Hydrobiologia vol. 45, 2—3 pag. 199—215, 1974

Effects of the Discharge of Thermal Effluent from a Power Station on Lake Wabamun, Alberta, Canada - The epipelic and epipsamic algal communities.

by

M. Hickman*

Abstract

1. The epipelic algal standing crops were increased by the discharge of thermal effluent into Lake Wabamun, particularly in the discharge canal at station (03—04) and 05.
2. The increase in the standing crop size of the epipelon was due to *Oscillatoria amoena* and *O. borneti* in the heated area, while the discharge canal provided the inoculum of the algae for the heated area of the lake.
3. At station (03—04) the increased standing crop size was also a function of increased light penetration to the sediment due to the heated effluent keeping an area of the lake free of ice during the winter.
4. The species composition of the diatoms was similar at all stations except in the discharge canal where there was a reduction in the number of diatom species.
5. *Navicula cuspidata* developed best in the discharge canal in the summer where water temperatures of 31°C were recorded.
6. *Amphora ovalis* var. *pediculus* was the dominant diatom species during the winter under ice-cover.
7. The heated effluent had no effect upon the standing crop or species composition of the epipsammon.
8. Results obtained from the sediment core study showed that the shallow littoral zone of the lake is very disturbed due to wind-induced wave action.

Introduction

In each algal division there are many species that grow over a wide range of temperatures. There are species that prefer very warm water, those that prefer cold water and finally, those that have no preference. However, the group of species which are in the intermediate temperate ranges are the most important because they are

* Department of Botany, University of Alberta Edmonton, Alberta T6G 2El
Received February 2, 1973

so widespread (PATRICK, 1969). This paper described the effect of discharging thermal effluent into Lake Wabamun on the epipelic and epipsamnic algal communities in the vicinity of the Wabamun Power Station discharge canal (Fig. 1).

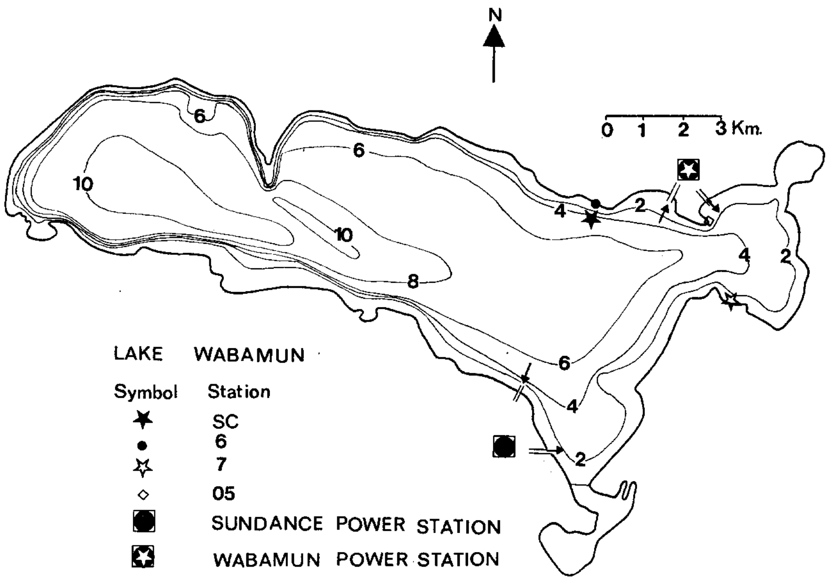

Fig. 1. Bathymetric map of Lake Wabamun, showing the locations of the two power stations and the sampling stations SC, 6, 7 and 05. Depth contours are drawn at 2 m. intervals.

LAKE WABAMUN-DESCRIPTION

Lake Wabamun is a shallow, eutrophic lake situated 64 km west of Edmonton, Alberta (Fig. 2) (longitudes 114°26′ and 114°44′W; latitudes 53°30′ and 53°34′N). The phytoplankton can be classified at eutrophic diatom, eutrophic chlorococcalean and myxophycean plankton associations (GALLUP & HICKMAN, in preparation) according to the classification of HUTCHINSON (1967). The lake lies in the Boreal Parkland Transition vegetation zone (Moss 1955). GALLUP & HICKMAN (1972, and in preparation) showed that there were considerable differences in temperature and dissolved oxygen in the heated areas and non-heated areas of the lake. The spring and summer normal lake condition was one of relatively complete mixing with only transient stratification occurring, whereas the situation in the heated area was more complex and the temperature, throughout the water column, attained higher values. During winter a lake at

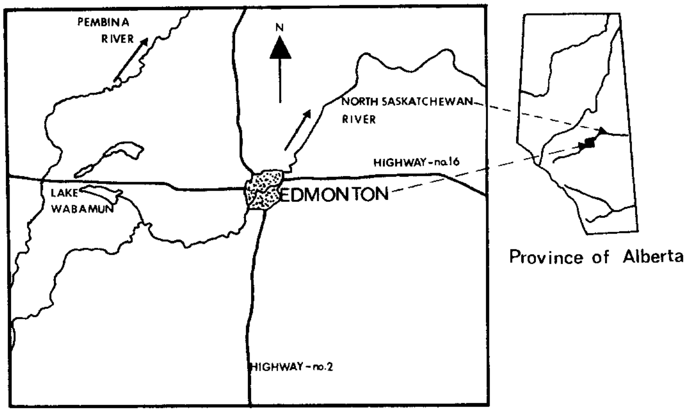

Fig. 2. Location of Lake Wabamun in Alberta.

