A STUDY OF THE BOTTOM DIATOMS OF A FERTILIZED SEA LOCH.

by

John C. Smyth, B.Sc.

Thesis presented for the degree of Ph.D. in the
University of Edinburgh.
November 1948.
[From the Department of Zoology]

CONTENTS.

I INTRODUCTION.

From 1942 - 1947 a series of investigations has been carried out in arms of Loch Sween, a sea loch in Argyll, to study the possibility of increasing the productivity of these areas by the addition of artificial fertilizers to the water. Results of these investigations are given by Gross, Raymont, Marshall and Orr (1944) and separate papers by the same authors (1947), Gross, Raymont, Nutman and Gauld (1946), Marshall and Orr (1947), and separate papers by Gross, Raymont, Nutman and Gauld (in the press). These results have given evidence of the beneficial effect of fertilizers on plankton, bottom fauna and fish growth in Loch Craiglin (which was closed by a dam) and Kyle Scotnish, (which was left open).

The fact that much of the fertilizers applied sank to the bottom of the loch drew attention to the question of their utilization at or just above the mud surface. In the past little consideration has been given to the possible importance of the mud flora in the productivity of shallower areas of the sea. This flora consists mainly of pennate diatoms, and the present investigation was carried out to study its importance.

The many species of diatoms encountered were identified by Mr. R. Ross of the British Museum (Natural History) who is also preparing a detailed list of the bottom diatoms of Loch Sween. The chief systematic works consulted were Hustedt (1928, 1930), Peragallo (1897 - 1908) and Cleve (1894 - 5).

II DESCRIPTION OF STATIONS.

The bottom diatom flora was studied mainly from samples taken in various parts of Loch Sween (Fig.1). Some of the stations sampled corresponded with those at which plankton and bottom grab samples were taken, while others were specially selected. Stations differed mainly in depth and in the nature of the substratum. Those in Loch Craiglin differed from other stations in salinity. Fertilizers were applied to Loch Craiglin (1942 - 1946) and to Kyle Scotnish (1944 - 1946) but not to Sailean More.

The bottom at all stations consisted of mud, sometimes admixed with sand, shell fragments, or gravel. Overlying it was a layer of similar but less compact mud, varying in thickness according to the station, but usually about $\frac{1}{2}$ cm. This layer usually contained animal and plant remains in various stages of decomposition, as well as indeterminate particulate matter. It was easily stirred up, particularly in stormy weather.

(a) Stations in Kyle Scotnish - North Basin.

1 m. - Fairly clean, muddy sand, with few shell fragments and no weed near. This station is referred to as N B 1.

2 m. (K.G.2) - Sandy mud with shell fragments and gravel, and patches of Fucus nearby, (N B 2).

3 m. - Fine, flocculent mud with shell fragments or gravel, (N B 3).

5 m. and 7 m. (KII) - Similar to the 3 m. station/

station. (N B 5 and N B 7).

(b) Stations in Kyle Scotnish - South Basin.

1 m., 3 m. and 5 m. (Seal Bay) - Gravelly, muddy sand, with stone and higher algae abundant but decreasing with greater depth, (S B 1, S B 3, S B 5).

7 m. and 10 m. (K.G.6) - Fine, flocculent mud similar to that at North Basin 7 m. ; the 7 m. station had a fair amount of terrigenous debris, (S B 7, S B 10).

20m. (KI) - A deep pit in the bottom of the loch, with flocculent mud, and occasional weed deposited after storms, (S B 20).

(c) Stations in Sailean More.

1 m., 3 m. and 5 m. (Faery Isles) - Clean, sandy mud, without stones and only a little weed near the 1 m. station. These stations were abandoned in favour of KIII for convenience in sampling,(F I 1, F I 3, F I 5).

2m. (KIII) - Sand with weed (*Fucus*) and stones, (L S 2).

7 m.(KIII) - Sand with gravel and shell fragments (L S 7).

10m.(KIII) - Similar, but muddier and with rocks nearby, (L S 10).

The salinity was approximately the same at all stations in Kyle Scotnish and Sailean More varying from 32 to 33.3°/oo.

(d) Stations in Loch Craiglin.

1 m. (St. V) - Compact sand with stones, and a/

a rich growth of *Enteromorpha*, particularly May - July; salinity 15-20°/oo.

3 m. (between St.I and St.II) - Sandy mud, with a rich summer growth of *Ruppia*; salinity 30-32°/oo.

5 m. (St.I) - Slimy mud; salinity probably similar to that at the 3 m. station.

In addition to the above, a few samples were taken in deep-water stations at 20 fathoms in Loch Sween and in Fairlie Roads, Firth of Clyde, at 40 fathoms off Little Cumbrae, Firth of Clyde, and at 60 fathoms in Cumbrae Sound, Firth of Clyde, and in Loch Fyne off Tarbert.

A few samples of shore or shallow water mud were also taken in Kyle Scotnish and Loch Craiglin for culture purposes. The nature of the flora in these samples was similar to that at 1 m. and 2 m. stations nearby.

III METHODS.

(a) Exposure of Glass Slides.

The chief method of sampling used was the colonization by diatoms of 3" X 1" glass slides. The slides were held in specially made metal frames (holding 5 - 8 slides) which were lowered to the mud surface, attached at one end to a cord buoyed at the surface of the water with a cork. Later in the investigation it became necessary to make certain which side of the slides touched the mud surface; for this reason a wire "handle" was added lengthwise to the top of the tray. (Fig. 2). The slides were left on the mud surface for different lengths of time. Sometimes a tray was taken up and one or more of the slides removed and replaced by fresh slides. In the later part of the investigation two slides were always removed at a time, and one mounted on the lower (mud) surface, the other on the upper side.

On removal from the trays the slides were stored in dry stoppered bottles and taken back to the laboratory. As this usually took less than an hour, the diatoms were always found to be still alive. The diatoms were then fixed in Bouin's fixative, stored in 70°/o alcohol or 4°/o formalin, and sent to Edinburgh for further treatment.

For ordinary purposes diatoms were stained in Ehrlich's haematoxylin, sometimes counterstained with eosin or light green, and mounted in Canada balsam. This treatment was necessary to show whether or not the cells/

cells were alive when placed in fixative. For identification a few slides were heated to carbonize the cell contents, and mounted in Hyrax mounting medium (refractive index 1.80).

Counts were made of 20 ocular micrometer fields on each slide, the size of field varying from 0.006 sq. mm. to 0.12 sq. mm. according to the density of colonization.

In order to test whether any loss of diatoms occurred during the process of fixation, staining and mounting, a series of slides was taken through the whole process, and the containers examined afterwards. Counts were made on the slides in sea water before the process, and subsequently in balsam. The counts gave no evidence of loss, and the only material left in the staining jars was a few small lumps of mud or detritus which had been adhering loosely to the slide. The colonizing diatoms remained attached to the glass.

As a further test on the method a number of glass slides ~~were~~ was colonized in the laboratory in crystallizing dishes containing pure cultures of <u>Nitzschia affinis</u>, <u>Nitzschia subcapitellata,</u> and <u>Amphora coffeaeformis</u>. The two species of <u>Nitzschia</u> are markedly motile forms, while <u>Amphora coffeaeformis</u> tends to be much more sessile. Counts were made while the slides were still in the dishes, and after they had been stained and mounted; no appreciable differences were found on any of the slides.

The only loss of colonizing diatoms likely to occur after the slide leaves the mud surface, seems to be the inevitable loss during handling, when the slide is being removed from the tray. Such damage certainly did occur, but was usually obvious, and damaged areas were avoided during the counts.

(b) <u>Core samples.</u>

In order to supplement the slide data a number of core samples were taken at various stations. The apparatus used is described by Nutman (in the press).

The mud cores so obtained were brought back to the laboratory and sampled immediately. This was done by pushing the core up to the top of the tube and into a small tube of the same diameter held over the top. When the flocculent brown layer of the mud (the top $\frac{1}{2}$ - 1 cm.) had entered the small tube a cover slip was inserted between the two tubes, slicing this layer off. The sample was then transferred to a bottle and preserved in 4°/o formalin. Methods of treating these samples proved difficult, and are discussed later.

(c) <u>Culture methods.</u>

Several species of pennate diatoms were kept for various purposes in pure culture. They were isolated with a fine pipette either from mud samples, or from Petri dish cultures in which a few drops of raw mud had been added to the culture medium and diatoms allowed to develop. Isolated diatoms were washed repeatedly on a slide with sea water which had been filtered and sterilized/

sterilized by boiling. ~~sea water~~. They were then transferred to Petri dishes filled with culture medium and allowed to develop and sub-cultures set up from time to time. All pipettes and dishes used were thoroughly sterilized.

The culture media used were Föyn's "Erdschreiber" (Gross, 1937) usually with the addition of a trace of ferric citrate, and occasionally sodium silicate, and 1°/o agar plates prepared according to Pringsheim's method (1946) using Föyn's "Erdschreiber" nutrients in the same concentration as for liquid cultures. Eventually all stock cultures of diatoms were kept on agar plates, as this proved the most satisfactory method of keeping them bacteria-free.

The diatoms kept in pure culture were:-

Amphiprora paludosa W. Sm. var. duplex (Donk) V.H.
Amphiprora sp. 1.
Amphora coffeaeformis (Ag.) Kütz.
Navicula sp. 1.
Navicula spp. (3 unidentified forms).
Nitzschia affinis Grun.
Nitzschia ? dubiiformis, Hust.
Nitzschia subcapitellata Hust.
Nitzschia sp. 1.
Stauroneis amphoroides Grun.

IV DIATOMS OF LOCH SWEEN.

The following diatoms were the most abundant forms identified from Loch Sween material. In addition to these a large number was present on slides but not identified; these diatoms belonged mainly to the genera Fragilaria and Navicula, (including forms 3 - 8 µ in length), Nitzschia and a few other genera. Mr. Ross is at present identifying many other diatoms from core material. The diatoms listed are given along with their halobion ratings where these are known (see p.53); this will be discussed later.

Achnanthes adnata Bory (Achnanthes brevipes Bory) (mesohalobous)

Achnanthes affinis Grunow apud Cleve & Grunow. (mesohalobous)

Achnanthes orientalis Hustedt.

Achnanthes Strömi Hustedt.

Achnanthes subsalsoides ? var. nov.

Achnanthes sp. nov.

Amphiprora sp. indet.

Amphora acutiuscula Kützing.

Amphora coffeaeformis (Agardh) Kützing. (mesohalobous)

Amphora costata W. Smith. (euhalobous)

Amphora laevis Gregory. (mesohalobous)

Amphora macilenta Gregory.

Amphora marina Van Heurck.

Amphora Proteus Gregory. (mesohalobous)

Amphora truncata Gregory (Amphora Graeffii Grunow ex A. Schmidt auct. non Grunow) (euhalobous)

Cocconeis/

Cocconeis placentula Ehrenberg. (oligohalobous, indifferent).

Cocconeis Scutellum Ehrenberg. (meso-e~~n~~uhalobous).

Diploneis spp. indet.

Fragilaria spp. indet.

Grammatophora sp. indet.

Gyrosigma rectum Donkin. (e~~n~~uhalobous)

Licmophora sp. indet.

Mastogloia elliptica (Agardh) Cleve (mesohalobous)

Mastogloia pumila (Grunow) Cleve (e~~n~~uhalobous)

Melosira sulcata (Ehrenberg) Kützing(e~~n~~uhalobous)

Navicula bahusiensis (Grunow apud Van Heurck) Grunow var. *arctica* Grunow.

Navicula bahusiensis (Grunow apud Cleve & Grunow) var. *bahusiensis* (Grunow apud Cleve & Grunow) Ross ms.

Navicula Bulnheimii Grunow.

Navicula cryptocephala Kützing var. *exilis* Kützing Grunow.

Navicula Cyprinus (Ehrenberg) Kützing (includes *Navicula digito-radiata* (Gregory) (Ralfs).

Navicula forcipata Greville. (e~~n~~uhalobous)

Navicula gothlandica Grunow. (e~~n~~uhalobous)

Navicula gregaria Donkin. (mesohalobous)

Navicula palpebralis Brébisson ex W. Smith. (e~~n~~uhalobous)

Navicula pygmaea Kützing. (mesohalobous)

Navicula ramosissima (Agardh) Cleve.

Navicula retusa Brébisson. (e~~n~~uhalobous)

Navicula scopulorum Brébisson var. *belgica* Van Heurck. (e~~n~~uhalobous)

Nitzschia/

Nitzschia acuminata (W. Smith) Grunow apud Cleve & Grunow. (euhalobous)

Nitzschia closterium (Ehrenberg) W. Smith. (mesohalobous)

Nitzschia palea var. *perminuta* Grunow.

Nitzschia Sigma (Kützing) W. Smith.

Nitzschia spathulata Brébisson ex W. Smith. (euhalobous)

Nitzschia sp. indet. (tryblionellid form).

Pleurosigma formosum W. Smith (includes *Pleurosigma decorum* W. Smith).

Pleurosigma minutum Grunow.

Pleurosigma thuringicum (Kützing) Ralfs var. *quadratum* (W. Smith) Ross ms. (*Pleurosigma angulatum* (Quekett) W. Smith) (euhalobous)

Rhopalodia musculus var. *constricta* W. Smith. (mesohalobous)

Stauroneis sp. indet.

Synedra pulchella (Ralfs) Kützing. (mesohalobous)

Tropidoneis sp. indet.

On the slides the colonizing flora consisted of a number of regularly occurring forms such as *Navicula pygmaea*, *N. retusa*, *Amphora laevis*, *A. marina*, *A. macilenta*, *Pleurosigma minutum* and others all of which colonized slides quickly and evenly but showed no striking variation in numbers. A smaller number of forms occurred less regularly but sometimes formed a dense carpet on the slides - notably *Cocconeis Scutellum*, *Amphora coffeaeformis* and *Navicula bahusiensis*. Since these and a few less common forms tended to occur in fairly close patches, they were considered to be more sessile in habit.

V RESULTS OF SLIDE INVESTIGATION.

Slide trays were laid out in various stations in Loch Sween from March 1944 until September 1946. The earlier series were considered too irregular in their exposure to be of much value and were not counted in detail. The composition of the flora which colonized the slides was similar to that colonizing later ones. No slides were laid out between 30th. March and 28th. September 1945. Up to this time only one slide at each station was taken out at a time, and the side to be examined was chosen arbitrarily, as there was no check on which side had been uppermost. As later investigation showed that differences occurred in both numbers and species between the two sides of a slide, some of the variation among these earlier slides may be due to this factor. From September 1945 onwards two slides were removed at a time so that both sides could be examined, and to make this possible the trays were modified as described above. From this time onwards periods of exposure in each series were arranged to overlap in order to give a clearer picture of changes in the population.

Exposed slides were colonized by pennate diatoms (Figs. 3-5). Changes in the population made it impossible to determine the time when colonization was complete, and the lengths of exposures were varied considerably.

The method of colonization varied in

different/

different species. As already noted some tended to colonize all slides fairly evenly, while others, usually more sessile forms, occurred in patches. Since the latter type was usually more numerous, the twenty fields chosen at random and counted on each slide often showed considerable variation; counts as different as 0 and 200 diatoms per field on the same slide were occasionally recorded. It is probable that some of this variation was also due to grazing by animals, a factor on which there is as yet no information. Similar differences sometimes occurred between different slides in the same tray.

Occasionally lumps of mud and detritus adhered to the slide. These usually contained large diatoms which were otherwise uncommon on the slides. Faeces of animals often containing masses of live or empty diatom frustules, molluscan eggs, and the tubes of small polychaetes were also present. When such lumps of material fell off the slide they left the usual colonizing diatoms still adhering to the glass underneath.

Pennate diatoms were by far the most important forms colonizing these slides. Bottom-living centric forms and planktonic forms were rare and usually appeared moribund. Spores and young stages of higher algae were occasionally present, especially on slides colonized near weed in autumn 1944. The blue-green alga Oscillatoria was of fairly regular occurrence in mud patches, and in June-July 1946/

1946, a fungoid growth which was not identified occurred on North Basin slides.

Animals rarely occurred on the slides. Although many ciliates and flagellates were common in the mud, the only protozoans found were a few rhizopods, foraminifera, and *Vorticella.* A few nematodes and one harpacticoid copepod nauplius were found in mud clumps, and one or two small polychaetes were present in tubes adhering to the slides.

(i) Slides from Kyle Scotnish and Sailean More.

(a) Stations from 1 - 10 m.

Slides were examined from these stations in series D - S (see Table 1) and are dealt with in these series below for convenience in comparison between stations. The total numbers of diatoms counted for each date of collection are given in Table 1. Each series is dealt with separately in Tables 2 - 19.

Series D, August 1944. Counts on this and the next four series were only made for the total number of diatoms. Colonization was heavy at N B 1 and at S B 1 and 5. The dominant forms at N B 1 were *Amphora coffeaeformis* and *Cocconeis Scutellum*, at S B 1 *Nitzschia closterium* and at S B 5 several non-encrusting forms were numerous. The composition of the flora was similar at all stations.

Series E, September 1944. Colonization was heavy at all stations. At N B 1 about 70°/o of the diatoms/

diatoms were *Cocconeis Scutellum*, about 10% *Amphora coffeaeformis* and *Navicula bahusiensis, bahusiensis*, and the remainder chiefly *Navicula retusa*, *N. pygmaea* and *Amphora laevis*. At N B 3 where colonization was heavier, the chief form was *Amphora coffeaeformis* (about 65%) with *N. bahusiensis bahusiensis* (20%), *Cocconeis Scutellum* (9%) and *Amphora laevis*, *A. Proteus*, *A. truncata* and *Navicula retusa* also present. At S B 1 *Cocconeis Scuttelum* again formed about 65% of the colonization with *Amphora coffeaeformis* (20%) and *Nitzschia closterium* (8%). *Cocconeis* was dominant at S B 3 and S B 5 also. At F I 1 *Amphora coffeaeformis* was dominant (60%) with *Cocconeis* (25%) and *Navicula bahusiensis bahusiensis* and *N. pygmaea*. The colonization at 5 m. was due mainly to the common forms with *A. coffeaeformis* the most numerous.

Series F, October - November 1944. Slides of this series were heavily colonized by encrusting forms possibly as a result of long exposure (45 days). There were also fertilizations on October 16th and November 11th. The slide from N B 1 was particularly interesting; one field in a corner of the slide had an exceptionally dense colonization of *Navicula bahusiensis bahusiensis*/

bahusiensis (about 5,700 per sq. mm.) and *Cocconeis Scutellum* (930 per sq.mm.), while the rest of the slide was covered by scattered patches of *Cocconeis* of irregular density, some *N. bahusiensis* and *Amphora coffeaeformis*, and non-encrusting forms such as *A. laevis*, *A. marina*, *Navicula pygmaea*, *N. retusa*, *N. bahusiensis arctica*, *Pleurosigma* spp. and *Nitzschia closterium*. Experience of other slides has shown that with a dense colonization, such as the corner showed, the whole slide is usually similarly covered. It seems probable therefore that this slide had been heavily grazed late in the exposure, leaving only one corner of the original colonization, and that subsequent re-colonization was from the remaining scattered *Cocconeis* patches and, more slowly, from *N. bahusiensis* patches, together with re-colonization from the mud by other forms which had been ousted from the original colonization by the dense growth of encrusting forms. The slide from S B 1 was one of the most densely colonized slides taken during the investigation. *Cocconeis Scutellum* formed a close carpet at an average density of 4,350 per sq. mm. with *Navicula bahusiensis bahusiensis* reaching an average of 1,750 per sq. mm.

Cocconeis/

Cocconeis in some patches reached a density of 11,700 per sq. mm., and *N. bahusiensis* a density of 15,900 per sq. mm. where they were mutually exclusive. In patches where they were less dense *Amphora coffeaeformis* occurred in small numbers. *Cocconeis* with *A. coffeaeformis* was also the dominant form at F I 1.

Series G, December 1944 - March 1945. Colonization in this series was much sparser than in the previous series chiefly on account of a decline in the growth of the main encrusting forms. The forms mainly occurring were *Navicula pygmaea*, *N. forcipata*, *N. retusa*, some unidentified species of *Navicula*, *Amphora marina*, *A. Proteus*, *Nitzschia closterium* and *Pleurosigma* spp. All of these occurred in about the same numbers as on earlier slides. *Cocconeis Scutellum*, *Amphora coffeaeformis* and *Navicula bahusiensis* were usually present in small numbers. The rise in population density at S B 1 and 3 on March 29th. was due to *Cocconeis*, with *Navicula bahusiensis* at 1m. and *N. pygmaea* at 3 m.

Series H, March - May 1945. A series of low colonization by non-encrusting forms. Several of the slides, however, were of such/

such irregular colonization as to suggest grazing, particularly on the slides from N B 3 and S B 3. This was indicated by the fact that in spite of the general low figures Cocconeis was regularly the most abundant. At S B 3 it formed 80% of the flora, with Amphora laevis and some isolated patches of A. coffeaeformis.

Series J, October 1945. Colonization was sparse with patches of encrusting forms and others, suggesting grazing in some cases. Details are given in Table 2.

Series K, October 1945. (Table 3) Similar to the previous series, and probably grazed; Navicula pygmaea showed a slight increase and the development of sessile forms in North Basin was reflected in the domination of a small species of Navicula. A fertilization took place on October 10th. Slides were only taken from 4 m. and the Sailean More station was changed to KIII.

Series L, November 1945. (Table 4) A low density of colonization by regular forms; the flora at KIII appeared particularly stable. There was no evidence of any effect by the fertilization of November 11th. Cocconeis was dominant at S B 3.

Series M, December 1945. (Table 5) Sparsely colonized./

colonized. A rise in the number of *Cocconeis* at N B 2 on slides removed on 21st. December, occurring independent of length of exposure, may have been related to a fertilization on December 11th. The flora at L S stations remained stable with *Achnanthes Strömi* as the most important form. The 7 m. stations were hardly colonized.

Series N, December 1945 - January 1946 (Table 6). At N B 2 there was a weak development of encrusting forms, with *Navicula pygmaea* still important. At KIII there was a fairly heavy colonization by *Amphora coffeaeformis* and *Achnanthes Strömi*. The second batch of slides at KIII was lost owing to gales.

Series O, February 1946 (Table 7). At N B 2 there was a strong development of *Cocconeis* showing an increase after longer exposure. The N B 7 colonization was still weak. At KIII there was a fairly even colonization, *Achnanthes* still being prominent. At L S 4 it was rather heavier than at L S 2 because of an increase in *Navicula bahusiensis* and other species. There was a fertilization on Feb. 11th.

Series P, March - April 1946 (Tables 8 - 10). Increases occurred at N B 2 in *Amphora coffeaeformis* and later *Navicula bahusiensis*.

Cocconeis/

Cocconeis tended to be patchy. N B 7 and S B 7 and 10 showed weak colonizations by *Navicula pygmaea* as the most important form. At L S 2 the colonization was sparse; some slides were partly covered with sand, and the trays had been dragged further inshore by the tide, possibly scouring off some of the diatoms. At L S 7 there was a strong development of the main colonizing forms, and also at L S 10 where *Navicula ramosissima* became dominant. Fertilizations in Kyle Scotnish were carried out on March 2nd. and April 10th.

Series Q, May - June 1946 (Tables 11 - 13). At N B 2 slides were evenly colonized throughout the series. *Navicula* spp. and small forms were dominant, *Amphora coffeaeformis* fewer, and *Cocconeis* sparse. The 8-day slide removed on May 30th. appears to have been grazed and re-colonized. A big increase of *Navicula banusiensis* occurred on one slide on June 6th. N B 7 and S B 10 showed little change from the previous series but at S B 7 there was a development of *Cocconeis* with the colonizing forms present. *Nitzschia closterium* was also important. The colonization at L S 2 was irregular, an increase in *Amphora coffeaeformis* being followed by *Navicula banusiensis*. At L S

colonization/

colonization was fairly heavy and included Navicula ramosissima, and Nitzschia closterium which was also important ~~at~~ at L S 10. The second exposure at L S 10 was possibly grazed. There was a fertilization in North Basin on May 21st.

