THE NATURAL HISTORY OF SLAPTON LEY NATURE RESERVE

2. PRELIMINARY STUDIES ON THE FRESHWATER ALGAE

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CONTENTS

I. INTRODUCTION

SLAPTON LEY is a shallow body of fresh water separated from the sea by a low shingle ridge which runs almost north–south along the shore of Start Bay in south Devon. Its setting and physiographic history have been described in the first paper of the series (Mercer, 1966).

The Ley is divided by Slapton Bridge into two unequal parts, respectively Higher and Lower Leys. The Higher Ley is now largely silted up, and an almost continuous reed swamp has developed, with a few islands of willow carr. The Lower Ley is still open, with reeds in the deep bays of the inner shore, and as a continuous fringe on the seaward side. The main inflow is the River Gara, which enters the Ley at its extreme northern end. It follows a fairly well defined channel through the Higher Ley reed bed, and a main current can be detected through the Lower Ley, which has a marked effect on the distribution of phytoplankton populations. The deeper parts of the Ley bed follow the line of this current. A less important stream enters the Lower Ley in Ireland Bay, and there are several small water channels entering the lake elsewhere.

The Lower Ley is approximately half a mile wide at its widest point, and nearly a mile and a half long, with a maximum depth in summer of 2·8–3·1 metres. The depth varies considerably with rainfall and this affects the state of the effluent through the culvert at the southern extremity. This culvert is easily blocked at its seaward end by the shingle, should onshore winds persist, and is cleared only if road flooding is imminent or has occurred. The lip of the culvert is 1·0 m. below the nearest road level. In 1962 the Ley rose about 1·3 m. between June and December.

II. AIMS AND METHODS

(1) *Sampling stations*

Twenty-one sampling stations were chosen; fourteen of these were in the Lower Ley, six in the Higher Ley and one on the Gara River at Gara Mill (see section III). Of these, eight main stations on the Lower Ley were sampled at approximately monthly intervals for a period of twelve months beginning in June 1962. Further seasonal surveys were carried out during 1963 and 1964, to check the nutrients and the seasonal periodicity of the algae. The other stations were visited sporadically.

(2) *Weather records*

Rainfall, wind, air temperature and other weather records were provided by Slapton Ley Field Centre, from daily readings at their own station.

(3) *Collection of plankton samples*

Samples were collected from the surface, bottom and occasionally at one metre depth, using a Casella sampling bottle with a siphon system. The contents of the inner glass bottle were concentrated by filtering through netting of 180 meshes/inch and then washing the concentrated plankton into a known volume of distilled water in a 2 inch by 1 inch tube, fitted with a polythene cap. Counts were made of these organisms. General collections using hand and tow nets were made at intervals as a check on total species present.

(4) *Collection of epiliths and epiphytes*

Stones were collected and rocks scraped or brushed for epiliths. Normally a known area was washed off into a known volume of water, e.g. a 2 inch by 1 inch tube. As Lund and Talling (1957) mention in their review, attached algae are notoriously difficult to sample. For qualitative purposes most may be transported in a damp container such as a plastic bag, or well stoppered bottle containing as little water as possible. The latter may also be used for quantitative work since such cells as are removed during transportation can easily be washed out of a bottle and recovered in a known volume of water.

Macroscopic algae and bryophytes were collected for identification, transported in bottles with a limited amount of water present, and then a known wet weight of alga or bryophyte was shaken up in a known volume of distilled water so that the epiphytic algae growing on them could be washed off and counts made of them. Leaves and stems of the macrophytic vegetation were also collected, transported in the same way, scraped and examined for epiphytes. (Some useful notes on the collection and maintenance of samples are given by Lund (1961).)

(5) *Collection of substrate material*

Mud and gravel were collected in screwcap polythene bottles, and a known weight of the substrate material was shaken in each case with a standard volume of distilled water, and counts were made of the organisms present.

The above methods are sufficiently accurate to allow comparison between different sampling stations.

(6) *Estimations of abundance of algae*

Various methods of estimating the abundance of algae are given by Lund and Talling (1957), Lund, Kipling and LeCren (1958) and Welch (1948). The following method has been adopted by the authors.

All samples were examined as soon as possible on return to the laboratory, but to prevent decay and alteration of the population a few drops of iodine in potassium iodide were added as a preservative.

When making a quantitative analysis of an area, information about the following is required:

(i) The best method of obtaining a fairly standard sample. (See section IIc.)
(ii) The minimum amount of work necessary to ensure a reasonable chance of noting the presence of all the species in the sample.
(iii) The minimum amount of work necessary to give an accurate estimate of the relative numerical importance of the species.
(iv) The significance to be placed on the terms abundant, frequent, occasional and rare.

In order to ascertain (ii) and (iii) above, the Species:Area curve concept of ecology (Jaccard, 1902) was adopted. Curves were constructed by scoring the number of species found, against the number of squares looked at in a Sedgewick-Rafter type of counting cell. This Rafter cell holds one ml. of sample and is divided into one thousand squares by lines etched in its base. In discussing the Species:Area curve, Goodall (1952) pointed out that three methods of obtaining such curves are in use and that, of these, the only satisfactory method is where separate samples each randomly placed are examined for each area to be plotted. Data was accordingly obtained in this manner.

Four stations were selected for this study. The curves obtained showed that there was a rapid rise in the first part of the curves which levelled out in the area corresponding to the first thirty squares examined. In all cases it was noted that if only thirty squares are counted, at worst 85 per cent of the total species will be seen, and at best, all of them. As it is suspected that a certain amount of heterogeneity in the distribution of the species in the Rafter cell occurs, counts were made by selecting squares at random (using random tables).

Individual cells were normally counted, but colonies consisting of numerous small cells were also counted as a unit, e.g. *Microcystis*, *Volvox*, etc. Coenobial algae were counted as one organism, as were also single cells of these species, being considered as potential colonies. The following definitions can then be applied:

Abundant—more than 1,000 individual cells per ml.

Locally Abundant—more than 1,000 individual cells per ml. but applying to localized intense growths.

Frequent—between 400 and 1,000 individual cells per ml.

Occasional—between 80 and 400 individual cells per ml.

Rare—less than 80 individual cells per ml.

(7) *Physical and chemical factors*

(i) *Light*. Readings of the intensity of the incident light were taken at the surface using an E.E.L. light meter with a selenium cell. At greater depths readings were taken using an underwater light meter. The spectral sensitivity of these light meters is given in Table 1. This table shows that maximum sensitivity occurs within the range where greatest photosynthesis may be expected *viz.* 400–700 mμ. One lux as measured by this meter is very approximately equivalent to 1·5 ergs/cm²/sec. and measurement can be carried out down to depths associated with approximately 1 per cent of the surface intensity.

Table 1. *Relative spectral response values for E.E.L. photocells* based on equal energy spectrum

Wavelength (Millicrons)	Relative Response %	Wavelength (Millicrons)	Relative Response %	Wavelength (Millicrons)	Relative Response %
240	1·0	420	66·2	600	92·2
260	7·0	440	72·0	620	72·5
280	14·0	460	77·7	640	46·0
300	21·5	480	82·0	660	27·0
320	29·5	500	87·2	680	12·0
340	37·7	520	93·5	700	4·2
360	45·0	540	98·7	720	2·0
380	53·0	560	100·0	740	1·0
400	60·0	580	99·7		

(ii) *Temperature.* Readings were taken at the surface, one metre depth and at the bottom using a Sifam thermister and galvanometer (°C).

(iii) *Water samples* for chemical analysis and for oxygen were collected in a Casella sampler.

(iv) *Rate of flow.* The rate of flow of surface currents was either estimated by timing a small float over a known distance and taking the average of several readings, or measured with a Flowmeter. In the Gara River a conversion figure given by Welch (1948) could convert such readings into a figure applying to the whole stream. Deeper currents, indicating the flow of the river water through the Ley, were measured using the Flowmeter.

(v) *pH* was recorded using an E.I.L. pH meter.