this latitude becomes frozen to a depth of approximately 1 m with inverse stratification occurring. However, the heated effluent maintained an area of water open all winter (Fig. 3). The heated water

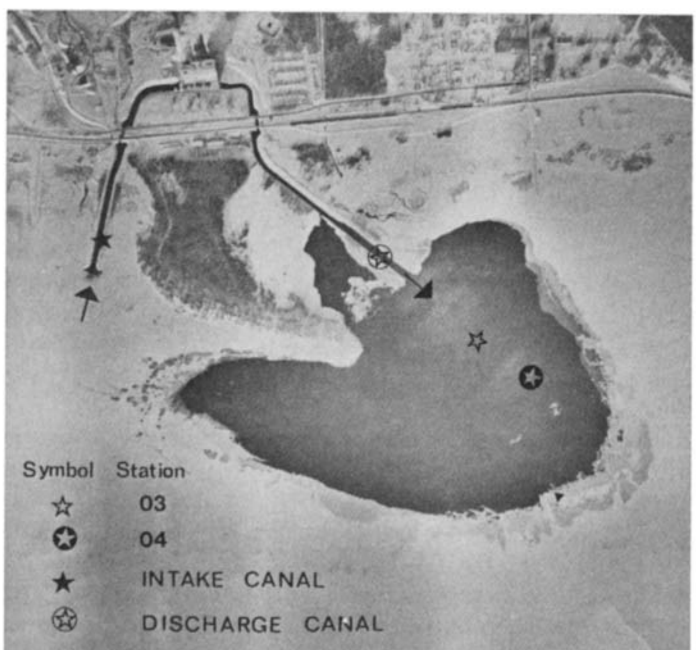

Fig. 3. Aerial photograph showing the Wabamun Power Station, the intake and discharge canals together with the area of the lake kept ice free due to the discharged heated water (December 12, 1970). Also shown are sampling stations 03 and 04, and those in the intake and discharge canals.

maintained an area of the lake 18°C warmer than ambient at times in the winter at the surface, and 7°C in the summer compared with the normal lake where surface water temperature ranged from 0 to 24°C (GALLUP & HICKMAN, 1972 and in preparation).

A detailed series of surface temperature measurements showed that the discharged heated water formed a plume over the lake surface whose direction of flow depended upon wind direction, and dissipation upon wind speed (NURSALL & GALLUP, 1971).

Dissolved oxygen values were high in both the heated and non-heated portions of the lake while the occurrence of a large standing crop of submerged macrophytes just off the mouth of the discharge canal complicated the distribution of dissolved oxygen (GALLUP & HICKMAN, 1972 and in preparation). Higher percentage saturation values were found in the heated area in the winter due to taking water of 90—100% saturation into the condensers and raising the temperature of the water.

METHODS

Sampling stations were chosen after a preliminary survey. The locations of the stations are presented in Figures 2 and 3. Stations 03, 04 and 05 were in the area most affected by the heated discharge water. Stations 01 and 02 used by GALLUP & HICKMAN (1972, and in preparation) were not used in this study because of the submerged macrophyte populations. The depth of water was 3 m and 4 m at Stations 03 and 04, while it was 50 cm at Station 05 in the shallow littoral zone of the lake. Station SC was a control station representative of normal lake conditions with a water depth of about 4 m. This station was ice-covered in winter. Stations 6 and 7 were in the shallow littoral area of the lake unaffected by heated water. Station 6 was on the north shore and station 7 on the south shore of the lake. Two further stations were used, one in the intake canal and the other in the discharge canal (Fig. 3).

The standing crops of the epipelon (those algae free living on the submerged sediments) were investigated at stations in the intake and discharge canals SC, 03, 04, 05, 6 and 7 (Fig. 2 and 3) while the standing crops of the epipsammon (those algae which live attached to sand grains) were investigated at stations 05, 6 and 7. At stations in the intake and discharge canals and 05, 6 and the submerged sediment (under 50 cm of water) and algae were sampled using the quantitative technique of EATON & MOSS (1966). At stations SC, 03 and 04 three short undisturbed, surface sediment cores were removed and combined together (MOSS 1969, HICKMAN 1971).

The samples from stations 05, 6 and 7 were treated, and the standing crop of the epipelic algae subsequently estimated, using the tissue trapping technique of EATON & MOSS (1996). Sediments from stations 03, 04 and SC were highly fluid and organic. Therefore, the modified method of Moss (1969) was used to prepare the sediment.

