0.36	0.10	0.60	0.20
21.11	T	0.40	T	0.40
5.12	0.35	0.10	0.22	0.10
1985				
3.01	0.20	T	0.02	T
31.01	0.20	T	T	T
20.02	0.07	0.09	0.20	1.20
6.03	1.00	1.30	0.34	0.10
13.03	5.0	5.10	1.60	0.80
20.03	12.5	13.7	7.60	10.4
29.03	17.7	18.1	5.70	3.70
3.04	4.70	4.50	2.50	2.40
19.09	4.65	3.10	1.40	0.50
9.10	4.80	2.45	0.65	1.35
30.10	1.83	1.25	T	0.20
11.11	0.80	0.68	0.40	0.40

Table 3. 3. 1. (Continued)

	Chlorophyll a		Phaeopigments	
Date	S	5m	S	5m
1985				
25.11	0.44	0.35	0.40	0.20
9.12	2.70	0.88	0.40	0.10
1986				
6.01	1.36	0.23	0.96	0.20
12.02	0.40	0.25	0.02	0.02
10.03	1.00	0.80	0.25	0.08
19.03	2.20	1.20	0.80	0.53
26.03	2.40	2.34	0.25	0.23
2.04	9.52	2.10	1.10	0.35
9.04	2.30	1.60	0.70	0.32
23.04	4.40	4.50	1.00	0.55
7.05	4.83	3.45	T	0.85
4.06	9.67	10.2	T	0.32
18.06	3.00	1.90	0.20	0.83
2.07	2.00	4.00	0.84	0.60
16.07	1.80	1.42	0.63	0.53
30.07	7.00	6.66	0.60	T
10.09	6.67	4.80	1.53	1.30
6.10	0.80	0.90	0.22	0.00
27.10	1.50	0.50	2.77	0.13
12.11	0.27	0.50	0.43	0.73
23.12	1.00	0.00	0.97	0.00
1987				
24.01	0.40	0.36	0.00	0.00
18.02	0.00	0.00	0.00	1.00
11.03	1.20	1.34	0.20	0.10
18.03	1.00	0.90	0.65	0.52
25.03	1.22	0.70	0.00	1.64

Table 3. 3. 1. (Continued)

	Chlorophyll a		Phaeopigments	
Date	S	5m	S	5m
1987				
8.04	8.00	7.50	0.00	0.00
15.04	10.0	9.30	0.70	0.60
22.04	12.0	9.40	0.50	0.00

Table 3. 3. 2. Chlorophyll a and phaeopigments levels recorded for samples collected from station 9 (mg m^{-3}). (T = trace)

	Chlorophyll a		Phaeopigments	
Date	S	5m	S	5m
11.04	3.90	4.10	5.00	5.20
11.05	3.20	3.45	8.00	9.00
25.05	3.00	4.00	0.42	2.20
6.06	1.20	1.60	0.00	0.00
20.06	1.00	0.90	0.00	0.00
11.07	0.24	0.30	0.00	0.20
23.07	0.40	2.47	0.42	0.92
15.08	0.34	0.50	0.32	0.61
29.08	1.34	0.45	0.16	0.22
19.09	1.60	1.86	0.00	0.00
3.10	1.36	1.82	0.26	0.00
17.10	1.24	0.83	0.32	0.16
7.11	0.20	0.03	0.34	0.05
21.11	0.00	0.94	0.00	0.05
5.12	0.04	0.16	0.26	0.00
1985				
3.01	0.00	0.03	0.00	0.00

Table. 3. 3. 2. (Continued)

	Chlorophyll a		Phaeopigments	
Date	S	5m	S	5m
1985				
31.01	0.130	0.200	0.000	0.000
20.02	0.320	0.450	0.000	0.050
6.03	1.150	1.130	0.100	0.000
13.03	5.000	3.800	2.400	0.660
20.03	15.97	14.42	17.89	15.93
29.03	12.98	12.42	3.300	4.780
3.04	4.960	4.730	2.630	1.720
19.09	4.000	3.400	0.620	0.160
9.10	3.000	2.000	0.000	0.430
30.10	2.330	2.400	0.240	0.000
11.11	0.700	0.700	0.430	0.500
25.11	0.270	0.440	0.260	0.720
9.12	2.700	0.510	0.120	0.080
1986				
6.01	0.560	1.340	0.550	0.120
12.02	0.280	0.300	0.040	0.140
10.03	1.200	1.100	0.220	0.100
19.03	1.600	2.000	0.520	0.140
26.03	3.200	1.670	0.350	0.140
2.04	10.20	2.640	0.350	0.300
9.04	2.870	2.300	1.770	0.470
23.04	4.900	3.700	1.000	0.800
7.05	3.380	3.830	0.890	0.710
4.06	11.54	7.520	0.320	T
18.06	2.600	1.530	0.770	0.320
2.07	1.650	8.850	0.000	2.140
16.07	1.580	2.300	0.650	T
30.07	6.470	6.330	T	T
10.09	3.630	2.800	0.860	0.730

Table 3. 3. 2. (Continued)

	Chlorophyll a		Phaeopigments	
Date	S	5m	S	5m
1986				
6.10	1.53	1.20	0.00	0.58
27.10	2.15	0.67	0.52	1.27
12.11	0.66	0.72	0.32	0.23
23.12	1.28	0.16	1.44	0.30
1987				
24.01	0.73	0.46	0.00	0.00
18.02	0.65	0.46	0.82	0.00
11.03	1.00	1.30	0.22	0.15
18.03	1.00	0.98	0.62	0.40
25.03	1.00	0.98	1.00	0.00
8.04	8.45	7.80	0.00	0.00
15.04	10.0	9.20	0.50	0.55
22.04	11.2	9.20	0.30	0.00

Following the above increase in chlorophyll concentration in the spring two subsequent chlorophyll peaks were observed during the summer between May and July. The first peak was recorded on 4 June in which the levels were 9.7 and 10.2 mg m^{-3} at surface and 5 metres depth, at station 11 and 11.5 and 7.5 mg m^{-3} at station 9. The second peak was recorded on 30 of July with the following levels; 7.1 and 6.6 mg m^{-3} at the surface and 5 metres depth at station 11 and 6.5 and 6.3 mg m^{-3} at station 9.

Relatively low chlorophyll concentrations were found on 16 July at both stations and at both depths with levels ranging between 1.4 to 2 mg m^{-3}.

During this period phaeopigment levels fluctuated between very low (trace quantities) and relatively high values (2mg m^{-3}).

An autumnal peak was observed in 10 September. Chlorophyll concentrations were 6.7 and 4.8 mg m^{-3} at station 11 at surface and 5 metres depth respectively and 3.6 and 2.8 mg m^{-3} at station 9. Following this initial autumnal peak chlorophyll concentrations declined at both stations through 6th and 27th of October.

On the 6 October recorded surface levels were 0.8 and 1.53 mg chlorophyll m^{-3} at stations 11 and 9 respectively, whilst 5 metres levels were 0.9 mg m^{-3} at station 11 and 1.2 mg m^{-3} at station 9.

Slightly higher surface levels were recorded on 27 October (1.5 mg m^{-3} at station 11 and 2 mg m^{-3} at station 9), whilst lower 5 metres levels were recorded at the same date (0.5 mg m^{-3} at station 11 and 0.67 mg m^{-3} at station 9).

Highly variable phaeopigment levels were recorded on each sampling date during the autumn period. On 10 September the measured phaeopigments levels ranging between 0.73 - 1.53 mg m^{-3}, on 6 October ranging between analytical zero - 0.58 mg m^{-3} and on 27 October ranging between 0.13 - 2.8 mg m^{-3}.

Winter chlorophyll levels were reached at both stations by 12 November. Chlorophyll concentrations at station 11 were 0.27 mg m^{-3} at surface and 0.5 mg m^3 at 5 metres depth, at station 9 chlorophyll levels were 0.66 mg m^{-3} at surface and 0.7 mg m^{-3} at 5 metres depth.

An increase in surface levels was recorded on 23 December at both stations (1 mg m^{-3} at station 11 and 1.28 mg m^{-3} at station 9), very low levels were recorded at 5 metres depth at both stations (analytical zero at station 11 and 0.16 mg m^{-3} at station 9).

During 22 January and 17 February . very low chlorophyll levels were recorded at both stations, at both depths with quantities ranging from analytical zero to 0.7 mg m^{-3}.

On 12 November phaeopigment levels were higher for samples collected from station 11(0.44 and 0.73 mg m^{-3} at surface and 5 metres depth respectively), than those collected from station 9 (0.3 and 0.2 mg m^{-3} at surface and 5 metres depth respectively). Relatively high phaeopigment levels were recorded on 23 of December for samples collected from the surface at both stations (0.97 and 1.44 mg m^{-3} at stations 11 and 9 respectively); much lower 5 metres levels were recorded (analytical zero at station 11 and 0.3 at station 9). Unmeasurable quantities of phaeopigments were present on 22 January.

On 17 February phaeopigment levels were 1 mg m^{-3} for samples collected from station 11, at 5 metres depth and 0.82 mg m^{-3} for samples collected from station 9, at surface. For samples collected from station 11 at surface and station 9, at 5 metres depth unmeasurable quantities of phaeopigments were present.

The spring outburst of 1987 started on 11 March in which chlorophyll concentrations first exceeded 1 mg m^{-3} at both stations, at both depths. Phytoplankton biomass levels during 11 March were more or less similar at both stations, with chlorophyll quantities ranging from 1 - 1.3 mg m^{-3}.

During the month of March chlorophyll levels remained low, ranging from 0.98 and 1 mg m^{-3} on 18 March to 1.22 and 1 mg m^{-3} on 25 March, at the surface for stations 11 and 9 respectively and from 0.9 and 0.98 mg m^{-3} on 18 March to 0.7 and 0.98 mg m^{-3} at 5 metres depth.

The levels of 8 and 7.5 mg m^{-3} at the surface and 5 metres depth, at station 11, and 8.5, 6 mg m^{-3} at station 9 were recorded on 8 of April.

Following this initial peak, a second major peak was observed at all depths on the 15 April, in which chlorophyll concentrations at station 11 were 10 and 9.25 mg m^{-3} at surface and 5 metres depth respectively and 11.2 and 8.3 mg m^{-3} at station 9.

The peak in biomass quantity at station 11 was observed on 22 April in which chlorophyll levels were 12 mg m^{-3} at surface and 10.9 mg m^{-3} at 5 metres depth. It is interesting to note that the maximum levels of this spring were recorded later than those maxima recorded in the two previous years.

On 8, 15 and 22 April chlorophyll values were measured at surface, 1 metre, 5 metres and 10 metres depth at station 11 (Table. 3. 3. 3.).

Table 3. 3. 3. Recorded values of chlorophyll a at station 11 (mg m^{-3})

Depth	(April 8)	(April 15)	(April 22)
Surface	8.00	10.00	12.00
1 metre	8.80	10.55	14.20
5 metres	7.50	9.250	10.90
10 metres	6.00	7.250	10.20

From this table, chlorophyll levels increased gradually throughout the month of April at all depths. The highest chlorophyll values were found at 1 metre depth, the levels decreased with the increase of depth. The maximum chlorophyll concentration was observed at 1 metre depth on 22 April and was 14.2 mg m^{-3}. The between variations were quite small and may be as a result of the mixing in the water column. During each date of this period phaeopigment levels fluctuated between very low (analytical zero) and relatively high quantities (1.65 mg m^{-3}).

The highest maximum chlorophyll a levels were recorded during 1985 (Tables. 3. 3. 4. and 3. 3. 5.).

Table 3. 3. 4. Maximum recorded values of chlorophyll a at station 11 (mg m^{-3})

Depth	1984	1985	1986	1987
Surface	3.4	17.7	9.70	12.4
5 metres	3.9	18.0	10.1	13.7

Table 3. 3. 5. Maximum recorded values of chlorophyll a at station 9 (mg m^{-3})

Depth	1984	1985	1986	1987
Surface	3.9	15.9	11.5	11.6
5 metres	4.1	14.4	8.80	8.10

3. 3. 2. Profiles of algal pigments:

Pigment analysis on chromatograms can provide indicators of algal types or biological processes in the water column.

The following were the major photosynthetic pigments separated and developed from phytoplankton samples collected from surface and 5 metres depth at stations 11 and 9, using thin layer chromatography as described on p.53 .

Pigment fraction : 1 : chlorophyll c (light green) ; 2 : Chlorophyll b (olive green) ; 3 : phaeophorbide a (grey) ; 4 : neoxanthin (yellow) ; 5 : chlorophyllide a (blue green) ; 6 : diadinoxanthin (yellow) ; 7 : fucoxanthin (orange) ; 8 : carotene (orange) ; 9 : chlorophyll a (blue green) ; 10 : astaxanthin (pink) ; 11 : phaeophytin (grey).

For this study the major definitive pigments based on R_f values and colours were chlorophyll a and carotene (all algae), chlorophyll b (green algae), chlorophyll c (diatoms and dinoflagellates), fucoxanthin (diatoms), neoxanthin (green algae) and the chlorophyll breakdown products phaeophytin a, chlorophyllide a and phaeophorbide a.

Fig. 3. 3. 9. shows the set of chromatograms obtained from stations 11 and 9 at surface and 5metres depth for spring 1984.

For samples collected from surface and 5metres depth at station 11, chlorophylls a and c, carotene, diadinoxanthin, and fucoxanthin were found, which were typical of the photosynthetic pigments of diatoms. In addition, chlorophyll b and neoxanthin, definitive pigments of green algae were present. The presence of chlorophyllide a indicated chlorophyllase activity in senescent diatoms, or it can be a filtration artifact. According to Barret and Jeffrey, (1964, 1971) the presence of chlorophyllide a indicated in the samples a small number of the senescent diatoms, whose lamellar bound chlorophyllase had hydrolysed the phytol chain from the parent chlorophyll. The

presence of the chlorophyll degradation products phaeophytin a and phaeophorbide a indicated possible feeding activity by copepods and other zooplankton.

At station 9 at surface and 5 metres depth the same general pigment pattern occured with the absence of identifiable quantities of diadinoxanthin and carotene.

Microscopic examination of the samples from both stations showed that there was an abundance of chain forming diatoms. The dominant organisms were *Skeletonema costatum, Thalassiosira spp and Coscinodiscus spp.* The microscopic examination of samples collected on 25 May also showed the presence of green flagellates in considerable numbers.

Figs. 3. 3. 10a. and 3. 3. 10b. show the set of chromatograms for samples collected from surface and 5 metres depth at stations 11 and 9 in the early summer of 1984.
The diatom pigments (chlorophylls a and c, carotene, diadinoxanthin and fucoxanthin) were found at both stations and at both depths except for 5 metres depth at station 9, where fucoxanthin was not detected. Chlorophyll b and neoxanthin indicated the presence of green algae. Astaxanthin, the copepod carotenoid, was found on chromatograms obtained from surface and 5 metres depth at station 11 and from surface only at station 9.
The chlorophyll breakdown products phaeophytin a and phaeophorbide a were found at both depths while chlorophyllide a occurred at surface and 5 metres at station 11 and only at the surface at station 9.

Microscopic examination showed a large numbers of green flagellates on 20 June. The dominant diatoms were *Nitzschia seriata, S. costatum* and *Thalassiosira nordenskioldii.* Other organisms present included the diatoms *Coscinodiscus spp, Diatoma spp, Grammatophora marina, Melosira spp, Melosira sulcata* and *Navicula spp.* During this period diatoms were the dominant fraction of the population.

Figs. 3. 3. 11a. and 3. 3. 11b. show the set of chromatograms for samples collected from both stations at both depths in late summer of 1984.

The diatom pigments chlorophylls a and c, carotene, diadinoxanthin, and fucoxanthin were found at both stations, at both depths. In addition, chlorophyll b and neoxanthin, definitive pigments of green algae were present on chromatograms of pigments obtained from station 9 only. Astaxanthin was found on chromatograms obtained from station 11 at both depths and at station 9 from 5 metres depth only. The chlorophyll break down product phaeophytin a was found at both stations, at both depths, while chlorophyllide a was present only on the chromatograms obtained from station 11, at the surface and 5 metres depth.

Microscopic examination of the samples showed a bloom of green flagellates on the 23 July. On the 15 and the 29 August diatoms made up most of the population. The dominant species were *Nitzschia spp, S. costatum* and *Thalassiosira nordenskioldii.* Other organisms present included the diatoms *Chaetoceros spp, Coscinodiscus spp, Biddulphia mobiliensis, Diatoma spp* and *Rhizosolenia setigera.* Also present but in very small numbers were the dinoflagellates *Ceratium fusus, C. furca, C. tripos* and *Protoperidinium spp.* The silicoflagellate *Dictyocha speculum* was also present in a very small numbers.

Figs. 3. 3. 12a. and 3. 3. 12b. show the set of chromatograms for samples collected from stations 11 and 9 at surface and 5 metres depth in autumn 1984.

Large zones of chlorophyll a and carotene were observed for the samples collected from both stations at both depths. Although chlorophyll b was found, the microscopic examination of the samples did not show any green flagellates to be present. The presence of chlorophyll b could probably be attributed to the presence of fragments of

green filaments from shore habitats. Chlorophyll break down products were found including phaeophytin a, chlorophyllide a and phaeophorbide a.

The microscopic examination of samples collected during this period showed the presence of diatoms of which the most common species was *S. costatum.* Other diatoms were observed including *Achnanthes longipes, Chaetoceros spp, Chaetoceros hals*a*ticum, Melosira spp, Navicula spp, Nitzschia spp, Nitzschia longissima, Rhabdon*e*ma arcuatum* and *Thalassiosira spp.* On the 3 and 17 October, dinoflagellates succeeded diatoms as the dominant fraction of the population, with *Ceratium furca* and *C. tripos* as the dominant species. Also present was the silicoflagellate *Dictyocha speculum.* The paramount carotenoid band may have included some dinoflagellate xanthophyll which failed to separate.

Figs. 3. 3. 13a. and 3. 3. 13b. show the set of chromatograms obtained from both stations, at both depths for early winter 1984.

Again zones of chlorophyll a and carotene were prominent at both stations and at both depths. Similar to autumn the green algal pigment chlorophyll b was observed in the absence of green flagellates. Also present at both stations , at both depths were the chlorophyll breakdown products of phaeophorbide a and chlorophyllide a.

Microscopic examination of the samples collected during this period showed the presence of diatoms of which the most dominant species were *Coscinodiscus spp, Navicula spp* and *S. costatum.* Also present were dinoflagellates, including *Ceratium* and *Protoperidinium species.* In relation to the total number of algal cells the silicoflagellate *Dictyocha speculum* was observed in relatively large numbers mainly on the 7 and 21 November.

Figs. 3. 3. 14a. and 3. 3. 14b. show the sets of chromatograms obtained from both stations at both depths for late winter of 1984. As seen in Fig. 3. 3. 14b the quantities were barely detectable.

The pigments of carotene, fucoxanthin and chlorophyll c were found at both stations, at both depths, while chlorophyll a was found only at station 11 (surface). The absence of chlorophyll a from station 11 (5 metres) and from station 9 at surface and 5 metres depth, suggest that the pigment was associated with detrital material. Because of the absence of green flagellates, the chlorophyll b observed could again be probably associated with fragments of green filaments from shore habitats. The presence of the chlorophyll degradation product phaeophytin a could be a further indication of decomposition.

Microscopic examination of samples collected during this period indicated the presence of small number of diatoms, and smaller number of dinoflagellates and silicoflagellates. The dominant organisms were *Navicula spp, S. costatum* and *Thalassiosira nordenskioldii.*

Figs. 3. 3. 15a. and 3. 3. 15b. show the set of chromatograms obtained from both stations, at both depths for spring of 1985.

Clear and distinct zones of chlorophyll a, carotene and chlorophyll c were found at both stations, at both depths, in addition although the microscopic examination did not reveal the presence of any green flagellates chlorophyll b was found at both stations, at both depths, which again could be associated with fragments of green filaments from shore habitats. The chlorophyll degradation products phaeophytin a and phaeophorbide a were found at both stations, at both depths which indicated feeding activity by zooplankton.

The microscopic examination of samples collected during this period showed that the population was made up mostly of diatoms and small numbers of dinoflagellates and silicoflagellates. The most common diatom was *S. costatum.* The diatom *Leptocylindrus danicus* was observed in large numbers on 6 and 13 March. The diatoms *Coscinodiscus spp, Cocconeis disculus, Navicula spp, Nitzschia spp, Nitzschia bilobata, Synedra spp, Thalassiosira decipiens and T. nordenskioldii* were present in all samples collected during this period. The only dinoflagellate species observed was *Ceratium lineatum* on 13 March.

Figs. 3. 3. 16a. and 3. 3. 16b. show the set of chromatograms obtained from both stations, at surface and 5 metres depth for autumn of 1985.

The most prominent pigments were chlorophyll a, diadinoxanthin, fucoxanthin and chlorophyll c found at both stations. In addition chlorophyll b was present on chromatograms of pigments from both stations at both depths. Astaxanthin, the copepod carotenoid, was found on chromatograms obtained from both stations. The presence of chlorophyllide a, which indicated chlorophyllase activity in diatoms, was found at both stations. The chlorophyll degradation products phaeophytin a and phaeophorbide a were found on all chromatograms, again a possible indication of grazing activity.

Microscopic examination showed the presence of diatoms, dinoflagellates and silicoflagellates. The dominant diatoms were *S. costatum* (on 19 September) and *Coscinodiscus spp* (on 30 October). Other diatoms observed during this period included *Chaetoceros spp, Diatoma spp, Melosira spp* and *T. nordenskioldii.* The most common dinoflagellate was *Ceratium lineatum,* also observed was the silicoflagellate *Dictyocha speculum.* The presence of chlorophyll b could be attributed to fragments of green filaments algae from shore habitats.

Figs. 3. 3. 17a. and 3. 3. 17b. show the set of chromatograms obtained from both stations at surface and 5 metres depth for winter of 1985 - 1986.
Although quantities were very small chlorophyll a, carotene and chlorophyll c were found at both stations. Also present was chlorophyll b which indicated the presence of green flagellates. The chlorophyll degradation products phaeophytin a, chlorophyllide a and phaeophorbide a were found on all chromatograms.

The microscopic examination of samples collected during this period showed that diatoms were the dominant fraction of the population, with the exception of samples collected on 12 February when green flagellates succeded diatoms as the dominant fraction. *Coscinodiscus spp* succeded *S. cotatum* as the dominant diatom. Other diatoms observed included *Gomphonema spp, Grammatophora marina, Melosira spp, Rhabdonema arcuatum* and *Synedra spp. Ceratium lineatum* was the most common dinoflagellate observed. Also present was the silicoflagellate *Dictyocha speculum.*

Figs. 3. 3. 18a. and 3. 3. 18b. show the set of chromatograms obtained from both stations, at both depths in spring of 1986.

Chlorophylls a and c, carotene, diadinoxanthin and fucoxanthin, which were typical of the photosynthetic pigments of diatoms were found on all chromatograms. Also present in all chromatograms was the green algal pigment chlorophyll b, which could be probably attributed to the presence of fragments of green filaments. Also present was the copepod carotenoid astaxanthin. The chlorophyll degradation products phaeophytin a, chlorophyllide a and phaeophorbide a were present in all chromatograms, which were possible indicators of grazing activities.
The microscopic examination of samples collected during this period shows that the population was almost made up entirely of diatoms. No green flagellates nor dinoflagellates were observed. *S. costatum* was the dominant species, other species were present including *Achnanthes longipes, Biddulphia aurita, Coscinodiscus spp,*

Grammatophora marina, Licmophora spp, Navicula spp, Nitzschia spp and *T. nordenskioldii*. Also present was the silicoflagellate *Dictyocha speculum*.

Figs. 3. 3. 19a. and 3. 3. 19b. show the sets of chromatograms obtained from stations 11 and 9 at surface and 5 metres depth for summer of 1986.

From these chromatograms it is evident that living diatoms were present, due to the presence of chlorophylls a and c and fucoxanthin. In addition, chlorophyll b and neoxanthin, showed the presence of green algae. Astaxanthin, the copepod carotenoid, was found on all of the chromatograms. The chlorophyll breakdown products phaeophytin a, chlorophyllide a and phaeophorbide a were found on all chromatograms, which indicated possible feeding activity by copepods and other zooplankton.

Microscopic examination of samples collected on 4 June, 2, 16 and 30 July showed that the population was made up entirely of diatoms, of which the dominant species was *S. costatum*. Other diatom species observed during this period were *Coscinodiscus spp, Cocconeis disculus, Diatoma spp, Diatoma elongatum, Melosira spp, Navicula spp, Pleurosigma spp* and *T. nordenskioldii*. On 7 May green flagellates succeded diatoms as the dominant fraction of the population. On 18 June green flagellates contributed largely to the total biomass of the population.

Figs. 3. 3. 20a. and 3. 3. 20b. show the set of chromatograms obtained from station 11 at surface and 5 metres depth, Figs. 3. 3. 20a. and 3. 3. 20c. show the sets of chromatograms obtained from station 9 at surface and 5 metres depth for autumn 1986.

Chlorophyll a, carotene and chlorophyll c were found on all chromatograms. In addition chlorophyll b the green algae pigment and astaxanthin the copepod carotenoid were found on all chromatograms. Also found on all chromatograms were the breakdown products of chlorophyll including phaeophytin a, chlorophyllide a and phaeophorbide a.

The microscopic examination of samples collected during this period showed the presence of diatoms as the dominant fraction of the population, together with dinoflagellates. Silicoflagellates were represented by *Dictyocha speculum,* and green flagellates were observed. The dominant diatom was *S. costatum,* with the exception of samples collected on 10 September when *S. costatum* was succeeded by *Diatoma spp* as the dominant species. Other diatoms were present including *Amphora spp, Asterionella spp, Chaetoceros spp, Chaetoceros atlanticum, Chaetoceros externum, Grammatophora marina, Leptocylindrus danicus, Nitzschia seriata, Rhizosolenia spp, T. decipiens* and *T. nordenskioldii.* Also present were the dinoflagellates *Ceratium fusus, C. furca, C. lineatum, C. tripos* and *Protoperidinium spp.* On 27 October green flagellates were present in large numbers.

Figs. 3. 3. 21a. and 3. 3. 21b. show the set of chromatograms obtained from station 11 and 9 at surface and 5 metres depth for winter 1986 - 1987.

The complement of diatom pigments (chlorophyll a, carotene and diadinoxanthin) was found at all chromaograms. The only other pigments found were the chlorophyll breakdown products of phaeophytin a, chlorophyllide a and phaeophorbide a which indicated possible feeding activity by zooplankton.

The microscopic examination of samples collected during this period showed that diatoms were dominant, of which *Coscinodiscus spp, Diatoma spp, Leptocylindrus danicus, Melosira spp, Nitzschia seriata* and *S. costatum* were frequent . The dinoflagellates *C. extensum, C. lineatum, C. tripos* and *Protoperidinium spp* were present in small numbers. Also present in a very small numbers were the silicoflagellate *Dictyocha speculum* and green flagellates.

Figs. 3. 3. 22a. and 3. 3. 22b. show the set of chromatograms obtained from both stations, at both depths for spring 1987.

The full range of photosynthetic pigments for this study were found on all chromatograms, except for diadinoxanthin which was absent from the chromatograms which represented the samples collected from station 9 (surface).

The microscopic examination of samples collected during this period showed the presence of diatoms, dinoflagellates, silicoflagellates and green flagellates. Diatoms made up most of the population with *S. costatum* as the dominant species. Other diatoms were present including *Coscinodiscus spp, Cocconeis disculus, Diatoma spp, Leptocylindrus danicus, Nitzschia bilobata, N. seriata* and *T. nordenskioldii*. The contribution of green flagellates increased gradually throughout the spring months. Other organisms were present but in small numbers included the dinoflagellates*C. extensuum and Protoperidinium spp* and the silicoflagellate *Dictyocha speculum*.

Fig. 3. 3. 9. Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth.
(spring, 1984).

1 = Chlorophyll c

2 = Chlorophyll b

3 = Phaeophorbide a

4 = Neoxanthin

5 = Chlorophyllide a

6 = Diadinoxanthin

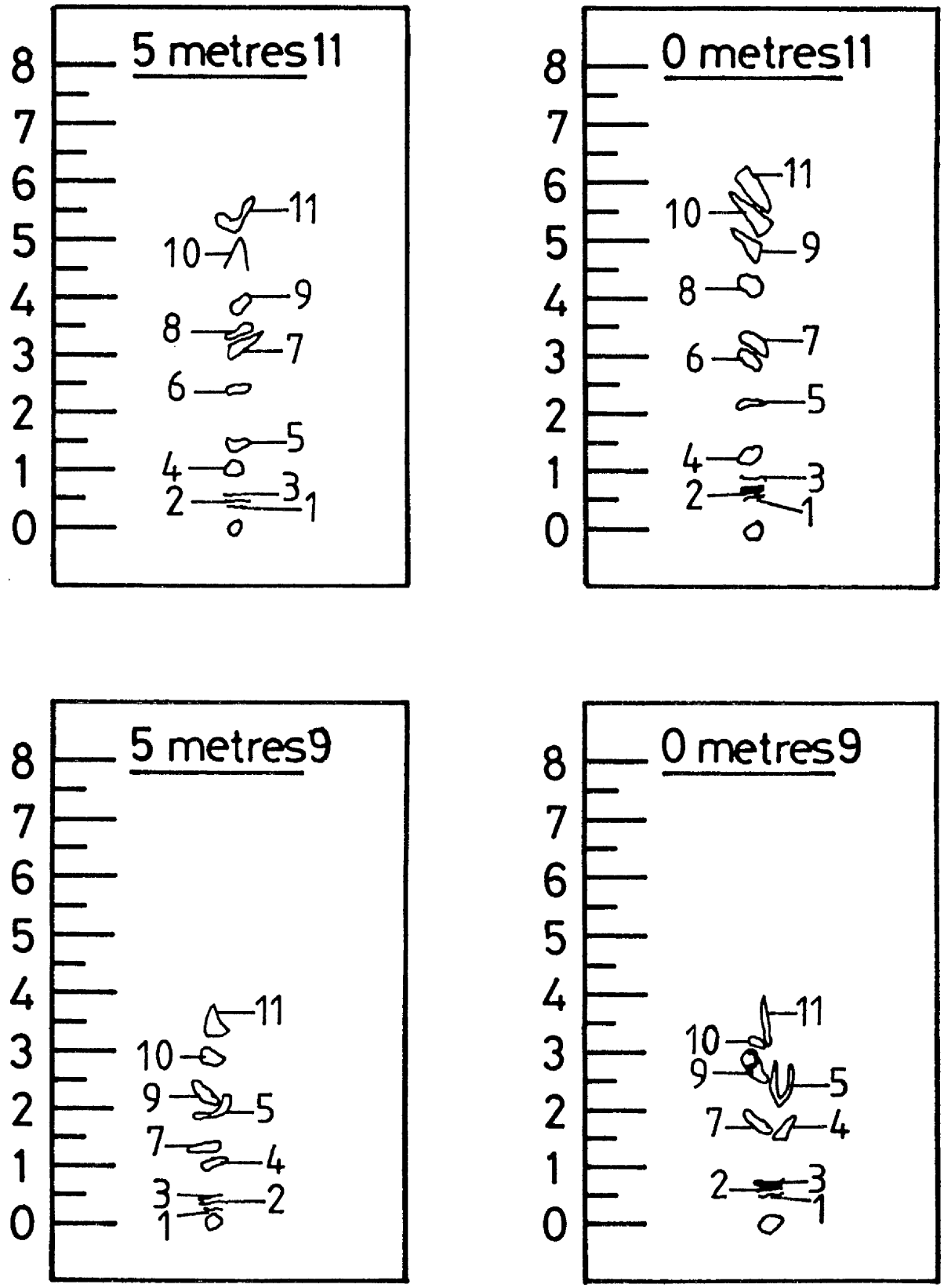
7 = Fucoxanthin

8 = Carotene

9 = Chlorophyll a

10 = Astaxanthin

11 = Phaeophytin a



SPRING (1984)

Figs. 3. 3. 10a and . 3. 3. 10b. Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth. (early summer, 1984).

1 = Chlorophyll c

2 = Chlorophyll b

3 = Phaeophorbide a

5 = Chlorophyllide a

6 = Diadinoxanthin

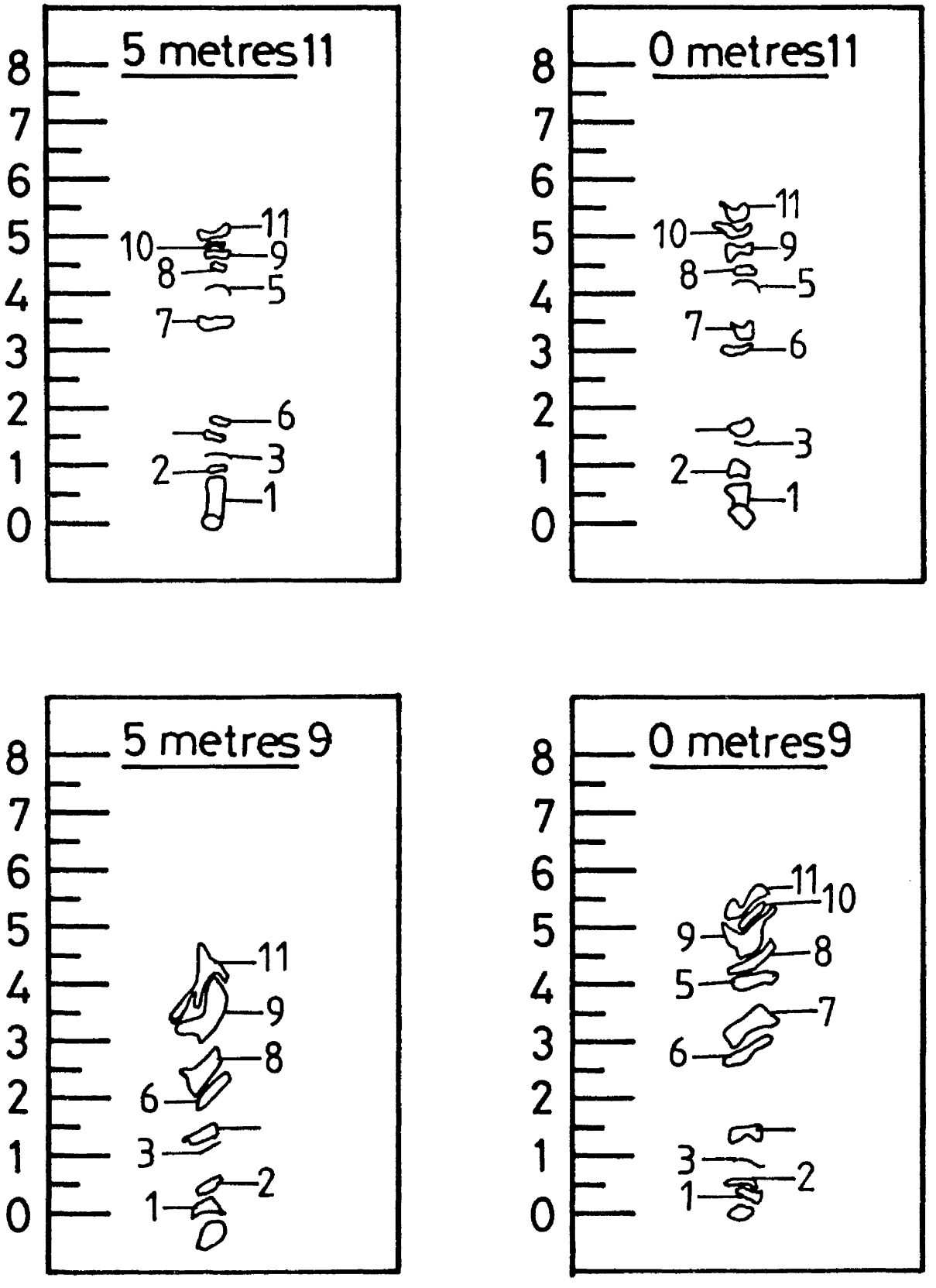
7 = Fucoxanthin

8 = Carotene

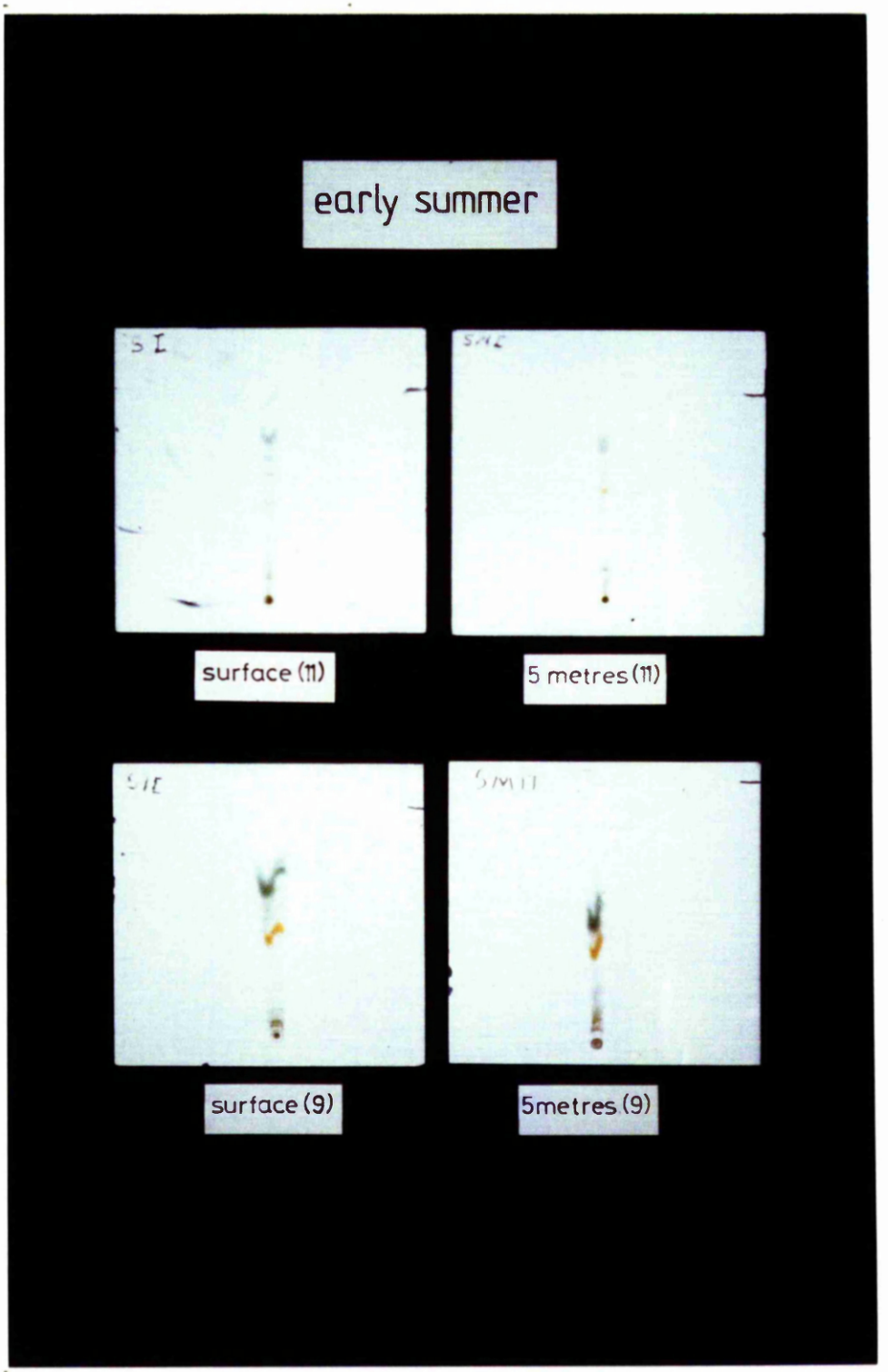
9 = Chlorophyll a

10 = Astaxanthin

11 = Phaeophytin a



early summer (1984)


early summer
surface (11)
5 metres (11)
surface (9)
5metres (9)

Figs. 3. 3. 11a. and . Chromatograms of algal pigments at stations 11
3. 3. 11b. and 9, at surface and 5 metres depth.
(late summer, 1984).

1 = Chlorophyll c

2 = Chlorophyll b

4 = Neoxanthin

5 = Chlorophyllide a

6 = Diadinoxanthin

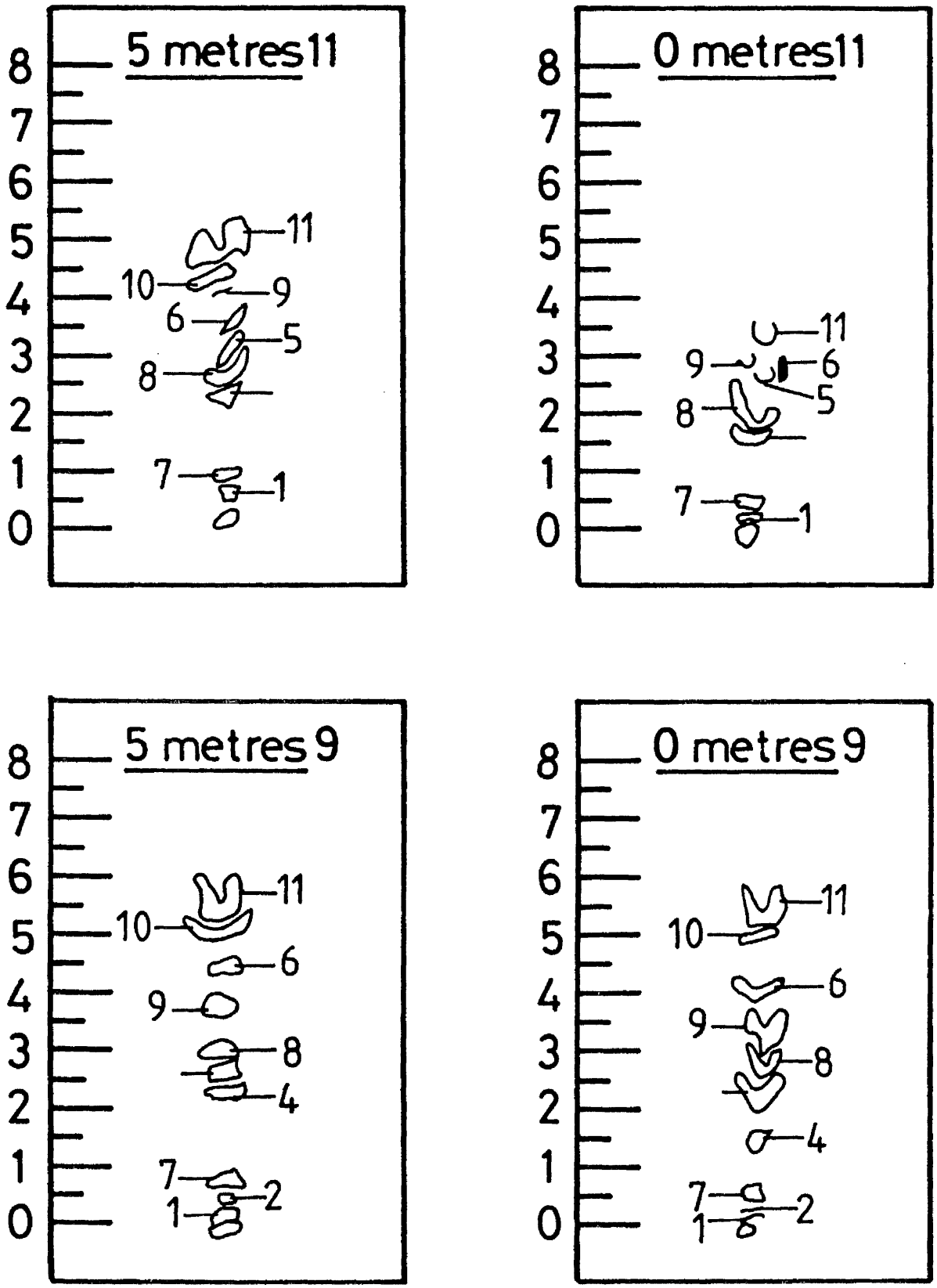
7 = Fucoxanthin

8 = Carotene

9 = Chlorophyll a

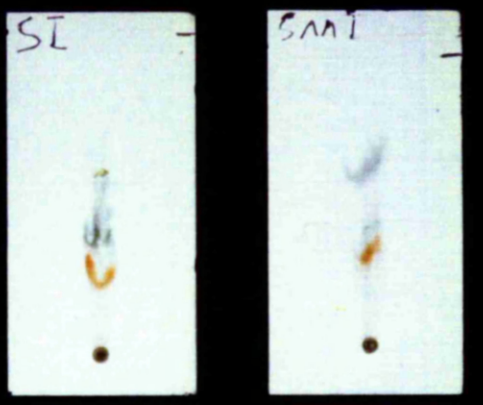
10 = Astaxanthin

11 = Phaeophytin a



late summer(1984)

late summer



surface (11)

5 metres (11)

surface (9)

5metres (9)

Figs. 3. 3. 12a. and 3. 3. 12b.

Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth.

(autumn, 1984).

2 = Chlorophyll b

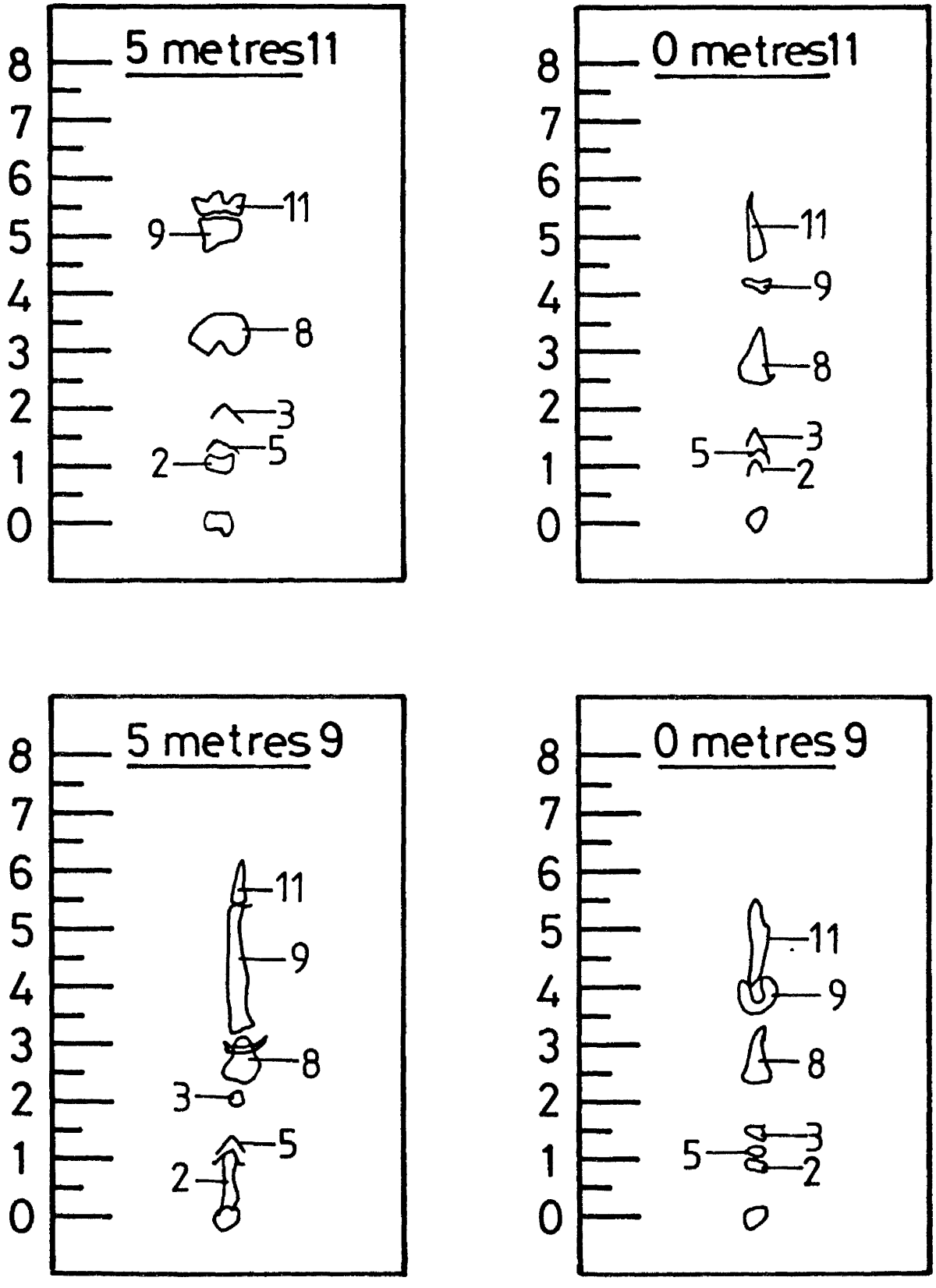
3 = Phaeophorbide a

5 = Chlorophyllide a

8 = Carotene

9 = Chlorophyll a

11 = Phaeophytin a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0 metres 9
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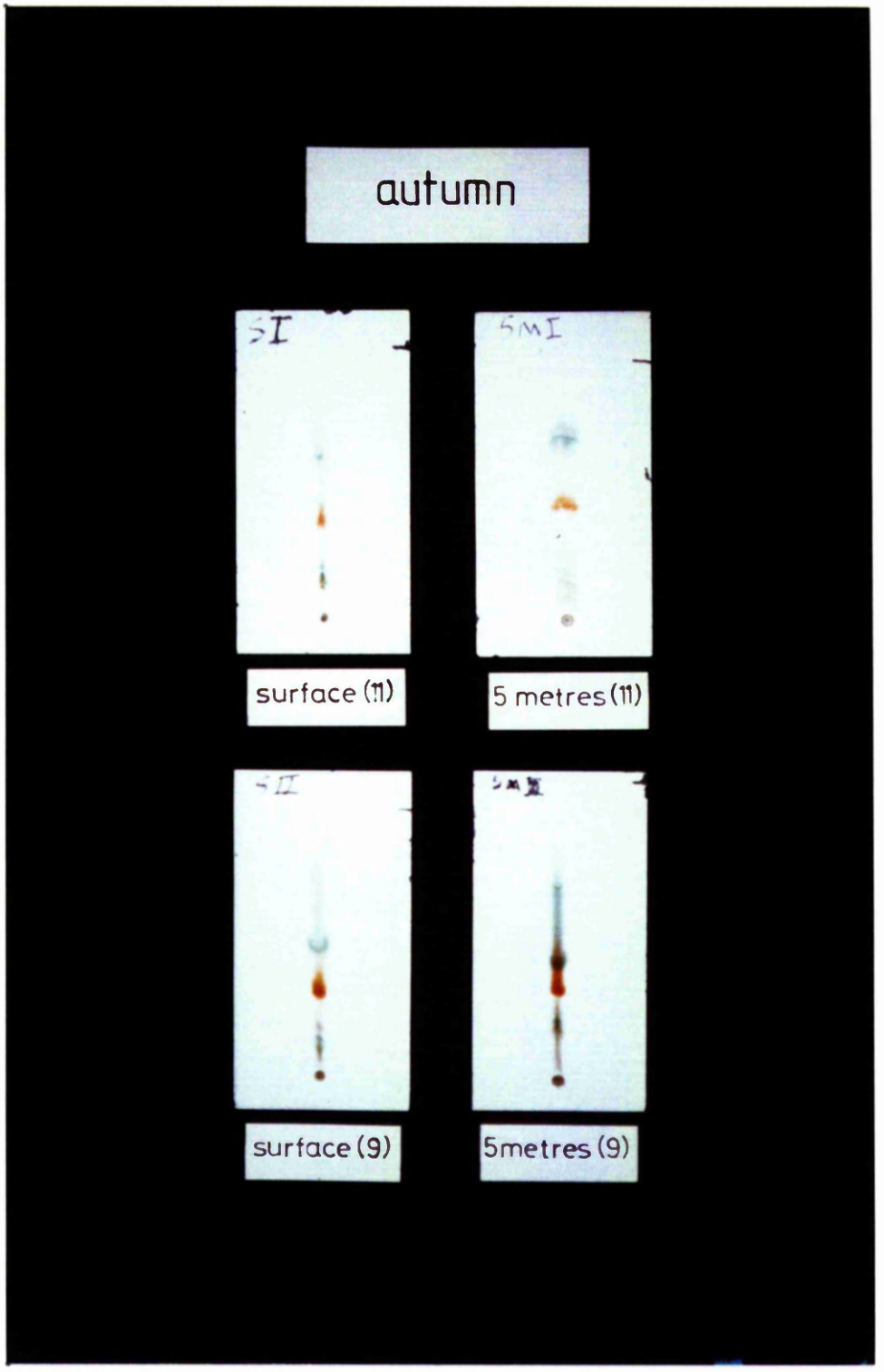
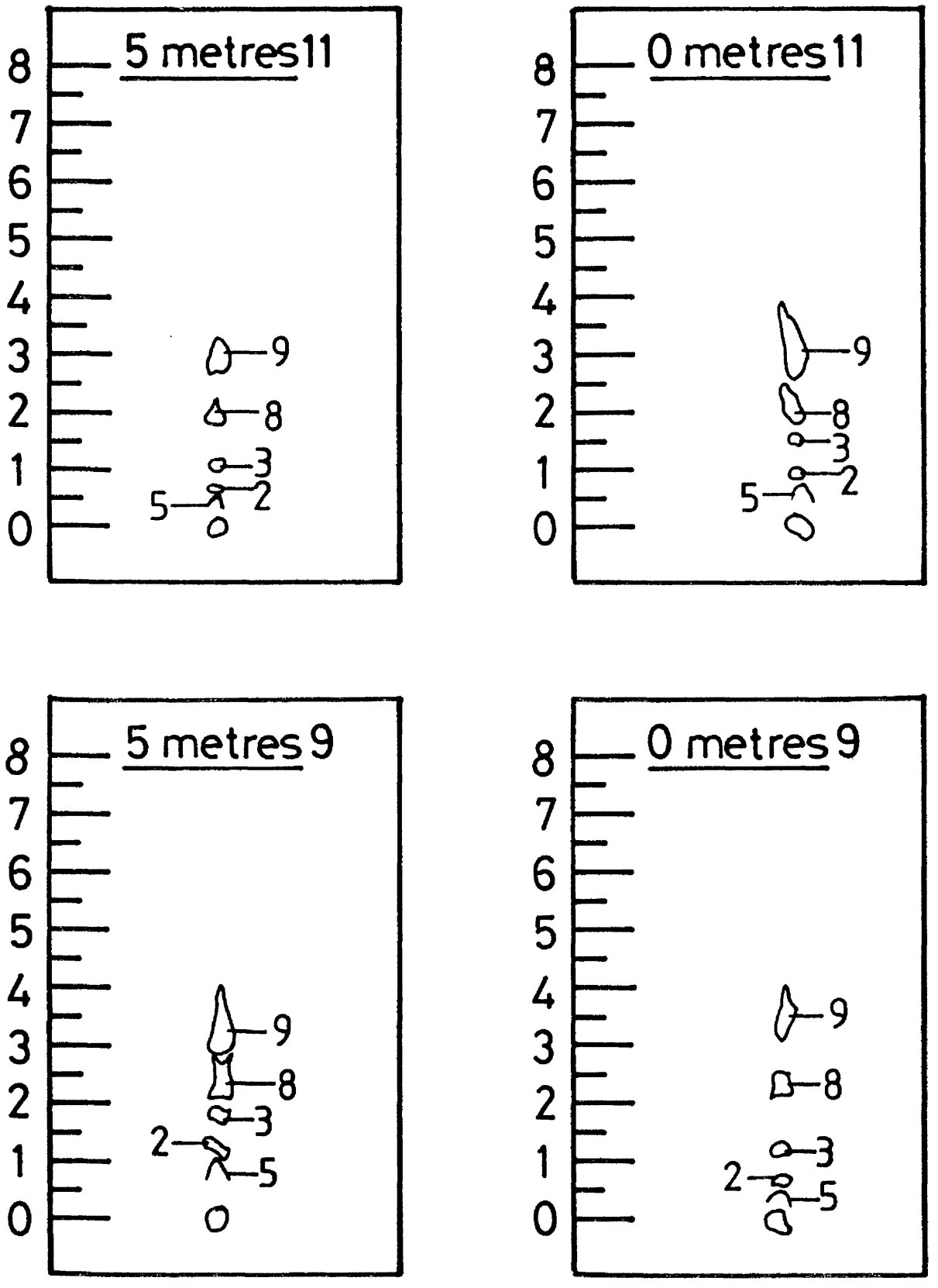
2

autumn (1984)

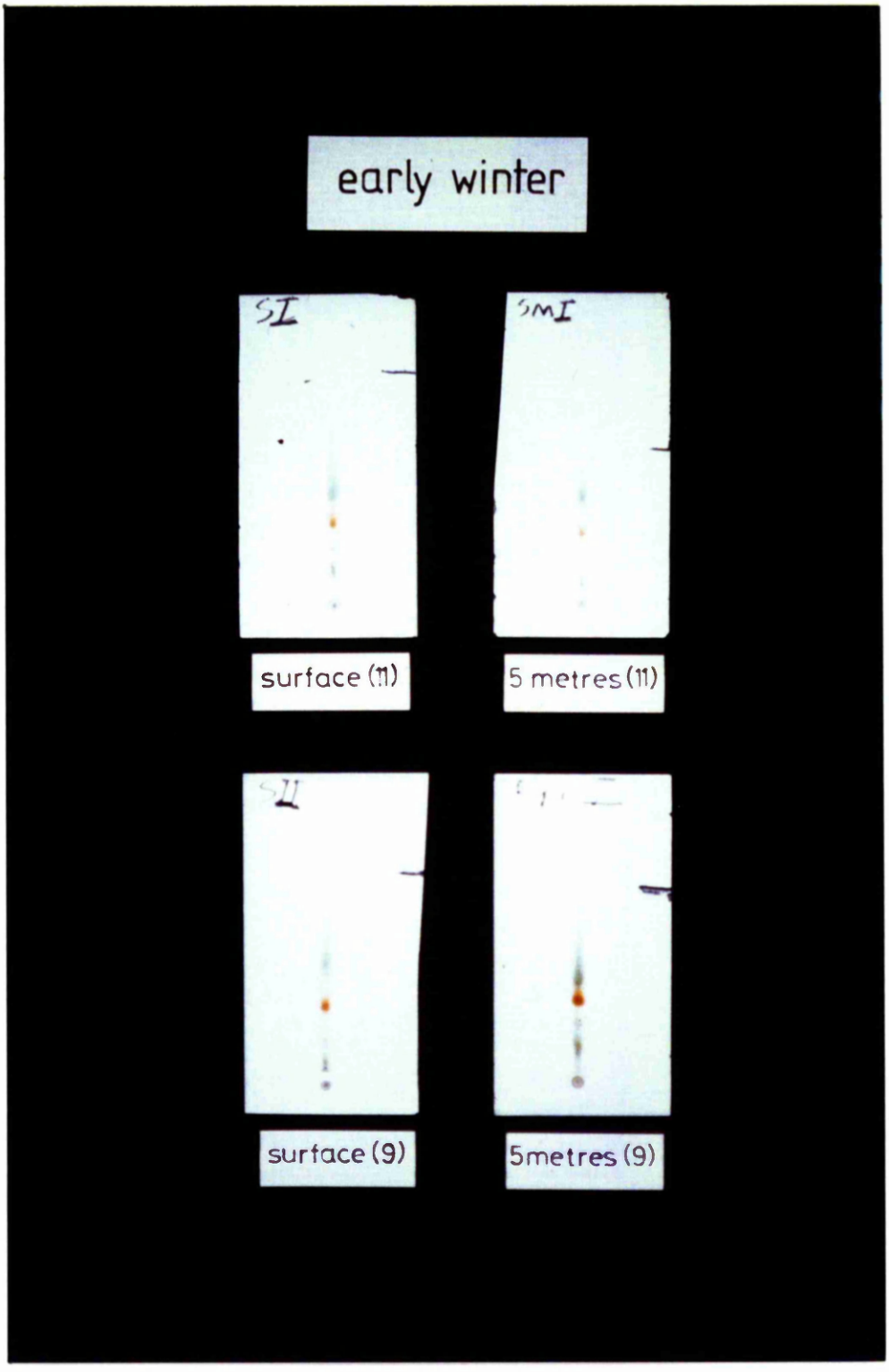

autumn
SI
5MI
surface (11)
5 metres (11)
surface (9)
5metres (9)

Figs. 3. 3. 13a. and 3. 3. 13b.

Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth.
(early winter, 1984).
2 = Chlorophyll b
3 = Phaeophorbide a
5 = Chlorophyllide a
8 = Carotene
9 = Chlorophyll a



early winter (1984)


early winter
SI
SMI
surface (11)
5 metres (11)
SII
surface (9)
5metres (9)

Figs. 3. 3. 14a. and 3. 3. 14b.

Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth.

(late winter, 1984).

1 = Chlorophyll c

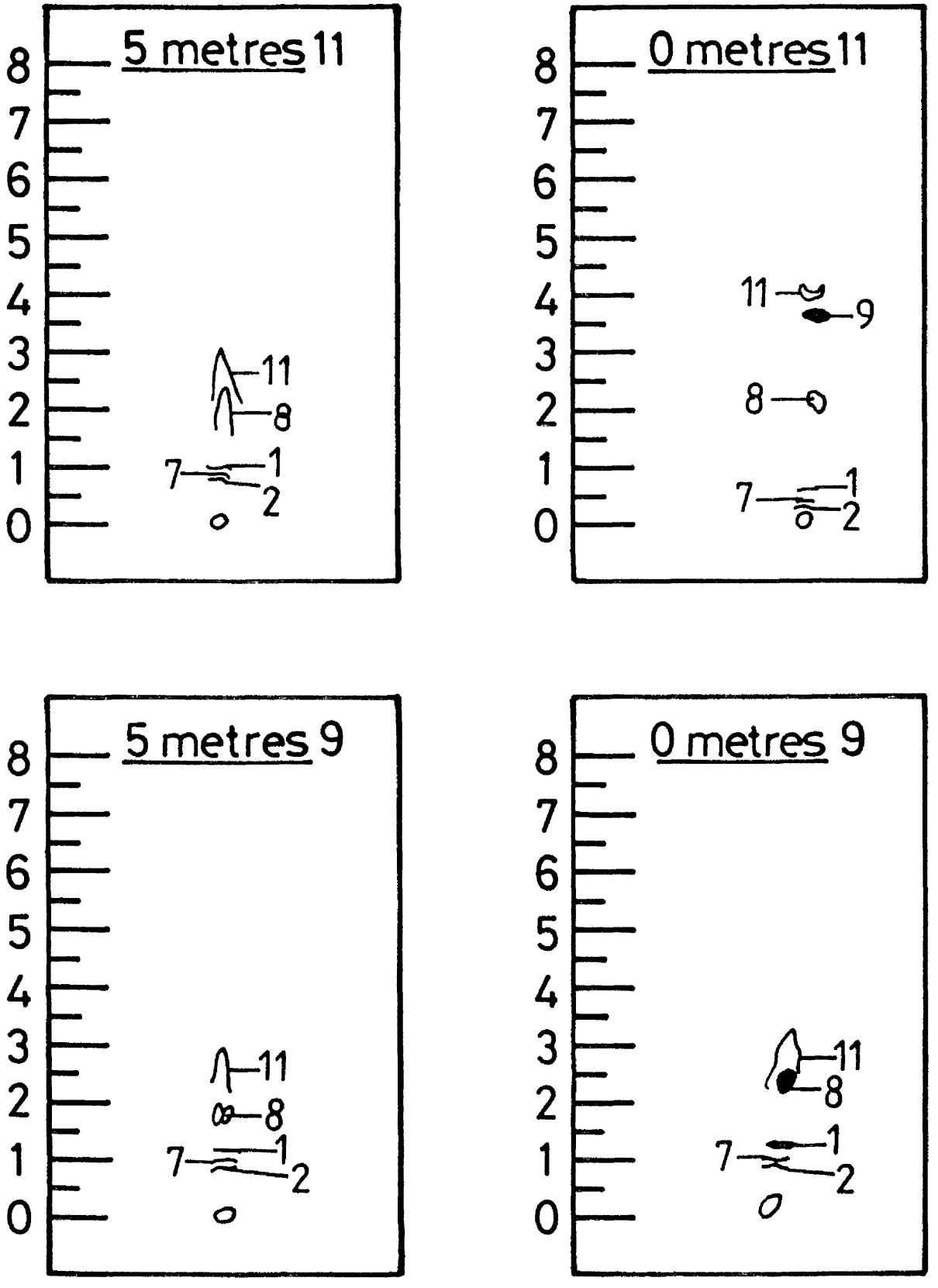
2 = Chlorophyll b

7 = Fucoxanthin

8 = Carotene

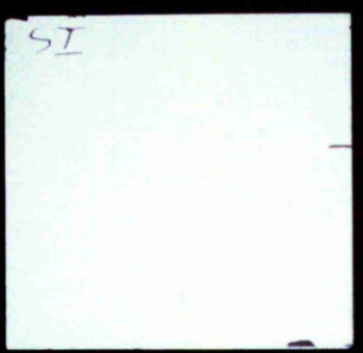
9 = Chlorophyll a

11 = phaeophytin a

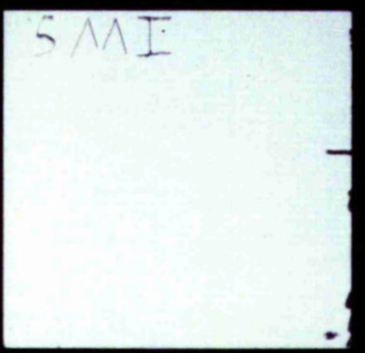


late winter (1984)

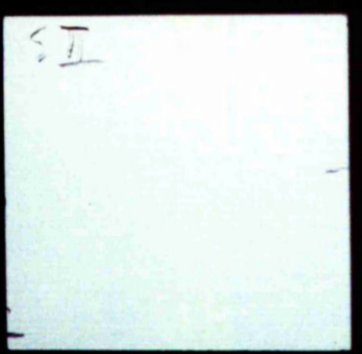
late winter



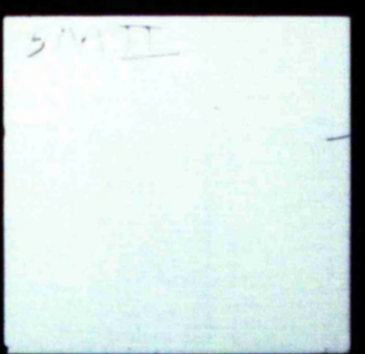
surface (11)



5 metres (11)



surface (9)



5metres (9)

Figs. 3. 3. 15a. and 3. 3. 15b.

Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth.

(spring, 1985).

1 = Chlorophyll c

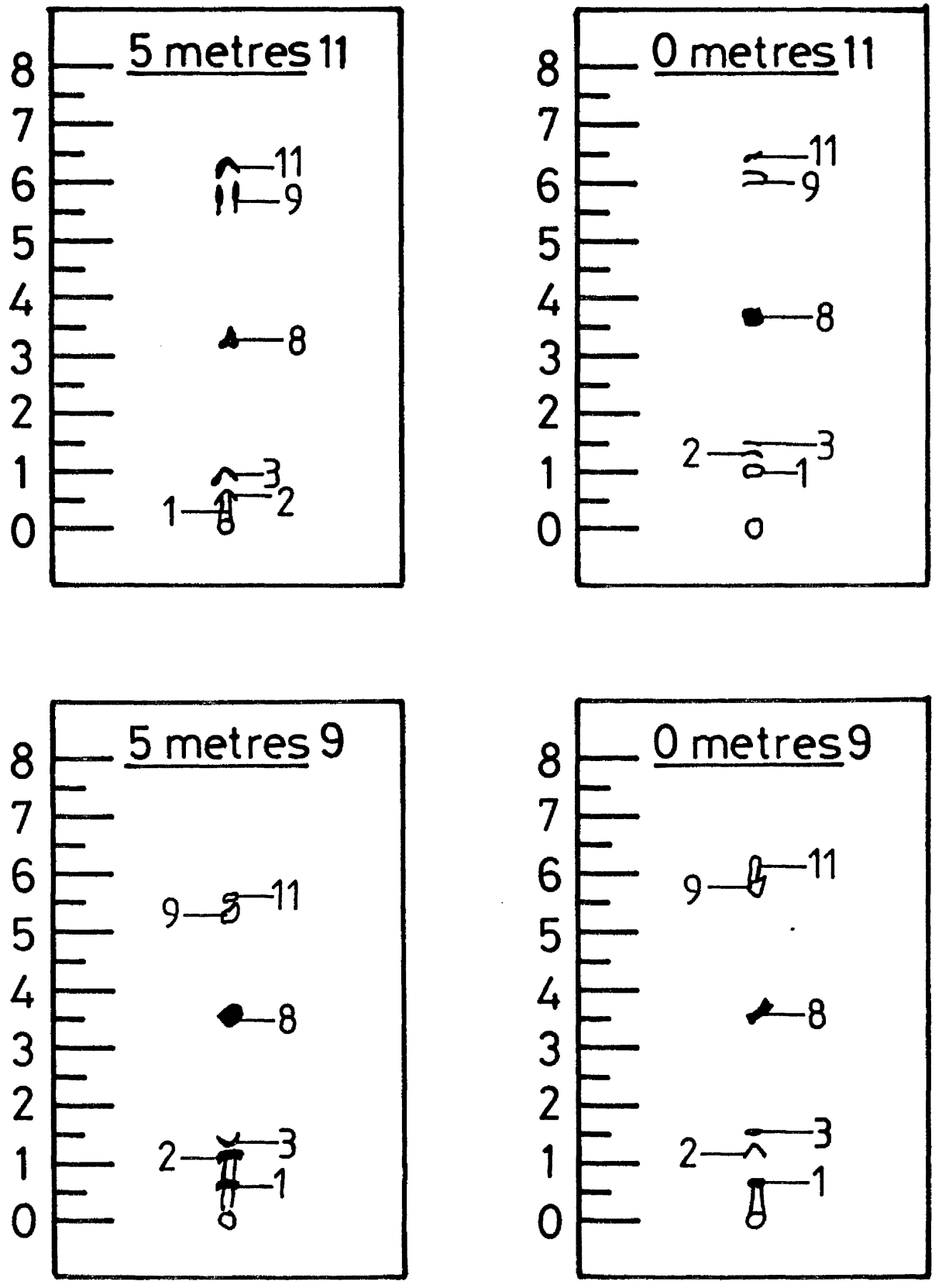
2 = Chlorophyll b

3 = Phaeophorbide a

8 = Carotene

9 = Chlorophyll a

11 = Phaeophytin a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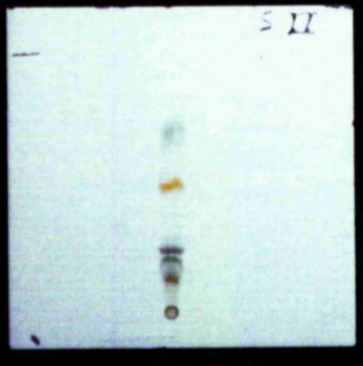
8
3
2
1

spring(1985)

spring 85

surface (11)

5 metres (11)



surface (9)

5metres (9)

Figs.3. 3. 16a. and 3. 3. 16b.

Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth.
(autumn, 1985).

1 = Chlorophyll c

2 = Chlorophyll b

3 = Phaeophorbide a

5 = Chlorophyllide a

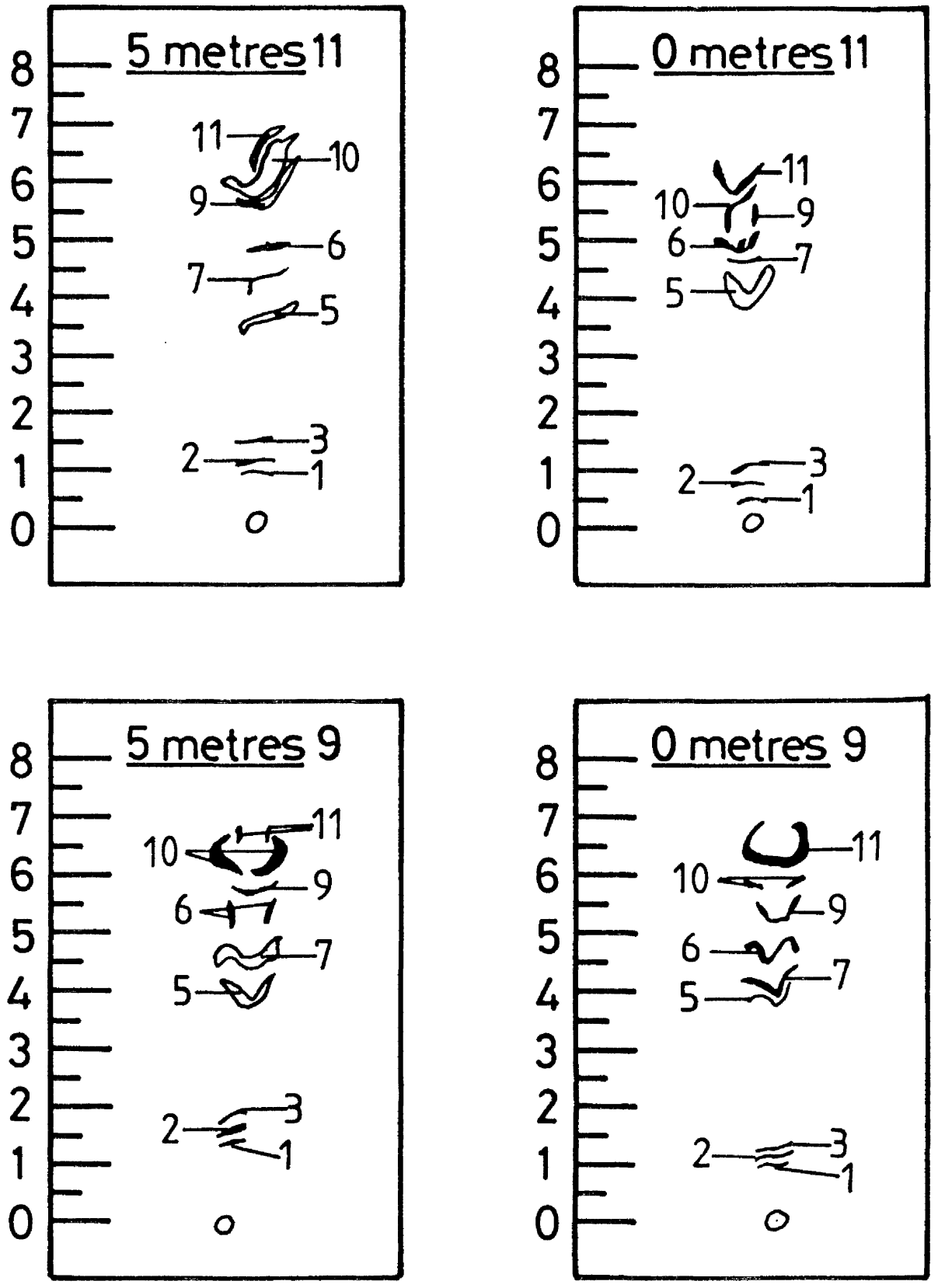
6 = Diadinoxanthin

7 = Fucoxanthin

9 = Chlorophyll a

10 = Astaxanthin

11 = Phaeophytin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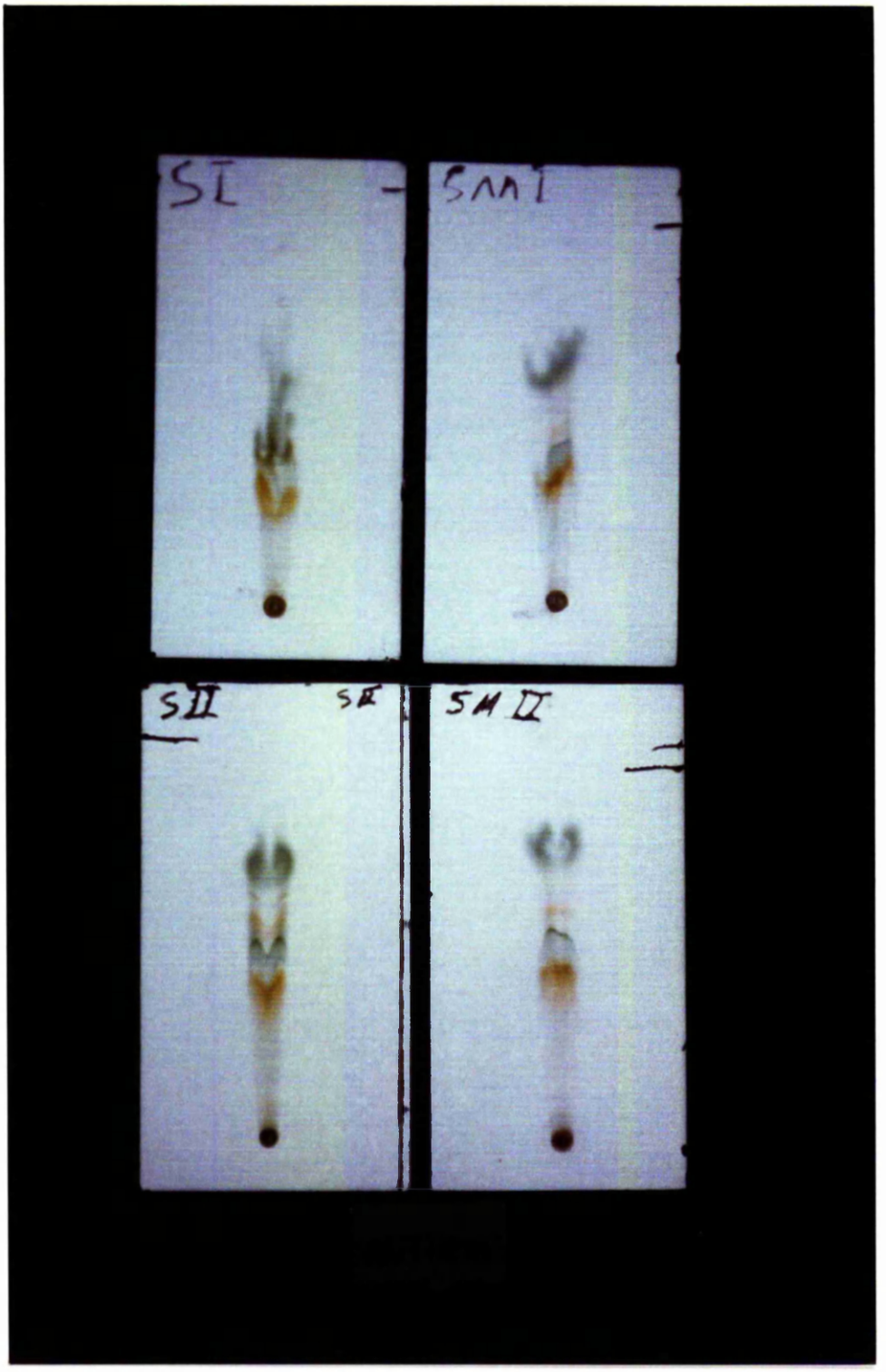
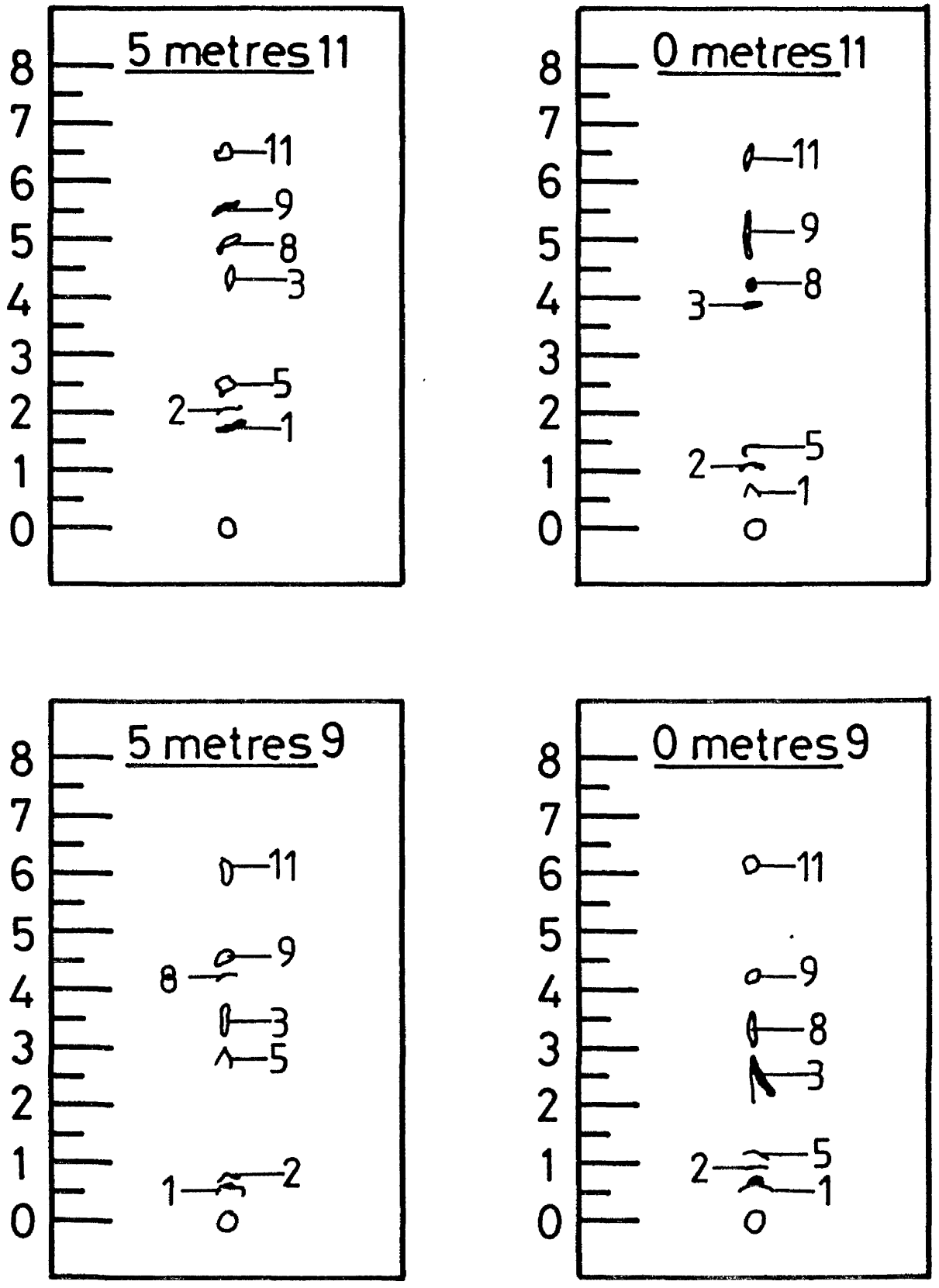
0

autumn(1985)

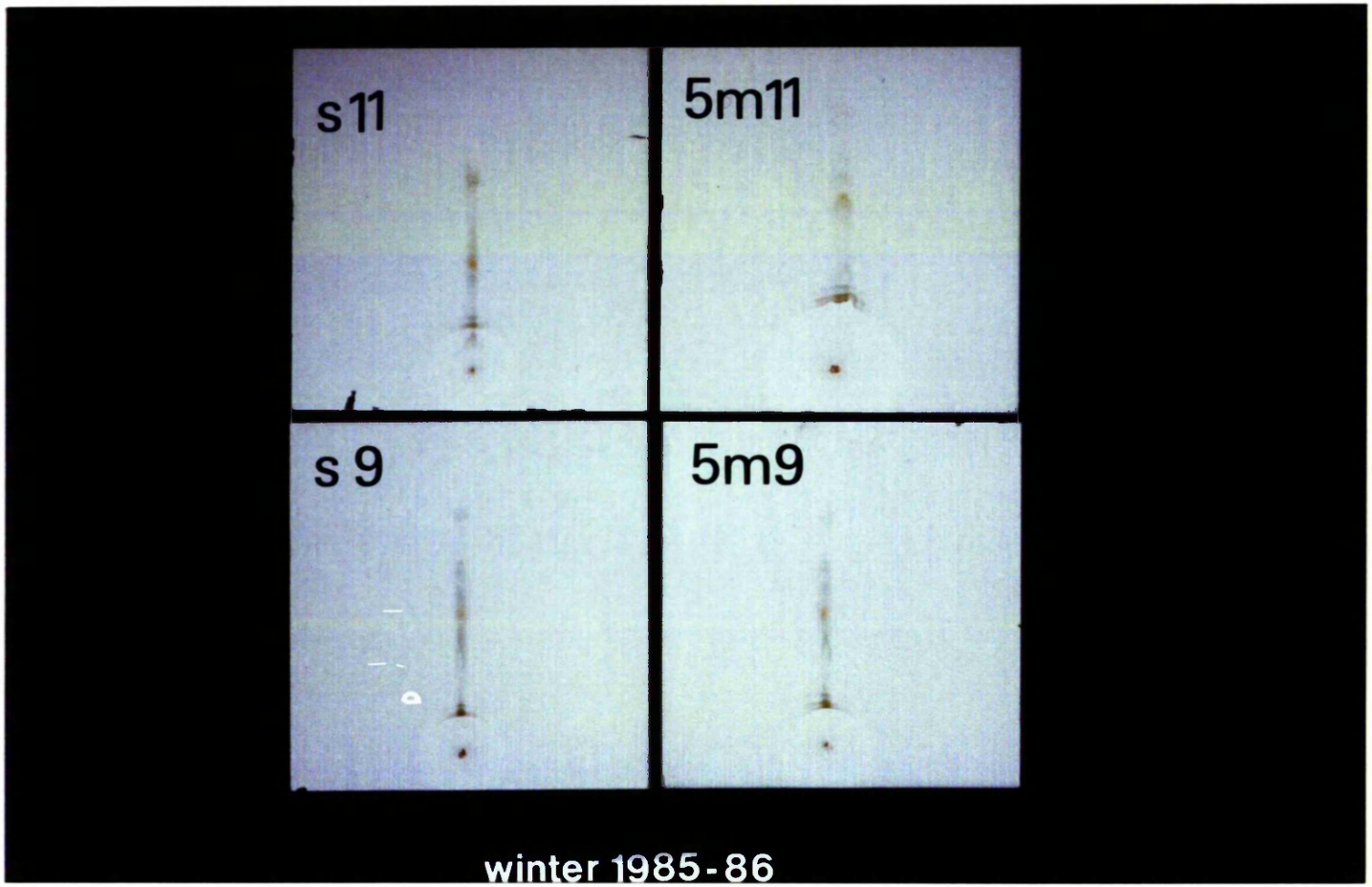

SI
SMI
SII
SMII

Figs. 3. 3. 17a. and 3. 3. 17b.

Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth.
(winter, 1985 - 1986).
1 = Chlorophyll c
2 = Chlorophyll b
3 = Phaeophorbide
5 = Chlorophyllide a
8 = Carotene
9 = Chlorophyll a
11 = Phaeophytin a



winter(1985_1986)


s11
5m11
s 9
5m9
winter 1985-86

Figs. 3. 3. 18a. and 3. 3. 18b.

Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth.
(spring, 1986).

1 = Chlorophyll c

2 = Chlorophyll b

3 = Phaeophorbide a

5 = Chlorophyllide a

6 = Diadinoxanthin

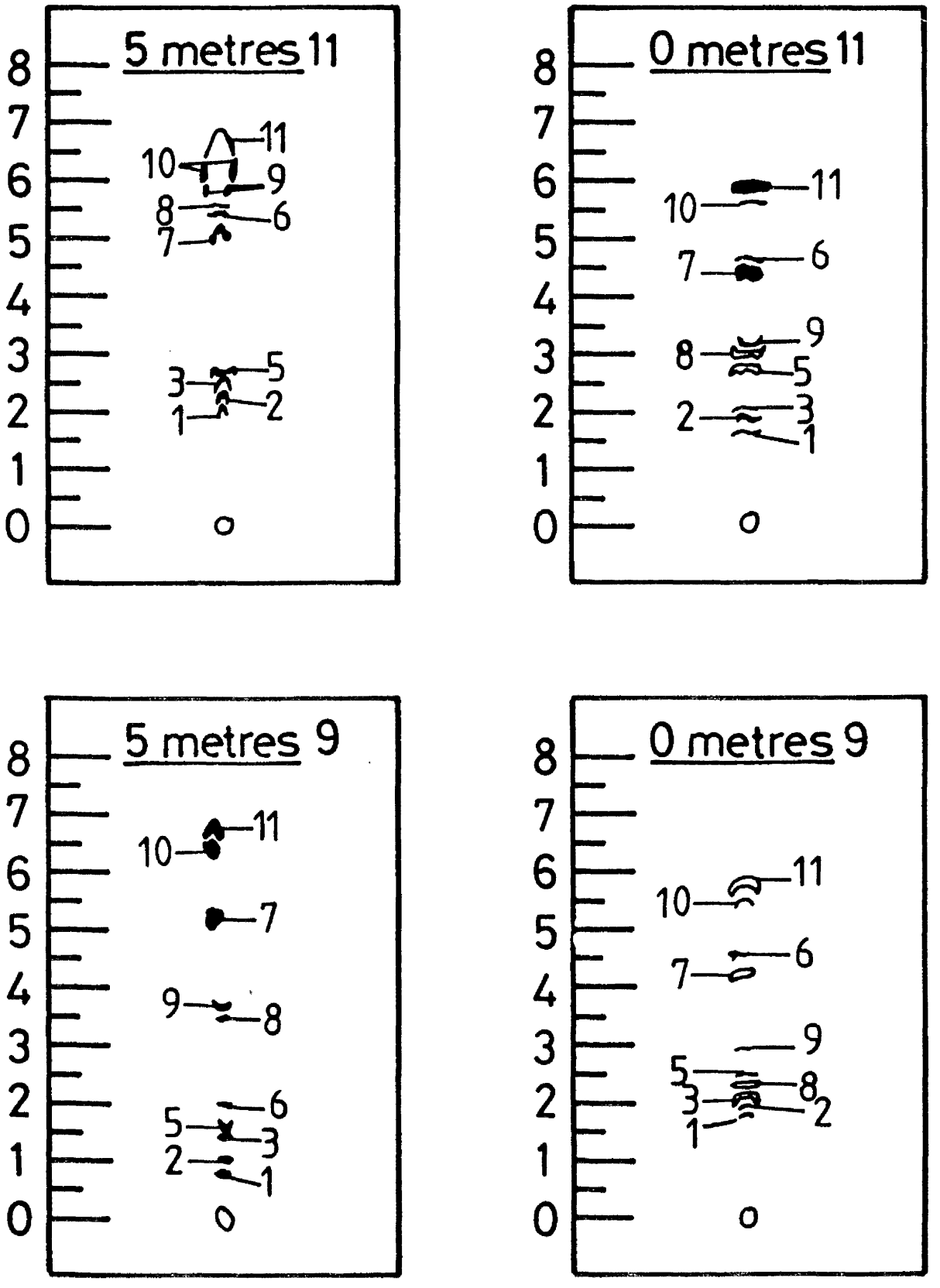
7 = Fucoxanthin

8 = Carotene

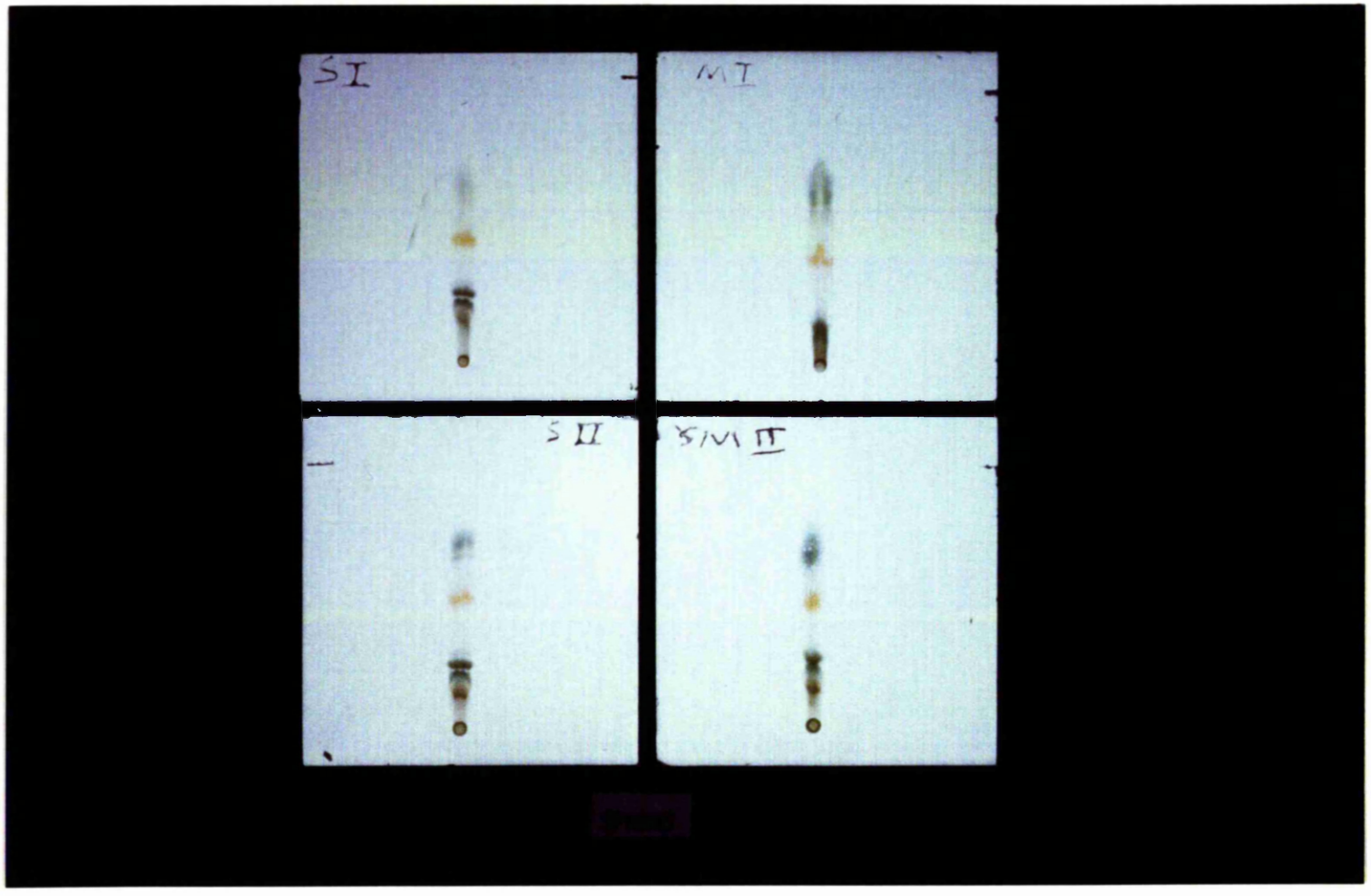
9 = Chlorophyll a

10 = Astaxanthin

11 = Phaeophytin a

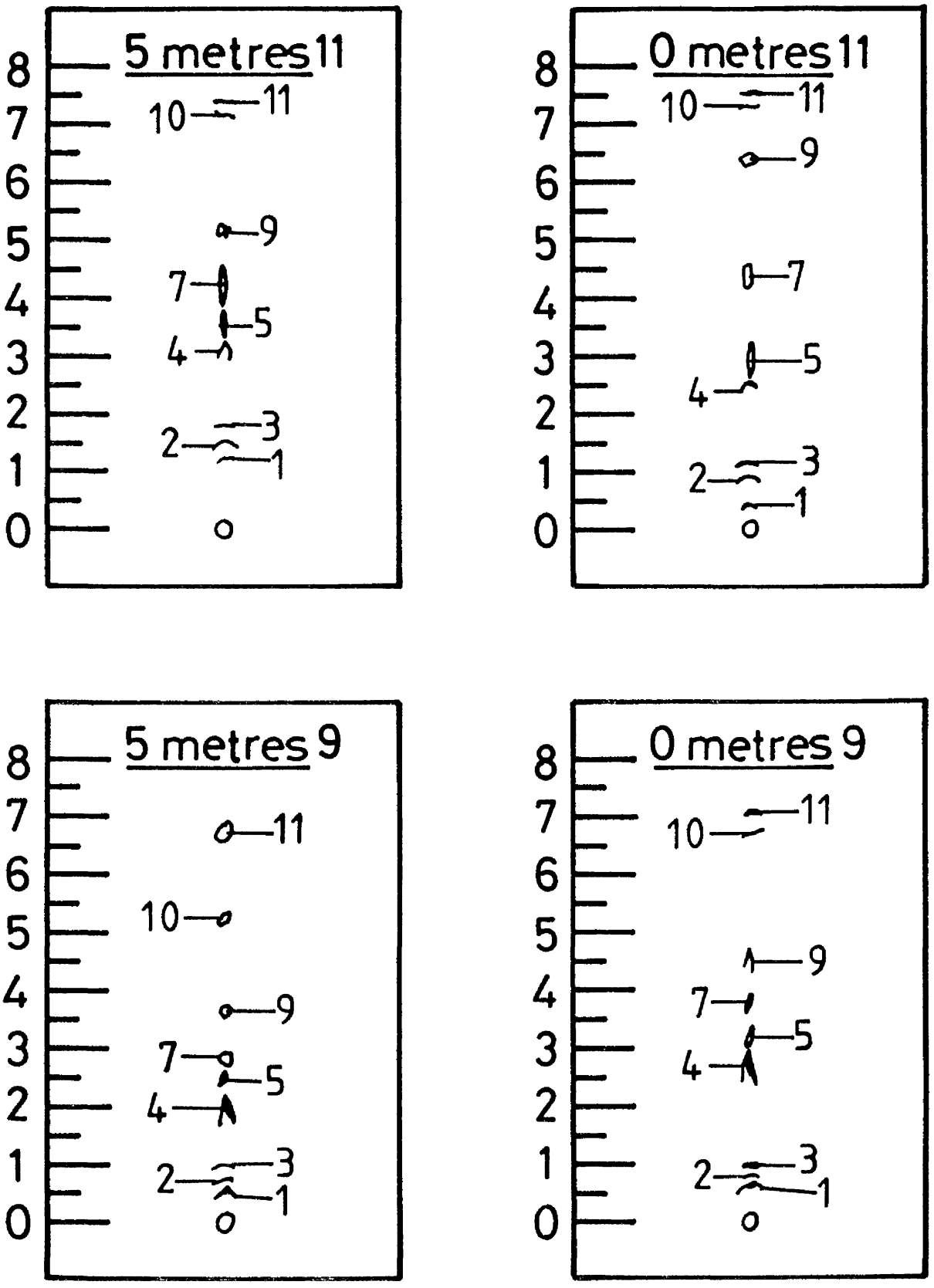

5 metres 11
0 metres 11
5 metres 9
0 metres 9
8
7
6
5
4
3
2
1
0
11
10
9
8
7
6
5
3
2
1

spring(1986)


SI
MI
S II
S/M II

Figs. 3. 3. 19a. and 3. 3. 19b.

Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth.
(summer, 1986).
1 = Chlorophyll c
2 = Chlorophyll b
3 = Phaeophorbide a
4 = Neoxanthin
5 = Chlorophyllide a
7 = Fucoxanthin
9 = Chlorophyll a
10 = Astaxanthin
11 = Phaeophytin a


5 metres 11
0 metres 11
5 metres 9
0 metres 9
summer (1986)

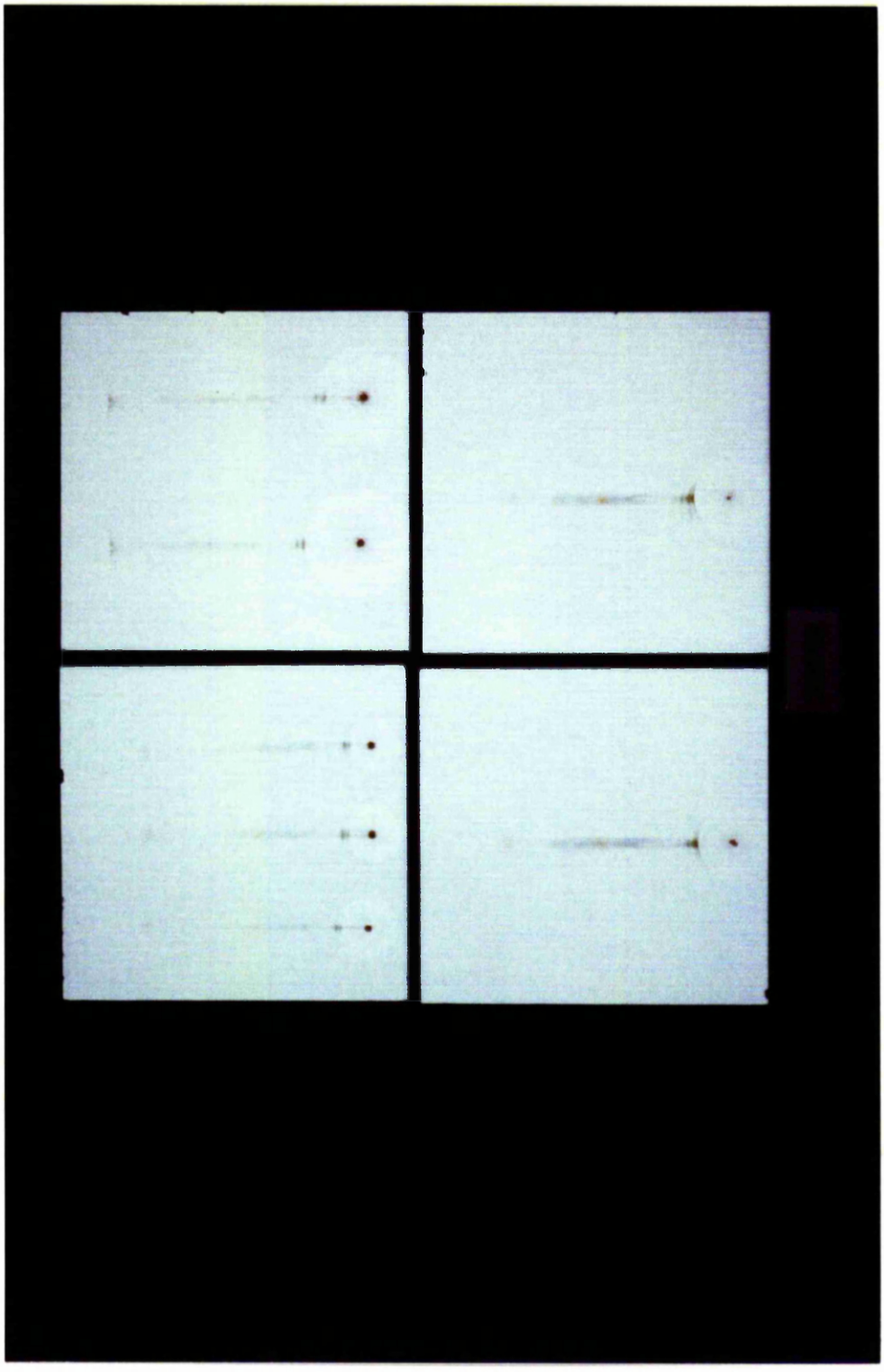


Fig.3.3.20a. Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth. (autumn, 1986).

Fig. 3. 3. 20b. Chromatograms of algal pigments at station 11, at surfac and 5 metres depth.

Fig. 3. 3. 20c. Chromatograms of algal pigments at station 9, at surface and 5 metres depth.

1 = Chlorophyll c

2 = Chlorophyll b

3 = Phaeophorbide a

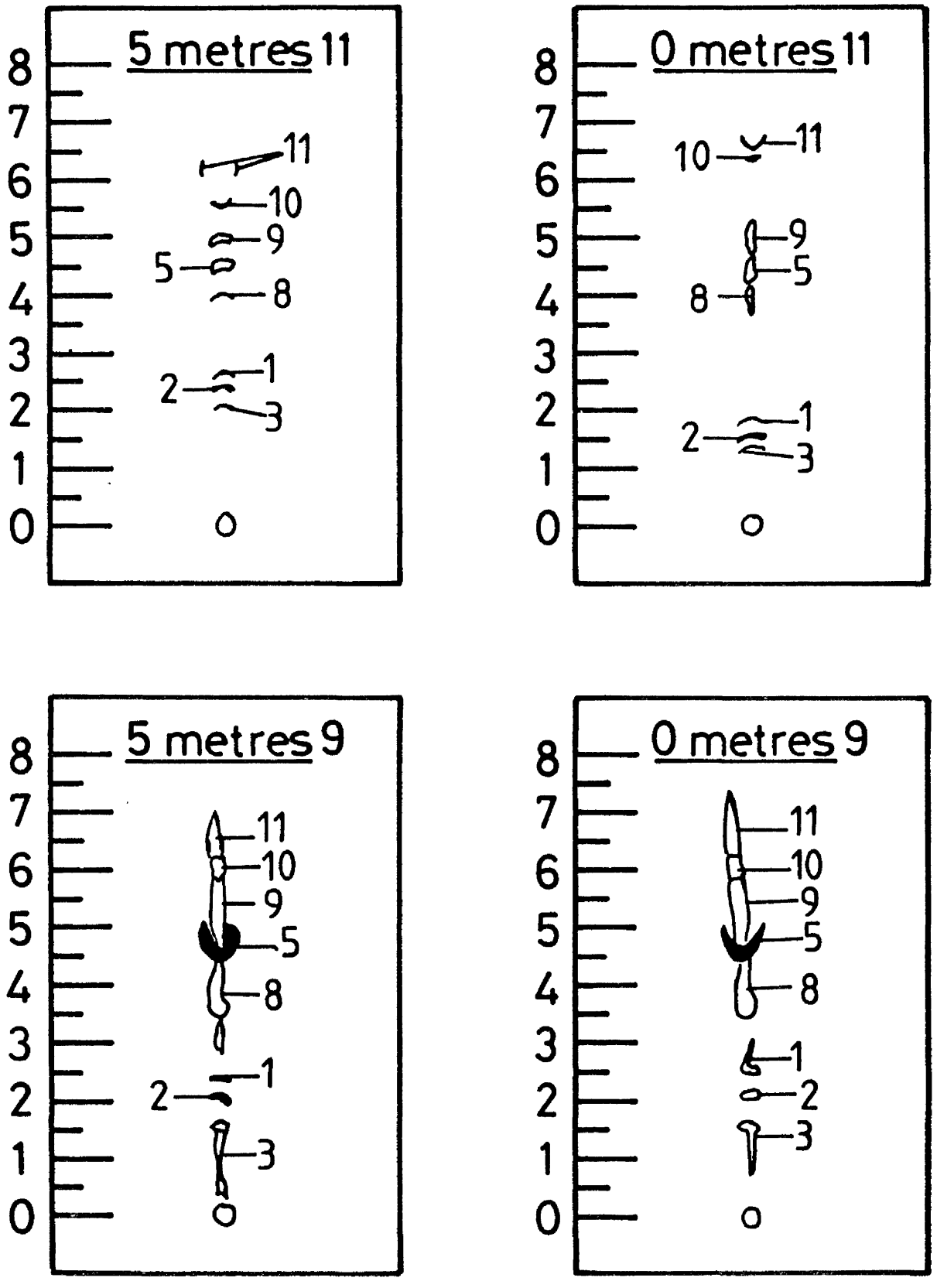
5 = Chlorophyllide a

8 = Carotene

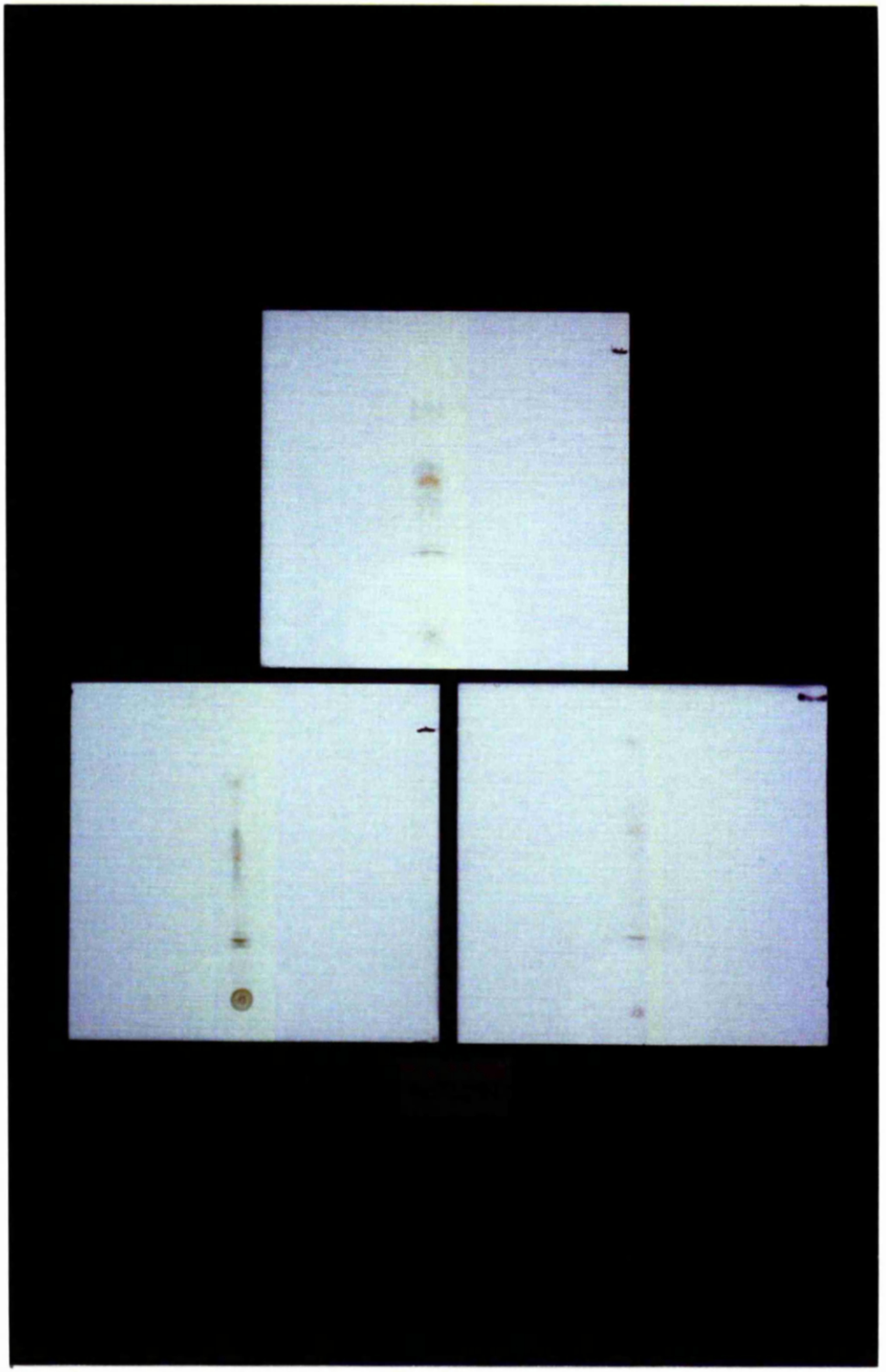
9 = Chlorophyll a

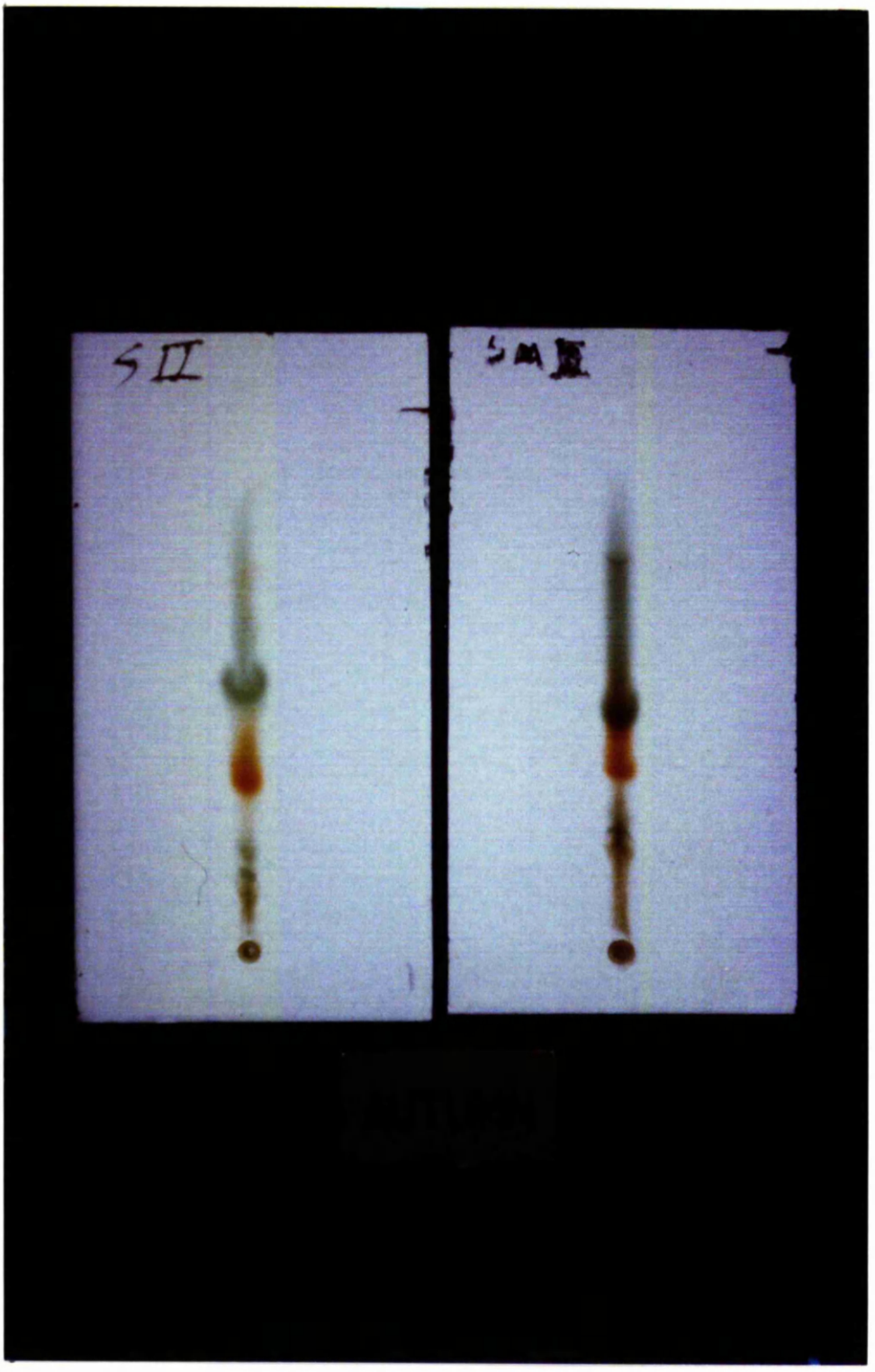
10 = Astaxanthin

11 = Phaeophytin a


5 metres 11
11
10
9
5
8
2
1
3
0 metres 11
10
11
9
5
8
2
1
3
5 metres 9
11
10
9
5
8
2
1
3
0 metres 9
11
10
9
5
8
1
2
3
8
7
6
5
4
3
2
1
0

autumn(1986)




S II

Figs. 3. 3. 21a. and 3. 3. 21b.

Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth.

(winter, 1986 - 1987).

3 = Phaeophorbide a

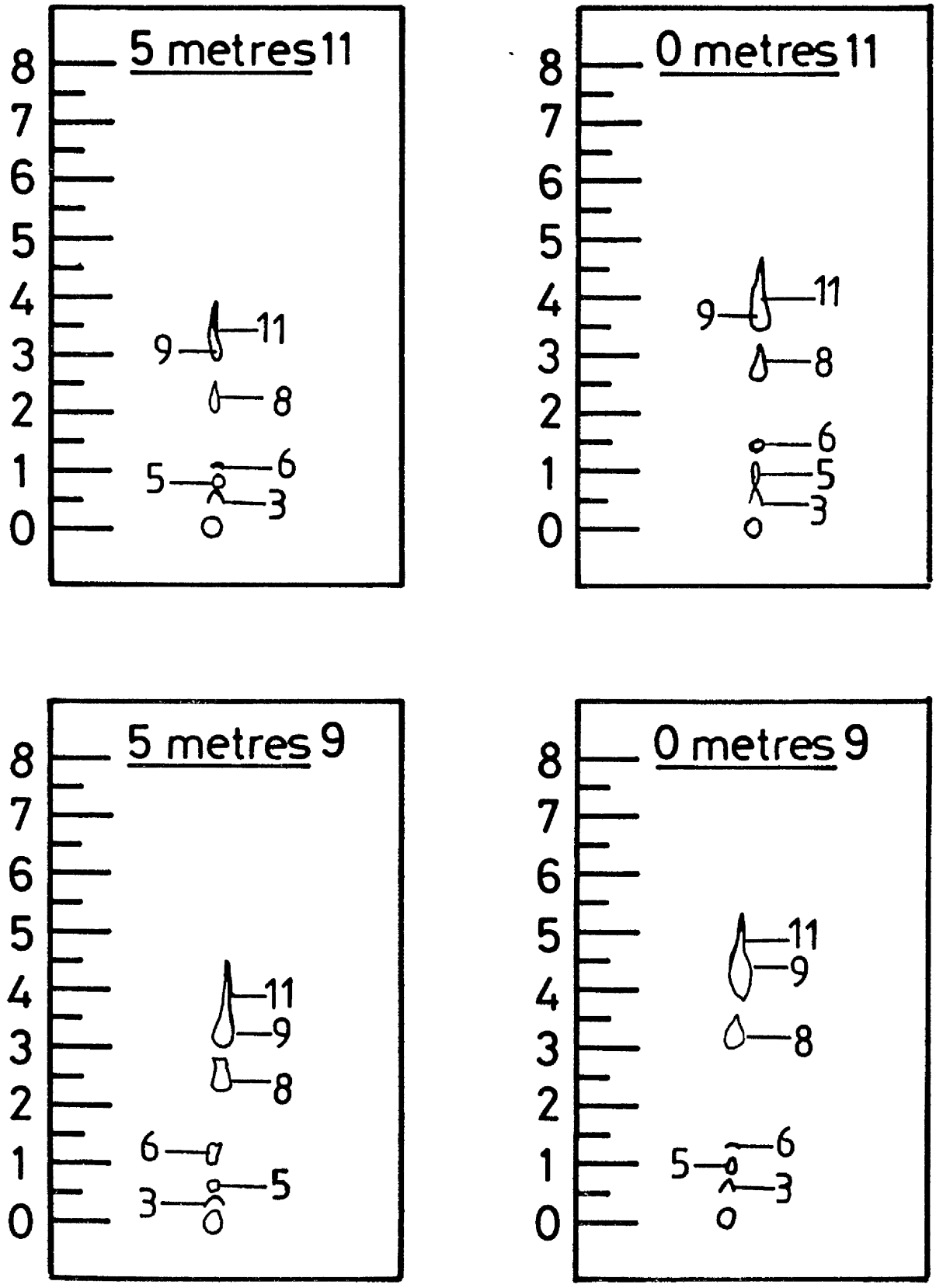
5 = Chlorophyllide a

6 = Diadinoxanthin

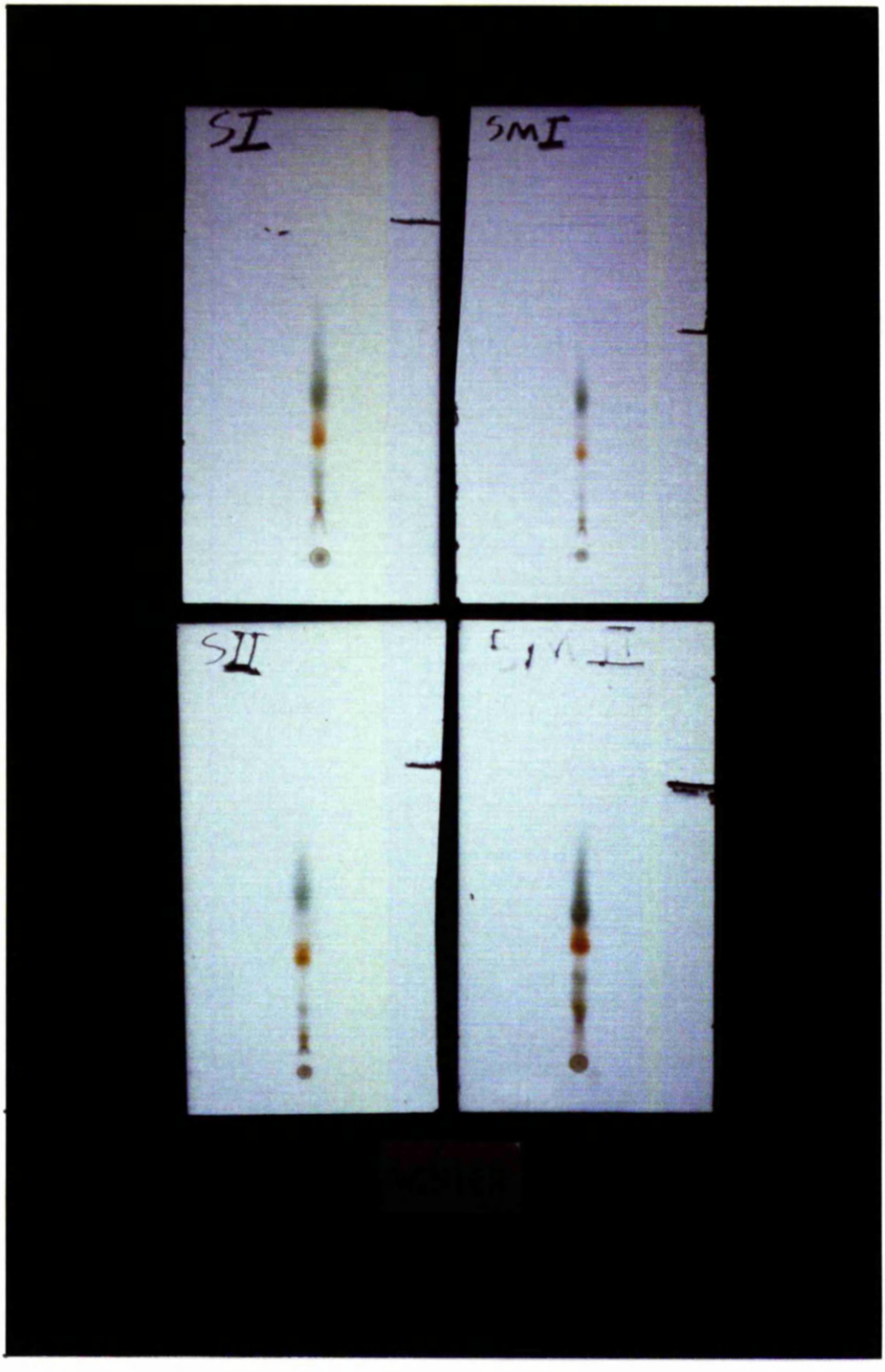
8 = Carotene

9 = Chlorophyll a

11 = Phaeophytin a



winter (1986_1987)


SI
SMI
SII

Figs.3. 3. 22 a. and 3. 3. 22b.

Chromatograms of algal pigments at stations 11 and 9, at surface and 5 metres depth.
(spring, 1987).

1 = Chlorophyll c

2 = Chlorophyll b

3 = Phaeophorbide a

4 = Neoxanthin

5 = Chlorophyllide a

6 = Diadinoxanthin

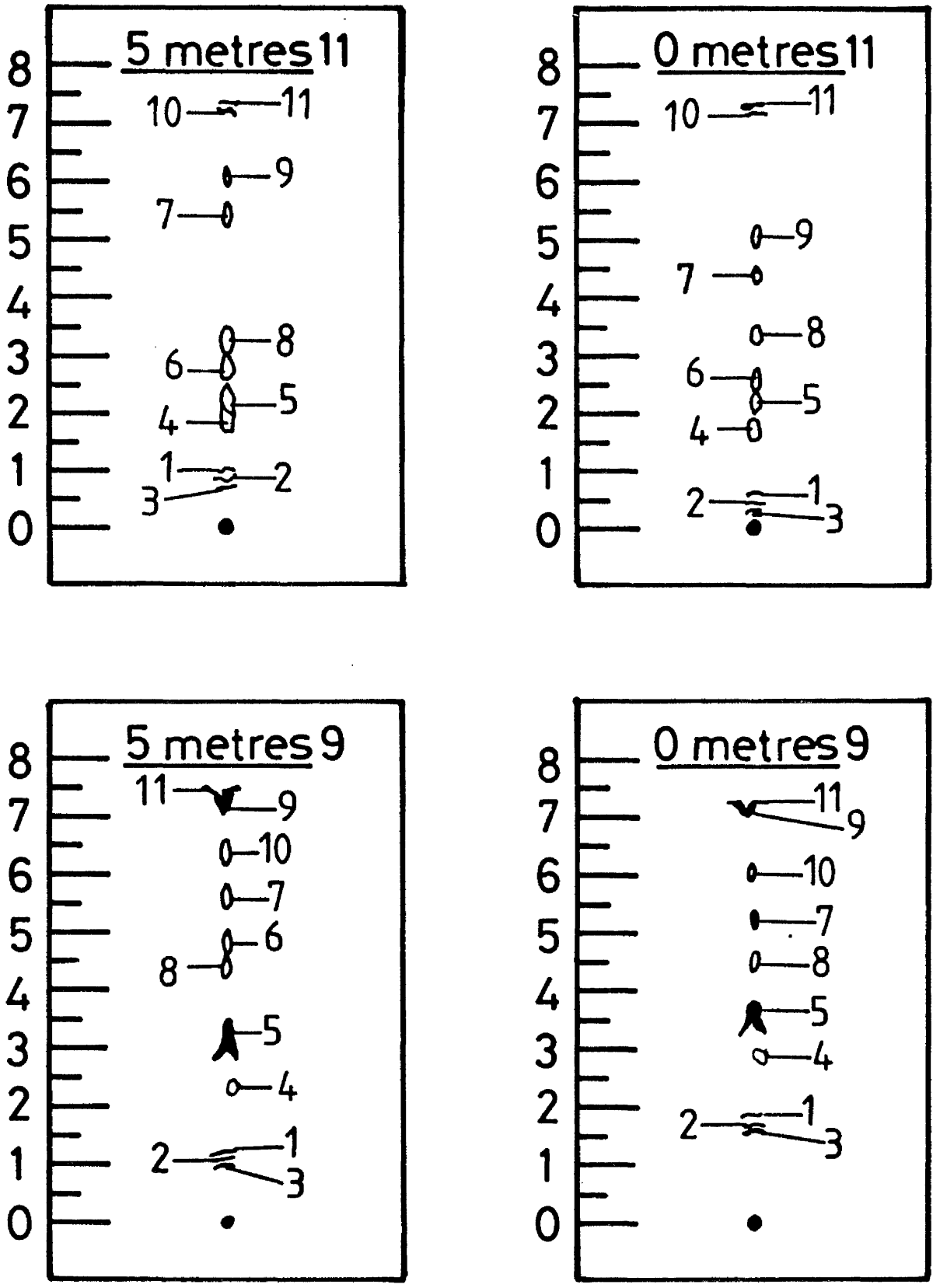
7 = Fucoxanthin

8 = Carotene

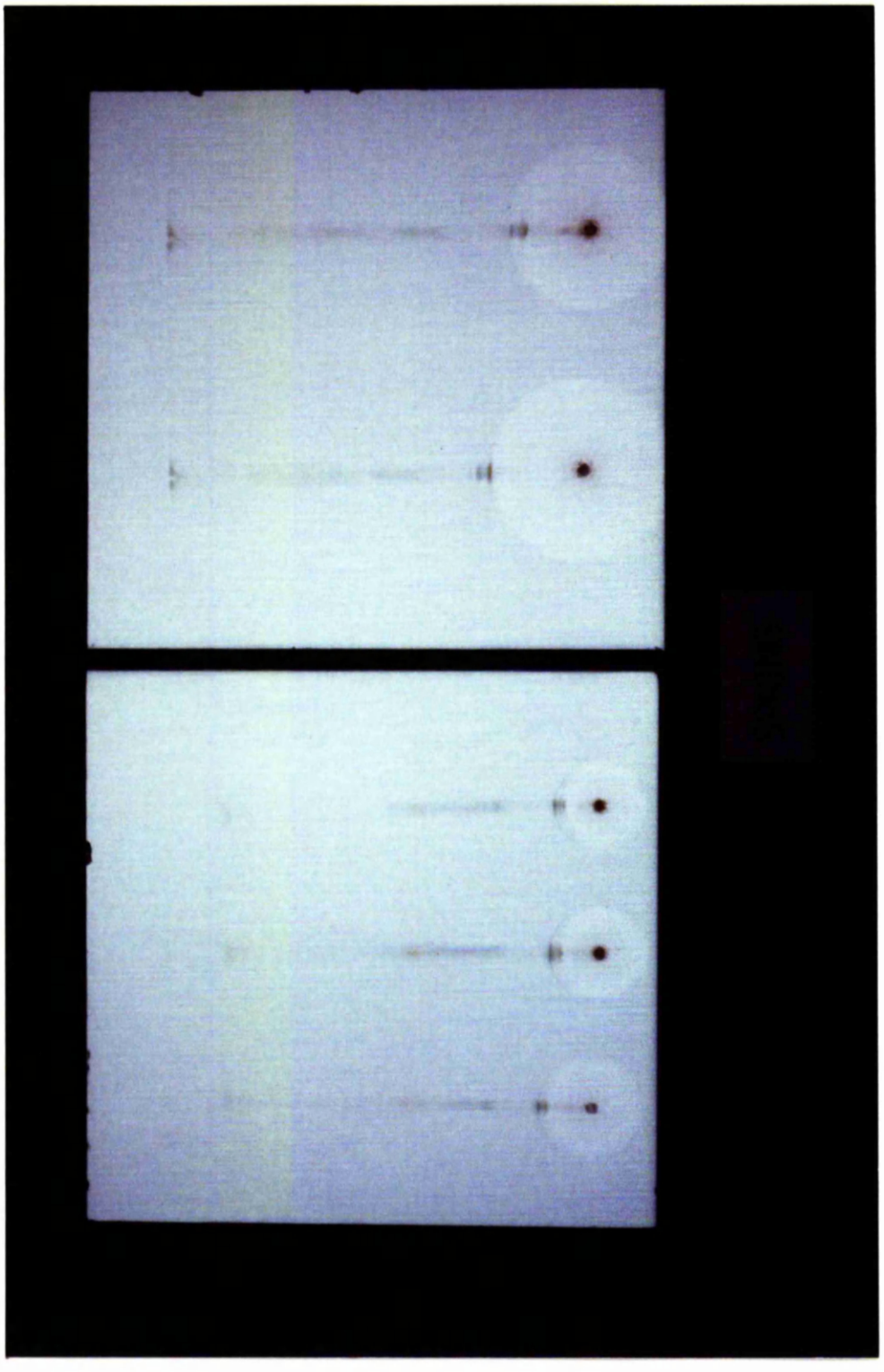
9 = Chlorophyll a

10 = Astaxanthin

11 = Phaeophytin



spring(1987)



3. 3. 3. Discussion:

A group of related pigments or just one specific component can be used not only to determin the distribution of algal types present but also to indicate the biological processes in the water column. For example, the cluster of chlorophyll a and c, carotene, diadinoxanthin and fucoxanthin denoted the presence of living diatoms. The presence of chlorophyll b and neoxanthin indicated the presence of green algae. Astaxanthin was the specific pigment which indicated the presence of copepods. Chlorophyllide a indicated chlorophyllase activity in senescent diatoms (or it can be a filtration artefact), and the chlorophyll degradation products phaeophytin a and phaeophorbide a indicate feeding activity of copepods and other zooplankton , or can be a sign of the decline of a population.

A distinctive and close correlation between the types of pigments obtained , and the algal composition of the different samples collected on the different sampling dates was observed. A similar system for pigment identification and results interpretation was mentioned by Jeffrey, (1974).

During the course of this study the principal definitive pigments reflected the components in the samples. For example, the chromatograms obtained for samples collected during the spring of 1985 showed clear and distinct zones of chlorophyll a, carotene and chlorophyll c, which correlated with the large increase of diatoms during this period; diatoms being by far the dominant part of the population.

The density and colour intensity of different pigment spots were also good indications for the quantity of phytoplankton populations as expected. For example, the small and vague chlorophyll a, carotene, chlorophyll c and chlorophyll b spots obtained on chromatograms of samples collected during the winter of 1985 - 1986. This indicated that small total algal biomass was present. Similarly the microscopic examination of

samples collected during the same period showed the presence of small sized populations of phytoplankton.

One of the obvious features of this study was the frequent presence of chlorophyllide a. The presence of this pigment has been mentioned by (Patteson and Parsons, 1963; Jeffrey, 1965), which probably indicated the presence of senescent diatoms in the samples.

The presence of chlorophyll a indicates the presence of living algal cells. During late winter, 1984 with the exception of samples collected from station 11 (surface), the absence of detectable chlorophyll a meant that the pigments were associated with senescent cells or detrital material.

The occurrence of phaeophorbide a as a double decomposition product of chlorophyll a (loss of phytol and magnesium), was also mentioned by Jeffrey, (1971) as being most likely a result of the passage of the algae through the gut of small marine animals, which was confirmed by the chromatographic study of copepod faecal pellets.

Lorenzen, (1965, 1967b); Yentsch, (1965) had given the phaeophytin a a central role in chlorophyll a degradation processes in the oceans. Quite often during this study due to the absence of green algae the presence of chlorophyll b was attributed to the presence of fragments of green filaments from shore habitats.

The three chlorophyll a degradation products were observed almost in all the chromatograms, in different clarities and distinctiveness with the exception of the chromatograms for late summer (1984), where phaeophorbide a was absent, the chromatograms for late winter (1984 - 1985) in which the only chlorophyll break down product present was phaeophytin a and the chromatograms for spring (1985), in which chlorophyllide a was absent.

3. 4. Phytoplankton quantities and composition:

Table 3. 4. 1. lists the diatoms, dinoflagellates and other algae recorded at the two stations 11 and 9 (surface and 5 metres depth) during the period of this study. Figs. 3. 4. 1. - 3. 4. 4. summarize the total number of phytoplankton cells per litre at the time of sampling 1984-1987; Figs. 3. 4. 5. - 3. 4. 8. show the percentages of planktonic to benthic organisms over the same period and Figs. 3. 4. 9. - 3. 4. 12. illustrate the percentages of diatoms to dinoflagellates and other flagellates.

Table 3. 4. 1. The systematic list of the organisms recorded in the Fairlie Channel during the period of this study. B= Benthic, P= Planktonic.

Diatoms.

1 *Achnanthes spp.* Bory. (B)

2 *Achnanthes brevipes* Agardh. (B)

3 *Achnanthes longipes* Agardh. (B)

4 *Amphiprora paludosa* W. Sm. (P)

5 *Amphiprora surirelloides* Hendey. (P)

6 *Amphora spp.* Ehrenberg.(B)

7 *Amphora macilenta* Greg. (B)

8 *Amphora robusta* Greg. (B)

9 *Asterionella spp.* Hassall ex W. Smith, 1856 (P)

10 *Asterionella japonica* Cleve and Moller. (P)

11 *Biddulphia spp.* Gray, 1821. (P)

12 *Biddulphia aurita* (Lyngb.) de Breb. (P)

13 *Biddulphia mobiliensis* (Bail.) Grun. ex Van Heurck (P)

14 *Biddulphia regia* (Schultze) Ostenf. (P)

15 *Biddulphia sinensis* Grev. (P)

16 *Chaetoceros spp.* (Ehrenberg) (P)

17 *Chaetoceros atlanticum* Cleve. (P)

18 *Chaetoceros didymum* Ehrenb. (P)

19 *Chaetoceros externum* Gran. (P)

20 *Chaetoceros holsaticum* Schutt (P)

21 *Cistula lorenziana* (Grun.) Cleve (B). (Very rarely observed on British shores).

22 *Cocconeis spp.* Ehrenberg, 1894

23 *Cocconeis clandestina* Schm. (B)

24 *Cocconeis disculus* (Schum.) Cleve (B)

25 *Cocconeis sublittoralis* Hendey (B)

26 *Coscinodiscus spp.* Ehrenberg, 1838

27 *Diatoma spp.* (B)

28 *Diatoma elongatum* (B)

29 *Diploneis bomboides* (Schm.) Cleve (B)

30 *Diploneis chersonensis* Grun. (B)

31 *Diploneis crabro* Ehrenberg (B)

32 *Ditylum brightwellii* (West) Grun. ex Van Heurck (P)

33 *Epithemia spp.* de Brebisson, 1838 (B)

34 *Eucampia zodiacus* Ehrenb. (P)

35 *Fragilaria spp.* Lyngbye, 1819 (B)

36 *Fragilaria capucina* Desmaz (B)

37 *Fragilaria islandica* Grun. ex Van Heurck (B)

38 *Fragilaria virescens* Grun. (B)

39 *Gomphonema spp.* Husted in Pascher, 1930 (P)

40 *Grammatophora marina* (Lyngb.) Kutz. (B)

41 *Grammatophora serpentina* Ehrenb. (B)

42 *Gyrosigma spp.* Hassall, 1845 (B)

43 *Isthmia enervis* Ehrenb. (B)

44 *Leptocylindrus danicus* Cleve (P)

45 *Licmophora spp.* Agardh, 1827 (B)

46 *Melosira spp.* Agardh, 1824 (P)

47 *Melosira nummuloides* (Dillw.) Agardh

48 *Navicula spp.* Bory, 1822 (B)

49 *Navicula distans* (W. Sm.) Cleve (B)

50 *Nitzschia spp.* Hassall, 1845 (B)

51 *Nitzschia bilobata* W. Sm. (B)

52 *Nitzschia frigida* Grun. Cleve and Grun (B)

53 *Nitzschia longissima* (de Breb.) Ralphs ex Pritch (P)

54 *Nitzschia seriata* Cleve (P)

55 *Pinnularia spp.* Ehrenberg, 1843 (B)

56 *Pinnularia ambigua* Cleve (B)

57 *Pinnularia rectangulata* (Greg.) Cleve (B)

58 *Pleurosigma spp.* W. Smith, 1852 (B)

59 *Pleurosigma aestuarii* (de Breb. ex Kutz.) W. Sm. (B)

60 *Pleurosigma elongatum* (Lyngb.) Kutz (B)

61 *Rhabdonema arcuatum* (Lyngb.) Kutz. (B)

62 *Rhizosolenia spp.* Brightwell, 1858 (P)

63 *Rhizosolenia delicatula* Cleve (P)

64 *Rhizosolenia setigera* Brightwell. (P)

65 *Rhizosolenia stolterfothii* Perag. (P)

66 *Rhoicosphenia curvata* (Kuz.) Grun. (B)

67 *Scoliopleura tumida* (de Breb. ex Kutz.) Rab (B)

68 *Skeletonema costatum* (Grev.) Cleve (P)

69 *Stauroneis membranacea* (Cleve) Hust. (P)

70 *Surirella salina* W. Sm. (B)

71 *Synedra spp.* Ehrenberg, 1830 (B)

72 *Synedra gaillonii* (Bory) Ehrenb. (B)

73 *Synedra ulna* (*Nitzschia*) Ehrenb.

74 *Thalassiosira spp.* Cleve, 1873 (P)

75 *Thalassiosira decipiens* (Grun.) Jorg. (P)

76 *Thalassiosira gravida* Cleve (P)

77 *Thalassiosira nordenskioldii* Cleve (P)

Dinoflagellates.

78 *Ceratium extensum* (Gourret) Cleve (P)

79 *Ceratium fusus* (Ehrenberg) Dujardin (P)

80 *Ceratium furca* (Ehrenberg) Clapared and Lachmann (P)

81 *Ceratium inflatum* (Kofoid) Jorgensen (P)

82 *Ceratium lineatum* (Ehrenberg) Cleve (P)

83 *Ceratium longipes* (Bailey) Gran. (P)

84 *Ceratium longirostrum* Gourret (P)

85 *Ceratium macroceros* (Ehrenberg) Vanhoffen (P)

86 *Ceratium tripos* (O.F. Muller) Nitzsch (P)

87 *Dinophysis acuta* Ehrenberg (P)

88 *Protoperidinium spp.* Ehrenberg, 1831. (P)

89 *Protoperidinium conicum* (Gran) Balech. (P)

90 *Protoperidinium divergens* (Ehrenb.) Balech. (P)

91 *Protoperidinium excentricum* (Pauls.) Balech. (P)

92 *Protoperidinium ovatum* Pouchet. (P)

93 *Protoperidinium pyriforme* (Pauls.) Balech. (P)

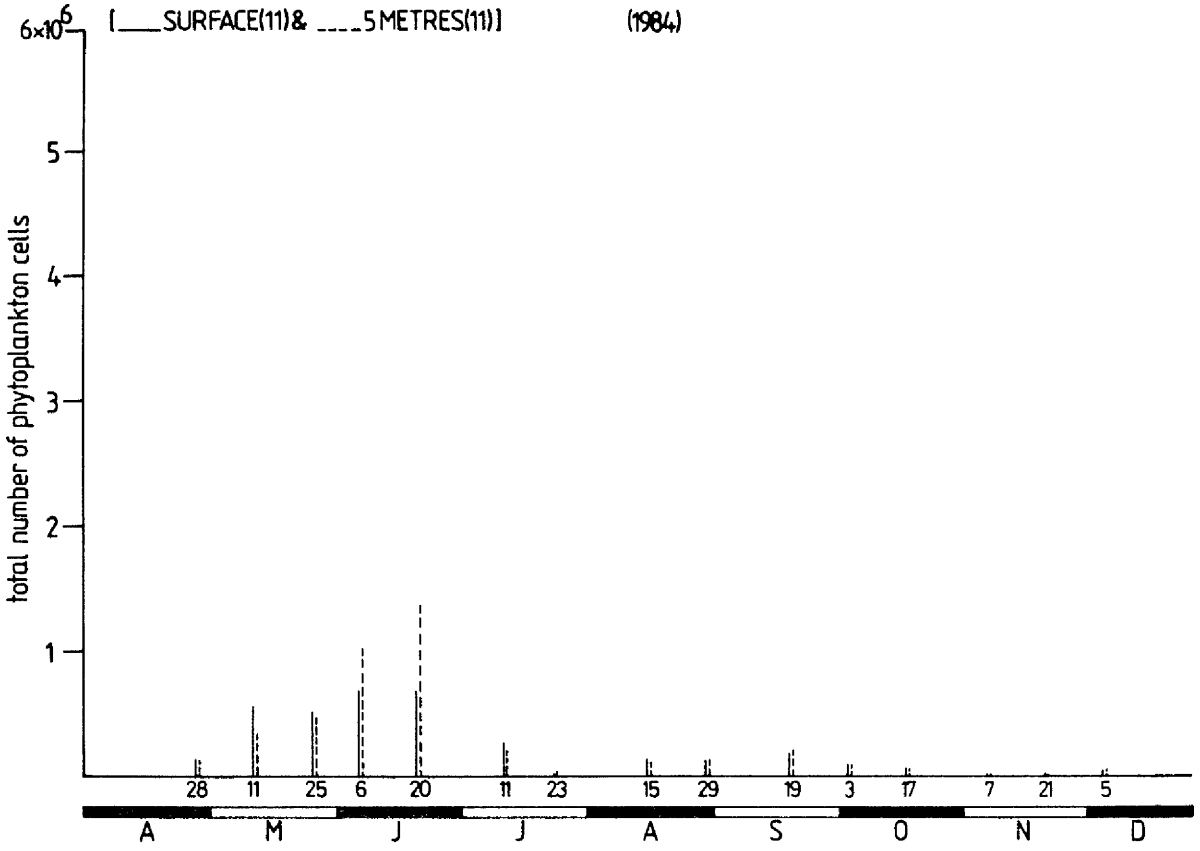
Silicoflagellates.

94 *Dictyocha speculum* (P)

Other Flagellates.

95 Green flagellates (P)

Figure. 3. 4. 1. The total number of phytoplankton cells. l^{-1} at the surface and 5 metres depth. Station 11. From 28 April 1984 to 6 January 1986.


6×10^6
[___SURFACE(11)& ____5METRES(11)]
(1984)
total number of phytoplankton cells
5
4
3
2
1
28 11 25 6 20 11 23 15 29 19 3 17 7 21 5
A M J J A S O N D

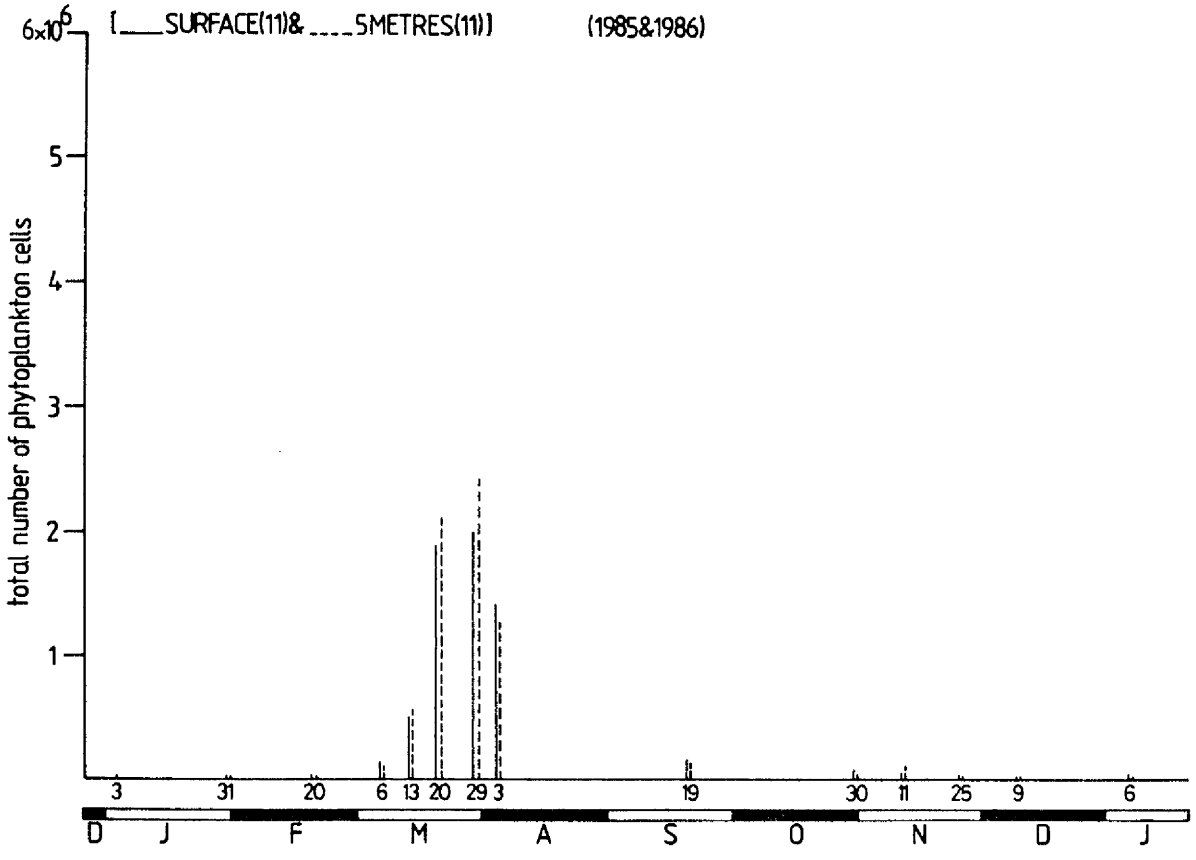
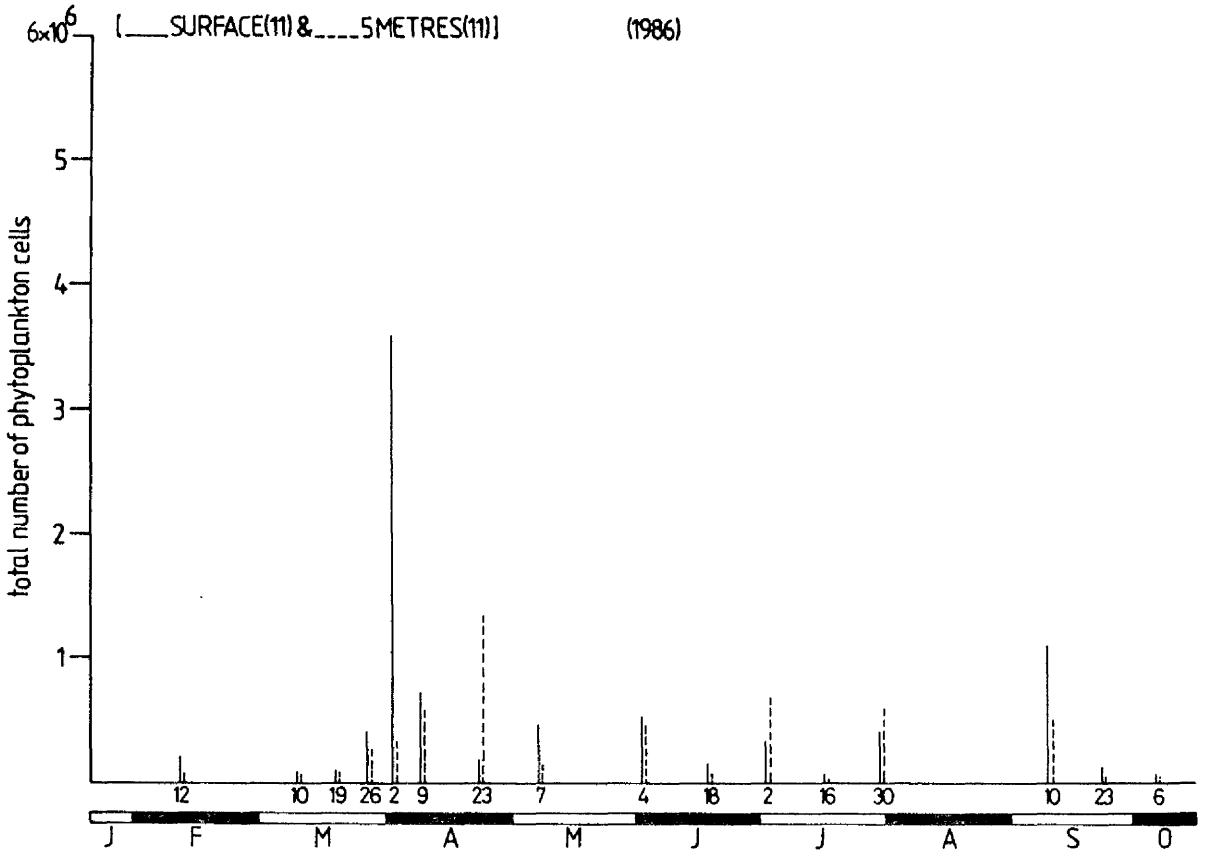

6×10^6
[___SURFACE(11)& ____5METRES(11)]
(1985&1986)
total number of phytoplankton cells
5
4
3
2
1
3 31 20 6 13 20 29 3 19 30 11 25 9 6
D J F M A S O N D J

Figure. 3. 4. 2. The total number of phytoplankton cells. l^{-1} at the surface and 5 metres depth. Station 11.
From 12 February 1986 to 22 April 1987.


6×10^6
[___SURFACE(11) &____5METRES(11)]
(1986)
total number of phytoplankton cells
5
4
3
2
1
12
10 19 26 2 9 23 7 4 18 2 16 30 10 23 6
J F M A M J J A S O

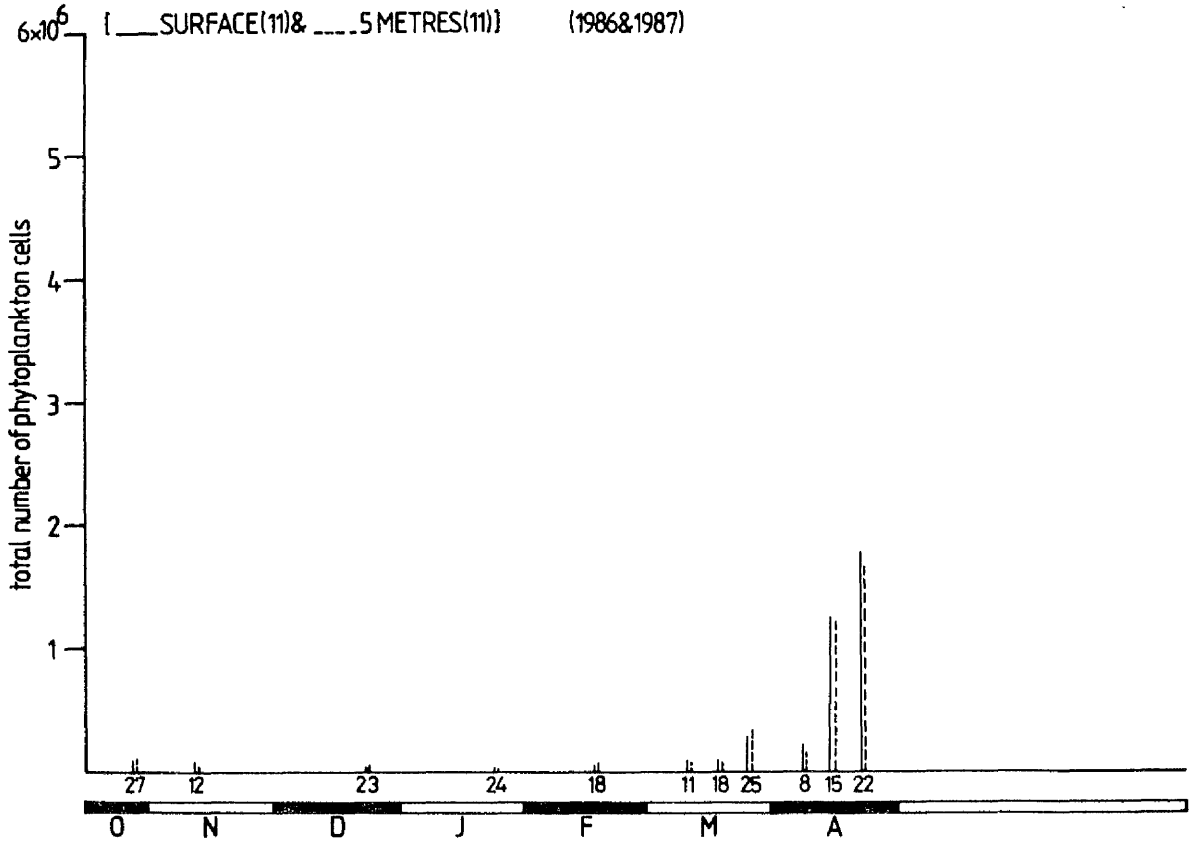
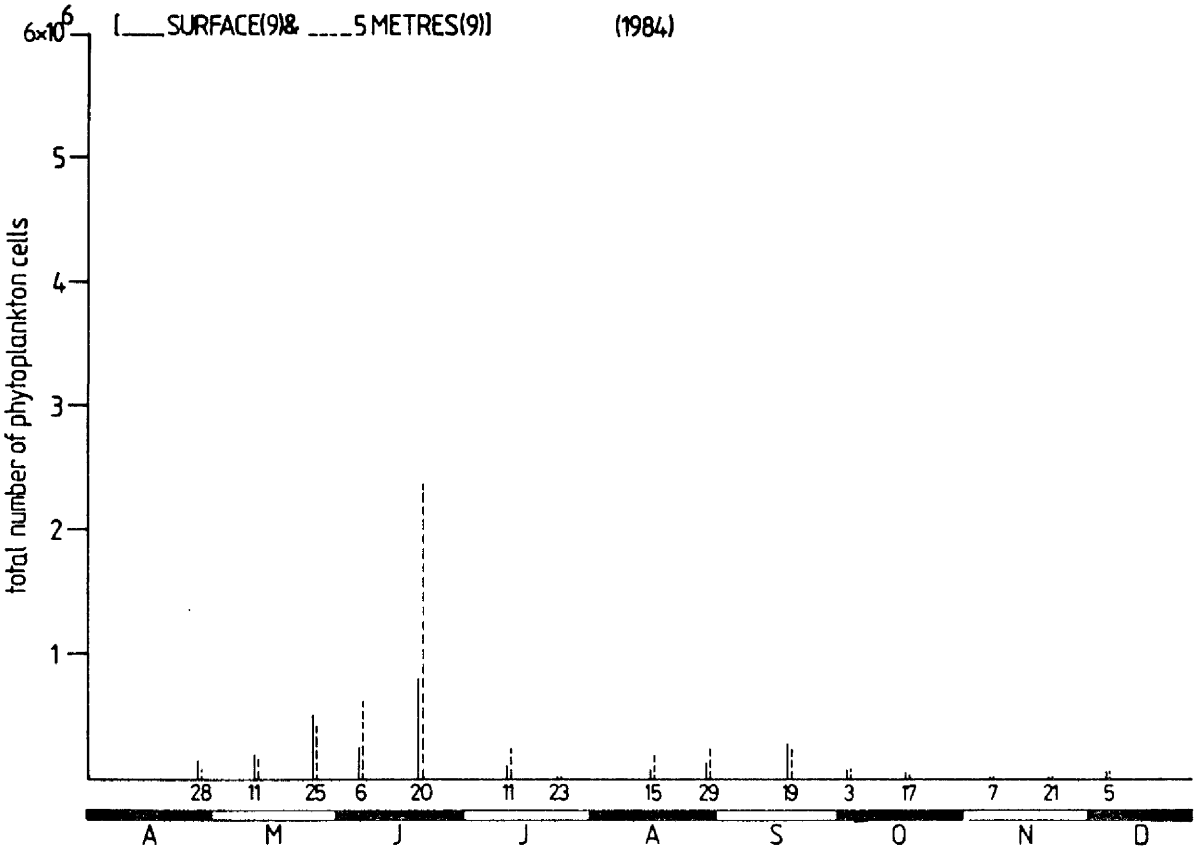

6×10^6
[___SURFACE(11)& ____5 METRES(11)]
(1986&1987)
total number of phytoplankton cells
5
4
3
2
1
27 12 23 24 18 11 18 25 8 15 22
O N D J F M A

Figure 3. 4. 3. The total number of phytoplankton cells. l^{-1} at the surface and 5 metres depth. Station 9. From 28 April 1984 to 6 January 1986.