(vi) *Water analyses* were carried out according to the methods of Mackereth (1963), British Drug Houses (1963) and Taylor (1949).

III. STATIONS

1.* Slapton Mile Post (inland).
2.* Mid Ireland Bay.
3.* Hartshorn Plantation.
4.* West shore of the Ley.
5. West shore of the Ley midway between 4 and 6.
6. Stokeley Bay.
7. Inland mile post at Torcross.
8.* Culvert at Torcross.
9. By the Torcross mile Post—east shore.
10. Midlake Torcross end.
11. Midlake opposite Stokeley Bay.
12. East shore opposite boathouse.
13.* Opposite station 4 east shore.
14.* East shore opposite Ireland Bay.
15.* Pool near the bridge.
16. Below birdwatchers' hut, Higher Ley.
17. Higher Ley.
18. Higher Ley.
19. Higher Ley.
20. Higher Ley.
21. River Gara at Gara Mill.

* Stations sampled at approximately monthly intervals.

For map showing the position of these stations see Fig. 1.

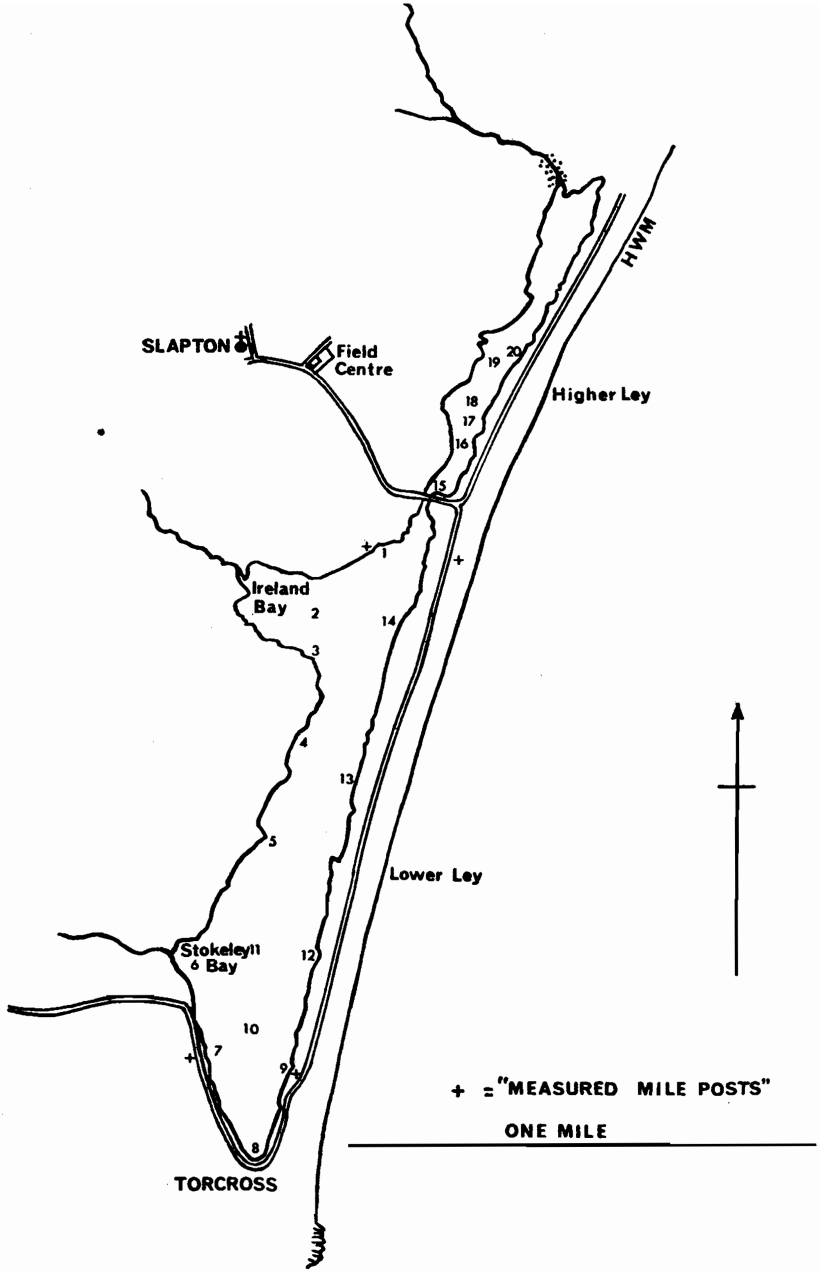

FIG. 1.
A map of Slapton Ley showing the position of the sampling stations.

IV. PHYSICAL AND CHEMICAL DATA

(1) *Temperature*

The temperature of the surface waters in the Ley varied between 23° C in July and 2·3° C in December. In quiet summer periods there was some evidence of a decrease in temperature with depth, the maximum bottom temperature being about 1·5° C lower on an average than the maximum surface temperatures at the same station. During winter, the minimum bottom temperatures were frequently 0·5° C higher than the minimum temperatures recorded at the surface, probably due to the cooling of surface waters by wind action. There has been no evidence of the formation of a thermocline during the period of observations; the Ley is apparently sufficiently shallow to be fairly uniform throughout. The water from the Gara river is generally a little colder than that of the open Ley, and the water temperatures of the east side of the Ley are consequently 0·5–1·0° C lower than in the middle of the lake and the west side. Temperature readings taken at station 9 at the Torcross end were generally higher than at other stations, and this is probably due to its protected position in the reeds.

In the Higher Ley temperature varied very slightly with depth, it being about 1·0° C lower in areas over 1·5 metres deep.

(2) *Rainfall, flow and turbidity*

Rainfall records were provided by the weather station at Slapton Ley Field Centre situated on the landward side, northwest of the Lower Ley and 31·7 m. above sea level. Average weekly rainfall varied between 0 and 1 inch, the highest precipitation being in the months of March, April and August.

The rate of flow was most conspicuous in the eastern half of the Ley where depth soundings revealed a deeper channel where the Gara river flows through the Ley, and flow readings indicated water movements at depth as well as at the surface. Speed of flow in this area varied from 1·2 cms/sec. to 0·22 cms/sec. Surface movements, due to wind, varied from 1·12 cms/sec. to 0·2 cms/sec. and would contribute little to movement of plankton. In the Gara river flow varied, on the same day, from 106·6 cms/sec. at the surface to 139·1 cms/sec. at the bottom in a depth of 0·5 m. This slowed to 61·0 cms/sec. at the surface in the Higher Ley channel on the north side of the road bridge, and 68·6 cms/sec. at the bottom (0·6 m.). As the channel widens on entering the Lower Ley speeds are considerably reduced, ranging from 18·2 cms/sec. at the surface to 27·4 cms/sec. at the bottom (0·8 m.).

Light penetration, rainfall and flow showed a close correlation. Readings for light penetration varied from a few centimetres in rainy periods, when organisms, debris and colloidal organic matter were washed in from the Higher Ley and the drainage streams in Ireland Bay, to a maximum figure of 1·5 m. in dry sunny periods. Changes in turbidity and cloud also affected the quality of light penetrating to these depths.

(3) *Light*

Measurements of the incident light striking the surface of the water varied from 74,240 lux in full sunlight in June to 1,290 lux in December. Considerable loss of light occurred with increasing depth at both seasons. For example, at a depth of 0·6 m. in June in clear water at midday full sunlight penetrated, but at 2·9 m. this was reduced to 9,685 lux on the same day, whereas in December, using the same meter, no reading could be obtained at a depth of 0·9 m.

(4) *Oxygen and biochemical oxygen demand*

Oxygen concentration has varied from 2 mg/l. to 12 mg/l. there being a greater deficiency near the shore than in the open water.

Biochemical oxygen demand (B.O.D.) ranged from 0·1 mg/l. to 5·0 mg/l., the higher figures, obtained on the west shore of the Ley near the Hartshorn plantation, indicating water verging on "doubtful purity" according to the classification of the Royal Commission on Sewage Disposal (1912), in Hynes (1960).