The epipsammic algae at stations 05, 6 and 7 were separated from the epipelic algae and detritus by repeatedly swirling the sediment with lake water previously filtered through Whatman GF/C glass fibre filter paper to remove phytoplankton and detritus. The lighter, non-attached material was swept into suspension and was decanted off, leaving behind the heavier sand grains together with the attached epipsammic algae (MOSS & ROUND 1967, BAIRD & WETZEL, 1968, HICKMAN & ROUND 1970).

The standing crop of these two communities, as measured by chlorophyll *a*, was determined spectrophotometrically using the method and equations of MOSS (1967a, b). All results are expressed as mg chlorophyll *a* per m^2 and those for stations 03 and 04 have been combined to give an average value for the heated area.

The epipelic algae were identified using the tissue-trapping method of EATON & MOSS (1966), except for the diatoms. The latter were cleaned in a mixture of nitric and sulphuric acids, washed and mounted. The frustules were then identified. Sediment cores taken from stations 05 and 6 were prepared following the method of HICKMAN & ROUND (1970).

DISCUSSION OF RESULTS

Epipelon

The standing crops in the area affected by the thermal effluent were generally greater than those in the control area, when station (03—04) and SC, were compared, particularly in October, November and December (Fig. 4). Ice was forming at Station SC in early November. However, in December/January the standing crops were similar because wind induced turbulence in the heated area removed sediment and algae, while ice cover at Station SC reduced light penetration which in turn reduced the standing crop size of the epipelic algae. This was even more evident in the February to May 1972 period. The water temperature at the mud water interface in the heated area at this time averaged only one to three degrees warmer than that at Station SC (GALLUP & HICKMAN, 1972 and in preparation). Therefore, the heated discharge water did not affect the epipelic algae population directly but instead indirectly by keeping an area of the lake free of ice thus allowing greater light penetration to the sediment surface compared with the ice-covered station SC. The algae, therefore, were able to produce a large stand-

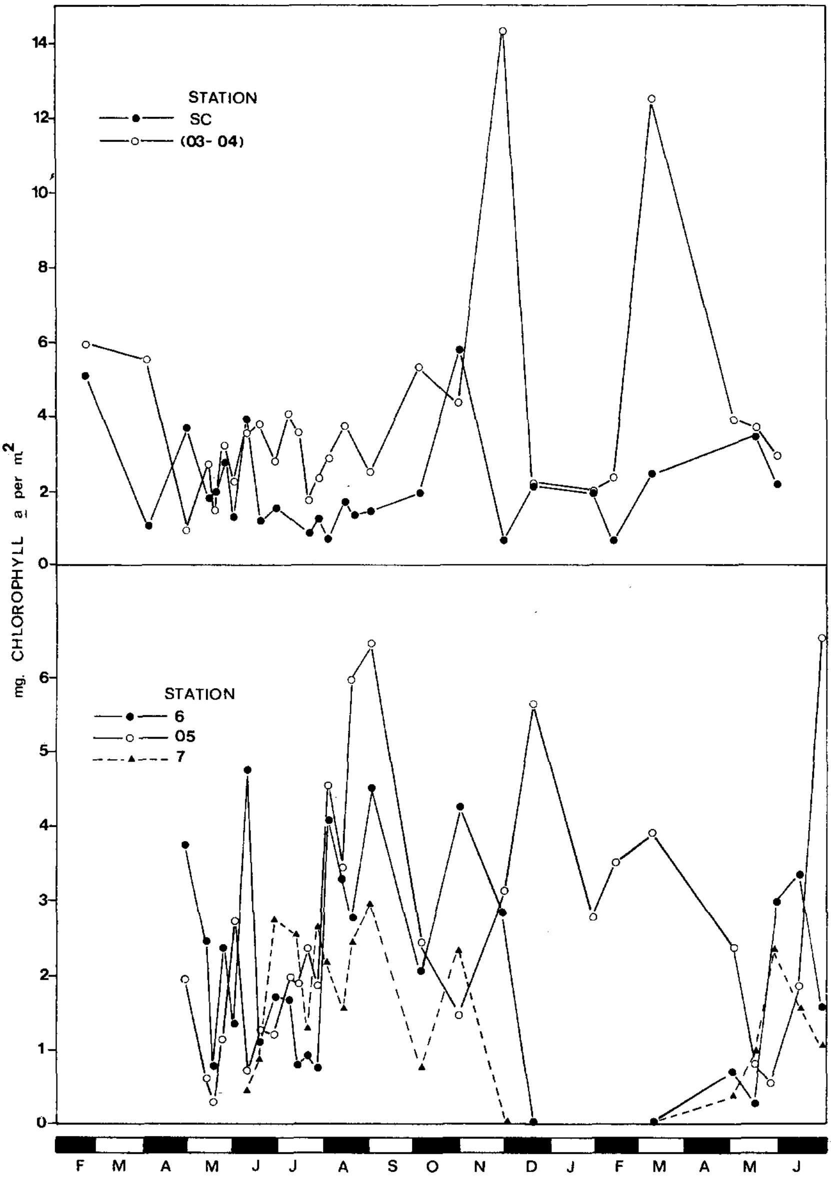

Fig. 4. Standing crops of the epipelic algae in heated (Stations 03—04 and 05) and non-heated areas of the lake (stations SC, 6 and 7).

ing crop during the winter which did not occur under normal winter lake conditions. As the ice thawed the standing crop at Station SC increased slowly to a value just below that of Station (03—04), whose standing crop had decreased rapidly. This was again due to increasing water turbulence as greater areas of the lake became ice free. The mean standing crop values showed that the standing crop of the affected area was nearly twice that of the control area (Table I). This was due mainly to the autumn and winter populations.