Series R, June - July 1946 (Tables 14 - 16). The slides from N B 2 showed a uniform colonization of non-encrusting forms, the main encrusting forms occurring in very low numbers. This was ~~probably~~ correlated with the fact that these slides were found covered with mud. At N B 7 and S B 7 and 10 the population was similar to previous series. Colonization at L S 2 was heavy; an initial outburst of Amphora coffeaeformis was followed by Cocconeis. At L S 7 it was also heavy - with Navicula ramosissima and N. bahusiensis as important constituents. At L S 10 the first exposure showed a heavy colonization of Amphora coffeaeformis and numerous Navicula bahusiensis and small forms. This colonization was much increased during second exposure, which was obscured by quantities of mud making only a rough estimate of numbers possible. Amphora coffeaeformis was still dominant,

Cocconeis/

Cocconeis and Navicula ramosissima numerous, and Diploneis sp., Nitzschia spp., Pleurosigma spp., Synedra sp., Amphora marina and others also present. Fertilizations in Kyle Scottish during this period, on June 14th. and July 10th., had no discernible effect.

Series S, July - September 1946 (Tables 17 - 19). This series was more or less continuous with the previous one. Colonization at N B 2 was similar to that in Series R, but showing an increased density of the main colonizing forms in the earlier part of August. At N B 7 there was a heavy colonization on the lower surface of the 24-day slide by Navicula bahusiensis with Amphora coffeaeformis. The South Basin slides showed a low, even colonization by non-encrusting forms, with patches of the main encrusting forms. The colonization at L S 2 produced the densest carpet encountered on any slide. Cocconeis, the dominant form, rose to an average density of over 7,000 per sq. mm.; Amphora coffeaeformis was also fairly heavy on areas of the slides which were not already heavily colonized by Cocconeis. At L S 7 on the 24-day slide (upper surface) there was again a heavy colonization of Cocconeis with Amphora coffeaeformis and Navicula ramosissima.

ramosissima. On the 30-day slide the upper surface showed a decrease in numbers of these forms, but the lower surface was heavily colonized by *Navicula bahusiensis*, *Amphora coffeaeformis* and small species of *Navicula*. At L S 10 colonization was similar but more patchy, with *Navicula pygmaea* in greater numbers.

(b) *Station at 20 m. (S B 20)*.

Slides were laid out at this station in Series J, K, M - P, and S. The results are given in Table 20. This was a poor station for all bottom samples. Colonization of slides was regular but weak; most of the usual forms were present but thinly distributed. *Cocconeis Scutellum* and species of *Navicula* and (in winter) *Nitzschia* were the most regular forms. *Cocconeis* may have come from shore weed which frequently drifted to the bottom at this station after storms. The same may apply to *Licmophora* sp. and may explain the denser colonizations of Nov. 5th. and Dec. 31st. The poor colonization at this station is probably due to unusual conditions at the bottom of such a pit, rather than to the greater depth. This was also reflected in the relative sparsity of bottom animals.

(c) *General Observations*.

It will be seen from the above data that slides from stations N B 1 andNB 3; S B 1 - 5, F I 1 - 5 and L S 2 showed similar colonization with regard to/

to species occurring. All stations showed heavy colonizations, although not always at the same times.

N B 7 and S B 7 and 10 were also similar. Numbers were lower and the non-encrusting forms, especially *Navicula pygmaea*, were the most important. Encrusting forms were much less common, and only scattered colonizations by these forms occurred.

The flora at L S 7 and L S 10 was more similar to that at L S 2 than to the flora at 7 and 10 m. stations in Kyle Scotnish. Increases tended to be later and less regular at L S 7 and 10 but encrusting forms with *Navivula ramosissima* in addition as a dominant form, were the main constituents of the flora. Of the non-encrusting forms *Nitzschia closterium* and *Amphora marina* tended to be more important than *Navicula pygmaea*.

Evidence of seasonal variation at each station is summarised in Tables 20 - 26. In general there is a rise in February and again in April, followed by a fairly steady high summer population, a rise again in August, and a slow decrease to the winter level.

The occurrence and seasonal variation in density of individual species of diatoms present is summarised below.

Achnanthes affinis Grunow. Occurred at N B 2 where it was most abundant in March, but regularly present until May, and occasionally at other times. It was recorded/

recorded from F I 1 and L S 10. It showed a marked preference for the upper surface of slides.

Achnanthes Strömi Hustedt. Occurred at L S 2 from November to May, and was dominant in December and February. At L S 7 it was recorded in November and February, and was more numerous in April. It was also recorded from N B 2 (October and May), N B 7 (October), S B 10 (August) and S B 20 (December and February). At L S stations where it was typical, distribution was even throughout the year.

Achnanthes subsalsoides var. nov. Recorded at L S 2 in July. It was a very small form which may have been more numerous but usually unidentified and grouped with other small forms.

Achnanthes sp. nov. Occasionally found at N B 2 February - May, and L S 7 February - June. It was recorded at S B 7 in June. A colonization by a small Achnanthes at N B 7 in August 1946 was ascribed to this species, but the identification is doubtful. It usually occurred in small groups, and tended to colonize the lower surface of the slide. It is probably fairly sessile.

Amphiprora spp. indet. Two species occurred. One was a small form occurring in November 1945 at S B 20/

S B 20. The other was a larger form which was recorded in August 1944 from S B 5.

Amphora acutiuscula Kützing. Occurred in small numbers at N B 2 (April - June and October - November), at S B 20 (April), and at L S 2 (February - June and October, maximum June), L S 7 (February - June and November, maximum April) and L S 10 (February - May, maximum May). Probably a fairly sessile form, showing a preference for the underside of slides.

Amphora coffeaeformis (Agardh) Kützing. Occurred throughout the year at N B 2 (especially February - August, dominant in April, numerous in August), L S 2 (dominant in December, very heavy colonization from May - August), L S 7 (heavy colonization from April - August, dominant June - July), L S 10 (heavy colonzation from June - August). It occurred regularly in smaller numbers at N B 7 and S B 7 and 10. It was recorded at S B 20. This form is probably fairly sessile; slide colonization may depend largely on existing neighbouring colonies; colonies tend to increase with length of exposure.

Amphora costata W. Smith. Recorded at L S 2 (April).

Amphora laevis Gregory. Regular in occurrence in small/

small numbers at all stations. At N B 2 the highest numbers were from May to July, at N B 7 July, and at L S 7 June - July. At L S 10 it was only recorded in May - June. It colonizes slides very soon after exposure.

Amphora macilenta Gregory. Regular in occurrence in small numbers at all stations. It is most frequent from June to September, except at N B 2 (October - January) and L S 2 (October - April). It colonizes soon after exposure.

Amphora marina Van Heurck. Regular in occurrence in small numbers at all stations over most of the year; it colonizes soon after exposure. It seems that high colonizations of encrusting forms favour it.

Amphora Proteus Gregory. Recorded at N B 1 - 3 (August - December 1944, December 1945) and N B 7 (May 1945); at S B 10 (July), L S 7 (April and June) and L S 10 (June).

Amphora truncata Gregory. Recorded at N B 1 - 3 (September 1944, May 1945), S B 10 (July), S B 20 (December), L S 2 (February - March), L S 7 (December and June) and L S 10 (July). Tends to occur in the presence of mud particles on the slides or when encrusting forms are abundant.

Cocconeis Scutellum Ehrenberg. Regular in occurrence /

occurrence all the year round at all stations; at N B 2 it rises to dominance in February and August, at S B 7 in June - July at L S 2 in July - August and at L S 7 in August. It is markedly sessile, and at 2 m. stations it tends to oust all other forms; at deeper stations, though important, it is not so dominant. Colonization probably depends on infection from neighbouring colonies and increases in density with length of exposure. It normally colonizes the upper surface of slides (c.f. Godward, 1934) and colonies on the underside probably originate by migration from above.

Diploneis spp. indet. Recorded at N B 1 - 3 (November 1944, 1945), L S 2 (April, August), L S 7 (August), L S 10 (June), and at S B 20 (December).

Grammatophora sp. indet. Recorded at L S 7 (June and August) and L S 10 (August).

Gyrosigma rectum Donkin. Recorded at N B 2 (August - September), S B 7 (June), L S 2 (June - July) and L S 10 (May, August), in presence of mud and debris.

Licmophora sp. indet. Recorded at N B 1 - 3 September - December 1944, May 1945, April, August, September 1946), at S B 1 - 3 in higher numbers (August - December 1944, May 1945) at F I 1 (December 1944), at

L S 2/

L S 2 (June - August) and L S 7 (April, July - August), and at S B 20 (October). Probably only colonizes from nearby weed.

Melosira sulcata (Ehrenberg) Kützing. Recorded at N B 1 (September, November 1944), S B 1 - 3 (December 1944) and F I 1 (September, November 1944). Some of these may have been moribund as were a number of chains recorded later.

Navicula bahusiensis (Grunow apud Cleve and Grunow) Grunow var. arctica Grunow. Regular in occurrence in small numbers all year at N B 2 (maximum October) and recorded at times at all other stations. The "peak" of 625 per sq. mm. in August at L S 7 may have been a small Navicula of another species. This is probably a fairly sessile form.

Navicula bahusiensis var. bahusiensis (Grunow apud Cleve and Grunow) Ross ms. Occurred regularly all year at N B 2 (maximum April, and also June and August); less frequent at all other stations, but large colonies were recorded at N B 7 (August), S B 7 (June), L S 2 (May - August), L S 7 (April and August) and L S 10 (August). Probably a fairly sessile form, colonization depending on infection from neighbouring colonies. It often occurs along with other encrusting forms, but tends to be slower in development.

Navicula/

<u>Navicula Bulnheimii</u> Grunow. Recorded in small numbers at N B 2 (March - June, November) and N B 7 (May), S B 7 (June), L S 2 (April - June, October, December), L S 7 (April) and L S 10 (April - May).

<u>Navicula gregaria</u> Donkin. Recorded in small numbers at N B 2 (March - June, October and November) and N B 7 (April), L S 2 (April, August, October) L S 7 (November, April) and L S 10 (April).

<u>Navicula pygmaea</u> Kützing. Recorded at all stations and occurring regularly over most of the year, but most frequent from May to July; smaller numbers at L S stations than in Kyle Scotnish. It colonizes slides very soon after exposure.

<u>Navicula ramosissima</u> (Agardh) Cleve. Occurred as an important encrusting form at L S 7 (May - August, maximum July) and L S 10 (April and June - August). It was recorded between July and September at all other stations, except S B 20 where it occurred in December. It occurred in mucillaginous tubes.

<u>Navicula retusa</u> Brébisson. Occurred regularly in small numbers at all stations over most of the year, except at S B 20 where it was recorded in December. It tended to occur/

occur in patches, but colonized soon after exposure. It also tended to increase in numbers with increases in encrusting forms.

Navicula scopulorum Brébisson. var. belgica Van Heurck. Recorded at S B 7 and 10 (September) and at L S 2 (October, December), L S 7 (December, February, April, August) and L S 10 (July), in the presence of heavy colonizations by other forms.

Nitzschia closterium (Ehrenberg) W. Smith. Occurred in fairly large numbers at S B 1 (August - September 1944, dominant) and at L S 7 and 10 (April - August). At other times and at all stations it was recorded from time to time in small numbers. It was the only pennate form occurring regularly in the plankton.

Nitzschia Sigma (Kützing) W. Smith. Recorded at S B 10 (July), at F I 1 and 5 (September 1944) and at L S 2 (November) and L S 7 November and August). Occasional, in mud clumps etc. It is a very motile form.

Nitzschia sp. indet. (tryblionellid type). Recorded at N B 1 - 3 (December 1944, October 1945, January 1946) and N B 7 (October 1945), S B 5 (August 1944), F I 5 (September 1944) and L S 4 (November), L S 7 (June and August) and L S 10 (August).

Pleurosigma minutum Grunow. Occurred regularly in small/

small numbers over most of the year at N B 1 - 3 and L S 7. Recorded at S B 7 (June, August), L S 2 (August, November) and L S 10 February, May). It is a very motile form, tending to favour well-colonized slides.

Pleurosigma thuringicum (Kützing) Ralfs. Recorded at N B 1 and F I 5 in September 1944; it occurred occasionally elsewhere but was recorded under "Pleurosigma spp."

Tropidoneis sp. indet. Recorded irregularly along with dense colonizations of other forms, at N B 2, S B 7 and L S 2 - 10.

Surface Preference.

Most diatoms colonized both upper and lower surfaces of slides. Generally, however, the lower surface tended to be more heavily colonized than the upper, possibly because of its proximity to the mud surface. Achnanthes sp. nov., Amphora acutiuscula, Navicula Bulnheimii and Navicula gregaria regularly colonized the lower surface rather than the upper. Two forms, however, favoured the upper surface - Achnanthes affinis and Cocconeis Scutellum.

(ii) Slides from Loch Craiglin.

Slides were laid out in Loch Craiglin in Series A - F covering the period April 3rd. to November 20th., 1944. Details of the colonization are given in Tables 27 - 29.

Series A, May 1944. Two slides were examined from 1 m. and 3 m., and three from 5 m. after

43/

43 days exposure. Differences between the two slides from 1 m. and 3 m. may be due to different surfaces having been examined, or to grazing. At 1 m. (one slide) there was a heavy colonization by *Cocconeis*, *Placentula* with *Cocconeis Scutellum*, *Amphora coffeaeformis* and numerous small unidentified forms. The 3 m. and 5 m. slides were only lightly colonized.

Series B, June - July 1944. At 1 m. there was a heavy colonization by *Cocconeis Placentula* with *Achnanthes* sp., *Amphora coffeaeformis*, and *Mastogloia pumila* in high numbers. At 3 m. a similar but heavier colonization occurred earlier, but *Mastogloia* was absent and *Navicula banusiensis* present in smaller numbers. No slides were collected at 5 m.

Series C, July - August 1944. Colonization was much lighter. *Mastogloia pumila* was the most important form at 1 m. At 3 m. *Amphora Proteus* and *Pleurosigma thuringicum* occurred. Colonization at 5 m. was very weak.

Series D, August - September 1944. At 1 m. *Amphora coffeaeformis* became dominant. *Mastogloia pumila* was less numerous and *Mastogloia elliptica* more important. There was also a patch of *Navicula banusiensis*. At 3 m. colonization was restricted to a few

Amphora/

Amphora Proteus; the reduction in numbers may be correlated with a sharp fall in the oxygen content of the water recorded by Marshall and Orr (1947). Numbers at 5 m. remained low.

Series E and F, September and November 1944.

Colonization was almost nil, except at 5 m. where it was slight.

Out of twenty-one species of diatoms which were identified as members of this flora, only ten were also found in Kyle Scotnish. The occurrence of diatoms in Loch Craiglin is summarised below. Those found on Loch Craiglin slides but not Kyle Scotnish slides are marked with an asterisk.

* Achnanthes adnata Bory. Recorded at 1 m. in May, July and September, and at 3 m. in August.

Achnanthes sp. nov. This was the same species as was recorded in Kyle Scotnish. It occurred in small groups at 1 m. (May - June), 3 m. (May - August, especially on slides lifted on June 28th. and July 12th.) and 5 m. (August).

Achnanthes spp. indet. This included at least two small species of which by far the most common was a form closely resembling Achnanthes orientalis Hustedt. These species formed dense colonies in June and July at 1 m. and 3 m. and were recorded at 5 m.

* Amphiprora/

* *Amphiprora* sp. indet. A species different from the Kyle Scotnish forms, recorded at 3 m. in June.

Amphora coffeaeformis (Agardh) Kützing. Regularly occurred at 1 m. and heavy in July and September; at 3 m. it took part in the heavy June - July colonization; it was recorded at 5 m.

Amphora laevis Gregory. Recorded at 5 m. (May).

Amphora Proteus Gregory. Recorded in small numbers at 3 m. from June to August.

* *Cocconeis Placentula* Ehrenberg. Regularly occurred at 1 m. (heavy in May and July) and 3 m. (May - August, maximum June 28th.); it was present in small numbers at 5 m. This form largely took the place of *C. Scutellum* in Kyle Scotnish. It probably colonized from surrounding weed.

Cocconeis Scutellum Ehrenberg. Regularly occurred in small numbers at 1 m. and 3 m. along with *C. Placentula*.

Diplonies sp. Recorded at 3 m.

* *Mastogloia elliptica* (Agardh) Cleve. Regularly occurred at 1 m. (July - September); an isolated colonization at 3 m. in June; recorded at 5 m.

* *Mastogloia pumila* (Grunow) Cleve. Regularly occurred at 1 m. (July - September) becoming dominant after the decline of *Cocconeis*; recorded/

recorded at 3 m. (May) and 5 m.

* *Navicula abrupta* (Gregory) Donkin. Recorded at 1 m. (August) and 3 m. (June).

Navicula bahusiensis (Grunow apud Cleve and Grunow) Grunow var. *bahusiensis* (Grunow apud Cleve and Grunow), Ross ms. Occurred at 1 m. (September 5th.), 3 m. (June - July) and 5 m. (recorded May and September).

**Navicula gothlandica* Grunow. Recorded in small groups at 1 m. and 3 m. (June 18th. only); recorded also at 5 m.

Navicula pygmaea Kützing. Recorded at 3 m. and 5 m.

Navicula retusa Brébisson. Recorded at 5 m. (September).

Nitzschia closterium (Ehrenberg) W. Smith. Recorded at 5 m.

Pleurosigma thuringicum (Kützing) Ralfs. Recorded at 3 m. (July - August) and once at 5 m. It appears to take the place which *P. minutum* holds in Kyle Scotnish.

* *Rhabdonema minutum* Kützing. Recorded at 1 m. (May).

* *Rhopalodia musculus* var. *constricta* W. Smith. Of regular occurrence at 1 m. (July - September), and recorded at 5 m.

* *Stauroneis Gregorii* Ralfs. Occurred regularly in small numbers at 3 m., less so at 1 m., and was recorded at 5 m.

* Synedra/

* Synedra pulchella (Ralfs) Kützing. Occurred in small numbers at all stations.

In addition to the above species, several unidentified species of Navicula and Pleurosigma occurred.

It will be seen from the above data that the flora of Loch Craiglin was different from that of other Loch Sween stations. In addition, the three stations sampled differed more between themselves than did stations outside; the 3 m. station differed from 1 m. chiefly in the relative absence of Mastogloia spp. and Rhopalodia musculus, and in the presence of Amphora Proteus and Pleurosigma thuringicum; the 5 m. station more nearly resembled 1 m. in the composition of the flora, and was poorly colonized.

(iii) Slides from deep-water stations.

In order to gain some idea of the depth to which bottom diatoms can exist, slide trays were laid in Loch Sween at 22 fathoms and in Loch Fyne at 60 fathoms from January 23rd. to February 13th. 1946, and in Loch Sween, 22 fathoms, from July 8th. to August 1st. and 12th.

On all except one of the Loch Sween slides small individuals of Cocconeis Scutellum were observed, at least some of which showed chloroplasts. In addition the August 1st. slide (upper surface) had one/

one Navicula pygmaea, probably alive, and the lower surface slide had an unidentified small naviculoid form as well as several small ascidians.

The Loch Fyne slides were also sparsely colonized by a few scattered individuals of Cocconeis Scutellum.

(iv) Vertical distribution of diatoms in the mud.

From December 6th. to 17th. 1945, a covered breffit of sea water containing a layer of mud from South Basin was placed on the bottom in the narrows of Kyle Scotnish. Two glass slides were inserted into the mud in order to study the colonizing activity in the vertical direction at the mud surface. The results are given in Tables 30 and 31.

The area of densest colonization was 1 - 3 mm. above the surface of the mud. Below the mud surface numbers fell off rapidly to zero, while above it they fell more gradually to what appeared to be a stable level.

There was an interesting variation between individual species in the area of colonization. Amphora macilenta, Navicula bahusiensis var. arctica and Navicula pygmaea colonized at or below the mud surface. Amphora marina, Navicula bahusiensis var. bahusiensis, and Nitzschia closterium had a higher range. Amphora coffeaeformis, Amphora laevis, Amphora Proteus, Cocconeis Scutellum, Navicula Bulnheimii /

Bulnheimii, Navicula retusa, Nitzschia Sigma, Pleurosigma sp. and others occurred at or above the mud surface.

Under natural conditions water movement is likely to agitate the mud surface, and so make the surface area in effect deeper.

The general conclusion from these experiments that the area of greatest colonizing activity is just above the mud surface was confirmed by colonization experiments of a similar nature in the laboratory.

VI RESULTS OF CORE SAMPLE INVESTIGATION.

Core samples, obtained by the method described on p. 7 , were taken at slide stations in Kyle Scothish and Sailean More during August and September, 1946. Another series taken in March, 1947, was lost in transit.

The quantitative examination of samples of mud proved difficult for two reasons:- (i) particles of mud and detritus tend to clump together, especially when the cover-glass is laid on, thus hiding many diatoms and especially small forms. This was easily demonstrated by crushing a little mud under a cover-glass; diatoms which were uncommon before now appeared/

appeared numerous. (ii) In all except heavily populated muds the proportion of diatoms to mud particles is small; in order to obtain a satisfactory count the mud sample must be sufficiently diluted for diatoms to be visible. This necessitates the counting of relatively large quantities of material and renders the method extremely laborious.

In order to overcome the first difficulty, mud samples were diluted and shaken vigourously for several minutes. If this was still insufficient the mud was allowed to settle and the sediment ground with an agate pestel and mortar; the samples were then diluted and shaken again. Except when very dilute, however, particles still tended to clump together under the cover-glass. To overcome this agar was added to the suspension giving a 1% gel, known quantities of which could be stained and mounted easily on the slide. The necessary dilution proved too great however, for a satisfactory count.

A number of counts were made on drops of a known quantity and dilution which were mounted on a squared slide and the mud particles broken up by pressing the cover-glass. In a fairly richly populated mud a large enough area could be covered to give a satisfactory count. An advantage of this method was that live material could be used. It proved too laborious, however, for an adequate number of samples to be treated in this way. The only result worth/

worth quoting is for N B 7 where an estimate of 1,850 living diatoms per sq. mm. of mud surface was obtained; this figure confirms later ones.

The method finally used was to boil samples of mud in concentrated sulphuric acid. They were then oxidised with hydrogen peroxide, cleaned by centrifuging, and drops counted on a haemacytometer slide. This method served to concentrate the material and break up clumps. Its disadvantages were that it was impossible (except where frustules were broken) to distinguish between frustules which had been alive and those which had been empty. Further, live frustules were frequently (but not always) separated by the acid into their two valves, so that single valves had to be taken into account. As noted by Petersen (1943) large diatoms are more liable to fall apart than small ones.

The results of core sample counts using this method are given in Tables 32 and 33. Two cores were counted from N B 2, three from N B 7, two from S B 7, one from S B 10, three from S B 20, two from Loch Sween 22 fathoms, and four from L S 10. Many attempts to obtain core samples from L S 2 and L S 7 failed on account of the loose sandy nature of the bottom deposit. Of the samples at L S 10, three were taken from one place, and one from a point a little way off.

The figures given for the total number of diatoms per sq. mm. of mud surface are only very approximate/

approximate, but they show, nevertheless, a fair measure of agreement. The figures given under separate species are the total number of each counted in each sample, and are based on six haemacytometer counts.

In an attempt to estimate the proportion of living to dead material, a series of samples were examined from the raw material and rough counts made. The proportion of empty frustules observed by this method varied between 33% and 48%, average 43%. In practice this applied mainly only to larger forms since smaller species were rarely seen by this method. Even taking this proportion into account, however, the core sample counts indicate a fairly high population of bottom diatoms in the mud. It is probable that all individuals of Cocconeis Scutellum observed in the counts were either dead or moribund, since the mud did not represent their natural habitat.

In an attempt to confirm the observation of diatoms on slides in deep-water, a series of core samples were taken at Millport in April 1948, at depths of 20, 40 and 60 fathoms. Examination of these samples revealed only empty frustules of Navicula abrupta. A number of sub-samples were cultured in "Erdschreiber" at various dilutions, but the only diatom which developed was Skeletonema originating presumably from resting spores which had sunk to the bottom.

VII FEEDING EXPERIMENTS.

A number of feeding experiments were carried out to study the importance of bottom diatoms as food for animals. The animals used were the phyllopod crustacean *Artemia salina*, which is easy to handle in culture, the gastropod *Hydrobia jenkinsi* and a number of very young gastropods probably *Littorina littorea*, and the lamellibranchs *Abra prismatica*, *Macoma baltica*, *Tellina tenuis*, *Aloidis gibba* and *Cardium edule*.