6×10^6
[___SURFACE(9)& ____5 METRES(9)]
(1984)
total number of phytoplankton cells
5
4
3
2
1
28 11 25 6 20 11 23 15 29 19 3 17 7 21 5
A M J J A S O N D

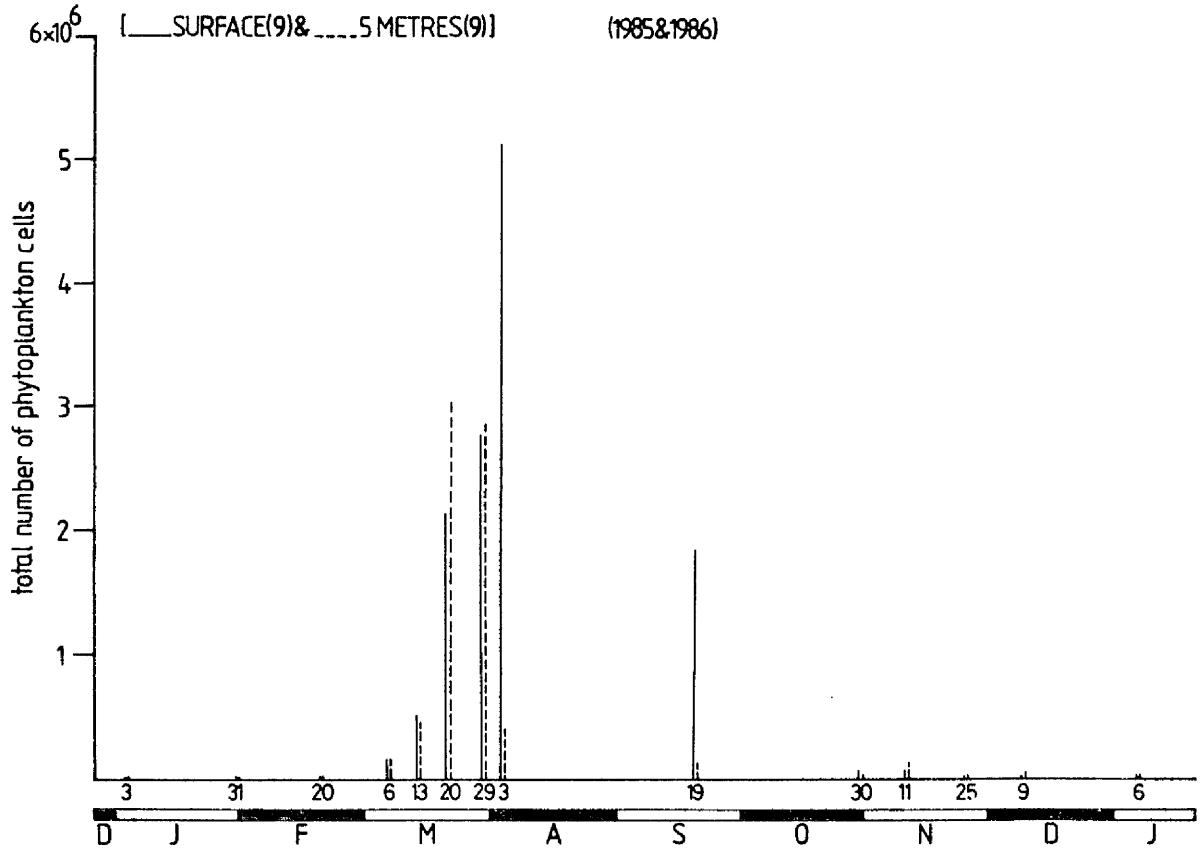
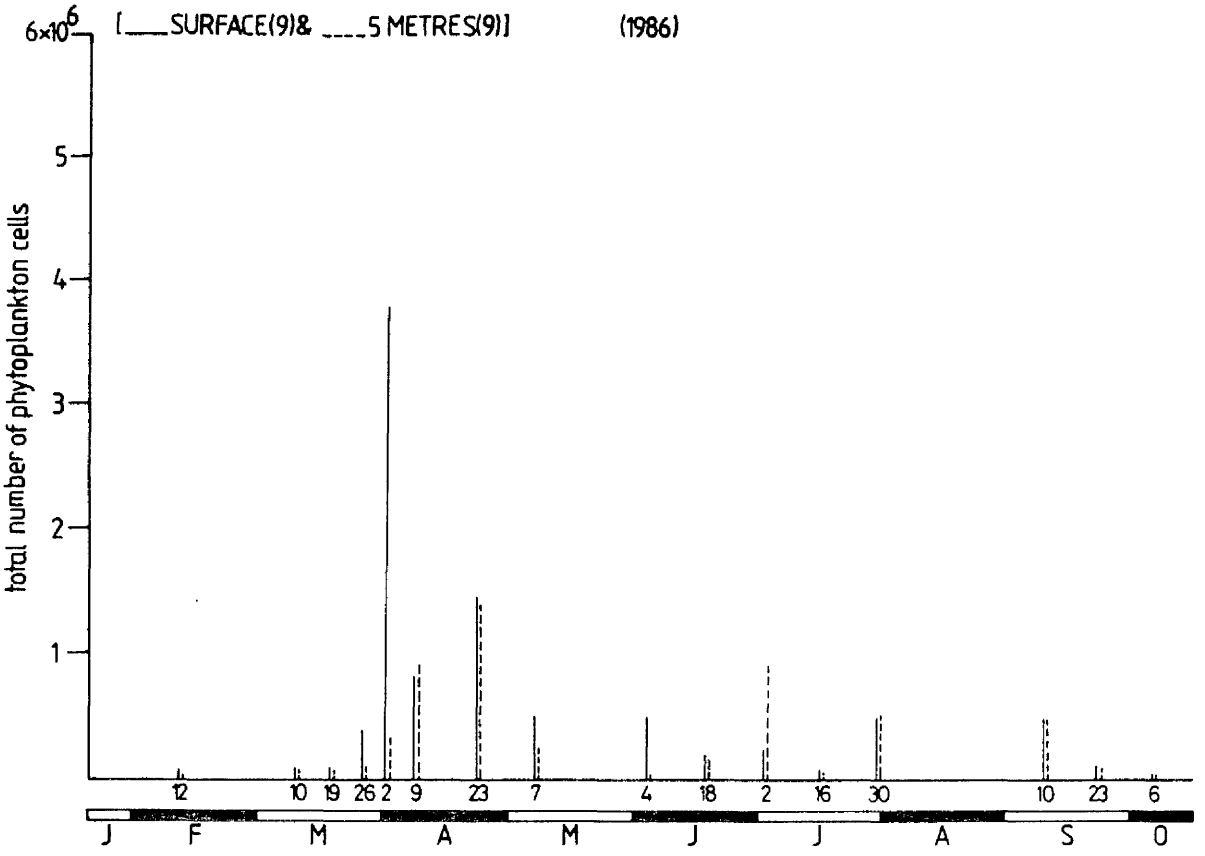

6×10^6
[___SURFACE(9)& ____5 METRES(9)]
(1985&1986)
total number of phytoplankton cells
5
4
3
2
1
3 31 20 6 13 20 29 3 19 30 11 25 9 6
D J F M A S O N D J

Figure 3. 4. 4. The total number of phytoplankton cells. l^{-1} at the surface and 5 metres depth. Station 9. From 12 February 1986 to 22 April 1987.


6×10^6
[___SURFACE(9)& ____5 METRES(9)]
(1986)
total number of phytoplankton cells
5
4
3
2
1
12
10 19 26 2 9 23 7 4 18 2 16 30 10 23 6
J F M A M J J A S O

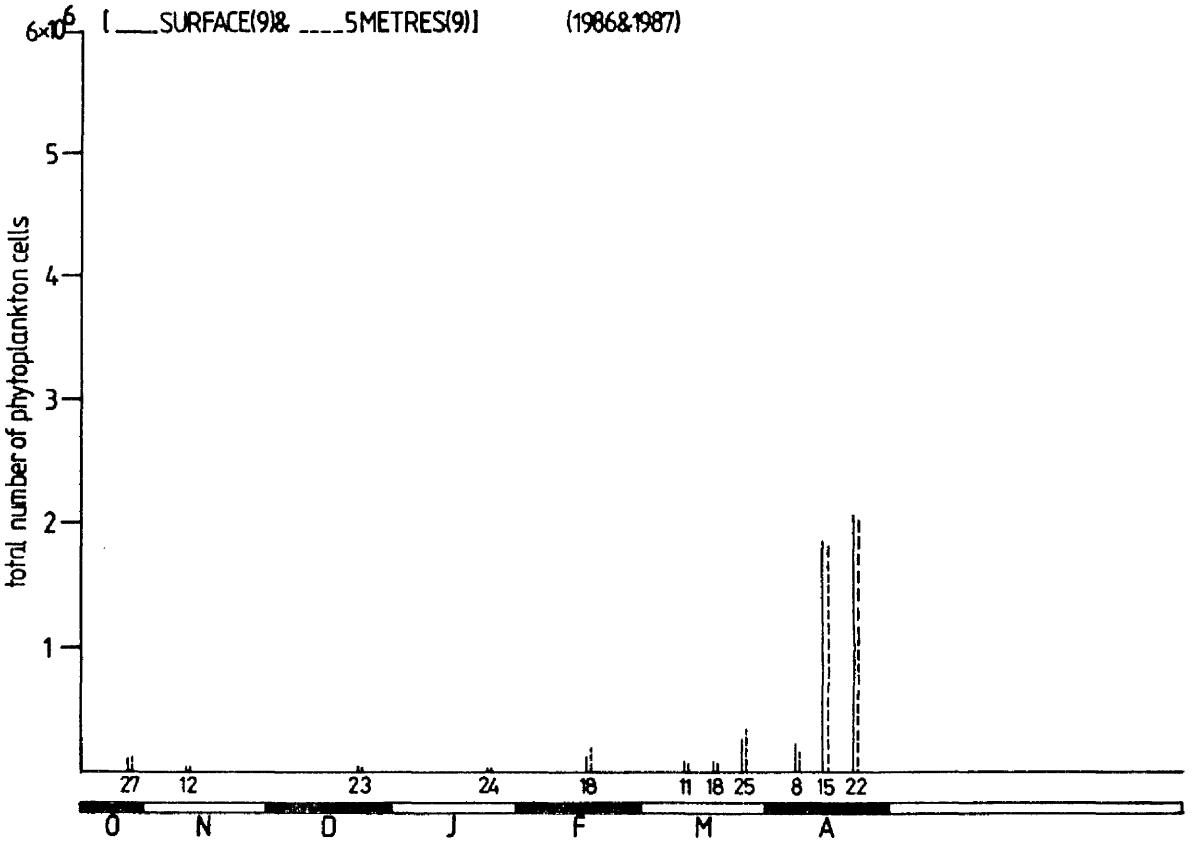
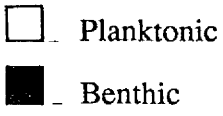
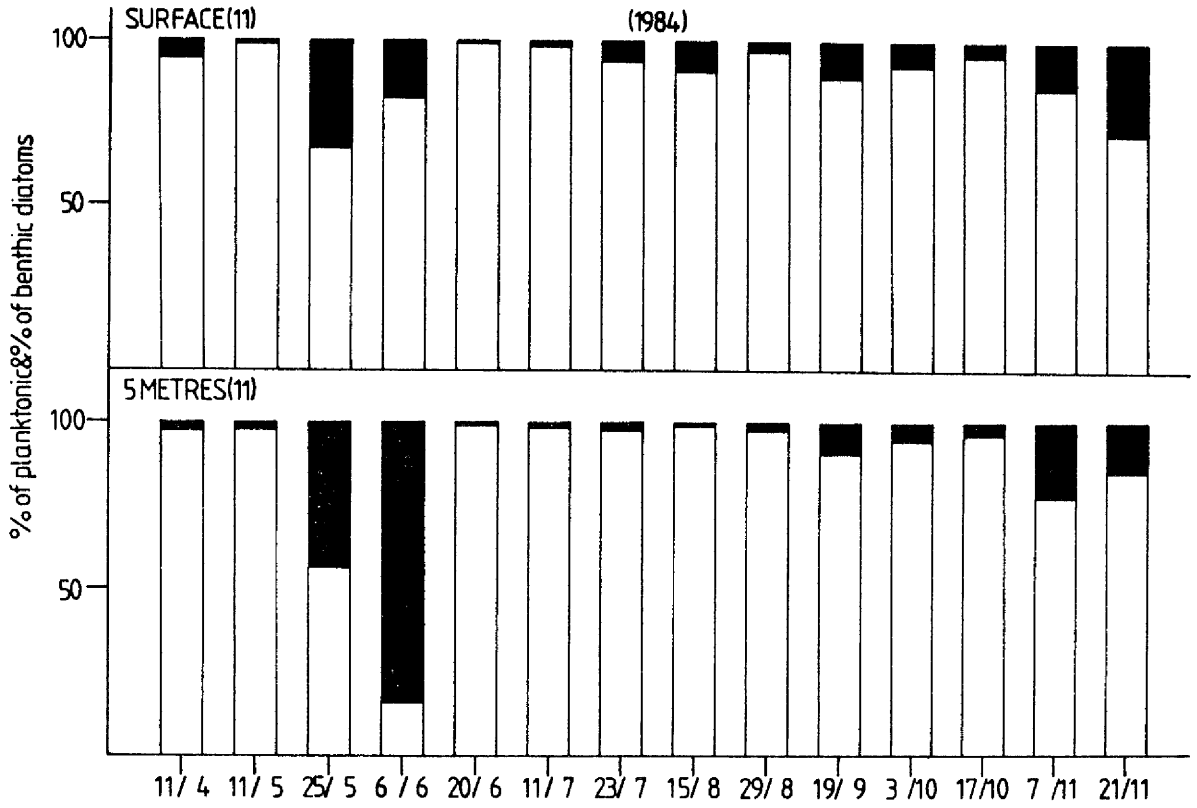

6×10^6
[___SURFACE(9)& ____5METRES(9)]
(1986&1987)
total number of phytoplankton cells
5
4
3
2
1
27 12 23 24 18 11 18 25 8 15 22
O N D J F M A

Figure 3. 4. 5. The percentages of planktonic to benthic organisms at the surface and 5 metres depth. Station 11. From 11 April 1984 to 9 December 1985.




SURFACE(11)
(1984)
100
50
5 METRES(11)
100
50
% of planktonic&% of benthic diatoms
11/ 4
11/ 5
25/ 5
6 / 6
20/ 6
11/ 7
23/ 7
15/ 8
29/ 8
19/ 9
3 /10
17/10
7 /11
21/11

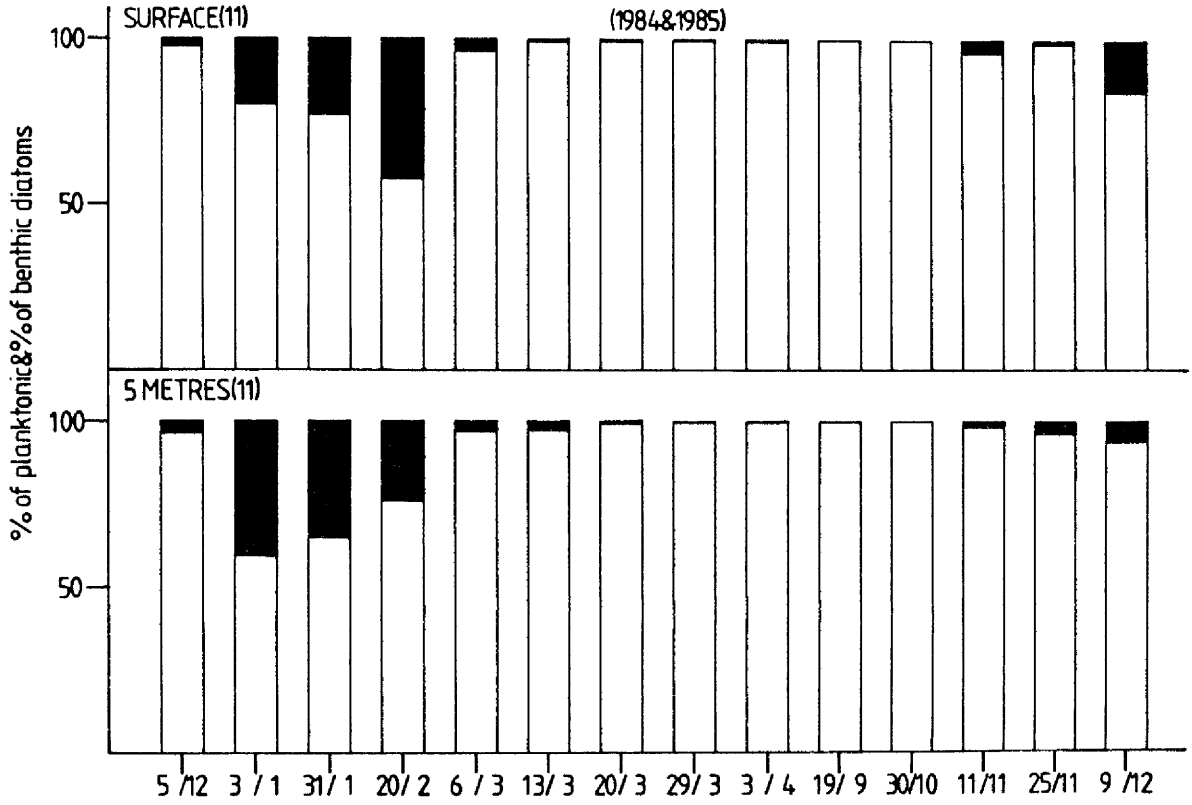
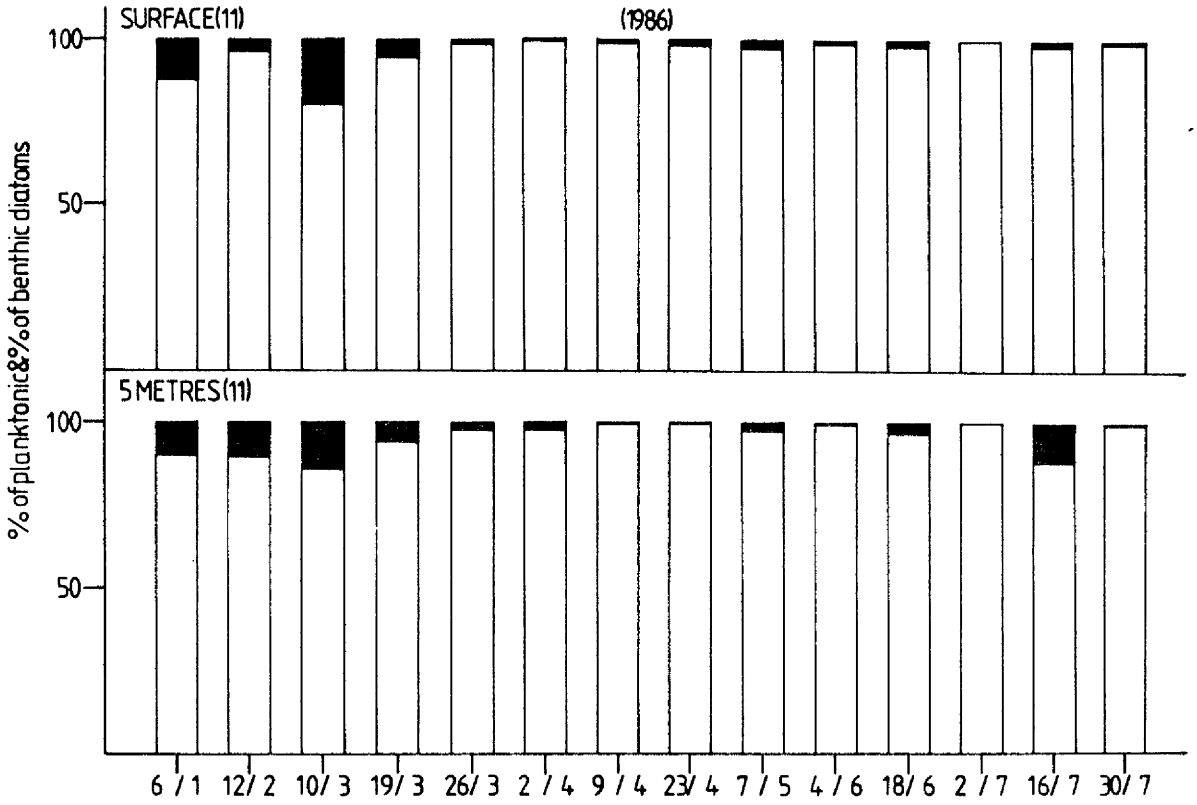

SURFACE(11)
(1984&1985)
100
50
5 METRES(11)
100
50
% of planktonic&% of benthic diatoms
5 /12
3 / 1
31/ 1
20/ 2
6 / 3
13/ 3
20/ 3
29/ 3
3 / 4
19/ 9
30/10
11/11
25/11
9 /12

Figure 3. 4. 6. The percentages of planktonic to benthic organisms at the surface and 5 metres depth. Station 11. From 6 January 1986 to 22 April 1987.


SURFACE(11)
(1986)
100
50
5METRES(11)
100
50
% of planktonic&%of benthic diatoms
6 / 1
12/ 2
10/ 3
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26/ 3
2 / 4
9 / 4
23/ 4
7 / 5
4 / 6
18/ 6
2 / 7
16/ 7
30/ 7

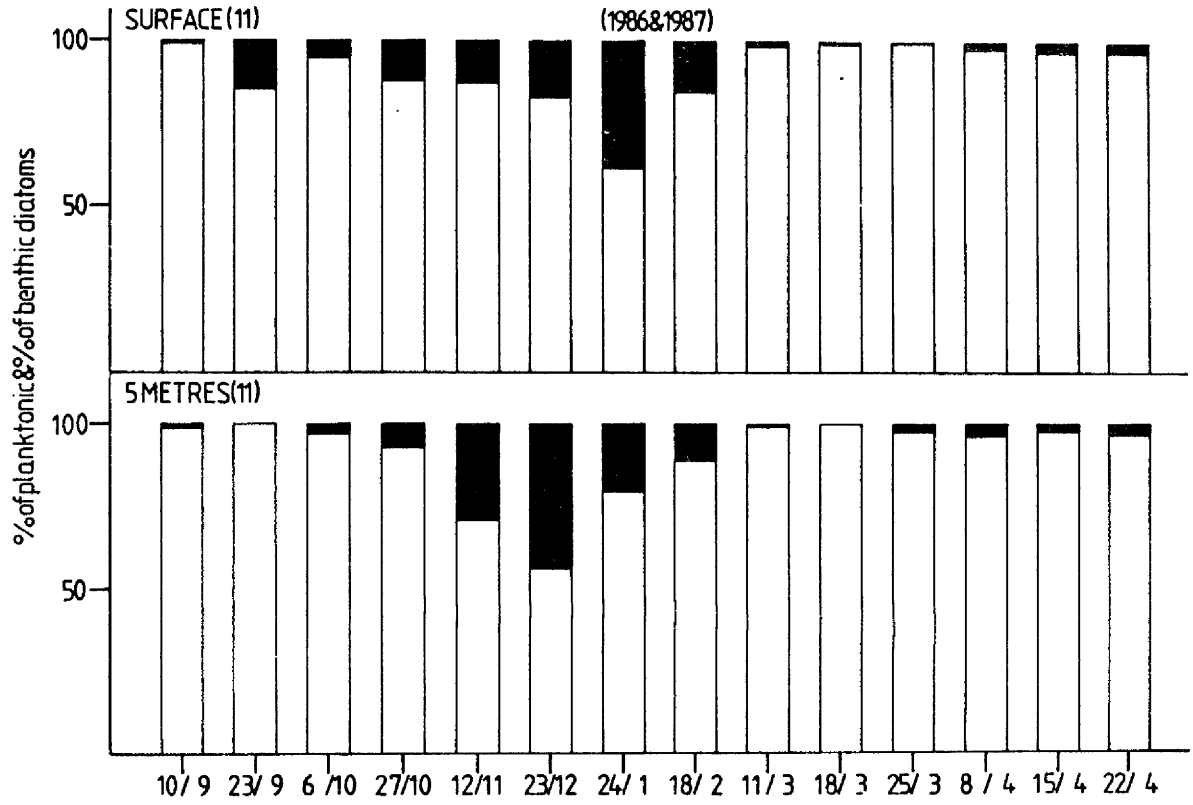
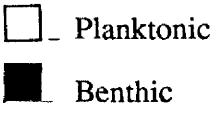
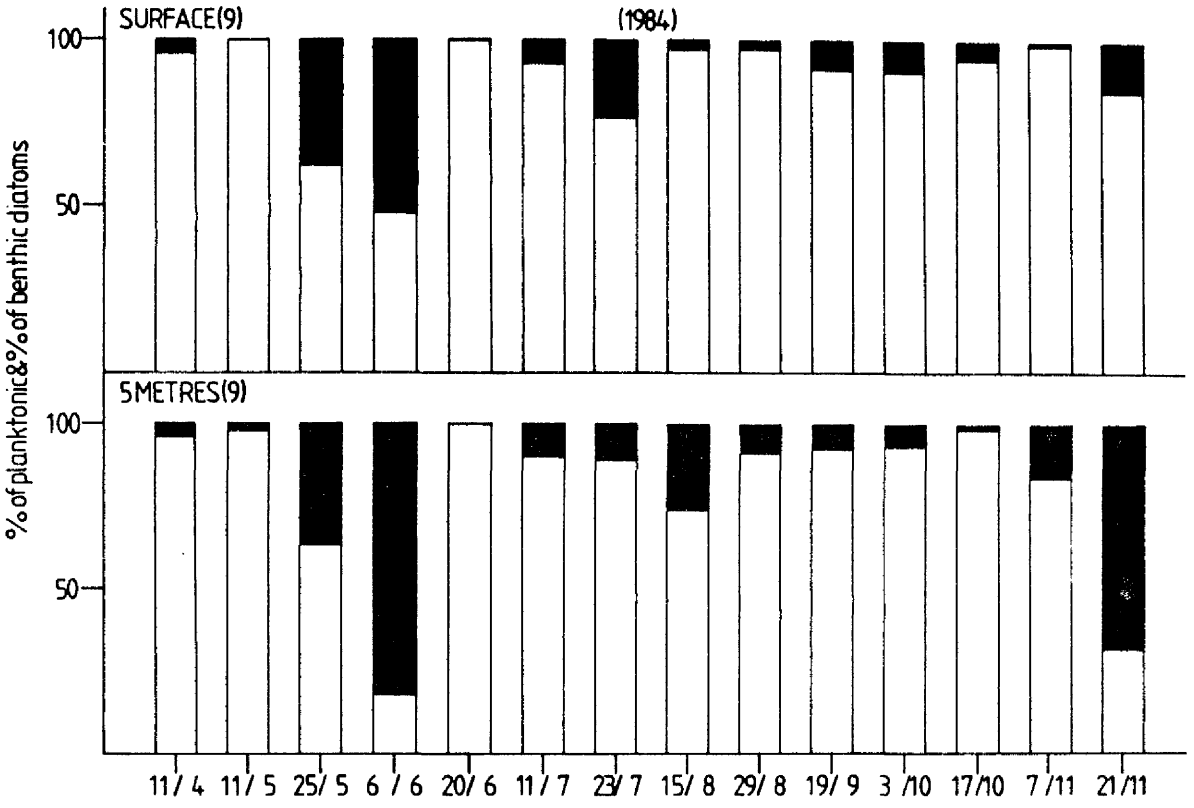

SURFACE(11)
(1986&1987)
100
50
5METRES(11)
100
50
%of planktonic&%of benthic diatoms
10/ 9
23/ 9
6 /10
27/10
12/11
23/12
24/ 1
18/ 2
11/ 3
18/ 3
25/ 3
8 / 4
15/ 4
22/ 4

Figure 3. 4. 7. The percentages of planktonic to benthic organisms at the surface and 5 metres depth. Station 9. From 11 April 1984 to 9 December 1985.




SURFACE(9)
(1984)
100
50
5METRES(9)
100
50
% of planktonic&% of benthic diatoms
11/ 4
11/ 5
25/ 5
6 / 6
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11 / 7
23/ 7
15/ 8
29/ 8
19/ 9
3 /10
17/10
7 /11
21/11

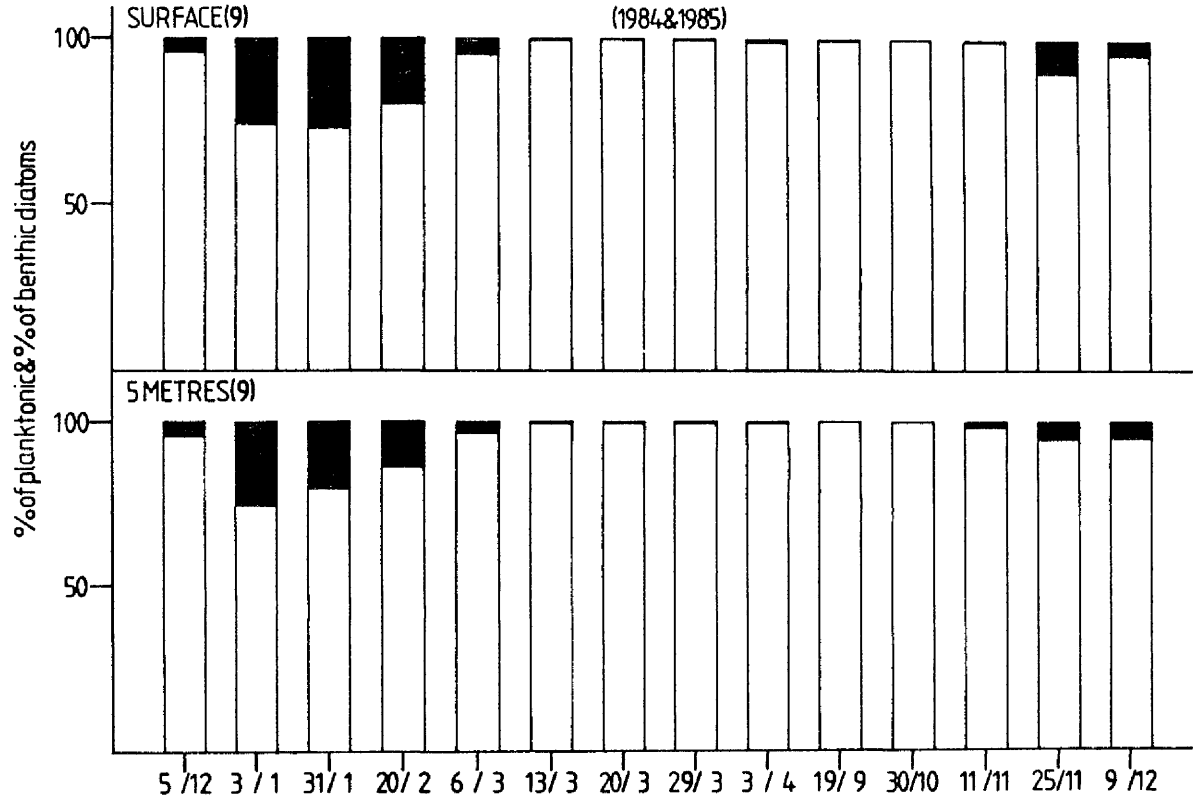
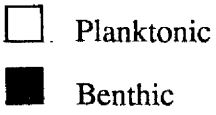
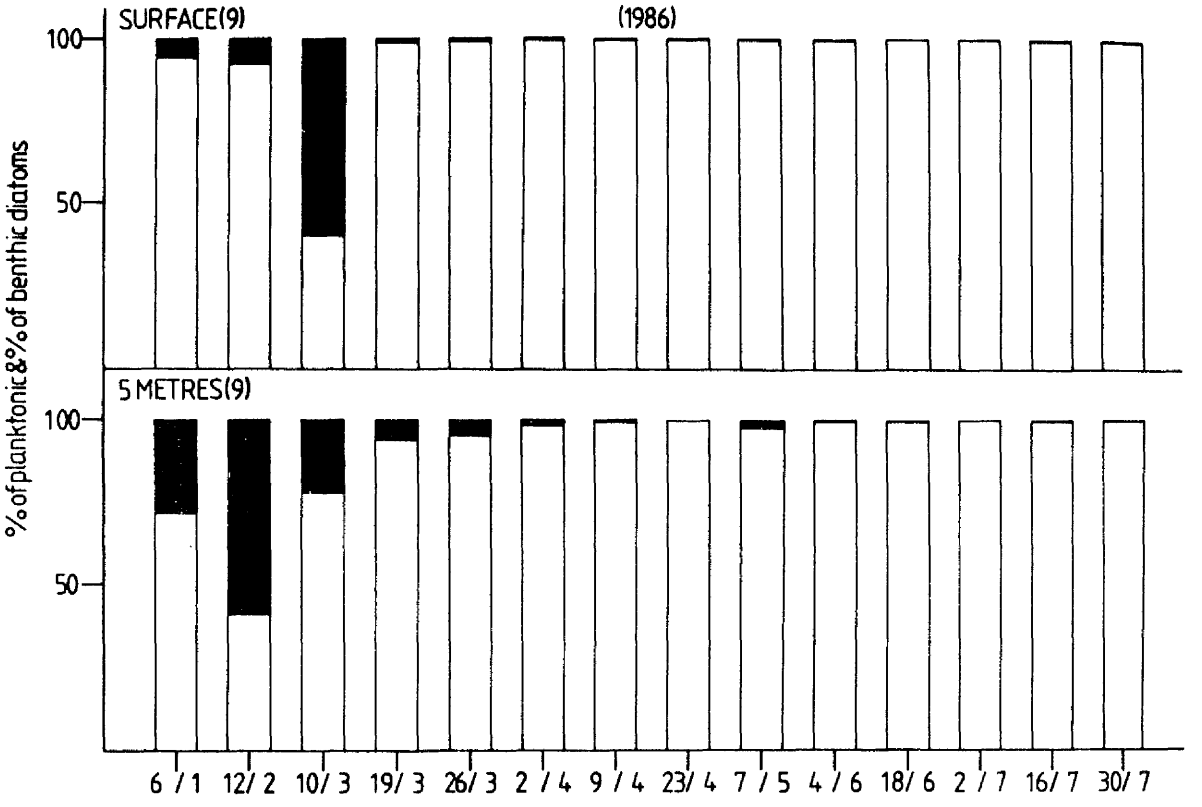

SURFACE(9)
(1984&1985)
100
50
5METRES(9)
100
50
% of planktonic&% of benthic diatoms
5 /12
3 / 1
31/ 1
20/ 2
6 / 3
13/ 3
20/ 3
29/ 3
3 / 4
19/ 9
30/10
11 /11
25/11
9 /12

Figure 3. 4. 8. The percentages of planktonic to benthic organisms at the surface and 5 metres depth. Station 9. From 6 January 1986 to 22 April 1987.




SURFACE(9)
(1986)
100
50
5 METRES(9)
100
50
% of planktonic & % of benthic diatoms
6 / 1
12/ 2
10/ 3
19/ 3
26/ 3
2 / 4
9 / 4
23/ 4
7 / 5
4 / 6
18/ 6
2 / 7
16/ 7
30/ 7

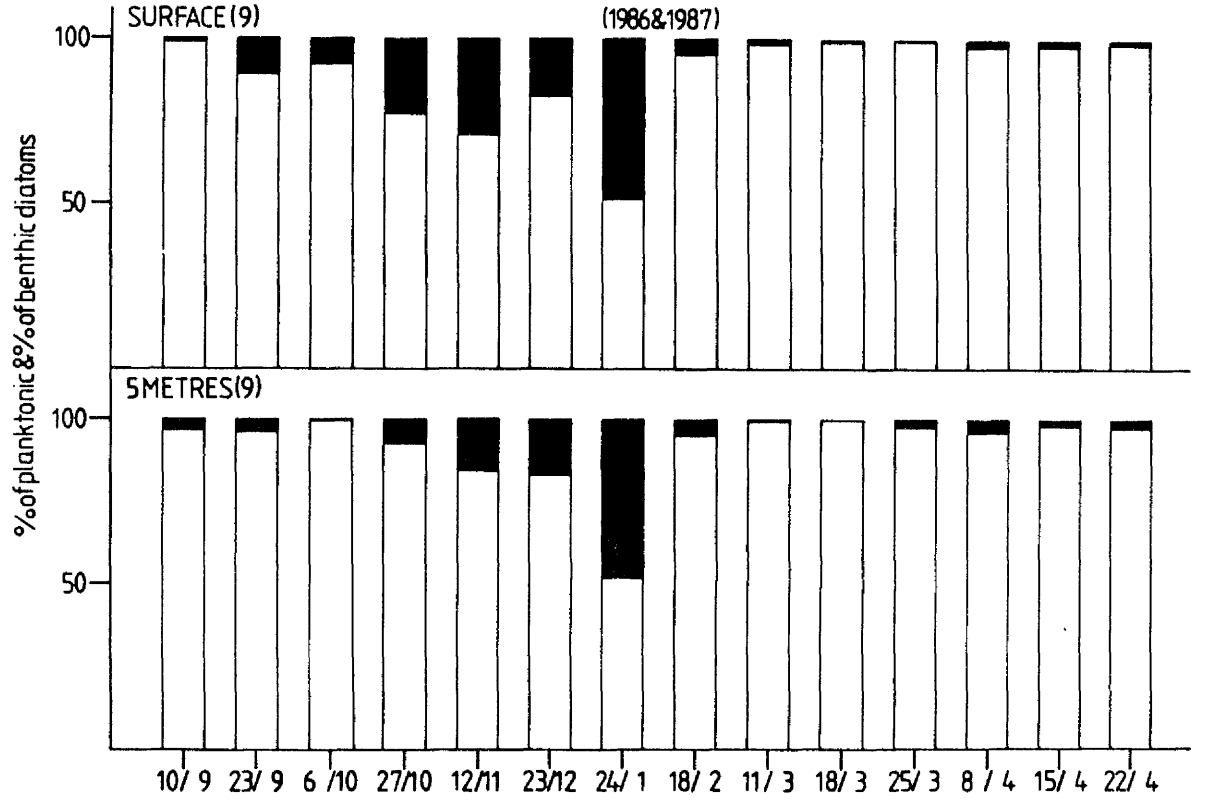
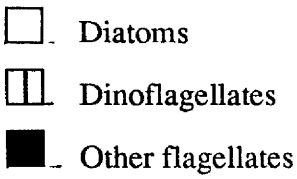
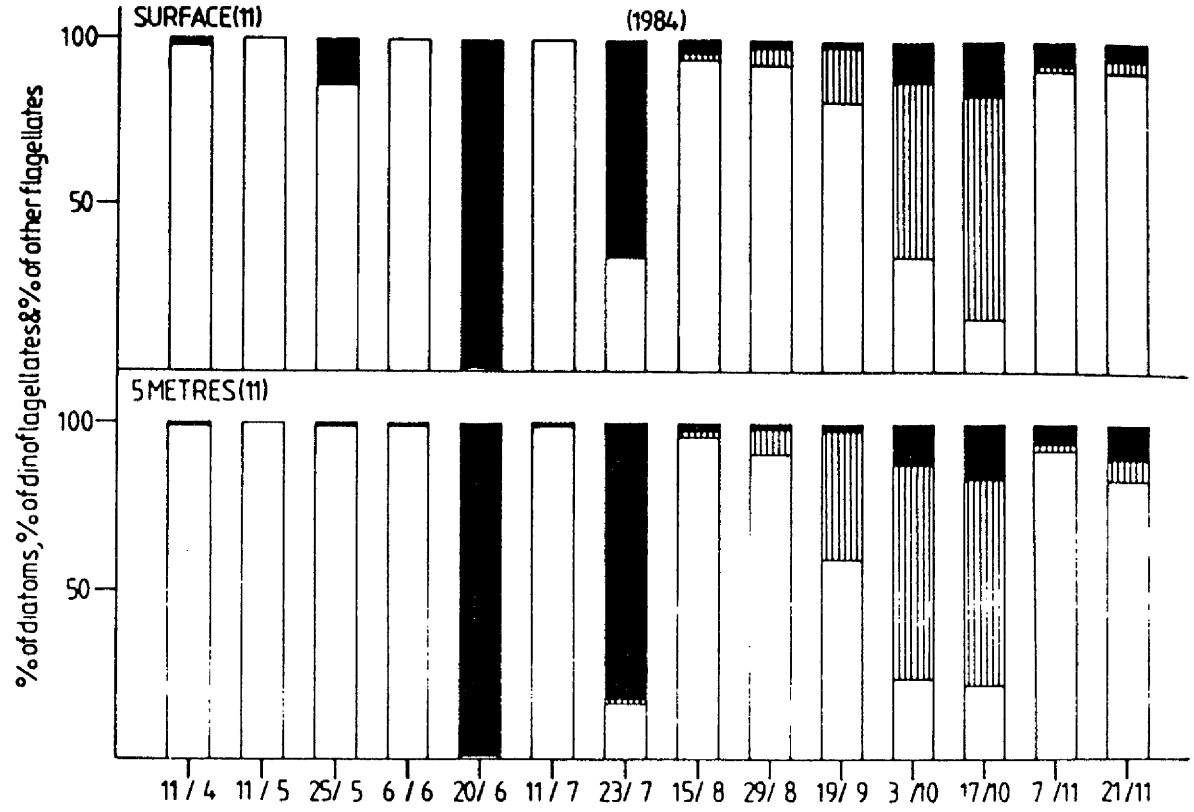

SURFACE (9)
(1986&1987)
100
50
5 METRES(9)
100
50
% of planktonic & % of benthic diatoms
10/ 9
23/ 9
6 /10
27/10
12/11
23/12
24/ 1
18/ 2
11/ 3
18/ 3
25/ 3
8 / 4
15/ 4
22/ 4

Figure 3. 4. 9. The percentages of diatoms to dinoflagellates and other flagellates at the surface and 5 metres depth. Station 11. From 11 April 1984 to 9 December 1985.




SURFACE(11)
(1984)
100
50
5METRES(11)
100
50
% of diatoms, % of dinoflagellates & % of other flagellates
11 / 4
11 / 5
25/ 5
6 / 6
20/ 6
11 / 7
23/ 7
15/ 8
29/ 8
19/ 9
3 /10
17/10
7 /11
21/11

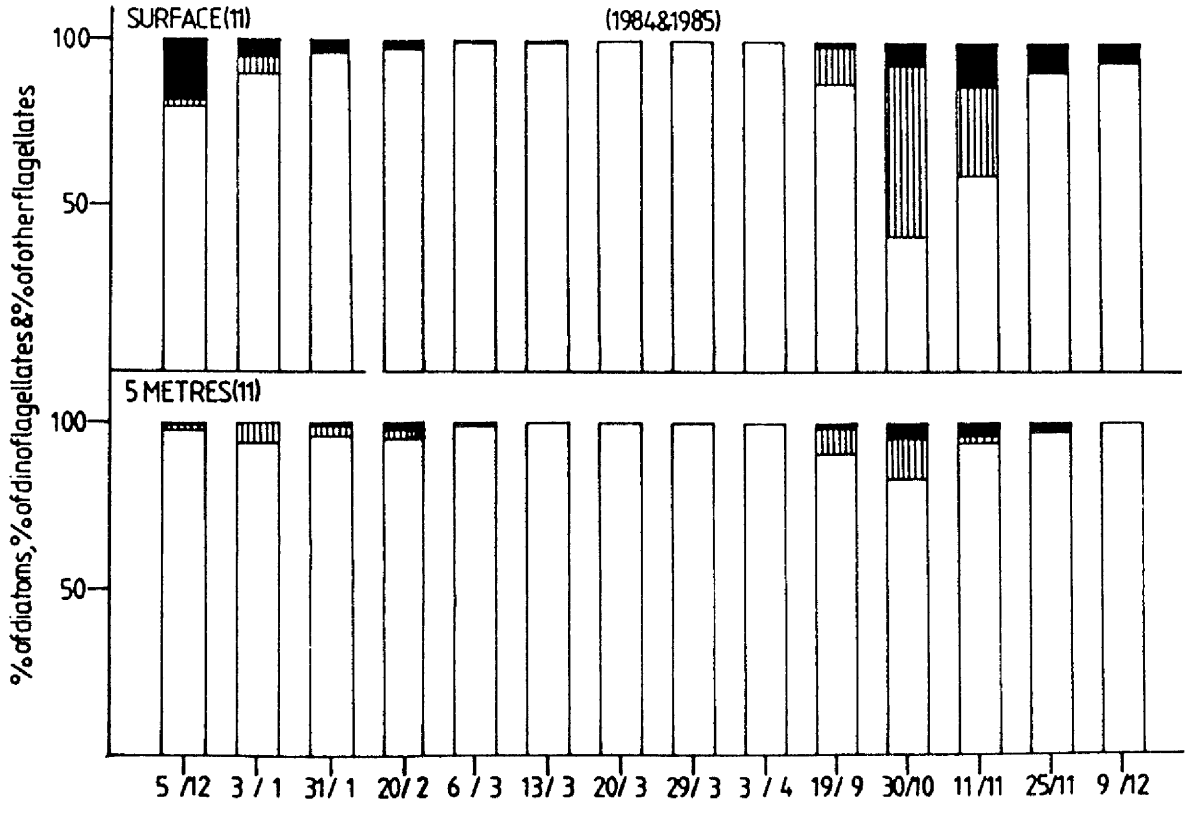
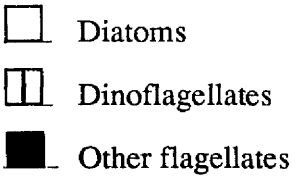
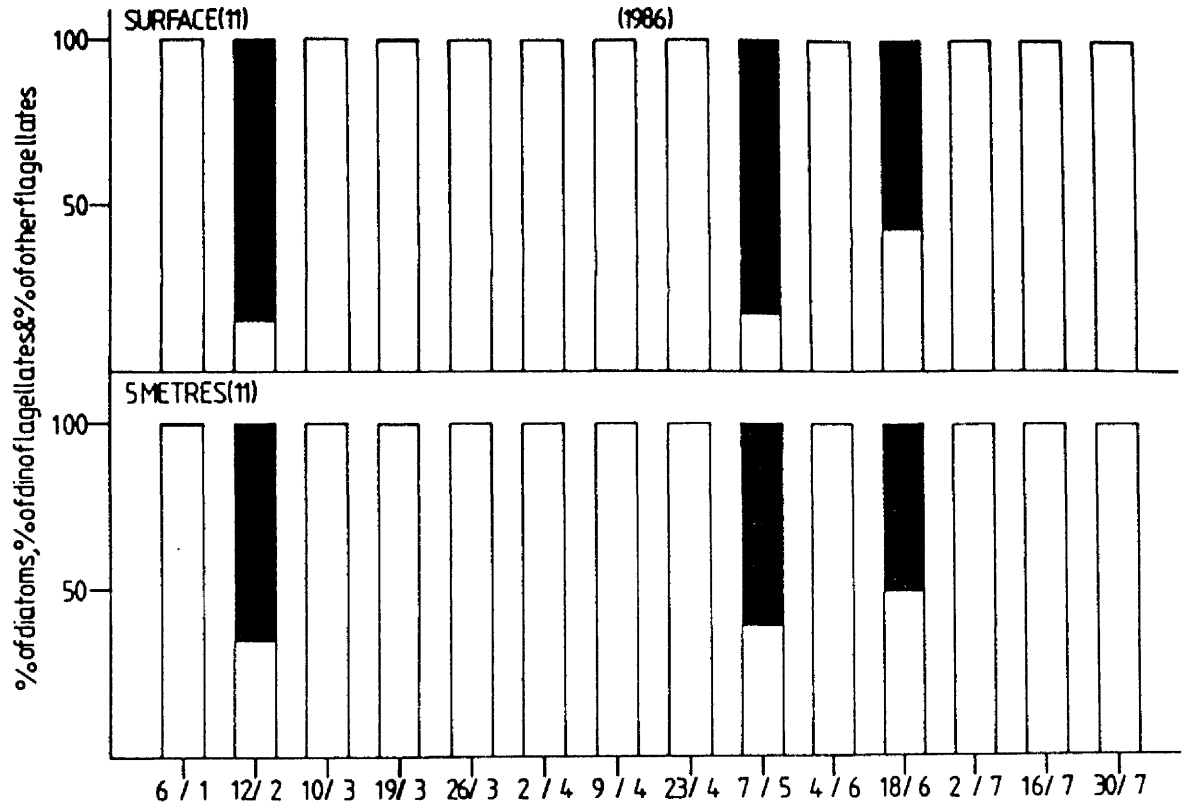

SURFACE(11)
(1984&1985)
100
50
5 METRES(11)
100
50
% of diatoms, % of dinoflagellates & % of other flagellates
5 /12
3 / 1
31/ 1
20/ 2
6 / 3
13/ 3
20/ 3
29/ 3
3 / 4
19/ 9
30/10
11/11
25/11
9 /12

Figure 3. 4. 10. The percentages of diatoms to dinoflagellates and other flagellates at the surface and 5 metres depth. Station 11. From 6 January 1986 to 22 April 1987.




SURFACE(11)
(1986)
100
50
5METRES(11)
100
50
%ofdiatoms,%ofdinoflagellates&%ofotherflagellates
6 / 1
12/ 2
10/ 3
19/ 3
26/ 3
2 / 4
9 / 4
23/ 4
7 / 5
4 / 6
18/ 6
2 / 7
16/ 7
30/ 7

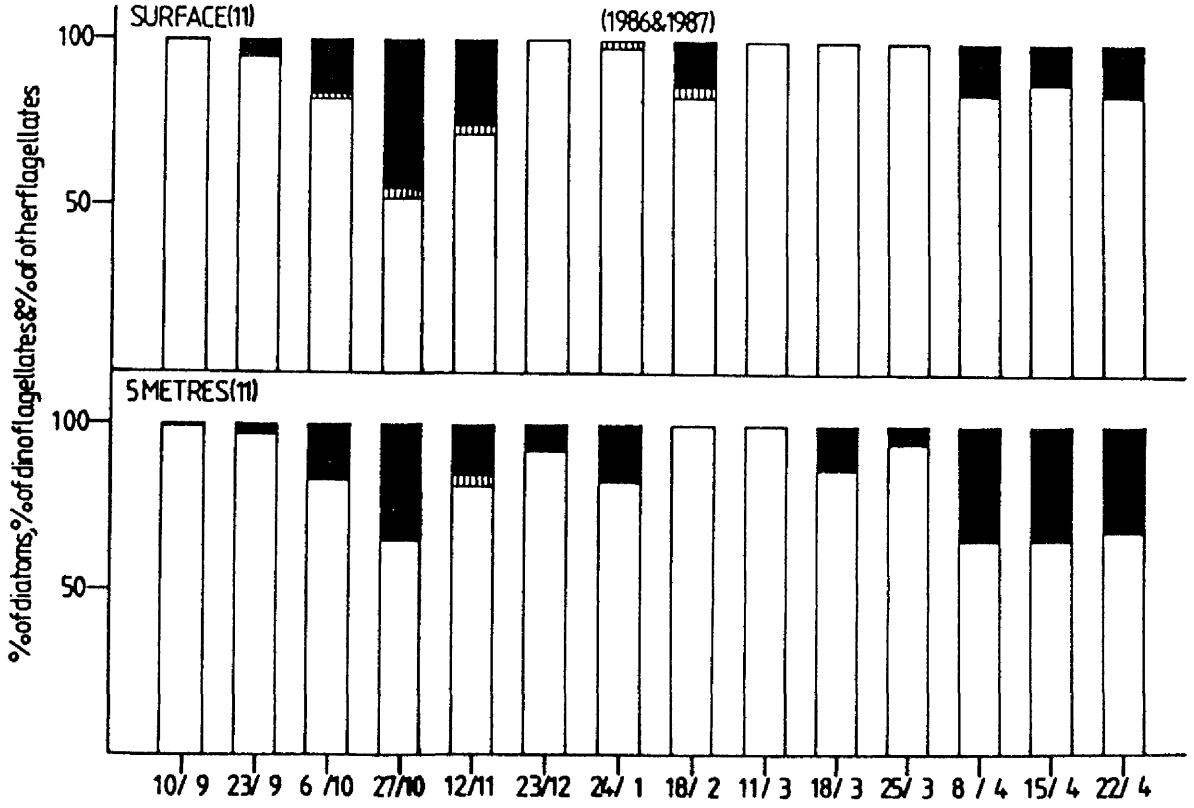
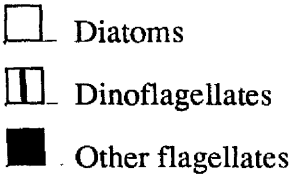
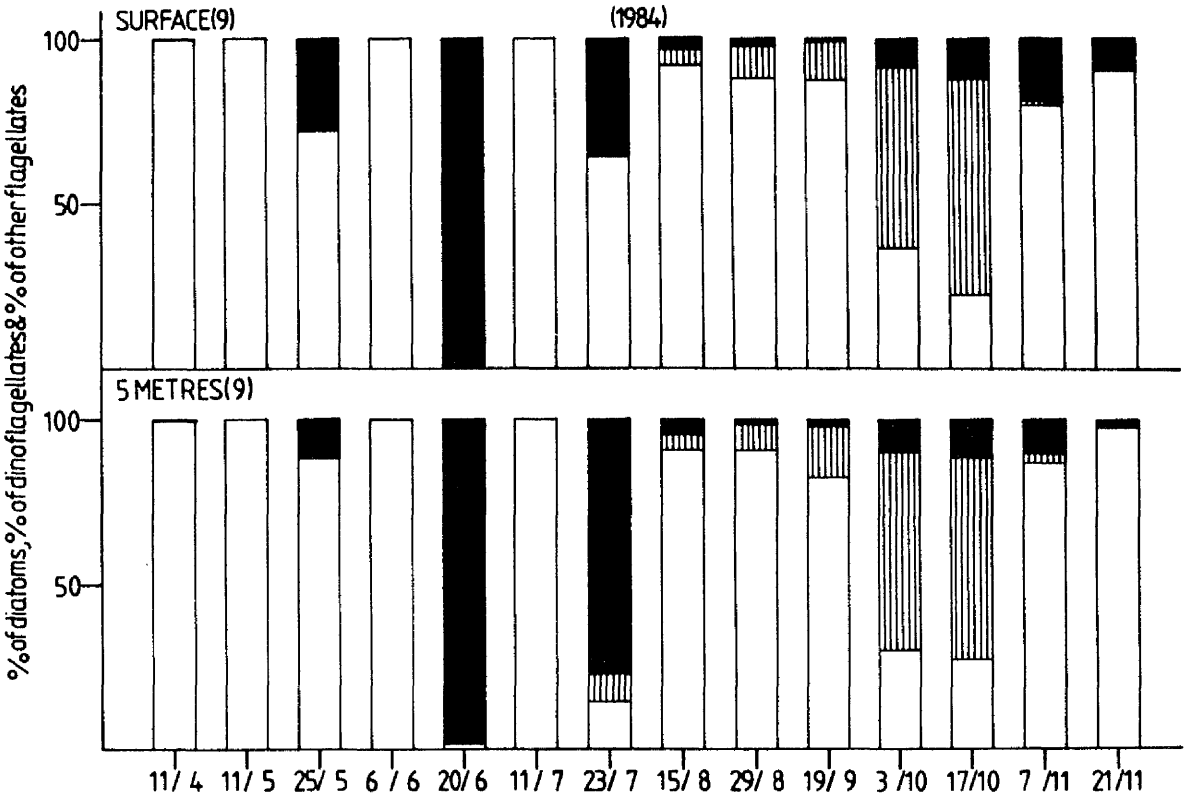

SURFACE(11)
(1986&1987)
100
50
5METRES(11)
100
50
%ofdiatoms,%ofdinoflagellates&%ofotherflagellates
10/ 9
23/ 9
6 /10
27/10
12/11
23/12
24/ 1
18/ 2
11/ 3
18/ 3
25/ 3
8 / 4
15/ 4
22/ 4

Figure 3. 4. 11. The percentages of diatoms to dinoflagellates and other flagellates at the surface and 5 metres depth. Station 9. From 11 April 1984 to 9 December 1985.




SURFACE(9)
(1984)
100
50
5 METRES(9)
100
50
% of diatoms, % of dinoflagellates & % of other flagellates
11/ 4
11/ 5
25/ 5
6 / 6
20/ 6
11/ 7
23/ 7
15/ 8
29/ 8
19/ 9
3 /10
17/10
7 /11
21/11

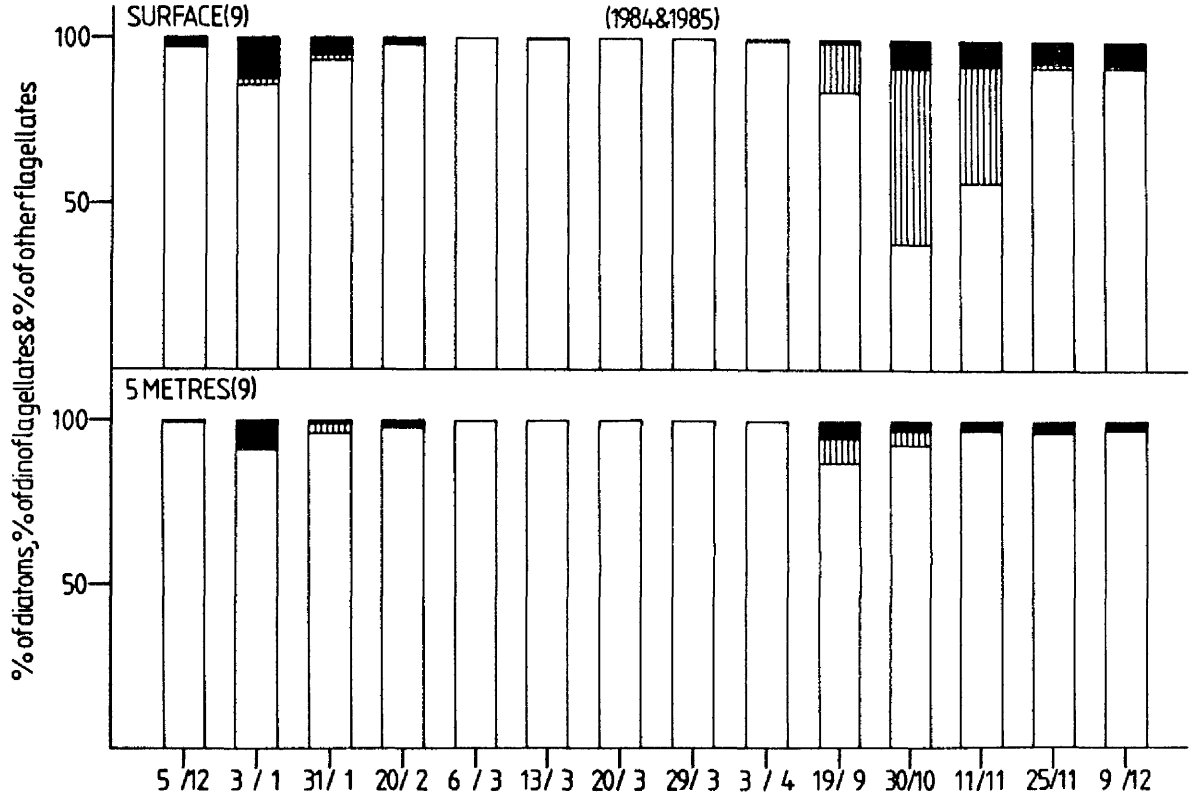
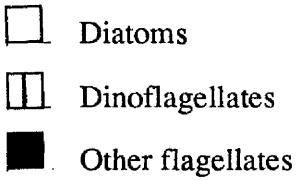
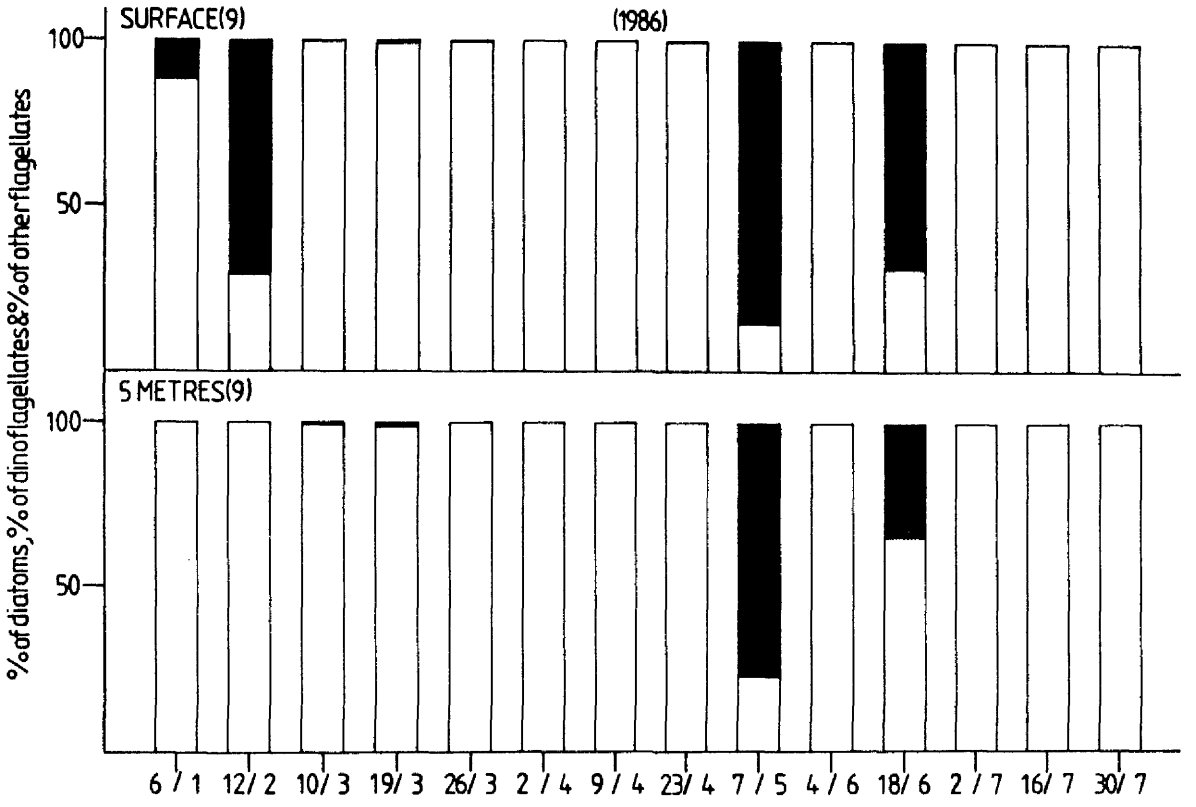
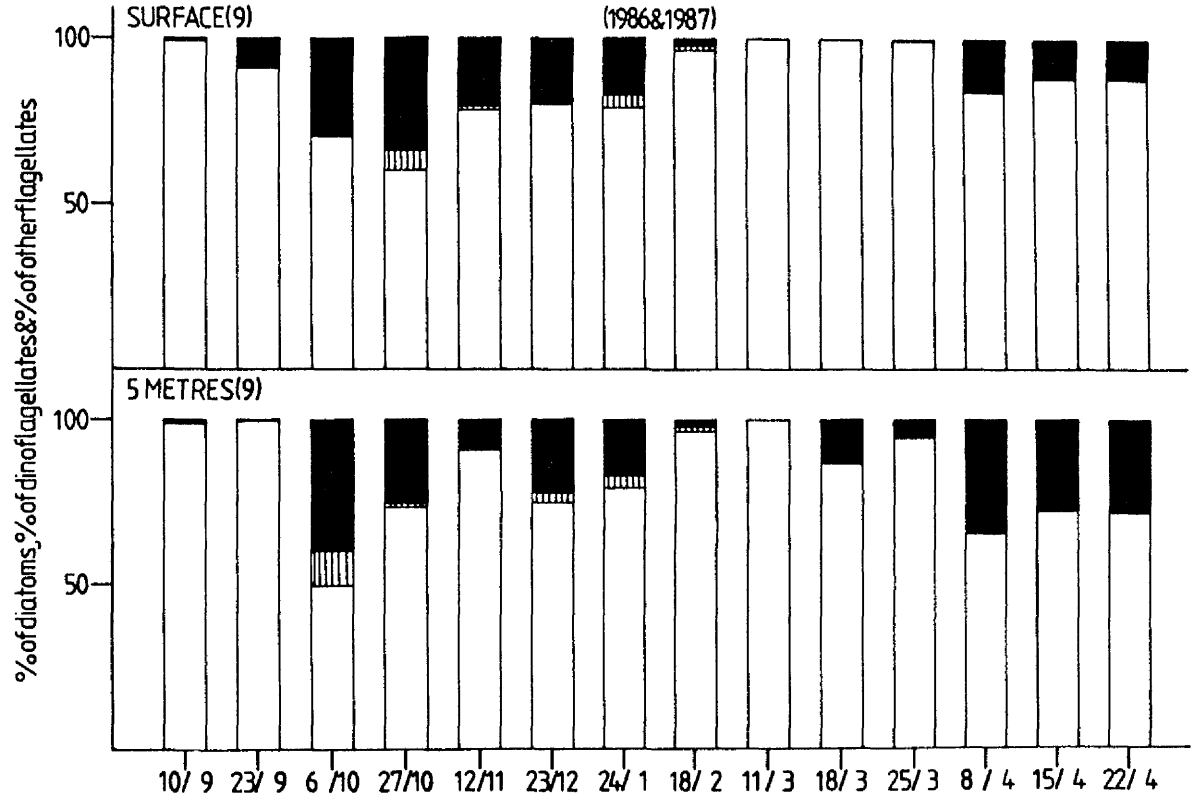

SURFACE(9)
(1984&1985)
100
50
5 METRES(9)
100
50
% of diatoms, % of dinoflagellates & % of other flagellates
5 /12
3 / 1
31/ 1
20/ 2
6 / 3
13/ 3
20/ 3
29/ 3
3 / 4
19/ 9
30/10
11/11
25/11
9 /12

Figure 3. 4. 12. The percentages of diatoms to dinoflagellates and other flagellates at the surface and 5 metres depth. Station 9. From 6 January 1986 to 22 April 1987.




SURFACE(9)
(1986)
100
50
5 METRES(9)
100
50
%of diatoms,%of dinoflagellates&%of otherflagellates
6 / 1
12/ 2
10/ 3
19/ 3
26/ 3
2 / 4
9 / 4
23/ 4
7 / 5
4 / 6
18/ 6
2 / 7
16/ 7
30/ 7


SURFACE(9)
(1986&1987)
100
50
5 METRES(9)
100
50
%of diatoms,%of dinoflagellates&%of otherflagellates
10/ 9
23/ 9
6 /10
27/10
12/11
23/12
24/ 1
18/ 2
11/ 3
18/ 3
25/ 3
8 / 4
15/ 4
22/ 4

Spring 1984

The algal biomass was relatively low for this time of the year; the climax of the spring diatom increase probably occurred prior to the beginning of the sampling dates.

On April 28th, at station 11 (surface), the total number of algal cells was 129.7 x 10^3 cells. l^{-1}, of which 94.5% were truly planktonic species and the rest were benthic. Diatoms represented 98% of the total biomass of which the most dominant species were *Skeletonema costatum* (58.2%); *Thalassiosira nordenskioldii* (19%) and *Coscinodiscus spp.* (16.9%). The diatoms *Navicula spp., Rhabdonema arcuatum* and *Rhizosolenia spp.* were observed in much smaller numbers (Table. 3. 4. 2.). The silicoflagellate *Dictyocha speculum* represented 2% of the total quantity.

At 5 metres depth, the total number of algal cells was 106 x 10^3 cell. l^{-1}, of which 97.56% were truly planktonic species and the rest were benthic. Diatoms represented 99.7% of the total biomass, of which the most dominant species were *Skeletonema costatum* (52.4%); *Thalassiosira nordenskioldii* (24.2%) and *Coscinodiscus spp* (20.6%).

The diatoms *Navicula spp, N. distans* and *Pleurosigma spp* were observed in very small numbers. The silicoflagellate *Dictyocha speculum* represented 0.33% of the total biomass. As expected, the proportions of the principal species were similar at the two levels sampled.

At station 9 (surface), the total number of algal cells was 137.2 x 10^3 cells. l^{-1}, of which 95.6% were truly planktonic species and the rest were benthic. Diatoms represented 99.8% of the total biomass, of which the most dominant were *S.costatum* (58.5%); *T. nordenskioldii* (18.58%) and *Coscinodiscus spp.* (16.7%). The diatoms *Diatoma spp, Navicula spp, Pleurosigma spp, Rhabdonema arcuatum* and *Synedra spp*

Table. 3. 4. 2. The number of algal cells (l^{-1}) and their percentages, for 28th April 1984, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5 m		S		5 m	
	n	%	n	%	n	%	n	%
Diatoms:								
Coscinodiscus spp. (P)	21952	16.9	21952	20.6	22920	16.7	15495	15.84
Diatoma spp. (B)	_	_	_	_	968	0.7	332	0.38
Gomphonema sp. (P)	_	_	_	_	332	0.23	_	_
Melosira sp. (P)	_	_	_	_	_	_	968	0.99
Navicula spp. (B)	3228	2.48	1614	1.51	2905	2.1	3551	3.6
Navicula distans (B)	_	_	322	0.3	_	_	_	_
Pleurosigma spp. (B)	_	_	645	0.6	645	0.47	322	0.33
Rh. arcuatum (B)	1291	0.99	_	_	322	0.23	_	_
Rhizosolenia spp. (P)	322	0.25	_	_	_	_	332	0.33
S. costatum (P)	75541	58.2	55849	52.42	80348	58.51	55526	56.76
Synedra sp. (B)	_	_	_	_	1936	1.54	_	_
T. nordenskioldii (P)	24857	19.15	25826	24.24	25503	18.58	20338	20.79
Silicoflagellates:								
D. speculum (P)	2582	2.03	322	0.33	1291	0.94	968	0.99

were present in very small numbers. The silicoflagellate *Dictyocha speculum* represented 0.94% of the total biomass.

At 5 metres depth, the total number of algal cells was the minimum for the spring, 97.81 x 10^3cells.l^{-1}, of which 95.99% were truly planktonic species and the rest were benthic. Diatoms represented 99% of the total biomass of which the most dominant species were *S. costatum* (56.76%); *T. nordenskioldii* (20.8%) and *Coscinodiscus spp* (15.84%). The diatoms *Diatoma spp, Melosira spp, Navicula spp.* and *Rhizosolenia spp* were present in small numbers (Table. 3. 4. 2.). The silicoflagellate *Dictyocha speculum* represented 0.99% of the total biomass.

On May 11th, the population was made up entirely of diatoms, with *Skeletonema costatum* as the dominant species.

At station 11 (surface), the algal biomass of diatoms was 577.2 x 10^3cells.l^{-1}, maximum for the spring, of which 99.93% were truly planktonic species and the rest were benthic. *Skeletonema costatum* was the most dominant species, being present in numbers of 397.7 x 10^3cells.l^{-1}, which accounted for 68.9% of the total biomass, next in abundance was *Thalassiosira nordenskioldii* (26.4%). The diatoms *Coscinodiscus spp* and *Licmophora spp* were found in much smaller numbers (Table. 3. 4. 3.).

At 5 metres depth, the algal biomass was 350.9 x 10^3cells.l^{-1}, of which 97.85% were truly planktonic species and the rest were benthic. *S. costatum* was the most dominant species, being present in numbers of 188.85 x 10^3cells.l^{-1}, which accounted for 53.8% of the total biomass, next in abundance was *T. nordenskioldii* (39%). The diatoms *Coscinodiscus spp, Licmophora spp* and *Navicula spp* were observed in much smaller numbers (Table. 3. 4. 3.).

Table. 3. 4. 3. The number of algal cells (l^{-1}) and their percentages, for 11th May, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5 m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms:								
Coscinodiscus spp. (P)	26471	4.58	17432	4.96	20983	10.48	15495	9.62
Licmorpha spp. (B)	322	0.07	322	0.13	_	_	_	_
Navicula spp. (B)	_	_	7102	2.02	_	_	3228	1.99
S.costatum (P)	397723	69	188853	53.8	135587	67.52	104918	65
T. nordenskioldii (p)	152697	26.45	137201	39.09	44227	22	37770	23.39

At station 9 (surface), the total number of diatom cells was 200.79 x 10^3cells.l^{-1}, made up entirely of truly planktonic species.

Skeletonema costatum was by far the most dominant species, being present in numbers of 135.58 x 10^3cells.l^{-1}, which accounted for 67.52% of the total biomass, next in abundance was *Thalassiosira nordenskioldii* (22%). The rest of the population was represented by *Coscinodiscus spp.*

At 5 metres depth the algal biomass was 161.4 x 10^3cells.l^{-1}, of which 98% were truly planktonic species and the rest were benthic. *S. costatum* was by far the most dominant species, being present in numbers of 104.92 x 10^3cells.l^{-1}, which accounted for 65% of the total biomass, ranking second in terms of biomass was *T. nordenskioldiii* (23%). The diatoms *Coscinodiscus spp* and *Navicula spp* were observed in much smaller numbers (Table. 3. 4. 3.).

On 25th May, an increase in the total number of algal cells was observed for samples collected from station 11 (surface) and for samples collected from 5 metres depth at both stations. Diatoms remained as the most dominant fraction of the population. *Nitzschia spp.* and *T. nordenskioldii* succeeded *S. costatum* as the dominant species.

At station 11 (surface), the algal biomass was 521 x 10 ^{3}cells.l^{-1}, of which 67.24% were truly planktonic species and the rest were benthic. Diatoms were dominant (85.76% of the total biomass). *T. nordenskioldii* was the dominant species, being present in numbers of 222.75 x 10^3cells.l^{-1}, which accounted for 42.75% of the total biomass, ranking second in terms of biomass was *Nitzschia spp* (32.46%). Also common was *Skeletonema costatum* (8.55% of the total biomass). The diatoms *Coscinodiscus spp. Diatoma spp.* and *Navicula spp.* were observed in much smaller numbers (Table. 3. 4. 4.). Also present were green flagellates (14.25% of the total quantity).

Table 3. 4. 4. The number of algal cells (l^{-1}) and their percentages, for 25th May, are summarised the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms:								
Coscinodiscus spp. (P)	8392	1.6	7102	1.48	_	_	_	_
Cocconeis sp. (B)	_	_	644	0.134	_	_	_	_
Diatoma spp. (B)	644	0.15	644	0.134	_	_	_	_
Leptocylindrus danicus (P)	_	_	2582	0.52	_	_	_	_
Melosira sp. (P)	_	_	2582	0.52	_	_	_	_
Navicula spp. (B)	1290	0.24	_	_	_	_	2582	0.61
Nitzschia spp. (B)	169160	32.46	212420	44.5	193696	37.84	154957	35.87
S. costatum (P)	44550	8.55	200152	41.71	132358	25.8	186594	43.19
Thalassiosira nordenskioldii (P)	222750	42.75	200152	41.71	132358	25.8	186594	43.19
Green flagellates (P)	74250	14.25	3872	0.8	145272	28.3	50361	11.66

At 5 metres depth, the total number of algal cells was 480.37 x 10^3cells.l^{-1},of which 55.8% were truly planktonic species and the rest were benthic. Diatoms were dominant, representing 99.2% of the total biomass, of which the most common species were *Nitzschia spp.* (41.66% of the total biomass); and *S. costatum* (10.48%). The diatoms *Coscinodiscus spp, Cocconeis spp, Diatoma spp, Leptocylindrus danicus* and *Melosira spp* were observed in small numbers (Table. 3. 4. 4.). Also present in small numbers were green flagellates (0.52% of the total population).

At station 9 (surface), the algal biomass was 512.65 x 10^3cells.l^{-1},of which 62.16%were truly planktonic species and the rest were benthic. Diatoms dominated the population (71.7% of the total biomass). *Nitzschia spp* (37%) with *T. nordenskioldii* (25.8%) were most dominant. *S. costatum* was observed in smaller numbers (Table. 3. 4. 4.). Green flagellates represented 28.3% of the total biomass.

At 5 metres depth, the total number of algal cells was 431.9 x 10^3cells.l^{-1}, of which 63.54% were truly planktonic species and the rest were benthic. Diatoms were dominant (88.34% of the total biomass) and the rest of the population was represented by green flagellates.

The most dominant diatoms were *Thalassiosira nordenskioldii* (43.2%) and *Nitzschia spp.* (35.9%). The diatoms *Navicula spp* and *Skeletonema costatum* were observed in much smaller numbers (Table. 3. 4. 4.).

Summer 1984

An increase in the total number of algal cells in suspension was observed on 6th June with absolute dominance of diatoms, of which the most were benthic. *Nitzschia spp.* succeeded *T. nordenskioldii* as the most dominant organism. This increase in benthic

diatoms followed a strong easterly wind exceeding 20 knots which kept the water column thoroughly mixed on the previous day.

At station 11 (surface), the population was made up entirely of diatoms. The total number of diatom cells was 703 x 10 ^{3}cells.l^{-1}, of which 82% were benthic and the rest were truly planktonic species.

The benthic species of the *Nitzschia* were by far the most dominant, being present in numbers of 581 x 10^{3}cells.l^{-1}, which accounted for 82.66% of the total biomass; ranking second in terms of biomass was *T. nordenskioldii* (16.44%). The diatoms *Coscinodiscus spp.*, *Diatoma spp* and *Navicula spp* were observed in much smaller numbers (Table. 3. 4. 5.).

At 5 metres depth, the algal biomass was 1028.8 x 10^{3}cells.l^{-1}, of which 84.8% were benthic and the rest were truly planktonic species. Diatoms were dominant (99.97% of the total biomass). *Nitzschia spp* were by far the dominant , being present in numbers of 871.63 x 10^{3}cells.l^{-1}, which accounted for 84.7% of the total biomass, ranking second in terms of biomass was *Thalassiosira nordenskioldii* (14.68%). The diatoms *Coscinodiscus spp, Navicula spp.* and *Pleurosigma spp.* were observed in much smaller numbers (Table. 3. 4. 5.). Also present was the silicoflagellate *Dictyocha speculum.*

At station 9 (surface), the population was made up entirely of diatoms. The total number of diatom cells was 254 x 10^{3}cells.l^{-1}, of which 52% were benthic and the rest were planktonic species. The population was composed predominantly of *Nitzschia spp* (52%) and *T. nordenskioldii* (47.8%). The only other diatom observed was *Coscinodiscus spp* (Table. 3. 4. 5.).

Table 3. 4. 5. The number of algal cells (l^{-1}) and their percentages, for 6th June, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms:								
Coscinodiscus spp. (P)	5810	0.82	5165	0.5	322	0.13	_	_
Diatoma sp. (B)	322	0.046	_	_	_	_	_	_
Melosira sp. (P)	_	_	_	_	_	_	7102	1.19
Navicula spp. (B)	322	0.046	322	0.031	_	_	1936	0.31
Nitzschia spp. (B)*	581089	82.658	871633	84.727	132359	52.1	503610	81.59
Pleurosigma spp. (B)	_	_	322	0.031	_	_	1936	0.31
T. nordenskioldii (P)	115572	16.43	151083	14.68	121383	47.77	102659	16.6
Silicoflagellates								
D. speculum (P)	_	_	322	0.031	_	_	_	_

* Footnote. As for Table 1, some of the *Nitzschia spp.* are planktonic .

At 5 metres depth, diatoms again represented 100% of the total biomass. The total number of diatom cells was 617 x 10^3cells.l^{-1}, of which 82.2% were benthic and the rest were truly planktonic species. *Nitzschia spp.* was by far the dominant species, being present in numbers of 503.6 x 10^3cells.l^{-1}, which accounted for 81.6% of the total biomass, ranked second in terms of biomass was *Thalassiosira nordenskioldii* (16.6%). The diatoms *Melosira spp., Navicula spp* and *Pleurosigma spp* were observed in much smaller numbers (Table. 3. 4. 5.).

A large increase in the algal biomass was recorded on June 20th mainly at 5 metres depth, with maximum summer levels at 5 metres at station 9. At the time of this increase 0.8 mm of rain was recorded, which might explain the smaller number of algal cells present at the surface. Green flagellates succeeded diatoms as the dominant fraction of the population.

At station 11 (surface), the total number of algal cells was 715.9 x 10^3 cells.l^{-1}, of which 99.93% were truly planktonic species and the rest were benthic. The population was composed predominantly of green flagellates, being present in numbers of 710.2 x 10^3cells.l^{-1}, which accounted for 99.2% of the total biomass. The diatoms *Coscinodiscus spp, Diatoma spp, Navicula spp* and *Thalassiosira spp* were present in numbers not exceeding 2.8 x 10^3cells.l^{-1} (Table. 3. 4. 6.). Also present in small numbers was the dinoflagellate *Ceratium tripos* (0.03%).

At 5 metres depth, the total number of algal cells was 1366.85 x 10^3cells.l^{-1}, of which 99.9% were truly planktonic species and the rest were benthic. The population was made up almost totally of green flagellates (99.2% of the total biomass). The diatoms *Coscinodiscus spp, Diatoma spp, Melosira nummuloides, Navicula spp.* and *Thalassiosira spp.* were present in numbers not exceeding 5.8 x 10^3cells.l^{-1} (Table. 3. 4. 6.).

Table. 3. 4. 6. The number of algal cells (l^{-1}) and their percentages, for 20th June, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms:								
Achnanthes longipes (B)	_	_	_	_	_	_	322	0.03
Coscinodiscus spp. (P)	2797	0.39	5810	0.42	2797	0.36	13881	0.65
Diatoma spp. (B)	968	0.13	645	0.047	_	_	2582	0.12
Melosira nummuloides (P)	_	_	1076	0.078	_	_	3228	0.15
Navicula spp. (B)	429	0.06	1076	0.078	430	0.06	3228	0.15
Thalassiosira spp. (P)	1291	0.28	2367	0.17	1076	0.14	5165	0.24
Dinoflagellates:								
Ceratium tripos (P)	215	0.03	_	_	_	_	_	_
Green flagellates (P)	710220	99.2	1355874	99.19	774785	99.44	2091920	98.66

At station 9 (surface), the algal biomass was 779 x 10^3cells.l^{-1}, of which 99.94% were truly planktonic species and the rest were benthic. Green flagellates were dominant (99.44% of the total biomass). The diatoms *Coscinodiscus spp, Navicula spp.* and *Thalassiosira spp.* were observed in numbers not exceeding 2.79 x 10^3cells.l^{-1} (Table. 3. 4. 6.).

At 5 metres depth, the total number of algal cells was 2120.3 x 10^3cells.l^{-1}, of which 99.66% were truly planktonic species and the rest were benthic. Again green flagellates were dominant, being present in numbers of 2091.9 x 10^3cells.l^{-1}, which accounted for 99.66% of the total biomass. The diatoms *Achnanthes longipes, Coscinodiscus spp., Diatoma spp., M. nummuloides, Navicula spp* and *Thalassiosira spp.* were present in numbers not exceeding 13.88 x 10^3cells.l^{-1} (Table. 3. 4. 6.).