An interesting feature of the species composition of the two areas was that members of the Cyanophyta *Oscillatoria amoena* (KUETZ.) GRUN and *O. borneti* ZUKAL were recorded only in the heated area. They occurred particularly in the late summer-early autumn and

TABLE I

The mean standing crops of the epipelic and epipsammic algae in heated and non-heated areas of Lake Wabamun.

Epipelon	mg. Chlorophyll a/m²
(1) Heated Areas	
Station (03—04)	3.54
05	2.60
(2) Non-Heated Areas	
SC	1.98
6	1.95
7	1.25
(3) Discharge Canal	9.82
(4) Intake Canal	1.96
Epipsammon	
Station	
(1) Heated Area	
05	16.2
(2) Non-Heated Area	
6	16.8
7	29.9

again in the winter-spring period. (A detailed species list of the epipelic algae is presented in Table II). At this time the temperature differences between stations (03—04) and SC were very small (GALLUP & HICKMAN 1972, in preparation), therefore temperature could not have been the sole factor for the growth of these populations at station (03—04). Both species of *Oscillatoria* were found in the epipelon of the discharge canal where the water temperatures at the water-mud interface followed those recorded at the surface at the mouth of the discharge canal (GALLUP & HICKMAN 1972, in preparation) but not the intake canal. The standing crops of the

Table II

Algae species found in the epipelon of Lake Wabamun

Bacillarophyta
Achnanthes exigua Grun.
A. gibberula Grun.
A. lanceolata Bréb.
A. lanceolata var. *elliptica* Cl.
A. lanceolata var. *rostrata*
Amphora ovalis Kütz.
A. ovalis var. *pediculus* Kütz.
Amonoeoneis sphaerophora (Kütz.) Pfitzner
Caloneis amphisbaena (Bory) Cl.
C. schumanniana (Grun) Cl.
C. silicula var. *truncatula* Grun.
Campylodiscus noricus var. *hibernica* (Ehr.) Grun.
Cocconeis disculus var. *minor* Fontell
C. placentula Ehr.
Cyclotella meneghiana Kütz.
Cymatopleura solea (Bréb.) W. Smith
Cymbella cistula var. *maculata* (Kütz.) van Heurck
C. caespitosa (Kütz.) Brun.
C. cistula (Hemprich) Grun.
C. cymbiformis var. *unipunctata* A. Cl.
C. ehrenbergii Kütz.
C. parva (W. Smith) Cl.
C. turgida (Greg.) Cl.
C. ventricosa Kütz.
C. ventricosa var. *minuta* (Hilse) Van. Heurck
Denticula tenuis Kütz.
Diatoma elongatum Agardh
D. vulgare var. *brevis* Grun.
Diploneis oblongella (Naegeli ex Kütz.) Ross
Epthemia argus Kütz.
E. argus var. *genuina* (Grun.) Mayer
E. intermedia Fricke
E. sorex Kütz.
E. turgida (Ehr.) Kütz.
E. turgida var. *plicata* Meister
E. zebra (Ehr.) Kütz.
Fragilaria capucina Desm.
F. construens (Ehr.) Grun.
F. construens var. *binodis* (Ehr.) Grun.
F. construens var. *venter* (Ehr.) Grun.
F. crotonensis Kitton
F. leptostauron (Ehr.) Hust.
F. pinnata Ehr.
F. vaucheriae (Kütz.) Boye Pet.
Gomphonema acuminutam var. *coronata* (Ehr.) W. Smith
G. bohemicum Reichelt and Fricke
G. constrictum Ehr.
G. gracile var. *auritum* Al. Br.
G. intricatum Kütz.
G. intricatum var. *geniunum* Mayer