(5) *pH*

The average figure for the Lower Ley is 8·2, but seasonal variations occur. The lowest pH recorded was 6·8 in November and the highest, 9·0, in periods of hot weather during spring and summer when the carbon dioxide and bicarbonate figures were at their lowest.

The River Gara usually has a pH below 8·0 and so influences the Higher Ley. The heavy growths of higher aquatics in this area also have an effect on carbon dioxide concentration and pH of the water. The influence of this water draining into the Lower Ley, especially after periods of heavy rain, can be measured in the narrow channel near the bridge, where lower pH values have always been recorded than in the rest of the lake. High rainfall, of course, lowers the pH value throughout the whole of the system.

(6) *Hardness*

Readings vary for total hardness from 76 mg/l. to 125 mg/l. the former being recorded in the narrow channel, by the bridge, in November during exceptionally heavy rain, and the latter in March, in open water. An average reading for the whole lake is 100 mg/l. This places the Ley in the category of moderately soft to slightly hard according to the classification in Thresh, Beale and Suckling (1904) p. 14. Unusually high readings of about 150 mg/l. have been recorded at station 3 by the Hartshorn plantation after heavy autumn rain, when drainage water from freshly limed fields enters the Ley. Hardness is due in the main to calcium rather than magnesium salts.

(7) *Nitrogen*

(i) *Nitrate nitrogen*

Concentrations varied between 0·02 mg/l. and 2·5 mg/l., the higher figure being recorded in March after heavy rain.

(ii) *Ammonia*

The highest figure recorded for ammonia was 0·32 mg/l. in June when breakdown of organic matter occurred in hot weather. The average figure was much lower, being well below figures quoted as indicating excess pollution.

(8) *Chlorides*

Concentrations varied from 29·2 mg/l. to 5,200 mg/l., the higher figure being recorded at the Torcross end of the Ley (station 12) after driving spray from the sea.

(9) *Phosphate Phosphorus*

Little variation in concentration of phosphate occurred in the Lower Ley. The maximum value recorded was 0·08 mg/l., in August, but higher values of up to 0·4 mg/l. were obtained from the Higher Ley. This was probably due to decay of debris from the angiosperm vegetation, since the phosphate figure for the inflow of the River Gara tended to be much lower (never exceeding 0·06 mg/l.).

(10) *Silica*

The average concentration was about 5·0 mg/l. with extreme values of 1·0 mg/l. and 8·0 mg/l. The lowest figures were recorded in April and August and corresponded in 1963 with the diatom maxima. A similar correlation was found to exist in other years but the maxima occurred in different months according to the weather.

V. BENTHIC ALGAE

Round (1956) defines the term "benthos" as enveloping all lake communities other than the plankton. Within the benthos at least four algal communities occur, the epiphytic (on macrophytic vegetation), epilithic (on stone and rock surfaces), epipelic (on the sediments) and the epizooic (on animals). Swale (1964) agrees with this definition, as applied to rivers, and both stress that the plankton will contain numerous species having their origin in the benthos.

The epilithic community at Slapton is present mainly in the Gara river and to a less extent on the few stones, pebbles, etc. found round the margin of the Ley, and under the road bridge. An epipelic community has developed in the silted areas of the river and the shallow marginal regions of the Ley. There is considerable macrophytic vegetation round the shore of the Lower Ley providing a substrate on which epiphytic algae develop. Dominating this situation is *Phragmites communis* which has successfully colonized the north end near Slapton Bridge, Ireland Bay, Stokeley Bay, the south end of the Ley and much of the east bank. The other species occurring in association with *Phragmites* include *Sparganium erectum*, *Phalaris arundinacea*, *Typha angustifolia*, *Schoenoplectus lacustris* and *Schoenoplectus tabernaemontani*. Areas of *Nymphaea alba* are to be found in the extreme north and south of the Lower Ley, Stokeley Bay and Ireland Bay, and beds of *Polygonum amphibium* lie off the west shore. Other aquatic species include *Elodea canadensis*, *Myriophyllum spicatum* and *Potamogeton crispus*.

The Higher Ley is a reed-swamp dominated by *Phragmites communis*. Other plants which are generally distributed include *Iris pseudacorus*, *Oenanthe crocata* and *Phalaris arundinacea*. (Nomenclature according to Clapham, Tutin and Warburg, 1962.)

The river Gara did not support any large growths of aquatic angiosperms at the sampling station, probably due to the high rate of flow. Aquatic mosses were present on some of the stones, the dominant being *Eurhynchium riparioides* which supported quite a good growth of epiphytic algae.

Round (*loc. cit.*) has indicated that many casual species, which are really soil or planktonic forms, are frequently caught up in the algal web of epiphytic and epilithic forms. Table 2 lists the benthic species recorded in samples collected in April and November, and indicates which are the true attached forms.

VI. Phytoplankton

A graph of the mean of cell counts per ml. of the plankton samples collected from January to December for the three years of the survey is given in Fig. 2. It shows a periodicity of growth with peaks in spring and autumn, the latter being the period of maximum development. Since only single monthly collections were taken, this growth curve does not show any irregular fluctuations caused by quickly changing conditions in the environment, such as rainfall, sunlight, turbidity or browsing by animals, and it should be noted that the significance given to any one point could easily be overestimated. Nevertheless, the general curve indicates that minimum growth occurs between December and February, with a rise in March. This early phase in the growth cycle is dominated by the diatoms, particularly the genera *Asterionella*, *Melosira*, *Tabellaria* and *Fragilaria* (see Table 3).

From May to August the Bacillariophyceae decline, and first the Chlorophyceae and then the Myxophyceae reach dominance. *Oedogonium*, *Volvox*, *Pediastrum* and *Pandorina* were dominant in May, but the desmid *Staurastrum anatinum* gave rise to a peak of growth in July that appeared to be associated with higher water temperatures and greater light intensities. Pearsall (1932) concluded that the main feature in the periodicity of the Chlorophyceae was the fluctuation in the proportion of colonial Chlorophyceae and desmids. The former are most abundant in early summer (see Table 3) when the nutrient level is slightly higher, and this is true of the Ley. He placed the desmid maximum at September for the Lake District, but this latter may be correlated with the geographical situation and greater size and depth of those lakes. In the Ley the Myxophyceae reached a peak in August usually with a waterbloom of *Anabaena flos-aquae*, *Microcystis aeruginosa*, and *Gloeotrichia echinulata*. Pearsall also concluded that the Myxophyceae occur in water having a low calcium content and a high organic content. Marshall (1930) states that such blooms are formed only after a period of strong winds which stir up the lake bottom thus releasing more nutrients into the water, and such wind action has been observed repeatedly prior to algal blooms in the Ley. Pickup (1963) has proved experimentally that when both *Microcystis* and *Gloeotrichia* are growing in competition, *Microcystis* becomes dominant. This may be due to liberated materials from the cells of the *Microcystis*, which are said to be toxic to other algae.

By September the population was again formed mainly of diatoms and the largest number of species and cell counts were recorded at the peak of growth in November (see Fig. 2 and Table 3). Lund (1950, 1954 and 1955b) found that the increase of *Asterionella formosa* in many lakes of the English Lake District ceases when the concentration of silica falls below 0·5 mg/l., but experiments by Hughes and Lund (1962) showed that the addition of small amounts of phosphate permits the growth of so large a crop that all the silica is utilized. Temperature, light intensity and duration affected this relationship between phosphate and silica. In the Ley, silica was always present in amounts greater

Table 2A and B. *The distribution of the benthic population in relation to higher aquatics, stones and sediments.* Attached forms are indicated by ° beside the name.