In the preceeding dates of sampling (July 11th, July 23rd, August 15th and August 29th) a much more mixed population, with an increased number of species was observed mainly at the two dates and with a decrease in the total number of algal cells.

On July 11, a clear decrease in the algal biomass was recorded. Diatoms were re-established as the dominant fraction of the population, with *Skeletonema costatum* as the dominant species.

At station 11 (surface), the total number of algal cells was 273.75 x 10^3cells.l^{-1}, of which 98.6% were truly planktonic species and the rest were benthic. Diatoms constituted 100% of the population. *Skeletonema costatum* was by far the dominant species, being present in numbers of 236.3 x 10^3cells.l^{-1}, which accounted for 86.32% of the total biomass. The diatoms *Coscinodiscus spp., Diatoma spp., Grammatophora marina, Melosira spp., Navicula spp., Nitzschia spp., Synedra spp.* and *Thalassiosira spp.* were present in numbers not exceeding 14.85 x 10^3cells.l^{-1} (Table. 3. 4. 7.).

Table. 3. 4. 7. The number of algal cells (l^{-1}) and their percentages, for 11th July, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms:								
Coscinodiscus spp. (P)	14850	5.42	4519	2.2	7747	7.12	6779	2.85
Diatoma spp. (B)	968	0.35	1291	0.63	_	_	968	0.4
Grammatophora marina (B)	322	0.12	322	0.16	2259	2.08	2259	0.95
Licmophora spp. (B)	_	_	322	0.16	645		0.59	_ _
Melosira spp. (P)	3551	1.3	3873	1.9	_	_	10007	4.2
Navicula spp. (B)	2582	0.94	2582	1.27	3551	3.26	6779	2.85
Nitzschia spp. (B)	322	0.12	_	_	_	_	13881	5.8
Pleurosigma spp. (B)	_	_	645	0.31	_	_	322	0.31
Rhabdonema arcuatum (B)	_	_	_	_	968	0.89	_	_
S. costatum (P)	236309	86.32	181751	89.36	82320	75.66	185625	78.12
Synedra sp. (B)	645	0.23	_	_	_	_	_	_
Synedra gaillonii (B)	_	_	_	_	322	0.29	_	_
Thalassiosira spp. (P)	14204	5.19	7102	3.5	10976	10.09	10976	4.62
Silicoflagellates:								
D. speculum (P)	_	_	968	0.47	_	_	_	_

At 5 metres depth, the algal biomass was 203.38 x 10^3cells.l^{-1}, of which 92.87% were truly planktonic species and the rest were benthic. Diatoms were dominant (89.36% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 181.75 x 10^3cells.l^{-1}, which accounted for 89.36% of the total biomass. The diatoms *Coscinodiscus spp., Diatoma spp., Grammatophora marina, Licmorpha spp., Melosira spp., Navicula spp., Pleurosigma spp.* and *Thalassiosira spp.* were present in numbers not exceeding 7.1 x 10^3cells.l^{-1} (Table.3. 4. 7.). Also present in small numbers was the silicoflagellate *Dictyocha speculum* (0.47%).

At station 9 (surface), the total number of algal cells was 203.37 x 10^3cells.l^{-1}, of which 92.87% were truly planktonic species and the rest were benthic. Diatoms constituted 100% of the population. *S. costatum* was by far the dominant species, being present in numbers of 82.32 x 10^3cells.l^{-1}, which accounted for 75.66% of the total biomass, ranked second in terms of biomass was *Thalassiosira spp.* (10%). The diatoms *Coscinodiscus spp., Grammatophora marina, Licmophora spp., Navicula spp., Rhabdonema arcuatum* and *Synedra gaillonii* were present in numbers not exceeding 7.74 x 10^3cells.l^{-1} (Table. 3. 4. 7.).

At 5 metres depth, the algal biomass was 237.6 x 10^3cells.l^{-1}, of which 90.19% were truly planktonic species and the rest were benthic. Again diatoms constituted 100% of the population. *S. costatum* was by far the dominant species, being present in numbers of 185.6 x 10^3cells.l^{-1}, which accounted for 78.12% of the total biomass. The diatoms *Coscinodiscus spp., Diatoma spp., Grammatophora marina, Melosira spp., Navicula spp., Nitzschia spp., Pleurosigma spp.* and *Thalassiosira spp.* were present in numbers not exceeding 10.9 x 10^3cells.l^{-1} (Table. 3. 4. 7.).

On July 23rd, a further decrease in the total number of algal cells was observed. Green flagellates succeeded diatoms as the dominant fraction of the population, with the

exception of samples collected from station 9 at surface where diatoms remained dominant.

At station 11 (surface), the total number of algal cells was 10.97 x 10^3cells.l^{-1}, of which 94.1% were truly planktonic species and the rest were benthic. Green flagellates were dominant, representing 66.17% of the total population. Diatoms represented 33.83% of the total biomass. *Thalassiosira nordenskioldii* was common (14.7% of the total biomass). The diatoms *Coscinodiscus spp., Navicula spp.* and *Skeletonema costatum* were observed frequently, they were present in numbers not exceeding 0.645 x 10^3cells.l^{-1} (Table. 3. 4. 8.).

At 5 metres depth, the total number of algal cells was 44.38 x 10^3cells.l^{-1}, of which 97.4% were truly planktonic species and the rest were benthic. Green flagellates were dominant (83.66% of the total biomass). Diatoms represented 15.62% of the total biomass, of which the common species was *Thalassiosira nordenskioldii* which represented 10.18% of the total quantity. The diatoms *Coscinodiscus spp.* and *Navicula spp.* were observed in much smaller numbers (Table. 3. 4. 8.). The dinoflagellate fraction was represented by *Ceratium tripos* and *Protoperidinium spp.* each accounted for 0.36% of the total biomass.

At station 9 (surface), the algal biomass was 17.75 x 10^3cells.l^{-1}, of which 89.1% were truly planktonic species and the rest were benthic. Diatoms remained as the dominant fraction of the population (63.73% of the total biomass). *S. costatum* was the most dominant species, being present in numbers of 2.42 x 10^3cells.l^{-1}, which accounted for 21.74% of the total quantity. Ranked third in terms of biomass after *Navicula spp.* (18.8%) was *Diatoma spp.* which represented (11.64%). The diatoms *Coscinodiscus spp., Grammatophora marina* and *T. nordenskioldii* were present in numbers not exceeding 0.645 x 10^3cells.l^{-1} (Table. 3. 4. 8.).

Table. 3. 4. 8. The number of algal cells (l^{-1}) and their percentages, for 23rd July, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms:								
Coscinodiscus spp. (P)	484	4.41	1291	2.9	161	1.45	322	1.82
Diatoma spp. (B)	322	2.94	_	_	1291	11.6	_	_
Grammatophora marina (B)	_	_	_	_	484	4.35	_	_
Navicula spp. (B)	484	4.41	1129	2.54	2098	18.8	1936	10.9
Nitzschia spp. (B)	161	1.49	_	_	_	_	_	_
S. costatum (P)	645	5.88	_	_	2421	21.6	_	_
T. nordenskioldii (P)	1614	14.7	4519	10.18	645	5.79	322	1.82
Dinoflagellates:								
Ceratium tripos (P)	_	_	161	0.36	_	_	1129	6.37
Protoperidinium spp. (P)	_	_	161	0.36	_	_	322	1.82
Green flagellates (P)	7263	66.17	37125	83.66	4035	36.23	13720	77.27

At 5 metres depth, the algal biomass was 17.75 x 10^3cells.l^{-1}, of which 89.1% were truly planktonic species and the rest were benthic. Green flagellates were dominant (77.27% of the total biomass). Diatoms represented 14.54% of the total biomass, dominated by the benthic diatom *Navicula spp.* which represented 10.9% of the total biomass. Also present were *Coscinodiscus spp.* and *Thalassiosira nordenskioldii*, each accounted for 1.82% of the total. The dinoflagellate fraction represented by *Ceratium tripos* (6.37%) and *Protoperidinium spp.* (1.82%).

On August 15th, a slight increase in the total number of algal cells was observed. Diatoms were re-established as the dominant fraction of the population, with *Skeletonema costatum* as the dominant species. No green flagellates were observed.

At station 11 (surface), the algal biomass was 126.548 x 10^3cells.l^{-1}, of which 91.34% were truly planktonic species and the rest were benthic. Diatoms were dominant, representing 94.14% of the total biomass. *S. costatum* was by far the dominant species, being present in numbers of 90.23 x 10^3cells.l^{-1}, which accounted for 71.3% of the total biomass. *Coscinodiscus spp.* and *Nitzschia spp.* were frequent, each accounted for 7.52% of the total quantity. The diatoms *Diatoma spp. Grammatophora marina, Melosira spp., Navicula spp., Rhizosolenia setigera* and *T. nordenskioldii* were present in numbers not exceeding 4.19 x 10^3cells.l^{-1} (Table. 3. 4. 9.).

The dinoflagellate fraction was represented by *Ceratium tripos* (2.04%) and *Protoperidinium spp.* (0.38%). Also present was the silicoflagellate *Dictyocha speculum* (3.44% of the total quantity).

At 5 metres depth, the total number of algal cells was 133.22 x 10^3cells.l^{-1}, of which 99.43% were truly planktonic species and the rest were benthic. Diatoms were dominant (96.02% of the total biomass). *S. costatum* was by far the dominant species being present in numbers of 82.96 x 10^3cells.l^{-1}, which accounted for 73.2% of the total

biomass. The diatoms *Coscinodiscus spp., Nitzschia spp.* and *Thalassiosira nordenskioldii* were frequent. The diatoms *Diatoma spp., Melosira spp.* and *Navicula* were present in numbers not exceeding 1.45 x 10^3cells.l^{-1} (Table. 3. 4. 9.).

The dinoflagellate fraction was represented by *C. tripos* (1.56%). Also present was the silicoflagellate *Dictyocha speculum* (2.42%).

At station 9 (surface), the algal biomass was 81 x 10^3cells.l^{-1}, of which 97% were truly planktonic species and the rest were benthic. Diatoms were represented (91.86% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 58.75 x 10^3cells.l^{-1}, which accounted for 72.56% of the total biomass. The diatom *Nitzschia spp.* was observed frequently. The diatoms *Coscinodiscus spp., Biddulphia mobiliensis, Diatoma spp., Navicula spp.* and *T. nordenskioldii* were present in numbers not exceeding 1.79 x 10^3cells.l^{-1} (Table. 3. 4. 9.). The dinoflagellate fraction was represented by *Ceratium fusus* (0.19%), *C. tripos* (4.18%) and *Protoperidinium spp.* (0.19%). Also present was the silicoflagellate *Dictyocha speculum* (3.58% of the total quantity).

At 5 metres depth, the total number of algal cells was 191.43 x 10^3cells.l^{-1}, of which 74.16% were truly planktonic species and the rest were benthic. Diatoms were dominant (90.94% of the total biomass). *Skeletonema costatum* was by far the dominant species, being present in numbers of 114.9 x 10^3cells.l^{-1}, which accounted for 60% of the total biomass, ranked second in terms of biomass was *Nitzschia spp.* (21%). The diatoms *Coscinodiscus spp., Diatoma spp., Navicula spp., Rhabdonema arcuatum* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 8.39 x 10^3cells.l^{-1} (Table. 3. 4. 9.). The dinoflagellate fraction was represented by *C. furca* (0.34%) and *C. tripos* (3.88%). Also present was the silicoflagellate *Dictyocha speculum* (4.72% of the total quantity).

Table. 3. 4. 9. The number of algal cells (l^{-1}) and their percentages, for 15th August, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms:								
Coscinodiscus spp. (P)	9523	7.52	6617	5.84	1775	2.19	2905	1.52
Biddulphia mobiliensis (P)	–	–	–	–	161	0.19	–	–
Diatoma spp. (B)	807	0.63	645	0.57	968	1.19	2905	1.5
Grammatophora marina (B)	161	0.18	–	–	–	–	–	–
Melosira spp. (P)	4196	3.3	1452	1.31	–	–	–	–
Navicula spp. (B)	1129	0.89	645	0.57	1452	1.79	8393	4.38
Nitzschia spp. (B)	9684	7.65	10491	9.26	9846	12.15	40353	21
Rhabdonema arcuatum (B)	–	–	–	–	–	–	645	0.34
Rhizosolenia setigera (P)	322	0.25	–	–	–	–	–	–
S. costatum (P)	90230	71.3	82966	73.2	58754	72.56	114926	60.12
T. nordenskioldii (P)	3066	2.42	5972	5.27	1452	1.79	4196	2.2
Dinoflagellates:								
Ceratium fusus (P)	–	–	–	–	161	0.19	–	–
Ceratium furca (P)	–	–	–	–	–	–	645	0.34
Ceratium tripos (P)	2582	2.04	1775	1.56	3389	4.18	7425	3.88
Protoperidinium spp. (P)	484	0.38	–	–	161	0.19	–	–
Silicoflagellates:								
D. speculum (P)	4358	3.44	2744	2.42	2905	3.58	9039	4.72

On August 29th, low numbers of algal cells were observed, more or less similar to those observed on August 15th. Diatoms remained as the dominant fraction of the population, with *S. costatum* as the dominant species.

At station 11 (surface), the algal biomass was 129.77 x 10^3cells.l^{-1},of which 97.2% were truly planktonic species and the rest were benthic. Diatoms were dominant (91.4% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 79.63 x 10^3cells.l^{-1}, which accounted for 61.43% of the total biomass. Also common was *Thalassiosira decipiens* (14.1%). The diatoms *Chaetoceros spp., Coscinodiscus spp., Diatoma spp., Licmophora spp., Melosira spp., Navicula spp., Navicula distans* and *T. nordenskioldii* were present in numbers not exceeding 7.1 x 10^3cells.l^{-1} (Table. 3. 4. 10.).

The dinoflagellate fraction was represented by *Ceratium fusus* (0.16%), *C. furca* (0.33%), *C. tripos* (5.8%) and *Protoperidinium spp.* (0.16%). Also present was the silicoflagellate *Dictyocha speculum* (2.15% of the total quantity).

At 5 metres depth, the algal biomass was 136.6 x 10^3cells.l^{-1}, of which 98.64% were truly planktonic and the rest were benthic species.
Diatoms were dominant (91.2% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 81.56 x 10^3cells.l^{-1}, which accounted for 62.45% of the total biomass. Also common was *T. decipiens* (16.38%). The diatoms *Chaetoceros spp., Coscinodiscus spp., Diatoma spp., Grammatophora marina, Navicula spp.* and *T. nordenskioldii* were present in numbers not exceeding 3.65 x 10^3cells.l^{-1} (Table. 3. 4. 10.).

The dinoflagellates *C. fusus, C. furca, C. tripos* and *Protoperidinium spp.* accounted for 6.59% of the total biomass, each contributed little to the total biomass of the

Table. 3. 4. 10. The number of algal cells (l^{-1}) and their percentages, for 29th August, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Chaetoceros spp. (P)	4734	3.65	5380	3.9	3443	2.57	1291	0.52
Coscinodiscus spp(P)	2367	1.82	4519	3.3	2797	2.1	2905	1.17
Diatoma spp (B)	1721	1.3	1721	1.26	1076	0.8	968	0.4
Diploneis chersonensis (B)	-	-	-	-	-	-	322	0.13
Grammatophora marina (B)	-	-	215	0.15	-	-	968	0.4
Licmophora spp (B)	215	0.16	-	-	215	0.16	-	-
Melosira spp (B)	1076	0.829	-	-	645	0.48	-	-
Navicula spp (B)	3228	2.48	1506	1.1	3228	2.4	3551	1.4
Navicula distans (B)	215	0.16	-	-	-	-	-	-
Nitzschia sp (P)	-	-	-	-	-	-	15495	6.26
Nitzschia longissima (P)	-	-	-	-	-	-	645	0.26
Pleurosigma sp (B)	-	-	-	-	215	0.16	-	-
Pleurosigma aestuarii (B)	-	-	-	-	-	-	322	0.13
Rhizosolenia delicatula (P)	-	-	-	-	-	-	10330	4.17
Skeletonema costatum (P)	79630	61.431	81567	62.45	83935	63.12	168838	68.62
Thalassiosira decipiens (P)	18293	14.1	22382	16.38	18508	13.85	15818	6.4
Thalassiosira nordenskioldii (P)	7102	5.47	3658	2.67	7532	5.4	816	0.33
Dinoflagellates								
Ceratium fusus (P)	215	0.16	215	0.15	-	-	-	-
Ceratium furca (P)	430	0.33	645	0.47	215	0.16	645	0.26
Ceratium tripos (P)	7532	5.8	7747	5.67	8608	6.4	19046	7.7
Protoperidinium sp (P)	215	0.16	430	0.3	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	2797	2.15	3013	2.2	3228	2.4	5488	1.85

population. Also present was the silicoflagellate *Dictyocha speculum* (2.2% of the total quantity).

At station 9 (surface), the total number of algal cells was 133.65 x 10^3cells.l^{-1}, of which 97.28% were truly planktonic species while the rest were benthic. Diatoms were dominant (91% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 83.93 x 10^3cells.l^{-1}, which accounted for 63.1% of the total biomass. Also common was *Thalassiosira decipiens* (13.85%).

The diatoms *Chaetoceros spp., Coscinodiscus spp., Diatoma spp., Licmophora spp., Melosira spp., Navicula spp., Pleurosigma spp.,* and *T. nordenskioldii* were present in numbers not exceeding 7.5 x 10^3cells.l^{-1} (Table. 3. 4. 10.). The dinoflagellate fraction was represented by *Ceratium furca* (0.16%) and *C. tripos* (6.4%). Also present was the silicoflagellate *Dictyocha speculum* (2.4% of the total population).

At 5 metres depth, the algal biomass was 247.45 x 10^3cells.l^{-1}, of which 91.42% were truly planktonic species and the rest were benthic. Diatoms were dominant (90.2% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 168.84 x 10^3cells.l^{-1}, which accounted for 68.62% of the total biomass. The diatoms *Nitzschia spp., Rhizosolenia delicatula* and *T. decipiens* were observed frequently. The diatoms *Chaetoceros spp., Coscinodiscus spp., Diatoma spp., Diploneis chersonensis, Grammatophora marina, Navicula spp., Nitzschia longissima, Pleurosigma aestuarii* and *T. nordenskioldii* were present in numbers not exceeding 3.55 x 10^3cells.l^{-1} (Table. 3. 4. 10.). The dinoflagellate fraction was represented by *Ceratium furca* (0.26%) and *C. tripos* (7.7%). Also present was the silicoflagellate *Dictyocha speculum* (1.85% of the total quantity).

Autumn 1984

A slight autumnal increase in the total number of algal cells was recorded on September 19th. Diatoms remained as the dominant fraction of the population. A slight increase in the contribution of dinoflagellates to the total biomass of the population was observed.

At station 11 (surface), the algal biomass was 181.75 x 10^3cells.l^{-1}, of which 89.55% were truly planktonic species and the rest were benthic. Diatoms were dominant (80.89% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 95.55 x 10^3cells.l^{-1}, which accounted for 52.66% of the total biomass, ranking second in terms of biomass was *Thalassiosira nordenskioldii* (15.27%).

The diatom *Nitzschia spp.* were frequent (8.5%). The diatoms *Chaetoceros holsaticum, Coscinodiscus spp., Diatoma spp., Navicula spp.* and *T. decipiens* were present in numbers not exceeding 3.55 x 10^3cells.l^{-1} (Table. 3. 4. 11.). The dinoflagellate fraction which represented 17.34% of the total biomass of the population was dominated by *C. tripos* which accounted for 12.78% of the total biomass. *C. fusus, C. furca, C. lineatum, C. macroceros, Protoperidinium conicum, P. divergens* and *P. pyriforme* were present in numbers not exceeding 2.9 x 10^3cells.l^{-1} and constituted little to the total biomass of the population. Also present was the silicoflagellate *Dictyocha speculum* (1.77% of the total biomass).

At 5 metres depth, the total number of algal cells was 213.7 x 10^3cells.l^{-1}, of which 90.95% were truly planktonic species and the rest were benthic. Diatoms were dominant (82% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 129 x 10^3cells.l^{-1}, which accounted for 60.42% of the total

Table. 3. 4. 11. The number of algal cells (l^{-1}) and their percentages, for 19th September, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Chaetoceros spp (P)	-	-	-	-	12913	4.43	6456	2.6
Chaetoceros holsaticum (P)	1291	0.71	-	-	-	-	-	-
Coscinodiscus spp (P)	1614	0.88	645	0.3	322	0.11	645	0.26
Diatoma spp (B)	322	0.18	968	0.45	-	-	645	0.26
Navicula spp (B)	3551	1.95	2259	1.05	1291	0.22	2259	0.9
Nitzschia spp (B)	15495	8.5	16787	7.85	25503	8.75	16141	6.54
Nitzschia longissima (P)	-	-	322	0.15	-	-	-	-
Rhizosolenia delicatula (P)	-	-	2259	1.05	3551	1.2	3551	1.44
Skeletonema costatum (P)	95556	52.66	129130	60.49	156248	53.87	137847	55.96
Thalassiosira decipiens (P)	968	0.53	968	0.45	645	0.22	-	-
Thalassiosira nordenskioldii (P)	27763	15.27	22275	10.4	52620	18.05	36479	14.79
Dinoflagellates								
Ceratium fusus (P)	1291	0.71	968	0.45	2582	0.88	3228	1.3
Ceratium furca (P)	2905	1.59	5488	2.56	5488	1.88	7425	3.01
Ceratium lineatum (P)	645	0.35	-	-	-	-	-	-
Ceratium macroceros (P)	1936	1.06	-	-	-	-	-	-
Ceratium tripos (P)	23243	12.78	24212	11.33	23889	8.19	24857	10.07
Dinophysis acuta (P)	-	-	2259	1.06	1936	0.66	1291	0.51
Protoperidinium spp (P)	-	-	968	0.45	645	0.22	645	0.26
Protoperidinium conicum (P)	645	0.35	-	-	-	-	-	-
Protoperidinium divergens (P)	322	0.18	-	-	-	-	-	-
Protoperidinium pyriforme (P)	968	0.53	-	-	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	3228	1.77	4196	1.96	3873	1.32	5165	2.1

biomass, ranking second in terms of biomass was *Thalassiosira nordenskioldii* (10.4%).

The diatom *Nitzschia spp.* was observed frequently and accounted for 7.85% of the total quantity. The diatoms *Coscinodiscus spp., Diatoma spp., Navicula spp., Nitzschia longissima, Rhizosolenia delicatula* and *T. decipiens* were present in numbers not exceeding 2.26 x 10^3cells.l^{-1} (Table. 3. 4. 11.). The dinoflagellate fraction which represented 15.85% of the total biomass and was dominated by *Ceratium tripos* (11.33%). *C. fusus, Dinophysis acuta* and *Protoperidinium spp.* were present in small numbers (Table. 3. 4. 11.). Also present in small numbers was the silicoflagellate *Dictyocha speculum.*

At station 9 (surface), 91.25% of the total biomass were truly planktonic species and the rest were benthic. Out of a total standing crop of 291.5 x 10^3cells.l^{-1}, about 86.85% were diatoms, of which *Skeletonema costatum* was the dominant species, being present in numbers of 156.2 x 10^3cells.l^{-1}, which accounted for 53.87% of the total biomass, ranking second in terms of biomass was *Thalassiosira nordenskioldii* (18%). *Chaetoceros spp., Coscinodiscus spp., Navicula spp., Nitzschia spp.* and *T. decipiens* were present in small numbers (Table. 3. 4. 11.). Dinoflagellates accounted for 11.83% of the total biomass, of which *Ceratium tripos* was the dominant species (8.2%), accompanied by *C. fusus, C. furca, Dinophysis acuta* and *Protoperidinium spp.* Also present was the silicoflagellate *Dictyocha speculum.*

At 5 metres depth, the total number of algal cells was 246.6 x 10^3cells.l^{-1}, of which 92.56% were truly planktonic species and the rest were benthic. Diatoms were dominant (82.7% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 137.85 x 10^3cells.l^{-1}, which accounted for 55.9% of the total population. *Nitzschia spp.* and *T. nordenskioldii* were frequent. *Chaetoceros spp., Coscinodiscus spp., Navicula spp., Rhizosolenia delicatula* and *T. decipiens*

were present in small numbers (Table. 3. 4. 11.). Dinoflagellates accounted for 15% of the total biomass. *Ceratium tripos* was the dominant species (10.1%), accompanied by *C. fusus, C. furca, Dinophysis acuta* and *Protoperidinium spp.* Also present was the silicoflagellate *Dictyocha speculum.*

A decrease in the algal biomass was observed on October 3rd. Dinoflagellates succeeded diatoms as the dominant fraction of the population, with *C. tripos* as the dominant species. An increase in the contribution of the silicoflagellate *Dictyocha speculum* to the total biomass was observed.

At station 11 (surface), the total number of algal cells was 99.4 x 10^3cells.l^{-1}, of which 34.45% were diatoms, 53.2% were dinoflagellates, while the rest was represented by the silicoflagellate *Dictyocha speculum.* 92.87% of the total biomass were truly planktonic and the rest were benthic. The diatom fraction was dominated by *Skeletonema costatum* (14.28%) and *Coscinodiscus spp.* (7.46%) with *Nitzschia spp.* present in considerable numbers. The diatoms *Chaetoceros spp., Diatoma spp., Melosira spp., Navicula spp., Rhabdonema arcuatum* and *Thalassiosira nordenskioldii* were present in much smaller numbers (Table. 3. 4. 12.). The dinoflagellate fraction was dominated by *C. tripos* (29.3% of the total biomass); ranking next was *C. furca* (10.4%). *Ceratium fusus* and *C. macroceros* were frequent (Table. 3. 4. 12.). *C. inflatum, C. lineatum, Dinophysis acuta* and *Protoperidinium spp.* were observed in very small numbers (Table. 3. 4. 12.).

At 5 metres depth, out of a total standing crop of 88 x 10^3cells.l^{-1}, about 23.46% were diatoms, 63.7% were dinoflagellates and the rest were represented by the silicoflagellate *Dictyocha speculum.* The diatoms *Coscinodiscus spp., Nitzschia spp., Rhizosolenia delicatula, Skeletonema costatum* and *Thalassiosira nordenskioldii* comprised a large portion of the diatom fraction. The diatoms *Diatoma spp., Melosira spp.* and *Navicula spp.* were present in smaller numbers (Table. 3. 4. 12.). The dinoflagellate

fraction was dominated by *C. tripos* which accounted for 40.35% of the total biomass, ranking second was *C. furca* (14.28%) and ranking third was *C. macroceros* (5%). *C. fusus, Dinophysis acuta* and *Protoperidinium spp.* were present in small numbers (Table. 3. 4. 12.).

At station 9 (surface), out of a total standing crop of 79.7 x 10^3cells.l^{-1}, 36.47% were diatoms, 54.2% were dinoflagellates and the rest was represented by the silicoflagellate *Dictyocha speculum.* 90.6% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was dominated by *S. costatum* (12.4%), followed by *Nitzschia spp.* (6%). The diatoms *Achnanthes longipes, Biddulphia spp., Chaetoceros didymum, Coscinodiscus spp., Diatoma spp., Melosira spp., Navicula spp., Synedra gaillonii* and *Thalassiosira nordenskioldii* were present in smaller numbers (Table. 3. 4. 12.). The dinoflagellate fraction was dominated by *Ceratium tripos* (34.8%), ranked second in terms of biomass was *C. furca* (13.36%). *C. fusus, C. longipes, Dinophysis acuta* and *Protoperidinium spp.* were present in small numbers (Table. 3. 4. 12.).

At 5 metres depth, out of a total standing crop of 87 x 10^3cells.l^{-1}, 29.7% were diatoms, 60.28% were dinoflagellates and the rest was represented by the silicoflagellate *Dictyocha speculum.* 93.38% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was dominated by *Coscinodiscus spp.* (8.15% of the total biomass) and *Skeletonema costatum* (8.89%), *Navicula spp.* was frequent. The diatoms *Chaetoceros spp., Diatoma spp., Grammatophora marina, Nitzschia spp.* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 12.). The dinoflagellate fraction was dominated by *C. tripos* (33.3% of the total population) and *C. furca* (13.7%). *C. inflatum* and *C. macroceros* were frequent (Table. 3. 4. 12.). *C. fusus, C. lineatum* and *Dinophysis acuta* were present in small numbers not exceeding 1.6 x 10^3cells.l^{-1} (Table. 3. 4. 12.).

Table. 3. 4. 12. The number of algal cells (l^{-1}) and their percentages, for 3rd October, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Achnanthes longipes (B)	-	-	-	-	322	0.4	-	-
Biddulphia sp (P)	-	-	-	-	322	0.4	-	-
Chaetoceros spp (P)	645	0.65	-	-	-	-	1614	1.85
Chaetoceros didymum (P)	-	-	-	-	1936	2.4	-	-
Coscinodiscus spp (P)	7425	7.46	4519	5.12	3873	4.85	7102	8.15
Diatoma spp (B)	1291	1.29	968	1.1	1614	2.02	1936	2.2
Grammatophora marina (B)	-	-	-	-	-	-	322	0.37
Melosira spp (P)	1614	1.62	322	0.36	1291	1.62	-	-
Navicula spp (B)	1291	1.29	1936	2.2	2259	2.83	3873	4.4
Nitzschia spp (B)	4842	4.87	2259	2.56	4842	6.07	1614	1.85
Rhabdonema arcuatum (B)	968	0.97	-	-	-	-	-	-
Rhizosolenia delicatula (P)	-	-	3551	4	-	-	-	-
Skeletonema costatum (P)	14204	14.28	4196	4.76	9684 1	12.43	7747	8.89
Synedra gaillonii (B)	-	-	-	-	645	0.08	-	-
Thalassiosira nordenskioldii (P)	1936	1.95	2905	3.3	2259	2.83	1291	1.48
Dinoflagellates								
Ceratium fusus (P)	3873	3.89	2905	3.3	1291	1.62	1291	1.48
Ceratium furca (P)	10330	10.39	12590	14.28	10653	13.36	11944	13.7
Ceratium inflatum (P)	968	0.97	-	-	-	-	4842	5.55
Ceratium lineatum (P)	968	0.97	-	-	-	-	1614	1.85
Ceratium longipes (P)	-	-	-	-	1291	1.62	-	-
Ceratium macroceros (P)	5810	5.84	4519	5.13	-	-	3873	4.4
Ceratium tripos (P)	29054	29.29	35511	40.35	27440	34.83	29054	33.3
Dinophysis acuta (P)	1614	1.62	322	0.36	2259	2.83	322	0.37
Protoperidinium spp. (P)	322	0.32	322	0.36	322	0.4	-	-
Silicoflagellates								
Dictyocha speculum (P)	12267	12.33	11298	12.82	7425	9.3	8716	10

On 17th October, a further decrease in the algal biomass was observed, which was characterised by a further decrease in the contribution of the diatom fraction to the total biomass of the population, *Coscinodiscus spp.* succeeded *Skeletonema costatum* as the dominant diatom. Dinoflagellates again were the dominant fraction of the population, of which *Ceratium tripos* was the most common species. Also observed was a slight increase in the contribution of the silicoflagellate *Dictyocha speculum* to the total biomass. No green flagellates were present.

At station 11 (surface), out of a total standing crop of 51.4 x 10^3cells.l^{-1}, about 15.5% were diatoms, 66.9% were dinoflagellates and the rest was represented by the silicoflagellate *Dictyocha speculum.* The diatom fraction was composed predominantly of cells of *Coscinodiscus spp.* (6.27% of the total biomass), followed by *S. costatum* (2.5%). The diatoms *Diatoma spp., Grammatophora marina, Navicula spp., Pleurosigma spp., Rhabdonema arcuatum* and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 13.). The dinoflagellate fraction was dominated by *C. tripos* (39.3% of the total biomass), ranking second was *C. macroceros* (13.4%). Also common was *C. furca* (9.2%). *C. fusus* and *C. lineatum* were present in small numbers (Table. 3. 4. 13.).

At 5 metres depth, out of a standing crop of 53 x 10^3cells.l^{-1}, about 21.8% were diatoms, 62% were dinoflagellates and the rest was represented by the silicoflagellate *Dictyocha speculum.* 96.78% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was composed predominantly of *Coscinodiscus spp.* (8% of the total biomass). The diatoms *Diatoma spp., Grammatophora marina, Melosira spp., Navicula spp., Skeletonema costatum* and *Thalassiosira nordenskioldii* were present in smaller numbers (Table. 3. 4. 13.). The dinoflagellate fraction was dominated by *Ceratium tripos* (38.76% of the total biomass), ranking second was *C. macroceros* (13.3%). *C. furca* was observed frequently (8.46%). *C. fusus* and *C. lineatum* were present in small numbers (Table. 3. 4. 13.).

Table. 3. 4. 13. The number of algal cells (l^{-1}) and their percentages, for 17th October, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	3228	6.27	4304	8.06	5165	9.75	5810	13.24
Cocconeis sp (B)	-	-	-	-	215	0.4	-	-
Diatoma spp (B)	860	1.67	1076	2.01	430	0.81	645	1.36
Grammatophora marina (B)	645	1.25	215	0.4	645	1.22	-	-
Melosira spp (P)	-	-	1721	3.22	-	-	968	2.04
Navicula spp (B)	860	1.67	1506	2.82	2367	4.47	645	1.36
Pleurosigma sp (B)	215	0.46	-	-	-	-	-	-
Rhabdonema arcuatum (B)	215	0.42	-	-	-	-	-	-
Skeletonema costatum (P)	1291	2.5	860	1.61	430	0.81	2905	6.12
Thalassiosira nordenskioldii (P)	645	1.25	1076	2.01	1721	3.25	968	2.04
Dinoflagellates								
Ceratium fusus (P)	860	1.67	1076	2.01	1291	2.44	968	2.04
Ceratium furca (P)	4734	9.2	4519	8.46	5595	10.57	2259	4.76
Ceratium lineatum (P)	1721	3.35	645	1.21	1076	2.03	-	-
Ceratium longirostrum (P)	-	-	-	-	215	0.4	-	-
Ceratium macroceros (P)	6886	13.39	7102	13.3	5165	9.75	3873	8.16
Ceratium tripos (P)	20230	39.33	19800	39.76	21306	40.67	21952	47.3
Dinophysis acuta (P)	-	-	-	-	215	0.4	-	-
Silicoflagellates								
Dictyocha speculum (P)	9039	17.57	9608	16.13	6886	13.01	5488	11.58

At station 9 (surface), out of a total standing crop of 52.9 x 10^3cells.l^{-1}, about 21% were diatoms, 65.8% were dinoflagellates and the rest were represented by the silicoflagellate *Dictyocha speculum*. 94.3% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction of the population was composed predominantly of *Coscinodiscus spp.* (9.75% of the total biomass). *Navicula spp.* and *T. nordenskioldii* were frequent (Table. 3. 4. 13.). The diatoms *Cocconeis spp., Diatoma spp., Grammatophora marina* and *S. costatum* were present in small numbers (Table. 3. 4. 13.).

The dinoflagellate fraction was dominated by *Ceratium tripos* (40.67% of the total biomass), also common were *C. furca* (10.57%) and *C. macroceros* (9.75%). *C. fusus, C. lineatum, C. longirostrum* and *Dinophysis acuta* were present in very small numbers (Table. 3. 4. 13.).

At 5 metres depth, out of a standing crop of 47.4 x 10^3cells.l^{-1}, about 27% of the cells were diatoms, 61% were dinoflagellates and the rest were represented by the silicoflagellate *Dictyocha speculum*. 98.6% of the total biomass were truly planktonic species and the rest were benthic.

The diatom fraction was composed predominantly of *Coscinodiscus spp.* (13.2% of the total biomass) and *Skeletonema costatum* (6%). *Diatoma spp., Melosira spp., Navicula spp.* and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 13.).

The dinoflagellate fraction was dominated by *C. tripos* (47% of the total biomass), *C. macroceros* was frequent (8.16%). *C. fusus* and *C. furca* were present in smaller numbers (Table. 3. 4. 13.).

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A sharp decrease in the total number of algal cells was observed during this period. Diatoms were re - established as the dominant fraction of the population. No green flagellates were observed.

On 7th November, at station 11 (surface), the algal biomass was 15 x 10^3cells.l^{-1}, of which 91.4% were diatoms, 1.1% were dinoflagellates and 7.53% were represented by the silicoflagellate *Dictyocha speculum.* 86% of the total biomass were truly planktonic species while the rest were benthic.

The diatom fraction of the population was dominated by *Coscinodiscus spp.* (31.25% of the total biomass) and *Diatoma spp.* (17.2%). Also common were *Navicula spp., Skeletonema costatum* (each accounted for 9.7% of the total biomass) and *Thalassiosira nordenskioldii* (11.9%). The diatom *Cocconeis clandestina, Grammatophora marina, Melosira nummuloides, Pleurosigma spp.* and *Synedra spp.* were present in small numbers (Table. 3. 4. 14.). The dinoflagellate fraction was represented by *Ceratium macroceros.*

At 5 metres depth, the total number of algal cells was 16.62 x 10^3cells.l^{-1}, of which 91.27% were diatoms, 1.94 were dinoflagellates and the rest was represented by the silicoflagellate *Dictyocha speculum* . 77.7% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was dominated by *Coscinodiscus spp.* (29% of the total biomass), *Navicula spp.* (21.38%) and *Thalassiosira nordenskioldii* (15.54%). The diatom *Skeletonema costatum* was observed frequently (6.8%). The diatoms *Diatom elongatum, Grammatophora marina, Melosira islandica, Rhizosolenia spp.* and *T . decipiens* were present in small numbers (Table. 3. 4. 14.). The dinoflagellate fraction was represented by *Ceratium tripos.*

Table. 3. 4. 14. The number of algal cells (l^{-1}) and their percentages, for 7th November, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	4842	31.25	4842	29.13	5326	37.92	4035	32.48
Cocconeis clandestina (B)	161	1.07	-	-	161	1.15	-	-
Diatoma spp (B)	2582	17.2	1775	10.68	968	6.89	1614	12.98
Diatoma elongatum (B)	-	-	322	1.94	-	-	-	-
Fragilaria sp (P)	-	-	-	-	-	-	161	1.3
Grammatophora marina (B)	161	1.07	161	0.97	-	-	-	-
Melosira islandica (P)	-	-	161	0.97	322	2.29	-	-
Melosira nummuloides (P)	807	5.37	-	-	-	-	-	-
Navicula spp (B)	1452	9.68	3542	21.38	1129	8.04	2098	16.88
Nitzschia spp (B)	-	-	-	-	161	1.15	-	-
Pleurosigma spp (B)	161	1.07	-	-	-	-	161	1.3
Rhizosolenia spp (P)	-	-	161	0.97	161	1.15	-	-
Skeletonema costatum (P)	1452	9.68	1192	6.79	1452	10.34	1129	9.1
Synedra sp (B)	322	2.15	-	-	-	-	-	-
Thalassiosira decipiens (P)	-	-	484	2.9	322	2.29	-	-
Thalassiosira nordenskioldii (P)	1775	11.87	2582	15.54	1129	8.04	1614	12.98
Dinoflagellates								
Ceratium macroceros (P)	161	1.07	-	-	-	-	322	2.6
Ceratium tripos (P)	-	-	322	1.94	161	1.15	-	-
Silicoflagellates								
Dictyocha speculum (P)	1129	7.52	1129	6.79	2744	19.59	1291	10.38

At station 9 (surface), the algal biomass was 14 x 10^3cells.l^{-1}, of which 79.3% were diatoms, 1.15% were dinoflagellates and the rest were represented by the silicoflagellate *Dictyocha speculum.* 98.8% of the total biomass were truly planktonic and the rest were benthic. *Coscinodiscus spp.* was by far the dominant diatom species being present in numbers of 5.33 x 10^3cells.l^{-1}, which accounted for 37.9% of the total biomass, ranking second in terms of biomass was *S. costatum* (10.34%). The diatoms *Diatoma spp., Navicula spp.* and *T. nordenskioldii* were observed frequently. The diatoms *Cocconeis disculus, Melosira islandica, Nitzschia spp., Rhizosolenia spp.* and *T. decipiens* were observed in small numbers (Table. 3. 4. 14.). The dinoflagellate fraction was represented by *C. tripos.*

At 5 metres depth, the total number of algal cells was 12.43 x 10^3cells.l^{-1}, of which 87% were diatoms, 2.6% were dinoflagellates and the rest were represented by the silicoflagellate *Dictyocha speculum.* 81.8% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was dominated by *Coscinodiscus spp.* (32.5% of the total biomass), ranking second in terms of biomass was *Navicula spp.* (16.8%). Also common were *Diatoma spp.* and *Thalassiosira nordenskioldii,* each accounted for 12.9% of the total biomass. The diatom *Skeletonema costatum* was observed frequently. Also present were *Fragilaria spp.* and *Pleurosigma spp.,* each contributed little to the total biomass of the population. The dinoflagellate fraction was represented by *Ceratium macroceros.*

On 21st November, the algal biomass remained low, with a further decrease for samples collected from station 11 at both depths and a slight increase for samples collected from station 9 at both depths. Diatoms remained as the dominant fraction of the population, with *Coscinodiscus spp.* the most dominant species.

At station 11 (surface), the algal biomass was 11.78 x 10^3cells.l^{-1}, of which 72.6% were truly planktonic species and the rest were benthic. Diatoms were dominant (89%) ,

dinoflagellates represented 5.47% of the total biomass and the rest was represented by the silicoflagellate *Dictyocha speculum* . The diatom fraction was dominated by *Coscinodiscus spp.* (35.67% of the total biomass), *Diatoma spp.* (15%) and *Navicula spp.* was observed frequently. *Amphora macilenta, Pleurosigma spp., Synedra spp.* and *Thalassiosira decipiens* were observed in small numbers (Table. 3. 4. 15.). The dinoflagellate fraction was represented by *Ceratium tripos* and *Dinophysis acuta.*
At 5 metres depth, the total number of algal cells was 10.2 x 10^3cells.l^{-1}, of which 82.6% were diatoms, 6.33% were dinoflagellates and the rest was represented by the silicoflagellate *Dictyocha speculum.* 85.7% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was dominated by *Coscinodiscus spp.* (33.4% of the total biomass) and *Diatoma spp.* (19%). Also common was *T. nordenskioldii* (12.7%). The diatom *Navicula spp.* was observed frequently. *Amphora robusta, Grammatophora marina, Licmorpha spp.* and *T. decipiens* were observed in small numbers (Table. 3. 4. 15.). The dinoflagellate fraction was represented by *C. macroceros, C. tripos* and *Protoperidinium spp.*

At station 9 (surface), the algal biomass was 14 x 10^3cells.l^{-1}, of which 89.9% were diatoms and the rest was represented by the silicoflagellate *Dictyocha speculum.* 85.4% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was dominated by *Coscinodiscus spp.* (23.65% of the total biomass), *Melosira spp.* (14.6%) and *Skeletonema costatum* (21.3%). *Diatoma spp.* and *Navicula spp.* were observed frequently. *Chaetoceros spp., Grammatophora marina, Rhabdonema arcuatum* and *Thalassiosira nordenskioldii* were observed in small numbers (Table. 3. 4. 15.).

At 5 metres, the total number of algal cells was 28.2 x 10^3cells.l^{-1}, of which diatoms represented 97.7%, dinoflagellates represented 0.57% and the rest was represented by the silicoflagellate *Dictyocha speculum.* 32% of the total biomass were truly planktonic species and the rest were benthic. *Navicula spp.* was by far the dominant

Table. 3. 4. 15. The number of algal cells (l^{-1}) and their percentages, for 21st November, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Amphora macilenta (B)	161	1.37	-	-	-	-	-	-
Amphora robusta (B)	-	-	161	1.58	-	-	-	-
Chaetoceros spp (P)	-	-	-	-	161	1.12	161	0.57
Coscinodiscus spp (P)	4196	35.67	3389	33.4	3389	23.65	3392	13.14
Diatoma spp (B)	1775	15.06	1936	19.04	1291	8.98	1291	4.57
Grammatophora marina (B)	-	-	161	1.58	484	3.37	161	0.57
Licmophora sp (B)	-	-	161	1.58	-	-	-	-
Melosira spp (P)	-	-	-	-	2098	14.6	807	2.85
Navicula spp (B)	2259	19.17	645	6.35	1452	10.11	18723	66.33
Pleurosigma spp (B)	484	4.1	322	3.17	-	-	322	1.14
Rhabdonema arcuatum (B)	-	-	-	-	161	1.12	-	-
Skeletonema costatum (P)	-	-	-	-	3066	21.34	1129	3.99
Synedra sp (B)	322	2.73	-	-	-	-	-	-
Thalassiosira decipiens (P)	161	1.37	322	3.17	-	-	-	-
Thalassiosira nordenskioldii (P)	1129	9.58	1291	12.69	807	5.6	1291	4.57
Dinoflagellates								
Ceratium furca (P)	-	-	-	-	-	-	161	0.57
Ceratium macroceros (P)	-	-	161	1.58	-	-	-	-
Ceratium tripos (P)	484	4.1	322	3.17	-	-	-	-
Dinophysis acuta (P)	161	1.37	-	-	-	-	-	-
Protoperidinium sp (P)	-	-	161	1.58	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	645	5.48	1129	11.11	1452	10.11	484	1.7

diatom species, being present in numbers of 18.7 x 10^3cells.l^{-1}, which accounted for 66.33% of the total biomass, ranking second in terms of biomass was *Coscinodiscus spp.* (13%). The diatoms *Chaetoceros spp., Diatoma spp., Grammatophora marina, Licmophora spp., Pleurosigma spp., S. costatum* and *T. nordenskioldii* were present in low numbers (Table. 3. 4. 15.). The dinoflagellate fraction was represented by *Ceratium furca.*

Although a slight increase in the total number of algal cells was observed on 5th December, the numbers remained low. Diatoms remained as the dominant fraction of the population, *S. costatum* succeeded *Coscinodiscus spp.* as the dominant species.

At station 11 (surface), the algal biomass was 43.5 x 10^3cells.l^{-1}, of which 97.78% were diatoms, 1.48% were dinoflagellates and the rest of the population was represented by the silicoflagellate *Dictyocha speculum.* 97.7% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was composed predominantly of short strains of *Skeletonema costatum* which represented 82.9% of the total biomass, ranking next in abundance was *Thalassiosira nordenskioldii* (10.37%).

The diatoms *Coscinodiscus spp., Melosira spp., Navicula spp., Pleurosigma spp., Rhabdonema arcuatum* and *Rhizosolenia spp.* were observed in small numbers (Table. 3. 4. 16.). The dinoflagellate fraction was represented by *Ceratium furca, C. lineatum* and *C. tripos.*

At 5 metres depth, the total number of algal cells was 49.4 x 10^3cells.l^{-1}, of which 99% were diatoms. 0.64% were dinoflagellates and the rest of the population was represented by the silicoflagellate *Dictyocha speculum.* 96.4% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was composed predominantly of *S. costatum* which represented 79.14% of the total biomass, ranking next in abundance was *T. nordenskioldii* (12.42%). The diatoms

Table. 3. 4. 16. The number of algal cells (l^{-1}) and their percentages, for 5th December, are summarised in the following table.

P = planktonic B = benthic n = number of algal cells % = percentage of different algal cells

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Biddulphia sinensis (P)	-	-	322	0.64	-	-	-	-
Coscinodiscus spp (P)	161	0.37	1291	2.61	807	1.18	484	1.1
Diatoma spp (B)	-	-	-	-	322	0.47	645	1.46
Melosira spp (P)	645	1.48	-	-	-	-	968	2.19
Navicula spp (B)	645	1.48	1291	2.61	807	1.18	1614	3.66
Nitzschia sp (B)	-	-	484	0.98	-	-	-	-
Pleurosigma spp (B)	161	0.37	-	-	-	-	161	0.36
Rhabdonema arcuatum (B)	161	0.37	-	-	-	-	-	-
Rhizosolenia spp (P)	161	0.37	161	0.32	-	-	-	-
Skeletonema costatum (P)	36156	82.97	39062	79.14	60530	88.455	34865	79.15
Thalassiosira decipiens (P)	-	-	161	0.32	484	0.7	-	-
Thalassiosira nordenskioldii (P)	4519	10.37	6133	12.42	3873	5.66	5165	11.72
Dinoflagellates								
Ceratium furca (P)	161	0.37	-	-	161	0.235	161	0.36
Ceratium lineatum (P)	322	0.74	-	-	-	-	-	-
Ceratium tripos (P)	161	0.37	-	-	-	-	-	-
Protoperidinium excentricum (P)	-	-	161	0.32	-	-	-	-
Protoperidinium ovatum (P)	-	-	161	0.32	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	322	0.74	161	0.32	1452	2.12	-	-

Biddulphia sinensis, Coscinodiscus spp., Navicula spp., Nitzschia spp., Rhizosolenia spp. and *T. decipiens* were observed in smaller numbers. The dinoflagellate fraction was represented by *Protoperidinium excentricum* and *Protoperidinium ovatum* (Table. 3. 4. 16.).

At surface (9), the algal biomass was 68.4 x 10^3cells.l^{-1}, of which 97.6% were diatoms, 0.2% were dinoflagellates and the rest was represented by the silicoflagellate *Dictyocha.* 98.8% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was composed predominantly of *Skeletonema costatum,* which represented 88.45% of the total biomass, ranking next in abundance was *T. nordenskioldii* (5.66%). The diatoms *Coscinodiscus spp., Diatoma spp., Navicula spp.* and *T. decipiens* were observed in smaller numbers (Table. 3. 4. 16.). The only dinoflagellate observed was *Ceratium furca.*

At 5 metres depth, the total number of algal cells was 44 x 10^3cells.l^{-1}, of which 99.64% were diatoms, the rest of the population was represented by the dinoflagellate *C. furca.* The diatom fraction was composed predominantly of *S. costatum* which represented 79% of the total biomass, again ranking next in abundance was *T. nordenskioldii* (11.7%). The diatoms *Coscinodiscus spp., Diatoma spp., Melosira spp., Navicula spp.* and *Pleurosigma spp.* were observed in small numbers.

On 3rd January, a further decrease in the total number of algal cells was observed. Diatoms remained as the dominant fraction of the population.

At station 11 (surface), the algal biomass was 9 x 10^3cells.l^{-1}, of which 80.36% were truly planktonic species and the rest were benthic. Diatoms were dominant (89.3% of the total biomass). The diatom fraction consisted mainly of *Skeletonema costatum* (34.8% of the total biomass), *Coscinodiscus spp.* (17.85%) and *Navicula spp.* (16%). Also common was *Thalassiosira nordenskioldii* (10% of the total biomass). The

diatoms *Chaetoceros spp., Diatoma spp.* and *Grammatophora marina* were observed in smaller numbers (Table. 3. 4. 17.). Although *S. costatum, Coscinodiscus spp.* and *Navicula spp.* were the dominant organisms, they appeared unhealthy under the microscope, with many empty frustules being present. The dinoflagellate fraction was represented by *Ceratium fusus* and *C. tripos.* Also present was the silicoflagellate *Dictyocha speculum.*

At 5 metres depth, the total number of algal cells was 10.8 x 10^3cells.l^{-1}, of which 59.7% of the total biomass were diatoms and the rest was represented by the dinoflagellates *C. furca* and *Dinophysis acuta. Coscinodiscus spp., Diatoma spp., Melosira spp., Navicula spp., Synedra spp.* and *Thalassiosira nordenskioldii* comprised a large proportion of the biomass. *Grammatophora marina* and *Skeletonema costatum* were present and contributed little to the total biomass of the population (Table. 3. 4. 17.).

At station 9 (surface), out of a total standing crop of 11.62 x 10^3cells.l^{-1}, 86% were diatoms, 1.38% were represented by the dinoflagellate *Ceratium lineatum* and 12.5% were represented by the silicoflagellate *Dictyocha speculum.* 82.3% of the total biomass were truly planktonic species and the rest were benthic.

The diatom fraction was dominated by *Coscinodiscus spp.* (25.2% of the total biomass) and *Melosira spp.* (20.8%). Also common were *Diatoma spp.* (8.3%), *Navicula spp.* (13.88%) and *Skeletonema costatum* (11.11%). *Grammatophora marina, Pleurosigma spp.* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 17.).

At 5 metres depth, out of a total standing crop of 12.5 x 10^3cells.l^{-1}, 90.96% were diatoms and the rest were represented by the silicoflagellate *Dictyocha speculum.* 72% of the total biomass were truly planktonic species and the rest were benthic. The

Table. 3. 4. 17. The number of algal cells (l^{-1}) and their percentages, for 3rd January, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Chaetoceros sp (P)	322	3.57	-	-	-	-	-	-
Coscinodiscus spp (P)	1614	17.85	2582	23.94	2905	25.2	4101	33.37
Diatoma spp (B)	484	5.35	1452	13.43	968	8.33	968	7.75
Grammatophora marina (B)	322	3.57	322	2.98	322	2.7	484	3.87
Melosira spp (P)	-	-	1614	14.9	2421	20.83	1775	14.21
Navicula spp (B)	1452	16.07	1452	13.43	1614	13.88	2744	21.96
Pleurosigma sp (B)	-	-	-	-	161	1.38	-	-
Skeletonema costatum (P)	2905	34.82	322	2.98	1291	11.11	322	2.5
Synedra sp (B)	-	-	968	8.95	-	-	-	-
Thalassiosira nordenskioldii (P)	968	10.07	1452	13.43	322	2.7	968	7.75
Dinoflagellates								
Ceratium fusus (P)	161	1.78	-	-	-	-	-	-
Ceratium furca (P)	-	-	161	1.49	-	-	-	-
Ceratium lineatum (P)	-	-	-	-	161	1.38	-	-
Ceratium tripos (P)	322	3.57	-	-	-	-	-	-
Dinophysis acuta (P)	-	-	484	4.47	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	484	3.35	-	-	1452	12.49	1129	9.04

diatom fraction was dominated by *Coscinodiscus spp.* (33.37% of the total biomass) and *Navicula spp.* (21.96%). Also common was *Melosira spp.* (14.2%). *Diatoma spp.* and *Thalassiosira nordenskioldii* were observed frequently and each accounted for 7.75% of the total biomass. *Grammatophora marina* and *Skeletonema costatum* were present in small numbers (Table. 3. 4. 17.).

On 31st January, again the total number of algal cells remained low, with diatoms as the dominant fraction of the population. *S. costatum* was the most prominent species with the exception of samples collected from station 11, at 5 metres depth, where *Navicula spp.* and *T. nordenskioldii* were the most dominant species.

At station 11 (surface), out of a total standing crop of 11.94 x 10^3cells.l^{-1}, about 96% were diatoms and the rest of the population was represented by the silicoflagellate *Dictyocha speculum*. *S. costatum* was the most dominant species (31% of the total population), also common were *Coscinodiscus spp.* (14.86%), *Navicula spp.* (13.5%) and *T. nordenskioldii* (13.5%). *Diatoma spp., Eucampia zodiacus, Leptocylindrus danicus, Nitzschia spp.* and *Pleurosigma spp.* were present in small numbers (Table. 3. 4. 18.). 77% of the total biomass were truly planktonic species and the rest were benthic.

At 5 metres depth, out of a total standing crop of 10.65 x 10^3cells.l^{-1}, 95.5% were diatoms, 3% were dinoflagellates, which were represented by *Ceratium lineatum* and *Dinophysis acuta*, each accounted for 1.5% of the total biomass and the rest of the population was represented by the silicoflagellate *Dictyocha speculum.* 63.5% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was composed predominantly of *Navicula spp.* (27.47% of the total biomass) and *Thalassiosira nordenskioldii* (22.7%). *Coscinodiscus spp.* and *Diatoma spp.* were also common. *Achnanthes brevipes, Amphiprora paludosa, Amphiprora surirelloides, Cistula lorenziana, Grammatophora marina, Leptocylindrus danicus,*

Table. 3. 4. 18. The number of algal cells (l^{-1}) and their percentages, for 31st January, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Achnanthes brevipes (B)	-	-	161	1.5	-	-	-	-
Amphiprora paludosa (P)	-	-	161	1.5	-	-	-	-
Amphiprora surirelloides (P)	-	-	161	1.5	-	-	-	-
Biddulphia regia (P)	-	-	-	-	-	-	161	1.35
Chaetoceros sp (P)	-	-	-	-	-	-	968	8.1
Coscinodiscus spp (P)	1775	14.86	1614	15.15	807	6.57	1614	13.51
Cistula lorenziana (B)	-	-	161	1.5	-	-	-	-
Diatoma spp (B)	484	4.05	1129	10.6	1291	10.52	968	8.1
Eucampia zodiacus (P)	161	1.35	-	-	-	-	-	-
Fragilaria capucina (P)	-	-	-	-	322	2.63	322	2.7
Grammatophora marina (B)	-	-	161	1.5	-	-	161	1.35
Gyrosigma spp (B)	-	-	-	-	161	1.31	484	4.05
Leptocylindrus danicus (P)	161	1.35	161	1.5	-	-	-	-
Melosira spp (P)	807	6.75	-	-	968	7.891	1291	10.8
Navicula spp (B)	1614	13.51	2905	27.47	3066	25	1452	12.16
Nitzschia sp (B)	807	6.75	-	-	-	-	-	-
Nitzschia closterium (B)	-	-	161	1.5	322	2.63	-	-
Nitzschia obtusa (B)	-	-	-	-	161	1.31	-	-
Pleurosigma spp (B)	322	2.7	322	3	-	-	161	1.35
Rhabdonema arcuatum (B)	-	-	-	-	-	-	161	1.35
Scoliopleura tumida (P)	-	-	-	-	161	1.31	-	-
Skeletonema costatum (P)	3712	31.08	645	6.06	2098	17.18	2098	17.62
Thalassiosira nordenskioldii (P)	1614	13.51	2421	22.72	1936	15.78	1614	13.51
Dinoflagellates								
Ceratium lineatum (P)	-	-	161	1.5	-	-	-	-
Ceratium tripos (P)	-	-	-	-	-	-	322	2.7
Dinophysis acuta (P)	-	-	161	1.5	-	-	-	-
Peridinium sp (P)	-	-	-	-	161	1.31	-	-
Silicoflagellates								
Dictyocha speculum (P)	484	4.05	161	1.5	807	6.56	161	1.35

Nitzschia closterium, Pleurosigma spp. and *Skeletonema costatum* were present in small numbers (Table. 3. 4. 18.).

At station 9 (surface), out of a total standing crop of 12.3 x 10^3cells.l^{-1}, 93.4% were diatoms, 1.3% were represented by the dinoflagellate *Protoperidinium spp.* and the rest of the population was represented by the silicoflagellate *Dictyocha speculum.* 68.44% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was dominated by *Navicula spp.* (25% of the total population), *Skeletonema costatum* (17.2%) and *Thalassiosira nordenskioldii* (15.78%). *Coscinodiscus spp., Diatoma spp.* and *Melosira spp.* were observed frequently. The diatoms *Fragilaria capucina, Gyrosigma spp., Nitzschia closterium, Nitzschia obtusa* and *Scoliopleura tumida* were present in small numbers (Table. 3. 4. 18.).

At 5 metres depth, out of a total standing crop of 12 x 10^3cells.l^{-1}, 95.95% were diatoms, 2.7% were represented by the dinoflagellate *Ceratium tripos* and the rest of the population was represented by the silicoflagellate *Dictyocha speculum.* 79.74% of the total biomass were truly planktonic species and the rest were benthic.

The diatoms *Coscinodiscus spp., Melosira spp., Navicula spp., S. costatum* and *Thalassiosira nordenskioldii* comprised a large proportion of the total biomass (Table. 3. 4. 18.). Also common were *Chaetoceros spp.* and *Diatoma spp.*, each accounted for 8.1% of the total biomass. The diatoms *Biddulphia regia, Fragilaria capucina, Grammatophora marina, Gyrosigma spp., Pleurosigma spp.* and *Rhabdonema arcuatum* were present in small numbers (Table. 3. 4. 18.).

The total number of algal cells remained low on 20th February. Diatoms remained as the dominant fraction of the population. An increase in the contribution of the benthic species was observed mainly for samples collected from station 11 at both depths.

At station 11 (surface), out of a total standing crop of of 10 x 10^3cells.l^{-1}, 96.78% were diatoms and the rest of the biomass was represented by the dinoflagellates *Ceratium furca* and *C. lineatum.* 58% of the total biomass were truly planktonic species and the rest were benthic.

The diatom fraction was dominated by *Navicula spp., Thalassiosira nordenskioldii,* each accounted for 27.42% of the total biomass and *Skeletonema costatum* (16%). The diatoms *Diatoma spp.* and *Nitzschia bilobata* were frequent. *Coscinodiscus spp., Grammatophora marina, Pinnularia ambigua* and *Pleurosigma spp.* were present in small numbers (Table. 3. 4. 19.).

At 5 metres depth, out of a total standing crop of 10 x 10^3cells.l^{-1}, 9% were diatoms, 3% were represented by the dinoflagellates *Ceratium lineatum* and *Peridinium spp.* and the rest of the population was represented by the silicoflagellate *Dictyocha speculum.*

The diatom fraction was dominated by *S. costatum* (35.7% of the total biomass) and *Thalassiosira nordenskioldii* (29.6%). Also common was *Navicula spp.* (18.36% of the total quantity). The diatoms *Biddulphia aurita, Diatoma spp., Nitzschia bilobata* and *Pleurosigma spp.* were present in small numbers (Table. 3. 4. 19.).

At station 9 (surface), out of a total standing crop of 19.85 x 10^3cells.l^{-1}, 97.56% were diatoms and the rest of the biomass was represented by the silicoflagellate *Dictyocha speculum.* 80.5% of the total biomass were truly planktonic species and the rest were benthic.

The diatom fraction was dominated by *Skeletonema costatum* (38.3% of the total biomass) and *Thalassiosira nordenskioldii* (22.76%). Also common was *Navicula spp.* which accounted for 15.44% of the total quantity. The diatoms *Biddulphia aurita, Coscinodiscus spp., Diatoma spp., Grammatophora marina, Melosira spp.,*

Table. 3. 4. 19. The number of algal cells (l^{-1}) and their percentages, for 20th February, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Biddulphia aurita (P)	-	-	161	1.02	484	2.44	-	-
Coscinodiscus spp (P)	322	3.22	-	-	645	3.25	807	2.97
Diatoma spp (B)	807	8.06	807	5.1	807	4.06	322	1.19
Diploneis crabro (P)	-	-	-	-	-	-	161	0.59
Grammatophora marina (B)	161	1.61	-	-	161	0.81	322	1.19
Melosira spp (P)	-	-	-	-	1452	7.3	14365	52.97
Navicula spp (B)	2744	27.42	2905	18.36	3066	15.44	3066	11.31
Nitzschia bilobata (B)	968	9.67	645	4.08	161	0.81	-	-
Niztschia closterium (B)	-	-	-	-	322	1.62	161	0.59
Pinnularia ambigua (B)	161	1.61	-	-	-	-	-	-
Pleurosigma spp (B)	161	1.61	161	1.02	161	0.81	161	0.59
Skeletonema costatum (P)	1614	16.16	5649	35.73	7586	38.26	968	3.56
Thalassiosira nordenskioldii (P)	2744	27.48	4680	29.59	4519	22.76	6133	22.66
Dinoflagellates								
Ceratium furca (P)	161	1.61	-	-	-	-	-	-
Ceratium lineatum (P)	161	1.61	322	2.04	-	-	-	-
Peridinium sp (P)	-	-	161	1.02	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	-	-	322	2.04	484	2.44	645	2.38

Nitzschia bilobata, N. closterium and *Pleurosigma spp.* were present in small numbers (Table. 3. 4. 19.).

At 5 metres depth, out of a total standing crop of 27 x 10^3cells.l^{-1}, 97.6% were diatoms and the rest of the population was represented by the silicoflagellate *Distephanus speculum.* 86.3% of the total biomass were truly planktonic species and the rest were benthic.

Melosira spp. was by far the dominant species, being present in numbers of 14.36 x 10^3cells.l^{-1}, which accounted for 53% of the total biomass, ranking second in terms of biomass was *T. nordenskioldii* (22.66% of the total population). Also common was *Navicula spp.* (11.3%). The diatoms *Coscinodiscus spp., Diatoma spp., Diploneis crabro, Grammatophora marina, Nitzschia closterium, Pleurosigma spp.* and *Skeletonema costatum* were present in small numbers (Table. 3. 4. 19.).

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A gradual increase in the total number of algal cells was observed, with the maximum for this study recorded on 3rd April for samples collected from the surface at station 9. For samples collected from 5 metres depth at station 9 and from station 11 at surface and 5 metres depth, the maximum numbers of algal cells were observed on 29th March. Diatoms were the dominant fraction of the population, with *Skeletonema costatum* as the dominant species.

On 6th March, at station 11 (surface), the algal biomass was 133.97 x 10^3cells.l^{-1}, of which 96.64% were truly planktonic species and the rest benthic. The population was almost entirely made up of diatoms (99.76% of the total biomass), and the rest of the population was represented by the silicoflagellate *Dictyocha speculum.* The diatom fraction was dominated by *Skeletonema costatum* (66% of the total biomass), ranked

second in terms of biomass was *Leptocylindrus danicus* which represented 27.47%. Also present were *Coscinodiscus spp., Cocconeis disculus, Diatoma spp., Grammatophora marina, Nitzschia spp., Nitzschia bilobata, Synedra spp., Thalassiosira decipiens* and *T. nordenskioldii* (Table. 3. 4. 20.).

At 5 metres depth, the total number of algal cells was 109 x 10^3cells.l^{-1}, of which 97.36% were truly planktonic species and the rest were benthic. Diatoms were dominant (99.4% of the total biomass). The diatom *Leptocylindrus danicus* (51.9%) succeeded *Skeletonema costatum* (36.3%) as the dominant species. The diatoms *Achnanthes longipes, Coscinodiscus spp., Cocconeis disculus, Diatoma spp., Navicula spp., Nitzschia bilobata, Synedra spp, Thalassiosira decipiens* and *T. nordenskioldii* were present in small numbers not exceeding 6.6 x 10^3cells.l^{-1} (Table. 3. 4. 20.). The silicoflagellate *Dictyocha speculum* was also present in small numbers.

At station 9 (surface), the population was made up entirely of diatoms. The algal biomass was 161.4 x 10^3cells.l^{-1}, of which 99.44% were truly planktonic species and the remainder were benthic.

The population was dominated by *S. costatum* (49.4% of the total biomass) and *Leptocylindrus danicus* (33%). The diatom *Biddulphia aurita* was frequent. The diatoms *Coscinodiscus spp., Cocconeis disculus, Melosira spp., Melosira nummuloides, Navicula spp., Navicula distans, Nitzschia spp., Nitzschia bilobata, Pleurosigma spp., Synedra spp., T. decipiens* and *T. nordenskioldii* were present in very small numbers (Table. 3. 4. 20.).

At 5 metres depth, again diatoms represented 100% of the biomass. The total number of algal cells was 154.2 x 10^3cells.l^{-1}, of which 96.6% were truly planktonic species and the rest were benthic. *Skeletonema costatum* was dominant (60% of the total biomass), ranked second in terms of biomass was *Leptocylindrus danicus* (23.65%).

Table. 3. 4. 20. The number of algal cells (l^{-1}) and their percentages, for 6th March, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Achnanthes longipes (B)	-	-	322	0.29	-	-	-	-
Biddulphia aurita (P)	-	-	-	-	11298	7	6456	4.18
Coscinodiscus spp (P)	322	0.24	645	0.59	968	0.59	1936	1.25
Cocconeis disculus (B)	322	0.24	322	0.29	322	0.2	1209	0.78
Diatoma spp (B)	322	0.24	645	0.59	-	-	-	-
Grammatophora marina (B)	322	0.24	-	-	-	-	-	-
Gyrosigma sp (B)	-	-	-	-	-	-	322	0.209
Leptocylindrus danicus (P)	36802	27.47	56817	51.99	53326	33	36479	23.65
Melosira sp (P)	-	-	-	-	2905	1.8	-	-
Melosira nummuloides (P)	-	-	-	-	1291	0.8	-	-
Navicula spp (B)	-	-	645	0.59	645	0.39	1936	1.25
Navicula distans (B)	-	-	-	-	322	0.2	-	-
Nitzschia spp (B)	1614	1.2	-	-	645	0.4	-	-
Nitzschia bilobata (B)	645	0.48	968	0.88	3228	1.99	1936	1.25
Pleurosigma sp (B)	-	-	645	0.39	-	-	-	-
Skeletonema costatum (P)	88454	66.05	39707	36.38	79738	49.39	92651	60.12
Synedra spp	1936	1.44	968	0.88	1936	1.19	645	0.42
Thalassiosira decipiens (P)	645	0.48	6617	6.05	1291	0.8	7425	4.8
Thalassiosira nordenskioldii (P)	2259	1.68	968	0.88	2905	1.8	3228	2.09
Silicoflagellates								
Dictyocha speculum (P)	322	0.24	645	0.59	-	-	-	-

The diatom *Biddulphia aurita* was frequent. The diatoms *Coscinodiscus spp., Cocconeis disculus, Gyrosigma spp., Navicula spp., Nitzschia bilobata, Synedra spp., Thalassiosira decipiens* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 20.).

On March 13th a further increase in the total numbers of algal cells was observed. Diatoms remained as the dominant fraction of the population with *Leptocylindrus danicus* and *S. costatum* as the dominant species.

At station 11 (surface), the total number of algal cells was 503.3 x 10^3cells.l^{-1}, of which 99.53% were truly planktonic species and the rest were benthic, Diatoms were dominant (99.74% of the total biomass). *Leptocylindrus danicus* 51.6%) and *S. costatum* (45.3%) were dominant. The diatoms *Coscinodiscus spp., Isthmia enervis, N. bilobata, Synedra spp., T. decipiens* and *T. nordenskioldii* were present in small numbers not exceeding 7 x 10^3cells.l^{-1} (Table 21). Also observed in very small numbers was the dinoflagellate *Ceratium lineatum* (0.06%) and the silicoflagellate *Dictyocha speculum* (0.02%).

At 5 metres depth, the population was made up entirely of diatoms. The total number of diatom cells was 568.2 x 10^3cells.l^{-1}, of which (0.44% were truly planktonic species and the rest were benthic. *Skeletonema costatum* was the dominant species being present in numbers of 367.7 x 10^3cells.l^{-1}, which accounted for 64.7% of the total biomass, ranking second in terms of biomass was *Leptocylindrus danicus* (32%). The diatoms *Coscinodiscus spp., Cocconeis disculus, Navicula spp., Nitzschia bilobata, Synedra spp.* and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 21.).

At station 9(surface), the total algal biomass was 509 x 10^3cells.l^{-1}, of which 99.56% were truly planktonic species and the rest were benthic. The population was almost

Table. 3. 4. 21. The number of algal cells (l^{-1}) and their percentages, for 13th March, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	1129	0.22	1936	0.34	2582	0.5	1291	0.28
Cocconeis disculus (B)	-	-	322	0.056	-	-	322	0.069
Diatoma sp (B)	-	-	-	-	322	0.063	-	-
Isthmia enervis (B)	161	0.032	-	-	-	-	-	-
Leptocylindrus danicus (P)	259875	51.63	182074	32.04	120737	23.71	141075	30.49
Melosira sp (P)	-	-	-	-	968	0.19	-	-
Navicula spp (B)	-	-	645	0.11	645	0.12	645	0.139
Nitzschia bilobata (B)	1291	0.25	1936	0.34	1291	0.25	1614	0.348
Pleurosigma sp (B)	-	-	-	-	322	0.063	-	-
Skeletonema costatum (P)	227916	45.314	367700	64.734	375770	73.591	307977	66.585
Synedra spp (B)	968	0.19	645	0.11	-	-	322	0.069
Thalassiosira decipiens (P)	3551	0.7	-	-	-	-	-	-
Thalassiosira nordenskioldii (P)	7102	1.41	12913	2.27	7425	1.45	9361	2.02
Dinoflagellates								
Ceratium lineatum (P)	322	0.064	-	-	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	968	0.19	-	-	322	0.063	-	-

entirely made up of diatoms (99.9% of the total biomass), of which *S. costatum* was by far the dominant species, being present in numbers of 375.7 x 10^3cells.l^{-1}, which accounted for 73.6% of the total biomass, ranking second in terms of biomass was *Leptocylindrus danicus* (23.7%). The diatoms *Coscinodiscus spp., Diatoma spp., Melosira spp., Navicula spp., Nitzschia bilobata, Pleurosigma spp.* and *T. nordenskioldii* were observed in small numbers (Table. 3. 4. 21.). Also present in small numbers was the silicoflagellate *Dictyocha speculum* (0.06% of the total quantity).

At 5 metres depth, the population was made up entirely of diatoms. The total number of diatom cells was 462.6 x 10^3cells.l^{-1}, of which 99.44% were truly planktonic species and the rest were benthic. *Skeletonema costatum* was the dominant species, being present in numbers of 307 x 10^3cells.l^{-1}, which accounted for 66.58% of the total biomass, ranking second in terms of biomass was *Leptocylindrus danicus* (30.5%). The diatoms *Coscinodiscus spp., Cocconeis disculus, Navicula spp., Nitzschia bilobata, Synedra spp.* and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 21.).

A further increase in the total number of algal cells was observed on 20th March. The population was made up entirely of diatoms, with *S. costatum* as the dominant species.

At station 11 (surface), the total number of diatom cells was 1990.5 x 10^3cells.l^{-1} ,of which 99.87% were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species, being present in numbers of 1952 x 10^3cells.l^{-1}, which accounted for 98.07% of the total biomass. The diatoms *Coscinodiscus spp., Leptocylindrus danicus, Navicula spp., N. bilobata, Synedra spp., T. decipiens* and *T. nordenskioldii* were present in small numbers, each contributing little to the total quantity (Table. 3. 4. 22.). At 5 metres depth, the total number of diatom cells was 2844 x 10^3cells.l^{-1}, of which 99.93% were truly planktonic species and the rest were

Table. 3. 4. 22. The number of algal cells (l^{-1}) and their percentages, for 20th March, are summarised in the following tables.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	12267	0.616	14850	0.52	9039	0.426	19046	0.62
Cocconeis disculus (B)	-	-	322	0.011	-	-	-	-
Leptocylindrus danicus (P)	6133	0.308	-	-	7747	0.365	2582	0.085
Navicula spp (B)	1614	0.081	322	0.011	-	-	-	-
Nitzschia bilobata (B)	645	0.032	1291	0.045	968	0.045	322	0.01
Pleurosigma sp (B)	-	-	322	0.011	-	-	-	-
Skeletonema costatum (P)	1952136	98.07	2805369	98.63	2084495	98.32	2996805	98.665
Synedra spp (B)	322	0.016	-	-	322	0.015	322	0.01
Thalassiosira decipiens (P)	1291	0.06	5582	0.09	645	0.03	645	0.02
Thalassiosira nordenskioldii (P)	16141	0.81	19046	0.67	16787	0.79	18078	0.59

benthic. *Skeletonema costatum* was by far the dominant species, being present in numbers of 2805.3 x 10^3cells.l^{-1}, which accounted for 98.6% of the total biomass. The diatoms *Coscinodiscus spp., Cocconeis disculus, Navicula spp., Nitzschia bilobata, Pleurosigma spp., Thalassiosira decipiens* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 22.).

At station 9 (surface), the total number of diatom cells was 2120 x 10^3cells.l^{-1}, of which 99.9% were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species, being present in numbers of 2084.5 x 10^3cells.l^{-1}, which accounted for 98% of the total population. *Coscinodiscus spp., Leptocylindrus danicus, N. bilobata, Synedra spp., T. decipiens* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 22.).

At 5 metres depth, the total number of diatom cells was 3037.8 x 10^3cells.l^{-1}, of which 99.98% were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species, being present in numbers of 2996.8 x 10^3cells.l^{-1}, which accounted for 98.7% of the total quantity. *Coscinodiscus spp., Leptocylindrus danicus, Synedra spp., T. decipiens* and *T. nordenskioldii* were present in small numbers.

The total number of algal cells on March 29th increased to a maximum at surface and 5 metres at station 11, for samples collected at station 9 the increase was only observed for samples collected from surface, while a decrease in the total number of algal cells was observed for samples collected from 5 metres depth. The population was made up entirely of diatoms, of which *Skeletonema costatum* was the dominant species.

At station 11 (surface), the total number of diatom cells was 2102 x 10^3cells.l^{-1}, of which 99.94% were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species, being present in numbers of 2087 x 10^3cells.l^{-1}, which accounted for 99.3% of the total biomass. The diatoms *Chaetoceros spp.,*

Table. 3. 4. 23. The number of algal cells (l^{-1}) and their percentages, for 29th March, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Chaetoceros spp (P)	1614	0.07	-	-	-	-	3551	0.12
Coscinodiscus spp (P)	9039	0.43	6456	0.26	9684	0.35	10976	0.38
Cocconeis disculus (B)	-	-	322	0.013	-	-	-	-
Diatoma sp (B)	322	0.015	-	-	-	-	-	-
Gyrosigma sp (B)	-	-	322	0.013	-	-	-	-
Melosira sp (P)	-	-	-	-	-	-	3228	0.11
Navicula spp (B)	322	0.015	-	-	322	0.01	645	0.022
Nitzschia bilobata (B)	322	0.015	-	-	-	-	-	-
Pleurosigma spp (B)	322	0.015	-	-	645	0.023	-	-
Skeletonema costatum (P)	2087401	99.30	2414102	99.35	2743386	99.43	2849919	99.217
Synedra spp (B)	322	0.015	645	0.026	645	0.023	322	0.011
Thalassiosira decipiens (P)	968	0.046	645	0.026	968	0.035	-	-
Thalassiosira nordenskioldii (P)	1614	0.07	7425	0.305	3551	0.128	4196	0.14

Coscinodiscus spp., Diatoma spp., Navicula spp., Nitzschia bilobata, Pleurosigma spp., Synedra spp., Thalassiosira decipiens and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 23.).

At 5 metres depth, the total number of diatom cells was 2430 x 10^3cells.l^{-1}, of which 99.9% were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species, being present in numbers of 2414 x 10^3cells.l^{-1}, which accounted for 99.35% of the total population. *Coscinodiscus spp., Cocconeis disculus, Gyrosigma spp., Synedra spp., T. decipiens* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 23.).

At station 9 (surface), the total number of diatom cells was 2759 x 10^3cells.l^{-1}, of which 99.94% were truly planktonic species and the rest were benthic. *Skeletonema costatum* was by far the dominant species, being present in numbers of 2743 x 10^3cells.l^{-1}, which accounted for 99.4% of the total biomass. *Coscinodiscus spp., Navicula spp., Synedra spp., Thalassiosira decipiens* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 23.).

At 5 metres depth, the total number of diatom cells was 2872.8 x 10^3cells.l^{-1}, of which 99.96% were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species, being present in numbers of 2849.9 x 10^3cells.l^{-1}, which accounted for 99.2% of the total population. The diatoms *Chaetoceros spp., Coscinodiscus spp., Melosira spp., Nitzschia bilobata, Synedra spp.* and *T. nordenskioldii* were observed in small numbers (Table. 3. 4. 23.).

On April 3rd, the total number of algal cells decreased at station 11 at both surface and 5 metres depth. A similar decrease in the total number of algal cells was recorded for samples collected from 5 metres depth at station 9. A maximum total number of algal cells for the spring was recorded for samples collected from surface at station 9.

Diatoms dominated the population both numerically and also in terms of biomass, *Skeletonema costatum* was by far the dominant organism.

At station 11 (surface), the total algal biomass was 1413 x 10^3cells.l^{-1}, which was made up entirely of diatoms, of which 99.7% were truly planktonic species and the rest were benthic. *Skeletonema costatum* with long chains was dominant which represented (97.5% of the biomass). Other organisms present included the diatoms *Chaetoceros spp., Coscinodiscus spp., Grammatophora marina, Navicula spp., Nitzschia bilobata, Synedra spp., Thalassiosira decipiens* and *T. nordenskioldii* (Table. 3. 4. 24.).

At 5 metres depth the total number of algal cells was 1282.6 x 10^3cells.l^{-1}. The population was made up entirely of diatoms of which 99.7% were truly planktonic species and the rest were benthic. *Skeletonema costatum* was by far the dominant diatom, being present in numbers of 1250.6 x 10^3cells.l^{-1}, which represented 97.5% of the population. Other organisms present included the diatoms *Chaetoceros spp., Coscinodiscus spp., Diatoma spp., Navicula spp., Nitzschia bilobata, Synedra spp.* and *Thalassiosira nordenskioldii* (Table. 3. 4. 24.).