G. longiceps var. *subclavata* GRUN.
G. montanum v. *acuminatum* MAYER
G. olivaceum (LYNGBY.) KÜTZ.
G. parvulum var. *genuinum* MAYER
Gyrosigma acuminatum (KÜTZ.) RABH.
Mastogloia smithii var. *lacustris* GRUN.
Melosira ambigua (GRUN.) O. MÜLL.
M. granulata (EHR.) RALFS.
Navicula anglica var. *subsala* GRUN.
N. aurora SOV.
N. cari EHR.
N. cuspidata KÜTZ.
N. cryptocephala KÜTZ.
N. eleginensis var. *lata* (M. PERAG.) PATR.
N. gastrum var. *hambergi* HUST.
N. gregaria DONKIN.
N. hungarica GRUN.
N. hungarica var. *capitata* (EHR.) CL.
N. notanda PANTOCSEK
N. placentula var. *rostrata* MAYER
N. pupula KÜTZ.
N. radians (OSTR.) CL.
N. radiosa SCHON.
N. rhynchocephala KÜTZ.
N. salinarum var. *intermedia* (GRUN.) CL.
N. scutelloides W. SMITH
N. seminulum GRUN.
N. torneenis CL.
N. vulpina KÜTZ.
Neidium dubium (EHR.) CL.
N. dubium var. *cuneatum* FONTELL
N. kozlowii (MER.) HUST.
Nitzschia acuta HANTZSCH.
N. amphibia GRUN.
N. angustata (W. SMITH) GRUN.
N. angustata var. *actua* GRUN.
N. filiformis (W. SMITH) HUST.
N. fonticola GRUN.
N. gracilis HANTZSCH.
N. ignorala KRASSKE
N. linearis (W. SMITH) GRUN.
N. obtusa W. SMITH
N. pseudoamiphioxis HUST.
N. recta HANTSCH.
N. sigmoidea (EHR.) W. SMITH
N. sinuata var. *tabellaria* GRUN.
N. sublinearis HUST.
Opephora martyii HÉRIBAUD
Pinnularia cuneata var. *reducta* CL.
P. gibba EHR.
P. interrupta W. SMITH
P. major var. *paludosa* MEIST
P. viridis (NITZSCH.) EHR.
Rhoicosphenia curvata (KÜTZ.) GRUN.

Rhopalodia gibba (Ehr.) O. Müll.
R. gibberula (Ehr.) O. Müll.
Stauroneis phoenicentron Ehr.
Stephanodiscus rotula (Kütz.) Hendey
Surirella biserata var. *genuina* Mayer
S. lapponica Cl.
S. linearis W. Smith
S. linearis v. *constricta* (Ehr.) Grun.
S. ovata Kütz.
Synedra pulchella Kütz.
S. ulna (Nitzsch) Ehr.

Cryptophyta

Cryptomonas erosa Skuja

Euglenophyta

Euglena acus Ehr.
Tranchelomonas volvocina Ehr.

Cyanophyta

Merismopedia glauca (Ehr.) Naegeli
Oscillatoria amoena (Kuetz.) Gom.
O. bornetii Zukal

Chlorophyta

Pediastrum boryanum (Trup.) Meneghini
P. duplex. Meyer
Scenedesmus quadricauda (Turp.) Bréb.
Cosmarium sexangularis Cook & Willis
Closterium gracilie var. *elongatum* W. & G. S. West
Mougeotia sp.
Spirogyra sp.
Zygnema sp.

---

epipelon in the discharge canal were always much greater than those of the intake canal (Fig. 5). The mean standing crop of the epipelon in the discharge canal was five times that of the epipelon of the intake canal (Table I) while the mean standing crop of the latter was almost identical to the other control stations (Table I). The high standing crops in the discharge canal were maintained by the two *Oscillatoria* species.

The diatom species composition was very similar in all areas except for the discharge canal. The most important species were *Amphora ovalis* vs. *pediculus* Kütz, *Cocconeis placentula* Ehr., *Cymbella* *ventricosa* KÜTZ., *Diatoma elongatum* AGARDH., *Fragilaria capucina* DESM. *F. construens* (EHR.) GRUN., F. *leptostauron* (EHR.) HUST., F. *pinnata* EHR., *Melosira ambigua* (GRUN) O. MÜLL., *M. granulata* (EHR.) RALFS. *Navicula cryptocephala* KÜTZ., *N. cuspidata* KÜTZ., *N. elginensis* var. *lata* (M. PERAG.) PATR. *N. pupula* KÜTZ., *N. rhynchocephala* KÜTZ., *N. hungarica* GRUN., *N. radians* (OSTR.) CL. *Nitzschia acuta* HANTZSCH., *N. amphibia* GRUN., *N. angustata* W. (SMITH) GRUN., *N. linearis* (W. SMITH) GRUN., *Opephora martyii* HÉRIBAUD, *Pinnularia interrupta* W. SMITH, *P. major* var. *paludosa* MEIST, P. *viridis* (NITZSCH.) EHR., *Rhoicosphenia curvata* (KÜTZ.) GRUN *Surirella linearis* W. SMITH, and *Synedra pulchella* KÜTZ. In the discharge canal the species which occurred infrequently or were absent were *Diatoma elongatum*, *D. vulgare*, *Fragilaria capucina*, *F. construens*, *F. leptostauron*, *Melosira ambigua*, *M. granulata*, *Opephora martyii*, *Pinnularia interruptia*, *P. major* var. *paludosa*, *Rhoicosphenia curvata*, and *Surirella linearis*.