A

PHRAGMITES COMMUNIS	IRIS PSEUDACORUS	MENTHA AQUATICA	EURHYNCHIUM RIPARIOIDES
°Coleochaete sp.	°Scenedesmus quadricauda	°Vaucheria sp.	°Protococcus viridis
°Cladophora glomerata	°Stigeoclonium tenue	°Oedogonium sp.	°Chlorococcum humicolum
°Ulothrix subtilissima	°Draparnaldia plumosa	°Ulothrix tenuissima	°Ulothrix tenuissima
°Stigeoclonium tenue	°Chantransia pygmaea	°Ulothrix moniliformis	°Stigeoclonium tenue
°Scenedesmus quadricauda	°Gomphonema olivaceum	°Hormidium flaccidum	°Cladophora glomerata
°Nostoc sp.	°Synedra pulchella	°Chantransia pygmaea	°Chantransia pygmaea
°Chroococcus giganteus	°Licmophora ehrenbergii	°Ophiocytium cochleare	°Cocconeis placentula
°Chantransia pygmaea		°Chroococcus giganteus	°Fragilaria capucina
°Tabellaria fenestrata		°Tabellaria flocculosa	°Gomphonema parvulum
°Fragilaria capucina	Pediastrum boryanum	°Fragilaria capucina	°Cymbella ventricosa
°Cocconeis placentula	Cosmarium reniforme	°Cymbella ventricosa	
°Gomphonema olivaceum	Microcystis aeruginosa	°C. cymbiformis	
°Epithemia turgida	Anabaena flos-aquae	°Gomphonema olivaceum	Oscillatoria limosa
°E. zebra	Navicula minima	°G. parvulum	Navicula minima
	N. pupula	°G. constrictum	N. exigua
	Melosira arenaria	°G. acuminatum	N. gracilis
Closterium pritchardianum	Neidium iridis	°G. geminatum	N. cryptocephala
Euastrum oblongum		°Cocconeis placentula	N. viridula
Cosmarium reniforme		°Epithemia turgida	N. vulpina
Chlorella vulgaris		°Achnanthes hungarica	Frustulia rhomboides
Rhabdoderma lineare		°Synedra pulchella	Ceratoneis arcus
Microcystis aeruginosa		°S. acus	Pinnularia viridis
Oscillatoria limosa		°S. ulna	Melosira varians
O. brevis		°Eunotia exigua	M. arenaria
O. tenuis			Surirella ovalis
Rhoicosphenia curvata			Gyrosigma acuminatum
Diatoma vulgare		Chlorella vulgaris	Rhoicosphenia curvata
Navicula exigua		Anabaena flos-aquae	
N. gracilis		Dactylococcopsis raphidioides	
N. pupula		Coscinodiscus bathyamphalus	
N. cryptocephala		Navicula gracilis	
Frustulia rhomboides		N. pupula	
Amphora delicatissima		N. cryptocephala	
Melosira arenaria		N. scutum	
		Frustulia rhomboides	
		Rhoicosphenia curvata	
		Amphora ovalis	
		Melosira arenaria	
		M. varians	
		Anomoeneis sphaerophora	
		Gyrosigma attenuatum	
		Stauroneis phoenicenteron	
		Pinnularia viridis	
		Surirella ovalis	

7B

B

Epiphytic

MYRIOPHYLLUM SPICATUM

°Scenedesmus quadricauda
°Chroococcus giganteus
°Rivularia minutula
°Tabellaria fenestrata
°Fragilaria capucina
°Synedra ulna
°S. ulna var. splendida
°Eunotia gracilis
°E. pectinalis
°Cocconeis placentula
°Cymbella lanceolata
°Gomphonema parvulum
°G. constrictum
°G. acuminatum

Gloeothece confluens
Nostoc sp.
Anabaena flos-aquae
Amphora ovalis
Nitzschia linearis

POLYGONUM AMPHIBIUM

°Oedogonium macrosporum
°Spirogyra nitida
°Zygnema insigne
°Cocconeis placentula
°Achnanthes lanceolata
°A. hauckiania
°A. minutissima
var. cryptocephala

NYMPHAEA ALBA

°Draparnaldia plumosa

Cosmarium reniforme

CERATOPHYLLUM SUBMERSUM

°Scenedesmus quadricauda
°Draparnaldia plumosa
°Chroococcopsis gigantea
°Cocconeis placentula
°Gomphonema parvulum
°Fragilaria capucina

Cosmarium reniforme
Oscillatoria limosa
Navicula exigua
N. gracilis
N. cryptocephala

Epilithic

°Oedogonium sp.
°Cladophora glomerata
°Ulothrix zonata
°U. tenuissima
°Stigeoclonium tenue
°Protococcus viridis
°Gloeocapsa magma
°Stigonema hormoides
°Nostoc sp.
°Rivularia minutula
°Lemanea mamillosa
°Chantransia pygmaea
°Hildenbrandia rivularis
°Meridion circulare
°Cocconeis placentula
°Cymbella turgida
°C. lacustris
°C. affinis
°C. ventricosa
°C. lanceolata
°Rhopalodia gibba
°Gomphonema parvulum
°G. constrictum
°G. intricatum
°G. geminatum
°G. olivaceum
°Epithemia argus
°E. turgida
°Synedra pulchella
°Achnanthes hungarica

Gleothece confluens
Dactylococcopsis raphidioides
Aphanocapsa grevillei
Lyngbya sp.
Phormidium tenue
Melosira arenaria
M. varians
Nitzschia linearis
Navicula exigua
N. viridula
N. cryptocephala
Amphora ovalis

Epipelic

°Chlorococcum humicolum
°Scenedesmus quadricauda
var. maxima
°Ulothrix zonata
°U. moniliformis
°Spirogyra nitida
°Meridion circulare

Pediastrum boryanum
Chlorella vulgaris
Scenedesmus bijugatus
Microcystis aeruginosa
Anabaena flos-aquae
Oscillatoria limosa
Gyrosigma attenuatum
Navicula cryptocephala
Amphora ovalis
Nitzschia linearis
Cymatopleura elliptica

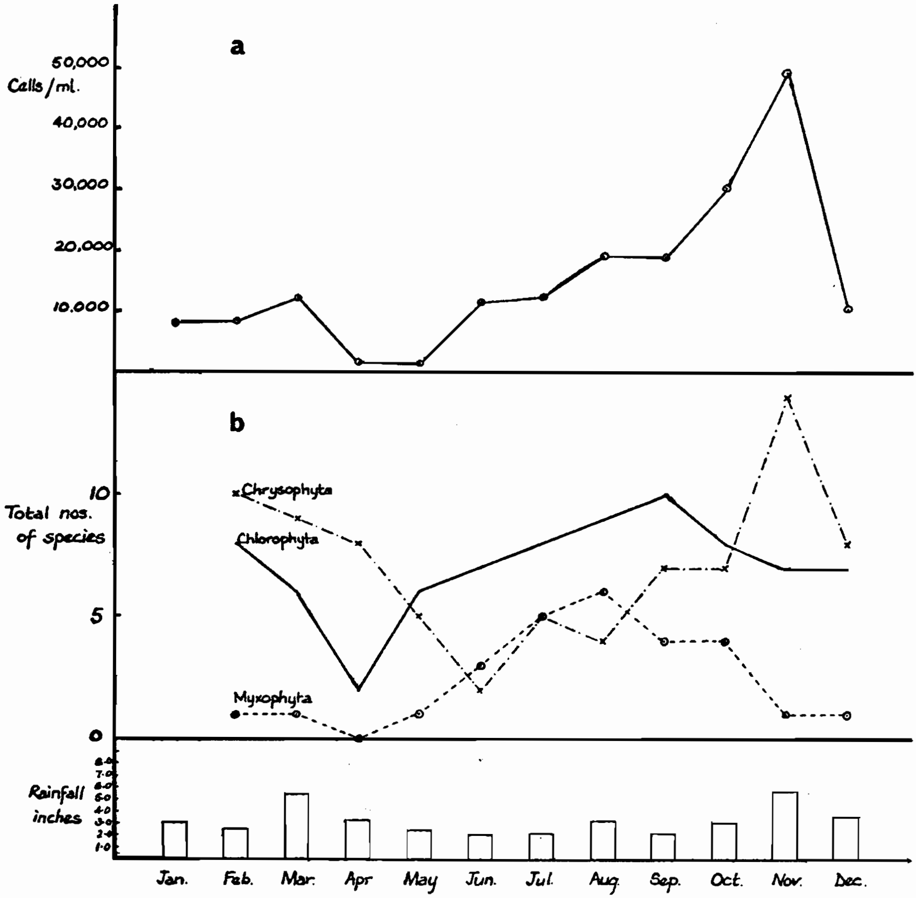

FIG. 2.