(i) Artemia.

Experiments were carried out using adults and nauplii hatched in the laboratory from eggs of a bisexual strain originating from California. Pure cultures were used of *Nitzschia ? dubiiformis*, *Nitzschia affinis*, *Stauroneis amphoroides*, and *Amphiprora paludosa* var. *duplex*, in crystallizing dishes. Six to ten adult *Artemia* were washed in sterile sea water and put into each dish. Gut contents and faeces were examined from time to time. The gut was found to be packed with diatoms, and the faeces with empty frustules when kept in cultures of *Nitzschia* or *Amphiprora*. Those in *Stauroneis* cultures, although they ingested some diatoms, did not appear to digest them and the hind-gut and faeces contained dead but apparently undigested diatoms. All the *Artemia* in *Stauroneis* cultures died in a few days. Those in *Nitzschia* cultures were kept for two months, while two survived in Amphiprora cultures for five months.

Three series of feeding experiments were carried out with Artemia nauplii, using the same diatoms as with the adults. In the first two series newly hatched nauplii were washed in successive changes of sterile sea water and six put into each dish of culture, as well as six into a dish containing only sea water with "Erdschreiber". In the third series nauplii were washed by the method used by Bond (1933) of holding them on bolting silk and pouring sterile sea water over them. In addition to the four diatom cultures, cultures of yeast and Chlamydomonas were used in this series.

The results of these experiments are given in Table 34 along with some of Bond's results for similar experiments. The instars were identified from the paper by Heath (1924). The growth rate varied with the food material used, the rate in Amphiprora cultures being equal to that in yeast, while Nitzschia cultures gave a lower rate. Stauroneis again appeared unsuitable as food. Faeces were examined; pellets from Amphiprora and Nitzschia affinis cultures were packed with empty frustules, those from Nitzschia ? dubiiformis cultures (with a lower growth-rate in the nauplii) seemed to contain fewer, while those from Stauroneis cultures contained relatively few empty frustules. Nauplii in Amphiprora cultures were brought up to maturity.

(ii) Hydrobia.

A large number of Hydrobia were kept in a tank of muddy sand in the laboratory. Faeces examined were formed from indeterminate particulate matter. The gut of one individual, however, contained empty frustules of a small diatom.

A number of individuals were isolated for twenty-four hours in sterile sea water, and then placed for two days into pure cultures of the same diatoms as were used in the Artemia experiments. Faeces which were examined afterwards were again composed of unidentifiable particulate matter with some chloroplast material present; only individuals from the Nitzschia affinis culture had recognizable diatom remains in the faeces.

A number of Hydrobia were washed in sterile sea water, scrubbed free of encrusting algae, etc. on filter paper and weighed in groups of eight. They were then washed again in 30% alcohol in sterile sea water, rinsed, and each group of eight put into a crystallizing dish containing food culture. Two dishes each were used of Amphiprora and the two Nitzschias and one each of Stauroneis and sterile culture medium. They were weighed again and washed after 14 days, 40 days, and 62 days, and the results are given in Table 35. Owing to a high mortality the results are rather inconclusive. They do seem to show, however, that Hydrobia can be maintained in a pure culture of diatoms. Some of the deaths and

lack/

lack of growth may be ascribed to the fact that the shellfish frequently climbed out of the water up the glass sides of the vessels, and remained there for considerable periods. All the cultures became contaminated with bacteria and green algae after the last weighing.

(iii) <u>Small Gastropods</u>.

About twenty very small gastropods, probably <u>Littorina littorea</u>, were placed in pure cultures of the same four diatoms where they were observed feeding actively, and left for periods varying from two days to three weeks. Faeces and gut contents were examined. Those in <u>Amphiprora</u> cultures died after four days, and neither faeces nor gut contents gave any conclusive result, probably on account of the fragile nature of the frustule which is sometimes very difficult to see. Those in cultures of <u>Nitzschia</u> thrived well; faeces and gut contents contained some empty or broken frustules and many which were apparently untouched. Those in <u>Nitzschia affinis</u> cultures died after two weeks but both faeces and gut contents contained many empty and broken frustules. Those in <u>Stauroneis</u> cultures lived over the whole period of three weeks and both faeces and gut contents were packed with empty frustules.

Here again there appears to be a curious variation in the species most readily available for food.

(iv) *Abra prismatica*.

A number of these molluscs was kept for over a year in a tank of mud in the laboratory. They were frequently observed feeding with their trunk-like inhalent siphons on the surface layer of the mud, which was rich in diatoms. The faeces were examined from time to time, and contained an almost exact replica of the mud flora, except that all frustules were empty, whereas very few were empty in the mud. The main species present were a small species of *Epithemia*, and *Nitzschia closterium*, along with small species of *Navicula*, *Nitzschia*, and *Diploneis*. One or two *Abra* were kept in a breffit containing a different mud where the flora included a number of larger species of *Navicula* (including *Navicula retusa*) and *Pleurosigma*, and *Nitzschia Sigma*. In the faeces these forms were usually present but untouched, while smaller forms were all empty.

Several attempts were made to feed *Abra* in pure cultures but they refused to do so. A culture was also made up of sterilized mud innoculated with *Nitzschia affinis*, but here the *Abra* all died without feeding.

(v) *Aloidis gibba*.

Eighteen *Aloidis* were kept in a tank of mud for several months. Although they lay with their siphons open much of the time, there was very little evidence of feeding. Only one of several animals opened/

opened showed a number of small diatoms in the region of the digestive diverticula. It is possible that the mud in the tank was too still and compact to be easily taken in by their siphons. Attempts to feed them in pure or mud cultures failed, as under these circumstances they did not even open.

(vi) Tellina tenuis.

Two Tellina which had been feeding actively in a tank of muddy sand were isolated and faeces examined. They were found to contain much indeterminate matter with a few empty frustules, and what appeared to be broken remains of frustules. The gut contents were similar.

(vii) Macoma baltica.

Several specimens of Macoma which had been feeding in the same tank as the Tellina were isolated and faeces examined. As in Tellina there was much indeterminate matter and many broken and splintered frustules, quite unlike anything seen in the mud. But there were also numbers of empty, unbroken frustules of Nitzschia closterium and small species of Navicula, and occasional frustules containing chloroplasts. None of the larger diatoms which occurred in the sand were present, at least as complete frustules. These shellfish also did not feed in pure cultures.

(viii) Cardium edule.

Three/

Three *Cardium* were isolated from the same tank as *Macoma* and *Tellina*. The faeces here made an interesting comparison with that of *Macoma*. A large concentration of diatoms, representing a replica of the natural sand flora, was present and many were alive, while some were dead but undigested; those identified were *Amphora coffeaeformis* (all empty), *A. laevis* (almost all dead but undigested), *Cocconeis Scutellum* (mostly dead, some undigested), *Diploneis* sp. (some alive, mostly undigested), *Navicula gregaria* (about 50% empty, some alive), *N. pygmaea* (mostly dead but undigested), large *Navicula* spp. (50% empty, the rest mostly dead), small *Navicula* spp. (mostly empty, some alive), *Nitzschia closterium* (50% empty, the rest mostly alive), *Nitzschia* sp. (tryblionellid type, dead but undigested), and *Tropidoneis* sp. (dead but undigested). Generally speaking small diatoms were either digested or alive, while large ones were dead but undigested. In addition to the diatoms (which were far more numerous and varied than in *Macoma*), there was some indeterminate matter though not so much as in *Macoma*. The occurrence of living organisms in the faeces of this form is in line with previous experiments when *Cardium* was fed in cultures of *Chlamydomonas* and a large proportion of live material occurred in the faeces.

VIII DISCUSSION AND CONCLUSIONS.

Previous work on bottom diatom populations has been largely confined to qualitative observation. Much of this work is summarised by Kolbe (1932) in his outline of diatom ecology, where he indicates many lines for further research. As a result of his work and later research along similar lines, the best known field in diatom ecology is probably the constitution of the diatom population in relation to salinity of the water. Petersen (1943) refers to one or two authors who have made counts of diatoms, but it seems that such work has usually been done on oxidised material.

Mare (1942a), in her study of a marine benthic community, made a census of bottom diatoms by a dilution culture method modified from that used by soil microbiologists. As she herself states, however, results obtained by this method must be treated with caution, as both the numbers and composition of the flora obtained may differ substantially from that occurring naturally in the mud.

A number of workers have studied the settlement of diatoms on surfaces. Wilson (1925) studied the algal succession on wooden blocks, and also on cleared rock surfaces as did Bokenham and Stephenson (1938). The main body of work along this line, however, has been done by students of marine fouling communities. In America, Coe (1932),

Coe,

Coe and Allen (1937), and Scheer (1945) used wooden and cement blocks, cement plates, and glass plates. Scheer concluded that no differences in settlement were to be found on different materials. Also in America, Lackey (1936) obtained heavy colonizations of diatoms on glass Syracuse dishes suspended near the bottom. In this country the recent work of the Marine Corrosion Sub-committee at Millport, Caernarvon and other stations has included the study of diatom fouling on steel panels, and other surfaces. Mare (1942 b), in contrast to Scheer, records that bacteria and some diatoms, notably *Achnanthes* sp., were scarcer on glass than on other surfaces.

The flora which the above workers were concerned with was similar to that colonizing Loch Sween slides in that sessile forms were most important, but rather different in species composition. Coe and Allen give a list of sixty species few of which occurred in Loch Sween; of fourteen which were abundant only two - *Cocconeis Scutellum* and *Nitzschia closterium* - were common in Loch Sween, while two others were recorded occasionally - *Nitzschia longissima* and *Rhabdonema minutum*. The others are small species of *Navicula* which were unidentified, *Navicula grevillei* which resembles *Navicula ramosissima* *Achnanthes longipes*, and species of *Licmophora*, *Fragilaria*, *Grammatophora*, *Striatella* and *Synedra*. Less common forms included several similar to Loch Sween forms.

The/

The flora recorded in the Marine Corrosion Sub-committee studies is similar. All the above forms are recorded by Fritsch (1942), Mare (1942 b) or Bishop (1946), with the addition of *Amphiprora* sp., *Navicula ramosissima* (very common), and species of *Biddulphia*, *Melosira*, *Gyrosigma* and *Bacillaria*. Mare and Pyefinch (1942) record small species of *Amphiprora* and *Amphora* in bacterial slime.

It seems likely that the differences in species between these floras and that found in Loch Sween slides was, at least in part, due to the fact that they were colonizing surfaces closer inshore than the Loch Sween slides, and usually at some distance from the bottom. The origin of this colonization would probably be chiefly the epiphytic diatom population of inshore higher algae such as *Fucus*, *Laminaria* etc. This is to some extent borne out by the greater similarity to this flora of the slide and mud sample flora of Loch Craiglin, where weed was abundant. In Kyle Scotnish *Licmophora* was only common at 1 m. and 3 m. in South Basin, where there was also much weed. The species recorded by Wilson (1925) and Bokenham and Stephenson (1938) also belonged to this inshore type.

The floras recorded in the above investigations resembled Loch Sween floras in that the dominant forms colonizing such surfaces were characteristically sessile forms.

Recently/

Recently a series of investigations on the diatom flora of certain rivers has been carried out by Butcher (1931, 1932, 1940, 1946) using a technique similar to that employed in the present investigation. Glass slides (3" X 1") were submerged in a photographic printing frame, held usually flat but sometimes vertical; they were left for twenty to thirty days and counted direct, or if colonization was dense the growth on 200 sq. mm. was scraped off and suspended in a litre of water before counting. The quantitative results which he obtained were comparable with those of the present investigation. The dominant member of the flora was again a markedly sessile form - Cocconeis Placentula. This method was also used by Godward (1934), investigating epiphytic algae, to obtain material for identification.

It seems probable that three external factors were of importance in the variation between floras of the bottom, and depth. These factors are considered in turn.

(i) Salinity.

The effect of salinity on the composition of diatom floras was studied by Ko~~bl~~lbe (1932), who developed what is known as the Halobion system (summarised, 1932), in which diatoms are classified into groups according to the optimum range of salinity in which they occur. These groups are (a) Euhalobous forms, which have an optimum salinity range of 30 - 40‰; (b)/

(b) Mesohalobous forms with optimum range 5 - 20‰; and (c) Oligohalobous forms occurring in water with a very low salt concentration. The oligohalobous group is further divided into halophilous forms preferring slightly brackish water, indifferent forms (the majority fresh-water) and halophobous forms which are strongly stenohaline. This system has been developed since by Hustedt (1939), Petersen (1943) and others. The diatom populations of different stations are analysed by Petersen and arranged under the halobion groups as number of individuals and as species so as to give a frequency distribution which is described as the Halobion Spectrum.

Halobion spectra have been prepared for the floras at N B 2 and L S 2, and at the three stations in Loch Craiglin; they are given in Tables 36 - 40. Halobion ratings for different species are from Hustedt (1939) and Petersen (1943) and are given on pages 9-11. It is doubtful, however, if the slide method of sampling is a fair method of obtaining data for these spectra in view of the unequal development of sessile and non-sessile forms (discussed later on p.64); a more accurate determination might be obtained by combining slide data with core sample data. These spectra seem to suggest, however, that salinity does not account for the main differences in the composition of the flora at the stations analysed.

(ii)/

(ii) Nature of the bottom.

This is probably the most important factor affecting the distribution of diatoms in Loch Sween. Its importance has already been noted in discussing the floras recorded by workers on marine fouling.

It was observed in the course of the slide investigation that there was a general resemblance between the diatom population on slides from N B 2, S B 1 - 5, and L S 2 - 10, in that they were frequently dominated by markedly sessile forms. Similarly, N B 7 and S B 7 and 10 slides resembled each other in the relative scarcity of such forms. This can be correlated with the presence or absence of weed, gravel, and sand surfaces which these forms colonize under natural circumstances.

Two diatoms colonized chiefly the upper surface of slides - *Achnanthes affinis* and *Cocconeis Scutellum*. *Achnanthes* was only numerous at N B 2; *Cocconeis* was an important form at all stations from 1 m. - 3 m. (where weed was present) and at L S 7 but was much less important at L S 10; at N B 7 and S B 7 and 10 it was irregular. Godward (1934), working with *Cocconeis* cultures on aquatic plants in the laboratory, noticed that reproducing individuals tend to fall off the plant on to any substrate beneath. She laid glass slides horizontally and vertically on the bottom of the vessel and found that *Cocconeis* colonized only the horizontal one, and multiplied very quickly. This is apparently the method/

method by which *Cocconeis* is distributed, as it is a sessile, non-motile form. The distribution of these two diatoms, and in the case of *Cocconeis* the method of colonization, seem to suggest that they occur naturally as epiphytes on weed. *Cocconeis* was only observed in the sea on weed; it must persist in mud in some form, however, as it occasionally colonized slides on the lab. from mud or sand.

The two other important encrusting forms which occurred on slides were *Amphora coffeaeformis*, and *Navicula bahusiensis*. They were more regular in their occurrence, and plentiful on slides from stations where gravel or sand was present. They colonized both sides of slides but tended to favour the underside. It seems likely that these forms occurred naturally on gravel, shell fragments or sand grains. *Navicula bahusiensis* var. *arctica* was observed on sand from N B 2, forming a dense growth on some faces of sand grains. Remane (1933) also recorded sand grains covered with small diatoms.

Navicula ramosissima which became a dominant encrusting form on slides from L S 7 and 10 (see Tables 25 and 26) seems to colonize most types of surfaces. Workers on marine corrosion found it as a common colonial form occurring in mucillaginous tubes, but Harris (in the press) has seen it forming a film on exposed surfaces. Nelson (1947) records it on Cape May tidal flats forming a film over sand grains. It is surprising that this form was not

more/

more common on slides.

It was characteristic of these encrusting forms that they tended to increase in numbers with increased length of exposure. Other species did not usually do this; they colonized slides quickly and the population remained at a fairly stable level. Such forms were Navicula pygmaea, N. retusa, N. gregaria, N. Bulnheimii, Amphora laevis, A. marina, A. macilenta, and the more irregular Nitzschia closterium, together with a few unidentified species of Navicula and Nitzschia. Forms in this group occurred at all stations, including N B 7 and S B 7 and 10. Occasionally they increased with an increase in encrusting forms. It seems likely that these forms are members of the regular mud flora. Some of them e.g. Amphora spp. are probably sessile or semi-sessile on sand grains or shell fragments, but they occurred where such surfaces were rare, and the speed with which they colonized slides suggests that they were common in the mud. The above conclusions were borne out by the flora of mud from core samples. This might be expected to give the most accurate picture of the mud flora, and it is significant that the dominant forms were the most actively motile - Navicula spp. and Nitzschia spp.

In addition to the "mud forms" listed above was a number of larger forms, mostly free-living in the mud; these forms occurred occasionally, usually when the slide was heavily colonized with encrusting forms/

forms or when it was covered with mud or detritus. It seems likely, that when large numbers of encrusting diatoms are present, the mucus which they secrete binds mud and organic particles to the slide. Large forms which might otherwise fall off the slide when it is brought out of the water, under these circumstances stick to the slide. This is borne out by the fact that (a) the heaviest diatoms found on slides - large species of *Pleurosigma* - although not uncommonly seen in mud samples, were only found on the slides in presence of large quantities of mud or detritus; and (b) heavy chains of *Melosira sulcata* and similar forms, though occasionally seen in mud samples, never occurred on slides.

Such forms were large *Navicula* spp. (including *N. Scopulorum*, *N. palpebralis* and *N. Cyprinus*), *Pleurosigma* spp., *Gyrosigma* spp., *Amphora Proteus*, *A. truncata*, *A. costata*, *Tropidoneis* sp., *Diploneis* spp., and *Nitzschia* spp. (including *N. Sigma* and *N. spathulata*). Some of these such as *Pleurosigma minutum*, *Amphora Proteus* (especially small individuals), small *Diploneis* spp., and *Nitzschia Sigma*, must be regarded as "border-line" cases since they often occurred on slides which were not densely colonized.

The diatoms colonizing slides in Loch Sween can therefore be roughly classified according to habitat as:

(i) Encrusting forms, multiplying to give dense/

dense colonies:

(a) forms sessile particularly on weed (*Cocconeis*).

(b) forms sessile or semi-sessile on gravel, shell fragments, sand grains etc. *Amphora coffeaeformis*, *Navicula bahusiensis*, *N. ramosissima*).

(ii) Forms occurring regularly in the mud, sometimes numerous but not forming dense colonies:

(a) forms sessile or semi-sessile, particularly on weed (*Licmophora*, *Achnanthes affinis*).

(b) forms sessile or semi-sessile on shell fragments, sand grains etc. (e.g. *Amphora* spp. and possibly *Navicula pygmaea* and *Diploneis* spp.);

(c) More or less active, free-living in the mud or on the surface of weed, gravel, shells etc. (e.g. *Navicula* spp., *Nitzschia* spp., *Pleurosigma* spp. *Gyrosigma* spp.).

To complete this habitat classification there should possibly be added tychopelagic forms, such as *Melosira* and other chain forms, which lie in the mud or on surfaces but are neither strictly sessile nor active.

No position was suggested for *Achnanthes* spp. such as *Achnanthes Strömi*; it is probable that they/

they fall into (ii) b however.

There are not enough data available to classify Loch Craiglin diatoms according to habitat. The 1 m. and 3 m. stations were overgrown with weed, and it is likely that weed-living forms were most important.

(iii) Depth.

Between 1 m. and 10 m. there was no evidence that depth has much effect on the composition of the flora, except indirectly through its influence on the nature of the bottom deposit and the presence of higher algae. Nor is it likely that depth was directly a limiting factor on the flora at SB20.

Evidence of the presence of living diatoms in deeper water is very scarce. Mare (1942a) records Cocconeis sp. as being quite abundant at 72 m. in the English Channel, and also that a large naviculoid developed in culture from mud at 113 m. near the mouth of the Channel.

Evidence from the present investigation is likewise slight, but the fact that slides were colonized if only very slightly at c. 110 m. in Loch Fyne in January bears out Mare's suggestion that the compensation point of bottom diatoms is probably much lower than that of planktonic forms. At greater depths the density and periodicity of the phytoplankton population is likely to be a factor of importance, on account of its effect upon the transparency/

transparency of the water.

The above three factors are considered to be those primarily affecting the occurrence at any station of different species of diatoms. The inter-relationships of these diatoms in the process of slide colonization throughout the year are influenced by some other factors. Pyefinch (1946), dealing with fouling organisms in general deals with these under the headings of settlement, occurrence, aggression, and persistence. Broadly, these factors also apply to colonization by diatoms alone.

(a) Settlement.

This is defined as the period over which settling stages are available. Data from the present investigation seem to suggest that most bottom diatoms are available over most of the year. Most forms show periods of greater abundance in spring or summer, but these vary somewhat between stations, and only a few seem to be definitely restricted in occurrence to these periods. It is possible that what appears as seasonal variation is in fact due to slight changes in the substrate or other reasons. The data are not sufficient to draw definite conclusions regarding the seasonal occurrence of different species.

While the level of the diatom flora falls in winter, the species composition remains much the same. The bottom diatom flora, in contrast to the phytoplankton/

phytoplankton, appears to be, on the whole, a remarkably stable population. This is in line with seasonal data obtained by other authors. Coe and Allen (1937) recorded a steady diatom population, showing an early spring increase and a smaller autumn increase. Mare (1942a) noted a rise up to May. Bishop (1946) and Pyefinch (1947) recorded a spring increase in March, the population remaining high until September. Similar results for freshwater forms were obtained by Butcher (1931, 1932, 1940) who regarded the winter population as consisting of the forms common in summer though much reduced in numbers. Fritsch (1942) stated that fouling colonies of some diatoms persist in winter but do not disperse.

It seems probable therefore that the bottom diatom flora remains fairly stable throughout the year, but that winter conditions, in particular low temperature and low light intensity, reduce the reproduction rate and colonizing activity. Thus the rate of infection of slides is reduced, and forms which occur regularly but are not numerous in the spring or summer, become only casual colonizers in the winter.

The work of Coe and Allen (1937) and the results of the present investigation so far as they go (c.f. Autumn and Winter 1944 and 1945) seem to suggest that even this pattern of activity is variable from year to year.

(b) <u>Occurrence</u>. /

(b) Occurrence.

It is possible in these investigations to distinguish as Pyefinch (1946) did between "occurrence" in the sense of the original settlement of surfaces by organisms, and their continued presence on artificial substrata. The maintenance of a diatom population on natural or artificial substrata depends on the length of life of the original colonizers and their rate of reproduction. Very little is known about the first factor, so it is probably safe to assume from laboratory experience that individual diatom cells can survive long periods as vegetative cells.

On Loch Sween slides, situated as they were in contact with the mud, these two factors probably operated differently for the two main groups of colonizing diatoms. This was brought out on slides collected on the same day after different periods of exposure; (it was occasionally obscured by other factors such as grazing but see particularly slides lifted on Dec. 21st. 1945, Table 5, and July 2nd. 1946, Table 14). In the absence of other factors non-encrusting forms such as Navicula pygmaea occurred independently of length of exposure. Slides taken out on the same day after different exposures tended to resemble each other more closely in respect of these forms than slides taken out on different days (though in the same series) after the same length of exposure. This/

This suggests that the slide population of these forms even when they are semi-sessile, is the same as the population in the surrounding mud. In fact the population of non-encrusting forms may be regarded as an approximate sample of the surrounding mud population as regards both variety of species and their relative numbers. Under these circumstances the rate of reproduction factor will have the same effect on slides as in the mud. In the case of encrusting forms, however, the slide colony was isolated; infection did not always occur as soon as a slide was exposed, and a colony once started continued to reproduce on the slide, without any such dispersal to the surrounding mud as is responsible for the balance of the non-encrusting population. Thus the density of a colony increased with length of exposure. The density of encrusting forms on slides collected on the same day depended not on the density of the surrounding population but on the intensity of the infection which started the colonies (i.e. the proximity and activity of neighbouring colonies) and the period during which they were able to grow, together with the reproduction rate factor which operated both on the slide colony and parent colonies.

There are no data on rates of reproduction of different species of diatoms. It is possible however that the later development already noted of <u>Navicula bahusiensis</u> as compared with other encrusting forms may be due to a lower rate of reproduction.