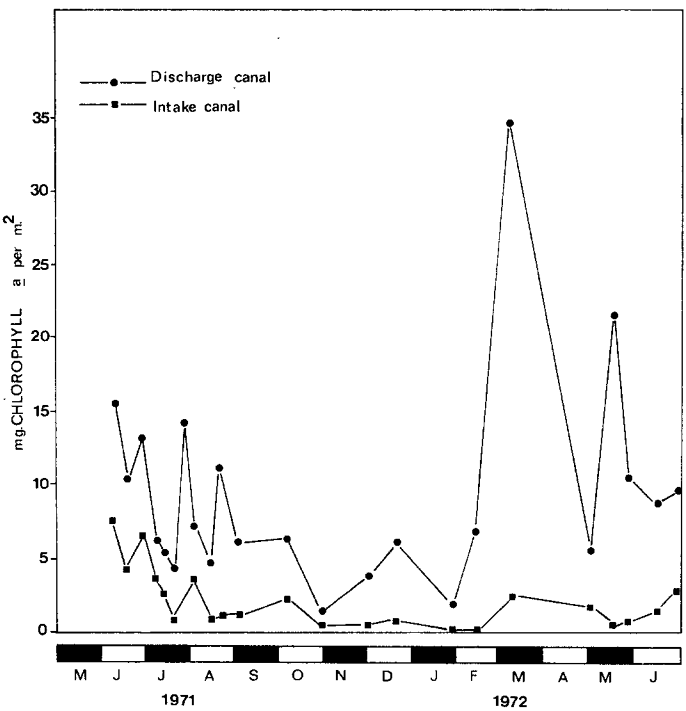

Fig. 5. Standing crops of the epipelic algae in the intake and discharge canals.

Navicula cuspidata found in all areas developed best in the discharge canal in the summer when water temperature was 30°C. STRANGENBERG & PAWLACZYK (1961) studying the effects of warm water from a power station also found that high temperatures (30°C) favored the growth of *N. cuspidata*. Thus, the heated water had an effect on the species composition of the diatoms in the discharge canal but a lesser effect in the lake.

Since, the two *Oscillatoria* species were found as large populations in the discharge canal it would appear that they formed the inoculum for the populations at Station (03—04) and lake currents did not carry them to the control stations. These species must have a wide temperature range for growth because in the summer temperatures of 31°C were recorded in the discharge canal while during the winter-spring peak these algae were found growing at temperatures as low as 4°C at Station (03—04), while in the discharge canal, where a maximum also occurred during this period, temperatures were 16—18°C.

When the standing crop was low during February to April at Station SC the epipelic algae population still contained the same diatom species composition as the other stations, but *Amphora ovalis* var. *pediculus* was the dominant species. This species has also been found as a component of the epipsammon where, for varying periods of time, the sand grains to which this species attaches become buried (HICKMAN & ROUND 1970). Thus, it would appear to be adapted to very low light intensities and/or be capable of a heterotrophic mode of existence.

Euglena acus EHR. and *Trachelomonas volvocina* EHR. were only found at station (03—04) which was probably due to the presence of the submerged decaying marcrophytes in late summer. *Cryptomonas erosa* SKUJA was found at both stations (03—04) and SC in the spring but not in the intake or discharge canals, therefore, flowing water did not suit this species. Members of the Chlorophyta (*Pediastrum boryanum* (TURP.) MENEGHINI, *P. duplex* MEYER, *Scenedesmus quadricauda* (TURP.) BRÉB., *Cosmarium sexangularis* COOK & WILLIS, *Closterium gracile* var. *elongatum* W. and G. S. WEST, *Mougeotia* and *Zygnema* sp. were found irregularly in all areas.

At the stations in the shallow littoral zone there was little difference in the standing crop values until August/September, when at Station 05 which was affected by the heated water, the blue-green algae populations increased in size. Again *Oscillatoria amoena* and *O. bornetii* were the species present. From December to March Stations 6 and 7 were completely frozen, including the sediment. This did not occur at Station 05. Here the standing crops remained large due to the blue green algae. There was a similar maximum at Station 05 as recorded for Station (03—04) and the discharge canal during February to May. The influence of wave action at the littoral edge stations was effective in maintaining the populations at very similar levels throughout the year, except for the winter period of ice-cover. This was shown by comparing the mean standing crops at stations SC and 6 which were nearly identical (Table I), although the algae at Station SC were growing under about 4 m of water, hence at a lower light intensity. The mean standing crop of the epipelon at Station 05 was greater than at the other two stations but this was due to the station remaining free of ice all winter and the large blue green algae populations. If the natural temperature ranges of algae are exceeded, species composition will also alter (PATRICK 1969). This appears to have occurred in the discharge canal with the dominance of blue-green algae, the increased numbers of *Navicula cuspidata* and decrease in the number of diatom species, while the shift at Stations (03—04) and 05 appear to be a result of this shift in the discharge canal.