(a) The seasonal cell counts of phytoplankton in Slapton Ley. The numbers represent the monthly mean for the three years of the survey.

(b) The seasonal counts of species for each of the main algal classes represented in the phytoplankton.

than 1·0 mg/l. and so should not have been a limiting factor. Pearsall suggested that in addition to obvious dominants at certain seasons, there is also another group of algae that are conspicuous because of their presence more or less continuously throughout the year. These he termed "constants". This group is represented in the Ley by *Navicula spp.*, *Scenedesmus spp.*, *Pediastrum spp.* and *Chlorococcum*. Appendix II gives some indication of the period of months over which various algae form living units of the lake population.

Table 3. *The dominant species of the phytoplankton for each month of the year.*

January	February	March	April
Asterionella formosa	Melosira arenaria Tabellaria fenestrata Fragilaria capucina	Melosira varians Tabellaria fenestrata Fragilaria capucina	Tabellaria fenestrata Fragilaria capucina
May	**June**	**July**	**August**
Oedogonium sp. Volvox aureus Pediastrum boryanum Pandorina morum	Staurastrum anatinum Pandorina morum Pediastrum boryanum Anabaena flos-aquae	Staurastrum anatinum Chlorococcum humicolum	Microcystis aeruginosa Anabaena flos-aquae Gloeotrichia echinulata Asterionella formosa
September	**October**	**November**	**December**
Gloeotrichia echinulata Anabaena flos-aquae Tabellaria fenestrata Asterionella formosa	Tabellaria fenestrata Asterionella formosa	Tabellaria fenestrata Asterionella formosa	Asterionella formosa

According to Hutchinson (1957), the energy which distributes heat in a lake is derived chiefly from the wind and is certainly sufficient to cause a fairly even distribution of heat in Slapton Ley, where the mean maximum depth is approximately 2·8 m. Thus the incidence of thermal stratification is very infrequent, circulation being continuous except on the few occasions (e.g. January, 1963) when freezing of the surface water occurs. According to the classification developed by Forel and modified by Whipple, Welch (1935) and Hutchinson (1957, p. 157), the Ley may be included in Order 3 of the temperate lakes. Such regular circulation of the water mass tends to distribute the plankton evenly within the turbulent area. As Einsele and Grimm (1938) point out, however, variations of water movements with time, and especially where a river flows through a lake (as in the Ley), can give rise to alternating layers of stronger and weaker turbulence. This can lead to temporary differences in population density, as well as to a certain amount of sorting according to specific gravity. Forms with excess weight (e.g. many diatoms), therefore, sink out of weakly turbulent layers into strongly turbulent zones having a greater supporting ability, and there they accumulate. According to Fogg (1965), nonmotile phytoplankters usually show a decided decrease in numbers just below the water surface, as the surface film acts as a brake on the eddy diffusion currents. Only those nonmotile algae with a specific gravity less than that of the water, e.g. blue-green algae with "gas vacuoles", can aggregate at the surface in large numbers during calm weather and give rise to water blooms. Evidence for such layering and "blooms" in the Ley are exemplified in Table 4. Diurnal vertical movements of many flagellates occur and have been observed for *Volvox* in the Ley. There may be considerable differences in horizontal

Table 4. *Vertical stratification of phytoplankton in Slapton Ley during calm weather in summer, and the influence of the colder water of the Gara river near the East shore.*

Species are recorded as the number of cells per ml.

Species	East Shore			West Shore		
	Surface	1 metre depth	Bottom	Surface	1 metre depth	Bottom
Pediastrum boryanum	165	221	1089	870	150	1080
Pandorina morum	231	198	0	1170	390	360
Staurastrum anatinum	4488	1584	8547	11310	1170	1290
Sphaerocystis schroeteri	363	264	429	561	0	330
Scenedesmus quadricauda var. maximus	396	198	1980	366	429	64
Navicula perpusilla	0	99	726	9045	0	0
Navicula viridis	957	959	3399	720	51	87
Frustulia rhomboides	231	363	1188	99	410	165
Tabellaria fenestrata	891	726	2178	7623	1584	429
Synedra pulchella	66	68	101	67	33	0
Microcystis aeruginosa	42	98	495	726	0	0
Anabaena flos-aquae	858	660	0	3003	759	462
Coelosphaerium kutzingiana	33	0	36	393	33	198
Gomphosphaeria lacustris	198	264	0	196	0	0

distributions also among the flagellates, whose own movements are probably important, as has been pointed out by Stange-Bursche (1963) (quoted in Lund, 1965).

VII. Discussion

Ruttner (1953), states that, without doubt, the most important agent affecting the distribution of the plankton is water movement, including water renewal, which affects the vertical distribution as much as turbulence does. The inflow and outflow in a lake can affect the species present and, in Slapton Ley, especially during heavy rains, many epiphytic species are scoured away from the angiosperms in the Higher Ley and the marsh in Ireland Bay, to be carried into the open waters of the Lower Ley, and make the largest contribution to the phytoplankton.

The phytoplankton population in the Lower Ley varies from station to station but, in general, the higher counts of organisms were obtained from Ireland Bay and the west shore (stations 2–6). Here protection is afforded from the south westerly winds by the sloping land backing the shore, and station 3 is a particularly protected area where the highest counts were obtained. The prevailing winds at Slapton are south westerly, but the surface currents set up by strong onshore winds tend to carry the organisms over to the west shore, so depleting the surface waters on the east side (see Fig. 3). Those organisms with efficient flotation mechanisms were most affected, e.g. *Staurastrum anatinum*, *Anabaena flos-aquae*, and *Pediastrum boryanum*.

Stations 12–14 lie in the path of the main inflow-outflow stream which runs from north to south, and is an extension of the river Gara entering at the northern end of the Higher Ley. Organisms tend to be carried to the southern part of the Lower Ley and to congregate in the reeds at the Torcross station (8), before being swept away through the outflow when the water level is high. Station 8 is also unique in that the organisms present in collections during any one month were usually those that had been recorded in samples for the previous month in the northern part of the Lower Ley. This may well be due to the fact that organisms, carried there by the flow of the mainstream, encountered a rather sheltered habitat during the low flows, and became well established there. The depth at which the Gara water flows through the Ley depends to a certain extent on relative densities. In summer months the river is a few degrees colder than the lake mass and sinks to the bottom of the channel near the east shore, thus affecting the stratification of the organisms in calm conditions, the bulk of the organisms being found in the lower water (see Table 4).

Periodicity of the plankton species is related to factors controlling the length of the vegetative stage, the onset of sexual reproduction, and the length of the resting stage (if any). Transeau (1916) indicated that six natural groupings of algae occur, based on their seasonal periodicity. Examples of these groups are apparent when examining the cycles of the algae in the Ley (see Table 5). Transeau claimed that such cycles were related to changes in temperature, light and nutrients.