Slides/

Slides were not exposed long enough to show how long old colonies could continue to exist after the source of infection had disappeared or died.

In general this factor is more important in colonization by encrusting forms, which are relatively isolated (as are marine fouling communities) than in colonization by non-encrusting forms which represent a regular sample of the surrounding population.

(c) *Aggression*.

The aggressive tendencies of a fouling organism are reflected in the extent to which it is capable of ousting other forms. Highly aggressive species give rise to cases of biological exclusion, (Pyefinch, 1946). The most aggressive diatom encountered on the slides was *Cocconeis*, and in an area where infection by this form occurred it is likely that if left long enough it would have ousted all others, owing to its sessile habit and high reproductive rate. This was almost the case on the slide at S B 1 in Series F (p.15) and at L S 2 in Series S (Table 19 and p.22). In the latter series surfaces less heavily colonized by *Cocconeis* carried higher populations of other encrusting forms. No other diatoms seemed to show this character to any great degree; other encrusting forms were generally found together.

(d) *Persistence*.

This is defined as the extent to which an organism/

organism can withstand competition from another, particularly a more aggressive member of the community. Except in the cases of heavy Cocconeis development all diatoms seemed to exhibit a high degree of persistence.

The above factors contribute to the only type of succession which occurred on the slides. The diatom colonization forms a stage in the marine fouling sequence known as the basal carpet (Harris, 1943). This comprises the diatom population and a bacterial slime on which they settle. Several authors have stressed the importance of a bacterial film in providing a surface for diatom colonization. Zo Bell and Allen (1935) observed larger numbers of micro-organisms on film-coated slides than on sterilized slides; they regarded the favouring influence of film-formers as being due to the provision of a mucillaginous surface and a richer food (or nutrient) supply. Coe and Allen (1937) and Scheer (1945) also recorded a better settlement of diatoms on surfaces with a bacterial film. Scheer, however, stated that the time of maximum increase was not affected by bacteria. Mare (1942b) found no evidence of the necessity of bacterial slime.

The present investigation gave no evidence on this question, since under the conditions of exposure of the slides a bacterial film would presumably always develop naturally. Nevertheless it/

it is worth drawing attention to the fact that such a film may have an influence on diatom colonization.

After the development of the film the first colonizers are usually the common mud forms and especially the more motile ones. This was well seen not only on slides which had been exposed for short periods - the period was generally not short enough - but also on slides which had been recently grazed. It was occasionally possible to see on a grazed slide an area colonized only by a few *Navicula* (including *Navicula pygmaea*); sometimes one or two *Amphora* were present, and the fringe of the area showed the start of recolonization by encrusting forms. These last, particularly *Cocconeis* seemed to recolonize an area fairly slowly unless there was fresh infection, the individuals of the colony usually being fairly close together. This early occurrence of motile forms in the colonization sequence is in line with observations of Wilson (1925) who recorded *Navicula* and *Nitzschia* spp. among pioneer species colonizing cleared surfaces.

Sooner or later, at this stage in colonization, the slide becomes infected with encrusting forms which then begin to multiply. At their highest densities they probably form the final stage in the diatom sequence before the development of higher algae or sessile animals. The large diatoms which, as already mentioned, are found usually on slides with a well developed population,

probably/

probably occur also at a much earlier stage but do not adhere to the slide.

Various periods have been mentioned by investigators as the time necessary for maximum diatom development. Wilson (1925) gave 7 days, Scheer (1945) gave 19 days, and Butcher (1946) with river forms gave 20 - 30 days, or 30 - 40 days in winter or with pond forms. Clearly the time will vary according to the nature of the flora, the proximity and activity of infecting forms, competition, and reproductive rate.

The chief factors affecting the colonization of slides may be summarised as:

(a) factors affecting the nature of the flora - salinity, bottom deposit, weed, depth;

(b) factors affecting the occurrence of the flora - seasonal periodicity, the number and proximity of neighbouring populations;

(c) factors affecting the activity of the flora - temperature and reproductive rate, length of exposure of the slide, aggression, persistence.

It will be evident that as a method for assessing the true nature of the bottom diatom population, the method of colonizing glass slides has several limitations.

(i) In all investigations involving the colonization of surfaces the dominant flora has been composed/

composed of sessile forms. In the case of the present investigations this flora has been drawn from scattered fragments of stone, or shells, sand grains, or weed. The forms concerned have overgrown the natural mud flora. Slides are therefore selective in the flora which they develop.

(ii) The dependence of this flora on neighbouring populations introduces another uncertain factor, since the intensity of the colonization will depend (as already observed) on the number and proximity of these populations - which may be largely a matter of accident in the placing of the slide tray.

(iii) The colonization of slides, depends, in the case of both encrusting and non-encrusting forms, on the activity and reproduction rate of colonizing forms as well as on their absolute number. Thus the colonization of slides in winter may give the impression of a lower population than actually exists; similarly the summer population may give too high a figure.

(iv) There are no data for assessing the degree to which slide populations are influenced by animal activity. Grazing certainly occurs, although to what extent is not known. Faeces often contain live diatoms, and the deposition of such pellets on a slide may cause an unusual concentration of forms.

(v) Tubes of polychaetes, faecal pellets, mud or detritus, particularly in the presence of mucus from populations of encrusting diatoms, may form a suitable habitat/

habitat for large diatoms and cause a concentration of these, and smaller forms. On the other hand when such material is absent from the slide these large forms may fall off.

(vi) These factors, together with the general nature of the colonization, make counts on the population so highly variable that they may well prove unsuitable for statistical treatment such as is desirable for studying populations.

The figures obtained from slide counts, therefore, do not give a satisfactory picture of the actual density of the natural diatom population of bottom mud. They give a reasonably accurate picture of the diatom population on exposed surfaces, such as weed or shells - direct examination of such surfaces has several times shown such a resemblance. They also provide material for the comparative study of different factors affecting diatom communities.

A fully satisfactory method has still to be found. The difficulties of direct searching have already been discussed, and in the past the method has led to highly erroneous results (see particularly Petersen and Boysen Jensen, 1911, p. 14). The limitations of a dilution culture method have also been mentioned. Core sampling seems to provide the best solution if its particular difficulties can be got over.

Work which has been done on the actual numbers of diatoms which occur in the mud has indicated/

indicated that these numbers must be high. Petersen and Boysen Jensen (1911) considered, as a result of direct examination, that their numbers in the mud of Limfjord were very low. More recently however Remane (1933) and Nelson (1947), also from direct observation, have recorded considerable numbers. Nelson refers to a brown diatom scum on Cape May tidal flats.

Figures obtained by colonization methods in the present investigation and in marine fouling investigations, while not giving an absolute value, have indicated that the habitats from which infection has come must have had large populations. One result in particular which emphasizes this is the figure given by Lackey (1936); in 24 hours his Syracuse dishes accummulated diatom populations of over 16,000 diatoms per square centimetre.

Mare (1942 a) calculated a minimal number of 590,000,000 bottom diatoms per square metre in the top half centimetre of mud. This figure is of the same order of magnitude as that obtained from core sample counts in Loch Sween stations.

It appears that the bottom diatom population, in some habitats particularly, is a very considerable one. Data are as yet inadequate to give a true estimate of their numerical importance. It is possible that a combination of several sampling methods might give the best results in such an estimation.

Effect of Fertilizers.

One of the original purposes of this investigation was to see if the bottom flora as well as the phytoplankton increases as a result of fertilization. Most slide series were laid out so as to cover a period before and after fertilization. One or two cases where fertilization may have had some effect are mentioned in the notes on each series, but on the whole no evidence was obtained to confirm such an effect, as the tables show. Even in the cases mentioned the variation was within the range of variations through other causes.

The reason for this lack of evidence may lie in the factors referred to above which make the slide method of sampling unsuitable for quantitative studies.

Another possible reason, however, is that at the mud surface, in contrast to upper water layers, the natural phosphate concentration may not be a limiting factor for bottom diatoms. Figures obtained by Nutman (in the press) in South Basin and in jars of mud suggest that as one approaches the mud surface the phosphate concentration increases significantly. In one jar, for instance, at 5 mm. above the mud surface, the phosphate concentration was 30 mgms. P_2O_5 per cubic metre of water while values for the water above were very low. Ketchum (1939) has shown that the reproduction rate of

Nitzschia/

Nitschia closterium is independent of phosphate concentrations above 39 mgms. P_2O_5 per cu. m. Nitzschia closterium occurred in irregular numbers in Loch Sween and it is possible that the figure for more regularly occurring forms is lower. It also seems likely that at the actual surface of the mud phosphate may always be present, though not in high concentrations, owing to the process of regeneration of nutrients from dead organic material.

Nelson (1947) records that on Cape May tidal flats a great rise in diatom numbers occurred soon after the disappearance of a heavy dinoflagellate population in the plankton (probably due to a temperature drop of 2 - 4°C). He considers it possible that the dead dinoflagellates may have been changed into diatom food by bacterial action, and that the increase in nutrients - a natural fertilization - was responsible for the rise in density of diatoms.

In conclusion, though bottom diatoms may have taken up a share of nutrients available in Kyle Scotnish, the data are insufficient to prove this.

Bottom Diatoms as Food.

In view of the abundance of pennate diatoms which occur on the sea bottom we may enquire into their importance as food for the bottom fauna.

The/

The importance of epiphytic forms as food for grazing herbivores such as gastropods has been recognized for some time. Rauschenplat (1901) found the stomachs of some gastropods filled with bottom diatoms. Their importance is also mentioned by Petersen and Boysen Jensen (1911) and Blegvad (1914). Such animals, however, do not form the most important part of the fauna in most areas, and it is necessary to consider also the importance of the mud flora to animals which normally feed on the mud.

Investigation of this problem was the subject of a series of investigations carried out by Danish workers in the Limfjord. Petersen and Boysen Jensen (1911) as a result of direct examination of the mud, considered bottom diatoms other than epiphytic forms to be relatively unimportant. They considered that the main food of most bottom animals was organic detritus, very largely derived from the breakdown of *Zostera*. Continuing these investigations Boysen Jensen (1914) showed that detritus in Limfjord was almost exclusively derived from *Zostera*, although plankton organisms might be important in the open sea. He found the quantity of "digestible proteids" in the mud to be low, but the quantities of pentosans were considerable. On the evidence of work by other authors on the digestion of pentosan by herbivorous mammals and by the gastropod *Helix pomatia*, he concluded that bivalves were probably capable of digesting pentosan. Blegvad (1914) stated that none of the bottom fauna feed on

pure/

pure phytoplankton and referred to aquarium experiments in which *Prorocentrum micans* was found to pass through the intestines of *Ostrea* and *Mytilus* and emerge alive. He also found that bottom diatoms may pass through alive or unchanged, but adds that these were only found in comparatively small quantities, and occurred only accidentally, mixed with detritus.

Since these investigations were carried out, however, the *Zostera*, which was regarded as being the most important food source for bottom animals, has died out; no evidence has been brought forward to suggest that "detritus"-feeding animals have suffered as a result. Further, Yonge (1926) has shown that the oyster cannot digest pentosans. The presence of live diatoms and other organisms (including *Chlamydomonas*) in the faeces of shellfish has been frequently recorded by other workers and in the present investigation, but cannot be taken as evidence that these organisms are not utilised as food. *Cardium*, *Mytilus*, *Ostrea* and other shellfish have, in fact, been kept for considerable periods feeding only on *Chlamydomonas*. Digestion in these shellfish is largely intracellular and the feeble development of extracellular enzymes accounts for the passage of living organisms undamaged through the gut (Yonge, 1926). On the other hand it has been observed in the present work that empty diatom frustules of more delicate forms such as are common

in/

in the mud (*Nitzschia* spp. and others) are often very difficult to see in water preparations of faeces, even when the animal concerned has been feeding in pure culture; this is much more the case in the examination of faeces from animals feeding on the mud layer. The Danish investigators may only have seen the larger diatoms of the flora in the faeces, and it has been observed that these are frequently undamaged.

The Danish investigators also paid little attention to bacteria in their work. Zo Bell (1936) has demonstrated the periphytic habits of some marine bacteria which were abundant round detritus fragments. It has been shown (Zo Bell and Feltham, 1938) that *Mytilus* and other animals can be maintained on a purely bacterial diet.

Jameson, Drummond, and Coward (1922) directed attention to bottom diatoms by showing that *Nitzschia closterium* is an extraordinarily potent source of Vitamin A. Enormous stores of this vitamin in the tissues of some marine animals led them to conclude that it was derived from some such potent source.

Hunt (1925) made a revaluation of the food of the bottom fauna. He studied the stomach contents of *Pecten opercularis* throughout the year, and found at some seasons large quantities of diatoms including bottom forms. He pointed out that seasonal fluctuation in the composition of the diet of many marine/

marine animals may be responsible for seasonal variation in growth (as indicated, for instance, by growth rings in lamellibranchs). He lists a large number of bottom-living animals of whose diet diatoms formed an important part.

A number of other references to animals which appear to feed on diatoms occur in the literature. Murphy (1923) fed *Oithona* on *Navicula* sp. Lebour (1922) identified the commonest food of larval molluscs as small naviculoid diatoms, *Pleurosigma*, Co~~A~~*scinodiscus* and colonial forms. Similar forms also occurred in decapod crustacean larvae, copepods and other zooplankton organisms. Remane (1933) considers some nematodes to be diatom eaters, and possibly also ostracods which he regards as mud eaters. Lackey (1936) records the predominance of diatom shells in the stomach contents of salps and copepods, and considers diatoms to be part of the food of some large protozoans. Mare (1942 a) quoting personal communications with other authors states that Foraminifera grow on a food supply of diatoms. Nelson (1947) publishes a photograph of the stomach contents of an oyster containing many frustules of *Cocconeis*, *Pleurosigma*, *Navicula*, *Nitschia*, and *Amphora* spp. Coe (1947) in his study of the Pismo Clam (*Tivela Stultorum*) records that solitary diatoms 0.05 - 0.2 mm. long, and smaller, were often ingested in large numbers, but colonial and spiny species were commonly rejected. Digestion of large forms/

forms was aided by migratory phagocytes in the lumen of the gut. He regards diatoms, however, as forming a small part of the animal's requirements.

On the other hand MacGinitie (1935) examined the stomachs of mud-living clams and shrimps, and found diatom frustules were scarce.

In general. the above records, together with evidence collected in the present investigation, seem to suggest that bottom diatoms do form an important part of the diet of many bottom animals. Much more work will be required to show the extent to which they are utilized, and the effect which grazing animals have on the bottom diatom population. Variation in the suitability for food of different diatoms to different animals, as indicated in the present studies of Cardium and Macoma, also deserves further investigation. It has been demonstrated that Artemia, Hydrobia, and small gastropods can be maintained on a diet of pure diatoms, and that Artemia can go through their life history.

Productivity.

In previous work on plant production and the primary conversion of nutrients into organic matter in the sea (summarised by Harvey, 1942) it has been customary to consider only the plankton population, taking as a unit the amount of phytoplankton produced in a column of water under a/

a square metre of surface. It seems, however, that over a large area of the sea floor in coastal areas the mud surface at the bottom is also an important life zone. The depth to which this area extends is as yet unknown but as a nursery ground for many important food fish it has possibly a greater economic importance relative to its area than deeper parts of the sea. This mud surface is the habitat of an actively photosynthesizing population of diatoms contributing to the production of organic from inorganic matter. It is grazed by animals which form part of the diet of fish. It probably also contributes a fairly considerable proportion of the detritus. This diatom population appears to be considerably more stable in numbers and distribution than the plankton population, and so may play an important part in the conversion of inorganic salts into organic matter, and represent an important source of food. In future evaluations of productivity in coastal areas it will be advisable to consider the unit column of water under 1 sq. m. as extending to, and including, the mud surface. (Gross, in the press).

IX SUMMARY.

1. A study was made of the population of bottom diatoms in arms of Loch Sween. These were collected (i) by exposure of glass slides for colonization on the mud surface over varying lengths of time; (ii) direct from the surface layer of a mud core obtained by a core sampling apparatus. A list of the more important forms is given, with notes on their status.

2. The occurrence of different species on the slides is discussed in relation to several factors:

   (i) those affecting the nature of the flora - salinity, the nature of the bottom, the presence of higher algae, and depth;

   (ii) those affecting the occurrence of the flora - seasonal periodicity, and the number and proximity of neighbouring populations;

   (iii) those affecting the activity of the flora - temperature and reproductive rate, length of exposure of the slide, aggression, persistence.

   Halobion spectra were prepared for several stations. A rough classification of diatoms according to habitat was arranged.

3. The limitations of the methods used are discussed in relation to the actual numbers of diatoms/

diatoms present in the mud.

4. The effect of the application of fertilizers on the flora is discussed, and it is concluded that while bottom diatoms may have taken up a share of nutrients available, the data are insufficient to prove this.

5. Experiments to test the suitability of bottom diatoms as food for various animals were carried out, and are discussed along with previous work on this problem. *Artemia* nauplii were raised to maturity on pure cultures of pennate forms, and evidence was obtained that these diatoms are important in the food of molluscs.

6. The position of the bottom diatom population in the productivity of the sea is discussed, and it is suggested that this population may play an important part in the over-all production.

X REFERENCES.

BISHOP, M.W.H., 1946. Second Report on the seasonal settlement of fouling at various exposure stations. Rept. N10/46 of the Marine Corrosion Sub-committee (unpublished).

BLEGVAD, H., 1914. Food and conditions of nourishment among the communities of invertebrate animals found on or in the sea bottom in Danish waters. Rep. Dan. Biol. Stat., 22 : 41.

BOKENHAM, N.A.H., and STEPHENSON, T.A., 1938. The colonization of denuded rock surfaces in the intertidal region of the Cape peninsula. Ann. Natal Mus., 9 (1) : 68.

BOND, R.M. 1933. A contribution to the study of the natural food cycle in aquatic environments. Bull. Bingham Coll. Oceanogr., 4 (4) : 1.

BOYSEN JENSEN, P., 1914. Studies concerning the organic matter of the sea bottom. Rep. Dan. Biol. Stat., 22 : 1.

BUTCHER, R.W., 1931. An apparatus for studying the growth of epiphytic algae with special reference to the River Tees. Trans. N. Nat. Union, 1 (1) : 1.

—— 1932. Studies in the ecology of rivers - II. Ann. Bot., 46 (184) : 813.

—— 1940. Studies in the ecology of rivers - IV. J. Ecol., 28 (1) : 210.

—— 1946. Studies in the ecology of rivers - VI. J. Ecol., 33 (2) : 268.

CLEVE, P. 1894-5. Synopsis of the naviculoid diatoms. Kgl. Sv. Vet. - Akad. Handl., 26 and 27.

COE, W.R., 1932. Season of attachment and rate of growth of sedentary marine organisms at the pier of the Scripps Institute of Oceanography, La Jolla, California. Bull. Scripps Inst. Oceanogr. La Jolla, Calif. Tech. Ser., 3 (3) : 50.

—— 1947. Nutrition, growth and sexuality of the Pismo clam (Tivela stultorum). J. Exper. Zool. 104 (1) : 1.

COE, W.R., and ALLEN, W.E., 1937. Growth of sedentary marine organisms on experimental blocks and plates for nine successive years. Bull. Scripps Inst. Oceanogr., La Jolla, California, Tech. Ser., 4 (4) : 101.

FRITSCH, F.E., 1942. The algal growth on the panels at Caernarvon. *Rept.N27/42 of the Marine Corrosion Sub-committee* (unpublished).

GAULD, D.T., in the press. A fish cultivation experiment in an open sea loch. IV : The plankton of Kyle Scotnish.

GODWARD, M.B., 1934. An investigation of the causal distribution of algal epiphytes. *Beih. Bot. Zbl.*, 52 (3) : 506

GROSS, F., 1937. The life history of some marine plankton diatoms. *Phil. Trans. Roy. Soc. London*, Ser. B, 228 (548) : 1.

——— 1947. An experiment in marine fish cultivation, I and V. *Proc. Roy. Soc. Edinburgh*, Section B, 63 (1) : 1 and 56.

——— in the press. A fish cultivation experiment in an open sea loch. I : Introduction; VI : Fish growth in Kyle Scotnish.

GROSS, F., RAYMONT, J.E.G., MARSHALL, S.M., and ORR, A.P., 1944. A fish-farming experiment in a sea loch. *Nature*, 153 : 483.

GROSS, F., RAYMONT, J.E.G., NUTMAN, S.R., and GAULD, D.T., 1946. Application of fertilizers to an open sea loch. *Nature*, 158 : 187.

HARRIS, J.E., 1943. First report of the Marine Corrosion Sub-committee : C. - Anti-fouling investigations. *J. Iron and Steel Inst.* 1 : 405.

——— in the press. Report on anti-fouling investigations. *J. Iron and Steel Inst.*, 2 : 154.

HARVEY, H.W., 1942. Production of life in the sea. *Biol. Rev.*, 17 : 221.

HEATH, H., 1924. The external development of certain phyllopods. *J. Morph.*, 38 (4) : 453.

HUNT, O.D., 1925. The food of the bottom fauna of the Plymouth fishing grounds. *J. Mar. Biol. Assoc.*, 13 : 560.

HUSTEDT, F., 1928. In Rabenhorst, *Krypt. Flora Deutschl.*, 7.

——— 1930. In Pascher, *Süsswasser Flora Mitteleur.*, 10 (2).

——— 1939. Die diatomflora des Kustengebietes der Nordsee, vom Dollart bis zur Elbemündung I. *Abh. Nat. Ver., Bremen*, 31 (3).

JAMESON, H.L., DRUMMOND J.C., and COWARD, K.H., 1922. Synthesis of vitamin A by a marine diatom (*Nitzschia closterium* W. Smith) growing in pure culture. *Biochem. J.*, 16 (4) : 482.

KETCHUM, B.H., 1939. The absorption of phosphate and nitrate by illuminated cultures of *Nitzschia closterium.* *Amer. J. Bot.* 26 : 399.

KOLBE, R.W., 1932. Grundlinien einer allgemeinen Ökologie der Diatomeen. *Ergeb. der Biol.*, 8 : 221.

LACKEY, J.B., 1936. Occurrence and distribution of the marine protozoan species in the Woods Hole area. *Biol. Bull.*, 70 : 264.

LEBOUR, M.V., 1922. The food of plankton organisms. *J. Mar. Biol. Assoc.*, 12 (4) : 644.

MACGINITIE, G.E., 1935. Ecological aspects of a California marine estuary. *Amer. Midland Nat., Indiana.*, 16 (5) : 648.

MARE, M.F., 1942a. A study of a marine benthic community with special reference to the micro-organisms. *J. Mar. Biol. Assoc.*, 25 (3) : 517.

—— 1942b. Early stages of fouling. *Rept. N32/42 of the Marine Corrosion Sub-committee I* (unpublished).

MARE, M.F., and PYEFINCH, K.A., 1942. Communities growing on test panels at Millport. *Rept. N32/42 of the Marine Corrosion Sub-committee II* (unpublished).

MARSHALL, S.M., 1947. An experiment in marine fish cultivation : *III*. The plankton of a fertilized loch. *Proc. Roy. Soc. Edinburgh,* Section B, 63 (1) : 21.

MARSHALL, S.M., and ORR, A.P., 1947. Further experiments on the fertilization of a sea loch (Loch Craiglin). The effect of different plant nutrients on the phytoplankton. *J. Mar. Biol. Assoc.*, 27 : 360.

MURPHY, H.E., 1923. The life-cycle of *Oithona nana* reared experimentally. *Univ. Calif. Publ. Zool.*, 22 : 449.

NELSON, T.C., 1947. Some contributions from the land in determining conditions of life in the sea. *Ecol. Monogr.*, 17 (3) : 337.

NUTMAN, S.R., in the press. A fish cultivation experiment in an open sea loch, *II* : Observations on some hydrographic factors in Kyle Scotnish. *III* The nannoplankton and micro-organisms at the mud surface.

ORR, A.P., 1947. An experiment in marine fish cultivation : *II.* Some physical and chemical conditions in a fertilized sea loch (Loch Craiglin, Argyll). *Proc. Roy. Soc. Edinburgh*, Section B, 63 (1) : 3.