At station 9 (surface), the total number of algal cells was 514 x 10^3cells.l^{-1}. Diatoms represented 99.9% of the total algal cells of which 98.6% were truly planktonic species and 1.25% were benthic.

Skeletonema costatum was by far the dominant diatom, being present in numbers of 475 x 10^3cells.l^{-1} which represented 92% of the total biomass. Other organisms present in small numbers included the diatoms *Achnanthes longipes, Chaetoceros spp., Coscinodiscus spp., Fragilaria spp., Grammatophora marina, Navicula spp., Nitzschia bilobata, Pleurosigma spp., Synedra spp., Thalassiosira decipiens* and *T. nordenskioldii* (Table. 3. 4. 24.).

Table. 3. 4. 24. The number of algal cells (l^{-1}) and their percentages, for 3rd April, are summarised in the following tables.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Achnanthes longipes (B)	-	-	-	-	322	0.062	322	0.078
Chaetoceros spp (P)	6133	0.43	1291	0.1	1614	0.314	-	-
Coscinodiscus spp	9039	0.64	8716	0.67	6779	1.32	6779	1.64
Diatoma spp (B)	-	-	322	0.025	-	-	322	0.078
Fragilaria spp (P)	-	-	-	-	322	0.062	322	0.078
Grammatophora marina (B)	645	0.045	-	-	322	0.062	-	-
Navicula spp (B)	1291	0.09	2582	0.2	3228	0.628	1614	0.4
Nitzschia bilobata (B)	645	0.045	322	0.025	968	0.188	322	0.078
Pleurosigma spp (B)	-	-	-	-	322	0.062	322	0.078
Skeletonema costatum (P)	1378149	97.5	1250632	97.5	475201	92.46	385132	93.34
Synedra spp (B)	968	0.068	968	0.075	1291	0.25	645	0.156
Thalassiosira decipiens (P)	645	0.045	-	-	322	0.062	-	-
Thalassiosira nordenskioldii (P)	15495	1.1	17755	1.38	22920	4.46	16787	4.06
Silicoflagellates								
Dictyocha speculum (P)	-	-	-	-	322	0.062	-	-

The planktonic silicoflagellate *Dictyocha speculum* was present in very small numbers, representing 0.06% of the total population. At 5 metres depth, the total number of algal cells was 412 x 10^3cells.l^{-1}, the population was made up entirely of diatoms of which 99% were truly planktonic species and the rest were benthic. *Skeletonema costatum* was by far the dominant diatom, being present in numbers of 385 x 10^3cells.l^{-1} which represented 93% of the total population. Other organisms present included the diatoms *Achnanthes longipes, Coscinodiscus spp., Diatoma spp., Fragilaria spp., Navicula spp., Nitzschia bilobata, Pleurosigma spp., Synedra spp.* and *Thalassiosira nordenskioldii.*

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On September 19th, the total number of algal cells was 188 x 10^3cells.l^{-1} at station 11 (surface). The population was made up entirely of truly planktonic species. Diatoms were dominant, representing 87% of the total biomass,of which by far the most dominant species was *Skeletonema costatum* (70.5%). Also common, *Thalassiosira nordenskioldii* (15%). The diatom *Coscinodiscus spp.* was observed in very small numbers (Table. 3. 4. 25.).

Dinoflagellates represented 10.9% of the population of which the dominant species was *Ceratium lineatum* (9.9%). Other dinoflagellates observed were *C. fusus, C. furca* and *C. tripos* (Table. 3. 4. 25.). The silicoflagellate *Dictyocha speculum* represented 1.7% of the population.

At 5 metres depth the total number of algal cells was 138 x 10^3cells.l^{-1}. 99.54% of the total algal cells were truly planktonic species and the rest were benthic, represented by the only benthic diatom present, *Navicula spp.* Diatoms were dominant representing 90% of the total biomass of which by far the most dominant species was *Skeletonema costatum* (73%). The diatoms *Chaetoceros spp., Coscinodiscus spp., Melosira spp.,*

Table. 3. 4. 25. The number of algal cells (l^{-1}) and their percentages, for 19th September, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Chaetoceros spp (P)	-	-	4519	3.25	-	-	3551	2.9
Coscinodiscus spp (P)	3228	1.7	10976	7.9	7102	3.82	3873	3.2
Melosira sp (P)	-	-	2582	1.86	-	-	-	-
Navicula spp (B)	-	-	645	0.46	322	0.17	-	-
Skeletonema costatum (P)	133004	70.5	101367	73.02	134296	72.34	82643	68.08
Thalassiosira nordenskioldii (P)	28408	15.06	5165	3.72	13558	7.3	18723	15.4
Dinoflagellates								
Ceratium fusus (P)	322	0.17	645	0.46	1936	1.04	1936	1.59
Ceratium furca (P)	645	0.34	1291	0.93	-	-	1291	1.06
Ceratium lineatum (P)	18723	9.93	2582	1.86	21306	11.47	3228	2.66
Ceratium tripos (P)	968	0.51	5810	4.18	4519	2.43	2582	2.12
Silicoflagellates								
Dictyocha speculum (P)	3228	1.7	3228	2.32	2582	1.4	6456	5.32

Navicula spp. and *Thalassiosira nordenskioldii* were observed in much smaller numbers (Table. 3. 4. 25.). The dinoflagellate fraction made up 7.4% of the total biomass of which the common species was *Ceratium tripos* (4.2%). The dinoflagellates *C. fusus, C. furca* and *C. lineatum* were observed in much smaller numbers (Table. 3. 4. 25.). The silicoflagellate *Dictyocha speculum* represented 2% of the total quantity.

At station 9 (surface), the total algal biomass was 185 x 10^3cells.l^{-1}, of which 99.8% were truly planktonic species. The only benthic species observed was *Navicula spp.* (0.2%). Diatoms were dominant representing 83.6% of the total biomass, of which by far the most dominant species was *Skeletonema costatum* (72%), next in abundance was *Thalassiosira nordenskioldii* (7.3%). The diatom *Coscinodiscus spp.* was observed in small numbers (3.8%). The dinoflagellate population represented 15% of the total biomass, which was mostly dominated by the species *Ceratium lineatum* (11.4%), the species *C. fusus, C. furca* and *C. tripos* were observed in small numbers (Table. 3. 4. 25.). The silicoflagellate *Dictyocha speculum* represented 1.4% of the total population.

At 5 metres depth the total number of algal cells was 121.4 x 10^3cells.l^{-1}. The population was made up entirely of truly planktonic species. Diatoms were dominant representing 87.2% of the total biomass of which by far the most dominant species was *Skeletonema costatum* (68%). Also common, *Thalassiosira nordenskioldii* (15.4%). The diatoms *Chaetoceros spp.* and *Coscinodiscus spp.* were recorded in very small numbers (Table. 3. 4 25.). The dinoflagellate population, including *Ceratium fusus, C. furca, C. lineatum* and *C. tripos* represented 7.4% of the total population. The silicoflagellate *Dictyocha speculum* represented 5% of the total quantity. At the date of sampling there were 6.9 hours of sunshine.

On 30th October, there is a sharp decrease in the total number of algal cells. For samples collected from the surface at both stations (11) and (9), dinoflagellates succeeded diatoms as the dominant population, while for 5 metres samples, the diatoms remained as the dominant fraction.

At station 11 (surface), of a total standing crop of 81.5 x 10^3cells.l^{-1}, about 40.6% were diatoms, 51.5% were dinoflagellates. The rest of the population was represented by the silicoflagellate *Dictyocha speculum.* The population was made up entirely of truly planktonic species. The diatom fraction was composed predominantly of cells of *Coscinodiscus spp.* (39.6%). The diatom *Melosira spp.* was observed in very small numbers (Table. 3. 4. 26.). The dinoflagellate fraction was composed predominantly of *Ceratium lineatum* (43%). The dinoflagellates *Ceratium extensum, C. fusus, C. furca* and *C. tripos* comprised a small proportion of the total biomass (Table. 3. 4. 26.).

At 5 metres depth, the total number of algal cells was 41 x 10^3cells.l^{-1}, of which 83.3% were diatoms, 10.4% were dinoflagellates and the rest was represented by the silicoflagellate *Dictyocha speculum.* The population was made up entirely of truly planktonic species. The diatom fraction was comprised predominantly of cells of *Coscinodiscus spp.* (83.6%). The diatom *Thalassiosira nordenskioldii* was observed in very small numbers (Table. 3. 4. 26.). The dinoflagellate fraction was represented by *Ceratium fusus* (2.6%) and *C. lineatum* (7.8%).

At station 9 (surface), of a total standing crop of 68.8 x 10 ^{3}cells.l^{-1}, about 38% were diatoms, 53% were dinoflagellates. The rest of the population was represented by the silicoflagellate *Dictyocha speculum.* The population was made up entirely of truly planktonic species. The diatom fraction was dominated by *Coscinodiscus spp.* (24%). Also common were *Melosira spp.* and *Skeletonema costatum* . The diatom *Thalassiosira nordenskioldii* was observed in very small numbers (Table. 3. 4. 26.).

Table. 3. 4 26. The number of algal cells (l^{-1}) and their percentages, for 30th October, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	32282	39.6	34434	83.66	16679	24.2	17217	92.7
Diatoma sp (B)	-	-	-	-	269	-	-	-
Melosira spp (P)	8	0.99	-	-	3766	5.46	-	-
Skeletonema costatum (P)	-	-	-	-	5380	7.8	-	-
Thalassiosira nordenskioldii (P)	-	-	269	0.65	269	0.39	-	-
Dinoflagellates								
Ceratium extensum (P)	538	0.66	-	-	-	-	-	-
Ceratium fusus (P)	3228	3.96	1076	2.61	1614	2.43	-	-
Ceratium furca (P)	538	0.66	-	-	-	-	-	-
Ceratium lineatum (P)	35511	43.56	3228	7.84	34972	50.78	807	4.34
Ceratium tripos (P)	2152	2.64	-	-	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	6456	7.92	2152	5.22	5918	8.6	538	2.89

The dinoflagellate fraction was comprised predominantly of *Ceratium lineatum* (50.7% of the total biomass). The dinoflagellate *Ceratium fusus* comprised a small proportion of the total population (Table. 3. 4. 26.).

At 5 metres depth, the total number of algal cells was 18.5 x 10^3cells.l^{-1}, which was dominated by the only diatom present *Coscinodiscus spp.* (92.7%). The dinoflagellate *Ceratium lineatum* represented 4.3% of the total population. The rest of the population was made up by the silicoflagellate *Dictyocha speculum.*

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This period of low phytoplankton biomass was dominated by diatoms of which most were truly planktonic species. The most dominant species during this period was *Coscinodiscus spp.* Also common were *Melosira spp., Navicula spp.* and *Skeletonema costatum.* Green flagellates succeeded diatoms as the dominant fraction of the population on 12th February.

On 11th November, at station 11 (surface), the algal biomass was 51 x 10^3cells.l^{-1}, of which 96% were truly planktonic species and the rest were benthic. Diatoms dominated the population (59% of the total biomass), *Coscinodiscus spp.* was by far the dominant organism, being present in numbers of 24.7 x 10^3cells.l^{-1} (48%). Also present in numbers were *Diatoma spp., Melosira spp.* and *Skeletonema costatum,* (2.1% of the total biomass each). Other diatoms such as *Grammatophora marina, Navicula spp., Navicula distans, Pleurosigma spp., Rhabdonema arcuatum, Synedra* and *Thalassiosira nordenskioldii* were present, but each alone contributed very little to the total biomass of the population (Table. 3. 4. 27.).

Table. 3. 4. 27. The number of algal cells (l^{-1}) and their percentages, for 11th November, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	24750	48.4	104380	90.65	38739	52.94	128154	92.07
Diatoma spp (B)	1076	2.1	-	-	807	1.1	-	-
Grammatophora marina (B)	538	1.05	269	0.23	-	-	-	-
Melosira sp (P)	1076	2.1	-	-	-	-	-	-
Navicula spp (B)	27	0.52	1076	0.93	538	0.73	2152	1.54
Navicula distans (B)	269	0.52	269	0.23	-	-	-	-
Pleurosigma sp (B)	269	0.52	-	-	-	-	-	-
Rhabdonema arcuatum (B)	269	0.52	-	-	-	-	-	-
Rhizosolenia sp (P)	-	-	-	-	-	-	538	0.38
Skeletonema costatum (P)	1076	2.1	1345	1.16	807	1.1	3497	2.5
Synedra sp (B)	269	0.52	-	-	-	-	-	-
Thalassiosira nordenskioldii (P)	269	0.52	269	0.23	269	0.36	538	0.38
Dinoflagellates								
Ceratium fusus (P)	269	0.52	269	0.23	538	0.73	-	-
Ceratium furca (P)	-	-	-	-	269	0.36	-	-
Ceratium lineatum (P)	12913	25.26	807	0.7	24750	33.8	-	-
Ceratium tripos (P)	269	0.52	-	-	269	0.36	-	-
Silicoflagellates								
Dictyocha speculum (P)	7532	14.7	6456	5.6	5918	8.08	4304	3.1

The dinoflagellate fraction (26% of the total biomass) was dominated by *Ceratium lineatum* (25.3%). The dinoflagellates *Ceratium fusus* and *C. tripos* were observed in very small numbers (Table. 3. 4. 27.).

The silicoflagellate *Dictyocha speculum* represented 14.7% of the total population.

At 5 metres depth, the total number of algal cells was 115 x 10^3cells.l^{-1}, of which 98% were truly planktonic species and the rest were benthic. Diatoms dominated the population (93% of the total biomass), *Coscinodiscus spp.* was by far the dominant organism, being present in numbers of 104 x 10^3cells.l^{-1} (90.6%). Also present in numbers was *Skeletonema costatum.* The diatoms *Grammatophora marina, Navicula spp., Navicula distans* and *Thalassiosira nordenskioldii* were present in very small numbers (Table. 3. 4. 27.). The contribution of the dinoflagellate fraction to the total biomass at 5 metres depth was much smaller than at surface (0.93%). The two dinoflagellate species observed were *Ceratium fusus* and *Ceratium lineatum* (Table. 3. 4. 27.). The silicoflagellate *Dictyocha speculum* represented 5.6% of the total population.

At station 9 (surface), the total number of algal cells was 73 x 10^3cells.l^{-1}, of which 99.3% were truly planktonic species and the rest were benthic. Diatoms were dominant, accounting for 55.6% of the total biomass. *Coscinodiscus spp.* was by far the dominant organism (53%), ranking second in terms of biomass was *Diatoma spp.* with *Skeletonema costatum* . The diatoms *Navicula spp.* and *Thalassiosira nordenskioldii* were present in small numbers not exceeding 0.5 x 10^3cells.l^{-1} and contributed little to the total biomass (Table. 3. 4. 27.).

The dinoflagellate fraction represented 35% of the total biomass and was dominated by *Ceratium lineatum* (33.8%). The dinoflagellates *Ceratium fusus, Ceratium furca* and

Ceratium tripos were observed in much smaller numbers (Table. 3. 4. 27.). The silicoflagellate *Dictyocha speculum* represented 8% of the total population.

At 5 metres depth, the total number of algal cells was 139 x 10^3cells.l^{-1} of which 98% were truly planktonic species and the rest were benthic.

Diatoms dominated the population (90% of the total biomass), *Coscinodiscus spp.* was by far the dominant organism, being present in numbers of 128 x 10^3cells.l^{-1} (92%). The diatoms *Navicula spp., Rhizosolenia spp., Skeletonema costatum* and *Thalassiosira nordenskioldii* were present in much smaller numbers (Table. 3. 4. 27.). The silicoflagellate *Dictyocha speculum* represented 3.1% of the total biomass.

On 25th November, the total number of algal cells remained low, not exceeding 20.9 x 10^3cells.l^{-1}. Diatoms were again dominant.

At station 11(surface), the total number of algal cells was 20.9 x 10^3cells.l^{-1}, of which 99.2% were truly planktonic species and the rest were benthic. Diatoms dominated the population (90.7% of the total biomass), *Coscinodiscus spp.* was by far the dominant organism, being present in numbers of 16.7 x 10^3cells.l^{-1} (80%). The diatoms *Diatoma spp., Melosira spp., Navicula spp.* and *Skeletonema costatum* were present in small numbers not exceeding 0.97 x 10^3cells.l^{-1} (Table. 3. 4. 28.). The silicoflagellate *Dictyocha speculum* represented 9.2% of the total quantity.

At 5 metres depth, the algal biomass was 8.8 x 10^3cells.l^{-1}, of which 96% were truly planktonic species and the rest were benthic. Diatoms dominated the population (96.4% of the total biomass) and the rest was represented by the silicoflagellate *Dictyocha speculum.* The diatom *Coscinodiscus spp.* was by far the dominant species (65.5%), ranking next in terms of biomass was *Skeletonema costatum* (12.7%). The diatoms *Cocconeis disculus, Diatoma spp., Gyrosigma spp., Melosira spp., Pinnularia*

Table. 3. 4. 28. The number of algal cells (l^{-1}) and their percentages, for 25th November, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Chaetoceros sp (P)	-	-	-	-	-	-	807	4.27
Coscinodiscus spp (P)	16787	80	5810	65.45	5810	50.7	12267	64.95
Cocconeis disculus (B)	-	-	161	1.82	-	-	161	0.85
Diatoma spp (B)	484	2.3	322	3.63	322	2.8	-	-
Fragilaria spp (P)	-	-	-	-	484	4.2	322	1.71
Gyrosigma spp (P)	-	-	161	1.82	161	1.41	1614	8.54
Navicula spp (B)	161	0.77	-	-	161	1.4	807	4.27
Nitzschia seriata (P)	-	-	-	-	645	5.6	-	-
Pinnularia rectangulata (B)	-	-	161	1.82	-	-	-	-
Pleurosigma sp (B)	-	-	-	-	-	-	161	0.85
Rhabdonema arcuatum (B)	-	-	-	-	161	1.4	-	-
Skeletonema costatum (P)	645	3.07	1129	12.72	2744	23.94	1614	8.54
Thalassiosira nordenskioldii (P)	-	-	484	5.45	-	-	484	2.56
Dinoflagellates								
Ceratium lineatum (P)	-	-	-	-	161	1.4	-	-
Silicoflagellates								
Dictyocha speculum (P)	1936	9.2	484	5.45	807	7.00	645	3.41

rectangulata and *T. nordenskioldii* were present in small numbers not exceeding 0.48 x 10^3cells.l^{-1} (Table. 3. 4. 28.).

At station 9 (surface), the total number of algal cells was 11.46 x 10^3cells.l^{-1}, of which 90.2% were truly planktonic species and the rest were benthic. Diatoms were dominant (91.7% of the total biomass), of which *Coscinodiscus spp.* was by far the most common species, being present in numbers of 5.8 x 10^3cells.l^{-1} (50.7%). Also common was *Skeletonema costatum* (23.9%). The diatoms *Diatoma spp., Fragilaria spp., Gyrosigma spp., Navicula spp., Nitzschia seriata* and *Rhabdonema arcuatum* were observed in small numbers (Table. 3. 4. 28.). The silicoflagellate *Dictyocha speculum* represented 7% of the total biomass.

At 5 metres depth, the total number of algal cells was 18.9 x 10^3cells.l^{-1} of which 94.9% were truly planktonic species and the rest were benthic. Diatoms dominated the population (96.6% of the total biomass), *Coscinodiscus spp.* was by far the dominant species, being present in numbers of 12.26 x 10^3cells.l^{-1} (65%), ranked next in terms of biomass were *Gyrosigma spp.* and *Skeletonema costatum* (8.54%). The diatoms *Chaetoceros spp., Cocconeis disculus, Fragilaria spp., Navicula spp., Rhabdonema arcuatum* and *Thalassiosira nordenskioldii* were present in small numbers not exceeding 0.8 x 10^3cells.l^{-1} (Table. 3. 4. 28.). The silicoflagellate *Dictyocha speculum* represented 3.4% of the total quantity.

On 9th December, diatoms remained as the dominant fraction of the population, with *Coscinodiscus spp.* as the dominant species. The dinoflagellate *Ceratium lineatum* was observed only for samples collected from station 9 (surface).

At station 11 (surface), the total number of algal cells was 10.3 x 10^3cells.l^{-1}, of which 84.4% were truly planktonic species and the rest were benthic. Diatoms were dominant (93.75% of the total biomass), *Coscinodiscus spp.* was the dominant species (31.3%).

Also common were *Diatoma spp.* (12.5%), *Melosira spp.* (9.4%) and *Skeletonema costatum* (18.75%). Other diatoms including *Cocconeis disculus, Cymbella turgida, Diatoma elongatum* and *Rhicosphenia curvata* were present, but each alone contributed little to the total biomass of the population. The silicoflagellate *Dictyocha speculum* represented 6.2% of the total population.

At 5 metres depth the algal biomass was 13.88 x 10^3cells.l^{-1}, of which 94.2% were truly planktonic species and the rest were benthic.

The population was made up entirely of diatoms of which the most dominant species was *Coscinodiscus spp.* (62.8%), also common was *Melosira spp.* (23.25%). The diatoms *Diatoma spp., Navicula spp., Synedra spp.* and *Thalassiosira nordenskioldii* were observed in much smaller numbers (Table. 3. 4. 29.).

At station 9 (surface), the total number of algal cells was 18.5 x 10^3cells.l^{-1}, of which 95.64% were truly planktonic species and 4.36% were benthic. Diatoms were dominant (92.15% of the total biomass), the most dominant species was *Coscinodiscus spp.* (36.65%). Also present in very large numbers were *Leptocylindrus danicus* (20.9%) and *Melosira spp.* (24.4%). The diatoms *Diatoma spp., Navicula spp., Skeletonema costatum* and *Synedra spp.* were present but in small numbers (Table. 3. 4. 29.). The dinoflagellate *Ceratium lineatum* represented 0.87% of the total biomass, also present was the silicoflagellate *Dictyocha speculum* (6.98%).

At 5 metres depth, the algal biomass was 13 x 10^3cells.l^{-1}, of which 95% were truly planktonic species and the rest were benthic.

Diatoms represented 97.5% of the total biomass, *Coscinodiscus spp.* was by far the dominant organism (69%), also present in large numbers 1.93 x 10^3cells.l^{-1} (14.8%) was *Navicula spp.* The diatoms *Cymbella turgida, Diatoma spp., Grammatophora*

Table. 3. 4. 29. The number of algal cells (l^{-1}) and their percentages, for 9th December, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	3228	31.25	8716	62.8	6779	36.65	9039	69
Cocconeis disculus (B)	161	1.56	-	-	-	-	-	-
Cymbella turgida (P)	161	1.56	-	-	-	-	161	1.23
Diatoma spp (B)	1291	12.5	807	5.81	161	0.87	322	2.47
Diatoma elongatum (B)	161	1.56	-	-	-	-	-	-
Grammatophora marina (B)	-	-	-	-	-	-	161	1.23
Leptocylindrus danicus (P)	-	-	-	-	3873	20.94	-	-
Melosira spp (P)	968	9.37	3227	23.25	4519	24.44	-	-
Navicula spp (B)	1614	15.6	484	3.48	645	3.5	1936	14.8
Nitzschia sp (B)	-	-	-	-	-	-	161	1.23
Rhicosphenia curvata (?)	161	1.56	-	-	-	-	-	-
Skeletonema costatum (P)	1936	18.75	-	-	807	4.36	-	-
Synedra spp (B)	-	-	322	2.32	161	0.87	-	-
Thalassiosira nordenskioldii (P)	-	-	322	2.32	-	-	161	1.23
Dinoflagellates								
Ceratium lineatum (P)	-	-	-	-	161	0.87	-	-
Silicoflagellates								
Dictyocha speculum (P)	645	6.25	-	-	1291	6.98	1129	8.64

marina, Nitzschia spp. and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 29.). The silicoflagellate *Dictyocha speculum* was observed in relatively large numbers 1.1 x 10^3cells.l^{-1} (8.64% of the total population).

On 6th January, although there was an increase in the total number of algal cells the actual numbers remained low.

Diatoms remained as the dominant fraction of the population, with *Coscinodiscus spp.* as the dominant species.

At station 11 (surface) the total number of algal cells was 45 x 10^3cells.l^{-1} of which 87.54% were truly planktonic species and the rest were benthic. Diatoms accounted for all of the population observed, *Coscinodiscus spp.* was by far the dominant species, being present in numbers of 19.37 x 10^3cells.l^{-1} (53%), ranked next in terms of biomass was *Melosira spp.* (26.5%). Also common were *Diatoma spp.* (17.7%) and *Skeletonema costatum* (12.4%). The diatoms *Navicula spp., Nitzschia spp., Pleurosigma spp.* and *Rhabdonema arcuatum* were observed in smaller numbers (Table. 3. 4. 30.).

At 5 metres depth the total number of algal cells was 29.67 x 10^3cells.l^{-1}, of which 90.24% were truly planktonic species and the rest were benthic.

Diatoms dominated the population (98.92% of the biomass), of which the most dominant species were *Coscinodiscus spp.* (36.98%) and *Skeletonema costatum* (26.1%). Also common were *Diatoma spp.* (10.87%), *Melosira spp.* (9.8%) and *Navicula spp.* (7.6%). The diatoms *Diatoma elongatum, Fragilaria spp., Navicula distans* and *Nitzschia spp.* were observed in small numbers (Table. 3. 4. 30.).

The silicoflagellate *Dictyocha speculum* represented 1.08% of the total biomass.

Table. 3. 4. 30. The number of algal cells (l^{-1}) and their percentages, for 6th January, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Achnanthes longipes (B)	-	-	-	-	-	-	1614	5.05
Asterionella spp (P)	645	1.77	-	-	645	2.38	-	-
Chaetoceros sp (P)	-	-	-	-	-	-	322	1
Coscinodiscus spp (P)	19369	53.1	10976	36.98	13558	50	10976	34
Cocconeis disculus (B)	-	-	-	-	-	-	968	3
Diatoma spp (B)	6456	17.7	3228	10.87	1291	4.76	3228	10
Diatoma elongatum (B)	-	-	968	3.26	322	1.2	-	-
Diploneis bomboides (B)	-	-	-	-	-	-	322	1
Fragilaria sp (P)	-	-	322	1.08	-	-	-	-
Gomphonema marina (B)	-	-	-	-	-	-	322	1
Grammatophora marina (B)	-	-	-	-	-	-	968	3
Melosira spp (P)	9685	26.54	2905	9.8	-	-	7747	25
Navicula spp (B)	1936	5.3	2259	7.61	1291	4.76	3228	10
Navicula distans (B)	-	-	322	1.08	-	-	-	-
Nitzschia spp (B)	1320	3.6	322	1.08	322	1.2	322	1
Pleurosigma sp (B)	322	0.83	-	-	-	-	-	-
Rhabdonema arcuatum (B)	968	2.65	-	-	-	-	-	-
Skeletonema costatum (P)	4519	12.38	7747	26.1	5165	19	-	-
Thalassiosira nordenskioldii (P)	-	-	-	-	1291	4.76	1936	6.06
Silicoflagellates								
Dictyocha speculum (P)	-	-	322	1.08	3228	11.9	-	-

At station 9 (surface), the algal biomass was 27.1 x 10^3cells.l^{-1}, of which 94% were truly planktonic species and the rest were benthic. Diatoms were dominant (88% of the total biomass), *Coscinodiscus spp.* was by far the most dominant species (50%). Ranked next in terms of biomass was *Skeletonema costatum* (19%). The diatoms *Asterionella spp., Diatoma spp., Diatoma elongatum, Navicula spp.* and *Nitzschia spp.* were observed in small numbers (Table. 3. 4. 30.).

The only non-diatom organism observed was the silicoflagellate *Dictyocha speculum* which represented 11.9% of the total biomass.

At 5 metres depth, the total number of algal cells was 32 x 10^3cells.$l^{-1}$of which 77% were truly planktonic species and 23% were benthic. The population was made up entirely of diatoms of which the most dominant species was *Cosciinodiscus spp.* (34%). Ranking next in terms of biomass were *Diatoma spp.* and *Navicula spp.*, each organism represented 10% of the total biomass. The diatoms *Achnanthes longipes, Chaetoceros spp., Cocconeis discalus, Diploneis bomboides, Gomphonema spp., Grammatophora marina, Melosira spp., Nitzschia spp.* and *Thalassiosira nordenskioldii* were observed in small numbers (Table. 3. 4. 30.).

On 12th February, green flagellates succeeded diatoms as the dominant fraction of the population with the exception of samples collected from station 9 (5 metres depth) where no green flagellates were observed. Again, planktonic species were dominant except for samples collected from station 9 (5 metres depth) where benthic organisms dominated the population. An increase in the total number of algal cells was observed at both stations, at both depths.

At station 11 (surface), the algal biomass was 201.6 x 10^3cells.l^{-1}, of which 96.4% were truly planktonic species and the rest were benthic. Green flagellates were dominant (85.37% of the total biomass). Diatoms represented 14.6% of the total population of which the dominant species was *Coscinodiscus spp.* (5.1%). The diatoms *Achnanthes*

spp., Diatoma spp., Diploneis crabro, Melosira spp., Navicula spp., Nitzschia spp., Skeletonema costatum, Synedra gaillonii, Thalassiosira gravida and *T. nordenskioldii* were present in numbers not exceeding 3.4 x 10^3cells.l^{-1} and each contributed little to the total biomass of the population (Table. 3. 4. 31.).

At 5 metres depth, the total number of algal cells was 71 x 10^3cells.l^{-1} of which 89.42% were truly planktonic species and the rest were benthic. Green flagellates dominated the population (63.63%). Diatoms accounted for 34.56% of the total biomass, of which the dominant species were *Coscinodiscus spp.* (9.7%), *Leptocylindrus danicus* (7.27%) and *Navicula spp.* (4.84%). The diatoms *Achnanthes spp., Achnanthes brevipes, Diatoma spp., Diploneis crabro, Nitzschia spp., Rhabdonema arcuatum, Skeletonema costatum, Synedra gaillonii* and *Thalassiosira nordenskioldii* were observed in small numbers (Table. 3. 4. 31.). Also present in small numbers was the silicoflagellate *Dictyocha speculum* (1.8% of the total population).

At station 9 (surface), the total number of algal cells was 104.8 x 10^3cells.l^{-1}, of which 92.2% were truly planktonic species and the rest were benthic. Green flagellates were dominant (70.84% of the total biomass). Diatoms represented 29.16% of the total biomass of which the dominant species were *Coscinodiscus spp.* (6.98% of the biomass), *Leptocylindrus danicus* (6.2% of the biomass), *Navicula spp.* (3.7% of the biomass) and *Skeletonema costatum* (4.9% of the biomass). The diatoms *Achnanthes spp., Diatoma spp., Fragilaria islandica, Nitzschia spp., Rhabdonema arcuatum, Synedra gaillonii* and *Thalassiosira nordenskioldii* were observed in small numbers not exceeding 1.7 x 10^3cells.l^{-1} (Table. 3. 4. 31.).

At 5 metres depth the algal biomass was 35 x 10^3cells.l^{-1} of which 41% were truly planktonic species and 58.86% were benthic. The population was made up entirely of diatoms, of which the most common species was *Navicula spp.* (43% of the biomass). Also present in large numbers (7.7 x 10^3cells.l^{-1}) was *Fragilaria virescens* which

Table. 3. 4. 31. The number of algal cells (l^{-1}) and their percentages, for 12th February, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Achnanthes spp (B)	1721	0.85	2152	3.03	1291	1.23	1291	3.68
Achnanthes brevipes (B)	-	-	215	0.3	-	-	215	0.6
Coscinodiscus spp (P)	10330	5.12	6887	9.7	7317	6.98	3443	9.8
Cocconeis disculus (B)	-	-	-	-	-	-	215	0.6
Diatoma spp (B)	2582	1.28	2582	3.63	430	0.32	-	-
Diploneis crabro (P)	215	0.1	215	0.3	-	-	-	-
Fragilaria spp (P)	-	-	-	-	-	-	215	0.6
Fragilaria islandica (P)	-	-	-	-	1291	1.23	860	2.45
Fragilaria virescens (P)	-	-	-	-	-	-	7747	22
Leptocylindrus danicus (P)	-	-	5165	7.27	6456	6.16	-	-
Licmophora sp (B)	-	-	-	-	-	-	215	0.6
Melosira spp (P)	301	1.48	-	-	-	-	1936	5.52
Navicula spp (B)	2152	1.06	3443	4.84	3873	3.7	15065	43
Nitzschia spp (B)	1721	0.85	430	0.6	860	0.82	215	0.61
Rhabdonema arcuatum (B)	-	-	215	0.3	860	0.82	1721	4.9
Skeletonema costatum (P)	3443	1.7	1721	2.42	5165	4.92	-	-
Synedra sp (B)	-	-	-	-	-	-	860	2.45
Synedra gaillonii (B)	1271	0.85	860	1.21	1291	1.23	-	-
Synedra ulna (B)	-	-	-	-	-	-	860	2.45
Thalassiosira gravida (P)	1721	0.85	-	-	-	-	-	-
Thalassiosira nordenskioldii (P)	860	0.42	430	0.6	1721	1.64	-	-
Silicoflagellates								
Dictyocha speculum (P)	-	-	1291	1.81	-	-	-	-
Green flagellates (P)	172174	85.37	45195	63.63	74250	70.84	-	-

ranked second in terms of biomass (22% of the biomass). Ranking third in terms of biomass was *Coscinodiscus spp.* (9.8% of the biomass). The diatoms *Achnanthes spp., Achnanthes brevipes, Cocconeis disculus, Fragilaria spp., Fragilaria islandica, Licmorpha spp., Melosira spp., Nitzschia spp., Rhabdonema arcuatum, Synedra spp.* and *Synedra ulna* were observed in small numbers (Table. 3. 4. 31.).

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A gradual increase in the total number of cells was observed. Maximum surface levels were recorded on 2nd April at both stations, while maximum 5 metres levels were observed on 23rd April.

The diatom fraction reestablished as the dominant part of the population, *Skeletonema costatum* succeeded *Coscinodiscus spp.* as the dominant organism.

On 10th March, at station 11 (surface), the total algal biomass was 74.5 x 10^3cells. l^{-1} of which 80.4% were truly planktonic species and the rest were benthic. The entire population was made up of diatoms of which by far the most dominant species was *Skeletonema costatum* (52.8% of the biomass), next in abundance was *Navicula spp.* (13.85%). The diatoms *Coscinodiscus spp., Melosira spp., Thalassiosira gravida* and *Thalassiosira nordenskioldii* were also common (Table. 3. 4. 32.). *Diatoma spp., Licmophora spp., Nitzschia spp* and *Synedra gaillonii* were observed in small numbers.

At 5 metres depth, the total number of algal cells was 63.27 x 10^3cells.l^{-1} of which 85.27% were truly planktonic species and the rest were benthic. Diatoms represented 99.5% of the total biomass, *Skeletonema costatum* was by far the dominant species, being present in numbers of 42 x 10^3cells.l^{-1} (66.32% of the biomass), ranking next in abundance before *Thalassiosira nordenskioldii* (9.2%), was *Navicula spp.* (10.2%of

Table. 3. 4. 32. The number of algal cells (l^{-1}) and their percentages, for 10th March, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Achnanthes longipes (B)	-	-	-	-	36479	41.7	1936	2.66
Coscinodiscus spp (P)	4519	6.06	2582	4.1	2582	2.9	4519	6.22
Diatoma spp (P)	322	0.43	968	1.53	1291	1.47	1291	1.77
Fragilaria spp (P)	-	-	645	1.02	-	-	322	0.44
Fragilaria islandica (P)	-	-	1936	3.06	322	0.36	645	0.88
Grammatophora marina (B)	-	-	645	1.02	-	-	-	-
Licmophora spp (B)	322	0.43	-	-	1936	2.2	-	-
Melosira spp (P)	4196	5.62	-	-	1291	1.47	-	-
Navicula spp (B)	1033	13.85	6456	10.2	12267	14.02	9684	13.33
Nitzschia spp (B)	2582	3.46	1936	3.06	1291	1.47	3228	4.4
Pleurosigma elongatum (B)	-	-	-	-	-	-	645	0.88
Rhabdonema arcuatum (B)	-	-	-	-	1291	1.47	322	0.44
Skeletonema costatum (P)	39384	52.8	41967	66.32	22597	25.8	41321	56.8
Synedra spp (B)	-	-	-	-	-	-	322	0.44
Synedra gaillonii (B)	1936	1.87	-	-	322	0.36	-	-
Thalassiosira gravida (P)	4519	6.06	-	-	1936	2.2	2582	3.55
Thalassiosira nordenskioldii (P)	6456	8.65	5810	9.2	3228	3.7	5165	7.1
Silicoflagellates								
Dictyocha speculum (P)	-	-	322	0.51	645	0.73	645	0.88

of the biomass). *Coscinodiscus spp., Diatoma spp., Fragilaria spp., Grammatophora marina* and *Nitzschia spp.* were observed in small numbers (Table. 3. 4. 32.).

At station 9 (surface), tha algal biomass was 87.48 x 10^3cells.l^{-1} of which 40.25% were truly planktonic species and 59.75% were benthic. The higher percentage of the benthic fraction referred to the presence of large numbers of the diatom *Achnanthes longipes.* Diatoms dominated the population (99.27% of the total biomass), *Achnanthes longipes* (41.7%), succeeded *Skeletonema costatum* (25.8%) as the dominant species. Also common were *Navicula spp.* (14%). *Coscinodiscus spp., Diatoma spp., Fragilaria islandica, Licmophora spp., Melosira spp., Nitzschia spp., Rhabdonema arcuatum, Synedra gaillonii, Thalassiosira gravida* and *T. nordenskioldii* were observed in small numbers. Also present was the silicoflagellate *Dictyocha speculum* (0.73% of the population).

At 5 metres depth, the total number of algal cells was 72.6 x 10^3cells.l^{-1} of which 77.88% were truly planktonic species and 22% were benthic. Diatoms were dominant (99% of the total biomass), *Skeletonema costatum* was by far the dominant species (56.8%). Also common was *Navicula spp.* (13.33%). *Achnanthes longipes, Coscinodiscus spp., Diatoma spp., Fragilaria spp., Fragilaria islandica, Nitzschia spp., Pleurosigma spp., Rhabdonema arcuatum, Synedra spp., Thalassiosira gravida* and *T. nordenskioldii* were observed in small numbers (Table. 3. 4. 32.).

Also present in small numbers was the silicoflagellate *Dictyocha speculum* (0.88% of the total biomass).

On 19th March, at station 11 (surface), the algal biomass was 97.2 x 10^3cells.l^{-1} of which 94.4% were truly planktonic species and the rest were benthic. Diatoms remained dominant (99.34% of the total biomass), of which by far the most dominant

species was *Skeletonema costatum* (63%), ranking next in terms of biomass was *T. nordenskioldii* (16.6%). Also common was *Coscinodiscus spp.* (12.6% of the total population). The diatoms *Melosira spp., Navicula spp., Nitzschia spp., Pleurosigma elongatum* and *Synedra spp.* were present, but contributed little to the total biomass of the population (Table. 3. 4. 33.). Also present in small numbers was the silicoflagellate *Dictyocha speculum* (0.66% of the total quantity).

At 5 metres depth the total number of algal cells was 71.3 x 10^3cells.l^{-1} of which 94% were truly planktonic species and the rest were benthic. Again diatoms were dominant (99% of the total biomass) of which the most dominant species were *Skeletonema costatum* (45.2%) and *Coscinodiscus spp.* (26.2%). Also common was *Thalassiosira nordenskioldii* (18% of the total biomass). *Biddulphia aurita, Diatoma spp., Grammatophora marina, Licmophora spp., Navicula spp., Nitzschia spp.* and *Synedra spp.* were present in small numbers (Table. 3. 4. 33.). Also present in small numbers was the silicoflagellate *Dictyocha speculum* (0.9% of the total quantity).

At station 9 (surface), the algal biomass was 84.6 x 10^3cells.l^{-1} of which 98.86% were truly planktonic species and the rest were benthic. Diatoms dominated the population (98.86% of the total biomass), of which by far the most dominant species was *Skeletonema costatum* (71.7%). Also common were *Coscinodiscus spp.* (10.68%) and *Thalassiosira nordenskioldii* (14.5%). The diatoms *Fragilaria spp., Navicula spp.* and *Pleurosigma elongatum* were present in small numbers (Table. 3. 4. 33.). Also present in small numbers was the silicoflagellate *Dictyocha speculum* (1.14% of the total population).

At 5 metres depth, the total number of algal cells was 68.4 x 10^3cells.l^{-1} of which 93.8% were truly planktonic species and the rest were benthic. Diatoms were dominant (99% of the total biomass), *Skeletonema costatum* was by far the most dominant species (63%), ranked next in terms of biomass was *Coscinodiscus spp.* (17%).

Table. 3. 4. 33. The number of algal cells (l^{-1}) and their percentages, for 19th March, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	12267	12.6	18723	26.2	9039	10.68	11621	16.9
Biddulphia aurita (P)	-	-	1291	2.7	-	-	-	-
Diatoma spp (B)	-	-	645	0.9	-	-	645	0.94
Fragilaria spp (P)	-	-	-	-	645	0.76	645	0.94
Grammatophora marina (B)	-	-	161	2.26	-	-	-	-
Licmophora sp (B)	-	-	645	0.9	-	-	-	-
Melosira spp (P)	1291	1.3	-	-	-	-	2582	3.77
Navicula spp (B)	3228	3.3	322	0.45	645	0.76	3228	4.7
Nitzschia spp (B)	1291	1.3	968	1.35	-	-	322	0.47
Pleurosigma elongatum (B)	645	0.66	-	-	322	0.38	- -	
Skeletonema costatum (P)	61337	63.1	32282	45.2	60691	71.1	43258	63
Synedra spp (P)	322	0.3	645	0.9	-	-	-	-
Synedra gaillonii (B)	-	-	-	-	-	-	968	1
Thalassiosira nordenskioldii (P)	16141	16.6	12913	18.1	12267	14.5	4519	6.6
Silicoflagellates								
Dictyocha speculum (P)	645	0.66	645	0.9	968	1.14	645	0.94

Diatoma spp., Fragilaria spp., Melosira spp., Navicula spp., Nitzschia spp., Synedra gaillonii and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 33.). The silicoflagellate *Dictyocha speculum* represented 0.94% of the total biomass.

On 26th March, an increase in the total number of algal cells was recorded for samples collected from both stations. The population was made up entirely of diatoms with the exception of samples collected from station 9 (surface) where small numbers of the silicoflagellate were observed. *Skeletonema costatum* remained as the dominant species.

At station 11 (surface) the total number of algal cells was 411 x 10^3cells.l^{-1} of which 99.1% were truly planktonic species and the rest were benthic. Diatoms represented 100% of the biomass, *Skeletonema costatum* was by far the dominant species, being present in numbers of 387 x 10^3cells.l^{-1}, which accounted for 94.26% of the total population. The diatoms *Coscinodiscus spp., Melosira spp., Navicula spp., Nitzschia spp.* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 11 x 10^3cells.l^{-1} and contributed little to the total biomass of the population (Table. 3. 4. 34.).

At 5 metres depth the algal biomass was 256 x 10^3cells.l^{-1} of which 97.5% were truly planktonic species and the rest were benthic. Again diatoms accounted for 100% of the biomass, of which *Skeletonema costatum* was by far the dominant species (86.76%). *Coscinodiscus spp., Melosira spp., Navicula spp., Pleurosigma spp., Synedra gaillonii* and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 34.). As expected, the proportions of the principal species were similar at the two levels sampled.

At station 9 (surface), the total number of algal cells was 383 x 10^3cells.l^{-1} of which 98.8% were truly planktonic species and the rest were benthic. Diatoms were dominant

Table. 3. 4. 34. The number of algal cells (l^{-1}) and their percentages, for 26th March, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	5165	1.25	9684	3.77	5165	1.34	6456	6.3
Diatoma spp (B)	-	-	-	-	645	0.16	968	0.9
Grammatophora marina (B)	-	-	-	-	-	-	322	0.3
Licmophora spp (B)	-	-	-	-	322	0.08	322	0.3
Melosira spp (P)	3550	0.86	10007	4	-	-	1614	1.58
Navicula spp (B)	2582	0.62	5165	2	3228	0.8	3228	3.16
Nitzschia spp (B)	1291	0.3	-	-	-	-	968	0.9
Pleurosigma elongatum (B)	-	-	322	0.1	-	-	-	-
Skeletonema costatum (P)	387392	94.26	222750	86.76	360275	93.9	87486	85.7
Synedra gaillonii (B)	-	-	968	0.37	968	0.2	-	-
Thalassiosira nordenskioldii (P)	10976	2.67	10330	4	12267	3.2	645	0.6
Silicoflagellates								
Dictyocha speculum (P)	-	-	-	-	645	0.16	-	-

(99.83% of the total biomass), *Skeletonema costatum* was by far the dominant species (93.9%). The diatoms *Coscinodiscus spp., Diatoma spp., Licmophora spp., Navicula spp., Synedra gaillonii* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 34.). Also present in small numbers was the silicoflagellate *Dictyocha speculum* (0.16% of the total population).

At 5 metres depth, the algal biomass was 102 x 10^3cells.$l^{-1}$of which 95.3% were truly planktonic species and the rest were benthic. The population was made up entirely of diatoms, which was dominated by *Skeletonema costatum* (85.7%). Also common was *Coscinodiscus spp.* (6.3% of the total quantity). *Diatoma spp., Grammatophora marina, Licmophora spp., Melosira spp., Navicula spp., Nitzschia spp.* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 34.).

Maximum surface total algal numbers were observed on 2nd April, which was caused by a bloom of *Skeletonema costatum* (Table. 3. 4. 35.). Diatoms made up the entire population with the exception of samples collected from station 11 (5 metres) where the silicoflagellate *Dictyocha speculum* was observed in very low numbers. *S. costatum* remained as the predominant species which almost accounted for all of the total biomass of the population, mainly for samples collected from surface at both stations (Table. 3. 4. 35.).

At station 11(surface), the total number of algal cells was 3649 x 10^3cells.l^{-1} of which 99.96% were truly planktonic species and the rest were benthic. Diatoms were the only fraction of the population present, of which by far the dominant species was *S. costatum*, being present in numbers of 3599 x 10^3cells.l^{-1}, which accounted for 98.6% of the total biomass. The accompanying diatoms were *Coscinodiscus spp., Navicula spp.* and *Thalassiosira nordenskioldii.* Each of these diatoms was present in very small numbers (Table. 3. 4. 35.).

Table. 3. 4. 35. The number of algal cells (l^{-1}) and their percentages, for 2nd April, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	18724	0.5	5810	1.8	9684	0.25	10976	3.3
Diatoma spp (B)	-	-	645	0.2	-	-	322	0.1
Melosira sp (P)	-	-	-	-	322	0.008	-	-
Navicula spp (B)	1291	0.03	5165	1.6	2582	0.06	387	1.17
Nitzschia spp (B)	-	-	1291	0.4	-	-	645	0.2
Pleurosigma elongatum (B)	-	-	322	0.1	-	-	-	-
Skeletonema costatum (P)	3599524	98.6	297646	93.9	3826149	98.9	309268	93.8
Thalassiosira nordenskioldii (P)	30345	0.8	5810	1.8	30345	0.78	4519	1.37
Silicoflagellates								
Dictyocha speculum (P)	-	-	322	0.1	-	-	-	-

At 5 metres depth the algal biomass was 317 x 10^3cells.l^{-1} of which 97.87% were truly planktonic species and the rest were benthic. Diatoms were dominant (99.9% of the total biomass), *S. costatum* was by far the dominant species, being present in numbers of 297 x 10^3cells.l^{-1}, which accounted for 93.9% of the total population. *Coscinodiscus spp., Diatoma spp., Navicula spp., Nitzschia spp., Pleurosigma spp.* and *Thalassiosira nordenskioldii* were present in very small numbers (Table. 3. 4. 35.). Also present in small numbers was the silicoflagellate *Dictyocha speculum* (0.1% of the total quantity).

At station 9 (surface), the total number of algal cells was 3826 x 10^3cells.l^{-1} of which 99.94% were truly planktonic species and the rest were benthic. Diatoms represented 100% of the biomass, of which by far the dominant species was *Skeletonema costatum* (98.9% of the total biomass). The accompanying diatoms were *Coscinodiscus spp., Melosira spp., Navicula spp.* and *T. nordenskioldii*. Each of these diatoms was present in very small numbers (Table. 3. 4. 35.).

At 5 metres depth the algal biomass was 329 x 10^3cells.l^{-1} of which 98.64% were truly planktonic species and the rest were benthic. Diatoms made up the entire population, of which *S. costatum* was by far the dominant species, being present in numbers of 309 x 10^3cells.l^{-1}, which accounted for 93.8% of the total population. *Coscinodiscus spp., Diatoma spp., Navicula spp., Nitzschia spp.* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 35.). From Table 35, *Diatoma spp.* and *Nitzschia spp.* were present only in samples collected from 5 metres depth at both stations.

On 9th April, an increase in the total number of algal cells was observed for samples collected from 5 metres depth at both stations. Diatoms made up the entire population. *Skeletonema costatum* remained as the predominant species which almost accounted for all of the total biomass of the population at both stations, at both depths (Table. 3. 4.

36.). A decrease in the total number of algal cells was observed for samples collected from surface at both stations.

At station 11 (surface), the algal biomass was 723 x 10^3cells.l^{-1} which was made up entirely of diatoms. 99% of the total biomass were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species, being present in numbers of 701 x 10^3cells.l^{-1}, which accounted for 97.3% of the total population. The accompanying diatoms *Coscinodiscus spp., Licmophora spp., Navicula spp., Nitzschia spp.* and *Thalassiosira nordenskioldii* were present in very small numbers (Table. 3. 4. 36.).

At 5 metres depth the total number of algal cells was 585 x 10^3cells.l^{-1} which was made up entirely of diatoms. 99.45% of the total biomass were truly planktonic species and the rest were benthic. Again, *S. costatum* was by far the dominant species, being present in numbers of 568 x 10^3cells.l^{-1}, which accounted for 97% of the total biomass. *Coscinodiscus spp., Navicula spp.* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 36.).

At station 9 (surface), the algal biomass was 814 x 10^3cells.l^{-1}, which was made up entirely of diatoms. 99.6% of the total biomass were truly planktonic species and the rest were benthic. Again, *Skeletonema costatum* was by far the dominant species, being present in numbers of 779 x 10^3cells.l^{-1}, which accounted for 95.8% of the total quantity. *Coscinodiscus spp., Navicula spp.* and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 36.).

At 5 metres depth, the total number of algal cells was 916 x 10^3cells.l^{-1} which was made up entirely of diatoms. 99% of the total biomass were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species, being present in numbers of 894 x 10^3cells.l^{-1}, which accounted for 97.6% of the total population.

Table. 3. 4. 36. The number of algal cells (l^{-1}) and their percentages, for 9th April, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	5165	0.7	5165	0.88	12913	1.58	11621	1.26
Diatoma sp (B)	-	-	-	-	-	-	322	0.03
Licmophora sp (B)	645	0.09	-	-	-	-	-	-
Navicula spp (B)	4519	0.6	3228	0.55	3228	0.4	1291	0.14
Nitzschia sp (B)	1936	0.26	-	-	-	-	-	-
Pleurosigma elongatum (B)	-	-	-	-	-	-	322	0.03
Skeletonema costatum (P)	701826	97.3	568176	97	779950	95.8	894877	97.6
Thalassiosira nordenskioldii (P)	7102	0.98	8393	1.43	18078	2.2	7747	0.8

Coscinodiscus spp., Diatoma spp., Navicula spp., Pleurosigma spp. and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 36.).

Maximum 5 metres total algal numbers were observed on 23rd April and were caused by a bloom of *S. costatum* (Table. 3. 4. 37.). Diatoms made up the entire population with the exception of samples collected from station 9 (surface) where the silicoflagellate *Dictyocha speculum* was observed in very small numbers (0.6 x 10^3cells.l^{-1}). *S. costatum* remained as the predominant species which almost accounted for all of the total biomass of the population, mainly for samples collected from station 11 (5 metres) and from station 9 at both depths. At station 11 (surface), tha algal biomass was 176.7 x 10^3cells.l^{-1} of which 98.54% were truly planktonic species and the rest were benthic. Diatoms made up the entire population, of which *S. costatum* was by far the dominant species, being present in numbers of 125 x 10^3cells.l^{-1}, which accounted for 71% of the total population. Also common were *Thalassiosira nordenskioldii* (15.7%) and *Coscinodiscus spp.* (9%). *Biddulphia aurita, Melosira spp.* and *Navicula spp.* were present in small numbers (Table. 3. 4. 37.).

At 5 metres depth the total number of algal cells was 1344 x 10^3cells.l^{-1} of which 99.78% were truly planktonic species and the rest were benthic. Again diatoms made up the entire population, *S. costatum* was by far the dominant species, being present in numbers of 1315.8 x 10^3cells.l^{-1} which represented 97.8% of the total biomass. *Coscinodiscus spp., Grammatophora marina, Navicula spp.* and *T. nordenskioldii* were present in numbers not exceeding 18.7 x 10^3cells.l^{-1} and contributed little to the total biomass (Table. 3. 4. 37.).

At station 9 (surface), the algal biomass was 1449 x 10^3cells.l^{-1} of which 97.9% were truly planktonic species and the rest were benthic. Diatoms were dominant (99.96% of the total biomass), *S. costatum* was by far the dominant species (98%). *Coscinodiscus spp., Navicula spp.* and *T. nordenskioldii* were present in very small numbers (Table.

Table. 3. 4. 37. The number of algal cells (l^{-1}) and their percentages, for 23rd April, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Biddulphia aurita (P)	645	0.36	-	-	-	-	-	-
Coscinodiscus spp (P)	16141	9	7425	0.55	4519	0.3	14204	1
Grammatophora marina (B)	-	-	968	0.07	-	-	-	-
Melosira sp (P)	3873	2.2	-	-	-	-	-	-
Navicula spp (B)	2582	1.46	1936	0.14	1936	0.1	1291	0.1
Skeletonema costatum (P)	125773	71	1315844	97.8	1417857	98	1366851	98.1
Thalassiosira nordenskioldii (P)	27763	15.7	18724	1.4	21952	1.5	10330	0.74
Silicoflagellates								
Dictyocha speculum (P)	-	-	-	-	645	0.04	-	-

3. 4. 37.). Also present in very small numbers was the silicoflagellate *Dictyocha speculum* (0.6 x 10^3cells.l^{-1}).

At 5 metres depth, the total number of algal cells was 1392 x 10^3cells.l^{-1} of which 99.9% were truly planktonic species and the rest were benthic. Diatoms made up the entire population, *Skeletonema costatum* was by far the dominant species, being present in numbers of 1366 x 10^3cells.l^{-1},which represented 98.1% of the total quantity. *Coscinodiscus spp., Navicula spp.* and *Thalassiosira nordenskioldii* were present in very small numbers (Table. 3. 4. 37.).

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On 7th May,a decrease in the total number of algal cells was observed at both stations with the exception of samples collected from station 11 (surface) where a slight increase in the total number of algal cells was recorded. Green flagellates succeeded diatoms as the dominant fraction of the population. *S. costatum* remained as the dominant species of diatom.

At station 11 (surface), the total algal biomass was 460 x 10^3cells.l^{-1} of which 97.9% were truly planktonic species and the rest were benthic. Green flagellates were dominant (83.2% of the total population). Diatoms accounted for 16.8% of the total biomass, of which *Skeletonema costatum* was by far the dominant species (12.6%). *Coscinodiscus spp., Diatoma spp., Licmophora spp., Navicula spp., Nitzschia spp., Pleurosigma elongatum* and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 38.).

At 5 metres depth, the algal biomass was 149 x 10^3cells.l^{-1} of which 97.85% were truly planktonic species and the rest were benthic. Green flagellates were dominant (61.16% of the total biomass). Diatoms accounted for 38.84% of the total biomass, of which *S.*

Table. 3. 4. 38. The number of algal cells (l^{-1}) and their percentages, for 7th May, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	3228	0.7	4519	3	3228	0.6	1291	0.5
Diatoma spp (B)	1291	0.28	1291	0.86	-	-	645	0.25
Diatoma elongatum (B)	-	-	-	-	-	-	27763	10.8
Grammatophora marina (B)	-	-	645	0.4	-	-	-	-
Licmophora sp (B)	322	0.07	-	-	-	-	-	-
Melosira sp (P)	-	-	-	-	-	-	6133	2.4
Navicula spp (B)	5810	1.26	2582	1.72	1936	0.4	5810	2.27
Nitzschia sp (B)	322	0.07	-	-	-	-	-	-
Pleurosigma elongatum (B)	322	0.07	-	-	-	-	-	-
Skeletonema costatum (P)	58108	12.6	47778	31.87	63919	12.7	14850	5.8
Synedra gaillonii (B)	-	-	-	-	-	-	322	0.1
Thalassiosira nordenskioldii (P)	3228	0.7	1397	0.9	3228	0.64	645	0.25
Dinoflagellates								
Ceratium lineatum (P)	-	-	-	-	-	-	322	0.1
Other flagellates								
Green flagellates (P)	382873	83.17	91682	61.16	431297	85.6	198215	77.4

costatum was by far the dominant species, being present in numbers of 47 x 10^3cells. l^{-1}, which accounted for 31.87% of the total population. *Coscinodiscus spp., Diatoma spp., Grammatophora marina, Navicula spp.* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 38.).

At station 9 (surface) the total number of algal cells was 503 x 10^3cells.l^{-1} of which 99.6% were truly planktonic species and the rest were benthic. Green flagellates were dominant (85.6% of the total biomass). Diatoms represented 14.36% of the total biomass, of which *S. costatum* was by far the dominant species (12.7%). *Coscinodiscus spp., Navicula spp.* and *T. nordenskioldii* were observed in much smaller numbers (Table. 3. 4. 38.).

At 5 metres depth the total number of algal cells was 256 x 10^3cells.l^{-1} of which 97.6% were truly planktonic species and the rest were benthic. Green flagellates were dominant (77.4% of the total population). Diatoms accounted for 22.45% of the total biomass, of which *Diatoma elongatum* (10.8%) succeeded *Skeletonema costatum* (5.8%) as the dominant species. *Coscinodiscus spp., Diatoma spp., Melosira spp., Navicula spp., Synedra gaillonii* and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 38.). Also present in small numbers was the dinoflagellate *Ceratium lineatum* (0.1% of the total quantity).

On 4th June an increase in the total number of algal cells was observed at both stations with the exception of samples collected from station 9 at 5 metres depth where a sharp decrease in the total number of algal cells was recorded. Diatoms made up the entire population, with *S. costatum* as the dominant species.

At station 11 (surface), the algal biomass was 525 x 10^3cells.l^{-1} of which 99.7% were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species, being present in numbers of 259 x 10^3cells.l^{-1}, which accounted for 49.47% of

Table. 3. 4. 39. The number of algal cells (l^{-1}) and their percentages, for 4th June, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	174972	33.3	84903	18.3	113312	20.7	5488	11.4
Diatoma spp (B)	1614	0.3	322	0.07	-	-	645	1.3
Melosira spp (P)	1291	0.24	1291	0.27	-	-	-	-
Navicula spp (B)	1614	0.3	1937	0.4	645	0.1	322	0.67
Skeletonema costatum (P)	259876	49.47	310882	66.96	372219	68.2	35511	73.8
Thalassiosira nordenskioldii (P)	85872	16.3	64565	13.9	59400	10.88	6133	12.7

the total biomass, ranking next in terms of biomass was *Coscinodiscus spp.* (18.3%). Also common was *Thalassiosira nordenskioldii* (14%). *Diatoma spp., Licmophora spp., Melosira spp.* and *Navicula spp.* were present in small numbers (Table. 3. 4. 39.).

At 5 metres depth the total number of algal cells was 464 x 10^3cells.l^{-1}, of which 99.52% were truly planktonic species and the rest were benthic. The population was dominated by *Skeletonema costatum* (66.96%) and *Coscinodiscus spp.* (18.3%). *Diatoma spp., Melosira spp.* and *Navicula spp.* were present in small numbers (Table. 3. 4. 39.).

At station 9 (surface), the total number of diatom cells was 545 x 10^3cells.l^{-1}, of which 99.89% were truly planktonic species and the rest were benthic. *S. costatum* was by far the most dominant species, being present in numbers of 372 x 10^3cells.l^{-1} which accounted for 68.2% of the total population. Ranking second in terms of biomass was *Coscinodiscus spp.* (20.7%). Also common was *T. nordenskioldii* (10.88% of the total population). *Navicula spp.* was the accompanying diatom.

At 5 metres depth the total number of diatom cells was 48 x 10^3cells.l^{-1} of which 99.3% were truly planktonic species and the rest were benthic. *Skeletonema costatum* was by far the dominant species being present in numbers fo 35 x 10^3cells.l^{-1}, which accounted for 73.8% of the total biomass. Ranking third in terms of biomass after *Thalassiosira nordenskioldii* (12.7%) was *Coscinodiscus spp.* (11.4%). *Diatoma spp.* and *Navicula spp.* were present in small numbers (Table. 3. 4. 39.).

On 18th June, a decrease in the total number of algal cells was observed at both stations, with the exception of samples collected from station 9 at 5 metres depth where a slight increase in the total number of algal cells was recorded. Green flagellates reappeared and were the most numerous fraction of the population for samples

collected from surface at both stations. For samples collected from 5 metres depth at station 11, there were more or less equal levels of contribution to the total biomass of the population by green flagellates and diatoms were observed, while for samples collected from station 9 at 5 metres depth, diatoms were the most dominant fraction of the population.

At station 11 (surface), the algal biomass was 150 x 10^3cells.l^{-1} of which 98.5% were truly planktonic species and the rest were benthic. Green flagellates were the most dominant fraction of the population (57.6% of the total biomass), while diatoms accounted for 42.4% of the total biomass, of which *S. costatum* was by far the dominant species being present in numbers of 55 x 10^3cells.l^{-1}, which represented 37% of the total population. *Coscinodiscus spp., Diatoma spp., Navicula spp., Navicula distans* and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 40.).

At 5 metres depth, the algal biomass was 73 x 10^3cells.l^{-1} of which 96.94% were truly planktonic species and the rest were benthic. The total biomass of the population divided equally between green flagellates and diatoms. *S. costatum* was by far the dominant species of the diatoms (45.6%). *Navicula spp., Navicula distans* and *Thalassiosira nordenskioldii* were observed in small numbers.

At station 9 (surface), the total number of algal cells was 198 x 10^3cells.l^{-1}, made up entirely of truly planktonic species. Green flagellates were the most dominant fraction of the population (68.8% of the total biomass). Diatoms accounted for 31.2% of the total biomass, of which *S. costatum* was the dominant species (28.9%). *Melosira spp.* and *T. nordenskioldii* were the accompanying diatoms and were present in very small numbers (Table. 3. 4. 40.).

Table. 3. 4. 40. The number of algal cells (l^{-1}) and their percentages, for 18th June, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	645	0.43	-	-	-	-	-	-
Diatoma sp (B)	1937	1.3	-	-	-	-	-	-
Melosira sp (P)	-	-	-	-	2582	1.3	-	-
Navicula spp (B)	1937	1.3	1937	2.6	-	-	1291	0.8
Navicula distans (B)	322	0.2	322	0.43	-	-	-	-
Skeletonema costatum (P)	55526	37	33574	45.6	57463	28.9	96848	60.2
Thalassiosira nordenskioldii (P)	3228	2.15	322	0.43	1937	0.97	7102	4.4
Other flagellates								
Green flagellates (P)	86517	57.6	37447	50.87	136878	68.8	55526	34.5

At 5 metres depth, the total number of algal cells was 160 x 10^3cells.l^{-1}, of which 99.2% were truly planktonic species and the rest were benthic. Diatoms remained as the dominant fraction of the population (65.47% of the total biomass). *S. costatum* was by far the dominant species being present in numbers of 96.8 x 10^3cells.l^{-1} which accounted for 60.2% of the total population. *Navicula spp.* and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 40.). Green flagellates represented 34.5% of the total quantity.

On 2nd July, an increase in the total number of algal cells was recorded mainly for samples collected from 5 metres depth at both stations,which were comparable to those observed during the spring. The population was made up entirely of truly planktonic diatoms, of which *S. costatum* was the dominant species.

At station 11 (surface), the total number of diatom cells was 335 x 10^3cells.l^{-1}. *S. costatum* was by far the dominant species being present in numbers of 284.7 x 10^3cells.l^{-1} which accounted for 85% of the total biomass. Also common was *T. nordenskioldii* (14.85%). *Diatoma elongatum* was present in small numbers (Table. 3. 4. 41.).

At 5 metres depth, the algal biomass was 692 x 10^3cells.l^{-1}. *Skeletonema costatum* was by far the dominant species being present in numbers of 577 x 10^3cells.l^{-1}, which accounted for 83.4% of the total population. Also common was *Thalassiosira nordenskioldii* (16.5%). The diatom *Cocconeis disculus* was present in very small numbers (Table. 3. 4. 41.).

At station 9 (surface), the total number of diatom cells was 226 x 10^3cells.l^{-1}, of which *S. costatum* was by far the dominant species, being present in numbers of 205 x 10^3cells.l^{-1}, which accounted for 90.85% of the total quantity. *T. nordenskioldii* was the only accompanying diatom present.

Table. 3. 4. 41. The number of algal cells (l^{-1}) and their percentages, for 2nd July, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus sp (P)	-	-	-	-	-	-	645	0.07
Cocconeis disculus (B)	-	-	322	0.046	-	-	-	-
Diatoma sp (B)	-	-	-	-	-	-	-	-
Diatoma elongatum (B)	322	0.1	-	-	-	-	-	-
Navicula sp (B)	-	-	-	-	-	-	645	0.07
Skeltonema costatum (P)	284733	85	577215	83.4	205318	90.85	695370	76.2
Thalassiosira nordenskioldii (P)	49715	14.85	114280	16.5	20660	9.14	215002	23.5

At 5 metres depth, the total number of diatom cells was 912 x 10^3cells.l^{-1}. *S. costatum* was by far the dominant species (76.2%). Also common was *T. nordenskioldii* (23.5%). *Coscinodiscus spp.* and *Navicula spp.* were present in very small numbers (Table. 3. 4. 41.).

On 16th July, a sharp decrease in the total number of algal cells was recorded. The population was made up entirely of diatoms with the exception of samples collected from station 11 (surface) where a very small number of dinoflagellates was observed. Relatively high numbers of benthic diatoms were observed for samples collected from station 11 at 5 metres depth (Table. 3. 4. 42.). *Leptocylindrus danicus* succeeded *Skeletonema costatum* as the dominant species, with the exception of samples collected from station 9 at 5 metres depth where *S. costatum* remained as the dominant species.

At station 11 (surface), the total number of algal cells was 68.7 x 10^3cells.l^{-1} of which 98.6% were truly planktonic species and the rest were benthic. Diatoms were dominant (99.53% of the total biomass), of which the most dominant species was *Leptocylindrus danicus* (56.3%), ranking next in terms of biomass was *S. costatum* (35.6%). The diatoms *Chaetoceros spp., Coscinodiscus spp., Gomphonema spp., Grammatophora marina, Navicula spp.* and *T. nordenskioldii* were present in numbers not exceeding 2.8 x 10^3cells.l^{-1} and contributed little to the total biomass of the population (Table. 3. 4. 42.). The dinoflagellate *Protoperidinium spp.* was present in small numbers (Table. 3. 4. 42.).

At 5 metres depth, the total number of diatom cells was 27 x 10^3cells.l^{-1}, of which 88% were truly planktonic species and the rest were benthic. *Leptocylindrus danicus* was the most dominant species (42.85%), ranking second in terms of biomass was *Melosira spp.* (19%). Also common was *S. costatum* (14.28% of the total biomass). *Coscinodiscus spp., Cocconeis disculus, Navicula spp., Nitzschia spp., Synedra spp.* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 42.).

Table. 3. 4. 42. The number of algal cells (l^{-1}) and their percentages, for 16th July, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Chaetoceros spp (P)	1937	2.8	-	-	4519	5.8	-	-
Coscinodiscus spp (P)	645	0.94	1291	4.76	-	-	-	-
Cocconeis disculus (B)	-	-	645	2.38	-	-	-	-
Diatoma elongatum (B)	-	-	-	-	-	-	322	0.5
Gomphonema sp (P)	322	0.47	-	-	-	-	-	-
Grammatophora marina (B)	322	0.47	-	-	-	-	-	-
Leptocylindrus danicus (P)	38739	56.3	11621	42.85	53589	69.16	8393	13.26
Melosira sp (P)	-	-	5164	19	-	-	-	-
Navicula spp (B)	645	0.94	1291	4.76	645	0.8	322	0.5
Nitzschia sp (B)	-	-	645	2.38	-	-	-	-
Skeletonema costatum (P)	24534	35.6	3874	14.28	18724	24.16	52298	82.6
Synedra sp (B)	-	-	1291	4.76	-	-	-	-
Thalassiosira nordenskioldii (P)	1291	1.8	1291	4.76	-	-	1937	3
Dinoflagellates								
Protoperidinium sp. (P)	322	0.47	-	-	-	-	-	-

At station 9 (surface), the total number of diatom cells was 77 x 10^3cells.l^{-1}, of which 99.2% were truly planktonic species and the rest were benthic. *Leptocylindrus danicus* was by far the dominant species (69.16% of the total biomass), ranking next in terms of biomass was *Skeletonema costatum* (24.16%). *Chaetoceros spp.* and *Navicula spp.* were present in small numbers (Table. 3. 4. 42.).

At 5 metres depth, the total number of diatom cells was 63 x 10^3cells.l^{-1}, of which *S. costatum* was by far the dominant species, being present in numbers of 52 x 10^3cells. l^{-1}, which accounted for 82.6% of the total biomass. Also common was *Leptocylindrus danicus* (13.26%). *Diatoma elongatum, Navicula spp.* and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 42.).

An increase in the total number of algal cells was observed at both stations on 30th July. The population was made up entirely of diatoms. *S. costatum* reestablished as the dominant species at both stations. At station 11 (surface), the total number of diatom cells was 413 x 10^3cells.l^{-1}, of which 99.53% were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species, being present in numbers of 331 x 10^3cells.l^{-1} which accounted for 80.1% of the total population. Also common was *T. nordenskioldii* (19.18%). *Diatoma spp., Navicula spp.* and *Nitzschia bilobata* were present in small numbers (Table. 3. 4. 43.).

At 5 metres depth, the total number of diatom cells was 613.4 x 10^3cells.l^{-1} of which 99.9% were truly planktonic species. *S. costatum* was by far the dominant species being present in numbers of 496.5 x 10^3cells.l^{-1}, which accounted for 80.9% of the total biomass. Also common was *Thalassiosira nordenskioldii* (18.9%). The only other organism observed was the benthic diatom *Navicula spp.*

At station 9 (surface), the total number of diatom cells was 419 x 10^3cells.l^{-1} of which 99.54% were truly planktonic species and the rest were benthic which was represented

Table. 3. 4. 43. The number of algal cells (l^{-1}) and their percentages, for 30th July, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Chaetoceros sp (P)	-	-	-	-	322	0.07	-	-
Coscinodiscus sp (P)	-	-	-	-	-	-	645	0.1
Diatoma sp (B)	645	0.15	-	-	-	-	-	-
Fragilaria sp (P)	-	-	-	-	645	0.15	-	-
Grammatophora marina (B)	-	-	-	-	-	-	645	0.1
Navicula spp (B)	645	0.15	645	0.1	19369	0.46	645	0.1
Nitzschia bilobata (B)	1291	0.3	-	-	-	-	-	-
Pleurosigma sp (B)	-	-	-	-	-	-	645	0.1
Skeletonema costatum (P)	331220	80.1	496508	80.9	326701	77.78	386101	74.5
Thalassiosira decipiens (P)	-	-	-	-	-	-	322	0.06
Thalassiosira nordenskioldii (P)	79415	19.18	116217	18.9	90391	21.5	129130	25

by the diatom *Navicula spp.* *S. costatum* was by far the dominant species, being present in numbers of 32.67 x 10^3cells.l^{-1}, which accounted for 77.78% of the total quantity. Also common was *Thalassiosira nordenskioldii* (21.5% of the total biomass). *Chaetoceros spp.* and *Fragilaria* were present in small numbers (Table. 3. 4. 43.).

At 5 metres depth, the total number of diatom cells was 51.8 x 10^3cells.l^{-1}, of which 99.64% were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species, being present in numbers of 386 x 10^3cells.l^{-1}, which accounted for 74.5% of the total , ranking next in terms of biomass was *T. nordenskioldii* (25%). *Coscinodiscus spp., Grammatophora marina, Navicula spp.* and *Pleurosigma spp.* were present in very small numbers (Table. 3. 4. 43.).

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The total number of algal cells remained more or less similar to that observed during the summer. The highest total number of algal cells for this period was observed on 10th September, for samples collected from surface at station 11. An increase in the number of diatom species was observed. Diatoms remained as the dominant fraction of the population. Dinoflagellates, silicoflagellates and green flagellates were also present.

On 10th September, at station 11 (surface) out of a total standing crop of 1121 x 10^3cells.l^{-1}, 99.37% were diatoms, 0.28% were represented by the silicoflagellate *Dictyocha speculum* and the rest were green flagellates. 98.7% of the total biomass were truly planktonic species and the rest were benthic species. The diatom fraction was composed predominantly of *Diatoma spp.*, being present in numbers of 960 x 10^3cells.l^{-1}, which accounted for 85.6% of the total biomass. The diatoms *Asterionella spp., Chaetoceros spp., Chaetoceros atlanticum, Coscinodiscus spp., Leptocylindricus danicus, Licmophora spp., Melosira spp., Navicula spp., Nitzschia seriata, Pinnularia*

spp., Pleurosigma spp., Skeletonema costatum, Thalassiosira decipiens and *T. nordenskioldii* were present in small numbers not exceeding 47.7 x 10^3cells.l^{-1} (Table. 3. 4. 44.).

At 5 metres depth, out of a total standing crop of 515 x 10^3cells.l^{-1}, about 99% were diatoms, 0.25% were represented by the silicoflagellate *Dictyocha speculum* and the rest were green flagellates. 98% of the total biomass were truly planktonic species and the rest were benthic.

The diatom fraction was composed predominantly of *Diatoma spp.*, being present in numbers of 353 x 10^3cells.l^{-1}, which accounted for 68.58% of the total population, ranking next in terms of biomass was *Skeletonema costatum* (14.67%). The diatoms *Chaetoceros spp., Chaetoceros atlanticum, Chaetoceros externum, Coscinodiscus spp., Grammatophora marina, Leptocylindrus danicus, Melosira spp., Navicula spp., Nitzschia seriata, Thalassiosira decipiens* and *T. nordenskioldii* were present in small numbers not exceeding 25.8 x 10^3cells.l^{-1} (Table. 3. 4. 44.).

At station 9 (surface), out of a total standing crop of 491 x 10^3cells.l^{-1}, about 99.35% were diatoms, 0.2 % were represented by the silicoflagellate *Dictyocha speculum* and the rest were greeen flagellates. 98.7% of the total biomass were truly planktonic species and the rest were benthic. The most dominant species of the diatom fraction was *Diatoma spp.*, being present in numbers of 252.4 x 10^3cells.l^{-1}, which accounted for 51.4% of the total quantity, ranking next in terms of biomass was *S. costatum* (26.3% of the total biomass). The diatoms *Asterionella spp., Chaetoceros spp., Chaetoceros atlanticum, Chaetoceros externum, Coscinodiscus spp., Fragilaria spp., Leptocylindrus danicus, Navicula spp., Nitzschia bilobata, Nitzschia seriata, Thalassiosira decipiens* and *T. nordenskioldii* were present in small numbers not exceeding 22 x 10^3cells.l^{-1} (Table. 3. 4. 44.).

Table. 3. 4. 44. The number of algal cells (l^{-1}) and their percentages, for 10th September, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Asterionella spp (P)	5810	0.5	-	-	12267	2.5	-	-
Chaetoceros spp (P)	15495	1.38	12267	2.38	16141	3.27	12267	2.5
Chaetoceros atlanticum (P)	10976	0.97	1291	0.25	9684	1.97	11621	2.38
Chaetoceros externum (P)	-	-	7747	1.5	10330	2.1	16787	3.44
Coscinodiscus spp (P)	7102	0.63	7102	1.38	21952	4.46	20660	4.2
Diatoma spp (B)	960160	85.6	353173	68.58	252450	51.4	323472	66.3
Fragilaria spp (P)	-	-	-	-	322	0.06	-	-
Grammatophora marina (B)	-	-	322	0.06	-	-	322	0.06
Leptocylindrus danicus (P)	4842	0.43	5165	1	6779	1.38	1614	0.33
Licmophora sp (B)	322	0.03	-	-	-	-	-	-
Melosira spp (P)	8393	0.74	6456	1.24	-	-	-	-
Navicula spp (B)	1291	0.1	1291	0.25	645	0.13	-	-
Nitzschia bilobata (B)	-	-	-	-	645	0.13	322	0.06
Nitzschia seriata (P)	12267	1.1	7747	1.5	5165	1	16141	3.3
Pinnularia sp (B)	322	0.03	-	-	-	-	-	-
Pleurosigma sp (B)	322	0.03	-	-	-	-	-	-
Skeletonema costatum (P)	37447	3.34	75541	14.67	12913	26.3	62628	12.84
Thalassiosira decipiens (P)	1936	0.17	5810	1.1	9039	1.84	4519	0.9
Thalassiosira nordenskioldii (P)	47778	4.26	25826	5	13558	2.75	13558	2.77
Dinoflagellates								
Protoperidinium sp (P)	-	-	-	-	-	-	322	0.06
Silicoflagellates								
Dictyocha speculum (P)	3228	0.28	1291	0.25	968	0.2	1936	0.4
Other flagellates								
Green flagellates (P)	3873	0.34	3873	0.75	2259	0.46	1614	0.33

At 5 metres depth, out of a total standing crop of 487.8 x 10^3cells.l^{-1}, 99.2% were diatoms, 0.06% were represented by the dinoflagellate *Peridinium spp.*, 0.4% were represented by the silicoflagellate *Dictyocha speculum* and the rest were green flagellates. 96.57% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was composed predominantly of *Diatoma spp.*, being present in numbers of 323.4 x 10^3cells.l^{-1}, which accounted for 66.3% of the total population. Also common was *Skeletonema costatum* (12.84%).

The diatoms *Chaetoceros spp., Chaetoceros atlanticum, Chaetoceros externum, Coscinodiscus spp., Grammatophora marina, Leptocylindrus danicus, N. bilobata, N. seriata, T. decipiens* and *T. nordenskioldii* were present in small numbers (Table. 3. 4. 44.).

On 23rd September, a sharp decrease in the total number of algal cells was observed. Diatoms remained as the dominant fraction of the population. *S. costatum* reestablished as the most dominant species.

At station 11 (surface), the algal biomass was 132 x 10^3cells.l^{-1}, of which 85% were truly planktonic species and the rest were benthic. Diatoms were dominant (94.39% of the total biomass), of which *Skeletonema costatum* was the most common species (41%). Also common were *Nitzschia seriata, Chaetoceros atlanticum* , each accounted for 14% of the total population and *Thalassiosira nordenskioldii* (12.22% of the total quantity). The diatoms *Coscinodiscus spp., Diatoma spp., Grammatophora marina, Navicula distans, Nitzschia bilobata, Rhizosolenia spp., Rhizosolenia stolferfothii, T. decipiens* and *Chaetoceros externum* were present in numbers not exceeding 7.7 x 10^3cells.l^{-1} (Table. 3. 4. 45.).

The dinoflagellate fraction was represented by *Ceratium lineatum* (0.97%) and *Peridinium spp.* (0.97%). The silicoflagellate *Dictyocha speculum* represented 0.97%

of the total biomass. Green flagellates were also present, and accounted for 4.4% of the total biomass.

At 5 metres depth, the total number of algal cells was 58 x 10^3cells.l^{-1}. The population was made up entirely of truly planktonic species. Diatoms were dominant (96.67% of the total biomass), of which the most dominant species was *S. costatum*, being present in numbers of 32.2 x 10^3cells.l^{-1}, which accounted for 55.5% of the total population, ranking second in terms of biomass was *Leptocylindrus danicus* (11%). Also common were *Chaetoceros atlanticum, Chaetoceros externum,* each accounted for 8.88% of the total biomass and *Rhizosolenia stolferfothii* (6.66%). The diatoms *Coscinodiscus spp.* and *Thalassiosira nordenskioldii* were present in small numbers (Table. 3. 4. 45.). Also present was the silicoflagellate *Dictyocha speculum* (2.2%) and green flagellates (1%).