It is interesting to note that in the Ley, highest values for nitrogen were obtained in March and June, both of which were periods of active vegetative

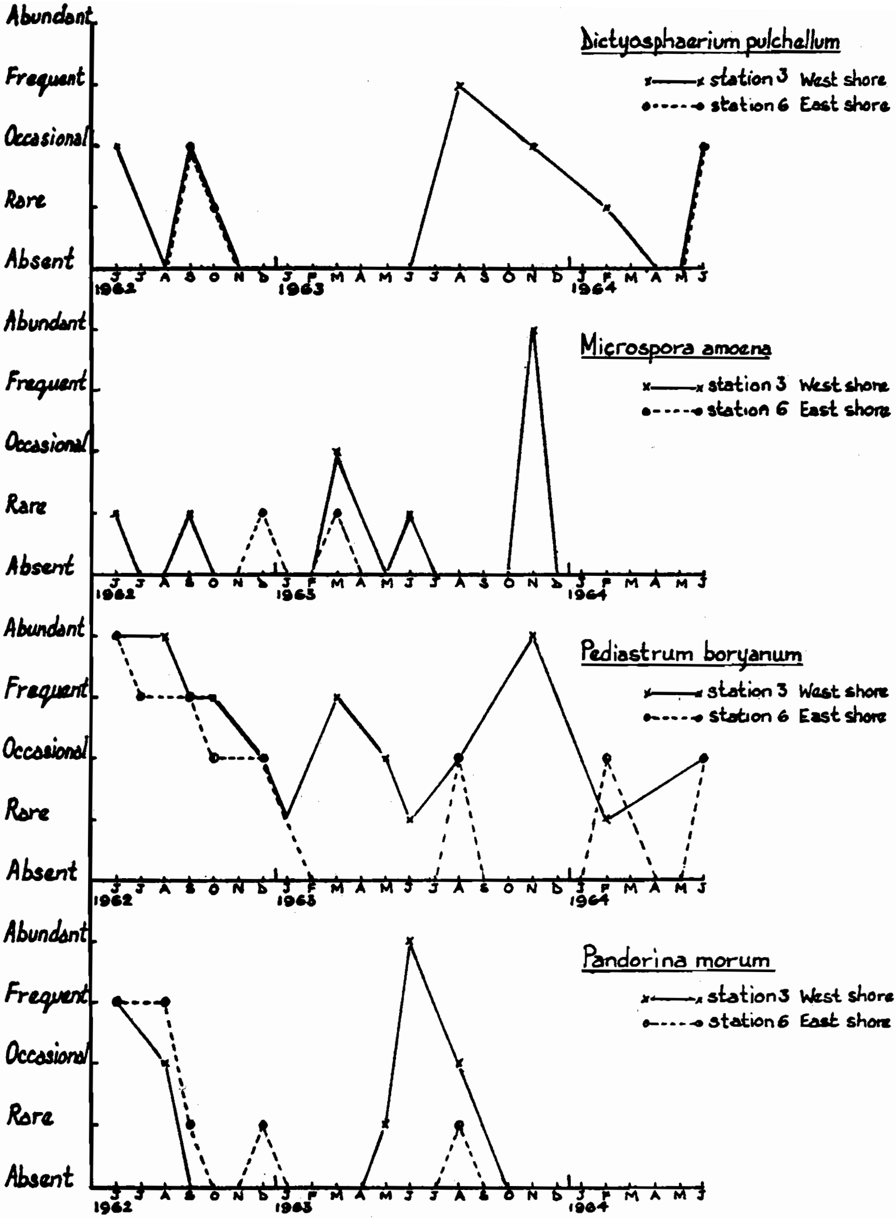

FIG. 3.

A comparison of cell counts of four species of the phytoplankton from samples taken at stations near the east and west shores of the Ley, to show the effect of wind on the movement of surface plankton.

Table 5. *The more common algae species of the Ley grouped according to Transeau's life forms.*

Spring Annuals Vegetative phase in late Autumn and early Spring Veg. and sex. rep.*—May	Summer Annuals Vegetative phase in Spring Veg. and sex. rep.*—July and August	Autumn Annuals Vegetative phase in late Spring Veg. and sex. rep.*—September and October
Coleochaete sp.	Oscillatoria limosa	Gloeotrichia echinulata
Melosira varians	Ulothrix moniliformis	Gomphosphaeria lacustris
Meridion circulare	Gloeocystis vesiculosa	Anabaena flos-aquae
Diatoma vulgare	Phormidium tenue	Melosira arenaria
Mougeotia capucina	Coelosphaerium naegelianum	Staurastrum anatinum
Chaetophora incrassata	Nostoc sp.	Cosmarium reniforme
Ulothrix zonata	Dictyosphaerium pulchellum	Oedogonium acrosporum
Achnanthes lanceolata		Oocystis solitaria
A. minutissima var. cryptocephala		Melosira arenaria
Synedra ulna		Eunotia gracilis
Navicula viridula		E. pectinalis
N. lanceolata		Navicula perpusilla
N. hungarica var. capitata		Cymbella turgida
N. peregrina		Nitzschia linearis
N. radiosa		Cymatopleura elliptica
N. rhyncocephala		Surirella linearis
Cymbella obtusiuscula		Cymbella lanceolata
Nitzschia sigma		Gomphonema geminatum
N. fonticola		
N. acicularis		
N. sublinearis		
Gomphonema geminatum		
G. constrictum		

Winter Annuals Vegetative phase in Autumn and Winter. Veg. rep.—March and April. Sex. rep.* Nov.–April	Ephemerals Vegetative cycle of a few days. Sex. rep.*—a few hours or a few days. Long resting stages	Perennials Reproduction* at any time. Vegetative cycle continues from one year to the next.
Stigeoclonium tenue	Chlamydomonas sp.	Chantransia pygmaea
Tabellaria fenestrata	Chlorella vulgaris	Cladophora glomerata
Vaucheria sp.	Chlorococcum humicolum	Rivularia minutula
Oedogonium sp.	Scenedesmus quadricauda	Lemanea mammillosa
Dictyosphaerium pulchellum	S. bijugatus	Hildenbrandia rivularis
Draparnaldia plumosa	Volvox globator	Frustulia rhomboides
Tribonema aequale	Pediastrum boryanum	Asterionella formosa
Gomphonema olivaceum	Synura uvella	Fragilaria capucina
	Dinobryon cylindricum	Gyrosigma attenuatum
	Haematococcus pluvialis	Navicula minima
	Spirulina major	Pinnularia viridis
	Hormidium flaccidum	
	Micrasterias denticulata	
	Arthrodesmus incus	
	Eremosphaera viridis	
	Chroococcus giganteus	
	Microcystis aeruginosa	
	Hantzschia amphioxys	

* where known.

growth, and not periods of sexual reproduction of the algae; also the highest values for the total concentration of nutrients in the Ley were recorded for March and November and corresponded with periods of heavy rain, low light intensities and vegetative activity of the plankton. Sexual reproduction followed some weeks later.

The light readings taken on the Ley, at the time of sampling over the three-year period, indicate that the light intensity would have limited the onset of sexual reproduction for some of the Spring, Summer and Autumn annuals. Turbidity, cloud cover and the depth of the water frequently reduce the light intensity below the threshold value for the induction of sexuality. According to Welch (1935), Ruttner (1953) and Golterman (1960), temperature and light are the dominant factors controlling algal periodicity, and Smith (1966) has shown that variations in these factors are more important than changes in nutrient concentration in affecting gamete and auxospore formation in diatoms. These stages in the life cycle are markedly influenced by photoperiod, short days of eight hours being particularly conducive to their formation, whereas long days of twelve or sixteen hours are less stimulatory, and the author suggests that this is probably true in nature. In the Ley the diatoms that are winter annuals produce auxospores during the winter months and early spring.

Table 6. *Possible "consumers" of the phytoplankton that have been recorded in Slapton Ley, and the algae they are known to ingest.*

Species	Sources of Food			
	Coccoid algae*	Diatoms†	Filamentous algae‡	Red algae§
Ephemeroptera				
Baetis rhodani‖	+	+	+	+
Ecdyonurus dispar		+		
E. torrentis		+		
E. venosus		+	+	
Ephemerella notata	+	+	+	
Heptagenia sulphurea		+		
Rhithrogenia semicolorata		+		+
Trichoptera				
Anabolia sp.	+		+	+
Hydropsyche sp.		+	+	+
Odontocerum albicorne	+	+	+	
Philopotamus sp.	+	+	+	
Rhyacophila sp.‖				
Diptera				
Simulium latipes	+		+	
Chironomid sp.		+	+	

* Coccoid algae—Mainly desmids, especially Cosmarium, Closterium and Staurastrum.
† Diatoms—Particularly Cocconeis, Achnanthes, Melosira, Navicula, Tabellaria, Ceratoneis and Synedra spp.
‡ Filamentous algae—Mainly greens, e.g. Ulothrix, Oedogonium, Spirogyra, Microspora, Stigeoclonium, Cladophora and Mougeotia.
—Phormidium was the chief representative of the blue-greens.
§ The red algae—Batrachospermum particularly in the Chantransia form, and Lemanea.
‖ Detritus, moss and particle feeders.