PERAGALLO, H. and M., 1897-1908. *Diatomées Marines de France.*

PETERSEN, C.G.Joh., and BOYSEN JENSEN, P., 1911. Valuation of the sea, *I.* *Rep. Dan. Biol.Stat.*, 20 : 3.

PETERSEN, J. Boye, 1943. Some halobion spectra (diatoms). *Kgl. Danske Vidensk. Selskab. Bibl. Medd.*, 17 (9) : 1

PRINGSHEIM, E.G., 1946. *Pure Cultures of Algae,* Cambridge.

PYEFINCH, K.A., 1946. Methods of assessment of anti-fouling compositions. *J. Iron and Steel Inst.*, 2 : 229.

——— 1947. The biology of Ship fouling. *New Biology*, 3 : 128

RAUSCHENPLAT, E., 1901 Über die Nahrung von Tieren aus der Kieler Bucht. *Wiss. Meeresunters. Abt. Kiel,* N.F.5.

RAYMONT, J.E.G., 1947. An experiment in marine fish cultivation : *IV.* The bottom fauna and the food of flatfishes in a fertilized sea loch. *Proc. Roy. Soc.* Edinburgh, Section B, 63 (1) : 34.

——— in the press. A fish cultivation experiment in an open sea loch : *V.* The bottom fauna of Kyle Scotnish.

REMANE, A., 1933. Verteilung und Organisation der beuthonischen Mikrofauna der Kieler Bucht. *Wiss. Meeresunters., Abt. Kiel*, N.F. 21 : 161.

SCHEER, B.T., 1945. The development of marine fouling communities. *Biol. Bull.*, 89 (1) : 103.

WILSON, O.T., 1925. Some experimental observations of marine algal successions. *Ecol.*, 6 (3) : 303.

YONGE, C.M., 1926. Structure and physiology of the organs of feeding and digestion in *Ostrea edulis*. *J. Mar. Biol Assoc.*, *N.S.*, 14 : 295.

ZO BELL, C.E., 1936. Periphytic habits of some marine bacteria. *Proc. Soc Exper. Biol. and Med.*, 35 : 270.

ZO BELL, C.E., and ALLEN E.C., 1935. The significance of marine bacteria in the fouling of submerged surfaces. *J. Bacteriol.*, 29 (3) : 247.

ZO BELL, C.E., and FELTHAM, C.B., 1938. Bacteria as food for certain marine invertebrates. *J. Mar. Research*, 1 (4) : 312.

XI. TABLES.

In tables of slide investigations (1 - 29) figures refer to the average number of diatoms per sq. mm. of slide surface. In most cases slides representing both upper and lower surfaces were examined, and the two figures are given with the upper surface figure above the lower. The letter m indicates that this slide was missing from the series.

TABLE I.

I.

Total numbers of diatoms
collected on slides.

Station				NB			SB			Sailean More			SB20
Depth				1m	3m	5m	1m	3m	5m	1m	3m	5m	20m
Date of Collection		Length of Exposure	Dates and places of fertilization.										
1944	Aug.16	8 days		859	69	9	212	35	400	38		41	
	Sep. 5	28 "											
	" 28	19 "	Sep.11 NB	205	640		448	102	69	625		253	
	Nov.20	45 "	Oct.16, Nov.13 NB	677		30	6308	2	3	342		1	
	Dec.12	11 "		128		17	3	21	0	31	73	3	
	" 27	26 "	Dec.18 NB	23	21	0		14		1			
1945	Mar.29	118 "	Feb.20 NB		2	29	162	86	2				
	May 5	34 "	Apr.3-4 NB	27	15	5	8	124	6	16			
	Oct. 2	4 "		(85		33	32	+	8	3			–
				(79		2	5	+		5	28		+
	" 4	6 "		(		18	4	4		2	9		+
				(55		11	8	91			11		–
	" 8	10 "		(									+
				(									–
					4m.						4m.		
	" 10	5 "	Oct.10 NB	(	18						8		
				(	3						1		
	" 15	10 "		(	19						47		3
				(	319						–		+
	" "	5 "		(	2						19		–
				(	0						32		–
					3m.						3m.		
	Nov.14	9 "	Nov.14 SB	(	10	7		11	25		2	7	18(5 Nov).
				(	26	1		+	–		6	60	–
	" 23	18 "		(	47	17		40	5		36	13	
				(	128	45		2	2		3	–	
	" "	9 "		(	8	0		1	3		16	14	
				(	23	0		9	–		32	11	
				2m.	7m.	10m.	2m.	7m.	10m.	2m.	7m.	10m.	
	Dec.11	6 "	Dec.11 SB	(4	6			3	3	9	12	5	3
				(6	0			3	1	30	3	0	–
	" 21	16 "		(43	0			3	1	7	14	2	1
				(6	0			2	1	–	3	1	–

TABLE I.

Station				NB		SB		KIII			KI
Depth				2m	7m	7m	10m	2m	7m	10m	20m
Date of Collection		Length of Exposure	Dates and places of fertilization								
1945	Dec.21	10 days		(40 (7	3 2	1 0	2 +	8 10	4 -	3 1	6 -
	" 31	10 "		(7 (112	1 2	+ 1	- -	13 635	13 2	1 0	- 34
1946	Jan.10	20 "		(19 (16	2 3	2 1	0 0	- -	- -	- -	- 5
	" "	14 "		(- (-	- -	- -	0 0	- -	- -	- -	- -
	Feb.13	21 "	Feb.11 SB	(412 (53	1 0	+ +	+ 1	6 3	17 276	10 10	- -
	" 22	30 "		(842 (28	4 0	2 1	0 -	53 43	44 40	10 8	3 9
	Mar.27	7 "	Mar. 5 SB " 15 NB	(43 (25				3 48			
	Apr. 2	13 "		(55 (927				6 13			
	" "	21 "		(1 (4	6 10	14 2	1 0	0 0	67 78	20 3	0 1
	" 11	9 "	Apr.10 SB	(56 (68				1 13			
	" "	22 "		(148 (334				8 35			
	" 16	14 "		(341 (1585				7 12			
	" "	27 "		(918 (1985				7 67			
	" "	35 "		(0 (46	29 0	13 2	4 9	0 0	671 1109	231 609	3 1
	May 15	8 "		(37 (464				8 0			
	" 22	15 "	May 21 NB	(57 (128	26 4	12 2	2 3	48 139	518 -	56 344	
	" 30	8 "		(13 (36				32 1			
	" "	23 "		(118 (290				281 329			
	June 6	15 "		(59 (64				- -			
	" "	30 "		(67 (1165	13 2	388 638	+ 3	38 435	456 1012	2 10	
	" 12	6 "		(185 (9				27 1			
	" 19	13 "	Jun.14 SB	(132 (5	13 11	11 4	12 6	297 6	1825 285	158 603	
	July 2	13 "		(28 (35				202 56			
	" "	26 "		(22 (33				726 229			

TABLE I.

Station			NB		SB		KIII			KI
Depth			2m	7m	7m	10m	2m	7m	10m	20m
Date of Collection	Length of Exposure	Dates and places of fertiliz-ation.								
1946 Jul.8	19 days		(40 (226				679 73			
" "	32 "		(101 (23	34 15	95 -	14 9	3 1517	776 859	c.1500 -	
" 18	10 "	Jul.10 NB	(15 (-	- -	- -	17 1	45 297	- -	18 5	
" "	29 "		(4 (77				647 418			
Aug. 1	24 "	Jul.31 SB	(129 (30	0 1144	18 10	8 3	747 2017 & 800	1758 -	94 365	+ -
" 12	35 "		(768 (306	3 1	15 18	13 3	1800 & 2067 4708	850 2675	55 1608	1 -
" 26	14 "		(5 (8				36 -			3 +
" "	38 "		(- (-				2683 7317			
Sep.9	28 days		(80 (67	1 0	23 4	69 0	- -	- -	- -	9 +
" 23	28 "		(61 (98	- -	- -	- -	- -	- -	- -	4 5
" "	42 "		(36 (3	3 1	- -	11 1	- -	- -	- -	5 12
" "	66 "		(- (-	- -	- -	13 2	- -	- -	- -	- -

TABLE 2.

Slide Series J, Oct., 1945.

Station	NB1		NB5		FI1		FI3	
Date of Collection	2.10	4.10	2.10	4.10	2.10	4.10	2.10	4.10
Length of Exposure	4	6	4	6	4	6	4	6
Achnanthes affinis	4	m	-	-	-	-	-	-
	-	-	-	-	1	m	-	-
A. Strömi	-	m	-	-	-	-	-	-
	-	5	-	1	-	m	-	-
Amphora coffeaeformis	13	m	2	1	1	1	-	-
	13	16	-	2	2	m	6	3
A. laevis	1	m	-	1	1	-	-	-
	2	3	-	-	-	m	-	-
A. macilenta	2	m	4	2	-	-	-	-
	1	-	-	-	-	m	1	-
A. marina	-	m	-	-	1	-	-	-
	-	-	-	-	-	-	-	-
Cocconeis Scutellum	25	m	2	4	3	-	1	2
	3	8	1	1	-	m	2	-
Navicula bahusiensis arctica	-	m	-	-	-	-	-	-
	-	1	-	-	-	m	-	-
N. bahusiensis bahusiensis	4	m	8	3	1	-	-	3
	30	5	-	1	-	m	6	-
N. gregaria	-	m	-	-	-	-	-	1
	2	1	-	-	-	m	-	-
N. pygmaea	8	m	2	3	-	-	-	1
	1	3	-	1	-	m	7	-
N. retusa	4	m	3	1	-	-	-	1
	11	5	-	1	-	m	1	1
Navicula spp. indet.	1	m	-	-	-	-	-	-
	-	-	-	-	-	m	1	-
Nitzschia closterium	5	m	5	-	1	-	-	-
	1	-	-	1	-	m	1	-
Nitzschia sp. (tryblionellid)	3	m	-	1	-	-	-	-
	-	-	-	-	-	m	-	-
Nitzschia spp. indet.	-	m	2	-	-	-	-	-
	-	-	-	-	-	m	-	-
Pleurosigma minutum	-	m	-	-	-	-	-	-
	-	1	-	-	-	m	-	-
Pleurosigma sp.	-	m	-	-	-	-	-	-
	-	-	-	-	1	m	-	-
Tropidoneis sp.	-	m	-	-	1	-	-	-
	-	-	-	-	-	m	-	-
Other forms.	18	m	7	3	-	1	1	2
	18	8	1	-	1	m	4	6

TABLE 3.

Slide Series K, Oct., 1945.

Station	NB4			LS4		
Date of Collection	10.10	15.10		10.10	15.10	
Length of Exposure	5	5	10	5	5	10
Amphora acutiuscula	–	–	–	–	1	–
	–	–	3	–	2	m
A. coffeaeformis	–	–	–	–	4	10
	–	–	23	–	9	m
A. laevis	1	–	1	–	–	–
	–	–	22	1	1	m
A. macilenta	–	–	–	–	3	2
	–	–	5	–	2	m
A. marina	–	–	–	1	3	1
	–	–	13	–	–	m
Cocconeis Scutellum	–	–	6	5	3	13
	–	–	13	–	3	m
Navicula bahusiensis arctica.	11	1	3	–	–	–
	–	–	68	–	–	m
N. bahusiensis bahusiensis.	–	–	1	–	1	3
	1	–	43	–	2	m
N. Bulnheimii	–	–	–	–	1	–
	–	–	–	–	1	m
N. gregaria	–	–	–	–	–	–
	–	–	2	–	1	m
N. pygmaea	6	1	6	1	–	–
	2	–	47	–	1	m
N. retusa	1	–	1	–	3	1
	–	–	–	–	3	m
N. scopulorum	–	–	–	1	–	–
	–	–	–	–	–	m
Navicula spp. indet.	–	–	–	1	–	–
	–	–	10	–	–	m
Nitzschia closterium	–	–	–	–	1	3
	–	–	3	–	1	m
Nitzschia spp. indet.	–	–	–	–	–	–
	–	–	1	–	–	m
Pleurosigma minutum	–	–	1	–	–	–
	–	–	3	–	–	m
Tropidoneis sp.	–	–	–	–	–	–
	–	–	–	–	1	–
Other forms	–	–	1	–	3	16
	–	–	67	–	–	m

TABLE 4.

Slide Series L, Nov., 1945.

Station	NB3			NB5			LS3			LS5		
Date of Collection	14.11	23.11		14.11	23.11		14.11	23.11		14.11	23.11	
Length of Exposure	9	9	18	9	9	18	9	9	18	9	9	18
Achnanthes Strömi	-	-	-	-	-	-	2	-	-	-	-	1
	-	-	-	-	-	-	-	3	2	2	-	m
Amphora acutiuscula	-	-	1	-	-	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-	-	1	-	m
A. coffeaeformis	-	-	8	-	-	-	-	1	1	3	6	2
	3	2	21	-	-	1	-	1	-	13	3	m
A. laevis	-	-	-	-	-	2	-	-	-	-	-	-
	1	-	1	-	-	-	-	1	-	-	-	m
A. macilenta	-	2	5	-	-	-	-	-	3	1	2	2
	3	2	1	-	-	-	-	13	-	1	1	m
A. marina	-	-	3	-	-	-	-	1	3	-	-	-
	-	2	2	-	-	5	-	2	-	9	-	m
Cocconeis Scutellum	4	1	15	-	-	-	-	2	3	-	2	4
	6	-	18	-	-	-	4	-	-	3	3	m
Diploneis sp.	-	-	1	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	m
Navicula bahusiensis arctica	3	-	1	2	-	4	-	-	-	-	-	-
	-	-	3	-	-	-	-	-	-	2	-	m
N. bahusiensis bahusiensis	1	-	1	-	-	-	-	-	2	-	1	2
	5	1	27	-	-	2	-	3	-	5	1	m
N. gregaria	-	-	1	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	1	-	m
N. pygmaea	2	1	6	4	-	7	-	-	-	1	1	-
	1	8	26	1	-	19	-	1	-	5	-	m
N. retusa	1	-	-	-	-	1	-	-	1	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	m
Navicula spp. indet.	-	2	1	-	-	-	-	1	3	-	-	-
	-	3	1	-	-	15	-	-	-	1	1	m
Nitzschia closterium	-	-	-	-	-	-	-	8	8	-	1	1
	1	-	2	-	-	-	1	-	1	1	-	m
N. Sigma	-	-	-	-	-	-	-	-	3	1	-	-
	-	-	-	-	-	-	1	-	-	-	-	m
Nitzschia sp. (tryblionellid)	-	-	-	-	-	-	-	1	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	m
Nitzschia spp. indet.	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	2	-	-	-	-	-	-	-	-	m
Pleurosigma minutum	-	-	-	-	-	-	-	-	1	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	m
Pleurosigma sp.	-	-	-	-	-	-	-	-	1	-	-	1
	-	-	-	-	-	-	-	-	-	-	-	m
Tropidoneis sp.	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	3	-	m
Other forms	-	3	6	1	-	-	-	3	-	2	3	2
	7	7	27	-	-	3	-	7	-	15	3	m

TABLE 5.

Slide Series M, Dec., 1945.

Station	NB2			NB7			LS2			LS7		
Date of Collection	11.12	21.12		11.12	21.12		11.12	21.12		11.12	21.12	
Length of Exposure	6	10	16	6	10	16	6	10	16	6	10	16
Achnanthes Strömi	-	-	-	-	-	-	8	2	5	-	-	-
	-	-	-	-	-	-	6	2	m	-	m	-
Amphora coffeaeformis	-	5	2	-	-	-	-	2	-	1	1	1
	-	1	-	-	-	-	7	-	m	1	m	-
A. laevis	-	2	-	-	-	-	1	-	-	-	-	1
	-	-	-	-	-	-	3	-	m	-	m	-
A. macilenta	-	-	2	-	2	-	-	2	-	1	1	1
	-	1	-	-	-	-	-	2	m	-	m	-
A. marina	-	-	-	-	-	-	-	-	-	1	-	-
	-	1	-	-	-	-	4	-	m	-	m	-
A. truncata	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	m	-	m	2
Cocconeis Scutellum	-	23	21	1	-	+	-	3	2	-	-	5
	-	3	2	-	-	-	-	-	m	-	m	-
Navicula bahusiensis arctica	-	3	3	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	m	-	m	-
N. bahusiensis bahusiensis	-	4	7	1	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	m	-	m	-
N. pygmaea	-	-	-	1	2	+	-	-	-	1	2	-
	-	-	1	-	-	-	-	-	m	-	m	-
N. retusa	-	1	1	-	-	-	-	-	-	2	-	-
	1	-	-	-	-	-	-	-	m	-	m	-
N. scopulorum	-	-	-	-	-	-	-	-	-	1	-	-
	-	-	-	-	-	-	-	1	m	-	m	-
Navicula spp. indet.	-	-	-	2	-	-	-	-	-	-	-	3
	1	-	1	-	-	-	-	-	m	1	m	-
Nitzschia closterium	-	-	2	-	-	-	1	-	-	1	-	-
	2	1	2	-	-	-	-	1	m	-	m	-
Nitzschia spp. indet.	1	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	m	-	m	-
Pleurosigma minutum	-	-	-	-	-	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-	m	-	m	-
Pleurosigma sp.	3	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	m	-	m	-
Tropidoneis sp.	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	1	-	-	-	-	-	m	-	m	-
Other forms	-	3	8	2	-	-	-	1	-	5	1	4
	2	-	-	-	2	-	11	5	m	1	m	2

TABLE 6.

Slide Series N, Dec.,1945 - Jan.,1946.

Station	NB2		NB7		LS2	LS7
Date of Collection	31.12	10.1	31.12	10.1	31.12	31.12
Length of Exposure	10	20	10	20	10	10
Achnanthes Strömi	-	-	-	-	1	-
	-	-	-	-	218	-
Amphora coffeaeformis	1	1	-	1	2	2
	12	2	-	-	262	-
A. laevis	-	-	-	-	1	-
	-	-	-	-	-	-
A. macilenta	1	3	-	-	3	-
	6	-	-	-	15	1
A. marina	-	1	-	-	-	3
	3	2	-	2	-	-
A. Proteus	-	-	-	-	-	-
	3	-	-	-	-	-
Cocconeis Scutellum	3	11	-	-	3	1
	3	11	-	-	-	-
Navicula bahusiensis arctica	-	-	-	-	-	-
	3	1	-	-	-	-
N. bahusiensis bahusiensis	1	1	-	-	-	1
	24	-	-	-	15	-
N. Bulnheimii	-	-	-	-	-	-
	-	-	-	-	18	-
N. pygmaea	-	-	-	1	-	2
	18	-	-	-	-	-
N. ramosissima	-	-	-	-	-	3
	-	-	-	-	-	-
N. retusa	-	-	-	-	-	-
	6	-	-	-	6	-
Navicula sp.	-	-	-	-	-	-
	-	-	-	1	-	-
Nitzschia closterium	-	-	-	-	-	-
	-	-	-	-	3	-
Nitzschia sp. (tryblionellid)	-	-	-	-	-	-
	-	1	-	-	-	-
Tropidoneis sp.	-	-	-	-	-	-
	3	-	-	-	-	-
Other forms	1	3	1	-	5	-
	29	-	2	-	100	1

TABLE 7.

Slide Series 0, Feb., 1946.

Station	NB2		NB7		LS2		LS7		LS10	
Date of Collection	13.2	22.2	13.2	22.2	13.2	22.2	13.2	22.2	13.2	22.2
Length of Exposure	21	30	21	30	21	30	21	30	21	30
Achnanthes affinis	-	-	-	-	-	-	-	-	-	-
	-	1	-	-	-	-	-	-	-	-
A. Strömi	-	-	-	-	5	15	-	1	-	-
	-	-	-	-	-	1	-	-	-	-
Achnanthes sp. nov.	3	-	-	-	-	-	-	1	-	-
	-	-	-	-	-	-	-	-	-	-
Amphora acutinscula	-	-	-	-	-	-	1	-	-	-
	-	-	-	-	-	4	-	2	-	2
A. coffeaeformis	9	25	-	1	-	11	6	8	1	2
	5	3	-	-	-	3	27	10	-	1
A. laevis	-	-	-	-	-	1	1	1	-	-
	-	-	-	-	-	7	9	-	-	-
A. macilenta	-	-	-	-	-	7	1	1	-	1
	-	-	-	-	-	3	6	1	-	-
A. marina	-	-	-	-	-	-	-	3	2	-
	3	-	-	-	-	-	18	10	7	-
A. truncata	-	1	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-
Cocconeis Scutellum	386	750	-	-	-	5	5	8	1	2
	7	3	-	+	2	1	3	2	-	3
Navicula bahusiensis arctica	-	8	-	1	-	-	-	-	-	1
	2	3	-	-	-	-	-	-	-	1
N. bahusiensis bahusiensis	12	58	-	-	-	3	-	3	-	-
	21	5	-	-	-	2	56	2	-	-
N. pygmaea	3	-	-	2	-	-	-	3	5	4
	1	-	-	+	-	3	9	2	2	-
N. retusa	-	-	1	-	-	-	-	2	-	-
	1	2	-	-	-	3	47	-	-	-
N. scopulorum	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	6	-	-	-
Navicula spp. indet.	-	-	-	-	-	-	-	4	1	-
	-	-	-	-	-	1	41	11	-	1
Nitzschia closterium	-	-	-	-	-	2	2	2	-	-
	-	-	-	-	-	2	-	-	-	-
Nitzschia sp. (tryblionellid)	-	-	-	-	-	1	-	-	-	-
	-	-	-	-	-	-	-	-	-	-
Pleurosigma minutum	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	3	-	-	1
Other forms	-	-	-	1	1	8	2	9	1	1
	14	11	-	-	1	14	12	7	2	-

TABLE 8.

Slide Series P, Mar.-Apr., 1946.

Station	NB2								NB7	
Date of Collection	27.3	2.4		11.4		16.4			2.4	16.4
Length of Exposure	7	13	21	9	22	14	27	35	21	35
Achnanthes affinis	12	11	-	-	1	3	3	-	-	-
	1	3	-	1	1	-	-	-	-	-
Achnanthes nov. sp.	-	-	-	1	-	-	+	-	-	-
	-	-	-	-	1	-	3	-	-	-
Amphora acutiuscula	-	+	-	-	-	-	+	-	-	4
	-	-	-	1	-	-	-	-	-	-
A. coffeaeformis	+	3	-	37	41	104	205	-	-	3
	-	502	-	37	220	1109	259	12	1	-
A. laevis	1	1	-	+	+	-	-	-	1	1
	+	1	-	-	1	-	-	2	-	-
A. macilenta	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	1	-
A. marina	+	-	-	5	-	-	3	-	-	-
	-	-	-	-	-	-	-	-	1	-
Cocconeis Scutellum	6	6	1	+	13	21	126	-	1	4
	+	1	-	1	-	6	24	-	2	-
Licmophora sp.	-	-	-	-	-	3	5	-	-	-
	-	-	-	-	-	-	-	-	-	-
Navicula bahusiensis arctica	4	3	-	-	-	-	2	-	-	-
	3	9	1	-	+	-	-	2	-	-
N. bahusiensis bahusiensis	-	1	-	5	45	68	61	-	-	-
	3	113	-	3	49	168	1403	1	-	-
N. Bulnheimii	+	2	-	-	-	-	-	-	-	-
	2	6	-	-	1	-	-	-	-	-
N. gregaria	+	3	-	-	1	3	4	-	-	-
	+	63	-	1	18	-	94	-	1	-
N. pygmaea	3	4	-	-	-	-	2	-	4	12
	+	2	-	-	-	-	-	1	5	-
N. retusa	3	3	-	-	1	9	1	-	-	-
	2	1	-	-	-	-	-	10	-	-
Navicula spp. indet.	6	2	-	-	14	18	41	-	-	-
	6	3	-	5	15	21	-	6	-	-
Nitzschia closterium	+	2	-	2	13	44	11	-	-	-
	2	71	-	3	2	68	6	1	-	-
Nitzschia spp. indet.	+	6	-	+	1	-	1	-	-	-
	-	63	-	-	1	-	3	-	-	-
Pleurosigma minutum	+	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-
Stauroneis sp.	+	+	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-
Other forms	7	8	-	5	20	65	442	-	-	7
	5	88	1	15	20	214	195	12	1	-

TABLE 9.

Slide Series P, Apr., 1946.