At station 9 (surface), the total number of algal cells was 112 x 10^3cells.l^{-1}, of which 89% were truly planktonic species and the rest were benthic. Diatoms were dominant (90.75% of the total biomass), of which *Skeletonema costatum* was the most dominant species (41.6%), ranking second in terms of biomass was *Chaetoceros atlanticum* (19.6%). Also common was *Nitzschia seriata* (8.67%). The diatoms *Coscinodiscus spp., Grammatophora marina, Leptocylindrus danicus, Melosira spp., Nitzschia spp., Pleurosigma spp., Rhabdonema arcuatum, Rhizosolenia stolterfothii, T. decipiens* and *Chaetoceros externum* were present in numbers not exceeding 6.4 x 10^3cells.l^{-1} (Table. 3. 4. 45.). Also present was the silicoflagellate *Dictyocha speculum* and green flagellates (8.1%).

At 5 metres depth, the algal biomass was 96 x 10^3cells.l^{-1}, of which 95.95% were truly planktonic species and the rest were benthic. Diatoms accounted for 99.67% of the total biomass, which was dominated by *Chaetoceros atlanticum* (27%), *Skeletonema costatum* (20.27%). Also common were *Leptocylindrus danicus* (9.46%),

Table. 3. 4. 45. The number of algal cells (l^{-1}) and their percentages, for 23rd September, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Chaetoceros atlanticum (P)	18723	14	5165	8.88	21952	19.6	25826	27
Chaetoceros externum (P)	3228	2.4	5165	8.88	1936	1.7	9684	10
Coscinodiscus spp (P)	4519	3.4	2582	4	6456	5.78	4519	4.7
Diatoma sp (B)	1291	0.97	-	-	-	-	-	-
Grammatophora marina (B)	322	0.2	-	-	322	0.28	-	-
Leptocylindrus danicus (P)	-	-	6456	11	1297	1.16	9039	9.46
Melosira sp (B)	-	-	-	-	5165	4.6	-	-
Navicula distans (B)	322	0.2	-	-	-	-	-	-
Nitzschia sp (B)	-	-	-	-	645	0.57	-	-
Nitzschia bilobata (B)	322	0.2	-	-	-	-	-	-
Nitzschia seriata (P)	18723	14	-	-	9684	8.67	3873	4
Pleurosigma sp (B)	-	-	-	-	1291	1.16	-	-
Rhabdonema arcuatum (B)	-	-	-	-	322	0.28	-	-
Rhizosolenia spp (P)	322	0.2	-	-	-	-	322	0.33
Rhizosolenia stolferfothii (P)	7747	5.8	3873	6.66	4519	4	11621	12.2
Skeletonema costatum (P)	54234	41	32282	55.5	46487	41.6	19369	20.27
Thalassiosira decipiens (P)	322	0.24	-	-	1291	1.16	2582	2.7
Thalassiosira nordenskioldii (P)	16141	12.22	645	1	-	-	8393	8.78
Dinoflagellates								
Ceratium lineatum (P)	322	0.24	-	-	-	-	-	-
Protoperidinium sp (P)	1291	0.97	-	-	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	1291	0.97	1291	2.2	1291	1.16	322	0.3
Other flagellates								
Green flagellates (P)	5810	4.4	645	1	9039	8.1	-	-

Rhizosolenia stolterfothii (12.2%), *Thalassiosira nordenskioldii* (8.78%) and *Chaetoceros externum* (10%). The diatoms *Coscinodiscus spp., Nitzschia seriata, Rhizosolenia spp.* and *T. decipiens* were present in numbers not exceeding 4.5 x 10^3cells.l^{-1} (Table. 3. 4. 45.). Also present was the silicoflagellate *Dictyocha speculum* (0.3% of the total population).

On 6th October, a further decrease in the total number of algal cells was observed. Although there was an increase in the percentage contribution by silicoflagellates and green flagellates to the total population, diatoms remained as the dominant fraction. *S. costatum* remained as the dominant species.

At station 11 (surface), the total number of algal cells was 77 x 10^3cells.l^{-1}, of which 82.43% were diatoms, 0.84% were dinoflagellates, 4.2% were represented by the silicoflagellate *Dictyocha speculum* and 12.55% were green flagellates. 94.57% of the total biomass were truly planktonic species and the rest were benthic. *Skeletonema costatum* was the most dominant species of the diatom fraction, being present in numbers of 33 x 10^3cells.l^{-1}, which accounted for 42.6% of the total biomass. Also common were *Chaetoceros spp.* (8.36%), *Coscinodiscus spp.* (9.2%) and *Leptocylindrus danicus* (10.87%). *Cocconeis disculus, Diatoma spp., Grammatophora marina, Navicula spp., Nitzschia seriata, Thalassiosira decipiens* and *T. nordenskioldii* were present in numbers not exceeding 2.58 x 10^3cells.l^{-1} (Table. 3. 4. 46.). The dinoflagellate fraction was represented by *Ceratium tripos* and *Protoperidinium spp.*, each represented 0.42% of the total.

At 5 metres depth, the algal biomass was 40 x 10^3cells.l^{-1}, of which 83% were diatoms, 0.8% were dinoflagellates, 9.67% were represented by the silicoflagellate *Dictyocha speculum* and 6.4% were green flagellates. 96.78% of the total biomass were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species of the diatom fraction, being present in numbers of 16.7 x 10^3cells.l^{-1}, which

Table. 3. 4. 46. The number of algal cells (l^{-1}) and their percentages, for 6th October, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Biddulphia aurita (P)	-	-	-	-	322	0.56	-	-
Chaetoceros spp (P)	6456	8.36	3228	8	6456	11.2	-	-
Coscinodiscus spp (P)	7102	9.2	4519	11.3	322	0.56	1297	3.65
Cocconeis disculus (B)	322	0.42	322	0.8	322	0.56	322	0.9
Diatoma spp (B)	2582	3.3	1936	4.8	-	-	1297	3.65
Grammatophora marina (B)	322	0.42	- -	322	0.56 -	-		
Leptocylindrus danicus (P)	8393	10.87	5165	13	11621	20.2	1297	3.65
Navicula spp (B)	1291	1.67	1291	3	-	-	-	-
Navicula distans (B)	-	-	-	-	322	0.56	-	-
Nitzschia seriata (P)	2582	3.3	-	-	3873	6.73	-	-
Pleurosigma sp (B)	-	-	-	-	-	-	322	0.9
Rhizosolenia stolterfothii (P)	-	-	-	-	2582	4.5	1291	3.65
Skeletonema costatum (P)	32928	42.6	16787	41.9	14204	24.7	9684	27.2
Thalassiosira decipiens (P)	322	0.42	-	-	-	-	-	-
Thalassiosira nordenskioldii (P)	1291	1.67	-	-	-	-	1936	5.4
Dinoflagellates								
Ceratium fusus (P)	-	-	322	0.8	-	-	-	-
Ceratium furca (P)	-	-	-	-	322	0.56	-	-
Ceratium tripos (P)	322	0.42	-	-	-	-	-	-
Protoperidinium sp (P)	322	0.42	-	-	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	3228	4.2	3873	9.67	3873	6.7	3873	11
Other flagellates								
Green flagellates (P)	9684	12.55	2582	6.4	12913	22.46	14204	40

accounted for 41.9% of the total population. Also common were *Chaetoceros spp.* (8%), *Coscinodiscus spp.*, (11.3%) and *Leptocylindrus danicus* (13%). *Cocconeis disculus, Diatoma spp.*, and *Navicula spp.* were present in numbers not exceeding 1.9 x 10^3cells.l^{-1} (Table. 3. 4. 46.). The dinoflagellate fraction was represented by *Ceratium fusus.*

At station 9 (surface), the total number of algal cells was 57.5 x 10^3cells.l^{-1}, of which 70.25% were diatoms, 0.56% were dinoflagellates, 6.7% were represented by the silicoflagellate *Dictyocha speculum* and 22.46% were green flagellates. 92.15% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was dominated by *Skeletonema costatum* (24.7%) and *Leptocylindrus danicus* (20.2%). Also common was *Chaetoceros spp.* (11.2% of the total population). The diatoms *Biddulphia aurita, Coscinodiscus spp., Cocconeis disculus, Grammatophora marina, Navicula distans, Nitzschia seriata* and *Rhizosolenia stolterfothii* were present in numbers not exceeding 3.87 x 10^3cells.l^{-1} (Table. 3. 4. 46.). The dinoflagellate fraction was represented by *Ceratium furca.*

At 5 metres depth, the algal biomass was 35.5 x 10^3cells.l^{-1}, of which 49% were diatoms, 11% were represented by the silicoflagellate *Dictyocha speculum* and 40% were green flagellates. 99.1% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was predominantly composed of *S. costatum* , being present in numbers of 9.7 x 10^3cells.l^{-1},which accounted for 27.2% of the total biomass. The diatoms *Coscinodiscus spp., Cocconeis disculus, Diatoma spp., Leptocylindrus danicus, Pleurosigma spp., Rhizosolenia stolterfothii* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 2 x 10^3cells.l^{-1} (Table. 3. 4. 46.).

On 27th October, a slight increase in the total number of algal cells was observed. Diatoms remained as the dominant fraction of the population, with *S. costatum* as the

dominant species, except for samples collected from station 9 at surface where *Nitzschia seriata* succeeded *S. costatum* as the most dominant species.

At station 11 (surface), the total number of algal cells was 81 x 10^3cells.l^{-1}, of which 51.6% were diatoms, 3.16% were dinoflagellates, 7% were represented by the silicoflagellate *Dictyocha speculum* and 38.88% were green flagellates. 87.3% of the total biomass were truly planktonic species and the rest were benthic. *S. costatum* was the most dominant species of the diatom fraction, being present in numbers of 13.5 x 10^3cells.l^{-1}, which accounted for 16.66% of the total biomass, ranking second in terms of biomass was *Coscinodiscus spp.* (9.5%). Also common was *Nitzschia spp.* (7.14%). The diatoms *Amphora spp., Chaetoceros spp., Diatoma spp., Fragilaria spp., Grammatophora marina, Navicula spp., Stauroneis membranacea* and *T. nordenskioldii* were present in numbers not exceeding 3.8 x 10^2cells.l^2 (Table. 3. 4. 47.). The dinoflagellate fraction was represented by *Ceratium furca, Ceratium tripos* each accounted for 0.8% of the total population and *Protoperidinium spp.* (1.58%).

At 5 metres depth, the total number of algal cells was 96 x 10^3cells.l^{-1}, of which 64.44% were diatoms, 0.67% were dinoflagellates, 6% were represented by the silicoflagellate *Dictyocha speculum* and 32.87% were green flagellates. 92.63% of the total biomass were truly planktonic species and the rest were benthic. *Skeletonema costatum* was the most dominant diatom, being present in numbers of 16 x 10^3cells.l^{-1}, which accounted for 16.77% of the total biomass. Also common were *Leptocylindrus danicus* (6.7%) and *Melosira spp.* (4%). *Coscinodiscus spp., Diatoma spp., Diatoma elongatum, Eucampia zodiacus, Grammatophora marina, Navicula spp., Nitzschia spp., Nitzschia seriata, Pleurosigma spp., Rhizosolenia spp., Stauroneis membranacea* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 5 x 10^3cells.l^{-1}. The dinoflagellate fraction was represented by *Ceratium lineatum.*

Table. 3. 4. 47. The number of algal cells (l^{-1}) and their precentages, for 27th October, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Amphora sp (B)	645	0.8	-	-	-	-	-	-
Chaetoceros spp (P)	1291	1.58	-	-	10330	9.4	8393	7.14
Coscinodiscus spp (P)	7747	9.5	5165	5.37	1291	1.17	9039	7.7
Cocconeis disculus (B)	-	-	-	-	-	-	645	0.55
Diatoma spp (B)	1936	3.38	1936	2	645	0.58	4519	3.84
Diatoma elongatum (B)	- -		1936	2 -		- 3228	2.74 →	
Ditylum brightwellii (P)	-	-	-	-	645	0.58	-	-
Eucampia zodiacus (P)	-	-	1291	1.3	-	-	9684	8.24
Fragilaria sp (P)	1291	1.58	-	-	-	-	-	-
Grammatophora marina (B)	645	0.8	645	0.67	645	0.58	645	0.55
Leptocylindrus danicus (P)	-	-	6456	6.7	9039	8.23	3228	2.74
Melosira spp (P)	-	-	9039	9.4	7102	6.47	2582	2.2
Navicula spp (B)	3873	4.76	1291	1.3	-	-	7102	6
Nitzschia spp (B)	5810	7.14	1936	2	1291	1.17	-	-
Nitzschia seriata (P)	-	-	2582	2.6	20015	18.23	1291	1.1
Pleurosigma spp (B)	-	-	645	0.67	645	0.58	-	-
Rhizosolenia spp (P)	-	-	645	0.67	-	-	645	0.55
Skeletonema costatum (P)	13558	16.66	16141	16.77	-	-	29700	25.57
Stauroneis membranacea (P)	3228	3.9	2582	2.68	2582	2.35	3228	2.74
Synedra sp (B)	-	-	-	-	2582	2.35	-	-
Thalassiosira nordenskioldii (P)	1291	1.58	3873	4	2582	2.35	1936	1.65
Dinoflagellates								
Ceratium elongatum (P)	-	-	-	-	-	-	645	0.55
Ceratium furca (P)	645	0.8	-	-	-	-	645	0.55
Ceratium lineatum (P)	-	-	645	0.67	-	-	-	-
Ceratium tripos (P)	645	0.8	-	-	-	-	-	-
Protoperidinium sp (P)	1291	1.58	-	-	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	5810	7	5810	6	6456	5.88	5165	4.4
Other flagellates								
Green flagellates (P)	30991	38.88	31636	32.87	38093	34.7	25180	21.4

At station 9 (surface), the total number of algal cells was 109 x 10^3cells.l^{-1}, of which 60% were diatoms, 5.88% were represented by the silicoflagellate *Dictyocha speculum* and 34.7% were green flagellates. 77% of the total number of algal cells were truly planktonic species and the rest were benthic. *Nitzschia seriata* was the most dominant diatom, being present in numbers of 20 x10^3cells. l^{-1}, which accounted for 18.23% of the total biomass. Also common were *Chaetoceros spp.* (9.4%), *Leptocylindrus danicus* (8.23%) and *Melosira spp.* (6.47%). The diatoms *Coscinodiscus spp., Diatoma spp., Ditylum brightwelli, Grammatophora marina, Nitzschia spp., Pleurosigma spp., Stauroneis membranacea, Synedra spp.* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 2.58 x 10^3cells.l^{-1}.

At 5 metres depth, the algal biomass was 117 x 10^3cells.l^{-1}, of which 73% were diatoms, 1.1% were dinoflagellates, 4.4% were represented by the silicoflagellate *Dictyocha speculum* and 21.4% represented by green flagellates. 92% of the total biomass were truly planktonic species and the rest were benthic. *Skeletonema costatum* was the most dominant diatom, being present in numbers of 29.7 x 10^3cells.l^{-1}, which accounted for 25.27% of the total biomass. Also common were *Chaetoceros* (7.14%), *Coscinodiscus spp.,* (7.7%), *Eucampia zodiacus* (8.24%) and *Navicula spp.,* (6%). *Cocconeis disculus, Diatoma spp., Diatoma elongatum, Grammatophora marina, Leptocylindrus danicus, Melosira spp., Nitzschia seriata, Rhizosolenia spp., Stauroneis membranacea* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 4.5 x 10^3cells.l^{-1} (Table. 3. 4. 47.). The dinoflagellate fraction was represented by *Ceratium elongatum* and *C. furca,* each accounted for 0.55% of the total.

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Low total numbers of algal cells were observed during this period. Diatoms remained as the dominant fraction of the population.

On 12th November, at station 11 (surface), out of a total standing crop of 77.5 x 10^3cells.l^{-1}, 71.7% were diatoms, 2.4 % were dinoflagellates, 5 % were represented by the silicoflagellate *Dictyocha speculum* and 20.8% were green flagellates. 86.68% of the total biomass were truly planktonic species and the rest were benthic. The diatom fraction was dominated by *Skeletonema costatum* (25.8%) and *Melosira spp.* (21.66%). Also common were *Diatoma spp.*, (5.8%) and *Nitzschia seriata* (7.5%). The diatoms *Achnanthes spp., Coscinodiscus spp., Cocconeis disculus, Navicula spp., Pleurosigma spp.* and *T. nordenskioldii* were present in numbers not exceeding 3 x 10^3cells.l^{-1}. The dinoflagellate fraction, represented by *Ceratium extensum, Ceratium furca* and *C. tripos* each accounted for 0.8% of the total.

At 5 metres depth, out of a total standing crop of 37.4 x 10^3cells.l^{-1}, 81% were diatoms, 3.4% were dinoflagellates, 6.9% were represented by the silicoflagellate *Dictyocha speculum* and 8.6% were green flagellates. 70.7% of the total biomass were truly planktonic species and the rest were benthic. *Nitzschia seriata* (15.5% of the total population) succeeded *Skeletonema costatum* as the most dominant diatom, ranking fourth in terms of biomass below *Diatoma spp.* (13.8%), *Eucampia zodiacus* (12%) and *Leptocylindrus danicus* (10.3%) was *Navicula spp.* (8.6%). Also common was *Thalassiosira nordenskioldii* (6.9% of the total quantity). The diatoms *Achnanthes longipes, Coscinodiscus spp., Cocconeis disculus, Grammatophora serpentina, Nitzschia bilobata* and *Synedra spp.* were present in numbers not exceeding 5 x 10^3cells.l^{-1} (Table. 3. 4. 48.). The dinoflagellate fraction was represented by *C. furca.*

At station 9 (surface), out of a total standing crop of 44 x 10^3cells.l^{-1}, 83.3% were diatoms, 0.7% was represented by the dinoflagellate *C. furca* and 16% was represented by the silicoflagellate *Dictyocha speculum* . 78.88% of the total biomass were truly planktonic species and the rest were benthic. The most dominant species of the diatom fraction was *Skeletonema costatum* (25.5%), ranking next in terms of biomass was *Coscinodiscus spp.* (14.6% of the total biomass). Also common were

Table. 3. 4. 48. The number of algal cells (l^{-1}) and their percentages, for 12th November, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Achnanthes sp (B)	645	0.8	-	-	-	-	-	-
Achnanthes longipes (B)	-	-	645	1.7	-	-	-	-
Coscinodiscus spp (P)	1936	2.5	1396	3.7	6456	14.6	14849	36.2
Cocconeis disculus (B)	645	0.8	645	1.7	1936	4.37	322	0.78
Diatoma spp (B)	4519	5.8	5165	13.8	3873	8.75	3873	9.45
Eucampia zodiacus (P)	-	-	4519	12	-	-	-	-
Grammatophora serpentina (B)	-	-	645	1.7	-	-	-	-
Leptocylindrus danicus (P)	-	-	3873	10.3	-	-	-	-
Melosira spp (P)	16786	21.66	-	-	3227	7.3	4519	11
Navicula spp (B)	2582	3	3228	8.6	3228	7.3	5810	14.17
Nitzschia bilobata (B)	-	-	645	1.7	-	-	322	0.78
Nitzschia seriata (P)	5810	7.5	5810	15.5	3873	8.75	- -	
Pleurosigma sp (B)	1291	1.66	-	-	-	-	-	-
Rhabdonema arcuatum (B)	-	-	-	-	2582	8.75	- -	
Rhizosolenia spp (P)	-	-	-	-	-	-	322	0.78
Skeletonema costatum (P)	20015	25.8	-	-	11298	25.5	5165	12.6
Synedra spp (B)	-	-	645	1.7	322	0.7	322	0.78
Thalassiosira nordenskioldii (P)	1291	1.66	2582	6.9	-	-	1291	3
Dinoflagellates								
Ceratium extensum (P)	645	0.8	-	-	-	-	-	-
Ceratium furca (P)	645	0.8	1291	3.4	322	0.7	-	-
Ceratium tripos (P)	645	0.8	-	-	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	3873	5	2582	6.9	7102	16	1291	3
Other flagellates								
Green flagellates (P)	16141	20.8	3228	8.6	-	-	2582	6.3

Diatoma spp., Nitzschia seriata, each accounted for 8.75% of the total population, *Melosira spp.* (7.3%) and *Rhabdonema arcuatum* (8.75%). The diatoms *Cocconeis disculus, Navicula spp.* and *Synedra spp.* were present in numbers not exceeding 1.9 x 10^3cells.l^{-1} (Table. 3. 4. 48.).

At 5 metres depth, out of a total standing crop of 41 x 10^3cells.l^{-1}, 90.56% were diatoms, 3% were represented by the silicoflagellate *Dictyocha speculum* and 6.3% were green flagellates. 84.27% of the total biomass were truly planktonic species and the rest were benthic.

Coscinodiscus spp. was the most dominant diatom, being present in numbers of 14.8 x 10^3cells.l^{-1}, which accounted for 36.2% of the total biomass. The diatoms *Diatoma spp., Melosira spp., Navicula spp.* and *S. costatum* comprised a large proportion of the total biomass. *Cocconeis disculus, Nitzschia bilobata, Rhizosolenia spp.* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 1.3 x 10^3cells.l^{-1} (Table. 3. 4. 48.).

On 23rd December, a decrease in the total number of algal cells was observed, with diatoms as the dominant fraction of the population. Diatoms made up the entire population for samples collected from station 11 at surface.

At station 11 (surface), the total number of diatom cells was 22 x 10^3cells.l^{-1}, of which 82.32% were truly planktonic species and the rest were benthic. The diatoms *Coscinodiscus spp., Diatoma spp., Leptocylindrus danicus, Melosira spp., Navicula spp., Skeletonema costatum* and *Thalassiosira nordenskioldii* comprised a large proportion of the biomass. *Amphora spp., Nitzschia spp., Nitzschia seriata, Pleurosigma spp.* and *Synedra spp.* were present but each alone contributed little to the total biomass of the population (Table. 3. 4. 49.).

At 5 metres depth, the algal biomass was 31 x 10^3cells.l^{-1}, of which 56.26% were truly planktonic species and the rest were benthic. Diatoms were dominant (91.6% of the total biomass). The diatoms *Asterionella japonica, Coscinodiscus spp., Cocconeis disculus, Melosira spp., Navicula spp., S. costatum* and *Surirella salina* comprised a large proportion of the biomass. *Amphora spp., Navicula distans* and *Nitzschia spp.* were present in numbers not exceeding 1.3 x 10^3cells.l^{-1} (Table. 3. 4. 49.).

At station 9 (surface), the total number of algal cells was 35.5 x 10^3cells.l^{-1}, of which 87.23% were truly planktonic species and the rest were benthic. Diatoms were dominant (80% of the total biomass). *Melosira spp.* was the most dominant species, being present in numbers of 12.2 x 10^3cells.l^{-1}, which accounted for 34.54% of the total biomass, ranking second in terms of biomass was *Skeletonema costatum* (14.54%). Also common were *Coscinodiscus spp., Nitzschia spp.* and *Synedra spp.* (Table. 3. 4. 49.). The diatoms *Diatoma spp., Grammatophora marina, Navicula spp., Rhizosolenia spp.* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 1.3 x 10^3cells.l^{-1} (Table. 3. 4. 49.). Also present were green flagellates (20% of the total quantity).

At 5 metres depth, the total number of algal cells was 22.6 x 10^3cells.l^{-1}, of which 82.8% were truly planktonic species and the rest were benthic. Diatoms were dominant (74.3% of the total biomass). The diatoms *Coscinodiscus spp., Melosira spp., Nitzschia spp., S. costatum* and *T. nordenskioldii* comprised a large proportion of the biomass. *Diatoma spp., Navicula spp., Nitzschia seriata* and *Synedra spp.* were present but each alone contributed little to the total biomass of the population (Table. 3. 4. 49.). The dinoflagellate *Protoperidinium spp.* was present in small numbers of 0.6 x 10^3cells.l^{-1}, which accounted for 2.85% of the total. Also present were green flagellates (22.85%).

Table. 3. 4. 49. The number of algal cells (l^{-1}) and their percentage, for 23rd December, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Amphora spp (B)	645	2.9	645	2.1	-	-	-	-
Asterionella japonica (P)	-	-	1936	6.24	-	-	-	-
Coscinodiscus spp (P)	2582	11.76	4519	14.57	2582	7.27	3228	14.28
Cocconeis disculus (B)	-	-	4519	14.57	-	-	-	-
Diatoma spp (B)	2582	11.76	-	-	645	1.8	645	2.85
Grammatophora marina (B)	-	-	-	-	645	1.8	-	-
Leptocylindrus danicus (P)	1936	8.8	-	-	-	-	-	-
Melosira spp (B)	2582	11.76	3873	12.5	12267	34.54	2582	11.42
Navicula spp (B)	3228	14.7	1936	6.2	1291	3.63	1291	5.7
Navicula distans (B)	-	-	645	2.1	-	-	-	-
Nitzschia spp (B)	645	2.9	1291	4.16	-	-	1936	8.58
Nitzschia seriata (P)	1291	5.88	-	-	1936	5.45	1291	5.7
Pleurosigma sp (P)	645	2.9	-	-	-	-	-	-
Rhizosolenia sp (P)	-	-	-	-	645	1.8	-	-
Skeletonema costatum (P)	3228	14.7	4519	14.57	5165	14.54	3228	14.28
Surirella salina (B)	-	-	4519	14.57	-	-	-	-
Synedra spp (B)	645	2.9	-	-	2582	7.27	645	2.85
Thalassiosira nordenskioldii (P)	1936	8.8	-	-	645	1.8	1936	8.57
Dinoflagellates								
Protoperidinium sp (P)	-	-	-	-	-	-	645	2.85
Other flagellates								
Green flagellates (P)	-	-	2602	8.4	7102	20	5165	22.85

On 24th January, the total number of algal cells remained low, with diatoms as the dominant fraction of the population. An increase in the contribution of the benthic fraction of the population was observed.

At station 11 (surface), the total number of algal cells was 23 x 10^3cells.l^{-1}, of which 61.13% were truly planktonic species and the rest were benthic. Diatoms were dominant (97.23% of the total biomass). *Nitzschia spp.* was the most dominant species, being present in numbers of 6.4 x 10^3cells.l^{-1}, which accounted for 27.77% of the total biomass, ranking second in terms of biomass were *Coscinodiscus spp.* and *Melosira spp.*, each accounted for 19.4% of the total population. Also common were *Diatoma spp.* and *Navicula spp.* (Table. 3. 4. 50.). Also present but in small numbers were *Asterionella spp.* and *Nitzschia bilobata*, each accounted for 2.77% of the total quantity. The dinoflagellate fraction was represented by *Ceratium lineatum* (2.77% of the total biomass). Also present in small numbers were the green flagellates (2.77% of the total population).

At 5 metres depth, the total number of algal cells was 18.7 x 10^3cells.l^{-1}, of which 79.34% were truly planktonic species and the rest were benthic. Diatoms were dominant (82.77% of the total biomass). The diatom fraction was dominated by *Coscinodiscus spp.* (27.58%) and *Skeletonema costatum* (24.13%). Also common were *Melosira spp.* (6.89%) and *Navicula spp.* (10.3%). The diatoms *Diatoma spp.*, *Grammatophora marina, Nitzschia bilobata* and *Synedra spp.* were present in small numbers, each accounted for 3.44% of the total population. Also present in small numbers was the silicoflagellate *Dictyocha speculum* (3.44% of the total quantity). Green flagellates were also present and accounted for 13.8% of the total biomass.

At station 9 (surface), the total number of algal cells was 18.7 x 10^3cells.l^{-1}, of which 51.76% were truly planktonic species and the rest were benthic. Diatoms were dominant (79.32% of the total biomass). *Synedra spp.* was by far the dominant

Table. 3. 4. 50. The number of algal cells (l^{-1}) and their percentages, for 24th January 1987, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Asterionella sp (P)	645	2.77	-	-	-	-	-	-
Chaetoceros sp (P)	-	-	-	-	-	-	1936	12
Coscinodiscus sp (P)	4519	19.4	5165	27.58	645	3.44	2582	16
Cocconeis disculus (B)	-	-	-	-	645	3.44	645	4
Diatoma spp (P)	3228	13.88	645	3.44	1291	6.9	1291	8
Grammatophora marina (B)	-	-	645	3.44	-	-	-	-
Gyrosigma sp (B)	-	-	-	-	-	-	1291	8
Melosira spp (P)	4519	19.44	1291	6.89	-	-	-	-
Navicula spp (B)	1936	8.33	1936	10.3	1291	6.9	1936	12
Nitzschia sp (B)	6456	27.77	-	-	-	-	-	-
Nitzschia bilobata (B)	645	2.77	645	3.44	-	-	-	-
Pinnularia sp (B)	-	-	-	-	645	3.44	-	-
Rhizosolenia spp (P)	-	-	-	-	645	3.44	645	4
Skeletonema costatum (P)	-	-	4519	24.13	1291	6.9	1936	12
Synedra spp (B)	-	-	645	3.44	6455	34.47	1291	8
Dinoflagellates								
Ceratium lineatum (P)	645	2.77	-	-	-	-	-	-
Protoperidinium sp (P)	-	-	-	-	645	3.44	-	-
Silicoflagellates								
Dictyocha speculum (P)	-	-	645	3.44	3228	17.24	645	4
Other flagellates								
Green flagellates (P)	645	2.77	2582	13.8	1936	10.3	1936	12

species, being present in numbers of 6.45 x 10^3cells.l^{-1}, which accounted for 34.47% of the total population. The diatoms *Coscinodiscus spp., Cocconeis disculus, Diatoma spp., Navicula spp., Pinnularia spp., Rhizosolenia spp.* and *S. costatum* were present in numbers not exceeding 1.3 x 10^3cells.l^{-1} (Table. 3. 4. 50.). The dinoflagellate *Protoperidinium spp.* represented 3.44% of the total biomass, and the silicoflagellate *Dictyocha speculum* represented 17.24% of the total population. Also present were green flagellates (10.3% of the total biomass).

At 5 metres depth, the total number of algal cells was 16.14 x 10^3cells.l^{-1}, of which 68% were truly planktonic species and the rest were benthic. Diatoms were dominant (96% of the total biomass). The diatoms *Chaetoceros spp., Coscinodiscus spp., Diatoma spp., Gyrosigma spp., Navicula spp., Skeletonema costatum* and *Synedra spp.* accounted for most of the diatom fraction. *Cocconeis disculus* and *Rhizosolenia spp.* were present and each accounted for 4% of the total biomass. The silicoflagellate *Dictyocha speculum* accounted for 4% of the total population. The green flagellates comprised a large proportion of the total biomass (12%).

On 18th February, a slight increase in the total number of algal cells was observed at both stations, at both depths. Diatoms remained as the dominant fraction of the population. Green flagellates were observed only in samples collected from surface at both stations.

At station 11 (surface), the algal biomass was 36.8 x 10^3cells.l^{-1}, of which 84.25% were truly planktonic species and the rest were benthic. Diatoms were dominant (82.47% of the total biomass). *S. costatum* was the most dominant species, being present in numbers of 12.2 x 10^3cells.l^{-1}, which accounted for 33.33% of the total quantity. Also common were *Leptocylindrus danicus* (12.28%) and *Melosira nummuloides* (8.77%). The diatoms *Amphora spp., Coscinodiscus spp., Diatoma spp., Epithemia spp., Navicula spp., Nitzschia bilobata, Pleurosigma spp., Thalassiosira decipiens* and *T.*

nordenskioldii were present in numbers not exceeding 1.9 x 10^3cells.l^{-1} (Table. 3. 4. 51.). The dinoflagellates *Ceratium lineatum* and *Protoperidinium spp.* were present, each accounted for 1.75% of the total population. Also present were green flagellates (14% of the total quantity).

At 5 metres depth, the total number of algal cells was 68.4 x 10^3cells.l^{-1}, of which 88.71% were truly planktonic species and the rest were benthic. The population was made up entirely of diatoms. *Skeletonema costatum* was the most dominant species, being present in numbers of 30.9 x 10^3cells.l^{-1}, which accounted for 45.28% of the total biomass, ranking second in terms of biomass was *Leptocylindrus danicus* (28.3%). The diatoms *Chaetoceros spp., Coscinodiscus spp., Cocconeis sublittoralis, Gomphonema, Grammatophora serpentina, Navicula spp., Nitzschia seriata, Synedra spp.* and *T. nordenskioldii* were present in numbers not exceeding 3.2 x 10^3cells.l^{-1} (Table. 3. 4. 51.).

At station 9 (surface), the algal biomass was 109.4x 10^3cells.l^{-1}, of which 94.72% were truly planktonic species and the rest were benthic. Diatoms were dominant (96.5% of the total biomass). *S. costatum* was the most dominant species, being present in numbers of 61.3 x 10^3cells.l^{-1}, which accounted for 55.88% of the total biomass, ranking second in terms of biomass was *Leptocylindrus danicus* (20.58%). The diatoms *Asterionella japonica, Chaetoceros spp., Coscinodiscus spp., Diatoma spp., Ditylum brightwellii, Gomphonema spp., Grammatophora serpentina, Navicula spp., Nitzcshia bilobata, Nitzschia seriata* and *Rhizosolenia setigera* were present in numbers not exceeding 4.5 x 10^3cells.l^{-1} (Table. 3. 4. 51.). The dinoflagellate fraction was represented by *Ceratium tripos* and *Protoperidinium spp.,* each accounted for 0.58% of the total biomass. Also present were green flagellates (2.35% of the total quantity).

Table. 3. 4. 51. The number of algal cells (l^{-1}) and their percentages, for 18th February 1987, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Achnanthes longipes (B)	-	-	-	-	-	-	645	1.36
Amphora sp (B)	645	1.75	-	-	-	-	-	-
Asterionella japonica (P)	-	-	-	-	2582	2.35	-	-
Chaetoceros spp (P)	-	-	3228	4.7	2582	2.35	-	-
Coscinodiscus spp (P)	1291	3.5	2582	3.77	3228	2.94	3873	8.16
Cocconeis sublittoralis (B)	-	-	645	0.9	-	-	645	1.36
Diatoma spp (B)	645	1.75	-	-	1291	1.2	-	-
Ditylum brightwellii (P)	-	-	-	-	645	0.58	-	-
Epithemia sp (B)	645	1.75	-	-	-	-	-	-
Fragilaria sp (P)	-	-	-	-	-	-	1291	2.72
Gomphonema spp (P)	-	-	1290	1.88	645	0.58	-	-
Grammatophora serpentina (P)	-	-	645	0.9	645	0.58	-	-
Leptocylindrus danicus (P)	4519	12.28	19369	28.3	22597	20.58	7747	16.33
Melosira sp (P)	-	-	-	-	-	-	3873	8.16
Melosira nummuloides (P)	3228	8.77	-	-	-	-	-	-
Navicula spp (B)	1291	3.5	3228	4.7	2582	2.35	3228	6.8
Nitzschia sp (B)	1291	3.5	-	-	-	-	-	-
Nitzschia bilobata (B)	1291	3.5	2582	3.77	2582	2.35	-	-
Nitzschia seriata (P)	-	-	1291	1.88	4519	4	7102	14.97
Pleurosigma sp (B)	645	1.75	-	-	-	-	-	-
Rhabdonema arcuatum (B)	-	-	-	-	-	-	1291	2.72
Rhizosolenia setigera (P)	-	-	-	-	645	0.58	-	-
Skeletonema costatum (P)	12267	33.33	30991	45.28	61337	55.88	11277	23.77
Synedra sp (B)	-	-	645	0.9	-	-	-	-
Thalassiosira decipiens (P)	645	1.75	-	-	-	-	1291	2.72
Thalassioisira nordenskioldii (P)	1936	5.26	1936	2.8	-	-	3228	6.8
Dinoflagellates								
Ceratium extensum (P)	-	-	-	-	-	-	645	1.36
Ceratium lineatum (P)	645	1.75	-	-	-	-	645	1.36
Ceratium tripos (P)	-	-	-	-	645	0.58	-	-
Protoperidinium spp (P)	6	1.75	-	-	645	0.58	-	-
Silicoflagellates								
Dictyocha speculum (B)	-	-	-	-	-	-	645	1.36
Other flagellates								
Green flagellates (P)	5165	14	-	-	2582	2.35	-	-

At 5 metres depth, the total number of algal cells was 47.4 x 10^3cells.l^{-1}, of which 87.76% were truly planktonic species and the rest were benthic. Diatoms were dominant (95.92% of the total biomass). *S. costatum* was the most dominant species, being present in numbers of 11.27 x 10^3cells.l^{-1}, which accounted for 23.77% of the total biomass, ranked third in terms of biomass after *Leptocylindrus danicus* (16.33%) was *Nitzschia seriata* (14.97%). Also common were *Coscinodiscus spp., Melosira spp., Navicula spp.* and *Thalassiosira nordenskioldii.* The diatoms *Achnanthes longipes, Cocconeis sublittoralis, Fragilaria spp., Rhabdonema arcuatum* and *T. decipiens* were present in numbers not exceeding 1.3 x 10^3cells.l^{-1} (Table. 3. 4. 51.). Also present were the dinoflagellates *Ceratium extensum, C. lineatum* and the silicoflagellate *Dictyocha speculum,* each accounted for 1.36% of the total population.

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A gradual increase in the total number of algal cells was observed. Diatoms remained as the dominant fraction of the population, of which *Skeletonema costatum* was the dominant species. The maximum total number of algal cells was observed on 22nd April for surface and 5 metres depth at both stations.

On 11th March, diatoms made up the entire population. At station 11 (surface) the total number of diatom cells was 88.45 x 10^3cells.l^{-1}, of which 98.55% were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species, being present in numbers of 74.2 x 10^3cells.l^{-1}, which accounted for 83.9%of the total biomass. The diatoms *Coscinodiscus spp., Diatoma spp., Leptocylindrus danicus., Nitzschia seriata., Synedra spp.* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 4.52 x 10^3cells.l^{-1} (Table. 3. 4. 52.).

At 5 metres depth, the total number of diatom cells was 72.6 x 10^3cells.l^{-1}, of which 99.12% were truly planktonic species and the rest were benthic.

Table. 3. 4. 52. The number of algal cells (l^{-1}) and their percentages, for 11th March 1987, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	4519	5.1	3228	4.49	4501	5.1	3190	4.4
Diatoma spp (P)	645	0.73	645	0.88	645	0.73	638	0.88
Leptocylindrus danicus (P)	3873	4.37	-	-	4854	5.5	-	-
Nitzschia bilobata (B)	968	1	645	0.88	1765	2	1283	1.77
Nitzschia seriata (P)	3228	3.65	2582	3.55	1588	1.8	1928	2.66
Skeletonema costatum (P)	74250	83.9	64565	88.88	73087	82.8	63437	87.5
Synedra spp (B)	322	0.3	-	-	1729	1.45	-	-
Thalassiosira nordenskioldii (P)	645	0.73	9	1.33	645	0.73	1928	2.66

S. costatum was by far the dominant species, being present in numbers of 64.56 x 10^3cells.l^{-1}, which accounted for 88.88% of the total population. The diatoms *Coscinodiscus spp., Diatoma spp., Nitzschia bilobata, Nitzschia seriata* and *T. nordenskioldii* were present in numbers not exceeding 3.2 x 10^3cells.l^{-1} (Table. 3. 4. 52.).

At station 9 (surface), the total number of diatom cells was 88.27 x 10^3cells.l^{-1} of which 96.48% were truly planktonic species and the rest were benthic. *Skeletonema costatum* was by far the dominant species, being present in numbers of 73 x 10^3cells.l^{-1}, which accounted for 82.8% of the total biomass. The diatoms *Coscinodiscus spp., Diatoma spp., Leptocylindrus danicus, Nitzschia bilobata, Nitzschia seriata, Synedra spp.* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 4.85 x 10^3cells.l^{-1} (Table. 3. 4. 52.).

At 5 metres depth, the total number of diatom cells was 72.5 x 10^3cells.l^{-1}, of which 98.28% were truly planktonic species and the rest were benthic. *S. costatum* was by far the dominant species being present in numbers of 63.4 x 10^3cells.l^{-1}, which accounted for 87.5% of the total population. The diatoms *Coscinodiscus spp., Diatoma spp., N. bilobata, N. seriata* and *T. nordenskioldii* were present in numbers not exceeding 3.2 x 10^3cells.l^{-1} (Table. 3. 4. 52.).

On 18th March, diatoms remained as the dominant fraction of the population with *S. costatum* as the dominant species. Also observed were green flagellates.

At station 11 (surface), the algal biomass was 116.2 x 10^3cells.l^{-1} of which 99.48% were truly planktonic species and the rest were benthic. Diatoms were dominant (85% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 62.9 x 10^3cells.l^{-1}, which accounted for 73% of the total biomass. The diatoms *Coscinodiscus spp., Diatoma spp., Leptocylindrus danicus, Nitzschia bilobata,*

Table. 3. 4. 53. The number of algal cells (l^{-1}) and their percentages, for 18th March 1987, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Coscinodiscus spp (P)	3228	3.74	2582	3.38	6455	7.5	5160	6.78
Diatoma spp (B)	1291	1.5	1291	1.7	1291	1.5	1292	1.7
Leptocylindrus danicus (P)	1291	1.5	1936	2.54	1291	1.5	3866	5.08
Nitzschia bilobata (B)	645	0.74	-	-	1291	1.5	-	-
Nitzschia seriata (P)	3228	3.74	2582	3.38	3219	3.74	1933	2.54
Skeletonema costatum (P)	62951	73	56817	74.57	59629	69.28	54182	71.18
Synedra sp (B)	-	-	-	-	-	-	-	-
Thalassiosira nordenskioldii (P)	645	0.74	645	0.84	636	0.74	1294	1.7
Other flagellates								
Green flagellates	12913	14.98	10330	13.55	12247	14.23	8373	11

Nitzschia seriata and *Thalassiosira nordenskioldii* were present in numbers not exceeding 3.2 x 10^3cells.l^{-1} (Table. 3. 4. 53.). Also present were green flagellates (14.98% of the total population).

At 5 metres depth, the total number of algal cells was 76.16 x 10^3cells.l^{-1}. The population was made up entirely of truly planktonic species. Diatoms were dominant (86.45% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 56.8 x 10^3cells.l^{-1}, which accounted for 74.57% of the total biomass. The diatoms *Coscinodiscus spp., Diatoma spp., Leptocylindrus danicus, Nitzschia seriata* and *T. nordenskioldii* were present in numbers not exceeding 2.58 x 10^3cells.l^{-1} (Table. 3. 4. 53.). Also present were green flagellates (13.55% of the total population).

At station 9 (surface), the algal biomass was 86.07 x 10^3cells.l^{-1} of which 98.5% were truly planktonic species and the rest were benthic. Diatoms were dominant (85.77% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 59 x 10^3cells.l^{-1}, which accounted for 69.28% of the total quantity. The diatoms *Coscinodiscus spp., Diatoma spp., Leptocylindrus danicus, Nitzschia bilobata, Nitzschia seriata* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 6.45 x 10^3cells.l^{-1} (Table. 3. 4. 53.). Also present were green flagellates (14.23% of the total quantity).

At 5 metres depth, the total number of algal cells was 76.12 x 10^3cells.l^{-1}. The population was made up entirely of truly planktonic species. Diatoms were dominant (89% of the total biomass). *Skeletonema costatum* was by far the dominant species, being present in numbers of 54.2 x 10^3cells.l^{-1}, which accounted for 71.18% of the total population. The diatoms *Coscinodiscus spp., Diatoma spp., Leptocylindrus danicus, Nitzschia seriata* and *T. nordenskioldii* were present in numbers not exceeding 7.5 x

10^3cells.l^{-1} (Table. 3. 4. 53.). Also present were green flagellates (11% of the population).

On 25th March, an increase in the total number of algal cells was observed for samples collected from both stations, at both depths. Diatoms remained as the dominant fraction of the population, with *S. costatum* as the dominant species. The dinoflagellate *Ceratium extensum* was observed in samples collected from 5 metres depth at both stations, while the silicoflagellate *Dictyocha speculum* was observed in samples collected from surface at both stations. Green flagellates were observed at both stations at both depths.

At station 11 (surface), the total number of algal cells was 270.06 x 10^3cells.l^{-1}, of which 99.33% were truly planktonic species and the rest were benthic. Diatoms were dominant (93.6% of the total biomass). *Skeletonema costatum* was by far the dominant species, being present in numbers of 229 x 10^3cells.l^{-1}, which accounted for 84.7% of the total population. The diatoms *Coscinodiscus spp., Diatoma spp., Leptocylindrus danicus, Navicula spp., Nitzschia seriata, Synedra spp., Thalassiosira gravida* and *T. nordenskioldii* were present in numbers not exceeding 7.7 x 10^3cells.l^{-1} (Table. 3. 4. 54.). The silicoflagellate *Dictyocha speculum* was present in small numbers (0.2% of the total biomass). Also present were green flagellates (6.2% of the total quantity).

At 5 metres depth, the total number of algal cells was 336 x 10^3cells.l^{-1}, of which 99.22% were truly planktonic species and the rest were benthic. Diatoms were dominant (82.62% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 306.6 x 10^3cells.l^{-1}, which accounted for 91.17% of the total population. The diatoms *Amphora spp., Coscinodiscus spp., Cocconeis disculus, Leptocylindrus danicus, Navicula spp., Nitzschia bilobata* and *N. seriata* were present in numbers not exceeding 4.5 x 10^3cells.l^{-1} (Table. 3. 4. 54.). The dinoflagellate

Table. 3. 4. 54. The number of algal cells (l^{-1}) and their precentages, for 25th March 1987, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Amphora spp (B)	-	-	1291	0.38	-	-	671	0.2
Coscinodiscus spp (P)	5810	2.14	4519	1.34	11570	4.28	9004	2.68
Cocconeis disculus (B)	-	-	645	0.2	-	-	671	0.2
Diatoma spp (B)	645	0.2	-	-	540	0.2	-	-
Leptocylindrus danicus (P)	4519	1.67	1291	0.38	9029	3.34	2553	0.76
Navicula spp (B)	1291	0.47	645	0.2	1270	0.47	1276	0.38
Nitzschia bilobata (B)	-	-	645	0.2	-	-	671	0.2
Nitzschia seriata (P)	7747	2.86	3228	0.95	7109	2.63	3191	0.95
Skeletonema costatum (P)	229207	84.7	306685	91.17	223219	82.57	301710	89.8
Synedra spp (B)	645	0.2	-	-	540	0.2	-	-
Thalassiosira gravida (P)	2582	0.95	-	-	2582	0.95	-	-
Thalassiosira nordenskioldii (P)	645	0.2	-	-	540	0.2	-	-
Dinoflagellates								
Ceratium extensum (P)	-	-	645	0.2	-	-	671	0.2
Silicoflagellates								
Dictyocha speculum (P)	645	0.2	-	-	1243	0.46	-	-
Other flagellates								
Green flagellates (P)	16787	6.2	16787	5	12246	4.53	13439	4

Ceratium extensum was present in small numbers (0.2% of the total biomass). Also present were green flagellates (5% of the total quantity).

At station 9 (surface), the total number of algal cells was 270.34 x 10^3cells.l^{-1}, of which 99.33% were truly planktonic species and the rest were benthic. Diatoms were dominant (95% of the total biomass). *Skeletonema costatum* was by far the dominant species, being present in numbers of 223.4 x 10^3cells.l^{-1}, which accounted for 82.57% of the total population. The diatoms *Coscinodiscus spp., Diatoma spp., Leptocylindrus danicus, Navicula spp., Nitzschia seriata, Synedra spp., Thalassiosira gravida* and *T. nordenskioldii* were present in numbers not exceeding 11.6 x 10^3cells.l^{-1} (Table. 3. 4. 54.). The silicoflagellate *Dictyocha speculum* was present in small numbers (0.46% of the total quantity). Also present were green flagellates (4.53% of the total biomass).

At 5 metres depth, the total number of algal cells was 335.98 x 10^3cells.l^{-1} of which 99% were truly planktonic species and the rest were benthic. Diatoms were dominant (95.8% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 302 x 10^3cells.l^{-1}, which accounted for 89.8% of the total population. The diatoms *Amphora spp., Coscinodiscus spp., Cocconeis disculus, Leptocylindrus danicus, Navicula spp., Nitzschia bilobata* and *Nitzschia seriata* were present in numbers not exceeding 9 x 10^3cells.l^{-1} (Table. 3. 4. 54.). The dinoflagellate *Ceratium extensum* was present in small numbers (0.2% of the total quantity). Also present were green flagellates (4% of the total biomass).

On 8th April, sampling was carried out on station 11 only, with samples collected from surface, 1 metre, 5 metres and 10 metres depth. A decrease in the total number of algal cells was observed. Diatoms remained as the dominant fraction of the population, with *Skeletonema costatum* as the dominant species. An increase in the contribution of green flagellates was observed. The dinoflagellate *Protoperidinium spp.* was observed in samples collected from 1 metre, while the silicoflagellate *Dictyocha speculum* was

observed only in samples collected from 5 metres depth. A decrease in the total number of algal cells was observed with the increase of depth.

At station 11 (surface), the total number of algal cells was 218.22 x 10^3cells.l^{-1}, of which 97.94% were truly planktonic species and the rest were benthic. Diatoms were dominant (83.43% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 164 x 10^3cells.l^{-1}, which accounted for 75.14% of the total population. The diatoms *Coscinodiscus spp., Gomphonema spp., Melosira spp., Navicula spp., Nitzschia bilobata* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 10.3 x 10^3cells.l^{-1} (Table. 3. 4. 55.). The green flagellates were also present and accounted for 15.97% of the total biomass.

At 1 metre depth, the total number of algal cells was 165.16 x 10^3cells.l^{-1}, of which 97.4% were truly planktonic species and the rest were benthic. Diatoms were dominant (67.18% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 94.9 x 10^3cells.l^{-1}, which accounted for 57.4% of the total biomass. The diatoms *Coscinodiscus spp., Gomphonema spp., Navicula spp., Nitzschia spp.* and *Nitzschia seriata* were present in numbers not exceeding 10.3 x 10^3cells.l^{-1} (Table. 3. 4. 55.). The dinoflagellate *Protoperidinium spp.* was present (0.4% of the total). Also present were green flagellates (32.42% of the total population).

At 5 metres depth, the total number of algal cells was 161.77 x 10^3cells.l^{-1}, of which 96% were truly planktonic species and the rest were benthic. 64.94% of the total biomass were diatoms, 0.4% were represented by the silicoflagellate *Dictyocha speculum* and 34.66% were represented by green flagellates. The diatom fraction was predominantly composed of *Skeletonema costatum,* being present in numbers of 89.7 x 10^3cells.l^{-1}, which accounted for 55.37% of the total quantity. The diatoms *Coscinodiscus spp., Leptocylindrus danicus, Navicula spp., Nitzschia spp., Nitzschia*

Table. 3. 4. 55. The number of algal cells (l^{-1}) and their percentages, for 8th April 1987, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		m		5m		10 m	
	n	%	n	%	n	%	n	%
Diatoms								
Amphora sp (B)	-	-	-	-	-	-	645	0.56
Chaetoceros sp (P)	-	-	-	-	-	-	3228	2.8
Coscinodiscus spp (P)	10321	4.73	10322	6.25	4519	2.78	6456	5
Diatoma sp (B)	-	-	-	-	-	-	1291	1
Gomphonema spp (P)	645	0.3	660	0.4	-	-	645	0.56
Leptocylindrus danicus (P)	-	-	-	-	1936	1.2	-	-
Melosira sp (P)	2547	1.18	-	-	-	-	-	-
Navicula spp (B)	1920	0.88	1932	1.17	645	0.4	645	0.56
Nitzschia spp (B)	-	-	660	0.4	1291	0.8	-	-
Nitzschia bilobata (B)	2547	1.18	-	-	3873	2.4	1936	1.7
Nitzschia seriata (P)	-	-	2576	1.56	1936	1.2	-	-
Skeletonema costatum (P)	163970	75.14	94801	57.4	89745	55.37	69730	61
Synedra spp (B)	-	-	-	-	645	0.4	645	0.56
Thalassiosira nordenskioldii (P)	1309	0.6	-	-	645	0.4	1291	1
Dinoflagellates								
Protoperidinium sp (P)	-	-	660	0.4	-	-	-	-
Silicoflagellates								
Dictyocha speculum (P)	-	-	-	-	645	0.4	-	-
Other flagellates								
Green flagellates (P)	34849	15.97	53544	32.42	56171	34.66	27763	24.3

bilobata, Nitzschia seriata, Synedra spp. and *Thalassiosira nordenskioldii* were present in numbers not exceeding 4.5 x 10^3cells.l^{-1} (Table. 3. 4. 55.).

At 10 metres depth, the total number of algal cells was 114 x 10^3cells.l^{-1},of which 96.62% were truly planktonic species and the rest were benthic. Diatoms were dominant (75.7% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 69.7 x 10^3cells.l^{-1}, which accounted for 61% of the total biomass. The diatoms *Amphora spp., Chaetoceros spp., Diatoma spp., Gomphonema spp., Navicula spp., Nitzschia bilobata, Synedra spp.* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 3.2 x 10^3cells.l^{-1} (Table. 3. 4. 55.). Also present were green flagellates (24.3% of the total quantity).

On 15th April, an increase in the total number of algal cells was observed. Diatoms remained as the dominant fraction of the population, with *Skeletonema costatum* as the dominant species. The only other fraction of the population observed was the green flagellates. The contribution of the green flagellates to the total biomass of the population was higher for samples collected from 5 metres depth at both stations than that observed for samples collected from surface.

At station 11 (surface), the algal biomass was 1369.8 x 10^3cells.l^{-1}, of which 95.6% were truly planktonic species and the rest were benthic. Diatoms were dominant (86.87% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 999.95 x 10^3cells.l^{-1}, which accounted for 73% of the total population. The diatoms *Amphora spp., Coscinodiscus spp., Leptocylindrus danicus, Navicula spp.* and *Nitzschia spp.* were present in numbers not exceeding 95.88 x 10^3cells.l^{-1} (Table. 3. 4. 56.). Also present were green flagellates (13.12% of the total quantity).

Table. 3. 4. 56. The number of algal cells (l^{-1}) and their percentages, for 15th April 1987, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Amphora spp (B)	30135	2.2	13750	1.1	38750	2	37500	2
Chaetoceros sp (P)	-	-	-	-	19375	1	-	-
Coscinodiscus spp (P)	95886	7	62500	5	116250	6	37500	2
Diatoma sp (B)	-	-	-	-	-	-	37500	2
Gomphonema sp (P)	-	-	-	-	-	-	18750	1
Leptocylindrus danicus (P)	5479	0.4	-	-	-	-	18750	1
Navicula spp (P)	27396	2	27187	2.175	38750	2	56250	3
Nitzschia spp (B)	30135	2.2	13750	1.1	19375	1	75000	4
Skeletonema costatum (P)	1999954	73	687500	55	1453215	75	993750	53
Thalassiosira nordenskioldii (P)	-	-	-	-	-	-	56250	3
Other flagellates								
Green flagellates (P)	179717	13.12	445250	35.62	236568	12.21	541125	28.86

At 5 metres depth, the total number of algal cells was 1250 x 10^3cells.l^{-1}, of which 97.8% were truly planktonic species and the rest were benthic. Diatoms were dominant (64.37% of the total biomass). *Skeletonema costatum* was by far the dominant species being present in numbers of 687.5 x 10^3cells.l^{-1}, which accounted for 55% of the total biomass. The diatoms *Amphora spp., Coscinodiscus spp., Navicula spp.* and *Nitzschia spp.* were present in numbers not exceeding 62.5 x 10^3cells.l^{-1} (Table. 3. 4. 56.). Green flagellates represented 35.62% of the total population.

At station 9 (surface), the total number of algal cells was 1937.5 x 10^3cells.l^{-1}, of which 98.15% were truly planktonic species and the rest were benthic. Diatoms were dominant (87.14% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 1453 x 10^3cells.l^{-1}, which accounted for 75% of the total population. The diatoms *Amphora spp., Chaetoceros spp., Coscinodiscus spp., Navicula spp.* and *Nitzschia spp.* were present in numbers not exceeding 116.2 x 10^3cells.l^{-1}. Also present were green flagellates (12.21% of the total).

At 5 metres depth, the algal biomass was 1875 x 10^3cells.l^{-1}, of which 98% were truly planktonic species and the rest were benthic. Diatoms were dominant (71% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 993.7 x 10^3cells.l^{-1}, which accounted for 53% of the total biomass. The diatoms *Amphora spp., Coscinodiscus spp., Diatoma spp., Gomphonema spp., Leptocylindrus danicus, Navicula spp., Nitzschia spp.* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 75 x 10^3cells.l^{-1} (Table. 3. 4. 56.). Also present were green flagellates (28.86% of the total quantity).

A further increase in the total number of algal cells was observed on 22nd April. Diatoms remained as the dominant fraction of the population, with *Skeletonema costatum* as the dominant species. The only other fraction of the population observed was the green flagellates. Again, the contribution of the green flagellates to the total

biomass of the population was higher for samples collected from 5 metres depth at both stations than for samples collected from the surface.

At station 11 (surface), the total number of algal cells was 1875 x 10^3cells.l^{-1}, of which 97.8% were truly planktonic species and the rest were benthic. Diatoms were dominant (83.75% of the total biomass). *S. costatum* was by far the dominant species of the population, being present in numbers of 1368.7 x 10^3cells.l^{-1}, which accounted for 73% of the total biomass. The diatoms *Chaetoceros spp., Coscinodiscus spp., Diatoma spp., Leptocylindrus danicus, Nitzschia spp., Nitzschia bilobata* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 75 x 10^3cells.l^{-1} (Table. 3. 4. 57.). Also present were green flagellates (16.25% of the total quantity).

At 5 metres depth, the total number of algal cells was 1750 x 10^3cells.l^{-1}, of which 96.7% were truly planktonic species and the rest were benthic. Diatoms were dominant (66.875% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 962.5 x 10^3cells.l^{-1}, which accounted for 55% of the total biomass. The diatoms *Coscinodiscus spp., Diatoma spp., Leptocylindrus danicus, Navicula spp., Nitzschia spp., Nitzschia bilobata* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 35 x 10^3cells.l^{-1}(Table. 3. 4. 57.). The green flagellates were also present (33.12% of the total population).

At station 9 (surface), the total number of algal cells was 2185 x 10^3cells.l^{-1}, of which 98.9% were truly planktonic species and the rest were benthic. Diatoms were dominant (88.9% of the total biomass). *S. costatum* was by far the dominant species, being present in numbers of 1682.4 x 10^3cells.l^{-1}, which accounted for 77% of the total biomass. The diatoms *Chaetoceros spp., Coscinodiscus spp., Leptocylindrus danicus, Navicula spp., Nitzschia spp., Nitzschia bilobata* and *T. nordenskioldii* were present in numbers not exceeding 109.4 x 10^3cells.l^{-1} (Table. 3. 4. 57.). Also present were green flagellates (11.1% of the total population).

Table. 3. 4. 57. The number of algal cells (l^{-1}) and their percentages, for 22nd April 1987, are summarised in the following table.

P = planktonic. B = benthic. n = number of algal cells. % = percentage of different algal cells.

	Station 11				Station 9			
	S		5m		S		5m	
	n	%	n	%	n	%	n	%
Diatoms								
Chaetoceros spp (P)	18750	1	-	-	21850	1	-	-
Coscinodiscus spp (P)	75000	4	35000	2	109250	5	74375	3.5
Diatoma spp (B)	18750	1	35000	2	-	-	21250	1
Leptocylindrus danicus (P)	937	0.5	17500	1	21850	1	42500	2
Navicula spp (P)	-	-	17500	1	21850	1	-	-
Nitzschia spp (B)	20625	1.1	26250	1.5	21850	1	31875	1.5
Nitzschia bilobata (B)	20629	1.1	31500	1.8	24035	1.1	14875	0.7
Skeletonema costatum (P)	1368750	73	962500	55	1682450	77	1275000	60
Thalassiosira nordenskioldii (P)	37500	2	35000	2	328	1.5	53125	2.5
Other flagellates								
Green flagellates (P)	304687	16.25	52838	33.12	242535	11.1	613275	28.86

At 5 metres depth, the total number of algal cells was 2125 x 10^3cells.l^{-1}, of which 97.8% were truly planktonic species and the rest were benthic. Diatoms were dominant (71.14% of the total biomass). *Skeletonema costatum* was by far the dominant species, being present in numbers of 1275 x 10^3cells.l^{-1}, which accounted for 60% of the total biomass. The diatoms *Coscinodiscus spp., Diatoma spp., Leptocylindrus danicus, Nitzschia spp., Nitzschia bilobata* and *Thalassiosira nordenskioldii* were present in numbers not exceeding 74.37 x 10^3cells.l^{-1} (Table. 3. 4. 57.). Green flagellates were also present, representing a substantial part of the population (28.86%).

3. 5. Carbon fixation studies:

3. 5. 1. Laboratory incubation:

The carbon fixation rates for the total phytoplankton are shown in Figs. 3. 5. 1. and 3. 5. 2. and the percentage contribution of different fractions of phytoplankton to total carbon fixed are shown in Fig. 3. 5. 3, while the actual values are summarized in Tables 3. 5. 3. and 3. 5. 4.

The measurement of the amount of carbon fixed by the total phytoplankton started from 10 March, 1986 and continued until 22 April, 1987. All these measurements were based on laboratory incubations, (see Materials and Methods), which in addition to showing the amount of fixation on each date of sampling, indicated the potential photosynthetic capacity of suspended algae.

In situ measurements were carried out at station 11 for surface, 1 metre, 5 metres and 10 metres depth samples on 8 and 22 April, 1987. Two sets of measurements were made, one involving the total phytoplankton, the other to assess the contribution of the major fractions after filtration through nylon nets of mesh size 20 and 10 µm, and finally using a membrane filter of 0.45 µm pore size; these data are summarized in Tables 3. 5 . 2. and 3. 5. 3.

The values of carbon fixed as observed in laboratory incubations during the spring of 1986 ranged between 4 - 299 mg C m^{-3}. h^{-1} for stations 11 and 9 respectively. Higher fixation rates were found at the latter station at most times.

During the spring diatom increase carbon fixation levels for samples collected from the surface increased from 6.7 mg C m^{-3}. h^{-1} on 10 March to 55 mg C m^{-3}. h^{-1} on 19 March at station 11 and from 4 mg C m^{-3}. h^{-1}on 10 March to 105 mg C m^{-3}. h^{-1} at station 9. For 5 metres depth samples the production levels increased from 6.4 mg C m^{-3}. h^{-1} on 10 March to 35.5 mg C m^{-3}. h^{-1} on 19 March at station 11 and from 6 mg

C m^{-3}. h^{-1} on 10 March to 46 mg C m^{-3}. h^{-1} on 19 th of March at station 9. A decrease in surface levels with an accompaying increase at 5 metres was observed on 26 March. Samples collected from the surface showed production values of 32 mg C m^{-3} . h^{-1} from station 11 and 43 mg C m^{-3}. h^{-1} from station 9; at 5 metres depth the levels were 43 and 52 mg C m^{-3}. h^{-1} for stations 11 and 9 respectively.

Higher photosynthetic activity levels were measured at both stations for samples collected from the surface on 2 April, being the highest at station 11, with 299 mg C m^{-3}. h^{-1}. At the same time for station 9 the highest value was obtained from samples collected at the surface (258 mg C m^{-3}. h^{-1}). For samples collected from 5 metres depth photosynthetic activities at this time were low in comparison with the surface values (18 and 2 mg C m^{-3}. h^{-1} at stations 11 and 9 respectively).

On the 9 April, for samples collected from the surface production levels decreased sharply to 27 and 51 mg C m^{-3}. h^{-1} at stations 11 and 9 respectively, higher levels being recorded at the same time at 5 metres (35 and 44 mg C m^{-3}. h^{-1} at stations 11 and 9 respectively). A further decrease in fixation values was recorded on 23 April with quantities ranging from 13 to 17.8 mg C m^{-3}. h^{-1} for samples collected from surface and 5 metres depth, with slightly higher levels observed for samples collected from surface.

Despite a slight increase in the photosynthetic output levels recorded for samples collected from station 11 (5 metres) and station 9 (surface), fixation values remaind low on 7 May, on this date samples collected from the surface showed production levels of 11.7 mg C m^{-3}. h^{-1} from station 11 and 21.4 mg C m^{-3}. h^{-1} from station 9. At 5 metres depth the levels were 21.4 and 5 mg C m^{-3}. h^{-1} for stations 11 and 9 respectively, the value found at the latter station represented the minimum post-peak level.

During the rest of the summer months the carbon fixation rates for the total phytoplankton population fluctuated between high and low levels.

Maximum production values for the year 1986 were observed in the samples collected from the surface at stations 11 and 9 on 4 th of June being the highest at station 9 with fixation levels of 766.7 and 599 mg C m^{-3}. h^{-1} for station 11. At 5 metres depth the levels were 264 and 418 mg C m^{-3}. h^{-1} for samples collected from stations 11 and 9 respectively.

On the 18 June carbon fixation levels declined sharply. The higher levels were observed with samples collected from the surface at both stations, 58 and 46 mg C m^{-3}. h^{-1} for stations 11 and 9 respectively. For samples collected from 5 metres depth the production levels were 9.4 and 28.4 mg C m^{-3}. h^{-1} for station 11 and 9 respectively.

On 2 July an increase in the photosynthetic activity was observed at 5 metres depth only (159 mg C m^{-3}. h^{-1} for samples collected from station 11 and 208 mg C m^{-3}. h^{-1} for samples collected from station 9). For samples colleected from surface the levels of fixation were lower (24.6 and 25.3 mg C m^{-3}. h^{-1} for stations 11 and 9 respectively). On 16 July slightly higher production levels were recorded for samples collected from the surface (47.7 mg C m^{-3}. h^{-1} from station 11 and 45 mg C m^{-3}. h^{-1} from station 9); for samples collected from 5 metres depth the fixation levels were 12 and 73 mg c m^{-3}. h^{-1} for stations 11 and 9 respectively.

A second summer major increase in carbon fixation levels was measured at both stations and at both depths on 30 July, being the highest at the surface for station 9 (402 mg C m^{-3}. h^{-1}), compared with 389 mg c m^{-3}. h^{-1} at station 11. Samples collected from 5 metres depth showed fixation levels of 389 and 356 mg C m^{-3}. h^{-1} for stations 11 and 9 respectively.

Equally comparable high levels of algal production were recorded on 15 August. Samples collected from the surface showed carbon fixation levels of 359 mg C m^{-3}. h^{-1} from station 11 and 420 mg C m^{-3}. h^{-1} from station 9; for samples collected from 5

metres depth production levels were of a similar order (393 and 375 mg C $m^{-3}.h^{-1}$ for stations 11 and 9 respectively).

During the autumn months the maximum photosynthetic outputs were recorded on 10 September when they were comparable to those obtained in the spring . The highest activity levels were recorded at station 11 in which samples collected from surface showed carbon fixations of 343 mg C m^{-3}. h^{-1} compared with 136 mg C m^{-3}. h^{-1} from station 9. For samples collected from 5 metres depth fixation levels were 180 and 158.5 mg C m^{-3}. $h^{-1}$for stations 11 and 9 respectively.

A decrease in photosynthetic activity at both stations was recorded on 25 September, with the higher value at station 9. Surface samples showed production levels of 19 mg C m^{-3}. h^{-1} for station 11 and 45.4 mg C m^{-3}. h^{-1} for station 9. For samples collected from 5 metres depth fixation levels were 14.4 and 33 mg C m^{-3}. h^{-1} for stations 11 and 9.

Higher levels of photosynthetic activity were recorded on 6 October, again being the highest at station 9. Samples collected from the surface showed carbon fixation levels of 39.4 mg C m^{-3}. h^{-1} from station 11 and 72.4 mg C m^{-3}. h^{-1} for station 9. For samples collected from 5 metres depth fixation levels were of a similar order (41.8 and 70.6 mg C m^{-3}. h^{-1} for stations 11 and 9 respectively).

On 27 October at station 11 further higher total productivity levels were recorded for samples collected from 5 metres depth than those recorded for surface samples, although a much higher chlorophyll a value was recorded at surface. Photosynthetic output at this time were 52 mg C m^{-3}. h^{-1} for surface samples and 112 mg C m^{-3}. h^{-1} for 5 metres samples collected from station 11. For samples collected from station 9 productivity levels were much lower particularly at 5 metres depth (32 and 6.2 mg C m^{-3}. h^{-1} for samples collected from surface and 5 metres depth respectively).

Low carbon fixation levels were reached at both stations by November 12th; carbon fixation levels were in the range 0 - 13 mg C m^{-3}. h^{-1}.

Dark fixation was normally low representing only a few percentages of the light fixation except during a period in February 1987, when the dark fixation levels were higher than those of the light (Table. 3. 5. 1.). This may be explained by the adsorption of ^{14}C on detritus which formed a large part of the suspended matter at this time of the year, or alternatively that the high dark fixation was due to heterotrophic bacterial uptake, possibly attached to the detrital material.

Table. 3. 5. 1. Dark and light fixation levels, February 17th, 1987 (mg C m^{-3}. h^{-1})

	Station 11		Station 9	
	Light	Dark	Light	Dark
Surface	7.20	7.85	6.57	7.30
5 metres	7.65	9.50	7.70	8.57

Spring fixation levels started to be observed from 11 March, the levels ranging between 37 - 42 mg C m^{-3}. h^{-1} at both stations. Productivity values showed a gradual increase throughout March and April to reach maximum levels on 22 April, the higher production values being measured at both stations from the 5 metres depth samples, and highest at station 9. At this time the surface samples showed fixation levels of 320 mg C m^{-3}. h^{-1} for station 11 and 350 mg C m^{-3}. h^{-1} for station 9; for samples collected from 5 metres depth the photosynthetic activity levels were 343 and 360 mg C m^{-3}. h^{-1} for stations 11 and 9 respectively.

3. 5. 2. <u>In situ</u> fixation:

<u>In situ</u> incubation was carried out for samples collected from surface, 1 metre, 5 metres and 10 metres depth at station 11 on the 8 and 22 of April (Table. 3. 5. 2.).

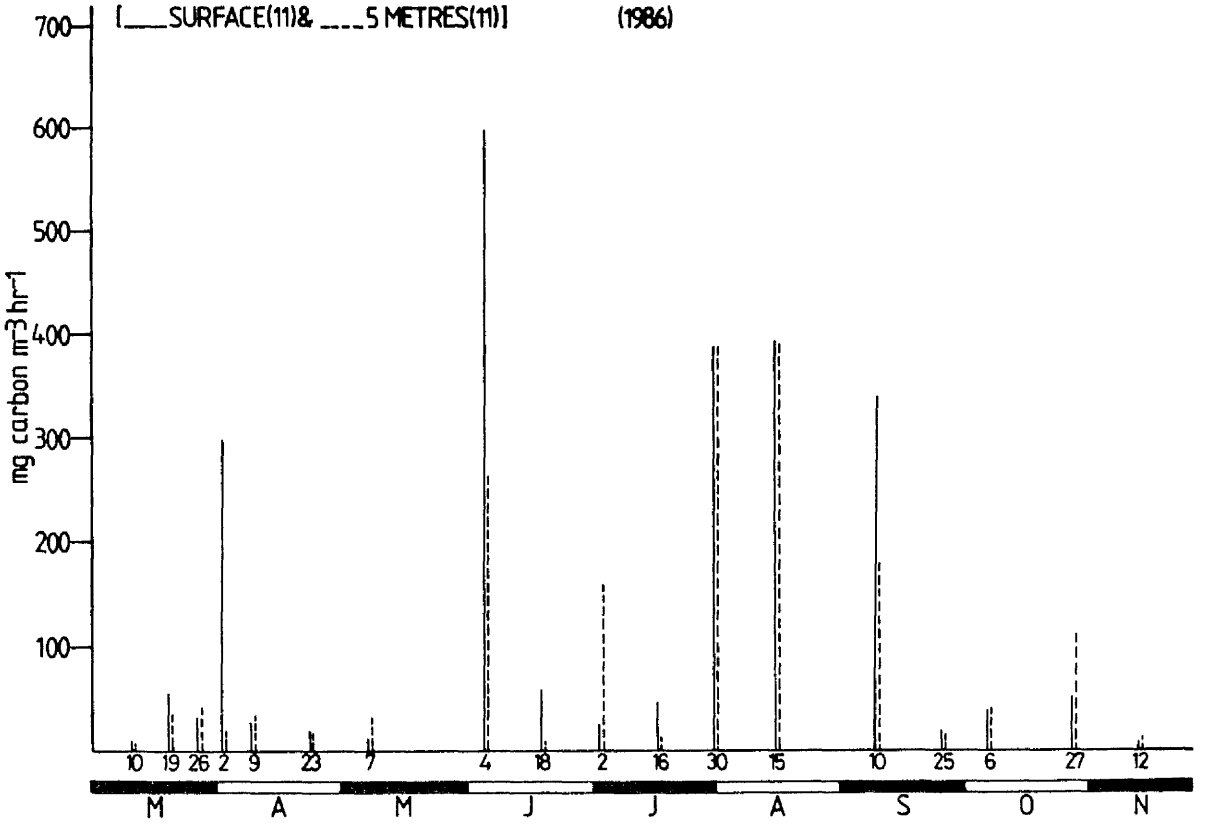
Table. 3. 5. 2. In situ based fixation levels measured at station 11 (mg C m^{-3}. h^{-1})

Depth	8 April	22 April
Surface	8.63	149.6
1 metre	15.62	249.2
5 metres	15.28	14.27
10 metres	8.38	00.00

From these results, higher in between depth variations in carbon fixation were recorded on 22 April as compared with those levels obtained on 8 April. This could be attributed to the much higher algal biomass present on 22 April at the upper layers of the water column which affected the light penetrability into the deeper waters, which in turn caused the much lower photosynthetic activity recorded at 5 and 10 metres depth.

On 8 and 22 April, because of the near to optimum conditions in which the laboratory incubations were carried out for samples collected from surface and 5metres depth, as expected the levels of fixation obtained through the in situ measurements were lower.

Fig. 3. 5. 1. Laboratory based carbon fixation rates with surface and 5 metres samples. Station 11.
From 10.3.1986 to 22.4.1987, (mg C m^{-3}. h^{-1}).


[___SURFACE(11)& ____5 METRES(11)]
(1986)
mg carbon m-3 hr-1
700
600
500
400
300
200
100
10 19 26 2 9 23 7 4 18 2 16 30 15 10 25 6 27 12
M A M J J A S O N

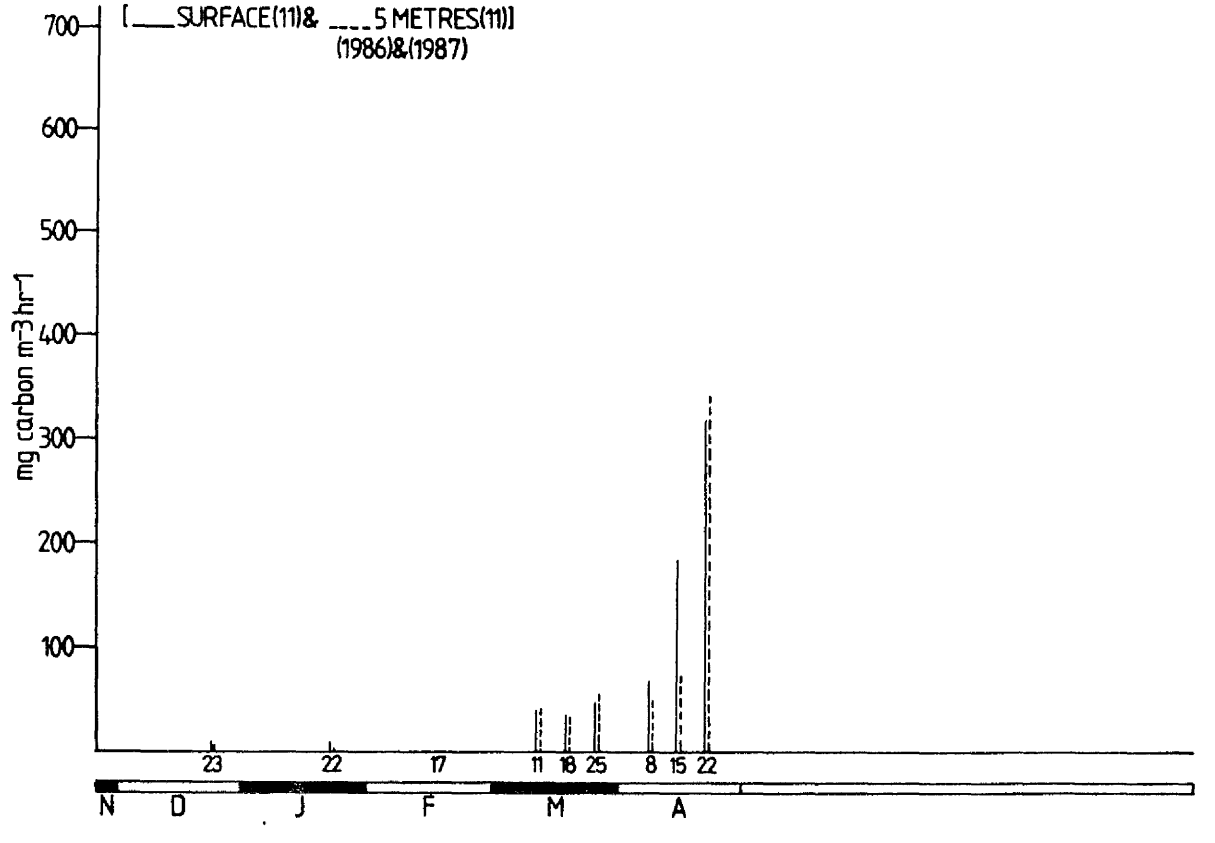
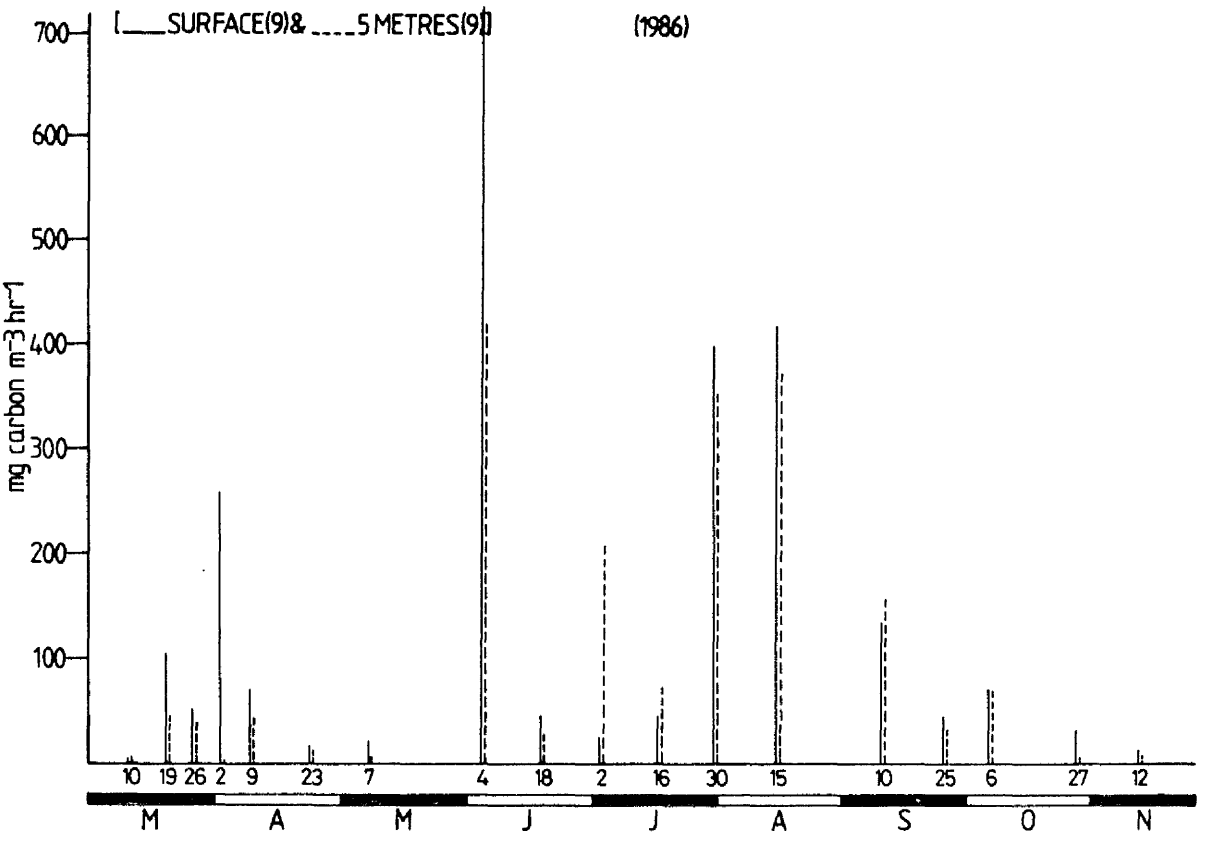
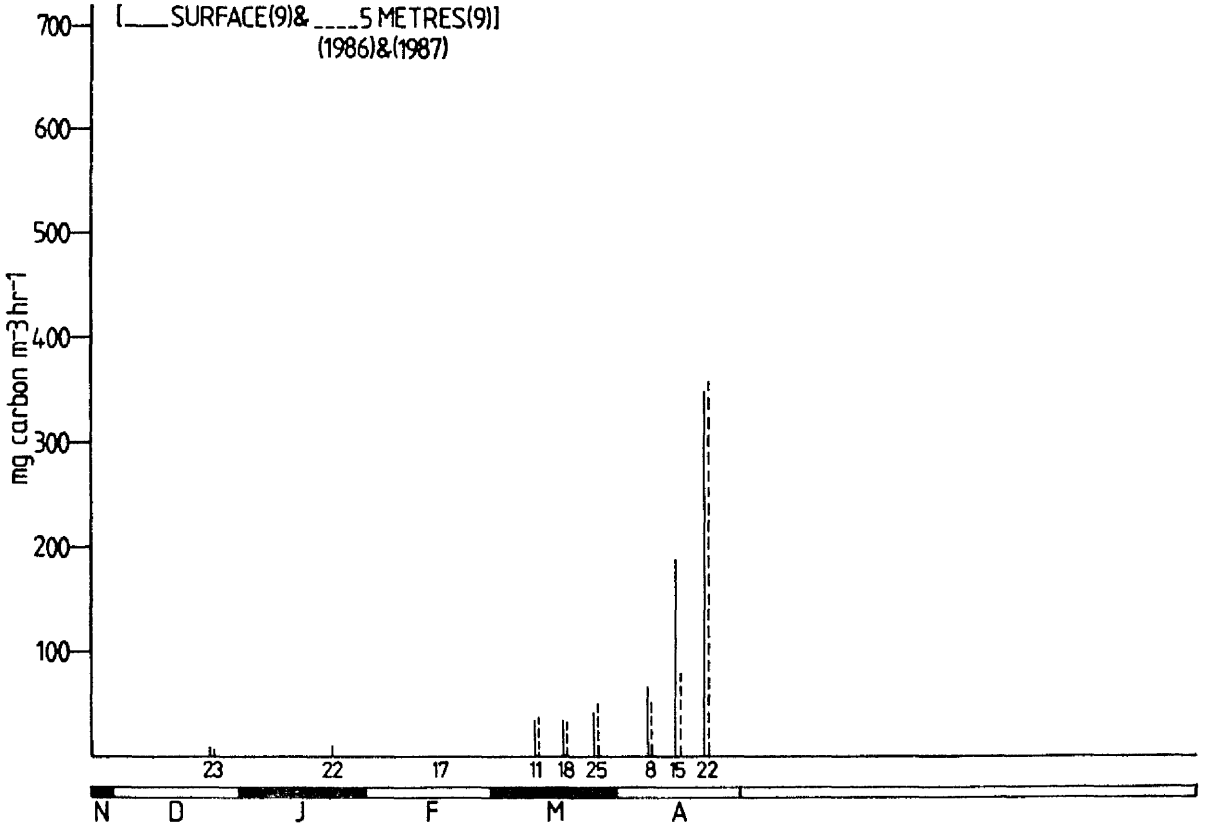

[___SURFACE(11)& ____5 METRES(11)]
(1986)&(1987)
mg carbon m-3 hr-1
700
600
500
400
300
200
100
23 22 17 11 18 25 8 15 22
N D J F M A

Fig. 3. 5. 2. Laboratory based carbon fixation rates with surface and 5 metres samples. Station 9.
From 10.3.1986 to 22.4.1987, (mg C m^{-3}. h^{-1}).