Another factor influencing the periodicity of organisms, especially the benthos in the Ley, is the consumption of the algae by the insect population. Erichsen-Jones (1949) and Brooks (1954) have investigated the gut contents of insects and listed the phytophagous species. Many of the Ephemeroptera, Trichoptera and Diptera that they mention have been recorded at Slapton Ley and probably contribute to a reduction in the number of certain species in the spring and summer months. A list of these "consumers" and the species that they are known to ingest are given in Table 6.

In conclusion, Slapton Ley shows every evidence of being a eutrophic, silted lake. Pearsall (1932) concluded from his work in the Lake District that the dominants of silted lakes were *Tabellaria spp.*, *Asterionella spp.*, *Coelosphaerium* and *Anabaena spp.* All of these have been recorded in abundance in the Ley. The high productivity of the water together with the appearance of "water-blooms" in the summer indicate that Slapton Ley is in a fairly advanced stage of eutrophy. Further evidence for this is provided by the presence of coarse fish such as perch and rudd.

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Appendix I
SPECIES LIST

EUPHYCOPHYTA

Chlorophyceae

VOLVOCALES

CHLAMYDOMONADINAE

SPHAERELLACEAE

Haematococcus pluvialis Flotow
Chlamydomonas sp.

VOLVOCACEAE

Pandorina morum Bory
Eudorina elegans Ehrenb.
Volvox globator Ehrenb.
V. aureus Ehrenb.

TETRASPORALES

PALMELLACEAE

Gloeocystis vesiculosa Naeg.
Sphaerocystis schroeteri Lemm.

PROTOCOCCALES

PROTOCOCCACEAE

Chlorococcum humicolum Rabenh.

PROTOSIPHONACEAE

Pediastrum boryanum Menegh.
P. boryanum var. brevicorne Al. Braun
P. boryanum var. longicorne Reinsch

EREMOSPHAERACEAE

Eremosphaera viridis De Bary

CHLORELLACEAE

Chlorella vulgaris Beyerinck

OOCYSTACEAE

Oocystis solitaria Wittr.
Nephrocytium agardhianum Naegeli.
Tetraëdron minimum Hansg.

SCENEDESMACEAE

Scenedesmus quadricauda Breb.
S. quadricauda var. maximus W. and G. S. West
S. bijugatus Kütz.
Selenastrum gracile Reinsch
Dictyosphaerium pulchellum Wood
D. ehrenbergianum Naegeli
Coccomyxa dispar Schmidle.
Dactylococcus caudatus Hansg.
Protococcus viridis Agardh

SIPHONOCLADIALES

CLADOPHORACEAE

Cladophora glomerata Kütz.

ULOTRICHALES

ULVACEAE

Ulva linza L.
Prasiola crispa Menegh.
Enteromorpha intestinalis Grev.

ULOTRICHACEAE

Ulothrix subtilissima Rabh.
U. tenuissima Kütz.
U. moniliformis Kütz.
U. aequalis Kütz.
U. zonata Kütz.
Hormidium flaccidum Kütz.

MICROSPORACEAE

Microspora amoena Kütz.

CHAETOPHORALES

CHAETOPHORACEAE

Stigeoclonium tenue Kütz.
Draparnaldia plumosa Agardh
Chaetophora incrassata Hazen.
Coleochaete sp. Breb.

OEDOGONIALES

OEDOGONIACEAE

Oedogonium acrosporum De Bary

CONJUGALES

ZYGNEMALES

ZYGNEMACEAE

Mougeotia capucina Agardh
Spirogyra reticula Nordst.
S. gallica Petit.
S. nitida Link.
Zygnema insigne Kütz.

DESMIDACEAE

Closterium pritchardianum Arch.
Euastrum oblongum Ralfs
Micrasterias denticulata Breb.
Cosmarium reniforme Arch.
C. botrytis Menegh.
Arthrodesmus incus Hass.
Staurastrum anatinum Cooke and Wills
Desmidium swartzii Agardh

Rhodophyceae

BANGIALES

LEMANEACEAE

Lemanea mamillosa Kütz.

BATRACHOSPERMACEAE

Batrachospermum pygmaea Kütz.

CERAMIACEAE

Hildenbrandia rivularis Agardh.

MYXOPHYCOPHYTA

Myxophyceae

CHROOCOCCALES

CHROOCOCCACEAE

Microcystis aeruginosa Kütz.
Aphanocapsa grevillei Rabh.
Chroococcus giganteus W. West
C. minutus Naeg.
Gloeocapsa magma Kütz.
Gloeothece confluens Naeg.
Gomphosphaeria lacustris Chodat
Coelosphaerium naegelianum Unger
Synechococcus aeruginosa var. maximus Lemm.
Rhabdoderma lineare Schmidle and Lauterborn
Dactylococcopsis raphidioides Hansgirg
Tetrapedia reinschiana Arch.

DERMOCARPALES

CHAMAESIPHONACEAE

Chamaesiphon confervicola A. Braun

STIGONEMATALES

STIGONEMATACEAE

Stigonema hormoides Kütz.

NOSTOCALES

RIVULARIACEAE

Gloeotrichia echinulata Richt.
Rivularia minutula Bornet and Flahault

SCYTONEMATACEAE

Scytonema crispum Bornet

NOSTOCACEAE

Nostoc sp.
Anabaena flos-aquae Breb.

OSCILLATORIACEAE

Spirulina major Kütz.
Oscillatoria limosa Agardh
O. tenuis Agardh
O. irrigua Kütz.
O. brevis Kütz.
Phormidium tenue Gom.
Lyngbya sp.

CHRYSOPHYCOPHYTA

CHRYSOPHYCEAE

Synura ulvella Ehrenb.
Dinobryon cylindricum Imhof

DINOPHYCEAE

Amphidinium amphidinioides Schiller

XANTHOPHYCEAE

HETEROTRICHALES

Stipitococcus urceolatus West
Ophiocytium cochleare A. Braun

TRIBONEMACEAE

Tribonema aequale Pascher

VAUCHERIACEAE

Vaucheria sp.

BACILLARIOPHYCEAE

CENTRICAE

MELOSIRINAE

Melosira varians Agardh
M. arenaria Moore
M. granulata Ralfs
Thalassiosira fluviatilis Hustedt
Cyclotella meneghiana Kütz.
Stephanodiscus hantzschii Grun.
Coscinodiscus lacustris Grun.
C. bathyamphalus Cleve.

PENNATAE

ARAPHIDAE

FRAGILARIOIDAE

TABELLARIINAE

Tabellaria fenestrata Kütz.
T. fenestrata var. asterionelloides Grun.
T. flocculosa Rabh.
Meridion circulare Agardh
Diatoma vulgare Bory.
D. vulgare var. producta Grun.
D. elongatum Agardh.

FRAGILARIINAE

Fragilaria capucina Desmazieres.
F. capucina var. mesolepta Rabh.
F. crotonensis Kitton.
Synedra ulna Kütz.
S. ulna var. splendens Kütz.
S. pulchella Kütz.
S. capitata Ehrenb.
S. vaucheriae Kütz.
S. gaillonii Ehrenb.
S. rumpens Kütz.
Asterionella formosa Hassall

EUNOTIEAE

Eunotia pectinalis Rabh.
E. exigua Grun.
E. pectinalis var. minor Rabh.
E. lunaris var. subarcuta Grun.
E. gracilis Rabh.
E. monodon var. major Hustedt

COCCONEIDEAE

Cocconeis placentula Ehrenb.
C. euglypta Cleve.