Station	SB7		SB10	
Date of Collection	2.4	16.4	2.4	16.4
Length of Exposure	21	35	21	35
Amphora acutiuscula	– –	– +	– –	– +
A. coffeaeformis	– –	– –	– –	– +
A. laevis	1 –	1 –	– –	– –
A. marina	– –	+ –	– –	– 1
Cocconeis Scutellum	1 –	2 1	– –	+ –
Navicula pygmaea	9 2	6 1	1 –	3 6
N. retusa	– +	– –	– –	– 1
Navicula spp. indet.	1 –	3 –	– –	+ +
Nitzschia closterium	– –	+ 1	– –	– –
Other forms	1 –	1 1	– –	1 1

TABLE 10.

Slide Series P, Mar.-Apr., 1946.

Station	LS2								LS7		LS10	
Date of Collection	27.3	2.4		11.4		16.4			2.4	16.4	2.4	16.4
Length of Exposure.	7	13	21	9	22	14	27	35	21	35	21	35
Achnanthes affinis	-	-	-	-	-	-	-	-	-	-	-	2
	-	-	-	-	-	-	-	-	-	-	-	-
A. Strömi	1	1	-	+	4	4	3	-	-	-	-	-
	5	1	-	1	3	8	10	-	-	56	-	-
Achnanthes sp. nov.	-	-	-	-	-	-	-	-	-	3	-	-
	-	-	-	-	-	-	-	-	2	6	-	-
Amphora acutiuscula	-	-	-	-	-	-	-	-	1	18	-	11
	2	-	-	+	2	-	10	-	1	24	-	13
A. coffeaeformis	+	-	-	-	-	1	2	1	3	118	1	23
	12	2	-	4	5	-	14	-	5	265	1	28
A. costata	-	-	-	-	-	-	-	-	-	-	-	-
	-	1	-	-	-	-	-	-	-	-	-	-
A. laevis	-	1	-	-	-	-	-	-	3	-	-	-
	12	1	-	1	1	-	2	-	1	-	-	-
A. macilenta	-	-	-	-	+	-	-	-	-	-	-	-
	4	-	-	+	+	-	-	-	3	-	-	-
A. marina	-	-	-	-	-	-	-	-	2	-	-	-
	+	-	-	-	-	-	-	-	9	6	-	2
A. Proteus	-	-	-	-	-	-	-	-	3	-	-	-
	-	-	-	-	-	-	-	-	5	-	-	-
A. truncata	+	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
Cocconeis Scutellum	-	1	-	+	1	2	1	-	12	121	6	33
	+	+	-	-	+	3	1	-	2	9	-	2
Diploneis sp.	-	-	-	-	-	-	-	-	-	-	-	-
	-	+	-	+	+	-	-	-	-	-	-	-
Licmophora sp.	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	1	-	-	-
Navicula bahusiensis	-	-	-	-	-	-	-	-	2	9	1	-
arctica	-	-	-	-	-	-	-	-	2	3	-	3
N. bahusiensis	-	-	-	-	-	-	-	-	5	53	-	10
bahusiensis	-	-	-	-	+	-	-	-	4	335	-	50
N. Bulnheimii	-	-	-	-	-	-	-	-	1	-	-	1
	-	+	-	-	-	-	-	-	-	29	-	23
N. gregaria	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	+	-	-	3	-	13	74	-	6
N. pygmaea	-	-	-	-	-	-	-	-	2	-	2	3
	-	-	-	-	-	-	-	-	5	3	-	-
N. ramosissima	-	-	-	-	-	-	-	-	-	-	-	55
	-	-	-	-	-	-	-	-	-	-	-	402
N. retusa	-	-	-	-	1	-	-	-	1	-	-	-
	-	-	-	+	14	-	6	-	-	-	-	-
N. scopulorum	-	-	-	-	-	-	-	-	1	3	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
Navicula spp. indet.	-	-	-	-	-	-	-	-	3	30	8	6
	2	1	-	-	2	-	3	-	1	27	+	4
Nitzschia closterium	-	-	-	-	+	-	-	-	1	9	-	13
	1	-	-	+	-	-	3	-	1	44	-	27
Nitzschia spp. indet.	-	1	-	-	-	-	-	-	-	12	-	-
	4	1	-	1	+	-	-	-	2	24	-	-
Pleurosigma minutum	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	1	6	-	-
Other forms	2	2	-	+	1	-	2	-	22	296	3	79
	7	6	-	4	8	2	17	-	15	200	1	51

TABLE 11.

Slide Series Q, May-June, 1946.

Station	NB2						NB7	
Date of Collection	15.5	22.5	30.5		6.6		22.5	6.6
Length of Exposure	8	15	8	23	15	30	15	30
Achnanthes affinis	2	5	1	3	-	-	-	-
	-	-	-	-	-	-	-	-
A. Strömi	2	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
Achnanthes nov. sp.	-	-	-	-	-	-	-	-
	6	2	+	1	-	-	-	-
Amphora acutiuscula	-	-	-	8	-	1	-	-
	21	1	-	1	3	15	-	-
A. coffeaeformis	1	5	-	2	2	3	-	-
	40	9	1	18	7	168	-	1
A. laevis	-	4	3	8	4	5	1	-
	2	1	1	8	1	15	-	-
A. marina	-	-	-	-	-	-	-	-
	8	-	1	7	5	-	-	-
A. Proteus	-	-	-	-	-	-	1	-
	-	-	-	-	-	-	-	-
A. truncata	-	-	-	-	-	-	-	-
	1	-	-	-	-	-	-	-
Cocconeis Scutellum	3	5	1	15	8	13	-	2
	3	1	1	7	1	-	-	-
Navicula bahusiensis arctica	-	3	-	2	-	-	-	-
	-	-	1	2	-	3	-	-
N. bahusiensis bahusiensis	2	8	-	15	3	8	2	1
	87	38	+	126	4	777	-	-
N. Bulnheimii	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-
N. gregaria	15	2	2	3	4	11	-	-
	56	23	-	6	-	-	-	-
N. pygmaea	3	4	3	22	21	12	17	10
	26	19	23	59	33	35	4	1
N. retusa	2	3	1	14	6	3	-	-
	76	21	1	14	3	12	-	-
Navicula spp. indet.	-	-	-	-	-	-	3	-
	-	-	-	-	-	-	-	-
Nitzschia closterium	-	-	-	1	-	-	1	-
	-	1	-	2	2	15	-	-
Nitzschia spp. indet.	-	-	-	3	-	-	-	-
	-	-	-	1	-	-	-	-
Pleurosigma minutum	1	2	-	2	1	1	-	-
	1	-	3	4	1	6	-	-
Tropidoneis sp.	-	-	-	2	-	1	-	-
	-	-	-	1	1	-	-	-
Other forms	9	17	3	21	11	9	2	1
	127	10	4	34	6	115	-	-

TABLE 12.

Slide Series Q, May-June, 1946.

Station	SB7		SB10	
Date of Collection	22.5	6.6	22.5	6.6
Length of Exposure	15	30	15	30
Achnanthes nov. sp.	– –	– 3	– –	– –
Amphora acutiuscula	– –	– 12	– –	– –
A. coffeaeformis	2 –	9 79	– 1	– –
A. laevis	– –	– 3	– –	– –
A. marina	– –	6 35	– –	– –
Cocconeis Scutellum	3 +	250 12	– –	– –
Gyrosigma rectum	– –	– 6	– –	– –
Navicula bahusiensis bahusiensis	– –	32 88	– +	– –
N. Bulnheimii	– –	12 47	– –	– –
N. pygmaea	6 2	6 38	1 2	+ 2
Navicula spp. indet.	– –	– 38	– –	– –
Nitzschia closterium	– –	– 88	– –	– –
Pleurosigma minutum	– –	– 9	– –	– –
Tropidoneis sp.	– –	– 12	– –	– –
Other forms	1 –	74 168	+ 1	– +

TABLE 13.

Slide Series Q, May-June, 1946.

Station	LS2					LS7		LS10	
Date of Collection	15.5	22.5	30.5		6.6	22.5	6.6	22.5	6.6
Length of Exposure	8	15	8	23	30	15	30	15	30
Achnanthes Strömi	-	-	-	-	-	-	-	-	-
	m	8	-	-	-	m	-	-	1
Achnanthes sp. nov.	-	-	-	-	-	3	-	-	-
	m	-	-	-	-	m	9	-	-
Amphora acutiuscula	-	-	-	-	-	3	3	2	-
	m	13	-	-	73	m	9	32	-
A. coffeaeformis	3	35	11	143	8	382	306	11	-
	m	10	-	229	62	m	329	44	3
A. laevis	-	-	-	-	-	-	6	-	-
	m	4	-	-	-	m	3	6	-
A. marina	-	-	-	-	-	-	-	3	-
	m	-	-	-	29	m	53	6	-
A. Proteus	-	-	-	-	-	-	-	-	-
	m	-	-	-	-	m	23	-	-
A. truncata	-	-	-	-	-	-	-	-	-
	m	-	-	-	-	m	3	-	-
Cocconeis Scutellum	2	7	15	49	15	17	47	3	1
	m	2	-	15	-	m	3	6	2
Diploneis sp.	-	-	-	-	-	-	-	-	-
	m	-	-	-	3	m	-	-	-
Grammatophora sp.	-	-	-	-	-	-	-	-	-
	m	-	-	-	-	m	35	-	-
Gyrosigma rectum	-	-	-	-	-	-	-	-	-
	m	-	-	-	3	m	-	6	-
Navicula bahusiensis arctica	-	-	-	-	-	-	-	-	-
	m	3	-	-	9	m	-	-	-
N. bahusiensis bahusiensis	-	2	1	3	-	23	6	7	-
	m	23	-	-	112	m	6	62	-
N. Bulnheimii	-	2	1	-	2	-	-	-	-
	m	-	-	-	9	m	-	3	-
N. pygmaea	-	-	-	-	-	-	-	6	-
	m	1	-	-	44	m	15	24	-
N. ramosissima	-	-	-	-	-	9	-	-	-
	m	-	-	-	-	m	112	-	-
N. retusa	-	-	-	-	-	-	-	-	-
	m	3	-	-	3	m	39	-	-
Navicula spp. indet.	-	-	-	-	-	-	-	-	-
	m	16	-	-	6	m	44	38	-
Nitzschia closterium	-	-	1	1	1	15	12	4	-
	m	29	-	-	18	m	150	62	1
Nitzschia sp. (tryblionellid)	-	-	-	-	-	-	-	-	-
	m	-	-	-	-	m	3	-	-
Pleurosigma minutum	-	-	-	-	-	-	-	-	-
	m	-	-	-	3	m	18	9	-
Pleurosigma spp. indet.	-	-	-	-	-	-	-	-	-
	m	-	-	-	3	m	-	-	-
Tropidoneis sp.	-	-	-	-	-	-	-	-	-
	m	-	-	-	3	m	-	-	-
Other forms	3	3	3	85	13	65	76	21	1
	m	28	1	85	56	m	153	50	3

TABLE 14.

Slide Series R, June-July, 1946.

Station	NB2							NB7	
Date of Collection	12.6	19.6	2.7		8.7		18.7	19.6	8.7
Length of Exposure	6	13	13	26	19	32	29	13	32
Achnanthes affinis	–	–	–	–	–	1	–	–	–
	–	–	–	–	–	–	–	–	–
Amphora coffeaeformis	1	3	1	–	2	8	–	1	2
	–	3	5	3	21	3	7	–	1
A. laevis	3	9	5	6	2	9	–	5	7
	2	–	2	–	6	2	2	–	–
A. macilenta	3	–	–	–	–	–	–	2	2
	–	–	–	–	–	–	–	–	–
A. marina	3	–	–	–	–	–	–	–	–
	–	–	–	–	1	–	1	–	1
Cocconeis Scutellum	3	12	3	3	9	9	3	–	3
	–	–	2	3	3	2	3	–	1
Navicula bahusiensis arctica	–	–	–	–	4	–	–	1	2
	–	–	2	–	18	–	8	–	–
N. pygmaea	62	44	15	13	7	43	–	4	14
	6	–	16	18	65	8	29	11	12
N. retusa	15	20	–	–	2	8	–	–	1
	–	–	2	–	9	1	2	–	–
Navicula spp. indet.	38	18	2	–	2	3	–	–	–
	–	–	–	3	15	–	2	–	–
Nitzschia sp.	3	–	–	–	3	–	–	–	–
	–	–	–	–	3	1	–	–	–
Pleurosigma minutum	9	12	–	–	1	4	–	–	–
	–	–	–	1	32	–	7	–	–
Tropidoneis sp.	6	3	–	–	–	1	–	–	–
	–	–	1	–	9	–	–	–	–

TABLE 15.

Slide Series R, June-July 1946.

Station	SB7		SB10	
Date of Collection	19.6	8.7	19.6	8.7
Length of Exposure	13	32	13	32
Amphora coffeaeformis	2 1	3 m	- -	1 -
A. laevis	- -	- m	2 1	3 -
A. macilenta	3 -	- m	- -	3 -
A. marina	- -	- m	- 3	1 2
A. Proteus	- -	- m	- -	1 -
Cocconeis Scutellum	- -	68 m	1 -	1 -
Navicula bahusiensis arctica	- -	- m	- -	- 1
N. bahusiensis bahusiensis	- -	13 m	1 -	1 -
N. pygmaea	6 3	1 m	4 3	5 4
N. ramosissima	- -	2 m	- -	- -
N. retusa	- -	- m	1 -	- -
Nitzschia Sigma	- -	- m	- -	- 1
Other forms	1 1	- m	3 -	- 2

TABLE 16.

Slide Series R, June-July, 1946.

Station	LS2							LS7		LS10
Date of Collection	12.6	19.6	2.7		8.7		18.7	19.6	8.7	19.6
Length of Exposure	6	13	13	26	19	32	29	13	32	13
Achnanthes Strömi	-	-	-	3	3	1	-	-	-	-
	-	-	-	3	-	-	-	-	-	-
Amphora coffeaeformis	5	138	51	76	200	-	103	1192	482	68
	-	-	11	115	8	450	50	94	415	129
A. laevis	1	-	-	-	-	1	-	-	6	1
	1	-	-	-	-	-	-	-	9	-
A. macilenta	-	-	-	-	-	-	-	16	-	-
	-	-	-	-	-	-	-	3	3	3
A. Proteus	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	3	-	3
Cocconeis Scutellum	12	47	84	559	362	-	509	16	103	4
	-	4	36	71	42	700	321	6	6	9
Diploneis sp.	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	12
Gyrosigma rectum	-	-	-	3	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-
Licmophora sp.	-	6	-	-	-	-	-	-	3	-
	-	2	-	-	3	8	-	-	-	-
Navicula bahusiensis arctica	-	3	-	-	3	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-
N. bahusiensis bahusiensis	1	24	2	-	68	-	3	100	24	11
	-	-	-	6	3	33	12	26	9	72
N. pygmaea	-	-	1	-	-	-	-	8	-	1
	-	-	-	21	1	-	-	3	-	21
N. ramosissima	-	-	-	-	-	-	-	100	-	29
	-	-	-	-	-	33	-	-	482	29
N. retusa	-	-	-	-	-	-	-	-	-	-
	-	-	-	3	-	-	-	-	-	27
Navicula spp. indet.	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	32	21	68
Nitzschia closterium	-	-	-	-	3	-	3	3	-	1
	-	-	1	-	1	25	3	-	18	41
Nitzschia spp. indet.	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	24
Tropidoneis sp.	-	-	-	-	-	-	-	-	-	-
	-	-	-	3	-	-	-	-	3	-
Other forms	8	79	64	84	41	1	29	370	156	40
	-	-	10	58	16	258	32	82	90	100

<u>TABLE 17</u>

Slide Series S, July - September 1946.

Station	NB2							NB7			
Date of Collection	18.7	1.8	12.8	26.8	9.9	23.9		1.8	12.8	9.9	23.9
Length of Exposure	10	24	35	14	28	28	42	24	35	28	42
Achnanthes affinis	-	-	-	-	2	-	-	-	-	-	-
	m	-	-	-	-	-	-	-	-	-	-
Achnanthes sp. nov.	-	-	-	-	-	-	-	-	-	-	-
	m	-	-	-	-	-	-	132	-	-	-
Amphora coffeaeformis	-	27	121	-	4	3	2	-	-	-	-
	m	5	288	-	5	13	-	276	-	-	-
A. laevis	3	3	-	1	4	1	-	-	-	-	-
	m	-	-	1	3	5	-	-	-	-	-
A. macilenta	-	-	-	-	-	-	-	-	-	-	-
	m	-	-	-	-	-	-	6	-	-	-
A. marina	-	-	-	-	-	-	-	-	-	-	-
	m	-	-	-	-	13	-	21	-	-	-
Cocconeis Scutellum	3	53	377	-	14	43	26	+	-	-	-
	m	3	-	-	6	18	2	27	-	-	-
Gyrosigma rectum	-	-	3	-	2	-	-	-	-	-	-
	m	-	-	-	-	-	-	-	-	-	-
Licmophora sp.	-	-	-	-	-	-	-	-	-	-	-
	m	2	-	-	1	-	-	-	-	-	-
Navicula bahusiensis	-	3	-	-	-	4	-	-	-	-	-
arctica	m	3	-	-	-	7	-	-	-	-	-
N. bahusiensis	-	29	218	-	4	1	2	-	-	-	1
bahusiensis	m	1	12	-	7	18	-	491	-	-	-
N. pygmaea	8	3	12	3	13	1	2	-	3	1	-
	m	2	3	2	21	11	-	3	1	-	-
N. ramosissima	-	-	-	-	-	1	-	-	-	-	-
	m	3	-	-	-	-	-	50	-	-	-
N. retusa	2	-	6	1	18	-	-	-	-	-	-
	m	-	-	3	16	4	-	-	-	-	-
Navicula spp. indet.	-	-	-	-	3	-	-	-	-	-	-
	m	1	-	-	4	-	-	3	-	-	-
Nitzschia closterium	-	-	-	-	3	2	-	-	-	-	-
	m	2	-	-	-	-	-	18	-	-	1
Nitzschia spp. indet.	-	-	-	-	-	-	-	-	-	-	-
	m	-	-	-	-	1	-	-	-	-	-
Pleurosigma minutum	-	-	3	-	2	-	-	-	-	-	-
	m	-	-	-	-	-	-	-	-	-	-
Tropidoneis sp.	-	-	-	-	1	-	-	-	-	-	-
	m	-	-	-	-	-	-	-	-	-	-

TABLE 18

Slide Series R, July - September 1946.

Station	SB7			SB10					
Date of Collection	1.8	12.8	9.9	18.7	1.8	12.8	9.9	23.9	
Length of Exposure	24	35	28	10	24	35	28	42	77
Achnanthes Strömi	- -	- -	- -	- -	- -	1 -	- -	- -	- -
Amphora coffeaeformis	1 1	2 3	3 -	- -	- -	- -	17 -	1 -	2 1
A. laevis	2 -	- 2	1 -	- -	- -	- -	1 -	2 -	- -
A. macilenta	2 -	- -	1 -	1 -	2 -	- -	2 -	1 -	- -
A. marina	- -	1 -	- 2	- -	- 1	- 1	3 -	- 1	- -
A. truncata	- -	- -	- -	1 -	- -	- -	- -	- -	- -
Cocconeis Scutellum	2 -	1 3	12 -	- -	- -	3 -	26 -	3 -	3 -
Navicula bahusiensis arctica	- -	- -	- -	- -	- -	- -	3 -	- -	- -
N. bahusiensis bahusiensis	- 2	2 1	- -	- -	1 -	- -	2 -	- -	- -
N. pygmaea	4 6	9 7	4 -	1 -	5 -	3 -	1 -	3 -	6 -
N. ramosissima	- -	- -	- -	- -	- -	- 2	10 -	- -	- -
N. retusa	- -	1 -	- -	- -	- -	- -	- -	- -	- -
N. scopulorum	- -	- -	1 -	- -	- -	- -	1 -	- -	- -
Navicula spp. indet.	6 1	- 1	- -	- -	- 3	1 -	- -	2 -	- -
Pleurosigma minutum	- -	- 1	- -	- -	- -	- -	- -	- -	- -
Other forms	2 1	- 2	3 3	16 1	- -	6 -	8 -	1 -	3 -

TABLE 19

Slide Series S, July - August 1946.

Station	LS2					LS7		LS10		
Date of Collection	18.7	1.8	12.8	26.8		1.8	12.8	18.7	1.8	12.8
Length of Exposure	10	24	35	14	38	24	35	10	24	35
Achnanthes Strömi	- -	- - -	- - -	- m	- -	- m	- -	- -	- -	- 8
A. subsalsoides	- -	1 - -	- - -	- m	- -	- m	- -	- -	- -	- -
Amphora coffeaeformis	13 109	174 183 425	183 1017 67	3 m	- -	508 m	217 892	6 2	12 82	18 542
A. macilenta	- -	- - -	- - -	- m	- -	8 m	17 -	- -	3 -	- 8
A. marina	1 -	- - -	- - -	- m	- -	8 m	25 50	- -	3 85	2 67
Cocconeis Scutellum	21 138	459 1792 283	147 1816 4550	27 m	2600 7260	900 m	84 17	5 1	71 15	17 50
Diploneis sp.	- -	- - -	- 8 8	- m	- -	- m	- 8	- -	- -	- -
Grammatophora sp.	- -	- - -	- - -	- m	- -	- m	42 -	- -	- -	2 -
Gyrosigma rectum	- -	- - -	- - -	- m	- -	- m	- -	- -	- -	1 -
Licmophora sp.	1 -	- 8	- - 33 -	- m	- -	8 m	- -	- -	- -	- -
Navicula bahusiensis arctica	- -	- - -	- - -	m m	- -	25 m	- 625	- -	- -	- -
N. bahusiensis bahusiensis	2 -	15 8 -	75 - 17	- m	33 8	33 m	17 825	- -	- 12	3 725
N. gregaria	- -	- 8 -	- - - - +	- m	- -	- m	- -	- -	- -	- -
N. pygmaea	- -	+ - - -	- - -	- m	- -	8 m	8 8	- -	3 44	5 50
N. ramosissima	- -	- - -	- - -	- m	- -	258 m	133 75	- 2	- 159	17 17
N. retusa	- -	- - -	- - -	- m	- -	- m	- 17	- -	- -	- -
N. scopulorum	- -	- - -	- - -	- m	- -	- m	8 17	1 -	- -	- -
Navicula spp. indet.	- -	- - -	- - -	- m	- -	- m	- -	- -	- -	1 -
Nitzschia closterium	- 3	- - 8	50 - 8 -	- m	- -	- m	17 -	- -	- -	- 17
N. Sigma	- -	- - -	- - -	- m	- -	- m	- 8	- -	- -	- -
Nitzschia sp. (tryblionellid)	- -	- - -	- - -	- m	- -	- m	8 -	- -	- -	- 17
Pleurosigma minutum	- -	- + - -	8 - 8 +	- m	- -	- m	8 17	- -	- -	- -
Other forms	8 47	9 17 50	8 8 50	7 m	50 8	- m	258 117	6 1	3 21	8 108

TABLE 20.

Slide Series at SB20.