[___SURFACE(9)& ____5 METRES(9)]
(1986)
mg carbon m-3 hr-1
700
600
500
400
300
200
100
10 19 26 2 9 23 7 4 18 2 16 30 15 10 25 6 27 12
M A M J J A S O N


[___SURFACE(9)& ____5 METRES(9)]
(1986)&(1987)
mg carbon m-3 hr-1
700
600
500
400
300
200
100
23 22 17 11 18 25 8 15 22
N D J F M A

3. 5. 3. Discussion:

The fixation values recorded during this study varied significantly at the different seasons. The productivity levels did not show a good correlation with the total number of algal cells during the same period but tended to follow more closely the chlorophyll a values. This was most evident during the summer of 1986.

During 10, 19 and 26 March the photosynthetic output levels were low as chlorophyll a and the total number of algal cells. The highest C^{14} fixation for this period was recorded on 19 March for samples collected from station 9 at surface (105 mg C m^{-3}. h^{-1}), at this date 2.2 mg chlorophyll a. m^{-3} was found and the total number of algal cells 84.6 x 10^3. l^{-1}, those biomass levels (chlorophyll a levels and the total number of algal cells) did not represent the maximum for this period. The maximum chlorophyll a and total number of algal cells for this period were observed on 26 March when lower photosynthetic activity levels than those found on 19 March were recorded (see. Figs. 3. 3. 3., 3. 3. 7., 3. 4. 2. and 3. 4. 4.).

On 2 April the maximum fixations for the spring were recorded for samples collected from the surface at stations 11 and 9, coinciding with the total number of algal cells and chlorophyll a levels which represented the maximum for this period.

Although there was a decrease in chlorophyll a levels an increase in the photosynthetic output was recorded for samples collected from both stations at 5 metres depth on 9 April coinciding with similar increase in the total number of algal cells, whilst on 23 April although a further increase in the total number of algal cells was observed for samples collected from station 11 at 5 metres depth and from station 9 at both depths, accompanied by an increase in chlorophyll a levels at both stations, at both depths, a decrease in C^{14} fixation was recorded. This low photosynthetic activity could be an indication that the population at this time was made up of unhealthy cells.

During the summer months the changes in carbon fixation levels from high to low and vice versa, directly correlated to the changes in chlorophyll a levels, not so with the total number of algal cells.

The highest levels of productivity observed during this study were those recorded on the 4 June, for samples collected from station 11 at surface and from station 9 at surface and 5 metres depth, coinciding with a noticeable pulse in chlorophyll a levels, at the same time relatively low total numbers of algal cells was observed. Although higher chlorophyll a levels were found for samples collected from station 11 at 5 metres depth than that at surface, much higher photosynthetic activity was recorded from samples collected at the surface.

On 18 June, a sharp decrease in fixation levels accompan ed by a similar decrease in chlorophyll a levels and in the total number of algal cells was recorded.

On 2 July, when much higher 5 metres fixation levels were recorded, similar ly much higher 5 metres chlorophyll a levels and total number of algal cells were recorded.

Equally comparable high productivity values were recorded at both stations at both depths on 30 July and on 15 August, which represented a second summer major increase with levels of fixation ranging from 355 - 401 mg carbon. m^{-3} being the highest at the surface for station 9, coinciding with a noticeable pulse in chlorophyll a levels and in the total number of algal cells.

On 10 September, maximum levels of fixation for the autumn period were recorded, coinciding with chlorophyll a levels and the total number of algal cells.
During winter months a decrease in the photosynthetic output levels at both stations, at both depths which was closely paralleled by the changes in chlorophyll a levels and the total number of algal cells recorded.

The gradual increase in the levels of carbon fixed during the spring of 1987, in which the maximum values were obtained on 22 April for both stations, at both depths was closely correlated to a similar gradual increase in chlorophyll a levels and in the total number of algal cells in which the maximum for both was recorded at the same date as that of the productivity.

For the in situ measurements the highest levels of photosynthetic activity were recorded at 1 metre depth, the levels decreased with the increase of depth coinciding with the changes of chlorophyll a levels at each depth.

Whilst it must be acknowleged that the laboratory incubations are not true indicators of what occurs in nature, these measurements can be indicators of the photosynthetic potential of a population when subjected to more favourable conditions of light and temperature. The data obtained in these experiments would seem to justify this view.

3. 5. 4. Carbon fixation studies and size fractions of phytoplankton:

In this study the levels of carbon fixation were measured for six size fractions ($\geq$100 µm, $\geq$50 to <100 µm, $\geq$20 to <50 µm, $\geq$10 to<20 µm, $\geq$5 to <10 µm and $\geq$0.45 to <5 µm) of phytoplankton populations from surface and 5 metres depth at stations 11 and 9. The fractions can be classified into two main groups; small, solitary forms passed by 20 µm mesh screen (Nanoplankton including Picoplankton) (<1 µm) and chain - forming diatoms or large - celled diatoms and dinoflagellates that were retained by 20 µm mesh screen (Net plankton). In the process of determining the contribution of different size fractions to the total carbon fixed by using the same amount of water sample (120ml) used to measure the total phytoplankton production proved unsatisfactory, due to the very low levels of production measured, often being unmeasurable. To overcome this problem the quantity of water samples used for fractionation ranged between 1 - 2 litres. Resuspension of these separate fractions was then made in 148 ml incubation bottles, using previously membrane filtered sea water. In consequence the incubation data will differ from those obtained in situ and in laboratory incubations in which the natural populations of mixed sizes were used.

Measurements were made from 15 August, 1986 to 8 April, 1987, using the method described on p. 59. Carbon fixation was measured after laboratory incubations. Results are summarized in Tables 3. 5. 3. and 3. 5. 4., and Fig. 3. 5. 3.

August 15, 1986:

At this time the net plankton production accounted for most of the carbon fixed with quantities ranging from 60 - 77% of the total at both stations.

For samples collected from station 11 the contribution of the net plankton fraction was higher at 5 metres depth than that at the surface, while for samples collected from station 9 the contribution of the same fraction was higher at surface than that at

Table. 3. 5. 3. Amount of carbon fixed by the different fractions of phytoplankton at station 11
(all based on laboratory incubations)
(mg carbon $m^{-3}. h^{-1}$)

		The size of different phytoplankton fractions in (µm)					
	Depth	≥100	≥50<100	≥20<50	≥10<20	≥5<10	≥0.45<5
Date							
	S	82.0	163.0	178.0	105.0	50.0	58.0
15.8.86							
	5 m	80.0	172.0	188.0	55.0	34.0	42.0
	S	80.0	156.3	167.5	103.2	41.5	52.0
10.9.86							
	5m	74.3	195.5	164.7	32.4	31.0	39.2
	S	4.55	12.3	67.6	22.3	18.4	45.0
25.9.86							
	5m	5.3	30.5	23.7	11.5	16.4	15.2
	S	34.8	14.3	24.8	14.7	18.3	14.0
6.10.86							
	5m	19.7	10.3	9.7	4.3	24.2	6.6
	S	3.0	16.7	35.8	29.0	24.0	35.0
27.10.86							
	5m	9.7	14.8	41.7	33.0	21.3	35.0
	S	0.0	0.0	0.0	0.0	25.5	3.2
12.11.86							
	5m	0.0	0.0	0.0	0.0	16.0	7.6
	S	0.0	0.0	0.0	0.0	24.8	4.8
23.12.86							
	5m	0.0	0.0	0.0	0.0	19.3	4.0
	S	1.2	3.2	4.0	1.6	24.0	4.0
22.1.87							
	5m	0.4	6.4	2.4	0.0	14.0	8.8
	S	1.2	3.2	5.6	3.2	25.6	5.6
17.2.87							
	5m	3.2	6.4	4.0	1.6	15.2	10.4
	S	23.0	3.0	29.9	27.0	22.0	23.0
11.3.87							
	5m	23.0	2.9	30.9	29.0	17.0	21.0
	S	20.6	3.0	28.4	26.2	21.0	22.0
18.3.87							
	5m	21.8	2.6	30.0	27.0	17.0	23.0
	S	27.0	4.0	31.0	29.7	23.9	24.7
25.3.87							
	5m	22.4	0.0	34.2	30.5	17.3	23.9
	S	32.0	6.0	40.0	36.0	30.0	38.0
8.4.87							
	5m	30.0	4.0	42.0	36.0	29.0	35.0

S = Surface and 5m = 5 metres.

Table. 3. 5. 4. Amount of carbon fixed by different fractions of phytoplankton at station 9
(all based on laboratory incubations)
(mg carbon $m^{-3}. h^{-1}$)

		The size of the different phytoplankton fractions in (µm)					
	Depth	≥100	≥50<100	≥20<50	≥10<20	≥5<10	≥0.45<5
Date							
	S	78.0	154.0	164.0	103.0	43.0	52.0
15.8.86							
	5m	62.0	117.0	77.0	78.0	43.0	49.0
	S	52.9	78.2	59.6	144.9	14.3	22.4
10.9.86							
	5m	63.0	120.3	70.4	70.55	42.3	48.0
	S	4.0	9.6	57.45	1.6	108.3	4.3
25.9.86							
	5m	9.0	6.36	8.1	6.6	11.87	13.7
	S	37.0	14.86	29.0	11.78	17.7	16.5
6.10.86							
	5m	24.78	6.0	12.2	17.2	23.2	10.0
	S	8.4	11.5	37.5	25.75	19.8	29.7
27.10.86							
	5m	5.9	6.2	34.9	30.0	22.0	30.2
	S	0.0	0.0	0.0	0.0	16.44	6.8
12.11.86							
	5m	0.0	0.0	0.0	0.0	10.7	1.73
	S	1.6	1.6	0.0	0.0	14.4	4.0
23.12.86							
	5m	0.0	0.0	0.0	0.0	8.0	1.6
	S	2.0	4.8	4.4	7.6	9.2	3.6
22.1.87							
	5m	1.6	5.2	4.8	1.6	7.2	3.2
	S	4.0	8.0	7.2	4.4	16.4	5.6
17.2.87							
	5m	5.2	8.8	6.4	2.4	11.2	6.4
	S	24.5	2.85	34.0	32.0	12.0	25.0
11.3.87							
	5m	26.0	3.9	25.9	28.0	14.9	22.8
	S	22.7	4.25	32.75	31.0	11.8	23.0
18.3.87							
	5m	22.2	4.5	25.7	27.8	14.0	20.5
	S	29.2	0.0	38.2	38.7	14.0	29.5
25.3.87							
	5m	34.2	3.1	27.34	32.0	17.8	29.2
	S	35.0	5.0	41.0	38.0	32.0	40.0
8.4.87							
	5m	31.0	2.8	40.0	35.0	27.0	36.0

S = Surface and 5 m = 5 metres depth.

5 metres depth. For station 11 (surface) the net plankton accounted for 66.5% of the total production, with the ≥50<100 and ≥20<50 µm fractions making the major contribution in about equal amounts. Of the 33.5% fixation by the nanoplankton, about half lay in the ≥10<20 µm size fraction, with the lesser fractions each making about equal contributions.

At 5 metres depth the net plankton population accounted for 77% of the photosynthetic activity, with the three fractions making almost equal contributions. The <20 µm size groups showed that most of its production occured in the ≥10<20 µm size, with smaller amounts, almost of equal proportions, in the smaller fractions.

At station 9 the fixation quantities for the different fractions were of the same order as at station 11, with the net plankton accounting for 66.7% of the total photosynthetic output, with the larger quantities in the ≥50<100 µm and ≥20<50 µm size fractions. With the nanoplankton, there were almost equal amounts of fixation in the ≥0.45<5 µm and ≥5<10 µm fraction, but with the greater quantity in the ≥10<20 µm size fraction.

September 10, 1986:

Again the net plankton population accounted for most of the total production (61 - 80.87%) with the exception of the levels obtained for samples collected from the surface at station 9 (51.2% of the total). The highest levels by the net plankton population were observed for samples collected from station 11 at both depths. For samples collected from stations 11 and 9 the contribution of the net plankton population was higher at 5 metres depth than that at the surface. The greatest measured production levels for the net plankton population were in the ≥50<100 µm and ≥20<50 µm size fractions, whilst the greatest fixation level for the nanoplankton population was in the ≥10<20 µm fraction.

At station 11 (surface) the net plankton accounted for 67.23% of the total photosynthetic activity, of which again the ≥50<100 and ≥20<50 µm fractions were the major contributors in about equal amounts. Of about 32.77% fixation by the nanoplankton population more than half was carried out by the ≥10<20 µm fraction, with the lesser fractions each making about equal contributions.

At 5 metres depth the net plankton population accounted for 80.87% of the total production, with the ≥50<100 and ≥20<50 µm fractions making the major contribution, of which that of the former fraction was slightly higher. Half the amount of photosynthetic activity by the nanoplankton population (19.1% of the total) was by the ≥10<20 µm fraction, with the other two smaller fractions accounting for the other half, of which the contribution of the ≥0.45<5 µm fraction was slightly higher.

For samples collected from station 9 (surface) the contribution of the net -plankton population was much lower than that observed for samples collected from station 11 (surface), (51.2% of the total production). The largest levels of activity by the net plankton population was in the ≥50<100 µm and the smallest was in the ≥100 µm size fraction. With the <20 µm size group most of its carbon fixation occurred in the ≥10<20 µm fraction, with smaller amounts, almost of equal proportions, in the smaller fractions.

At 5 metres depth the net plankton population accounted for 61.1% of the total photosynthetic output, of which there was equal amounts in the ≥100 and ≥20<50 µm fractions, but with a slightly greater quantity in the ≥50<100 µm size fraction. With the nanoplankton population the greater activity was recorded for the ≥10<20 µm size fraction, with the other two smaller fractions each making about equal contributions.

September 25, 1986:

An increase in the contribution of the nanoplankton population to the total photosynthetic activity was recorded at this date mainly for samples collected from station 9 at both depths. Most of the activity by the net plankton population was attributed to the ≥20<50 µm fraction, whilst the greatest measured production level for the nanoplankton population was in the ≥0.45<5 µm fraction.

For station 11 (surface) the net plankton accounted for 49.64% of the total photosynthetic out put, with the ≥20<50 µm fraction showing the most activity; much smaller levels of activity were carried out by the ≥100 and ≥50<100 µm fractions, of which the amount fixed by the former was the lowest. Of the 50.3% fixation by the nanoplankton, slightly more than half lay in the ≥5<10 µm fraction, with the lesser fractions each making about equal contributions.

For samples collected from 5 metres depth the net plankton population accounted for 58% of the total production, with the ≥50<100 and ≥20<50 µm fractions making the major contribution, of which the former fraction contribution was slightly higher. Of about 42% fixation by the nanoplankton, all the fractions made about equal contributions.

Although lower levels of contribution by the net plankton population were recorded for samples collected from station 9 at surface and 5 metres depth, the productivity percentages for the different fractions were more or less of the same order as at station 11. At the surface the net plankton population accounted for 38.35% of the total production, with most of the fixation carried out by the ≥20<50 µm size fraction. With the nanoplankton population almost all the photosynthetic activity was carried out by the ≥5<10 µm size fraction.

For samples collected from 5 metres depth, almost equal contributions to the total productivity were made by the different size fractions of the net plankton population, which accounted for 42.1% of the total carbon fixed. The nanoplankton population accounted for 57.8% of the total, with the ≥5<10 and ≥0.45<5 μm size fractions making the major contribution in about equal amounts.

October 6, 1986:

The net plankton population was re-established as the major contributor to the total carbon fixed for samples collected from surface at both stations. More or less equal levels of activity by the net plankton and nanoplankton populations was recorded for samples collected from 5 metres depth at both stations.

The greatest measured production levels for the net plankton population was in the ≥100 μm fraction in comparison to the previous dates when the highest net plankton levels of fixation were recorded in the ≥20<50 μm size fractions. The greatest measured production levels for the nanoplankton population was in the ≥5<10 μm size fraction. The highest were those recorded for samples collected from 5 metres depth at both stations.

For samples collected from station 11 (surface) the net plankton population accounted for 61% of the total photosynthetic activity with the ≥100 and ≥20<50 μm size fractions making the major contribution, of which that of the former fraction was slightly higher.

The nanoplankton population accounted for 39% of the total carbon fixed, with the three fractions making almost equal contributions; the activity by the ≥5<10 μm size fraction was the highest.

At 5 metres depth of about 53% fixation by the net plankton, about half lay in the ≥100 μm size fraction, with the lesser fractions each making about equal contributions. The

nanoplankton population accounted for 47% of the total activity, with the ≥5<10 µm size fraction making the major contribution and the lesser two fractions each making about equal contribution.

At station 9 the fixation quantities for the different fractions were of the same order as that at station 11, with the net plankton accounting for 63.7% of the total productivity for samples collected from surface, with the larger quantities in the ≥100 and ≥20<50 µm size fractions. With the nanoplankton, there was about equal amounts of fixation in the ≥5<10 and ≥0.45<5 µm size fractions, but with smaller quantities in the ≥10<20 µm size fraction.

For samples collected from 5 metres depth, the net plankton population accounted for 51.57% of the total activity, of which most was contributed to the ≥100 µm size fraction, whilst the levels fixed by the ≥50<100 µm size fraction were half of those for the ≥20<50 µm size fraction. More than half of the activity by the nanoplankton occurred in the ≥5<10 µm, with the smallest amount occurred in the ≥10<20 µm fraction.

October 27,1986:

From this date and throughout the autumn and winter months whilst minimum overall fixation values were obtained, the nanoplankton population accounted for most of the total carbon fixed, with quantities ranging from 56.7 - 100% of the total production.

On the 27 th of October the nanoplankton population succeeded the net -plankton as the major contributor to the total photosynthetic output, with levels of fixation ranging from 56.73 - 63.67% of the total.

At station 11 higher levels of production by the nanoplankton population was recorded for samples collected from the surface than for those collected from 5 metres depth,

while for samples collected from station 9, levels of fixation by the nanoplankton population was higher at 5 metres depth than at the surface.

Although the <20 µm fractions contribution to the total carbon fixed was higher than that of the >20 µm fractions at both stations, the greatest measured production level was by the net plankton cells which were ≥20<50 µm.

For station 11 (surface) the net plankton accounted for 38.6% of the total photosynthetic activity, with the ≥50<100 and ≥20<50 µm size fractions making the major contribution, in the latter the levels were higher. The nanoplankton fractions accounted for 61.38% of the overall activity, of which the largest levels of fixed carbon were in the ≥0.45<5 µm size group and the lowest in the ≥5<10 µm size group, with about 4% difference between the contribution of the three size groups making up the nanoplankton population.

At 5 metres depth the net plankton population accounted for 42.53% of the total production, with the ≥20<50 µm size fraction making the major contribution. The nanoplankton accounted for 57.47% of the total fixation, with the ≥10<50 and ≥0.45<5 µm size fractions making the major contribution in about equal amounts.

At station 9 (surface) the net plankton population accounted for 43.27% of the over all activity, with the ≥20<50 µm size fraction making the major contribution, with smaller amounts of about equal proportions, in the ≥100 and ≥50<100 µm size fractions.

The fixation quantities for the different fractions of the nanoplankton population were more or less of the same order as at station 11, with the nanoplankton accounting for 56.73% of the total production and with the larger quantities in the ≥10<20 µm and ≥0.45,5 µm size fractions, in the latter the levels were slightly higher.

For samples collected from 5 metres depth, the net plankton population accounted for 36.33% of the total productivity, with the ≥20<50 µm size fraction making the major contribution, with the other two fractions each making about equal contributions. The nanoplankton accounted for 63.97% of the total photosynthetic activity with the ≥12<20 and ≥0.45<5 µm size fractions making the major contribution in about equal amounts.

November 12 and December 23, 1986:

The nanoplankton population accounted for all of the photosynthetic activity at both stations at both depths, with the exception of samples collected from station 9, at surface on 23 rd of December, in which the net plankton population accounted for 14.8% of the total photosynthetic output, which was divided equally between the ≥100 and ≥50<100 µm size fractions.

Most of the nanoplankton production was in the ≥5<10 µm size fraction, ranging from 66.6 - 88.9% of the total. The rest occured in the ≥0.45<5 µm size fraction.

January 22, 1987:

Nanoplankton population accounted for most of the total photosynthetic activity, with the exception of samples collected from 5 metres depth at station 9 in which the nanoplankton and the net plankton populations each contributed in about equal amounts to the total productivity. The levels of production by the nanoplankton population were higher for samples collected from station 11 than from station 9. For samples collected from both stations, the contribution of the nanoplankton population was higher at surface than that at 5 metres depth, being the highest at station 11.

For station 11 (surface), the net plankton population accounted for 22.1% of the total activity, with the ≥50<100 and ≥20<50 µm making the major contribution in about equal amounts. The <20 µm size groups showed that most of its activity occurred in

the ≥5<10 µm size fraction, while the lowest levels of fixation occurred in the ≥10<20 µm size fraction.

At 5 metres depth, the net plankton population acccounted for 28.7% of the total productivity, with most of the fixation occurring in the ≥50<100 µm size fraction, whilst the ≥20<50 µm size fraction accounted for most of the remainder of total carbon fixed by the net plankton population. The >20 µm size fractions accounted for 71% of the total productivity, with the ≥5<10 µm size fraction making the major contribution. The rest occurred in the ≥0.45<5 µm size fraction.

For samples collected from station 9 (surface), the net plankton population accounted for 35.3% of the total production, with the ≥50<100 and ≥20<50 µm size fractions making the major contribution in about equal amounts. The nanoplankton population accounted for 64.68% of the total carbon fixed, with the ≥10<20 and ≥5<10 µm size fractions making the major contribution, of which the latter was slightly higher.

At 5 metres depth, the net plankton population accounted for half of the total production, with the ≥50<100 and ≥20<50 µm size fractions making the major contribution, of which that of the former was slightly higher. Of the other 50% fixed by the nanoplankton population more than half lay in the ≥5<10 µm size fraction, while in the ≥0.45<5 µm size fraction the quantities fixed were twice those in the ≥10<20 µm size fraction.

February 17. 1987:

For samples collected from station 11, at both depths and station 9 (surface), the nanoplankton population remained the major contributor to the total carbon fixed, whilst for samples collected from station 9 at 5 metres depth, the total levels of carbon fixed divided equally between net plankton and nanoplankton.

For station 11 (surface), the net plankton population accounted for 22.5% of the total photosynthetic activity, with the greatest measured levels in the ≥20<50 µm size fraction, whilst the lowest levels of activity occurred in the ≥100 µm size fraction. The nanoplankton population accounted for 75.46% of the total photosynthetic output, with most of the activity in the ≥5<10 µm size fraction, while the ≥0.45<5 µm size fraction accounted for most of the remainder of the nanoplankton fixation.

At 5 metres depth the net plankton population accounted for 33.3% of the total production, with the largest measured production in the ≥50<100 µm size fraction, whilst the lowest levels of fixation occured in the fraction ≥100 µm. The nanoplankton population accounted for 66.66% of the total carbon fixed, with the ≥5<10 and ≥0.45<5 µm size fractions making the major contribution, of which the former fraction was higher.

For station 9 (surface), the net plankton population accounted for 42% of the total carbon fixed, with the ≥50<100 and ≥20<50 µm size fractions making the major contributions in about equal amounts. The greatest measured nanoplankton production level was in the ≥5<10 µm size fraction , and the lowest levels of fixation in the ≥10<20 µm size fraction.

At 5 metres depth, the net plankton population accounted for 50.5% of the total productivity, with the greatest measured production levels lying in the ≥50<100 µm size fraction, while the levels of fixation recorded for the ≥100 and ≥20<50 µm size fractions did not show a significant difference. The nanoplankton population accounted for 49.5% of the total fixation, with the greatest measured production in the ≥5<10 µm size fraction, whilst the lowest levels of fixation occurred in the ≥10<20 µm size fraction.

March 11, 1987:

Although the levels of fixation by the nanoplankton population decreased, they remained slightly higher than those recorded for the net plankton population. For samples collected from station 11, the levels of fixation by the nanoplankton population were slightly higher in the surface samples than those at 5 metres depth, whilst for samples collected from station 9, the levels of productivity by the nanoplankton population were slightly higher at 5 metres depth than those recorded at surface.

For samples collected from station 11 (surface), the net plankton population accounted for 43.68% of the total productivity, with most of the fixation occurring in the ≥100 and ≥20<50 µm size fractions, in the latter being the highest. With the nanoplankton, there were almost equal amounts of fixation by the three fractions, despite the larger levels of production that were observed in the ≥10<20 µm size fraction.

At 5 metres depth, the net plankton population accounted for 45.8% of the total photosynthetic activity, with most of the fixation occurred in the ≥100 and≥20<50 µm size fractions, the latter being the highest. With the nanoplankton productivity, the largest production level occurred in the ≥10<20 µm size fraction and almost equal amounts of fixation in the other two smaller fractions.

At station 9 at both depths, the fixation quantities for the different fractions were more or less of the same order as at station 11, with the net plankton accounting for 47 and 45.9% of the total productivity at surface and 5 metres depth respectively, with the larger quantities in the ≥100 and ≥20<50 µm size fractions, the latter being the highest. With the nanoplankton the largest levels of fixation occurred in the ≥10<20 and ≥0.45<5 µm size fractions, slightly higher in the former.

March 18, 1987:

Again the levels of fixation by the nanoplankton population remained slightly higher than those recorded by the net plankton population, with the exception of samples collected at 5 metres depth from station 9 in which more or less equal levels of fixation by both populations were recorded.

The fixation quantities for the different fractions at both stations and at both depths were more or less of the same order as those recorded on the 11th of March, with the >20 µm size fractions accounting for 42.8 and 45% of the total photosynthetic out put for samples collected from station 11 at the surface and 5 metres depth respectively and 47 and 50.4% of the total photosynthetic activity for samples collected from station 9 at the surface and 5 metres depth respectively, with the larger quantities in the ≥100 and ≥20<50 µm size fractions, in the latter being the highest, while the ≥50<100 µm size fraction contributed very little to the net plankton productivity. In relation to the nanoplankton fixation although the largest quantities occurred in the ≥10<20 and ≥0.45<5 µm size fractions, the former were slightly higher. High levels of fixation by the ≥5<10 µm size fraction were recorded.

March 25, 1987:

Again the levels of fixation by the nanoplankton population remained slightly higher than those recorded by the net plankton population at both stations and at both depths. More or less equal levels of production by the <20 µm size fractions were recorded for samples collected from both stations, at both depths.

Again the fixation quantities for the different size fractions at both stations, at both depths were more or less of the same order as those recorded on the 11th and 18th of March, with the exception of samples collected from station 11 at 5 metres depth and station 9 (surface), where no measurable fixation was carried out by the net plankton cells which were ≥50<100 µm in size and which contributed very little to the net plankton production on the previous mentioned dates. The net plankton population accounted for

44.3 and 44% of the total productivity for samples collected from station 11 at the surface and 5 metres depth respectively and for 45 and 44.9% of the total carbon fixed for samples collected from station 9 at the surface and 5 metres depth respectively, with the ≥100 and ≥20<50 µm size fractions making the major contribution, of which the larger occurred in the latter size fraction. In relation to the nanoplankton activity, although the largest quantities occurred in the ≥10<20 and ≥0.45<5 µm size fractions, in the former were higher, considerably large levels of fixation by the ≥5<10 µm size fraction being recorded; the largest was observed for samples collected from station 11 (surface), almost equalling the level of of carbon fixed by the ≥0.45<5 µm size fraction.

April 8, 1987:

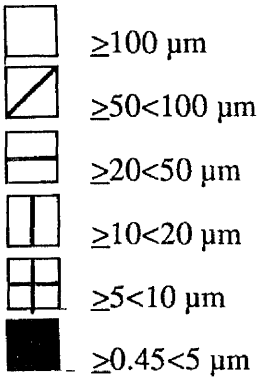
Again the levels of nanoplankton productivity remained higher than those recorded by the net plankton population at both stations, at both depths.

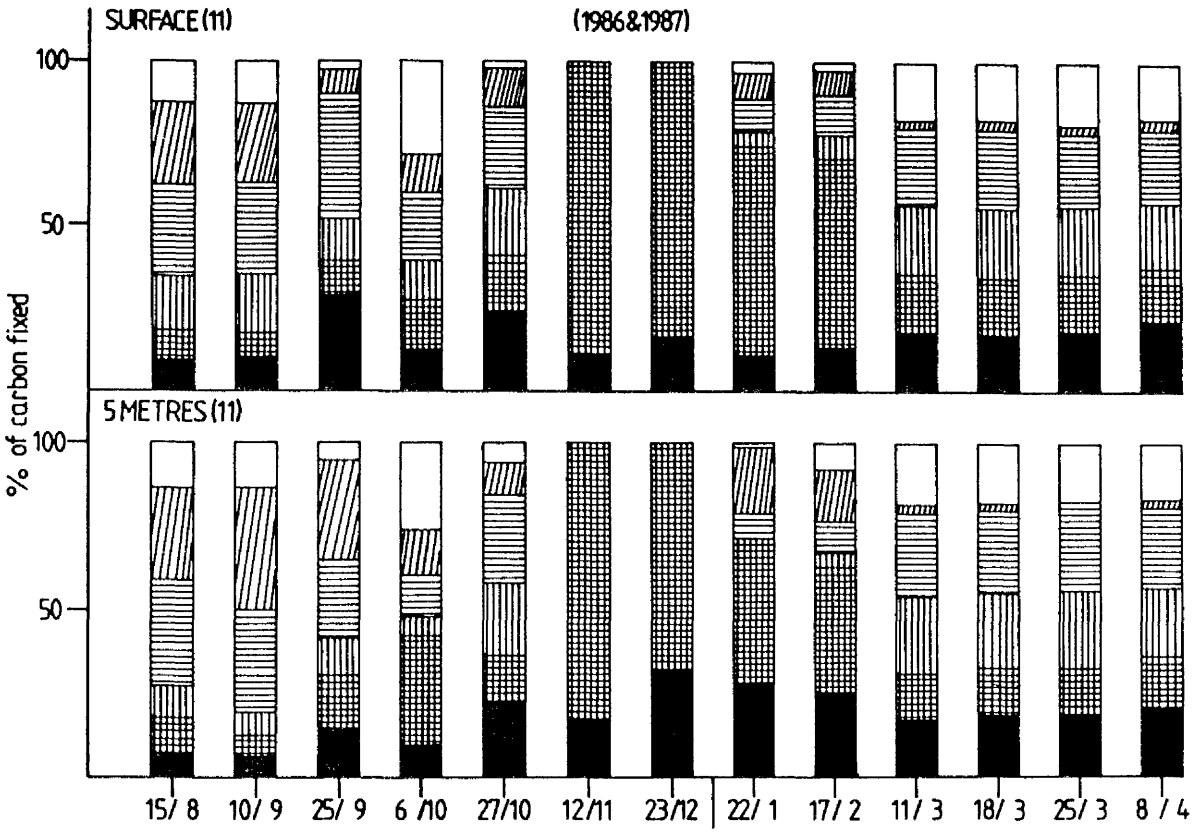
Although there was a slight increase in the fixation levels by the nanoplankton population, which was accompanied by an increase in the contribution of the ≥0.45<5 µm size fraction, again the fixation quantities for the different fractions at both stations at both depths were more or less of the same order as those recorded during the previous three sampling dates, with the >20 µm size fractions accounting for 42.86 and 43.2% of the total activity for samples collected from station 11, at surface and 5 metres depth respectively and for 42.4 and 42.9% of the total production for samples collected from station 9 at surface and 5 metres depth respectively, with the larger quantities in the ≥100 and ≥20<50 µm size fractions, in the latter being the highest, while the ≥50<100 µm size fraction contributed very little to the net plankton production.

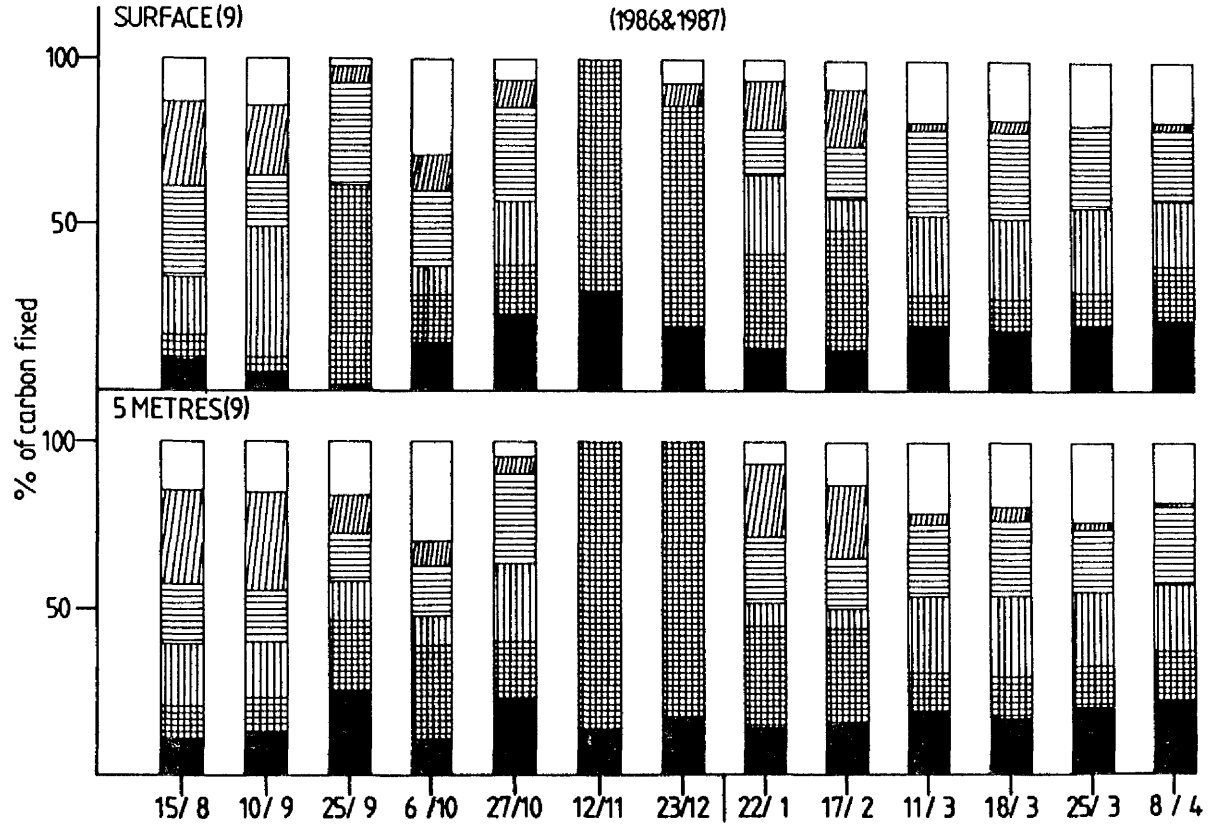
In relation to the nanoplankton activity, although the largest fixation levels occurred in the ≥10<20 and ≥0.45<5 µm size fractions, in about equal amounts, considerably higher levels of fixation by the ≥5<10 µm size fraction were recorded.

Figure. 3. 5. 3. % of contribution to the total C^{14} fixed by the different size fractions at surface and 5 metres depth.

Stations 11 and 9. From 15. 8. 1986 to 8. 4. 1987.




SURFACE (11)
(1986&1987)
100
50
% of carbon fixed
5 METRES (11)
100
50
15/ 8
10/ 9
25/ 9
6 /10
27/10
12/11
23/12
22/ 1
17/ 2
11/ 3
18/ 3
25/ 3
8 / 4


SURFACE (9)
(1986&1987)
100
50
% of carbon fixed
5 METRES (9)
100
50
15/ 8
10/ 9
25/ 9
6 /10
27/10
12/11
23/12
22/ 1
17/ 2
11/ 3
18/ 3
25/ 3
8 / 4

3. 5. 5. In situ measurements:

For the in situ measurements which were carried out for samples collected from surface, 1 metre, 5 metres and 10 metres depth at station 11 on the 8th and 22nd of April, the contribution of three size fractions (≥20 µm, ≥10<20 µm and ≥0.45<10 µm) to the total carbon fixation were measured (Table. 3. 5. 3.).

On the 8 April, for samples collected from surface and 5 metres depth all of the carbon fixation occured in the ≥0.45<10 µm size fraction.

For samples collected from 1 metre depth the nanoplankton population accounted for 89.1% of the total photosynthetic activity, with most of this fixation in the ≥0.45<10 µm size fraction, while the ≥10<20 µm contributed very little to the nanoplankton production. The net plankton population accounted for 10.9% of the total production.

For samples collected from 10 metres depth, the <20 µm size groups .. accounted for 99.68% of the total photosynthetic output, and that most occurred in the ≥0.45<10 µm size fraction.

On the 22 April, the net plankton population (≥20 µm) succeeded the nanoplankton population as the major contributer to the total productivity for samples collected from surface (63.23%) and 1 metre depth (59.6%).

For samples collected from surface, the levels of carbon fixed by the nanoplankton cells which were ≥10<20 µm in size was half of that fixed by the ≥ 0.45<10 µm cells. At 5 metres depth, the nanoplankton population remained as the major contributer to the total productivity (87.36%), with the ≥0.45<10 µm size fraction making the major contribution. The net plankton population accounted for 12.6% of the total photosynthetic activity.

At 10 metres depth, the net and nanoplankton populations contributed almost equally to the total productivity. The larger quantities of fixation by the nanoplankton population occurred in the ≥0.45<10 µm size fraction.

(Table. 3. 5. 5.)
Amount and % of C^{14} fixed by the diffrent fractions of phytoplankton at station 11
(all based on in situ measurements)
(mg carbon $m^{-3} \cdot h^{-1}$)

		The size of different phytoplankton cells (µm)					
Date	Depth	≥20	%	≥10<20	%	≥0.45<10	%
8.4.87	Surface	0.00	0.0	0.00	0.0	1.64	100
	1 metre	0.70	10.9	0.25	3.8	5.56	85.3
	5 metres	0.00	0.0	0.00	0.0	24.0	100
	10 metres	0.06	0.06	1.45	7.8	17.2	92.0
22.4.87	Surface	63.8	63.2	12.5	12.4	24.60	24.3
	1 metre	76.9	59.6	6.40	5.0	45.70	35.4
	5 metres	19.0	12.6	17.3	11.4	114.9	75.9
	10 metres	6.70	52.5	2.50	19.7	3.500	27.7

3. 5. 6. Discussion:

Under laboratory incubation conditions the fixation levels for both fractions were variable to a high degree. Nanoplankton production levels varied from 9.6 to 213 mg C m^{-3}. h^{-1} whilst the net plankton production levels varied from undetectable to 434.4 mg C m^{-3}. h^{-1}.

During the late summer of 1986, on 15 August and 10 th of September when a large total phytoplankton production was observed (Figs. 3. 5. 1. and 3. 5. 2.), the ≥20 µm size fraction accounted for most of the total photosynthetic activity, with the exception of samples collected from the surface at station 9, when almost equal levels of fixation by the net and nanoplankton population were recorded.

The nanoplankton photosynthetic activity exceeded that of the netplankton, on 25 September,1986 for samples collected from station 9, at both depths, with almost all the fixation occuring on the ≥5<10 µm size fraction for samples collected from surface, whilst most of the 5 metres fixation occured in the ≥5<10 and ≥0.45<5 µm size fractions, in about equal amounts.

At the time of low algal biomass and low photosynthetic output, on average the nanoplankton population accounted for most of the total phytoplankton activity mainly during the late autumn (on 27 October) and winter months, with most of the fixation occuring in the ≥5<10 µm size fraction (Fig. 3. 5. 3.). The complete nanoplankton production dominance recorded on 12 November and 23 December was associated with mixing and upwelling events due to relatively high westerly winds reaching 13 knots. On the 27 th of October most of the net plankton production occured in the ≥20<50 µm size fraction. On the 22 nd of January and 17 February most of the net plankton activity occurred in the ≥50<100 and ≥20<50 µm size fractions, with the former higher, the exception was in the sample collected from station 11, at surface on

17 February the largest net plankton fixation levels being recorded in the ≥20<50 µm size fraction.

Even during the spring diatom population increase the levels of carbon fixation of the < 20 µm fractions still exceeded that of the ≥20 µm fractions despite the decline in the former population. The ≥10<20 µm size fraction contributed most to the nanoplankton production. In relation to the net plankton fixation the largest quantities occurred in the ≥100 and ≥20<50 µm size fractions,in the latter were higher.

The contribution of the picoplankton population (<1 µm) which was a part of the ≥0.45<5 µm size fraction, to the total production levels was variable throughout the different seasons, as well as with stations and depth. The data obtained during this study, suggested that picoplankton can be responsible for significant proportions of primary production; generally picoplankton accounted for 5.86 - 11.6%of the summer production, for 8.8 - 29.6% of autumn production, for 11.2 - 32.2% of the winter fixation and for 17.87 - 20.9% of the spring photosynthetic activity.

The in situ measurements showed that most carbon fixation occurred at 5 metres depth, at the time of nanoplankton dominance (on 8 April), with most of the photosynthetic activity occuring in the ≥0.45<10 µm size fraction.

At the time of the peak of the spring diatom biomass and photosynthetic activity on 22 April, the net plankton population accounted for most of the total activity, with the exception for samples collected from 5 metres depth in which the nanoplankton population again accounted for most of the total algal production. Again most of the nanoplankton activity was attributed to the ≥0.45<5 µm size fraction.

4. Comparative Discussion on Physico - Chemical and Biological Data:

Late spring 1984:

A declining spring population was observed. The maximum diatom numbers found during this period, for samples collected from the surface at station 11 was recorded on the 11 May (577 x 10^3 cells. l^{-1}), whilst the maximum for the other sampling station, and for station 11, at 5 metres depth was recorded on 25 May (43 - 51 x 10^3 cells. l^{-1}). Those maxima were associated with the long sunshine hours recorded in the week previous to the day of sampling and with the formation of a thermocline caused by calm weather. In the week previous to the 11 May the total hours of sunshine were 67.7 hours, whilst the total number of sunshine hours in the week previous to the 25 May were 45.8 hours. The mean daily wind speed recorded in the week previous to both dates of sampling were 9.1 and 8.6 knots. This spring diatom population was dominated by *Skeletonema costatum* and *Thalassiosira nordenskioldii* , with *Coscinodiscus* spp present in considerable numbers. The diatom *Nitzschia seriata* and green flagellates were observed only for samples collected on the 25 May, and constituted a large proportion of the total population. During this period the population was made up of truly planktonic species (Figs. 3. 4. 5. and 3. 4. 7.), with the largest number of benthic species being recorded on 25 May (32 - 44 % of the total population). This large number of benthic species could be attributed to the effect of high gusts of 34 knots and more which occurred on 22 May for two hours.

The chlorophyll levels were low for this time of the year (2.5 - 4 mg m^{-3}); the climax of the spring chlorophyll increase having probably occurred prior to the beginning of the sampling dates. High phaeopigments levels (5 - 9 mg m^{-3}) were recorded during this period. These conditions were reflected in the chromatographic data obtained during this period which showed some correlation with the quantitative measurements of chlorophyll and phaeopigments, also with the microscopic examination of samples collected during the same period. Thus the pigments that denoted the presence of living

diatoms, including chlorophylls a and c, carotene, diadinoxanthin and fucoxanthin, in addition to chlorophyll b and neoxanthin, the definitive pigments of green algae, were present. The chlorophyll degradation products phaeophytin a and phaeophorbide a indicated possible feeding activity by copepods and other zooplankton; the presence of chlorophyllide a indicated chlorophyllase activity in senescent diatoms.

This spring diatom increase coincided with the decrease in nutrient levels, of which the minimum quantities were recorded on 25 May, with the exception of phosphate phosphorus minimum values for samples collected from both stations, at surface which were recorded on 11 May. The sharp decrease in nutrient levels on the 25 May might be due to the cumulative effect of consumption by the phytoplankton population. The nutrient levels recorded during this period were low, for dissolved silica ranging from 0.32 to 2.2 µg at. l^{-1}, nitrate nitrogen from 0.03 to 2 µg at. l^{-1} and phosphate phosphorus from trace quantities to 0.58 µg at. l^{-1}.

The change of season from winter to spring was indicated by the rising air temperature (Table. 3. 1. 1.), increasing sea surface temperature (Figs. 3. 1. 2.) and increasing number of hours of bright sunshine; the total number of sunshine hours during March were 70.6, during April were 196.8 and during May were 244.7 hours. The mean monthly wind speed recorded during April was 9.6 knots. The mean wind direction during the first six days of this month was north to north east, from 7 till 21 April the mean direction was west to north west whilst during the rest of the month the prevailing wind was again northerly to north easterly in direction. During May the mean monthly wind speed was 8.1 knots and the mean direction was south west to north west. The sampling site was open to winds from the west and south west, but protected from winds to the north, south, south east and north east. Easterly winds can cause some disturbance, but the turbulent conditions followed westerly winds.

Summer 1984:

On the 6 June an increase in the total number of diatom cells was observed (617 - 1028 x 10^{-3} cells. l^{-1}) with the exception of samples collected from station 9 at surface(245 x 10^{-3} cells. l^{-1}). This increase in the size of the population might be attributed to the long hours of bright sunshine recorded in the previous 10 days (62.7 hours). The highest numbers were observed for samples collected from 5 metres depth at both stations with most of the population was made up of benthic species (52 - 100%) mainly, *Nitzschia seriata*, which succeeded *Skeletonema costatum* and *Thalassiosira nordenskioldii* as the dominant species. This increase in benthic diatoms was probably due to the mixing of the water column caused by the strong gusts recorded on 3rd and 5th of June, in which the wind speed exceeded 34 knots for 3 hours in total. A decrease in chlorophyll values was recorded (1.6 - 1.7 mg m^{-3}), phaeopigments levels were unmeasurable, suggesting actively growing populations though small in size. A slight change in nutrient levels was recorded; trace quantities for dissolved silica, phosphate phosphorus ranging from 0.1 to 0.24 µg at. l^{-1} and nitrate nitrogen ranging from 0.77 to 0.88 µg at. l^{-1}.

A further increase in the algal biomass which represented the maximum measured for this period was observed on 20 June, in which the planktonic green flagellates succeeded diatoms as the dominant fraction of the population (98.6 - 99.4 % of the standing crop), most of the population was made up of truly planktonic species (99.6 - 99.94 %). This was associated with the calm weather observed in the previous week, with wind speeds ranging from 3.6 to 10.7 knots. Observed for the first time, for samples collected from station 11 at surface was the dinoflagellate *Ceratium tripos*. The diatoms, including *Achnanthes longipes, Coscinodiscus* spp, *Melosira* spp, *Navicula* spp and *Thalassiosira nordenskioldii,* contributed very little to the total biomass. Again low levels of chlorophyll were recorded(0.87 - 1.3 mg m^{-3}). Also, phaeopigments levels remained low with values ranging from unmeasurable quantities to 0.72 mg m^{-3}. Despite a slight increase in the dissolved silica levels (0.89 - 1.6 µg at.

l^{-1}) and a similar increase in nitrate nitrogen quantities for samples collected from station 11 at 5 metres depth (1.64 µg at. l^{-1}), nutrient values remained low, more or less equalling those recorded in the previous trip.

Low hours of sunshine were recorded in the week previous to the day of sampling (18.2 hours). The total hours of sunshine during June were 169.1. On the day of sampling the air temperature was 11°c and sea surface temperature was 11.4°c.

During the rest of this period lower numbers of algal cells were observed with the maximum for samples collected from both stations, at both depths were found on 11 July (Figs. 3. 4. 1. and 3. 4. 3.). On the 11 July the size of the population was relatively low (203 - 273 x 10^3 cells. l^{-1}), diatoms were re-established as the dominant fraction of the population (99.5 - 100% of the total biomass), of which most were truly planktonic species, mainly *Skeletonema costatum* (75 - 89 % of the total population). Observed frequently were *Coscinodiscus* spp and *Thalassiosira nordenskioldii* and *Melosira* sp. Also present were the benthic diatoms *Grammatophora marina, Rhabdonema arcuatum, Synedra* spp and *Synedra gaillonii,* and the silicoflagellate *Dictyocha speculum.*

On 23 July green flagellates succeeded diatoms as the dominant fraction of the population (66.17 - 83.66 %) with the exception of samples collected from station 9, at surface, whilst the dinoflagellates *Ceratium tripos* and *Protoperidinium* spp were observed only for samples collected from 5 metres depth. *Thalassiosira nordenskioldii* succeeded *Skeletonema costatum* as the dominant diatom species, with the latter species being observed only for samples collected from 5 metres depth. The differential reduction may be partly a function of the faster sinking rates of *Skeletonema* (0.3 - 1.35 metres per day) compared with *Thalassiosira* (0.5 - 0.7 metres per day) (Smayda, 1970). Again most of the population was made up of truly planktonic species.

On 11 July the decrease in the total number of algal cells was accompanied by a similar decrease in chlorophyll levels (0.24 - 0.33 mg m^{-3}). Phaeopigment levels remained low (trace quantities - 0.22 mg m^{-3}).

On 23 July although much lower numbers of algal cells were found (10.97 - 44.38 x 10^3 cells. l^{-1}), relatively higher chlorophyll levels were recorded (0.49 - 2.5 mg m^{-3}) mainly for samples collected from both stations, at 5 metres depth (1.6 and 2.47 mg m^{-3} at stations 11 and 9 respectively), this could be attributed to the dominance of green flagellates over diatoms, which constituted the majority of the population in the previous date of sampling.

The only increase in nutrient levels recorded was for dissolved silica (1.46 - 3.56 µg at. l^{-1}), of which the largest was found on 23 July. Phosphate phosphorus quantities remained low more or less equalling those recorded in the previous trips (0.3 - 0.37 µg at. l^{-1}), whilst lower nitrate nitrogen values were found (trace quantities - 0.14 µg at. l^{-1}) with the exception of that recorded for samples collected from station 11, at surface(0.82 µg at. l^{-1}) on 11 July.

In the week previous to the 11 July the total hours of sunshine were 56.2 hours, whilst in the week previous to the 23rd of the same month the total hours of sunshine were 61.2 hours. The total hours of sunshine were 232.7 during this month.

In the succeeding dates of sampling (15 and 29 August) a slight increase in the total number of algal cells was recorded (81 - 191.43 x 10^3 cells. l^{-1}) on 15 August and (129.77 - 247.45 x 10^3 cells. l^{-1}) on 29 August. A much more mixed population was observed, of which diatoms remained dominant (88.8 - 96% of the algal biomass), with *Skeletonema costatum* as the dominant species(60 - 73% of the standing crop). *Coscinodiscus* spp was observed frequently on 15 August whilst *T. decipiens* and *T. nordenskioldii* were the most observed diatoms after *Skeletonema*. Also observed and

for the first time, were the diatoms *Biddulphia mobiliensis* and *Chaetoceros* spp. The dinoflagellates *Ceratium fusus, C. furca, C. tripos* and *Protoperidinium* spp were observed at both dates, with the silicoflagellate *Dictyocha speculum*. Most of the population was made up of truly planktonic species(74 - 99.43 % of the total biomass). Although there was an increase in the total number of algal cells a decrease in chlorophyll levels was recorded (0.05 - 0.5 mg m^{-3}), which was probably due to the presence of a stressed population. The only increase in chlorophyll levels was recorded for samples collected from both stations, at surface on 29 August (1.06 and 1.34 mg. m^{-3} at stations 11 and 9 respectively) On 15 August phaeopigment levels exceeded that of chlorophyll (0.1 - 0.34 mg m^{-3}), with the exception of samples collected from station 9, at 5 metres depth (0.6 mg m^{-3}), which indicated that the chlorophyll measured was associated with senescent diatoms and unhealthy algal cells; it could also be an effect of grazing by zooplankton. On 29 August phaeopigment levels were lower than that of chlorophyll (0.16 - 0.37 mg m^{-3}), which indicated the recovery of the population.

The chromatograms obtained for samples collected during this period showed good correlation with the microscopic examination and chlorophyll and phaeopigments measurements for samples collected during the same period. Chlorophylls a and c, carotene, diadinoxanthin and fucoxanthin were found, i.e., diatoms and chrysomonads were present. Also found were chlorophyll b and neoxanthin which indicated the presence of green algae, which correlated with the microscopic examination of samples collected on 20 June and 23 July, where green flagellates succeeded diatoms as the dominant fraction of the population. Astaxanthin, the copepod carotenoid and the chlorophyll break down products phaeophytin a, phaeophorbide a and chlorophyllide a were found.

An increase in air temperature (Table. 3. 1. 1.), increase in sea surface temperature (Table. 3. 1. 2.), and increasing number of hours of bright sunshine (see appendix) were observed during this period. The monthly mean wind speed for the month of June

was 11.2 knots and the mean direction was west to south west . During the first 19 days of this month light to relatively strong winds were observed (3.6 - 16.8 knots) , during this period high gusts were recorded on 3 June (36 knots for 2 hours), on the sampling date 6 June (30 knots for 1 hour), which might explain the high percentages of benthic species found on the later date, also strong gusts were recorded on 12 June (34 knots or more for 6 hours). A windy period was also observed during the last 10 days of this month with daily mean velocity exceeding 16 knots and gusts of 34 knots and more recorded on 21, 22, 26 and 27 of June for a total of 20 hours, with the mean direction from west to north west. During July the monthly mean speed was 9.9 knots and the mean direction was south west to north west, whilst during August the daily mean speed was 9 knots and the wind direction was variable ranging from north east to south east and from south west to north west. The total sunshine hours recorded during August was 199.5.

Autumn 1984:

Highly mixed population was observed during this period, with most of the population made up of truly planktonic species (89.55 - 98.6 %). The autumnal phytoplankton increase was recorded on 19 September (181.7 - 291.9 x 10^3 cells. l^{-1}) and was composed predominantly of diatoms (80.89 - 86.85 %). This increase in the total algal biomass might be an effect of the substantial increase in the nutrient levels during late summer [e.g on 29 August relatively high nutrient levels were recorded: for phosphate phosphorus (0.35 - 0.83 µg at. l^{-1}), dissolved silica (2 - 7.2 µg at. l^{-1}) and nitrate nitrogen (0.9 - 5.37 µg at. l^{-1})]. Most of the population was made up of truly planktonic species (89.55 - 98.56 %). *Skeletonema costatum* was the dominant species (52 - 60 % of the standing crop), with *Thalassiosira nordenskioldii* and *Nitzschia seriata* present in considerable numbers. *Ceratium tripos* and *C. furca* were the dominant dinoflagellates. Also present was the silicoflagellate *Dictyocha speculum.*

During this increase in the total number of algal cells a corresponding increase in chlorophyll levels was recorded (1.6 - 1.9 mg m^3). The phaeopigment levels were unmeasurable, which indicated the presence of healthy growing algal cells. The decrease in nutrient levels, mainly in dissolved silica and nitrate nitrogen values, on 19 September might be due to the consumption of these nutrients by phytoplankton; phosphate phosphorus (0.5 - 0.7 µg at. l^{-1}), dissolved silica (1.7 - 5.7 µg at. l^{-1}) and ntrate nitrogen (0.1 - 0.14 µg at. l^{-1}).

A decrease in the algal biomass was recorded on 3 and 17 October (47.4 - 99.4 x 10^3 cells. l^{-1}), on which dinoflagellates succeded diatoms as the dominant fraction of the population (53 - 67 %), with *Ceratium tripos* as the dominant species (29 - 64 % of the total biomass). Observed frequently were *C. furca* and *C. macroceros*. *Skeletonema costatum* remained as the dominant diatom on 3 October, succeeded by *Coscinodiscus* spp on 17 October. Also present was the silicoflagellate *Dichtyocha speculum*. Again most of the population was made up of truly planktonic species (90.6 - 98.6 %).

Similarly a decrease in chlorophyll levels was recorded on 3 and 17 October (0.78 - 1.82 mg m^3), accompanied by an increase in nutrient levels, for phosphate phosphorus (0.48 - 0.85 µg at. l^{-1}), for dissolved silica (7.5 - 9.6 µg at. l^{-1}) and for nitrate nitrogen (3 - 6.9 µg at. l^{-1}). These increased nutrient levels probably stimulated the autumnal outburst, which commenced on 19 September. Phaeopigment levels remained low ranging from unmeasurable quantities to 0.3 mg m^3.

The chromatograms for samples collected during this period showed large zones of chlorophyll a and carotene pigments, which indicated the presence of living algal cells, mainly diatoms. This was closely correlated with the increase in the total algal numbers, mainly on 19 September which represented the maximum for this period, on which the microscopic examination showed that most of the population was made up of diatoms (80.89 - 86.85 %). The paramount carotenoid band may have included some

dinoflagellate xanthophyll which did not separate. Also present were the chlorophyll breakdown products phaeophytin a, chlorophyllide a and phaeophorbide a.

On the different dates of sampling air temperature during this period remained relatively high ranging from 8.9°c on 3 October to 12.3°c on 19 September, sea surface temperature ranging from 12.9°c on 3 and 17 October to 13.8°c on 19 September. The total monthly sunshine hours recorded during August were 199.5 and 93.7 in September. Short sunshine hours were recorded in the week previous to the 19 September (11 hours), and similarly short sunshine hours were recorded in the week previous to the 3rd and 17th of October (17 and 9.9 hours respectively). Although long periods of gusts (66 hours in September and 96 hours in October) were recorded in which the wind speed exceeded 34 knots, the truly planktonic fraction of the population remained dominant over the benthic. This might be due to the presence of much larger original planktonic population which exceeded by far the benthic or might be an artifact of the more nutriently rich surface waters. The monthly mean wind speed recorded during September was 12 knots, with mean direction of west to north west. A higher monthly mean wind speed was recorded during October (15 knots), the mean direction remained west to north west.

Winter 1984 - 1985:

This period of low algal biomass (9 - 68 x 10^3 cells. l^{-1}) was dominated by diatoms (89 - 97.65 %). Most of the population was made up of truly planktonic species (58 - 98.8 %), with the exception of samples collected from station 9, at 5 metres depth on 21 November, in which benthic species were dominant (68 % of the standing crop). The common diatoms observed during this period were *Coscinodiscus* spp, *Diatoma* spp, *Melosira* spp, *Navicula* spp, *Skeletonema costatum* and *Thalassiosira nordenskioldii*. The dinoflagellate species observed during this period included *Ceratium lineatum*, *C. macroceros*, *C. tripos*, *Dinophysis acuta* and *Protoperidinium* spp. Also present was the silicoflagellate *Dictyocha speculum*.

This decrease in the algal biomass was probably due to the combined effect of low air temperature (4.6 - 8°c on the different dates of sampling), low sea surface temperature (around 9°c) and short hours of sunshine (53.2 in November, 32.7 in December, 62.3 in January and 87.5 in February). The total hours of sunshine during the week previous to each sampling date were very short ranging between 4.1 - 17.6 hours with the exception of the week previous to 21 February when moderate sunshine hours were found (32.2 hours). Also the strong wind might be another reason for the low algal biomass found during this period, by keeping the water mixed. This time of the year was characterized by long periods (439 hours) of strong gusts in which the wind speed exceeded 34 knots even reaching 48 knots or more. The presence of a large number of benthic species on 21 November, mainly for samples collected from station 9, at 5 metres depth, might be due to the effect of the strong gusts (34 knots for 3 hours) recorded on the same date.

A corresponding decrease in chlorophyll levels was recorded during this period (0.02 - 0.94 mg m^3), also phaeopigments levels were low with quantities ranging from analytical zero to 0.26 mg m^3.

The qualitative analysis of pigments for samples collected during early winter showed the presence of the diatom pigments chlorophyll a and carotene which correlated with the microscopic examination of samples collected during the same period which showed in turn showed a diatom dominance. The set of chromatograms obtained for samples collected during late winter showed the presence of chlorophyll a at station 11 (surface) in small amounts. The absence of this pigment from station 9 at both depths and from station 11 (5 metres), indicated the presence of a low algal population, in agreement with the findings from the microscopic examination. The presence of the chlorophyll degradation product phaeophytin a could be an indication of decomposition.

From the 7 November onwards nutrients followed a continuously increasing trend and maximum levels were recorded on 5 December, (dissolved silica 15.2 - 19.4 µg at. l^{-1},

nitrate nitrogen from 11.7 to 14.2 µg at. l^{-1} and phosphate phosphorus from 1.1 to 1.3 µg at. l^{-1}).

The direction of the prevailing wind varied during this period from easterly and south easterly winds to westerly and south westerly winds. The monthly mean speed and direction during November was 14.3 knots (east to south east); during December 13.8 knots (south to north west); during January 10 knots (from east to west) and during February 13.1 knots (again from east to west).

Spring 1985:

A gradual increase in the total number of algal cells was recorded from the 6 March onwards (Figs. 3. 4. 1. and 3. 4. 3.). The maximum total number of algal cells for samples collected from both stations at surface were observed on 29 March (2102 and 2757 x 10^3 cells. l^{-1} at stations 11 and 9 respectively), whilst the maximum number of population for samples collected from both stations at 5 metres depth were found on 20 March (2844 and 3037.8 x 10^3 cells. l^{-1} at stations 11 and 9 respectively, the latter represent the maximum for this study). During this period diatoms were dominant (99.4 - 100 % of the standing crop), of which most were truly planktonic species (99.4 - 100 %). *Skeletonema costatum* was the dominant species, with *Leptocylindrus danicus* observed in considerable numbers on the 6 and 13 of March.

A similar increase in chlorophyll levels was recorded, by which the chlorophyll concentration increased from sparse levels (1 - 1.3 mg m^3) on 6 March into maximum levels ranging from 12.5 to 18 mg m^3 on the 20 and 29 of March. During 6 and 13 of March phaeopigment levels did not exceed 2.4 mg m^3, whilst on 20 March the levels were high, exceeding that of chlorophyll, for samples collected from station 9 at both depths (7.65 - 17.89 mg m^3). This could be attributed to the break down of chlorophyll through the feeding activity of copepods and other zooplankton. On 29 March and 3 April the phaeopigment quantities did not exceed 5.7 mg m^3.

The maximum for chlorophyll and the total number of algal cells were recorded at the same date for samples collected from station 11 (surface) and station 9 (5 metres), whilst for samples collected from from station 11 (5 metres) the maximum chlorophyll level of 18 mg m^3 was recorded on 29 March, 9 days later than the maximum number of algal cells, and for samples collected from station station 9, at surface the maximum chlorophyll level of 15.9 mg m^3 was recorded on 20 March, 9 days earlier than that of the total algal number.

A decrease in nutrient levels was recorded during this period (Figs. 3. 2. 1., 3. 2. 3., 3. 2. 5., 3. 2. 7., 3. 2. 9. and 3. 2. 11.). The depletion of dissolved silica occurred in three steps, firstly a sharp decrease from high winter levels on 20 February (9 - 16 µg at. l^{-1}) into much lower levels on 6 of March (5.2 - 6.7 µg at. l^{-1}), secondly a gradual decline to around 4 µg at. l^{-1} between 13 and 20 March followed by a rapid fall to levels less than 1 µg at. l^{-1} on 29 March and 3 April. For nitrate nitrogen a relatively small decline was observed on 6 of March when the high winter levels recorded on 20 February (11.8 - 13.9 µg at. l^{-1}) decreased into levels ranging from 7.6 to10 µg at. l^{-1}, after which almost half of these quantities were recorded on the 13 and 20 March (3.1 - 5.6 µg at. l^{-1}). An increase was recorded on 29 March which might be attributed to the upwelling of deeper and richer waters caused by strong westerly wind reaching 34 knots on the previous two days, followed by a decrease on 3 April (Figs. 3. 2. 5. and 3. 2. 7.). The phosphate phosphorus decline was not continuous but irregular (Figs. 3. 2. 9. and 3. 2. 11.).

On the different dates of sampling during this period the air temperature fluctuated between low temperatures which found during March (1.4 - 7.2 ^{o}c) and moderate temperatures during April and early May (6.5 - 9.5^{o}c), also moderate sea surface temperatures were recorded (between 7 and 9 ^{o}c). This spring diatom increase coincided with a long hours of sunshine (122.2 hours in March) and (133 hours in April).

The dominance of planktonic population over benthic was associated with relatively calm weather caused by the moderate to light winds. The mean monthly wind speed during March was 12.9 knots and the mean monthly direction was north east to south east during the first 11 days and west to north west during the rest of the month. During April the mean monthly wind speed was 12.6 knots and the mean direction was west to north west, whilst during May the mean monthly wind velocity was 9.9 knots and the mean direction was north easterly to north westerly.

The qualitative analysis of different algal pigments showed a close correlation with the microscopic examination of samples collected during this period also with the quantitative analysis of chlorophyll and phaeopigments. The clear and distinct zones of chlorophylls a and c and carotene, were clear indication of the presence of diatoms which made up most of the population during this period, in addition the presence of chlorophyll c indicated the presence of dinoflagellates which were observed in small numbers on 13 March. The chlorophyll degradation products phaeophytin a and phaeophorbide a indicated possible feeding activity by zooplankton. This correlated with the large levels of phaeopigments recorded mainly on 20 March.

Autumn 1985:

During this period the phytoplankton population was mixed and made up almost entirely of truly planktonic species (99.54 - 100 %). When the investigation was recommenced on the 19 September the algal biomass levels were high equalling those found during the spring in terms of total number of algal cells (121.4 - 188.5 x 10^3 cells. l^{-1}) of which diatoms were dominant (83.6 - 90.2 %) and in terms of chlorophyll levels (3.1 - 4.6 mg m^3). Phaeopigment levels were variable ranging from unmeasurable quantities to 1.39 mg m^3. The only occasions when the phaeopigment levels exceeded 1 mg m^3 were on 19 September (1.39 mg m^3) for samples collected from station 11, at surface and on 9 October (1.35 mg m^3) for samples collected from station 11, at 5 metres depth.

The predominant diatom was *Skeletonema costatum* (68 - 73 % of the total biomass), which was accompanied by *Coscinodiscus* spp and *Thalassiosira nordenskioldii*. Also present but in a very small numbers was *Navicula* spp. The most numerous dinoflagellates were *Ceratium lineatum* and *C. tripos*. Also observed was the silicoflagellate *Dictyocha speculum*.

The large sized population observed on 19 September might be attributed to the high nutrient levels found at the same date. The only low nutrient levels recorded were those for nitrate nitrogen(0.44 - 0.55 µg ast. l^{-1}). Relatively high dissolved silica levels (6.2 - 9.7 µg at. l^{-1}) and phosphate phosphorus levels (0.52 - 8 µg at.l^{-1}) were found.

On 30 October a sharp decrease in the total number of algal cells (18.5 - 81.5 x 10^3 cells. l^{-1}), was accompanied by a decrease in chlorophyll levels (1.2 - 2.4 mg m^3 were recorded). Low phaeopigment quantities were found (analytical zero - 0.24 mg m^3) which suggested the presence of actively growing populations though small in size. For samples collected from the surface at both stations dinoflagellates succeeded diatoms as the dominant fraction of the population(Figs. 3. 4. 9. and 3. 4. 11.), with *Ceratium lineatum* as the dominant species (Table. 3. 4. 26.), whilst for 5 metres samples diatoms remained as the dominant fraction (Figs. 3. 4. 9 and 3. 4. 11.). *Coscinodiscus* spp succeeded *Skeletonema costatum* as the dominant species (Table. 3. 4. 26.). Also observed was the silicoflagellate *Dictyocha speculum*.

This decrease in the standing crop was accompanied by a large increase in nitrate nitrogen (5 - 7.7 µg at. l^{-1}) and dissolved silica levels (12.3 - 14.3 µg at. l^{-1}). Smaller increases in phosphate phosphorus values was recorded (0.7 - 0.95 µg at. l^{-1}).

The chromatograms for samples collected during this period showed that the prominent pigments were those of diatoms (chlorophylls a and c, diadinoxanthin and fucoxanthin), which coincided with the microscopic examination of samples collected during the

same period, which showed that diatoms were present in numbers mainly on 19 September (83.6 - 90% of the biomass). The dinoflagellates were observed on 19 September and 30 October. The chlorophyll degradation products phaeophytin a and phaeophorbide a were found on all chromatograms, again a possible indication of grazing activity.

Relatively high air temperatures (around 11°c) and high sea surface temperatures (around 12°c) were recorded during the different dates of sampling and on the dates previous to the dates of sampling. Again the dominance of truly planktonic species over benthic was associated with the calm weather found during this period. The mean monthly wind speed recorded during September was 11.5 knots and the mean direction was south west to north west, whilst the mean wind speed during October was 10 knots and the mean direction was west to north west. On the week previous to each sampling date during this period the hours of sunshine were moderate, ranging from 26.1 to 27.5 hours. Relatively low total sunshine hours were recorded during September (84) and October (88.3).

Winter 1985 - 1986:

This period of low algal biomass (8.8 - 201 x 10^3 cells. l^{-1}) and low chlorophyll levels (0.23 - 2.7 mg m^3), was dominated by the truly planktonic species (77 - 99.2 % of the standing crop). Diatoms were dominant (55 -100% of the total biomass), with *Coscinodiscus* spp having the highest cell density. Also phaeopigment quantities were very low (0.01 - 0.96 mg m^3).

Although planktonic species were dominant throughout this period, the relatively high percentage of benthic organisms observed on certain occasions (e.g on 12 February 58.8% and 23% of the total biomass on 6 January for samples collected from station 9, at 5 metres depth) was associated with periods of strong gusts, with wind speed ranging from 34 to 48 knots or more. On 12 February green flagellates succeeded diatoms as

the dominant fraction of the population for samples collected from station 11, at both depths and station 9, at surface (63.6 - 85.4% of the algal biomass).
The maximum contribution of dinoflagellates was found on 11 November, for samples collected from surface, at both stations (26% of the total biomass for samples collected from station 11 and 35% for samples collected from station 9), with *Ceratium lineatum* comprising more than 98% of this fraction. Also observed during this period was the silicoflagellate *Dictyocha speculum*.

During this period a continuous increase in nutrient levels was recorded, by which the maximum values ranging from 14 to 15.7 µg at. l^{-1} for nitrate nitrogen, from 20 to 22.4 µg at. l^{-1} for dissolved silica and from 1.32 to 1.43 µg at. l^{-1} for phosphate phosphorus were reached on 6 January.

The results obtained from the qualitative analysis of the different algal pigments tended to follow closely the data obtained from the microscopic examination and the results obtained from the quantitative analysis of chlorophyll and phaeopigments for this period. Although quantities were very small, chlorophyll a, carotene (diatom pigments) and chlorophyll c were found. Also present were the chlorophyll degradation products phaeophytin a, chlorophyllide a and phaeophorbide a.

On the different dates of sampling and the days previous to the dates of sampling during this period low air temperatures (1.1 - 5.7°c) and low to moderate sea surface temperatures (5.2 - 9°c) were recorded. There were also long periods of gusts (279.58 hours in total) with wind speed ranging from 34 to 48 knots or more, which would have caused mixing of the water column. The monthly mean wind speed during November was 11.1 knots and the mean direction was west to north west during the first half of the month and north east to south east during the second half of the month. The mean wind speed during December was 12.9 knots and the mean direction was south east to north west, during January the monthly mean wind speed was 15.6 knots and the mean

direction was west to north west, whilst during February was 9.2 knots and the mean direction was north to north east. Another feature of this period was the shortness of sunshine hours, which probably accounted for the low algal biomass. On the week previous to each sampling date the hours of sunshine ranged from 5.5 to 23 hours. The total number of sunshine hours fluctuated from relatively low (66.8 in November and 85.8 in February) to low (34.2 in December and 46.2 in January).

Spring 1986 :

An increased spring population was found. A close correlation between the changes in the amount of standing crop in terms of total algal numbers, chlorophyll levels and photosynthetic activity (based on laboratory incubations) and with the changes in nutrient levels was observed.

During this period diatoms were re-established as the dominant fraction of the population (98.8 - 100%), with *Skeletonema costatum* as the dominant species. Most of the population was made up of truly planktonic species (77.88 - 99.96%) with the exception of samples collected from station 9, at surface on 10 March when the benthic fraction of the population accounted for 59.75% of the total biomass, which was mainly due to a large pulse in the numbers of the benthic diatom *Achnanthes longipes* (40.6% of the standing crop). Also observed during this period was the silicoflagellate *Dictyocha speculum.*

The early spring outburst of phytoplankton occurred during March with numbers rising from an initial sparse population (63 - 87 x 10^3 cells. l^{-1})on 10 March to (102 - 410 x 10^3 cells. l^{-1}) on 26 March. Similarly chlorophyll levels increased from quantities ranging from 1.67 to 3 mg m^3 on 26 March. Although an increase in phaeopigments levels was recorded, the actual quantities remained low ranging from 0.08 to 0.8 mg m^3. Highly variable carbon fixation values were recorded in the laboratory ranging from low quantities (4 - 6.7 mg C m^3. h^{-1}) on 10 March to higher fixation levels of 35 -

105 mg C m^3. h^{-1} on 19 March and 32 - 52 mg C m^3. h^{-1} on 26 March, coinciding with the changes in the total number of algal cells and the amount of chlorophyll found on the same dates.

The peak of diatom numbers for samples collected from surface, at both stations was observed on 2 April (3649.8 and 3869 x 10^3 cells. l^{-1} for stations 11 and 9 respectively), coinciding with the maximum levels of chlorophyll (9.5 and 10.2 mg m^3 for stations 11 and 9 respectively) and with the maximum levels of photosynthetic output (299.7 and 258 mg C m^3. h^{-1} for stations 11 and 9 respectively). Much lower diatom numbers were observed on the same date for samples collected from both stations, at 5 metres depth (317 and 329 x 10^3cells.l^{-1} for stations 11 and 9 respectively), coinciding with the lower chlorophyll levels (2 and 2.6 mg m^3 for stations 11 and 9 respectively) and with the lower photosynthetic activity (18 and 2 mg C m^3. h^{-1} for stations 11 and 9 respectively). At the same time low phaeopigments levels were recorded (0.31 - 1 mg m^3).

A sharp decrease in the total number of diatom cells was observed on 9 April for samples collected from both stations, at surface (721 and 814 x 10^3 cells. l^{-1} at stations 11 and 9 respectively), coinciding with the sharp decrease in chlorophyll levels (2.28 and 2.87 mg m^3 at stations 11 and 9 respectively) and in carbon fixation values (27 and 51 mg C m^3. h^{-1} at stations 11 and 9 respectively).

Although a slight decrease in chlorophyll levels was recorded on the same date for samples collected from both stations, at 5 metres depth (1.58 and 2.3 mg m^3 at stations 11 and 9 respectively), an increase in the total number of algal cells was observed (585 and 916 x 10^3 cells. l^{-1} at stations 11 and 9 respectively), coinciding with the increase in the photosynthetic activity levels (35.6 and 44.5 mg C m^3. h^{-1} at stations 11 and 9 respectively). Low phaeopigments levels were recorded on this date (0.32 - 1.77 mg m^3).

An increase in the total number of diatom cells for samples collected from station 9, at both depths and for samples collected from station 11, at 5 metres depth only (Figs. 3. 4. 2. and 3. 4. 4.) were recorded on 23 April, coinciding with an increase in chlorophyll levels (3.7 - 4.9 mg m^3). Very low values of carbon fixation were recorded for samples collected from both stations, at both depths (13.4 - 17.8 mg C m^3. h^{-1}).

A decrease in the total number of algal cells was observed on 7 May in which green flagellates succeeded diatoms as the dominant fraction of the population (61 - 85% of the standing crop). The chlorophyll (3.4 - 4.8 mg m^3) and photosynthetic out put (5 - 21.4 mg C m^3. h^{-1}) values were slightly variant from those recorded on the previous sampling date.

The nutrient condition of the water changed from around its high winter level on 10 March into low levels by the end of this period. This decrease in nutrient levels was discontinuous and occured in an irregular fashion during March (Figs. 3. 2. 2., 3. 2. 4., 3. 2. 6., 3. 2. 8., 3. 2. 10 and 3. 2. 12.), whilst the decrease during April until 7 May occured continuously and followed a regular trend with the exception of the sharp decrease in dissolved silica levels recorded on 9 April when a decline from 10.5 - 17.7 µg at. l^{-1} to 1.6 -1.8 µg at. l^{-1} was recorded within a week, which might be due to the consumption by diatoms which were observed in large numbers in the same date (585 - 916 x 10^3 cells. l^{-1}).