Epipsammon

The epipsammic algae flora was composed entirely of small diatoms species at all the shallow littoral stations. The dominant species were *Amphora ovalis* var. *pediculus*, *Fragilaria construens*, *F. construens* var. *venter* (EHR.) GRUN. *F. leptostauron* and *Opephora martyii*. No blue-green algae were found attached to the sand grains. Stations 05 and 6 (Fig. 6) were similar, however, the latter station had two bursts of growth in June, the other in July. *O. martyii* and *F. leptostauron* were the dominant species. A large increase in standing crop size at station 05 did not occur until August when the same two species were dominant. At station 7 the standing crop was generally greater than that of the other stations even though the standing crop of the epipelon was less than at the other stations. Although the winter epipelic algal standing crops were large at station 05, the epipsammic algal standing crops remained small while at stations 6 and 7 complete ice cover caused the disappearance of the algae. The small winter populations were due probably to the absence of blue-green algae so that the heated water had no effect upon the epipsammic algae but allowed them to maintain themselves during the winter as a small population at station 05. In fact, the mean standing crop value for station 7 was greater than at the other two stations, even though station 7 was frozen over during the winter (Table I). At all stations, as found by MOSS & ROUND (1967), and HICKMAN & ROUND (1970) in their studies on another epipsammic community in a lake in England, the standing crop of the epipsammic algae was much greater than that of the epipelic algae even though these edge stations were greatly disturbed by wave action. Also the standing crops of the epipelic algae are not low in comparison with other lakes (MOSS, 1969; MOSS & ROUND 1967; HICKMAN & ROUND 1970;

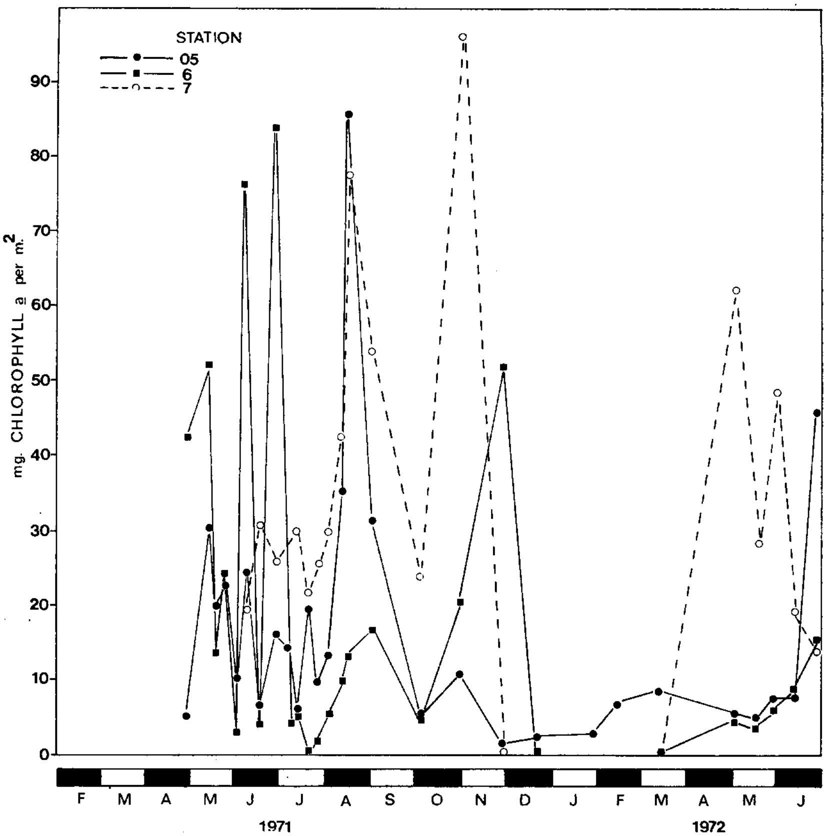

Fig. 6. Standing crops of the epipsammic algae in heated (Station 50) and non-heated areas of the lake. (Stations 6 and 7).

HICKMAN, 1971). The free living epipelic algae were subject to much easier removal by wind-induced wave action than the epipsammic algae because the latter were attached to the sand grains, therefore, the epipsammic diatoms persist for a longer period in the micro-environment than the epipelic algae (MOSS & ROUND, 1967). However, in the continual grinding action of moving sand grains some cells are undoubtedly lost, but the small size of the epipsammic diatoms allows them to exist in the crevices and hollows of the sand grains as well as attached to the edges.

Sediment cores

A study of cores taken at stations 05 and 6 helped to show how disturbed these stations were due to wave action, hence mixing of the sediment. The cores here were 10 cm in length. HICKMAN & ROUND (1970) found that there was a rapid decrease in chlorophyll

TABLE III

Chlorophyll a content expressed as a percentage of the maximum value

Depth (cm)	Mean of 10 Sampling dates at Stations 05 and 6
0— 1.0	100.0
1.0— 2.0	75.2
2.0— 3.0	72.5
3.0— 4.0	68.7
4.0— 5.0	58.2
5.0— 6.0	45.9
6.0— 7.0	30.6
7.0— 8.0	17.7
8.0— 9.0	10.1
9.0—10.0	2.5

a content when the results were expressed as a percentage of the maximum value. In fact by the 4.0—5.0 cm band the chlorophyll *a* value was only 16.8% of the maximum. However, at the exposed stations in Lake Wabamun a value of 17.7% of the maximum value was not recorded until the 7.0—8.0 cm band, while the maximum value was again recorded in the 0—1.0 cm band (Table III). This showed that at the stations in Lake Wabamun wave action mixed the sand greatly and hence, would also continually remove epipelic algae. That the cells lower down the core were still photosynthetically active was shown using the method described in HICKMAN & ROUND (1970) where the cores were sectioned into 1 cm lengths. Each 1 cm section was washed to remove the epipelic algae and incubated separately with carbon-14 under the same light conditions. The uptake was a function of standing crop size and again there was greater uptake lower down the Lake Wabamun core (Table IV) than found for a much less disturbed lake by HICKMAN & ROUND (1970). That the epipelic algae were washed away was shown by

TABLE IV

Carbon-14 uptake of the cores, expressed as a percentage of the maximum value

Depth (cm)	Epipsammon	Epipelon
0— 1.0	100.0	100.0
1.0— 2.0	82.2	21.0
2.0— 3.0	78.3	10.2
3.0— 4.0	62.0	0
4.0— 5.0	50.5	0
5.0— 6.0	45.3	0
6.0— 7.0	32.1	0
7.0— 8.0	20.2	0
8.0— 9.0	12.3	0
9.0—10.0	7.1	0

harvesting the epipelic algae and determining their carbon-14 uptake down the core (HICKMAN, 1969; HICKMAN & ROUND, 1970). This showed that the major proportion of the population was in the top 1 cm and epipelic algae were not found below the 3.0 cm mark (Table IV). Most probably the epipelic algae were restricted to the top 0.5 cm of the core since in general, epipelic algae live in the top few mm of the lake sediments (PALMER & ROUND, 1965).

ACKNOWLEGDEMENTS

Acknowledgement is made to the National Research Council of Canada for financial support for this work (N.R.C. grant A6384) and to the invaluable assistance of Mr. D. BELIVEAU & Mrs. M. McCAULEY.

REFERENCES

BAIRD, I. E. & WETZEL, R. G. - 1968 - A method for the determination of zero thickness activity of C^{14} labelled benthic diatoms. *Limnol. Oceanogr.* 13: 379—382.

EATON, J. W. & MOSS, B. - 1966 - The estimation of numbers and pigment content in epipelic algal populations. *Limnol. Oceanogr.* 11: 584—595.

GALLUP, D. N. & HICKMAN, M. - 1972 - The influence of thermal effluent on Lake Wabamun, Alberta. The temperature and dissolved oxygen regimes. Presented at the 35th Annual Meeting of Amer. Soc. of *Limnol.* and *Oceanogr.* Tallahassee, Florida, March, 1972.

GALLUP, D. N. & HICKMAN, M. – Effects of discharging thermal effluent from a Power Station on Lake Wabamun, Alberta, Canada – Limnological features. (in preparation).

HICKMAN, M. - 1969 - Methods for determining the primary productivity of epipelic and epipsammic algal associations. *Limnol. Oceanogr.* 14: 936—941.

HICKMAN, M. - 1971 - Standing crops and primary productivity of the epipelon of two small ponds in north Somerset, U.K. *Oecologia* 6: 238—253.

HICKMAN, M. & ROUND, F. E. - 1970 - Primary production and standing crops of epipsammic and epipelic algae. *Br. Phycol. J.* 5: 247—255.

HUTCHINSON, G. E. - 1967 - A treatise on limnology, Vol. II. Introduction to lake biology and limnoplankton. New York: John Wiley and Sons.

MOSS, E. H. - 1955 - The vegetation of Alberta. *Bot. Rev.* 21: 493—567.

MOSS, B. - 1967a - A spectrophotometric method for the estimation of percentage degradation of chlorophylls to pheopigments in extracts of algae. *Limnol. Oceanogr.* 12: 335—340.

MOSS, B. - 1967b - A note on the estimation of chlorophyll *a* in freshwater algal communities. *Limnol. Oceanogr.* 12: 340—342.

MOSS, B. - 1969 - Algae of two Somersetshire pools: Standing crops of phytoplankton and epipelic algae as measured by cell numbers and chlorophyll *a*. *J. Phycol.* 5: 158—168.

MOSS, B. & ROUND, F. E. - 1967 - Observations on standing crops of epipelic and epipsammic algae communities in Shear Water, Wilts. *Br. Phycol. Bull.* 3: 241—248.

NURSALL, J. R. & GALLUP, D. N. - 1971 - The response of the biota of Lake Wabamun, Alberta, to thermal effluent. Proceedings of International Symposium on the Identification and Measurement of Environmental Pollutants, Ottawa, p. 295—304.

PALMER, J. D. & ROUND, F. E. - 1965 - Persistent, vertical migration rhythms in benthic microflora. 1. The effect of light and temperature on the rhythmic behavior of *Euglena obtusa*. *J. mar. biol. Ass. U.K.* 45: 567—582.

PATRICK, R. - 1969 - Some effects of temperature on freshwater algae, in Biological Aspects of Thermal Pollution, P. A. KRENKEL & F. L. PARKER, (eds.) p. 161—185, Vanderbilt Univ. Press.

STRANGENBERG, M. & PAWLACZYK, M. A. - 1961 - Nauk. Pol. Wr. Wroclaw No. 40, *Inzyn. Sanit. Water Poll. Abst.* 1, 67—106.