	1945										1946										
Month	Oct.					Nov.	Dec.				Jan.	Feb.		Apr.		Aug.			Sept.		
Date of Collection	2.10	4.10	8.10	15.10		5.11	11.12	21.12		31.12	10.1	13.2	22.2	2.4	16.4	1.8	12.8	26.8	9.9		23.9
Length of Exposure	4	6	10	10	5		6	16	10	10	20	21	30	21	35	24	35	14	28	28	42
Achnanthes Strömi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-			-	-	-	-
Amphiprora sp.	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphora acutiuscula	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+			-	-	-	-
A. coffeaeformis	-	-	-	-	-	-	1	-	-	-	-	-	-	-	+	+	-	-	1	-	1
	-	-	-	-	-	-	-	-	-	4	-	-	-	-	+			-		-	1
A. laevis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	2	-	-	1	-	-			-	-	-	1
A. macilenta	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	1	-	-	-
	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-			-	-	-	-
A. marina	-	-	-	1	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-
	-	-	-	-	-	-	-	-	-	3	1	-	-	-	-			-	-	-	1
A. truncata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-			-	-	-	-
Cocconeis Scutellum	-	-	-	2	-	7	1	1	-	-	-	-	-	-	+	+	1	+	6	3	4
	+	-	-	-	-	-	-	-	-	2	2	-	3	-	-			-	-	4	8
Diploneis spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-			-	-	-	-
Licmophora sp.	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Navicula bahusiensis	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
arctica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
N. bahusiensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
bahusiensis	-	-	-	-	-	-	-	-	-	3	-	-	1	-	-			-	-	-	-
N. pygmaea	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	+	2	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			+	-	1	1
N. ramosissima	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-			-	-	-	-
N. retusa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-			-	-	-	-
Navicula spp. indet.	-	+	+	+	-	3	1	-	3	-	-	-	1	-	1	-	+	-	-	-	-
	-	-	-	+	-	-	-	-	-	5	1	-	2	-	+			-	+	-	-
Nitzschia closterium	-	-	-	-	-	2	-	-	-	-	-	-	-	-	+	-	-	-	2	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			-	-	-	-
Nitzschia spp. indet.	-	-	-	-	-	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	3	1	-	-	-	-			-	-	-	-
Other forms	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	1	1	-
	-	-	-	-	-	-	-	-	-	3	-	-	1	-	1			-	-	-	-

TABLE 21

Monthly Variation on slides from NBl-4.

		1945						1946				
Month of Collection	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Achnanthes affinis	1	-	-	-	-	12	3	3	-	+	-	1
	-	-	-	-	1	1	1	-	-	-	-	-
A. Strömi	-	-	-	-	-	-	-	1	-	-	-	-
	1	-	-	-	-	-	-	-	-	-	-	-
Achnanthes sp. nov.	-	-	-	-	2	-	+	-	-	-	-	-
	-	-	-	-	-	-	1	2	-	-	-	-
Amphora acutiuscula	-	+	-	-	-	-	+	2	+	-	-	-
	1	+	-	-	-	-	+	6	5	-	-	-
A. coffeaeformis	3	3	2	1	17	+	56	2	2	2	49	3
	10	9	3	2	4	-	306	17	45	8	98	6
A. laevis	1	-	1	-	-	1	+	4	5	4	1	2
	5	1	-	-	-	+	1	3	5	2	+	3
A. macilenta	+	2	1	3	-	-	-	-	1	-	-	-
	1	2	2	-	-	-	-	-	-	-	-	-
A. marina	-	1	-	1	-	+	1	-	1	-	-	-
	3	1	1	2	2	-	-	4	1	+	-	4
A. Proteus	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	1	-	-	-	-	-	-	-	-	-
A. truncata	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	+	-	-	-	-
Cocconeis Scutellum	8	7	12	11	568	6	24	6	9	5	143	28
	5	8	2	11	5	+	5	3	+	3	1	9
Diploneis sp.	-	+	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-
Gyrosigma rectum	-	-	-	-	-	-	-	-	-	-	1	1
	-	-	-	-	-	-	-	-	-	-	-	-
Licmophora sp.	-	-	-	-	-	-	1	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	1	+
Navicula bahusiensis arctica	4	1	2	-	4	4	1	1	-	1	1	1
	14	-	1	1	3	3	2	1	1	2	1	2
N. bahusiensis bahusiensis	1	1	3	1	35	-	26	6	3	1	82	2
	16	11	6	-	13	3	248	63	195	6	4	8
N. Bulnheimii	-	-	-	-	-	+	+	-	+	-	-	-
	-	+	-	-	-	2	1	5	2	-	-	-
N. gregaria	-	+	-	-	-	+	2	5	4	-	-	-
	1	-	-	-	-	+	25	20	-	-	-	-
N. pygmaea	5	3	-	-	2	3	1	8	35	14	6	5
	13	12	5	-	1	+	+	32	19	27	2	11
N. ramosissima	-	-	-	-	-	-	-	-	-	-	-	+
	-	-	-	-	-	-	-	-	-	-	1	-
N. retusa	1	+	1	-	-	3	2	5	11	2	2	6
	4	-	2	-	2	2	2	28	4	3	1	7
Nitzschia closterium	1	-	-	-	-	+	10	+	-	-	-	2
	1	1	-	-	-	2	22	1	4	-	1	-
Nitzschia sp. (tryblionellid)	1	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	1	-	-	-	-	-	-	-	-
Pleurosigma minutum	+	-	-	-	-	+	-	1	6	1	1	1
	1	-	+	-	-	-	-	2	2	8	-	-
Tropidoneis sp.	-	-	-	-	-	-	-	1	3	+	-	+
	-	-	1	-	-	-	-	-	+	2	-	-

TABLE 22.

Monthly variation on slides from NB5-7.

		1945					1946					
Month of Collection	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Achnanthes Strömi	-	-	-	-	-	No	-	-	-	-	-	-
	1	-	-	-	-	data	-	-	-	-	-	-
Achnanthes sp. nov.	-	-	-	-	-	"	-	-	-	-	-	-
	-	-	-	-	-	"	-	-	-	-	66	-
Amphora acutiuscula	-	-	-	-	-	"	2	-	-	-	-	-
	-	-	-	-	-	"	-	-	-	-	-	-
A. coffeaeformis	2	-	-	1	1	"	2	-	1	2	-	-
	1	+	-	-	-	"	-	1	1	1	138	-
A. laevis	1	1	-	-	-	"	1	1	3	7	-	-
	-	-	-	-	-	"	-	-	-	-	-	-
A. macilenta	3	-	1	-	-	"	-	-	2	2	-	-
	-	-	-	-	-	"	1	-	-	-	6	-
A. marina	-	-	-	-	-	"	-	-	-	-	-	-
	-	2	-	2	-	"	1	-	-	1	11	-
A. Proteus	-	-	-	-	-	"	-	1	-	-	-	-
	-	-	-	-	-	"	-	-	-	-	-	-
Cocconeis Scutellum	3	-	+	-	-	"	3	-	1	3	+	1
	1	-	-	-	+	"	1	-	-	1	14	-
Navicula bahusiensis arctica	-	2	-	-	-	"	-	-	-	1	-	-
	-	-	-	-	-	"	-	-	-	1	-	-
N. bahusiensis bahusiensis	6	-	+	-	-	"	-	2	1	2	-	1
	1	1	-	-	-	"	-	-	-	-	246	-
N. Bulnheimii	-	-	-	-	-	"	-	1	-	-	-	-
	-	-	-	-	-	"	-	-	-	-	-	-
N. gregaria	-	-	-	-	-	"	-	-	-	-	-	-
	-	-	-	-	-	"	1	-	-	-	-	-
N. pygmaea	3	3	1	1	2	"	8	17	7	14	2	1
	1	7	-	-	+	"	3	4	6	12	2	-
N. ramosissima	-	-	-	-	-	"	-	-	-	-	-	-
	-	-	-	-	-	"	-	-	-	-	25	-
N. retusa	2	+	-	-	1	"	-	-	-	1	-	-
	1	-	-	-	-	"	-	-	-	-	-	-
Nitzschia closterium	3	-	-	-	-	"	-	1	-	-	-	-
	1	-	-	-	-	"	-	-	-	-	9	1
Nitzschia sp. (tryblionellid)	1	-	-	-	-	"	-	-	-	-	-	-
	-	-	-	-	-	"	-	-	-	-	-	-

TABLE 23

Monthly variation on slides from SB7 and SB10, 1946.

Station	SB7						SB10					
Month of Collection	Apr.	May	June	July	Aug.	Sept.	Apr.	May	June	July	Aug.	Sept.
Achnanthes Strömi	-	-	-	-*	-	-	-	-	-	-	1	-
	-	-	-		-	-	-	-	-	-	-	-
Achnanthes sp. nov.	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	2	-	-	-	-	-	-	-	-	-
Amphora acutiuscula	-	-	-	-	-	-	-	-	-	-	-	-
	+	-	6	-	-	-	+	-	-	-	-	-
A. coffaeaformis	-	2	6	3	2	3	-	-	-	1	-	7
	-	-	40		2	-	+	1	-	-	-	+
A. laevis	1	-	-	-	1	1	-	-	1	2	-	1
	-	-	2		1	-	-	-	1	-	-	-
A. macilenta	-	-	2	-	1	1	-	-	-	2	1	1
	-	-	-	-	-	-	-	-	-	-	-	-
A. marina	+	-	3	-	1	-	-	-	-	1	-	1
	-	-	18		-	2	1	-	2	2	1	+
A. Proteus	-	-	-	-	-	-	-	-	-	1	-	-
	-	-	-		-	-	-	-	-	-	-	-
A. truncata	-	-	-	-	-	-	-	-	-	1	-	-
	-	-	-		-	-	-	-	-	-	-	-
Cocconeis Scutellum	2	3	125	68	2	12	+	-	1	1	2	11
	1	+	6		2	-	-	-	-	-	-	-
Gyrosigma rectum	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	3		-	-	-	-	-	-	-	-
Navicula bahusiensis	-	-	-	-	-	-	-	-	-	-	-	1
arctica	-	-	-	-	-	-	-	-	-	1	-	-
N. bahusiensis	-	-	16	13	1	-	-	-	1	1	1	1
bahusiensis	-	-	44		2	-	-	+	-	-	-	-
N. Bulnheimii	-	-	6	-	-	-	-	-	-	-	-	-
	-	-	24		-	-	-	-	-	-	-	-
N. pygmaea	8	6	6	1	7	4	2	1	2	3	4	3
	2	2	21		7	-	3	2	3	2	-	-
N. ramosissima	-	-	-	2	-	-	-	-	-	-	-	3
	-	-	-		-	-	-	-	-	-	1	-
N. retusa	-	-	-	-	1	-	-	-	1	-	-	-
	+	-	-		-	-	1	-	-	-	-	-
N. scopulorum	-	-	-	-	-	1	-	-	-	-	-	+
	-	-	-		-	-	-	-	-	-	-	-
Nitzschia closterium	+	-	-	-	-	-	-	-	-	-	-	-
	-	-	44		-	-	-	-	-	-	-	-
N. sigma	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-		-	-	-	-	-	1	-	-
Pleurosigma minutum	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	5		1	-	-	-	-	-	-	-
Tropidoneis sp.	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	6		-	-	-	-	-	-	-	-

* No data for the under surface were obtained.

TABLE 24.

Monthly variation on slides from LS1-4.

Month of Collection	1945 Oct.	Nov.	Dec.	1946 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Achnanthes affinis	-	-	-	No	-	-	-	-	-	-	-
	+	-	-	data	-	-	-	-	-	-	-
A. Strömi	-	1	4	"	10	1	2	-	-	1	-
	-	2	57		1	5	3	3	-	1	-
A. subsalsoides	-	-	-	"	-	-	-	-	-	+	-
	-	-	-		-	-	-	-	-	-	-
Amphora acutiuscula	+	-	-	"	-	-	-	-	-	-	-
	+	-	-		2	2	2	3	24	-	-
A. coffeaeformis	2	1	1	"	6	+	+	48	50	x74	275
	4	+	90		2	12	4	80	21	124	169
A. costata	-	-	-	"	-	-	-	-	-	-	-
	-	-	-		-	-	+	-	-	-	-
A. laevis	+	-	1	"	1	-	+	-	+	+	-
	1	+	1		4	12	1	1	+	-	-
A. macilenta	1	1	1	"	4	-	+	-	-	-	-
	1	4	4		2	4	+	-	-	-	-
A. marina	1	1	-	"	-	-	-	-	-	+	-
	-	1	1		-	+	-	-	10	3	-
A. truncata	-	-	-	"	1	+	-	-	-	-	-
	-	-	-	"	-	-	-	-	-	-	-
Cocconeis Scutellum	4	2	2	"	3	-	1	18	25	256	1235
	1	1	-		2	+	1	6	1	218	3474
Diploneis spp.	-	-	-	"	-	-	-	-	-	-	2
	-	-	-	"	-	-	+	-	-	-	2
Gyrosigma rectum	-	-	-	"	-	-	-	-	-	1	-
	-	-	-	"	-	-	-	-	1	-	-
Licmophora sp.	-	-	-	"	-	-	-	-	2	+	-
	-	-	-		-	-	-	-	1	2	10
Navicula bahusiensis arctica	-	-	-	"	-	-	-	-	1	1	-
	-	-	-		-	-	-	1	3	-	-
N. bahusiensis bahusiensis	1	1	-	"	2	-	-	2	8	13	25
	2	1	4		1	-	+	8	37	9	8
N. Bulnheimii	+	-	-	"	-	-	-	1	1	-	-
	+	-	5		-	-	+	-	3	-	-
N. gregaria	+	-	-	"	-	-	-	-	-	-	-
	+	-	-	"	-	-	+	-	-	-	2
N. pygmaea	+	-	-	"	-	-	-	-	-	+	-
	2	+	-		2	-	-	+	15	4	-
N. ramosissima	-	-	-	"	-	-	-	-	-	-	-
	-	-	-		-	-	-	-	-	6	-
N. retusa	1	+	-	"	-	-	+	-	-	-	-
	1	-	2		2	-	3	1	1	1	-
N. scopulorum	+	-	-	"	-	-	-	-	-	-	-
	-	-	+		-	-	-	-	-	-	-
Nitzschia closterium	1	5	+	"	1	-	+	1	+	1	10
	+	1	1		1	1	+	10	6	6	4
N. Sigma	-	1	-	"	-	-	-	-	-	-	-
	-	+	-		-	-	-	-	-	-	-
Nitzschia sp. (tryblionellid)	-	+	-	"	1	-	-	-	-	-	-
	-	-	-		-	-	-	-	-	-	-
Pleurosigma minutum	-	+	-	"	-	-	-	-	-	-	2
	-	-	-		-	-	-	-	-	-	2
Tropidoneis sp.	+	-	-	"	-	-	-	-	-	-	-
	+	-	-		-	-	-	-	-	1	-

TABLE 25.

Monthly variation on slides from LS5-7.

	1945		1946							
Month of Collection	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Augs.
Achnanthes Strömi	+	-	No	1	No	-	-	-	-	-
	1	-	data	-	data	28	m	-	-	-
Achnanthes sp. nov.	-	-	"	1	"	2	3	-	-	-
	-	-		-		4	m	4	-	-
Amphora acutiuscula	-	-	"	1	"	10	3	2	-	-
	1	-		1		13	m	5	-	-
A. coffeaeformis	4	1	"	7	"	61	382	704	482	363
	8	+		19		135	m	212	215	892
A. laevis	-	+	"	1	"	2	-	6	6	-
	-	-		5		1	m	6	9	-
A. macilenta	3	1	"	1	"	-	-	8	-	13
	1	+		4		2	m	2	3	-
A. marina	-	1	"	2	"	1	-	-	3	17
	5	-		14		8	m	44	3	50
A. Proteus	-	-	"	-	"	2	-	-	-	-
	-	-		-		3	m	8	-	-
A. truncata	-	-	"	-	"	-	-	-	-	-
	-	1		-		-	m	2	-	-
Cocconeis Scutellum	2	2	"	7	"	67	17	32	103	492
	3	-		3		6	m	5	6	19
Grammatophora sp.	-	-	"	-	"	-	-	-	-	24
	-	-		-		-	m	18	-	-
Licmophora sp.	-	-	"	-	"	-	-	-	3	4
	-	-		-		1	m	-	-	-
Navicula bahusiensis	-	-	"	-	"	6	-	-	-	13
arctica	1	-		-		3	m	-	-	625
N. bahusiensis	1	+		2		29	23	53	24	25
bahusiensis	2	-		29		170	m	16	9	825
N. Bulnheimii	-	-	"	-	"	1	-	-	-	-
	-	-		-		15	m	-	-	-
N. gregaria	-	-	"	-	"	-	-	-	-	-
	1	-		-		49	m	-	-	-
N. pygmaea	1	2	"	2	"	1	-	4	-	8
	3	-		6		4	m	9	-	8
N. ramosissima	-	1	"	-	"	-	9	50	-	146
	-	-		-		-	m	56	482	75
N. retusa	-	1	"	1	"	5	-	-	-	-
	-	-		24		4	m	20	-	17
N. scopulorum	-	+	"	-	"	2	-	-	-	4
	-	-		3		-	m	-	-	17
Nitzschia closterium	1	+	"	2	"	5	15	10	-	9
	1	-		-		23	m	75	18	-
N. Sigma	+	-	"	-	"	-	-	-	-	-
	-	-		-		-	m	-	-	8
Nitzschia sp.	-	-	"	-	"	-	-	-	-	4
(tryblionellid)	-	-	"	-		-	m	2	-	-
Pleurosigma minutum	-	-	"	-	"	-	-	-	-	4
	-	-		2		4	m	9	-	17
Tropidoneis sp.	-	-	"	-	"	-	-	-	-	-
	2	-		-		-	m	3	-	-

TABLE 26.

Monthly variation on slides from LS10, 1946.

Month of Collection	Feb.	Mar.	Apr.	May	June	July	Aug.
Achnanthes affinis	-	No	1	-	-	see	-
	-	data	-	-	-	below	-
A. Strömi	-	"	-	-	-	"	-
	-		-	-	1		4
Amphora acutiuscula	-	"	6	2	-	"	-
	1		7	32	-		-
A. coffeaeformis	2	"	12	11	34	"	15
	1		15	44	66		312
A. laevis	-	"	-	-	1	"	-
	-		-	6	-		-
A. macilenta	1	"	-	-	-	"	2
	-		-	-	2		4
A. marina	1	"	-	3	2	"	3
	4		1	6	28		76
A. Proteus	-	"	-	-	-	"	-
	-		-	-	2		-
Cocconeis Scutellum	2	"	20	3	3	"	44
	2		1	6	6		33
Diploneis sp.	-	"	-	-	-	"	-
	-		-	-	6		-
Grammatophora sp.	-	"	-	-	-	"	1
	-		-	-	-		-
Gyrosigma rectum	-	"	-	-	-	"	1
	-		-	6	-		-
Navicula bahusiensis arctica	1	"	1	-	-	"	-
	1		2	-	-		-
N. bahusiensis bahusiensis	-	"	5	7	6	"	2
	-		25	62	36		369
N. Bulnheimii	-	"	-	1	-	"	-
	-		12	3	-		-
N. gregaria	-	"	-	-	-	"	-
	-		3	-	-		-
N. pygmaea	5	"	3	6	1	"	4
	1		-	24	11		47
N. ramosissima	-	"	28	-	15	"	9
	-		201	-	15		88
N. retusa	-	"	-	-	-	"	-
	-		-	-	14		-
Nitzschia closterium	-	"	7	4	1	"	-
	-		14	62	21		9
Nitzschia sp. (tryblionellid)	-	"	-	-	-	"	-
	-		-	-	-		9
Pleurosigma minutum	-	"	-	-	-	"	-
	1		-	9	-		-

TABLE 27.

Diatoms on slides from Loch Craiglin, 1 m., (1944).

Month	May	June		July			Aug.		Sept.		Nov.
Date of Collection	15.5	18.6	28.6	12.7	22.7	29.7	7.8	16.8	5.9	28.9	20.11
Length of Exposure	43	11	21	35	5	12	21	8	28	19	45
Achnanthes brevipes	4	-	-	-	-	3	-	-	8	-	-
Achnanthes sp. like subsalsoides	16	-	7	-	-	-	-	-	-	-	-
Achnanthes spp. indet.	-	-	-	250	-	5	7	12	8	-	-
Amphora coffeaeformis	25	-	20	166	8	2	-	50	125	-	-
Cocconeis Placentula	208	-	35	670	35	10	50	-	13	-	1
C. Scutellum	58	-	2	13	3	-	3	-	4	-	-
Mastogloia elliptica	-	-	-	8	13	5	23	37	42	-	-
M. pumila	-	-	-	117	173	20	260	33	75	-	-
Navicula abrupta	-	-	-	-	-	-	7	-	-	-	-
N. bahusiensis	-	-	-	-	-	-	-	-	38	-	-
N. gothlandica	4	-	-	8	-	-	-	7	21	-	-
Navicula spp.indet.	8	-	-	-	3	1	7	5	8	-	-
Rhabdonema minutum	4	-	-	-	-	-	-	-	-	-	-
Rhopalodia musculus	-	-	-	4	2	2	3	5	8	-	-
Stauroneis Gregorii	-	-	-	4	2	-	3	-	-	-	-
Synedra pulchella	8	-	-	-	-	2	3	-	-	-	-
Other forms	63	-	-	33	15	8	17	-	4	-	-
TOTAL	398	-	64	1263	254	58	383	149	354	-	1

TABLE 28.

Diatoms on slides from Loch Craiglin, 3 m., (1944).

Month	May		June		July			Aug.		Sept.	Nov.
Date of Collection	15.5		18.6	28.6	12.7	22.7	29.7	7.8	16.8	28.9	20.11
Length of Exposure	43		11	21	35	5	12	21	8	19	45
Achnanthes brevipes	-	-	-	-	-	-	-	1	-	-	-
Achnanthes sp. like subsaloides	2	-	6	75	48	-	-	7	-	-	-
Achnanthes spp. indet.	2	-	32	750	230	13	12	12	-	-	-
Amphiprora sp.	-	-	1	-	-	-	-	-	-	-	-
Amphora coffeaeformis	-	-	46	833	385	2	2	2	-	-	-
A. Proteus	-	-	1	-	-	6	7	8	3	-	-
Cocconeis Placentula	2	-	30	840	320	40	32	6	-	-	-
C. Scutellum	-	-	1	-	4	2	3	-	-	-	-
Diploneis sp.	-	-	1	-	-	-	-	-	-	-	-
Mastogloia elliptica	-	-	-	13	-	-	-	-	-	-	-
M. pumila	2	-	-	-	-	-	-	-	-	-	-
Navicula abrupta	-	-	-	4	-	-	-	-	-	-	-
N. bahusiensis	-	-	33	83	60	-	-	-	-	-	-
N. gothlandica	-	-	21	-	-	-	-	-	-	-	-
N. pygmaea	2	-	-	-	-	-	2	-	-	-	-
Navicula spp.indet.	4	3	18	-	20	-	2	4	-	-	-
Pleurosigma thuringicum	-	-	-	-	-	-	5	12	-	-	-
Pleurosigma spp.indet.	-	-	-	-	-	-	-	1	-	-	-
Stauroneis Gregorii	3	3	4	8	4	1	2	2	-	-	-
Synedra pulchella	3	-	1	8	-	-	-	1	-	-	-
Other forms	-	2	13	-	-	-	-	1	-	-	-
TOTAL	20	8	208	2614	1071	64	67	57	3	-	-

TABLE 29.

Diatoms on slides from Loch Craiglin, 4.5 m., (1944).

Month	May	July		Aug.		Sept.
Date of Collection	15.5	22.7	29.7	7.8	16.8	28.9
Length of Exposure	43	5	12	21	8	19
Achnanthes sp. like subsalsoides	- - -	-	-	-	1	-
Achnanthes spp. indet.	1 - -	-	-	-	-	1
Amphora coffeaeformis	- - -	1	-	-	1	-
A. laevis	- 1 -	-	-	-	-	-
Cocconeis Placentula	1 - 1	1	1	-	1	2
Mastogloia elliptica	- - -	-	-	-	-	2
M. pumila	1 - -	-	1	1	1	2
Navicula bahusiensis	1 - -	-	-	-	-	2
N. gothlandica	1 - 2	-	-	-	-	1
N. pygmaea	- - -	-	-	-	1	-
N. retusa	- - -	-	-	-	-	1
Navicula spp. indet.	- 1 2	-	3	-	-	2
Nitzschia closterium	- - -	-	-	-	1	-
Pleurosigma thuringicum	- - -	-	1	-	-	-
Rhopalodia musculus	- - -	-	-	1	-	1
Stauroneis Gregorii	- - -	-	-	-	-	2
Synedra pulchella	- 1 -	1	1	1	1	3
Other forms	- - 2	-	-	2	2	2
TOTAL	5 3 7	3	7	5	9	21

TABLE 30.

Distribution of diatoms on a slide placed vertically in a breffit of mud and exposed from 6th December to 17th December, 1945. (I).