ACHNANTHEAE

Achnanthes minutissima var. cryptocephala Grun.
A. hungarica Grun.
A. hauckiana Grun.
A. lanceolata Grun.
Rhoicosphenia curvata Grun.

BIRAPHIDEAE

NAVICULOIDEAE

NAVICULAE

Stauroneis anceps Ehrenb.
S. phoenicenteron Ehrenb.
S. pygmaea Kreiger
Frustulia rhomboides de Toni
Gyrosigma acuminatum Rabh.
G. attenuatum Rabh.
Neidium iridis Cleve.
Anomoeoneis sphaerophora Pfitzner.
Navicula gregaria Donkin.
N. minima Grun.
N. scutum V. Heurck.
N. perpusilla Grun.
N. pupula Kütz.

N. placentula Ehrenb.
N. peregrina Kütz.
N. vulpina Kütz.
N. viridula Kütz.
N. rhynchocephala Kütz.
N. hungarica var. capitata Cleve.
N. cryptocephala Kütz.
N. gracilis Ehrenb.
N. exigua O. Müller
N. radiosa Kütz.
N. lanceolata Kütz.
Pinnularia microstauron var. brebissonii Kütz.
P. microstauron var. diminuta Grun.
P. viridis Ehrenb.
P. nobilis Ehrenb.

GOMPHOCYMBELLOIDEAE

Amphora ovalis Kütz.
A. delicatissima Krasske.
Cymbella obtusiuscula Grun.
C. turgida Cleve.
C. ventricosa Kütz.
C. affinis Kütz.
C. cymbiformis V. Heurck
C. lanceolata V. Heurck.
C. aspera Cleve.
C. lacustris Cleve.
Gomphonema geminata M. Schmidt
G. acuminatum Ehrenb.
G. parvulum Grun.
G. angustatum var. producta Grun.
G. longiceps var. subcalvata Grun.
G. olivaceum Kütz.
G. constrictum Ehrenb.

EPITHEMIOIDEAE

Epithemia argus Kütz.
E. zebra Kütz.
E. turgida Kütz.

RHOPALODIOIDEAE

Rhopalodia gibba O. Müller

NITZSCHIOIDEAE

Hantzschia amphioxys var. major Grun.
Bacillaria paradoxa Gmelin
Nitzschia linearis W. Smith
N. sublinearis Hustedt
N. amphibia Grun.
N. fonticola Grun.
N. palea W. Smith
N. sigma W. Smith
N. acicularis W. Smith

SURIRELLOIDEAE

Cymatopleura elliptica W. Smith
Surirella linearis W. Smith
S. angustata Kütz.
S. ovalis Breb.

CAMPYLODISCOIDEAE

Campylodiscus noricus var. hibernica Grun.

APPENDIX II

Seasonal distribution of the common species

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CHLOROPHYCEAE												
Haematococcus pluvialis			+		+		+		+	+		+
Chlamydomonas sp.					+	+						
Pandorina morum				+		+	+	+	+	+	+	+
Eudorina elegans				+							+	
Volvox globator						+	+	+	+	+		
Gloeocystis vesiculosa							+	+	+			
Sphaerocystis schroeteri					+		+	+	+	+		+
Chlorococcum humicolum			+	+	+	+	+	+	+	+	+	+
Pediastrum boryanum		+	+	+	+	+	+	+	+	+	+	+
P. boryanum var. longicorne				+		+		+				
Eremosphaera viridis				+	+							
Chlorella vulgaris		+		+	+	+	+	+	+	+	+	+
Oocystis solitaria				+	+	+	+	+	+	+		
O. solitaria var. elongata		+				+						
Scenedesmus quadricauda	+	+		+	+	+	+	+	+	+	+	+
S. quadricauda var. maximus		+		+	+	+	+	+	+	+	+	+
S. bijugatus		+		+	+			+	+		+	
Selenastrum gracile					+					+		+
Dictyosphaerium pulchellum			+		+	+	+	+	+	+	+	+
Coccomyxa dispar							+	+				
Dactylococcus caudatus					+	+		+				
Cladophora glomerata	+				+							
Ulothrix moniliformis		+			+			+				
Hormidium flaccidum	+			+		+				+		
Microspora amoena	+		+			+	+	+	+	+	+	+
Draparnaldia plumosa			+	+								
Oedogonium acrospora			+		+	+	+			+		
Mougeotia capucina			+			+					+	
Spirogyra nitida					+	+		+				+
Closterium pritchardianum			+	+		+	+			+		+
Cosmarium reniforme				+	+	+	+		+	+	+	
Staurastrum anatinum			+		+		+	+	+	+	+	+
MYXOPHYCEAE												
Microcystis aeruginosa	+				+	+	+	+	+	+		+
Aphanocapsa grevillei	+		+		+		+	+	+	+		+
Chroococcus giganteus				+			+			+		
Gloeocapsa magma					+	+	+		+		+	
Gloeothece confluens							+			+		
Gomphosphaeria lacustris			+		+	+	+	+	+	+		+
Coelosphaerium naegelianum				+		+	+	+				
Tetrapaedia reinschiana				+		+					+	
Gloeotrichia echinulata				+	+	+	+	+	+	+		+
Nostoc sp.				+	+	+						
Anabaena flos-aquae				+		+	+	+	+	+	+	
Oscillatoria limosa	+			+	+	+		+		+	+	
Spirulina major			+			+						
RHODOPHYCEAE												
Lemanea mammillosa	+	+	+	+	+	+	+	+	+	+	+	+
Hildenbrandia rivularis	+	+	+	+	+	+	+	+	+	+	+	+
Chantransia pygmaea	+											+
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Chrysophyceae

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Synura ulvella				+		+						
Dinobryon cylindricum					+						+	

Bacillariophyceae

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Melosira varians	+			+								
M. arenaria	+			+	+	+	+	+	+	+	+	
M. granulata	+									+		
Cyclotella meneghiana				+							+	
Stephanodiscus hantzschii				+						+		
Coscinodiscus lacustris										+	+	+
Tabellaria fenestrata			+	+	+		+	+	+	+	+	+
Meridion circulare			+	+								
Diatoma elongatum			+		+							+
Fragilaria capucina	+	+	+	+	+	+	+	+	+	+	+	+
Synedra ulna		+		+		+						
S. pulchella	+	+	+	+	+	+	+	+	+	+	+	+
Asterionella formosa		+	+	+	+	+	+	+	+	+	+	+
Eunotia pectinalis			+				+	+	+		+	
E. pectinalis var. minor				+			+					
E. gracilis					+	+	+		+	+	+	
Cocconeis placentula	+		+		+	+	+		+	+	+	+
Achnanthes lanceolata				+	+		+					
Rhoicosphenia curvata	+			+								
Stauroneis anceps	+			+								
Frustulia rhomboides	+	+	+	+	+	+	+	+	+	+	+	+
Gyrosigma acuminatum				+	+							
G. attenuatum	+		+	+	+	+	+	+	+	+	+	+
Navicula minima		+	+	+	+	+		+	+	+	+	+
N. perpusilla				+	+	+	+		+	+	+	
N. rhyncocephala	+			+								
N. viridula	+			+								
N. lanceolata		+		+		+						
Pinnularia viridis	+		+	+	+	+	+	+	+	+	+	+
Amphora ovalis	+				+	+				+	+	
Cymbella turgida				+	+		+		+	+		
C. affinis	+			+								
C. lanceolata				+	+	+	+	+	+	+		+
Gomphonema geminatum			+	+	+		+		+	+	+	+
G. parvulum	+			+								
G. constrictum	+			+							+	
G. olivaceum		+		+								
Epithemia argus				+							+	
E. turgida				+							+	
Nitzschia linearis			+		+	+	+	+	+			
N. sublinearis	+			+								
Cymatopleura elliptica		+			+				+	+	+	
Surirella linearis	+		+		+				+	+	+	
Campylodiscus noricus			+		+	+			+	+	+	+

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec