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The Annual Phytoplankton Cycle of a Landlocked Fjord near Bergen

(Nordåsvatn)

by

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Preface.

In 1941—42 KR. FR. WIBORG of the Fisheries Directorate, Marine Research Branch, Bergen, undertook a hydrographical-biological investigation of the land-locked fjord Nordåsvatn near Bergen. The phytoplankton material was worked up at the Botanical Laboratory of the University of Oslo by the junior author and presented as a thesis in 1943 II: (BRIGT HOPE: »Fytoplanktonundersøkelser av Nordåsvatnet 1941—42«). It is now deposited at the secretariate of the University of Oslo. Part of the material is used in the present paper, another part being published separately (HOPE 1952). WIBORG (1944) studied the zooplankton net haul material collected at the same stations. BRAARUD (1944) has discussed some of the results from both these studies. The zooplankton in the quantitative samples was examined by GUNDERSEN (1946).

Introduction.

Previous investigations of the phytoplankton in Norwegian coastal waters.

JØRGENSEN (1899) and NORDGAARD (1899) made the first extensive survey of the net plankton of Norwegian fjords. Later quantitative investigations of the phytoplankton of fjords and coastal waters, mainly in the spring, included the Oslo fjord (GRAN 1912, GAARDER and GRAN 1927, BRAARUD and BURSA 1939, BRAARUD 1945, WIULL 1949), the coastal region south of Bergen (GRAN 1927), the Romsdalsfjord and Møre coast (Gran 1929, 1930, BRAARUD and KLEM 1931) and the Lofoten area (FØYN 1929, GRAN 1930). The first all-year-round survey was RINGDAL GAARDER'S (1938) study in the Tromsø area. BRAARUD and BURSA'S material from the Oslofjord also covered one year.

The topography and hydrography of Nordåsvatn.

Nordåsvatn forms a branch of the fjord system south of Bergen, and is one of the numerous land-locked fjords along the Norwegian

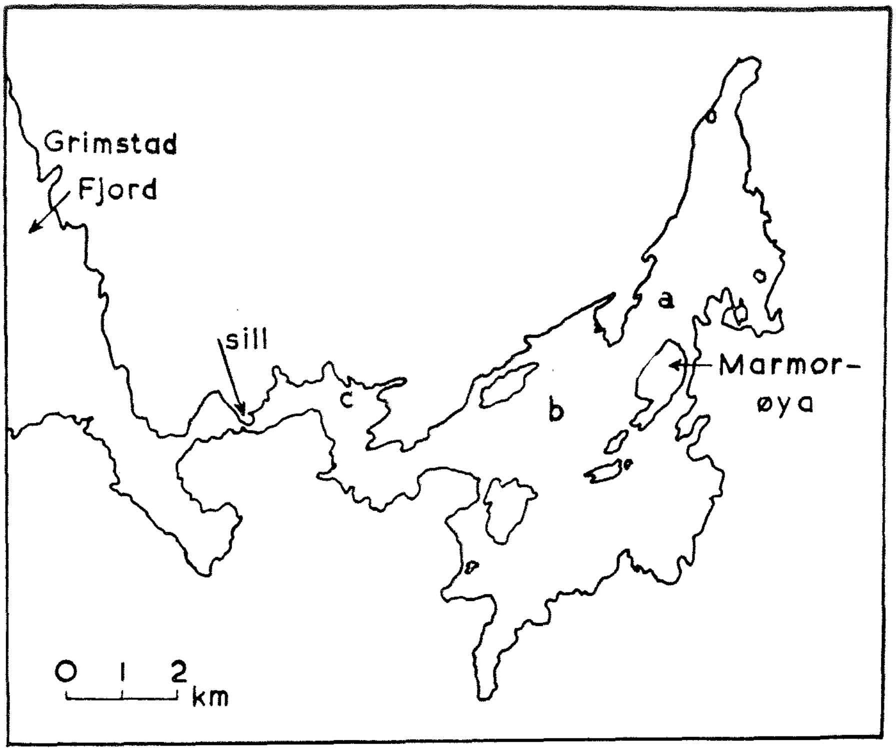

Fig. 1. Nordåsvatn. a, b, c localities where phytoplankton samples were collected in 1941—42.