	Number of diatoms counted in 5 fields.													
	Depth (mms) below surface					Surface of mud	Height (mms) above mud surface							
	10	7	5	3	1		1	3	5	7	10	15	20	25
Achnanthes sp.							1							
Amphora acutiuscula				1										
A. coffeaeformis						5	11	12	1			1		2
A. laevis								1		1	2	2	1	1
A. macilenta			1		2	1			1					
A. marina					1	1	3	4	1	1			1	1
A. Proteus										2				
Cocconeis Scutellum						1		1	1	1	2	2	1	2
Navicula bahusiensis arctica				1	1	1								
Navicula bahusiensis bahusiensis				1	2	3	9	18	2					
N. Bulnheimii						2		1						
N. pygmaea		1	1	1		2	1	1	1					
N. ramosissima							3							
Navicula spp. indet.					4	3	14	19	1	5	3	2	1	2
Nitzschia closterium				2		2		5	4	2	1		1	
N. Sigma						1	1	3	1	2	2			
Nitzschia sp. (tryblionellid)							1							
Nitzschia spp. indet.						3	7	12	5	2	1			
Pleurosigma sp.								1						
Other forms				1	1	4	3	1	4	1		1		
TOTAL	0	1	2	7	11	29	54	79	22	17	11	8	5	8
Average number per sq. mm.	0	3	7	23	37	97	180	263	73	57	37	27	17	27
Minimum number of species	0	1	2	6	6	1	13	12	13	11	9	6	5	5

TABLE 31.

Vertical distribution of diatoms in mud (II).

	Number of diatoms counted in 5 fields													
	Depth (mms) below surface					Surface of mud	Height (mms) above mud surface							
	10	7	5	3	1		1	3	5	7	10	15	20	25
Amphora coffeaeformis						1	1	1	1		1		2	
A. laevis						1		1	2	2	4	1	1	
A. macilenta			1	2										
A. marina			1			3		1	3	2				
A. Proteus								2	3	4	1			
Cocconeis Scutellum							2	1	2		1			
Navicula bahusiensis arctica					2		1							
N. bahusiensis bahusiensis						1	10	13	2	1				1
N. Bulnheimii							3	1						
N. pygmaea		1	2	4	3		2							
N. retusa						1	1							
Navicula spp.indet.			2	1	3	7	7	6	4	1	1			
Nitzschia closterium					1	4	2	2	2	2				
Nitzschia sp. (tryblionellid).							1							
Nitzschia spp.indet.						3	3	2	2		1		1	
Pleurosigma sp.						1				1				1
Other forms							1	1		1		1		
TOTAL	0	1	6	7	9	22	33	31	21	14	9	2	4	2
Average number per sq. mm.	0	3	20	23	33	73	108	103	70	47	33	7	13	7
Minimum number of species	0	1	4	3	4	9	12	11	9	8	6	2	3	2

TABLE 32.

Results of core sample counts - I : total number of diatoms

Station	Date	Approx. number of diatoms per sq. mm. of mud surface
NB2	5-9-46	5300, 5800
NB7	"	2700, 2300, 1900
SB7	"	3900, 2900
SB10	"	100
SB20	"	900, 400, 1000
LS10(a)	9.9.46	1000, 2000, 1300
(b)	"	5500
Loch Sween, 22f	"	500, 100

TABLE 33.

Diatoms recorded from core sample counts

Figures given are the total numbers of each species counted in each sample

Station	N.B.		S.B.		L.S.		S.B.	L.Sween
Depth	2	7	7	10	10		20	22f
Amphora acutiuscula						-	-	
	-	-	-	-	-	-	-	-
	1	-	-			-	-	-
Amphora coffeaeformis		(1				-	(1	
	2	(3	1	1	4	-	(1	+
	2	(1	-			-	(-	-
Amphora laevis		(1				-	(-	
	2	(2	-	-	-	-	(-	-
	1	(1	-			-	(+	-
Amphora macilenta		(-				(-	-	
	2	(-	-	-	1	(-	-	-
	-	(1	2			(1	-	-
Amphora marina		(1				(-	(1	
	2	(-	-	+	-	(1	(-	1
	1	(1	1			(1	(-	-
Cocconeis Scutellum		(2				(1	(2	
	2	(1	1	-	1	(-	(-	-
	3	(1	2			(1	(-	-
Diploneis spp		(-				(2	-	-
	-	(2	1	+	1	(-	-	-
	-	(-	1			(2	-	
Grammatophora sp.		-				-	(1	
	-	-	1	-	-	-	(-	1
	-	-	-			-	(-	-
Navicula bahusiensis arctica		(3				-	-	
	-	(-	-	-	-	-	-	-
	1	(-	-			-	-	-
Navicula bahusiensis bahusiensis		(1				-	-	
	-	(1	2	-	1	-	-	-
	4	(2	-			-	-	-
Navicula gregaria	2	=	-	-	-	=	=	-
	1	-	-			-	-	-
Navicula pygmaea		(5				(1	(-	
	4	(-	+	-	+	(-	(-	-
	3	(1	1			(-	(+	-
Navicula retusa		(-				(1	-	
	4	(-	-	-	2	(-	-	-
	4	(1	1			(2	-	-
Navicula scopulorum		-				-	-	
	2	-	-	-	1	-	-	-
	-	-	-			-	-	-
Navicula spp. indet.		(8				(1	(5	
	28	(10	14	-	6	(1	(3	1
	333	(6	8			(4	(1	1

TABLE 33 contd.

Station	N.B.		S.B.		L.S.	S.B.	L. Sween
Depth	2	7	7	10	10	20	22f
Nitzschia Sigma		(1			(1	-	
	2	(-	-	-	1(-	-	-
	-	(-	-		(-	-	-
Nitzschia sp. (tryblionellid)		(1			(1	(1	
	-	(1	-	-	+(-	(-	-
	1	(1	-		(1	(+	-
Nitzschia spp. indet.		(3			(2	(2	
	8	(5	1	+	9(4	(1	-
	4	(1	1		(1	(1	-
Pleurosigma minutum		(1			(-	(-	
	2	(-	-	-	1(-	(-	-
	2	(-	1		(1	(1	-
Pleurosigma spp. indet.		(-			(1	(-	
	-	(-	-	+	(1	(-	1
	4	(1	1		(1	(+	-
Stauroneis sp.		-			(-	-	-
	-	-	-	-	-(-	-	-
	1	-	-		(1	-	
Trachyneis aspera		(-			-	-	
	-	(1	-	+	- -	-	-
	-	(-	-		-	-	-
Tropidoneis sp.		-			-	-	
	-	-	-	-	--	-	-
	1	-	-		-	-	-
Other forms		(3			(1	(-	
	4	(4	1	-	3(-	(-	-
	6	(5	1		(3	(+	-

TABLE 34.

Growth of *Artemia* Nauplii

Figures refer to the instars reached at that time after hatching

Food	6-9 days	10-13 days	14-17 days	18-21 days	22-25 days	26-29 days	30-33 days
Amphiprora paludosa							
(i)	2	5	5	6	7	8	9
(ii)	2	5	5	6	6	7	8
(iii)	2	4	5	dead	-	-	-
Nitzschia affinis							
(i)	2	4	4	5	5	6	7
(ii)	2	4	4	5	5	dead	-
(iii)	2	4	4	4	5	5	6
Nitzschia ?dubiiformis							
(i)	2	3	3	4	4	5	5
(ii)	2	2	3	3	4	4	5
(iii)	2	3	3	4	4	4	5
Stauroneis amphoroides							
(i)	2	3	3	3	dead	-	-
(ii)	2	3	3	3	3	dead	-
(iii)	2	3	3	3	3	3	3
Yeast	2	3	4	5	5	8	9
Chlamydomonas	2	3	4	5	6	6	7
Nitzschia closterium) Bond (1933)	3	-	-	-	-	9	-
Platymonas)	-	3	-	-	8	mating	-
Dunaliella salina)	-	3	-	-	8	-	mating

TABLE 35.

Growth of Hydrobia in Diatom Cultures

Time of Weighing	1st day		14 days		40 days		62 days	
	No. alive	Total Wt. gms.	No. alive	Total Wt.	No. alive	Total Wt.	No. alive	Total Wt.
Amphiprora (i)	8	0.0657	8	0.0661	4	0.0385	2	0.0198
(ii)	8	0.0688	7	0.0596	4	0.0254	0	-
Nitzschia ?dubiiformis (i)	8	0.0774	8	0.0770	8	0.0762	4	0.0374
N. affinis (i)	8	0.0872	8	0.0871	7	0.0727	6	0.0686
(ii)	8	0.0740	7	0.0633	5	0.0346	5	0.0361
Stauroneis	8	0.0929	8	0.0929	8	0.0931	8	0.0942
Ster. sea water	8	0.0728	6	0.0727	0	-	0	-

TABLE 36.

Halobion spectrum of NB2.

		Number of forms	Number of individuals	% of individuals
Indifferent	(Halophobous	0	0	-
	(Indifferent	0	0	-
	(Halophilous	1	45	2
Mesohalobous		6	1828	62
Euhalobous		4	113	4
Uncertain		13	887	30
TOTAL		24	2873	98

TABLE 37.

Halobion Spectrum of LS2

		Number of forms	Number of individuals	% of individuals
Oligohalobous	(Halophobous	0	0	-
	(Indifferent	0	0	-
	(Halophilous	1	2	-
Mesohalobous		5	6307	95
Euhalobous		4	17	-
Uncertain		9	312	5
TOTAL		19	6638	100

TABLE 38.

Halobion Spectrum of Loch Craiglin 1 m.

		Number of forms	Numbers of individuals	% of individuals
Oligohalobous	(Halophobous	0	0	-
	(Indifferent	1	1025*	34
	(Halophilous	0	0	-
Mesohalobous		6	656	22
Euhalobous		5	743	25
Uncertain		5	516	19
TOTAL		17	2940	100

* *Cocconeis Placemtula*

TABLE 39.

Halobion Spectrum of Loch Craiglin 3 m.

		Number of forms	Number of individuals	% of individuals
Oligohalobous	(Halophobous	0	0	-
	(Indifferent	1	1270	31
	(Halophilous	0	0	-
Mesohalobous		7	1350	33
Euhalobous		5	57	1
Uncertain		8	1435	35
	TOTAL	21	4112	100

TABLE 40.

Halobion Spectrum of Loch Craiglin 4.5 m.

		Number of Forms	Number of individuals	% of individuals
Oligohalobous	(Halophobous	0	0	-
	(Indifferent	1	7	12
	(Halophilous	0	0	-
Mesohalobous		8	19	32
Euhalobous		3	11	18
Uncertain		6	23	38
	TOTAL	18	60	100

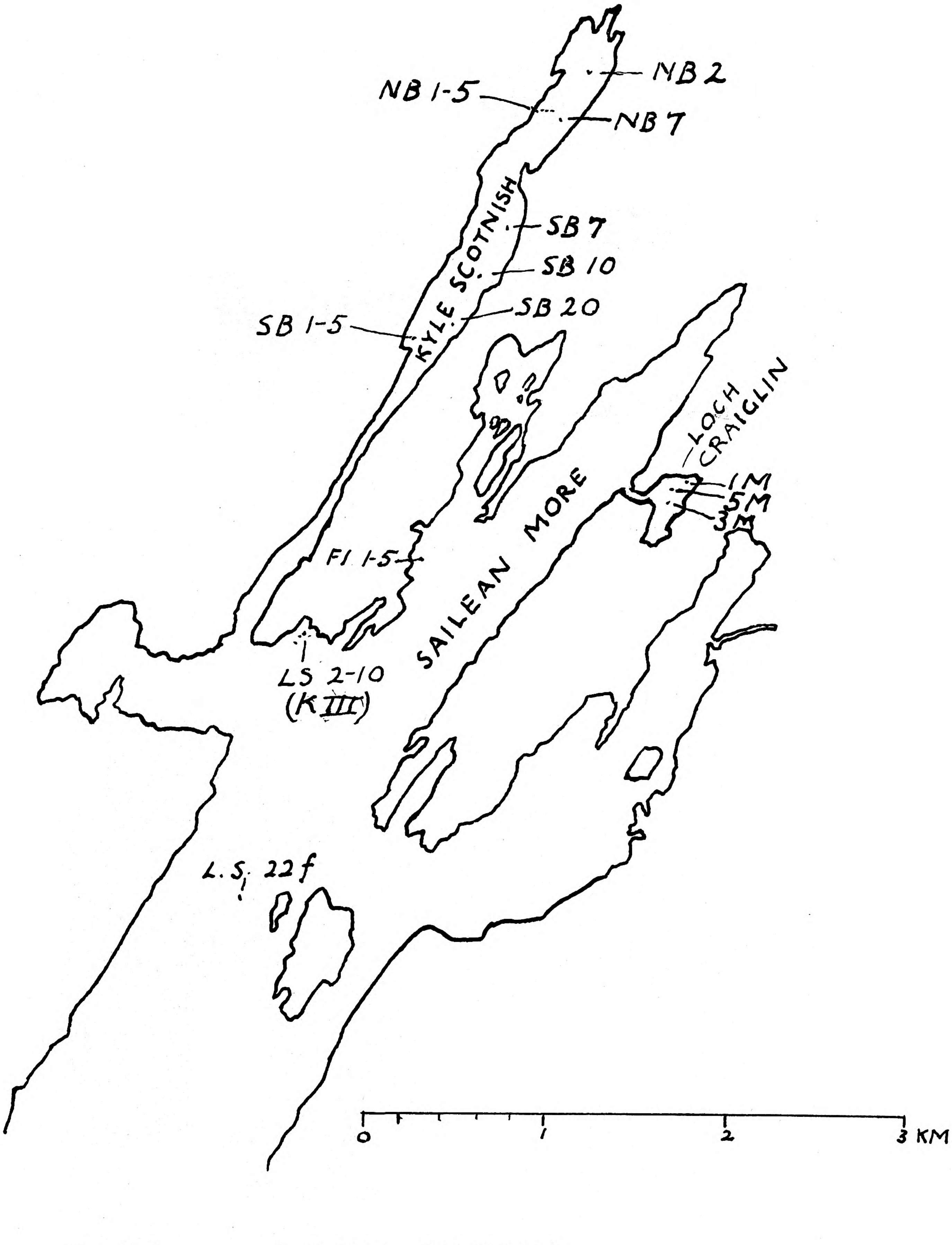

FIG. 1. LOCH SWEEN

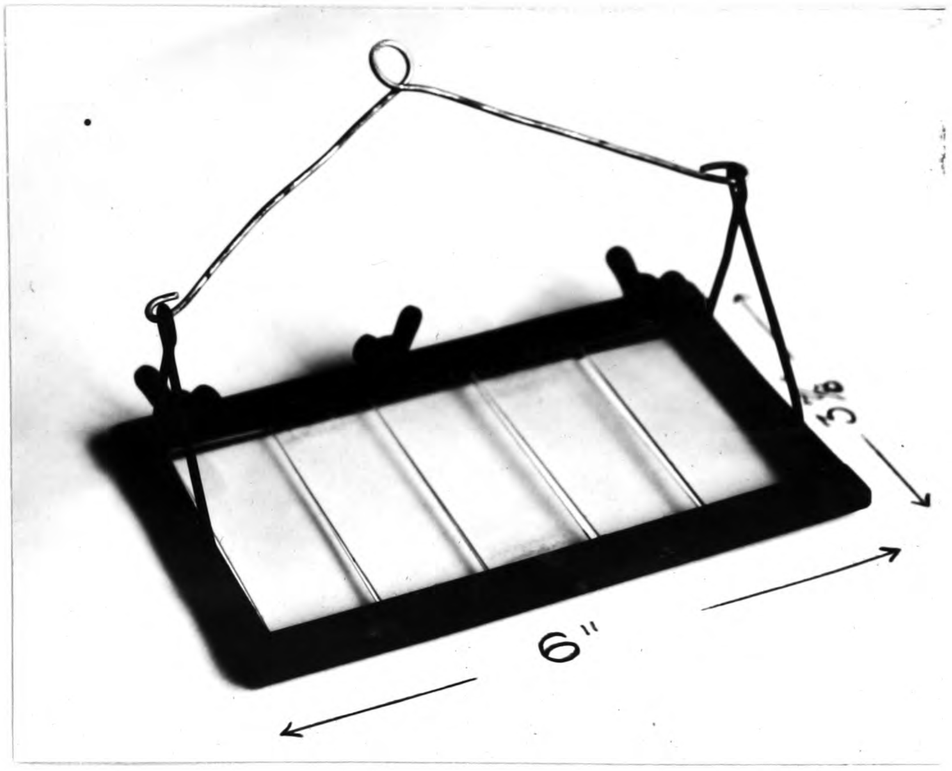

Fig.2. Slide tray with slides in position.

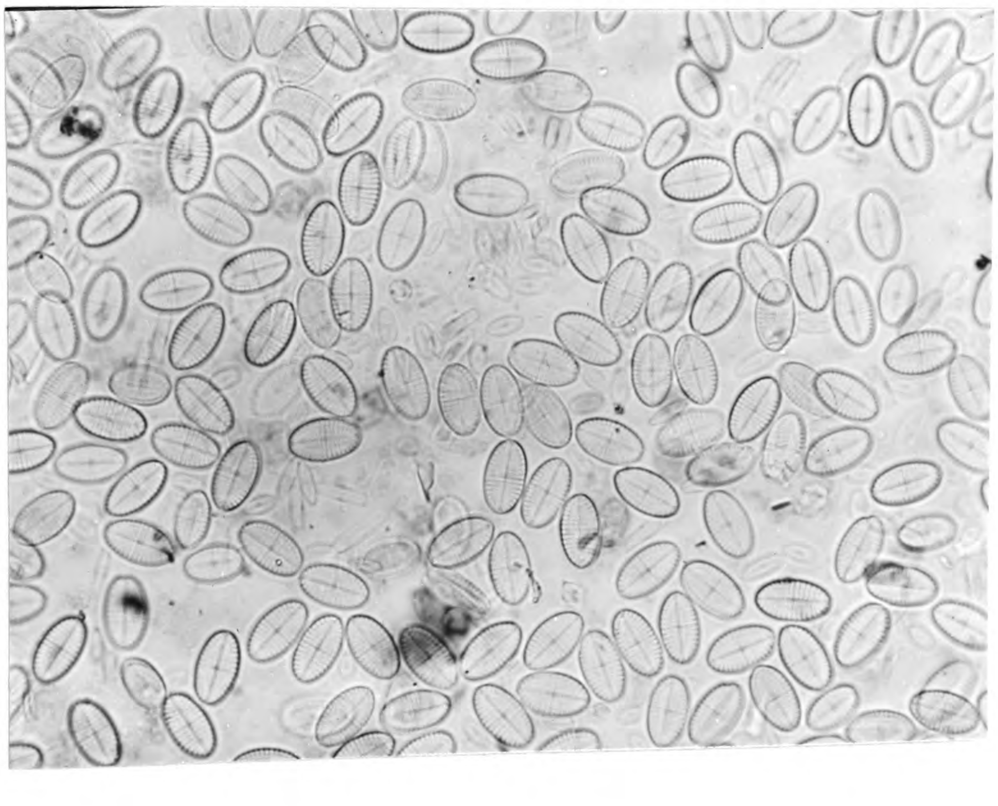

Fig.3. A dense colo~~ur~~nization of Cocconeis Scutellum with Navicula bahusiensis bahusiensis, Amphora coffeaeformis, and small Navicula spp. x 500

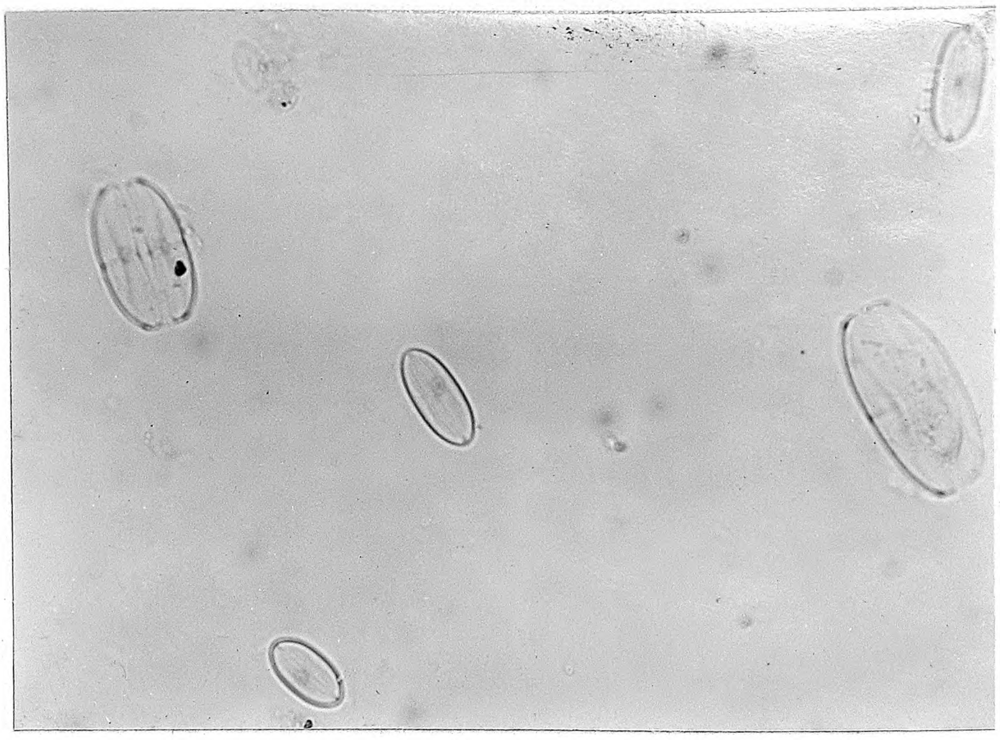

Fig.4. Slide colo~~ur~~nized by non-encrusting forms showing two <u>Amphora laevis</u> and three <u>Navicula pygmaea</u>. x 500

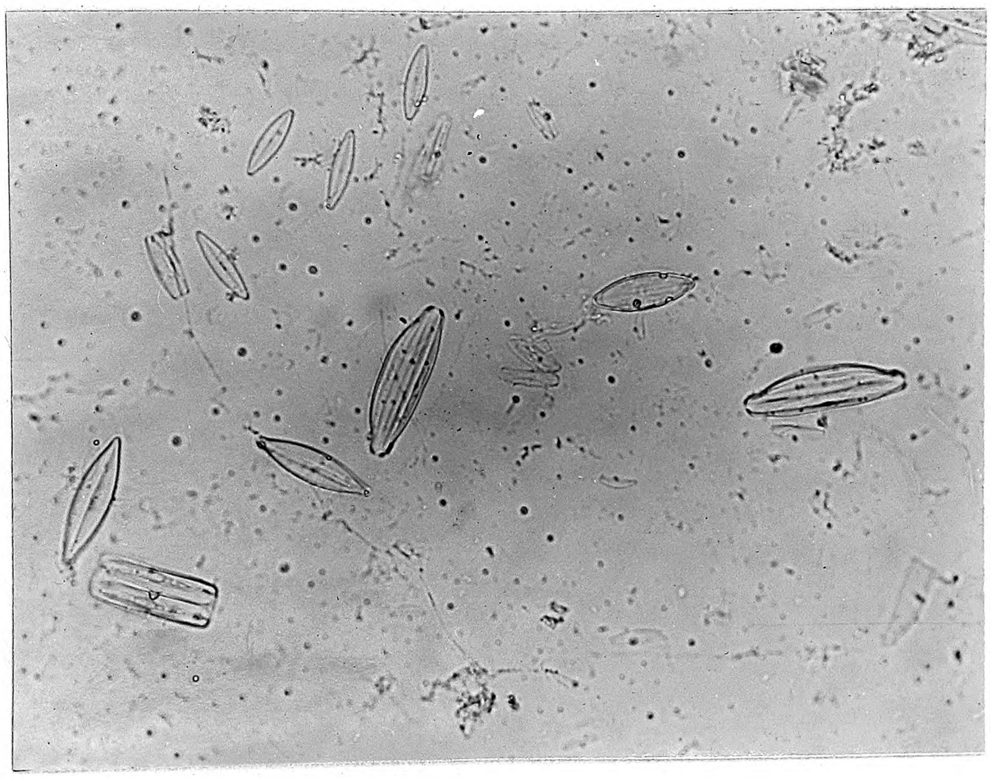

Fig.5. Loch Craiglin slide with two large <u>Amphora coffeaeformis</u>, <u>Mastogloia pumila</u>, and small <u>Navicula</u> spp. x 500