Qualitative data on the pigments obtained from the chromatographical analysis of samples collected during this period followed closely the results obtained from the microscopic examination and from the quantitative analyses of chlorophyll and phaeopigments. Chlorophylls a and c, carotene, diadinoxanthin and fucoxathin, the definitive pigments of diatoms, were found on all chromatograms, this coincided with the diatom dominance observed through the microscopic examination of samples collected during this period. The green algal pigment Chlorophyll b was found (green

algae dominated the population on 7 May). Also present were the copepod carotenoid and the chlorophyll degradation products phaeophytin a, chlorophyllide a and phaeophorbide a, which were possible indicators of grazing activities by copepods and other zooplanktons.

During this period measured air temperatures on the different dates of sampling and on the days previous to them were highly variable, ranging from low temperatures (about 2°c) to relatively high temperatures (about 11°c). Less variable sea surface temperatures were recorded (5.3 - 8.6°c). The high algal biomass observed during this period was associated with relatively long sunshine hours (124 in March, 138.3 in April and 136.2 in May). Although the hours of sunshine on the week previous to each sampling date tended to be long, extremely variable sunshine hours were recorded (5.3 - 9.7 hours). On the week previous to the 2nd of April when the maximum standing crop levels was recorded, the hours of bright sunshine were 39.1 hours. The dominance of planktonic species might be attributed to the relatively calm weather observed during this period. The mean monthly wind speed during March was 14 knots and the mean direction was north east to south east during the first 19 days and south west to north west during the rest of the month. The mean daily wind speed during April was 10.5 knots and the mean direction was south west to north west and the mean daily wind speed during May was 13.2 knots and the mean direction was south west to north west. On 10 March although planktonic species were dominant, an important benthic population was found (14 - 40% of the total biomass), which was associated with strong westerly to north westerly winds having a mean weekly speed of 16.75 knots, observed in the week previous to the day of sampling. Also the strong gusts observed on the 4th, 5th, 6th and 8th of March (34 to 48 knots or more for a total of 22 hours), causing the mixing of the water column might have been a further contributor to the relatively high benthic population found on 10 March.

Summer 1986 :

Most of the population was made up of truly planktonic species (88 - 100% of the standing crop). During this period the diatoms remained as the dominant fraction of the population, with the exception for samples collected from both stations, at surface on 18 June when green flagellates succeded diatoms as the dominant fraction of the poulation (57.6% for samples collected from station 11 and 68.8% for samples collected from station 9). *Skeletonema costatum* was the most numerous species (49.4 - 90.85% of the total biomass), with the exception for samples collected from station 11, at both depths and from station 9, at surface, on 16 July when *Leptocylindrus danicus* succeded *Skeletonema costatum* as the dominant species (42.85 - 69.2% of the algal biomass). *Coscinodiscus* spp was observed in considerable numbers on 4 June, *Thalassiosira nordenskioldii* was frequent on 4 June and 2nd and 30th of July.

An increase in the numbers of diatoms was observed on 4 June (464 - 545 x 10^3 cells. l^{-1}), with a concurrent increase in chlorophyll (7.5 - 11.54 mg m^3) and photosynthetic out put (264 - 766 mg C m^3. h^{-1}).

The nitrate nitrogen concentration decreased from quantities ranging between 0.6 - 1.25 µg at. l^{-1} on 7 May to 0.28 - 0.36 µg at. l^{-1} on 4 June, whilst the dissolved silica levels increased sharply from 0.16 - 1 µg at. l^{-1} on 7 May into 3.6 - 5 µg at. l^{-1} on 4 June with much smaller changes in phosphate phosphorus levels. Much lower nutrient quantities were recorded during the rest of this period (Figs. 3. 2. 2., 3. 2. 4., 3. 2. 6., 3. 2. 8., 3. 2. 10 and 3. 2. 12.).

On 18 June a sharp decrease in the total number of algal cells was observed for samples collected from both stations (73 - 198 x 10^3 cells. l^{-1}), with the exception of slight increase in samples collected from station 9, at 5 metres depth. This decrease in the number of algal cells was accompanied by a decrease in chlorophyll levels (1.5 - 3 mg m^3) and a similar decrease in carbon fixation values (9.4 - 58 mg C m^3. h^{-1}).

On 2 July an increase in the total number of algal cells was observed for samples collected from both stations, at both depths (225.9 - 911.6 x 10^3 cells. l^{-1}), the highest numbers being those observed for samples collected from 5 metres depth (691.8 and 911.6 x 10^3 cells. l^{-1} for stations 11 and 9 respectively), coinciding with chlorophyll levels (surface quantities - 1.97 and 1.65 mg m^3 for stations 11 and 9 respectively; 5 metres quantities - 4 and 8.85 mg m^3 for stations 11 and 9 respectively), and carbon fixation values (surface quantities - 24.6 and 25.3 mg C m^3. h^{-1} for stations 11 and 9 respectively; 5 metres quantities - 158.9 and 208.7 mg C m^3. h^{-1} for stations 11 and 9 respectively).

At the same time the lowest dissolved silica and phosphate phosphorus levels were recorded for samples collected from both stations, at 5 metres depth (surface values for dissolved silica were 1.86 and 2 µg at. l^{-1} for stations 11 and 9 respectively; 5 metrs values were 1.35 and 1.1 µg at. l^{-1}); (surface values for phosphate phosphorus were 0.087 and 0.15 µg at. l^{-1}; 5 metres values were 0.07 and 0.08 µg at. l^{-1}).

On 16 July, low photosynyhetic activity (27 - 51 mg c m^3. h^{-1}), chlorophyll levels (1.4 - 2.3 mg m^3) and total number of algal cells (27 - 77 x 10^3 cells. l^{-1}) were found.

On 30 July an increase in the total number of algal cells was observed for samples collected from both stations, at both depths (413 - 613 x 10^3 cells. l^{-1}), coinciding with an increase in chlorophyll levels (6.3 - 7 mg m^3) and photosynthetic output (355 - 401 mg C m^3. h^{-1}).

The chromatographic data found for samples collected during this period concurred with the results obtained from the quantitative analysis of chlorophyll and phaeopigments, also with the microscopic examination of samples collected during the same period. The presence of chlorophylls a and c and fucoxanthin indicated the presence of living diatoms, also it is evident that green algae were present due to the

presence of chlorophyll b. The presence of the chlorophyll degradation products phaeophytin a, chlorophyllide a and phaeophorbide a indicated a possible feeding activity by copepods (their presence was also indicated by the presence of astaxanthin, the copepod carotenoid) and other zooplanktons.

During this period on the different dates of sampling and the days previous to the days of sampling, high air temperatures (13.8 - 20.4°c) and moderate sea surface temperatures (10.8 - 14.8°c)were recorded. During this period which in most occasions was characterized by high standing crop values in terms of total algal numbers, chlorophyll levels and photosynthetic activity, long hours of bright sunshine were recorded (207.6 in June, 118.3 in July and 184.2 in August). On the week previous to the 2nd of July, on which the maximum algal number was found mainly for samples collected from from 5 metres depth, long hours of sunshine were recorded(67.9 hours). In the week previous to each of the other sampling dates the hours of sunshine were variable ranging from 17.4 to 44.6 houres. Again the dominance of planktonic species was associated with relatively calm weather. In the week previous to each sampling day the mean daily wind speed tended to be moderate, ranging from 7.24 to 11.5 knots.

Autumn 1986:

The total number of algal cells remained more or less similar to that observed during the summer. During this period most of the population was made up of truly planktonic species (77 - 100%). Highly mixed population was observed, including, diatoms, dinoflagellates, silicoflagellates and green flagellates of which diatoms were dominant (49 - 99.67%). *Skeletonema costatum* remained as the dominant species with the exception of samples collected on 10 September when *Diatoma* spp succeeded *S. costatum* as the dominant species (51 - 85.6% of the standing crop).

The largest levels of contribution by green flagellates to the total biomass were recorded on 27 October (21 - 38.88%) with the exception of samples collected from station 9, at 5 metres depth of which the the maximum green flagellates contribution was recorded 3 weeks earlier (40%). The highest total number of algal cells for this period was observed on 10 September (487.8 - 1121 x 10^3 cells. l^{-1}), coinciding with the highest chlorophyll levels (2.8 - 6.6 mg m^3) and carbon fixation values (136.78 - 343 mg C m^3. h^{-1}). A decrease in the total number of algal cells, accompanyed by a similar decrease in chlorophyll and productivity values was observed during the rest of this period (Figs.3. 4. 2., 3. 4. 4., 3. 3. 3., 3. 3. 4., 3. 3. 7., 3. 3. 8., 3. 5. 1. and 3. 5. 2.).

Phaeopigments levels were low (analytical zero - 1.53 mg m^3) and lower from chlorophyll levels obtained during this period, with the exception for samples collected on 27 October , from station 11 (surface) and station 9 (5 metres) where phaeopigments levels exceeded that of chlorophyll (Figs. 3. 3. 4. and 3. 3. 8.) which indicated that chlorophyll for those samples was associated with senescent diatoms.

A gradual and constant increase in nutrient levels was observed during this period, by which the maximum quantities were recorded on 27 October (Tables. 3. 2. 1. - 3. 2. 3.).

The data obtained from the qualitative analysis of chlorophyll pigments for samples collected during this period coincided with the results obtained from the quantitative analysis of chlorophyll and phaeopigments and with the results obtained from the microscopic examination of samples collected during the same period. The presence of chlorophylls a and c and carotene indicated the presence of living algal cells including diatoms and dinoflagellates. The presence of chlorophyll b indicated the presence of green algae which coincided with the the findings from the microscopic examination mainly on 27 October which showed that green flagellates were present in large numbers. The presence of the chlorophyll degradation products phaeophytin a, chlorophyllide a and phaeophorbide a indicated a possible feeding activity by copepods

and other zooplankton. The presence of copepods was indicated by the presence of astaxanthin.

During this period on the different dates of sampling and on the days previous to them, moderate air temperatures (11.5 - 13.1°c) and moderate sea surface temperatures (10.5 - 12.4°c) were recorded. Variable hours of sunshine were found on the week previous to each sampling date (11.4 - 42 hours), also during the different months (151.7 hours in September and 89.7 hours in October). The longest hours of sunshine were recorded in the week previous to the 10 September (42 hours) in which the maximum standing crop levels for this period were found. Again the dominance of planktonic species was associated with a relatively calm weather. The relatively large benthic population found on 27 October mainly for samples collected from both stations at surface (12.7% of the biomass at station 11 and 23% at station 9), was associated with strong northly to north westerly wind in the week before. Also strong gusts, with wind speeds exceeding 34 knots, in the week previous to the 27 October for 66 hours in total, might be a further cause for this increase in the benthic population. On September the mean monthly wind speed was 10.4 knots and the mean direction was west to north west, whilst in October the mean monthly velocity was 15.1 knots and the mean direction was south west to north west.

Winter 1986 - 1987:

Most of this declininig population was made up of truly planktonic species (68 - 96.5% of the total biomass). A highly mixed population was observed during this period, including diatoms, dinoflagellates, silicoflagellates (*Dictyocha speculum*) and green flagellates (Figs.3. 4. 10 and 3. 4. 12.). Diatoms were dominant (74.3 - 100% of the algal biomass). *Skeletonema costatum* remained as the dominant species, also observed in relatively large numbers were *Coscinodiscus* spp, *Diatoma* spp, *Melosira* spp and *Navicula* spp. On 24 January, ranking second after *S. costatum* was *Leptocylindrus*

danicus. The dinoflagellate fraction was represented by *Ceratium extensum, C. furca, C. lineatum, C. tripos* and *Protoperidinium* spp.

A very low photosynthetic output was recorded during this period not exceeding 13 mg C m^3. h^{-1}, with low algal numbers (16.14 - 77.5 x 10^3 cells. l^{-1}).

Although during this period phaeopigment levels were low ranging from analytical zero to 1.44 mg m^3, on most occasions phaeopigment quantities exceeded that of chlorophyll (Figs. 3. 3. 4. and 3. 3. 8.) which indicated that chlorophyll was associated with senescent diatoms and other algal cells. The only other pigments found on the chromatograms obtained from the qualitative analysis of samples collected during this period, in addition to those indicated the presence of diatoms which icluded chlorophyll a, carotene and diadinoxanthin, were the chlorophyll breakdown products of phaeophytin a, chlorophyllide a and phaeophorbide a.

Nutrient levels continued to increase throughout this period untill 22 January when the maximum quantities of (19.9 - 21.56 µg at Si. l^{-1}) and (13.97 - 14.9 µg at N. l^{-1}) were recorded. The maximum quantities for phosphate phosphorus were recorded on 23 December (1.24 - 1.4 µg at. l^{-1}).

During this period on the different sampling dates and on the days previous to the dates of sampling low air temperatures (0.2 - 9.9°C) and low to moderate sea surface temperatures (4.9 - 10°C) were recorded. The low levels of standing crop found during this period were associated with short hours of sunshine. On the week previous to each sampling date the hours of sunshine were low ranging from Nil to 12.5 hours, with the exception of the week previous to the 18 February when extremely long sunshine hours were recorded (43.3 hours), which reflected on the total number of algal cells found on the date of sampling (36.8 - 109.4 x 10^3 cells. l^{-1}). Although planktonic species were dominant the occasional high benthic population was found. This might be related to

the strong winds found during different times over this period. High mean daily wind speed found in the week previous to the sampling dates of 12 November and 23 December (20.98 knots in the formar date and 18.65 in the latter). Much lower mean daily wind speed found in the week previous to the 24 January (9.45) and 18 February (5.8 knots). Also throughout this period strong gusts with speed exceeding 34 knots were found (511 hours in total). The mean monthly wind speed during January was 10.1 knots and the mean direction was variable ranging from north east to south during the first 20 days of this month and during the rest of the month the prevailing wind followed north westerly direction. During February the mean monthly wind speed was 9.4 knots and the mean direction was variable ranging from north east to south east and from west to north west.

Spring 1987:

A gradual increase in the total number of algal cells accompanied by a similar increase in chlorophyll a levels and photosynthetic activity values was recorded during this period.

During this period, most of the population was made up of truly planktonic species (96 - 100% of the total biomass). Diatoms were dominant (64.94 - 100% of the standing crop), *Skeletonema costatum* was by far the dominant species. In difference to the previous spring, green flagellates were observed in numbers during March and April (Figs.3. 4. 10. and 3. 4. 12.).

On 18 March, although a slight decrease in chlorophyll concentrations, from (1.04 - 1.34 mg m^3) to (0.9 - 1.03 mg m^3) and carbon fixation levels, from (37 - 42 mg C m^3. h^{-1}) to (32 - 36 mg C m^3. h^{-1}) was recorded within a week, an increase in the total algal numbers was observed for samples collected from station 11 at both depths (at surface from 88.45 to 116.2 x 10^3 cells. l^{-1}; at 5 metres from 72.6 to 76.16 x 10^3 cells. l^{-1}) and station 9, at 5 metres depth (from 72.5 to 76.17 x 10^3 cells. l^{-1}).

An increase in the total number of algal cells for samples collected from both stations, at both depths was observed on 25 March (270 - 336 x 10^3 cells. l^{-1}), accompanyed by an increase in photosynthetic activity (42.78 - 50.3 mg C m^3. h^{-1}). Chlorophyll levels remained more or less equal to those recorded on the previous sampling date (0.7 - 1.22 mg m^3).

During April, a constant increase in the number of algal cells was observed, in which the maximum was found on 22 April (1750 - 2185 x 10^3 cells. l^{-1}), coinciding with the maximum values for chlorophyll (9.4 - 14.2 mg m^3) and carbon fixation levels (320 - 360 mg C m^3. h^{-1}). During this period phaeopigment levels were low ranging from analytical zero to 1.6 mg m^3.

Nutrient concentrations decreased constantly reaching minimum levels for this period on 22 April; dissolved silica around 1 µg at. l^{-1}, nitrate nitrogen around 2.5 µg at. l^{-1} and phosphate phosphorus around 0.5 µg at. l^{-1}.

The qualitative analysis of chlorophyll pigments for samples collected during this period closely correlated with the quantitative analysis of chlorophyll and phaeopigments and the microscopic examination of samples collected during the same period. The full range of photosynthetic pigments for this study were found.

During this period on the different dates of sampling and the dates previous to them, there were low to moderate air temperatures (3.7 - 13°C), and moderate sea surface temperatures (5.4 - 10°C). The increase in standing crop levels during this period was associated with relatively long sunshine hours (108.7 hours during March) and (117.6 hours during April). With the exception of the week previous to the 8 April when short sunshine hours were recorded (3.7 hours), relatively long sunshine hours were recorded on the week previous to other sampling days (from 24.5 to 31.4 hours). Again the dominance of planktonic species over benthic was associated with the relatively calm

weather observed during this period. The mean daily wind speed during March was 14.2 knots and the direction was variable ranging from south east to south west and from south west to north west, whilst the mean daily wind speed during April was 10.5 knots with again highly variable directions ranging from north east to east and from south west to north west.

5. General Discussion

The general pattern of variation of dissolved nutrients in the Firth of Clyde is typical of many temperate waters in as much as maximum concentrations occur during the winter when the biological activity is low and minimum values occur during the spring and summer periods when biological demand is high. The annual cycles of dissolved nutrients in temperate waters generally follow one another and result from the alternation of seasons which affected the physical and biological conditions of the area. The low air temperature observed during the winter period causes the cooling of surface waters followed by convectional mixing. According to Barnes (1957) the uniformly high nutrient levels found throughout the winter were due to gales which caused the mixing of the nutrient - rich deep water and the nutrient depleted surface water. The concentrations of dissolved nutrients observed at any time of the year is governed by the relative magnitude of the processes of demand and regeneration at that time.

The dissolved nutrient concentrations found during this study were comparable to those found by Hinton (1974) and Hannah (1979), although higher maximum dissolved silica levels found during the course of this investigation (19.4 - 22.45 µg at Si. l^{-1}), whilst the maximum dissolved silica values recorded by Hinton (1974) and Hannah (1979) were ranging between 11.5 and 13.4 µg at Si. l^{-1}. The maximum phosphate phosphorus values and the minimum quantities for all three nutrients observed during this study were more or less similar to those recorded by Hinton in 1973 and Hannah in 1976 and 1977.

Hinton (1974) and Hannah (1979), in the Fairlie Channel found that phosphate phosphorus levels generally exceeded 1 µg at P. l^{-1} from November till the middle of March. The same was found during the course of the present study. The levels found in the present study and those by Hinton (1974) and Hannah (1979) were higher than those given by Marshall and Orr (1927) from their studies on Loch Striven. They found a maximum phosphate phosphorus level of 0.97 µg at P. l^{-1} in November and indicated

that this winter rise was associated with the turbulent mixing following the breakdown of stratification in the autumn.

The maximum abundance of phosphate to the north of Scotland was given by Barnes (1957) as between 0.66 and 1.14 µg at P. l^{-1}. The maximum phosphate phosphorus levels (0.8 - 1.45 µg at P. l^{-1}) occuring in December, January and February throughout this study were higher than those reported by Marshall and Orr (1930) in early March in Loch Striven (0.45 - 0.8 µg at P. l^{-1}); by Armstrong (1970) at station E1 in the English Channel in 1961 (0.45 g at P. l^{-1}); by Braaraud (1973) for Hardangerfjord (maximum of 0.65 µg at P. l^{-1}); by Ewins and Spencer (1967) for the Menai Straits (maximum of 0.8 µg at P. l^{-1}) and for the North Sea by Cushing and Nicholson (1963) (maximum of 0.75 µg at P. l^{-1}). Winter maximum concentrations of phosphate phosphorus were similar to those reported by Cooper (1933) at station E1 in the English Channel in 1931 (1.28 µg at P. l^{-1}); by Sakshaug and Myklestad (1973) for Trondheimfjord (0.61 - 1.07 µg at P. l^{-1}); Hinton (1974) for the Gare loch and the Fairlie Channel, in the Firth of Clyde (maximum values of 2 and 1.63 µg at p. l^{-1} respectively); Sykes (1969) for coastal water off Aberystwyth, in Cardigan Bay (maximum level of 0.95 µg at P. l^{-1}) and by Riley and Conover (1956) for Long Island Sound (2.5 µg at P. l^{-1}).

The decrease in phosphate phosphorus levels during the spring diatom increase of 1985 and 1986 was not pronounced, dropping from around 1 µg at P. l^{-1} during early spring to levels ranging from 0.6 to 0.8 µg at P. l^{-1} during late spring, and the summer values remained around those quantities untill early July when the minimum levels (around 0.1 µg at P. l^{-1}) were recorded. The same pattern of decrease was found by Hannah (1979) during the spring increase of 1977 when phosphate phosphorus levels decreased from 0.97 µg at P. l^{-1} (April 21) to 0.51 µg at P. l^{-1} (April 28) and the levels remained around this value during most of the summer period with the minimum value of 0.31 µg at P. l^{-1} was recorded on 21 July. Summer concentrations of phosphate phosphorus are similar to levels found by Solorzano and Erlich (1977a) in Loch Etive, Hinton (1974)

and Hannah (1979) in Fairlie Channel. Regeneration in the surface waters is seen in many coastal waters during September and October.

The general pattern of variation of nitrate nitrogen is similar to that of phosphate phosphorus but some important differences exist. Ewins and Spencer (1967) for the Menai Straits reported that the concentrations of nitrate nitrogen increase steadily through out the winter and do not reach equilibrium levels as does phosphate phosphorus. Ewins and Spencer (1967) stated that in the Clyde Sea Area the normal nitrate nitrogen winter levels lie between 15 and 25 µg at N. l^{-1}. The maximum recorded nitrate nitrogen levels in the Clyde Sea Area were higher than those recorded for other areas around the coast of Britain. For the Fairlie Channel Hinton (1974) recorded 23.7 µg at N. l^{-1} at the end of January in 1973 and Hannah (1979) recorded a maximum of 21.9 µg at N. l^{-1} on 17 February in 1976. Although lower maximum winter levels were found during this study for the same area (14.2 - 15.7 µg at N. l^{-1}) they remained higher than those in other areas with the exception of the maximum reported by Sykes (1969) for Cardigan Bay (24 µg at N. l^{-1}) and by Hinton (1974) for Loch Long (22 µg at N. l^{-1}) which were comparable to those found by Hinton (1974) and Hannah (1979) for Fairlie Channel. Nitrate nitrogen levels found during this study were higher than those of 5.2 - 8.4 g at N. l^{-1} for the Irish Sea given by Slinn and Eastham (1970, 1971 and 1972) and that recorded for the same area by Cushing and Nicholson (1963) (9 µg at N. l^{-1}). Also lower maximum levels were recorded by Cooper (1933) during the course of 4 years for station E1 in the English Channel (6 - 8 µg at N. l^{-1}); by Solorzano and Erlich (1977a) for Loch Etive (3 - 7 µfg at N. l^{-1}) and by Solorzano and Grantham (1975) for Loch Linnhe (4.9 - 7.3c µg at N. l^{-1}). Although in some of the previously mentioned areas the minimum nitrate levels fell to undetectable quantities, most maintiained an equilibrium concentration below 0.5 µg at N. l^{-1}. Also in the Fairlie Channel often nitrate nitrogen levels fell below 0.5 µg at N. l^{-1}.

In all coastal waters during the summer period very low nitrate nitrogen levels were recorded, which reflects the generally high biological activity at this time. Although the summer levels of nitrate nitrogen are similar in several areas the algal biomass varies greatly, which might indicate that the size of the standing crop of phytoplankton during the summer period is dependent upon the rate of input / regeneration of nitrate nitrogen during the summer, or it may reflect the different grazing pressures in different areas or differences in the degree of mixing of the surface layers. The depletion of nitrate nitrogen to levels below or around 1 µg at N. l^{-1} during the growth recession points to nitrate limitation of productivity was recorded during this study. This feature has been also reported in studies of well - mixed French coastal waters (Wafar et al, 1983) and the Clyde Sea area (Hannah and Boney, 1983).

Dissolved silica exists in the sea as orthosilicate which is an essential part of the solid structure of the main primary producers in temperate waters (diatoms) (Armstrong, 1965). During the winter period from November until early March the dissolved silica levels were high ranging from 7.5 to 22.45 µg at Si. l^{-1}. Although the maximum levels found by Hannah (1979) in the Fairlie Channel were lower than those found during this study they remained high ranging from 9.6 to 13.1 µg at Si. l^{-1}. During the time of the spring diatom increase the dissolved silica levels declined rapidly. During March 1985, the dissolved silica levels decreased from around 6 µg at Si. l^{-1} on 6 March into levels ranging from 0.3 to 0.4 µg at Si. l^{-1} on 29 March. Similarly during the spring of 1986 the levels decreased sharply from around 7.5 µg at Si. l^{-1} on 11 March into around 1.5 µg at Si. l^{-1} on 22 April. Also during the spring diatom increase of 1987 the dissolved silica levels decreased sharply from quantities ranging between 6.85 and 10 µg at Si. l^{-1} on 10 March into levels levels around 1.7 µg at Si. l^{-1} on 9 April. The same rapid decline in dissolved silica levels during the spring period was recorded by Hannah (1979). During March 1976 the dissolved silica levels decreased from 6.9 µg at Si. l^{-1} to 3.14 µg at Si. l^{-1} and during April, after the main period of the bloom, was further reduced to 0.42 µg at Si. l^{-1} reaching a minimum value of 0.21 µg at Si. l^{-1} on 5 May.

In 1977, dissolved silica remained high until mid - April when it declined from 6.3 µg at Si. l^{-1} (21 April) to 0.95 µg at Si. l^{-1} within a week.

The maximum dissolved silica levels recorded in the Fairlie Channel were higher than those recorded by Cooper (1933) for the English Channel (5 - 9.4 µg at Si. l^{-1}) during the time span of 4 years. Cushing and Nicholson (1963) reported a maximum of 9 µg at Si. l^{-1} for the North Sea, which not far from that recorded for the Trondheimsfjord by Sakshaug et al, (1973) (around 8 µg at Si. l^{-1}) and similar to the maximum for the Menai Straits (9 µg at Si. l^{-1}) by Ewins and Spencer (1967). Although the maximum for Cardigan Bay recorded by Sykes (1969) was lower than those found during the present study (12 µg at Si. l^{-1}), it is similar to the maxima generally recorded in the Clyde Sea Area.

Earlier studies on changes in standing crop left little doubt, however, that nutrient limitation over summer restricted productivity in many areas. A limiting factor to biological activity is that material available in an amount most closely approaching the critical minimum required to sustain that activity (Odum, 1971). Most marine geochemists (e.g. Lerman et al, 1975; Meybeck 1982; Broecker and Peng 1982) hold the view represented by Redfield (1958) in which he stated that phosphorus availability limits net organic production in the sea. He pointed out that any nitrogen deficits can be met by the biological fixation of atmospheric nitrogen, hence nitrogenous compounds can accumulate until the the available phosphorus is utilized. Some marine biologists replaced Redfield's view with that represented by Ryther and Dunstan (1971) in which they stated that nitrogen not phosphorus is the limiting factor to algal growth in coastal waters; also they accepted the possibility that nitrogen fixation might be important in regulating the level or balance of nutrients in the ocean as a whole and over geological time, but they concluded "It (nitrogen fixation) is certainly not effective locally or in short run." Similarly, Thomas (1970a,b) and Goldman et al, (1979) have relied on experimental cultures of phytoplankton to evaluate nutrient limitation in the

marine environment. They stated that nitrogen appears to be the nutrient which is most often limiting to the specific growth rate of natural populations of phytoplankton grown in such cultures. In contrast to the marine biologists, biological limnologists now generally subscribe to the view that phosphorus availability is ordinarily the primary limit to net organic carbon production in lakes. This view was exemplified by the long term monitoring studies conducted by Edmondson (1970) and Edmondson and Lehman (1981) on Lake Washington. Smith (1982) stated that nitrogen is considered to have a significant, but secondary, effect on net production. Earlier studies on changes in the standing crop left no doubt that nutrient limitation over the summer period restricted productivity in many areas. Atkins (1928), Cooper (1933, 1937) and Harvey (1950) for the western English Channel, Marshall and Orr (1927, 1930) in the Clyde Sea Area and of Bigelow, suggested that lack of phosphate or nitrate, whichever was in shorter supply acted as limiting factor on production. In temperate coastal waters where diatoms were generally the dominant fraction of the population the limiting factors were considered to be either nitrate nitrogen (Barnes, 1957) or dissolved silica (Marshall and Orr, 1930).

In a review of recent evidence on the effects of enrichment Hecky and Kilham (1988), stated that phytoplankton can become limited by the availability of nutrients when light and temperature are adequate and loss rates are not excessive. The current paradigms for nutrient limitations in fresh water, estuarine and marine environments are quite different. A review of the experimental and observational data used to infer phosphate or nitrate limitation of phytoplankton growth indicates that phosphate limitation in fresh water environments can be demonstrated rigorously at several hierarchical levels of system complexity, from algal cultures to whole lakes. A similarly rigorous demonstration of nitrate limitation has not been achieved for marine waters. Therefore Hecky and Kilham (1988) concluded that the extent and severity of nitrate limitation in the marine environment remains an open question. Culture studies have established that internal cellular concentrations of nutrients determine phytoplankton growth rates, and these studies have shown that it is often difficult to relate growth rates to external

concentrations, especially in natural situations. Hecky and Kilham (1988), concluded that the dissolved nutrient concentrations are most useful in determining nutrient loading rates of aquatic ecosystems and that the relative proportions of nutrients supplied to phytoplankton can be a strong selective force shaping phytoplankton communities and affecting the biomass yield per unit of limiting nutrient.

Although silicon in the form of polymerized silicic acid (biogenic silica) is a major component of the cell walls of all important plankton diatoms, there is considerable variation between species in silica content (Parsons et al, 1961; Harrison et al, 1977). Within a given species, the Si content may vary as a function of cell size (Durbin, 1977) as well as of external factors. Paasche (1980) measured the silicon content of five species of marine planktonic diatoms grown in laboratory culture, he found that the increase in the temperature or light intensity during growth resulted in an increase in silica content in some species and a decrease in others.

Eppley et al, (1979) discussed the hypothesis that the transport of nitrate into the euphotic zone regulates the production of phytoplankton in southern California coastal waters. They concluded that the transport of nitrate into the euphotic zone appears to be a major factor regulating the standing crop and productivity in southern California coastal waters.

The seasonal changes in the standing crop levels and the pattern of phytoplankton succession observed during this study concurred with the majority of the earlier findings from the earlier investigations in temperate waters which was charactarized by a large spring peak, variable but lower summer densities, small autumn peak and a winter minimum. The spring diatom increase observed during 1985, 1986 and 1987 was typical of the studied area and of temperate regions although the increase in 1987 occured in late March with the maximum in the 22nd of April which was similar to that recorded by Hannah in 1976 and 1977 and slightly later than those recorded by others

in the past. From previous studies on temperate waters the initial increase in the phytoplankton population occurred mostly during late - February and early - March, similar to the timing observed by Riley and Conover (1956) for Long Island Sound (early - March); by Jensen and Sakshaug (1973) and Sakshaug and Myklestad (1973) in Trondheimsfjord; by Gauld (1950) and Marshall and Orr (1927, 1930) in Loch Striven and the Firth of Clyde (March); by Solorzano and Erlich (1977a) and Wood et al, (1973) in Loch Etive (March); by Steele and Baird (1968) in Loch Etive (March) and by the same workers in Loch Nevis (Steele and Baird, 1962b) (March). Marshall and Orr (1930) compared the timing, composition and magnitude of the spring increase in successive years and showed that, in general, the increase occured within a week of 20 March, in concordance with the findings of the present investigation.

Sakshaug and Myklestad (1973) stated that in the north temperate seas the threshold of solar radiation input and stabilisation of the water column are the main triggering processes of the spring diatom increase. Marshall and Boney (1974) found that in the Firth of Clyde a short period of 10 to 14 days with suitable climatic conditions was critical.

During the present study the standing crop values fluctuated during the summer period between relatively high to relatively low levels, similar to those found by Hinton (1974) and Hannah (1979). During the summer period as the air temperature increases stable layering takes place, cutting off the productive upper layer from the supply of nutrients. Thus the increase in the phytoplankton biomass during the summer is nutrient limited and the size of the population tend to be smaller than that found during the spring.

The levels of chlorophyll a recorded during the different seasons in the present study were of similar magnitude to those found by Hinton (1974) and Hannah (1979) although the maximum levels were slightly higher (18 mg m^{-3} in 1985; 11.5 mg m^{-3} in 1986 and 13.7 mg m^{-3} in 1987). Hinton (1974) recorded the presence of successive

pulses of phytoplankton following the first spring peak with a maximum chlorophyll level of 8.3 mg m^{-3}, each being smaller than the preceding. Also Hannah (1979) found that the spring peak of 1976 with chlorophyll maximum of 10 mg m^{-3} was followed by a series of pulses although, while the first subsequent peak was reduced, an increase in the succeeding pulses with the final peak being recorded at the end of July with a similar chlorophyll maximum to that found in the initial spring peak (10.5 mg m^{-3}). The spring peak of 1986 with maximum chlorophyll level of 10.2 mg m^{-3} recorded in 2nd of April was similarly followed by a series of successive pulses of which the first three were of decreasing magnitude with the final recorded peak at the early June having a similar chlorophyll levels to that of the initial spring peak (7.5 - 11.54 mg m^3). After the spring diatom increase of 1984, the following summer peaks were of decreasing magnitude only, which indicated the absence of a large diatom pulse.

The range of chlorophyll values which found at the peak of the spring increase in the Fairlie Channel during the course of the present study also encompasses the levels found in the Long Island Sound, 20 - 30 µg l^{-1} (Riley and Conover, 1956) and in Trondheimsfjord, 15 - 20 µg l^{-1} (Solorzano and Erloch, 1977a).

The spring diatom increase in the Fairlie Channel occurred earlier than that in the continental margins off the west coast of Scotland (designated "Area C4" by Colebrook and Robinson 1965), occuring between April and May; in the Menai Straits occuring during May (Al - Hassan et al, 1975; Ewins and Spencer, 1967) and in the Irish Sea occuring during April and May (Slinn and Eastham,1970, 1971,1972; Slinn and Offlow, 1967, 1968, 1969; Sykes, 1969).

Although a typical feature of the temperate waters to have a marked autumnal increase in the phytoplankton biomass, which may be true of some oceanic waters and in the North Sea (Colebrook and Robinson, 1965) it is not always the case. In the Fairlie Channel during the course of this investigation and from the previous studies carried

out by Hinton (1974) and Hannah (1979), chlorophyll levels rose during September to quantities similar to the maximum found during May and June. On some occasions continuation of the summer oscillation in chlorophyll levels was all that what seen during the autumn period, as in the autumn of 1984. This variability in the levels magnitude and timing of the autumn increase was seen in the Trondheimsfjord (Jensen and Sakshaug, 1973) in the Irish Sea, (Slinn and Eastham, 1970, 1972) and in Menai Straits (Al - Hassan et al, 1975; Ewins and Spencer, 1967) although in the latter area the chlorophyll levels recorded during the autumn period were similar to the levels found during the spring diatom increase.

Similar to the findings in all the previous studies the winter levels of chlorophyll were low representing the minimum. Hinton (1974) found that chlorophyll values never exceeded 0.05 $\mu g\ l^{-1}$ during the winter of 1972 - 1973 and were often undetectable.

Although the levels of productivity recorded during this study were higher, mainly the maximum values than those found by Hinton (1974) and Hannah (1979), due to the fact that during the present investigation the incubation of samples was carried out in the laboratory which provided extremely favourable conditions under which the fixation of carbon was carried out, a similar seasonal pattern was found. The fixation levels recorded during this study varied significantly at the different seasons. The recorded maximum levels of fixation were 599.2 mg C m^{-3}. h^{-1} for station 11, at surface (on 4 June); 393 mg C m^{-3}. h^{-1} for station, 11 at 5 metres depth (on 15 August); 766.7 and 418.2 mg C m^{-3}. h^{-1} were the maximum production levels for samples collected from station 9, at surface and 5 metres depth respectively. The maximum observed levels of fixation recorded by Hannah (1979) were 66.6 mg C m^{-3}. h^{-1} in July, 1976 and 55.7 mg C m^{-3} . h^{-1} in September, 1977, indicating similarity with the timing of the maximum levels of fixation found during this investigation. Although the levels of photosynthetic activity recorded in 10th of September, 1986 were high (136 - 343 mg C m^{-3}. h^{-1})

which was associated with large autumnal population, did not represent a maximum for photosynthetic out put, as found by Hannah in 1977.

The pattern of the annual cycle of photosynthetic activity observed during the course of this study was similar to that found by Wood et al, (1973) in Loch Etive. Similarly the same annual cycle for carbon assimilation was observed by Nielsen (1964a) in waters around Denmark. He found that a small production occured in winter followed by a sharp increase during the spring, whilst the maximum photosynthetic activity over a period of 4 years was recorded during the summer, possibly influenced by rapid regeneration of nutrients with higher temperature.

The seasonal variation of phytoplankton photosynthesis was measured by Eloranta and Salminen (1984), using ^{14}C - method, for a warmed ice free pond in central Finland. Simultaneously with in situ measurements they also measured the photosynthetic activity in an incubator with different water temperatures and constant light (ca. 16 Wm^2). They found that the total annual photosynthesis was 57.2 mg C m^2 a^{-1}. The portion of the winter and spring production of the annual photosynthesis was 18.4%; that of the autumn production was 17.4%. Thus 64.3% of the total annual phytoplankton photosynthetic out put occurred in the summer months. The photosynthetic rate per unit chlorophyll a varied in situ from 0.94 to 33.1 mg C (mg chl. a)$^{-1}$ d^1; the highest value was measured in the beginning of July and the lowest in mid - January. The photosynthetic rate increased in situ exponentially with increasing water temperature. Similarly in the incubator the highest photosynthetic rate values were found in July and August (at 20^0 C). Eloranta and Salminen (1984) stated that light was a limiting factor for photosynthesis from September to mid - January, low water temperature was a limiting factor from late January through May. Hitchcock and Smayda (1977) stated that the initiation of growth in spring is light limited.

Although the spring and autumn phytoplankton blooms are characteristic of temperate waters where thermal stratification occurs during the summer months (e.g. Raymont, 1976), in well - mixed coastal waters the phytoplankton cycle may consist of a single peak of growth during the summer period (Boalch, Harbour and Butler,1978; Wafar, Le Carre and Birrien, 1983). Brander and Dickson (1984) considered evidence from the Irish Sea continuous plankton recorder which reflected the phytoplankton growth cycle in the well - mixed areas of the sea. These data suggested a single late peak of production, in contrast to the bimodal blooms which are known to develop in the stratified areas of the Irish Sea (Slinn, 1974). Parker et al, (1988), in their study of the phytoplankton production cycle in Belfast Lough, which represented a well - mixed area, found that throughout the lough there was a single late peak of phytoplankton production similar to that reported in certain well - mixed areas of the Irish Sea and the bloom was later and shorter in duration in the deeper waters of the lough, compared with the less turbulent nutrient - enriched waters of the inner lough.

The high dark fixation found in 17 February, 1987, which exceeded the light fixation was associated with bacterial heterotrophic production. High dark fixation levels in marine environment were previously reported by Morris and Yentsch (1971), Taguchi and Platt (1977) and Hannah (1979). Hannah and Boney (1983) stated that dark fixation was normally low except for a period in January, 1977 when dark fixation levels were high, comparable to or exceeding light fixation levels. A possible explanation given by Hannah and Boney (1983) lies in the uptake of ^{14}C on detritus material which formed a large part of the particulate matter, or that the high dark production levels were due to bacterial uptake, possibly attached to the detrital material.

In the Bedford Basin (Nova Scotia coast), a small, enriched coastal inlet, Taguchi and Platt (1977) found that the assimilation of ^{14}C in the dark varied from 20% (summer) to 200% (winter) of the assimilation in the light. They estimated the annual fixation of

CO_2 in the dartk to be 50 g C m^{-2}. $year^{-1}$ or about 25% of the estimated annual photosynthetic production of 200 g C m^{-2}. $year^{-1}$.

In their study of the bacterioplankton biomasses and productivities, as well as chlorophyll a concentrations and phytoplankton productivities in Howe Sound, a temperate fjord - sound on the southern coast of British Columbia (Canada), Albright and McCrae (1987) found that bacterial production occurred throughout the year, although at reduced rates in late fall and early winter; primary production almost ceased during late fall and early winter. Because of this heterotrophic bacterioplankton production was a very large portion of the microbial (bacterial and plankton) production at this time. In mid - summer bacterial production was a small proportion of the microbial production. In relation to the phytoplankton activities Albright and McCrae (1987) found that from approximately mid - winter to early - summer they had generally moderate and variable fixation levels, whilst when the euphotic zone of the water column stabilized in June through September, photosynthetic activity greatly increased and remained high. By October fixation levels greatly decreased and remained low through December.

The interpretation of ^{14}C - uptake rates in the plankton is considerably complicated by ecological interaction between components of the microbial community (Peterson, 1980; Jackson, 1983; Smith et al, 1984). It has been suggested that ^{14}C - uptake will severely under estimate net primary productivity when phytoplankton are growing rapidly (as during the spring diatom increase), but net - population increase is kept in check by high loss rates to grazers (Sheldon and Sutcliffe, 1978).

In temperate sea areas, where there was a considerable variation in temperature, light and nutrient concentration throughout the year, there is a frequently a marked change in species composition of the phytoplankton community (seasonal - succession), accompanying fluctuations in the total number of the phytoplankton population.

The pattern of seasonal succession of phytoplankton observed during the course of the present investigation showed a clear similarity to that observed by Hinton (1974) and Hannah (1979)for the Fairlie Channel and by Marshall and Orr (1927) for Loch Striven in 1926. During the spring diatom increase of 1984, 1985, 1986 and 1987 the dominant species was *Skeletonema costatum* which is a typical vernal diatom of the Clyde sea area. The complete dominance of *Skeletonema* reported on several occasions in Loch Striven (Marshall and Orr, 1930) was observed during the late spring of 1986 (on 2nd and 9th of April). During the spring diatom increase the accompanying diatoms to *Skeletonema* were generally *Thalassiosira nordenskioldii, Coscinodiscus* spp and *Nitzschia seriata.* During the spring diatom increase of 1985, on 6th and 13th of March the diatom *Leptocylindrus danicus* was found in considerable numbers (23 - 51.99% of the total biomass). Green flagellates were found in considerable numbers during the spring and summer periods of this study, in accordance with the findings of Marshall et al, 1934, during the spring diatom increase in 1932 and 1933 for Loch Striven and with the observations reported by Marshall and Orr (1962) for the spring and summer periods.

During the summer period the algal population had a larger diversity of species composition than that found during the spring and a larger number of flagellates. The same features were reported by Hinton (1974) and Hannah (1979). The summer population included dinoflagellates (*Protoperidinium* and *Ceratium* spp) and diatoms (*Chaetoceros* spp; *Grammatophora marina* ; *Leptocylindrus danicus* ; *Nitzschia* spp and *Rhizosolenia* spp). Also observed during this period was the silicoflagellate *Dictyocha speculum.*

During the autumn period flagellated forms become relatively abundant; also during this period the diatoms *Coscinodiscus* spp, *Navicula* spp, *S. costatum* and *T. nordenskioldii* were observed frequently. The same findings were reported by Hinton (1974) and Hannah (1979) for the Fairlie Channel. During the winter period the

number of algal species increased, while the abundance of most species was reduced. One of the important features of this period was the absence of a clearly dominant species e.g. during the winter of 1984 the diatoms *Coscinodiscus* - spp, *Diatoma* spp, *Navicula* spp, *S. costatum* and *T. nordenskioldii* were all common. The only recorded exception was recorded on the 5th of December when *S. costatum* was dominant (79.14 - 88.45% of the total biomass). The absence of a clear dominant species during the winter period in temperate seas was also observed in some of the previous investigations including that of Hinton (1974) and Hannah (1979).

It has been assumed, in the past that diatoms were the major contributors to the total primary productivity in the Clyde Sea area. Marshall and Orr (1927) found that the changes in chemical factors coincided with changes in diatom numbers and these were therefore assumed to be the most important producers in the Firth of Clyde. Hannah (1979) stated that the probable role of the nanoplankton fraction of the phytoplankton population needs to be considered, especially in terms of its contribution to both biomass and productivity. During the course of the present investigation the contribution of the netplankton, nanoplankton and picoplankton fractions to the total primary production was considered.

The ecological importance of the net and nanoplankton fractions was related with the role of the cell size in the algal community. Odum (1956) and Williams (1964) stated that the shorter generation times and higher growth rates were associated with small cells, due to the high surface area to volume ratios of those small cells. In their discussion of the changes in nanoplankton organisms and their contribution to the chlorophyll a and productivity in the Fairlie Channel Hannah (1979) and Hannah and Boney (1983) stated that the nanoplankton population was made up mostly of small flagellates ($\leq$10 µm), of which most ranging between 2 - 5 µm; and this fraction formed a stable part of the total phytoplankton population. The seasonal variation of the netplankton population production was much wider than that of the nanoplankton

fraction; the same was reported by Hannah (1979) and Hannah and Boney (1983). The relative stability and constancy of the nanoplankton in comparison with the net plankton was reported on many occasions. Marshall (1974) found in Loch Craiglin that the numbers of small flagellates varied greatly, whilst there was no great increase of small flagellates at any time as there was with diatoms nor there any time of the year when they were very scarce.

During the present study although the netplankton contribution to the total photosynthetic activity was high the nanoplankton size fraction was the major contributor to the total phytoplankton productivity during the spring bloom (50 - 57.6%). During the spring of 1987 green flagellates were found in considerable numbers. Also during the late autumn bloom (on 27 October) the nanoplankton fraction accounted for most of the total productivity (56.73 - 63.67%); again on this date green flagellates were found in considerable numbers (21 - 38.88% of the total biomass). Hannah (1979) reported that while the contribution of the netplankton is high during bloom conditions, over the annual cycle the nanophytoplankton composed mainly of small flagellates, contributed at least 50% to the chlorophyll and productivity. Hannah and Boney (1983) stated that the results obtained for the Fairlie Channel station showed that the nanophytoplankton fraction (<20 μm) made the major contribution to carbon fixation in late autumn and winter, and at times in the summer months. In the Celtic Sea, at station E1 in the English Channel, Pingree et al, (1976) found that the relative contribution of the nanoplankton size fraction (<5 μm) was 70% before and after the spring bloom and fell below 10% during, although the actual production by the nanoplankton also increased during the bloom.

In a Norwegian fjord Lannergren and Skjoldal (1975) found that the increase in the number of small flagellates was regular and slow and did not seem to be effected by the changes in nutrient quantities, in contrast to the large fluctuation of diatoms. In the open waters of the English Channel, at station E1 Boalch et al, (1978) found that small

flagellates occurred throughout the year and did not show a marked seasonal fluctuations as did the diatoms and larger species, thus small flagellates did not alter the seasonal contribution but just increased the whole scale of cell numbers by about one - fifth. Malone (1971a) stated that in the Californian current there is a little seasonal variation in the nanoplankton productivity in comparison with that of the netplankton population which was associated with the upwelling. Others including Yentsch and Ryther (1959), and Teixeira et al, (1967), indicated that the nanoplankton fraction represented the more stable component of the phytoplankton population; also they stated that the nanoplanktons were less influenced by the changes of seasons. Hannah (1979) stated that in the Firth of Clyde, the relative importance of the net and nanophytoplankton fractions showed a marked seasonality. During late autumn, winter and early spring, the major part of the phytoplankton biomass is composed of nanoplankton whilst during the spring and summer the diatoms were dominant. Malone (1981) reported that the observed seasonality or net to nanoplankton transitions could be as a response to changes in temperature, water column stability and nutrient availability.

Mullin (1963) stated that the relative levels of net and nanophytoplankton productivity and standing crop was reflected in the distribution and abundances of herbivores which selectively graze one group or the other. Cole (1936), Bruce et al, (1940), Beers and Stewart (1969) and Parsons and Le Brasseur (1970) stated that the nanoplankton fraction appear to be grazed mainly by planktonic invertebrate larvae and microzooplanktons, whilst the copepods selectively graze on the netplankton fraction (Marshall and Orr, 1955; Richman and Rogers, 1969; Richaman et al, 1977). Marshall (1949), in a study of the gut content of *Microcalanus* and *Oithona* spp, found that the nanoplankton may provide a food source for the nauplii and adults of the smaller species of copepods found in the Firth of Clyde. The nanoplankton fraction found to be the essential food source for the microzooplankton in the Strait of Georgia, British Columbia (Parsons and Le Brasseur, 1970). Gold (1973) and Heinbokel (1978), stated

that if the microzooplankton were the principal consumers of the nanoplankton fraction, then the relatively short generation times of the microzooplankton, doubling times of 12 - 24 hours have been recorded for tintinnids, which could mean that the coupling between the phytoplankton production and primary consumers might be much closer with food chains based on the nanoplankton fraction than for those which are diatom based with larger crustaceans. Hannah and Boney (1983) reported that this close coupling between primary and secondary consumers would tend to prevent the rapid fluctuations in the numbers of nanoplankton; this might explain the relative stability of the nanoplankton size fraction during the different seasons in the Firth of Clyde.

During the course of the present investigation a substantial fraction of the primary production occurred in the size fraction $\geq 0.45 < 5$ µm, which included the picoplankton fraction (0.2 - 2 µm). During this study the contribution of the picoplankton fraction to the total photosynthetic activity was discussed within the size limits of the nanoplankton population (0.45 - 10 µm). The picoplankton fraction accounted for levels ranging from 5.86 to 32.2%of the total photosynthetic output during the course of the present investigation (from 15 August 1986 to 8 April 1987). The contribution of picoplankton to the total productivity varies and has been reported to be as high as 80% of the daily carbon fixation for the tropical Pacific Ocean (Li et al, 1983); Gieskes et al, (1979) working in the tropical Atlantic, found between 20 and 30% of the production in the <1 µm size fraction; and up to 60% for the subtropical Atlantic (Platt et al, 1983). The importance of picoplankton production appears to be less in temperate waters; Joint and Pomroy (1983) found that picoplankton accounted for 20 to 30% of the primary production in the Celtic Sea in summer and Douglas (1984) reported values of 12.7 to 29.7% for the continental shelf off Nova Scotia. Larsson and Hagstrom (1982) reported that in temperate waters the picoplankton contributed up to 25% of the phytoplankton biomass comprised of organisms which passed through a 3µm filter. During this investigation the picoplankton fraction was responsible for significant part of the total phytoplankton productivity (5.86 - 11.6% of the summer production, for 8.8 - 29.6% of

autumn production, 11.2 - 32.2% of the winter photosynthetic activity and for 17.87 - 20.9% of the spring photosynthetic out put). It is evident that the highest levels of contribution to the total primary productivity was recorded during the times of low nutrient levels; this in agreement with the findings of Dugdale, 1967; Eppley et al, 1969; Malone, 1971, 1977; McCarthy et al, 1974. Larsson[1] and Hagstrom[2] (1982) reported that the occurrence of picoplankton coincides with the depletion of nutrients from the water column.

The findings from the present study showed a close similarity with those reported by Joint, Owens and Pomroy (1986), in their measurement of the primary production by picoplankton and other phytoplankton in all seasons in the Celtic Sea. They reported that picoplankton production was greastest during the summer but was always less than that of small nanoplankton. Larger phytoplankton (>5 μm) was quantitatively the most important only for a short period of the spring diatom bloom. In winter small nanoplankton (<5 to >1 μm) accounted for almost 70% and picoplankton for 13% of the daily primary production. These findings were consistent with the data of Hannah and Boney (1983) who found that nanoplankton was responsible for all of the carbon fixation in the Firth of Clyde, in winter. Although the measurement of primary production made in 15 August, 1986 for the different size fractions are the only data for the late summer, in the Fairlie Channel but I believe that the rates measured are indicative of summer conditions.

The fate of picoplankton and small nanoplankton is unknown; the recent hypotheses of Azam et al, (1983) on the functioning of the microbial food web suggest that protozoan microflagellates are important in grazing bacteria and presumably also picoplankton. However, Joint and Williams (1985) calculated that there were insufficient heterotrophic microflagellates present in 1982 to make a significant grazing impact on picoplankton but the production of the heterotrophic microflagellates probably balanced the production of the heterotrophic bacteria. Joint et al, (1986) stated that the fate of

picoplankton production is still not known and the rate of which picoplankton and small nanoplankton production is incorporated into the food web requires quantification.

The observed changes during this study in the standing crop levels in terms of chlorophyll a quantities, total number of phytoplankton cells and amount of ^{14}C fixed was typical of temperate region and similar to those reported by Hinton (1974), Hannah (1979) and Hannah and Boney (1983) for the same area.

The seasonal changes in nutrient levels were also typical of the area with the maximum levels being recorded during the winter period at the time of low algal biomass, whilst the minimum nutrient quantities were found during the spring diatom increase and during the summer period.

The maximum standing crop levels were found during the spring diatom increase with variable but lower summer levels, small autumnal peaks and minimum winter quantities. Also found that the spring increase occured during late March and early April, with a duration of two to three weeks. The seasonal variations in the phytoplankton standing crop in terms of chlorophyll a levels, total number of algal cells and the rate of photosynthetic out put showed a very close relationship to each other mainly during the spring bloom and the winter decrease. The levels of standing crop during the spring and summer at the time of favorable weather conditions was limited by the availability of nutrients, whilst during autumn and winter at the time of high nutrient levels the standing crop quantities were climatic dependent.

During the spring increase in standing crop levels the maximum chlorophyll a quantities were recorded at the first spring peak, whilst the subsequent peaks were of decreasing magnitude, with the final early summer peak having chlorophyll a levels equal to those recorded in the initial spring peak. This feature was most evident during the spring and early summer of 1986.

In terms of photosynthetic out put although the presence of spring and autumnal peaks was evident with higher rates of production in the latter season, the maximum photosynthetic activity was recorded during the summer (4 June, 1986) possibly influenced by a rapidly regenerated nutrients with higher temperature and longer sunshine hours. A progressive increase in the photosynthetic out put was recorded during the spring of 1987, in contrast to that of 1986 in which only a single peak was recorded.

During the course of the present study the contribution of the net -, nano - and picophytoplankton fractions to the total photosynthetic out put was considered. Although the nanophytoplakton size fraction was the major contributer to the total phytoplankton productivity, the contribution of the netphytoplankton population to the total photosynthetic activity was relatively high. This might be in part as a result of the relative stability and constancy of the nanophytoplankton in comparison with the netphytoplankton and to the shorter generation times and higher growth rates associated with the smaller nanophytoplankton cells. The picophytoplankton fraction accounted for a significant part of the total phytoplankton production.

During the spring diatom increase the dominant species were *Skeletonema costatum* and *Thalassiosira nordenskioldii*, accompanied by *Coscinodiscus spp* and *Nitzschia seriata*. *Leptocylindrus danicus* also found in considerable numbers during the spring of 1985. During the spring diatom increase a competitive succession between *Skeletonema costatum* and *Thalassiosira nordenskioldii* was observed the outcome of which might be controlled by the following factors: 1) The initial concentration of nutrients. 2) Their differences in sinking rates. 3) The size of initial inoculum of the two species at the beginning of the bloom and 4) The relative rates of multiplication of the two species.

A larger diversity of species composition was found during the summer than during spring together with a larger number of flagellates. The summer population was made up of dinoflagellates (*Protoperidinium* and *Ceratium spp*) and diatoms (*Chaetoceros spp; Grammatophora marina; Leptocylindrus danicus; Nitzschia spp* and *Rhizosolenia spp*). The silicoflagellate *Dictyocha speculum* was also observed. During the autumn period flagellated forms, mainly dinoflagellates composed predominantly of the genus *Ceratium*, become relatively abundant together with the frequent observations of *Coscinodiscus spp; Navicula spp; S. costatum* and *Thalassiosira nordenskioldii*. During the winter period an increase in the number of algal species, accompanied by a reduction in the abundance of most species was recorded. Also a feature of the winter period was the absence of clearly dominant species.

The benthic organisms were found to be most numerous during autumn and winter months, at the time of strong winds and turbulent seas.

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Appendix I

Daily sunshine hours during March to December 1984 ($h.d^{-1}$)

	Months									
Day	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.0	7.0	12.4	0.0	2.4	7.5	0.0	3.1	0.0	0.0
2	7.8	10.2	11.4	14.2	14.7	0.1	0.8	0.0	4.4	0.9
3	0.5	9.3	11.3	2.5	15.3	3.4	1.7	0.2	0.0	0.0
4	0.1	1.5	9.5	6.1	14.4	5.2	9.1	7.5	6.2	0.0
5	1.2	0.0	12.0	3.6	12.7	14.0	4.1	7.4	5.6	0.0
6	0.3	7.7	1.1	0.9	4.5	0.0	0.1	7.1	6.2	4.6
7	0.0	0.2	13.6	14.0	10.6	12.2	3.1	5.2	0.0	0.0
8	0.0	6.3	13.5	15.8	9.3	0.6	0.7	0.1	0.0	0.0
9	0.0	0.4	5.1	9.8	0.3	7.2	7.1	7.1	0.1	0.0
10	0.0	0.0	12.9	3.5	4.4	14.1	0.2	0.0	0.6	0.3
11	0.3	6.8	9.0	0.0	0.0	9.6	6.8	7.2	0.0	0.7
12	4.6	0.0	14.5	2.8	3.9	9.8	0.0	0.0	0.7	0.0
13	1.1	3.0	13.5	1.6	4.6	6.8	0.0	0.0	3.4	0.0
14	0.0	2.2	10.0	5.1	4.5	4.6	0.9	2.6	0.0	0.0
15	1.2	7.7	0.1	0.9	7.0	10.3	10.2	0.0	3.2	3.9
16	9.8	10.3	4.9	8.8	3.2	10.9	2.3	0.1	1.9	5.0
17	6.3	5.9	0.0	0.8	0.0	8.2	0.6	1.2	0.0	0.0
18	3.4	0.0	13.9	0.1	14.9	0.0	1.2	0.0	0.0	2.8
19	0.2	0.0	1.9	0.9	9.8	11.2	2.8	2.1	4.9	0.3
20	0.2	1.2	3.9	0.8	14.0	11.3	3.3	0.4	4.2	0.0
21	0.0	6.5	5.3	5.8	12.6	6.8	2.2	1.2	0.5	0.0
22	0.3	3.5	0.5	9.5	6.7	10.2	1.9	1.4	0.9	0.0
23	0.0	12.9	8.7	1.9	11.9	6.0	2.5	6.8	2.0	0.5
24	0.0	3.4	11.6	2.2	14.7	4.0	2.7	0.0	0.9	4.2
25	2.7	13.3	0.4	6.5	14.5	11.7	7.1	0.0	0.1	1.1
26	0.0	13.1	7.4	2.6	13.0	6.3	8.4	4.9	4.2	1.4
27	5.1	11.7	13.0	8.8	0.0	7.1	0.1	5.0	0.0	2.1
28	2.3	12.0	11.9	13.3	0.0	0.0	2.3	0.0	3.2	0.0
29	6.2	9.8	4.4	11.2	3.0	0.3	6.2	0.5	0.0	0.0
30	7.8	10.9	0.8	15.1	0.1	0.0	5.3	0.5	0.0	0.0
31	9.2		6.2		5.7	0.1		5.6		4.9
total	70.6	196.8	244.7	169.1	232.7	199.5	93.7	76.6	53.2	32.7 h

Daily sunshine hours during January to December 1985 ($h.d^{-1}$)

	Months											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	5.9	0.0	0.0	0.3	12.9	14.9	3.5	0.5	5.6	0.5	1.4	0.0
2	4.7	2.8	0.0	1.9	13.1	14.8	3.7	4.3	0.0	2.5	8.0	0.0
3	5.4	0.2	0.0	4.9	5.4	15.8	0.0	6.3	0.7	3.6	1.5	0.0
4	6.3	0.0	1.1	1.4	0.3	8.9	7.8	1.3	0.0	1.7	0.0	0.0
5	1.0	4.2	6.8	2.3	0.0	0.5	0.0	11.4	9.2	2.7	2.4	0.4
6	4.6	4.8	6.2	1.3	0.6	3.5	3.6	9.2	5.7	9.7	5.7	0.0
7	2.3	0.0	7.6	4.9	10.3	7.9	2.4	2.9	0.0	6.9	4.5	0.0
8	3.2	0.0	1.4	0.6	9.8	2.4	0.0	0.9	0.0	0.5	0.0	0.0
9	3.5	0.0	0.0	0.0	1.8	7.2	2.7	7.1	0.0	3.8	0.1	3.3
10	0.0	2.2	8.4	0.1	0.4	8.1	0.0	8.1	7.2	0.0	5.8	0.0
11	5.5	7.2	8.7	5.1	13.1	0.3	0.0	0.0	0.0	6.7	5.3	1.7
12	0.0	6.3	0.5	0.5	13.9	6.4	0.9	4.7	3.6	0.7	6.3	0.0
13	0.0	2.5	6.8	3.2	4.2	10.9	4.6	1.9	3.9	0.0	0.9	0.9
14	0.0	6.8	7.1	9.3	0.4	13.8	13.2	0.0	4.5	1.8	0.0	0.0
15	3.2	8.4	5.9	0.0	0.0	12.6	4.9	0.4	5.4	0.0	2.8	0.0
16	0.0	8.2	10.2	0.0	5.8	12.8	2.7	0.3	0.0	1.8	1.1	0.0
17	0.0	3.9	9.9	10.1	0.0	0.5	0.9	10.9	8.7	0.0	0.0	0.0
18	0.0	1.0	8.9	10.6	4.8	9.5	2.3	0.0	0.0	8.3	0.0	3.2
19	0.0	1.5	7.8	5.6	0.8	12.3	8.5	3.1	7.9	0.0	0.8	0.0
20	1.3	0.2	4.2	11.1	10.4	13.6	5.5	0.2	0.1	0.0	0.1	0.0
21	0.0	4.1	3.4	10.9	10.8	0.0	8.7	0.2	0.0	3.1	1.3	0.0
22	0.2	1.9	0.1	9.9	0.3	0.8	6.3	4.6	0.0	0.0	0.1	1.6
23	4.6	0.0	0.6	11.9	1.3	0.5	0.6	0.0	0.0	5.9	5.0	2.8
24	0.0	4.4	0.0	4.6	4.3	1.7	0.5	6.1	0.3	2.8	3.4	0.5
25	0.2	2.3	0.0	11.1	2.1	5.2	5.1	1.1	0.0	4.6	2.9	0.0
26	7.1	2.1	8.1	2.1	0.5	1.1	0.0	2.5	5.6	4.7	4.0	3.9
27	0.0	3.8	8.9	12.4	0.6	2.7	3.2	0.0	0.2	0.5	3.8	3.7
28	0.8	7.3	4.1	0.0	11.2	3.9	0.6	3.6	6.6	2.8	0.0	6.0
29	0.2		0.0	0.1	14.4	5.8	1.3	0.1	4.7	6.2	5.3	6.0
30	0.0		0.0	2.7	13.9	2.2	11.4	0.3	0.1	2.1	0.0	0.0
31	2.1		0.4		13.8		2.4	0.4		8.4		0.0
Tot	62.3	87.5	122.2	138.2	184.1	200.7	108.9	88.8	84	88.3	66.8	34

Daily sunshine hours during January to December 1986 ($h.d^{-1}$)

	Months											
Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	10.0	0.0	8.9	7.8	10.3	0.0	12.7	4.3	8.2	0.0	8.4	1.7
2	1.4	0.1	7.8	8.3	8.1	1.6	2.0	0.0	1.8	5.3	0.3	0.0
3	6.5	0.0	1.8	10.9	0.3	8.7	3.5	4.1	12.2	4.1	2.8	0.0
4	0.0	0.0	0.0	10.8	6.8	4.1	2.4	4.3	0.0	6.9	0.0	0.0
5	0.1	4.6	6.8	5.7	0.4	12.3	6.8	3.6	0.0	0.5	2.7	1.0
6	1.3	1.8	5.3	6.9	8.7	14.9	1.3	0.3	6.9	1.9	2.3	4.3
7	0.0	7.2	5.6	6.8	0.0	4.7	5.6	2.3	2.8	0.6	0.0	0.0
8	0.0	0.0	0.1	3.5	1.6	1.1	13.8	13.3	11.6	0.4	2.2	0.0
9	0.0	0.0	4.0	7.9	0.9	5.2	0.1	11.2	8.5	2.6	0.6	1.7
10	3.3	0.3	4.0	7.1	0.7	0.0	1.4	4.5	10.7	8.8	0.5	0.0
11	0.3	0.0	0.0	2.3	6.5	14.7	9.7	13.3	10.4	7.2	1.2	0.3
12	1.2	1.6	2.8	0.0	0.8	0.0	5.4	8.5	8.6	5.3	0.0	0.0
13	0.0	7.5	0.0	3.2	0.1	1.1	0.0	0.2	8.5	4.7	0.0	1.5
14	0.0	0.0	0.0	0.0	0.2	5.2	0.0	10.6	11.3	2.3	0.0	3.1
15	4.4	0.0	0.0	0.0	10.4	14.1	0.9	7.1	9.5	5.5	5.2	1.0
16	0.0	0.0	1.6	0.0	11.6	8.9	0.6	7.9	7.8	2.5	3.0	0.2
17	0.0	2.8	9.7	3.2	0.7	0.6	5.2	6.3	4.0	5.0	2.2	0.0
18	0.0	6.2	5.6	1.3	0.6	5.8	1.6	9.9	7.9	0.2	2.0	0.0
19	1.2	0.3	8.8	0.0	2.3	10.4	0.0	4.6	0.3	3.1	3.6	0.8
20	0.0	2.8	0.9	8.1	4.1	12.4	4.1	6.8	2.2	3.2	3.3	2.4
21	1.5	1.8	1.2	4.4	6.1	14.9	4.4	0.0	0.0	0.8	2.5	3.4
22	0.8	9.3	0.0	0.7	12.4	10.8	4.9	1.9	0.1	0.0	0.0	5.7
23	5.5	7.8	4.6	2.7	5.6	0.7	11.6	12.9	4.1	8.1	1.4	0.1
24	6.7	6.8	5.6	10.8	2.3	0.2	1.7	9.4	4.5	0.0	0.0	0.0
25	5.3	2.5	7.8	5.3	6.9	5.7	1.2	0.4	1.3	0.2	0.0	0.8
26	0.0	7.2	3.7	0.9	6.6	6.1	4.1	3.7	0.0	2.3	0.0	2.0
27	3.5	7.7	4.8	8.7	5.4	8.2	2.3	5.9	0.0	0.0	0.0	0.3
28	0.0	7.5	0.8	5.3	11.5	10.1	0.8	9.8	0.0	1.6	1.7	0.0
29	2.7		4.1	5.4	4.3	11.8	7.9	5.0	3.3	4.1	0.0	0.0
30	0.8		7.6	0.0	0.0	13.3	0.0	10.9	5.2	1.4	0.0	0.0
31	0.0		10.3		0.0		2.3	1.2		2.7		0.0
Tot	46.2	85.8	124.2	138.4	136.4	207.6	118.3	184.2	151.7	89.7	45.9	30

Daily sunshine hours during January to April 1987 ($h.d^{-1}$)

	Months			
Day	Jan	Feb	Mar	Apr
1	0.0	0.0	0.0	0.0
2	5.1	0.0	8.3	1.2
3	0.0	0.1	3.0	0.0
4	1.6	0.2	5.6	0.0
5	0.6	0.0	0.0	0.0
6	6.1	4.4	0.0	0.0
7	5.8	0.0	0.0	2.5
8	0.0	1.7	0.0	0.1
9	0.0	0.0	0.0	0.2
10	0.0	4.3	9.4	3.0
11	5.7	3.9	10.0	8.8
12	3.5	6.2	6.5	8.4
13	2.9	6.3	2.4	4.0
14	0.0	6.5	3.4	0.0
15	0.0	7.2	6.3	0.1
16	0.0	8.9	0.0	9.5
17	0.0	4.3	2.8	11.1
18	0.0	7.9	8.0	0.8
19	0.0	2.4	7.9	1.9
20	0.0	2.6	3.3	7.8
21	0.0	0.0	1.8	0.2
22	0.0	8.4	3.6	1.4
23	0.9	0.0	0.8	0.8
24	0.0	0.0	0.8	7.9
25	0.5	0.0	6.7	11.4
26	3.6	0.0	3.2	8.6
27	0.0	0.9	0.0	8.3
28	5.4	1.6	8.4	10.8
29	0.0		4.7	8.1
30	0.0		1.6	0.7
31	5.6		0.2	
Tot	47.3	77.8	108.7	117.6

Appindix II

Daily mean wind speeds (KN)during March to December 1984

	Months									
Day	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	15	9.4	11.7	4.0	14.5	4.0	9.7	6.1	17.0	7.8
2	33	4.8	5.2	8.3	9.6	15.3	13.7	8.6	6.4	5.5
3	13.2	10.3	5.4	11.2	10.7	16.1	14.0	6.5	13.5	12.5
4	15.7	9.5	8.1	7.1	4.1	5.8	15.5	6.1	10.6	13.6
5	5.8	5.1	6.5	12.3	4.6	9.1	10.5	10.0	4.1	6.4
6	11.6	7.1	10.7	12.2	5.0	10.9	2.7	16.3	12.7	19.3
7	6.1	3.1	7.5	5.2	5.5	10.1	7.3	17.4	14.0	27.8
8	4.1	12.4	6.4	5.4	5.5	3.1	12.8	18.3	13.1	18.7
9	4.6	8.9	11.6	11.6	5.7	6.7	26.0	16.2	11.4	15.8
10	9.7	10.0	12.9	12.4	12.6	4.9	19.8	20.3	11.5	13.5
11	16.3	16.7	7.0	5.3	12.7	4.0	17.3	14.3	20.6	11.7
12	10.8	14.4	5.5	16.8	10.4	5.6	4.7	10.0	12.1	8.5
13	11.2	15.8	6.7	7.7	11.9	3.9	11.0	18.0	12.6	12.7
14	14.0	17.2	8.3	10.7	11.1	4.6	13.3	5.8	12.3	8.2
15	9.1	12.8	7.7	5.0	17.5	8.7	5.9	8.7	5.7	10.6
16	4.9	15.0	7.4	3.6	12.2	5.7	9.0	11.4	7.7	8.9
17	5.3	7.7	6.9	5.7	11.0	4.6	4.9	10.1	5.7	19.0
18	3.3	13.8	10.9	4.8	14.1	6.9	12.7	30.4	7.4	14.7
19	4.3	10.0	8.7	5.0	5.0	2.9	24.9	16.6	6.5	18.4
20	6.9	9.6	5.5	12.0	11.4	6.3	16.0	29.2	5.5	17.8
21	8.5	12.0	4.3	16.5	14.8	13.4	9.0	18.1	9.7	20.5
22	7.7	4.5	11.0	21.2	11.0	12.5	13.1	15.0	18.4	13.6
23	18.0	6.5	6.7	11.3	4.1	15.6	18.3	17.6	20.8	18.8
24	9.7	3.8	13.1	14.0	6.9	15.8	15.4	13.0	27.6	17.5
25	11.3	3.2	10.3	22.5	8.7	11.3	10.7	17.2	21.0	17.3
26	13.3	10.7	6.8	17.0	11.4	7.5	4.3	18.7	18.5	10.3
27	7.0	5.5	6.2	20.5	14.8	6.1	9.3	18.1	29.5	8.1
28	7.6	7.1	7.3	18.0	9.5	15.2	6.0	14.5	24.5	8.1
29	4.9	9.7	8.3	17.6	7.0	14.1	5.0	16.1	21.1	8.3
30	8.9	9.3	5.2	10.9	6.9	18.9	18.5	15.3	20.8	10.2
31	12.4		10.8		13.8	11.4		19.7		24.7

Daily mean wind speeds (KN) during January to December 1985

Day	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	10.8	26.9	14.5	12.5	19.0	3.3	7.6	13.0	21.2	9.9	12.8	18
2	3.5	20.0	10.3	15.7	11.2	4.2	4.8	18.7	8.6	13.3	12.5	12
3	5.0	9.7	12.5	15.5	4.6	7.0	4.0	15.0	7.9	18.1	12.0	24
4	7.3	8.6	16.5	10.7	4.1	12.8	4.7	9.4	4.8	25.5	21.1	11
5	6.0	12.9	11.7	10.3	7.3	9.9	10.3	16.6	18.5	19.4	20.9	11
6	11.0	14.0	17.0	7.0	7.6	7.6	13.9	17.3	13.2	17.2	23.3	6
7	3.0	13.9	7.4	10.7	6.9	9.2	9.8	10.4	7.8	17.2	15.6	11
8	8.0	19.6	15.2	10.9	9.3	9.5	12.9	12.3	8.8	13.6	13.2	12
9	2.3	19.6	14.1	8.3	13.3	11.3	14.1	16.1	8.6	14.6	17.0	5
10	5.0	15.3	15.7	10.1	7.6	11.8	9.7	14.5	6.7	16.0	16.8	8
11	4.0	12.7	8.0	17.4	6.9	11.0	16.8	8.6	5.8	18.7	13.2	13
12	8.5	11.8	16.5	16.6	11.5	16.9	11.9	13.4	11.2	4.7	6.5	17
13	6.5	11.5	16.0	18.7	16.1	12.3	3.9	10.5	16.3	5.3	7.0	11
14	5.8	13.0	19.0	26.5	12.7	11.1	14.2	18.8	23.5	4.1	13.1	14
15	9.8	6.1	17.7	7.8	16.0	9.7	15.9	16.9	22.6	3.9	7.5	15
16	8.8	7.4	15.7	13.7	6.2	7.0	13.4	16.4	16.1	5.5	13.1	19
17	7.3	12.6	8.9	3.8	2.8	8.9	14.6	7.3	18.9	5.3	5.7	11
18	9.2	19.6	12.1	4.7	10.4	6.5	19.7	9.6	9.0	6.4	8.8	16
19	5.5	20.2	14.1	25.4	14.9	3.2	13.0	6.6	16.4	6.6	6.9	21
20	8.5	5.0	13.1	16.1	17.0	6.0	15.7	14.8	14.3	9.5	6.2	22
21	16.3	7.3	13.8	10.4	13.3	12.9	10.8	15.3	15.9	3.1	6.2	20
22	30.5	15.7	14.7	7.6	7.3	10.7	11.5	15.6	15.8	6.9	6.9	16
23	24.5	19.0	8.3	10.7	6.6	4.7	12.6	17.3	9.4	7.5	6.8	19
24	9.7	12.3	2.9	15.8	11.4	10.0	8.5	18.8	6.1	6.4	5.2	10
25	11.6	7.7	5.5	12.1	8.3	10.5	5.9	23.0	4.4	12.8	3.4	13
26	5.3	4.9	5.7	14.7	13.5	15.5	13.8	13.3	5.8	7.2	7.2	11
27	11.5	4.3	15.4	18.5	13.8	18.0	13.0	20.7	2.5	5.9	16.0	7
28	7.1	14.6	13.4	8.5	14.0	15.9	9.7	11.9	7.2	10.5	5.2	5
29	11.6		13.7	2.7	7.5	8.8	10.0	7.3	6.2	2.5	9.5	4
30	21.7		13.2	14.3	3.3	3.7	6.3	12.3	12.6	7.1	13.6	12
31	24.1		10.4		3.4	11.4		19.7		24.7		8

Daily mean wind speeds (KN) during January to December 1986

Day	Months											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	7.8	12.1	7.6	5.9	14.9	8.0	6.3	9.2	14.4	16.0	9.3	20
2	13.7	12.0	2.7	6.1	10.4	7.9	5.5	21.2	16.4	12.5	13.6	18
3	6.4	11.7	16.3	6.5	12.4	16.8	8.7	6.0	14.6	5.5	15.2	23
4	8.0	9.0	20.1	4.7	12.2	16.4	9.8	4.0	14.7	6.7	15.7	15
5	8.4	9.7	19.3	5.3	10.5	13.3	10.4	7.2	16.6	12.0	23.8	24
6	6.5	9.6	17.9	10.6	10.7	3.3	14.2	12.6	14.1	11.8	19.3	18
7	13.1	7.5	12.2	16.7	11.6	14.7	14.2	19.6	17.7	11.6	18.5	19
8	9.3	4.3	20.9	12.0	9.7	13.1	14.4	15.7	7.4	8.7	22.1	14
9	15.9	5.1	10.6	10.3	7.3	16.7	10.1	3.8	10.5	12.5	27.6	16
10	29.7	15.8	4.6	8.3	18.3	13.7	11.0	8.7	6.9	13.4	23.7	19
11	28.7	10.5	10.4	13.2	15.1	8.7	5.3	9.5	5.1	13.3	11.9	17
12	28.6	9.0	15.2	7.7	6.7	11.6	7.6	4.6	4.8	15.3	17.0	22
13	26.0	15.7	10.9	6.9	19.1	5.7	2.5	9.5	4.5	9.4	16.7	15
14	34.5	13.0	15.3	14.7	11.7	5.1	8.5	9.8	11.9	11.0	13.5	12
15	16.7	12.0	19.8	22.3	15.6	6.2	4.0	13.5	7.6	11.5	16.6	18
16	8.2	11.5	13.3	13.8	5.8	9.7	16.1	21.0	8.9	9.4	22.6	19
17	10.3	13.7	11.1	8.3	14.5	18.3	19.3	15.5	6.5	16.5	18.2	20
18	14.0	6.0	10.4	6.0	15.5	11.1	8.2	12.0	6.7	19.0	16.7	19
19	14.3	3.0	8.3	10.3	5.3	11.8	10.3	8.8	11.5	17.7	9.3	21
20	22.6	6.1	29.1	11.7	9.1	14.4	11.1	5.5	13.0	19.0	11.6	23
21	15.7	7.9	16.6	11.2	17.9	15.1	11.1	7.1	13.5	16.8	10.0	19
22	22.0	4.5	21.3	8.3	17.0	14.6	15.0	11.7	11.6	18.3	32.3	9
23	27.9	7.5	19.9	6.3	16.3	4.2	15.7	4.7	8.7	19.0	24.3	10
24	19.6	2.7	15.0	8.7	12.9	5.9	7.6	3.7	6.0	29.8	18.5	18
25	11.3	6.7	15.7	7.1	13.5	10.0	10.0	15.1	4.7	29.1	20.2	12
26	10.0	9.1	12.3	10.0	14.5	7.3	10.2	17.5	5.7	16.5	19.1	20
27	16.5	10.7	16.0	10.7	19.9	12.0	12.4	13.8	10.0	16.7	20.1	27
28	13.0	10.1	11.1	13.3	11.0	8.2	5.0	15.9	16.8	11.4	19.7	24
29	4.8		13.6	15.6	11.9	10.7	16.0	13.7	10.9	23.3	10.0	14
30	15.7		9.3	18.9	13.3	14.1	9.7	10.0	9.3	30.7	18.3	14
31	13.1		4.7		11.9		14.4	10.2		13.6		12

Daily mean wind speeds (KN) during January to April 1987

	Months			
Day	Jan	Feb	Mar	Apr
1	14.3	9.7	11.3	8.5
2	11.5	8.6	19.6	4.0
3	9.9	11.0	11.8	14.7
4	23.6	16.3	10.6	23.5
5	28.7	20.7	13.6	16.7
6	19.1	26.5	12.9	15.6
7	4.2	10.6	15.3	15.1
8	8.1	10.0	9.8	8.6
9	11.5	11.5	12.7	12.8
10	10.2	18.6	11.2	15.4
11	8.0	7.2	10.8	18.4
12	12.5	3.4	6.0	7.5
13	13.6	8.8	6.1	13.7
14	13.5	3.8	16.2	8.0
15	8.0	2.9	18.5	9.0
16	10.7	7.9	13.3	6.5
17	13.6	6.9	22.5	5.0
18	10.3	5.3	18.7	10.1
19	12.5	6.4	18.3	15.2
20	10.8	5.3	10.3	16.6
21	10.6	3.2	8.6	8.6
22	6.1	7.3	11.7	5.8
23	1.3	6.7	7.1	4.7
24	2.3	6.7	13.1	6.7
25	12.5	9.7	15.7	9.8
26	4.9	11.6	16.2	4.4
27	3.0	9.2	22.3	5.6
28	2.8	8.9	27.4	3.5
29	3.3		17.3	8.0
30	5.3		12.5	11.6
31	5.7		17.5	