coast. It is about 5 km long and where it is widest, nearly 2 km broad. Its connection with the Grimstadfjord outside is a channel, 30 m long and 10 m broad with a maximum depth at mean water level of about 3 m. The fjord outside goes down to about 100 m. (Fig. 1). Localities where phytoplankton observations were made are indicated. The region is rich in precipitation. Fresh water is also contributed by rivers, the largest one, Fjøsanger river, having its outlet in the northernmost part. Here a'so the main contribution of sewage from the suburbs of Bergen takes place.

The hydrographical and chemical features characteristic of land-locked fjords, described by GAARDER (1915—16) and MÜNSTER STRØM (1935), obtain: pronounced stratification of the surface layers and during long periods stagnation and H_2S-formation in the deep layers. GAARDER (l.c.) found in this fjord H_2S up to 15—20 m below the surface. Inflow of new water to the deeper strata from outside leads to a lifting of the old deep layers to intermediate levels. Hydrographical conditions in

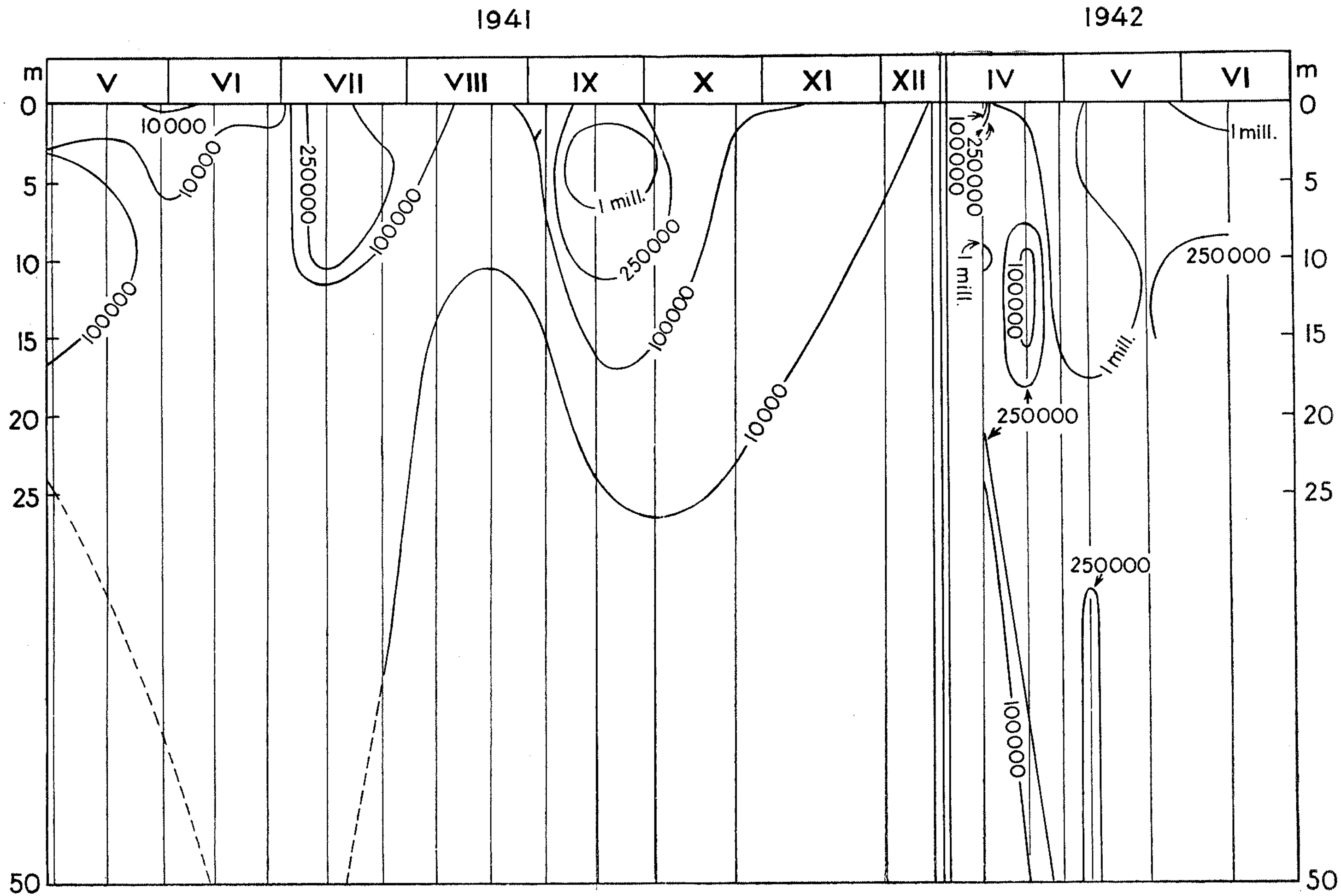

Fig. 2. Nordåsvatn. Seasonal changes in the *diatom* population. The figures show number of cells per liter.

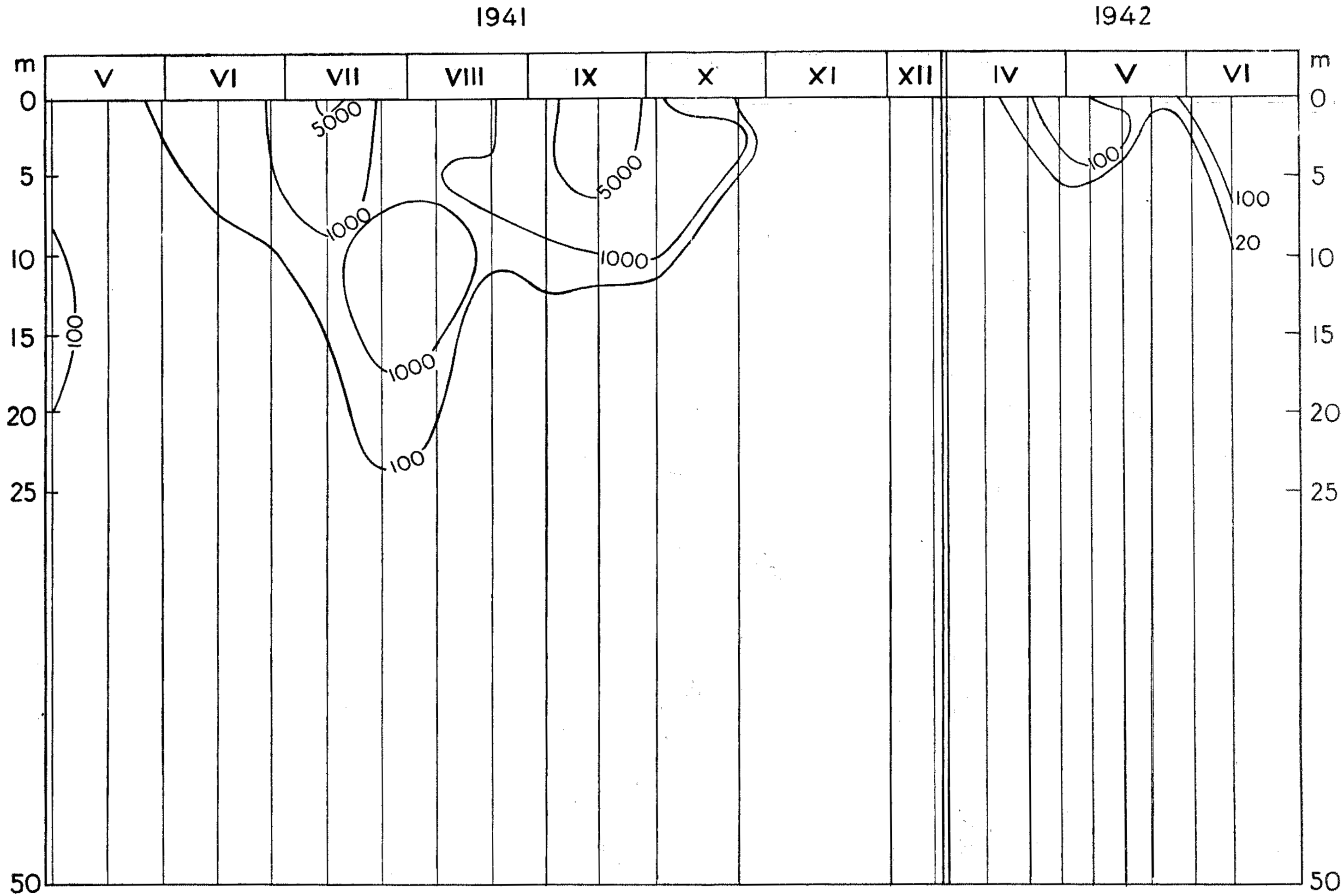

Fig. 3. Nordåsvatn. Seasonal changes in the population of *ceratia*. The figures show number of cells per liter.

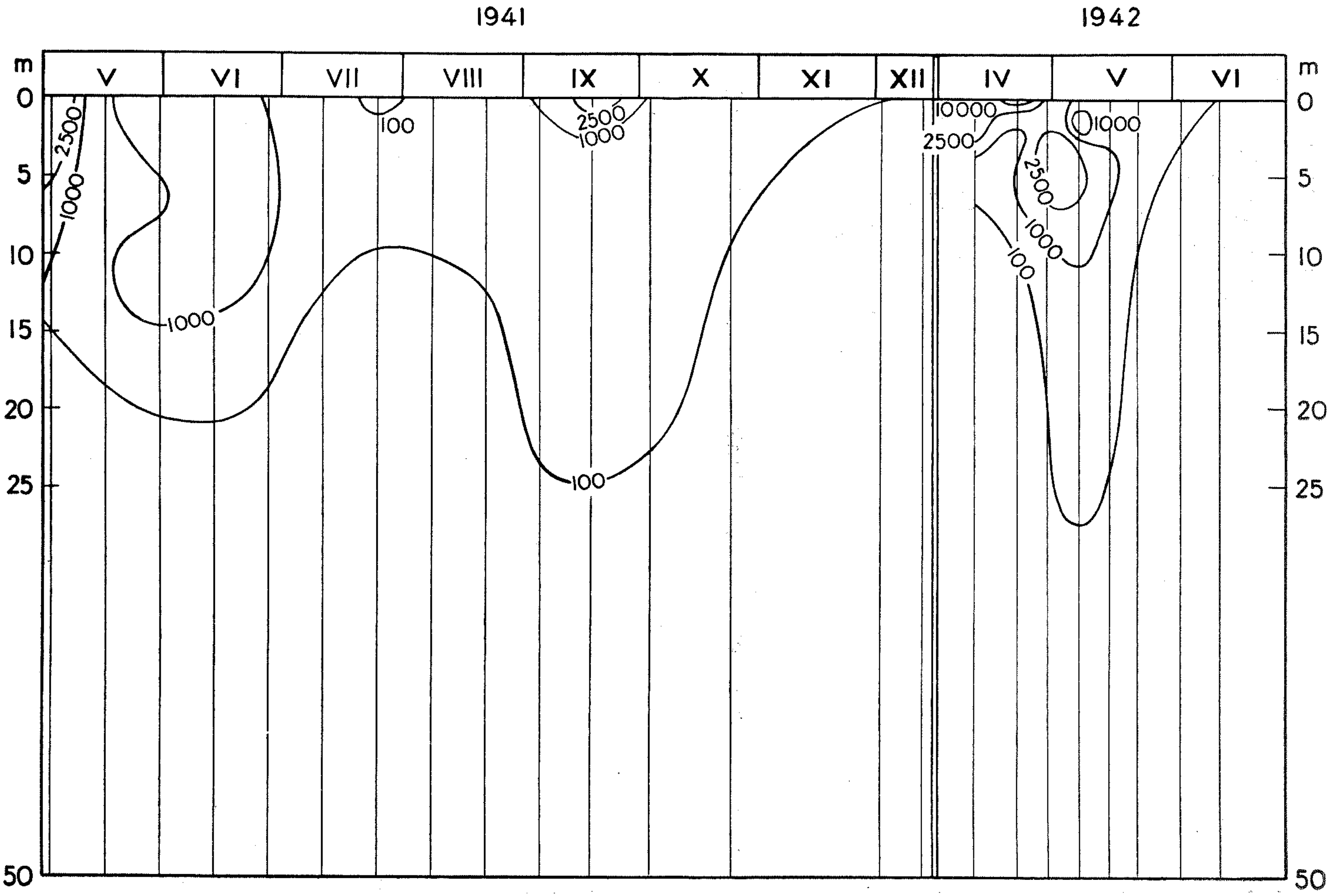

Fig. 4. Nordåsvatn. Seasonal changes in the population of *ciliates*. The figures show number of cells per liter.

Nordåsvatn consequently differ considerably from those which may be observed in the more open fjords in the same region. The hydrographic observations in 1941—42 are treated by WIBORG (1944).

During the winter of 1942 the surface of Nordåsvatn was covered with ice, while the waters outside were open (cf. page 16). Other special features which are of significance in connection with the phytoplankton observations are discussed below (page 15).

Material and Methods.

In fig. 1 are indicated the localities where phytoplankton samples were collected (a, b, c,). The majority of samples were taken at b, off Marmorøya. In table 1 the date and depth are given for the samples which were examined by the sedimentation method (UTERMÖHL 1931). The samples were preserved with neutralized formaldehyde.

The Annual Cycle of the Phytoplankton Vegetation in 1941—42.

The spring diatom vegetation.

In Norwegian coastal waters a spring diatom maximum is the most regular and conspicuous feature in the phytoplankton cycle and the best known (GRAN 1912, 1927, 1929, 1930). In Nordåsvatn ice covered the surface during the winter of 1942 and consequently conditions for growth of the phytoplankton population were poorer than in the open water outside. As long as the ice cover lasts, conditions are similar to those described by BRAARUD (1935) in the Polar current, where phytoplankton growth is extremely poor for lack of light until the ice breaks up.

In 1942 samples were taken through a hole in the thick ice covering the surface on April 10th. At this time the phytoplankton population was large, consisting mainly of diatoms with *Sceletonema costatum* and *Chaetoceros socialis* as the predominant species. Dinoflagellates were scarce, while a green flagellate, *Chlamydomonas sp.*, was fairly numerous at the surface. The vertical distribution was remarkable with a maximum for the diatoms at the 10 m level, while *Chlamydomonas* was observed only in the surface samples.

The vertical distribution of the phytoplankton, its subsequent development during the next week and the hydrographical data indicate that the large diatom populations were allochthonous, having been introduced from outside. tS-diagrams for the last station in 1941 and the April station in 1942 indicate clearly, as does the oxygen distribution, that the deeper layers of the Nordåsvatn in the interval between these two observations had been aerated through inflow of new bottom water across the sill at the entrance. Most probably the diatom population at the 10 m level had been introduced through a water exchange at intermediate levels, an exchange which is not easily traced in the hydrographical material which is available. This would explain why the oxygen value had a minimum at the 10 m level where the diatom population was largest.

The *Chlamydomonas* population, on the other hand, most probably was autochthonous, having developed at the low light intensity prevailing under the ice cover. The salinity of the surface water was only 0.8 per mille. Similar populations of green flagellates are characteristic of the Polar current where ice of much greater thickness covers the surface BRAARUD (1935).

The actual spring diatom maximum in Nordåsvatn was observed on the next date of sampling, April 21st 1942. Sunny weather had prevailed during the 11 days since the previous station. The ice had disappeared, the temperature at the surface had risen to 7.2° C and the phytoplankton had increased immensely. At the surface a population of more than 7 million diatoms per liter was recorded and considerable populations occurred at all levels. It is remarkable that the species which now were predominant, were different from those recorded in high numbers 11 days earlier. Now *Chaetoceros gracilis* numerically dominated the population of the surface layers while *Sceletonema* occurred only in numbers amounting to 1% of those recorded for the earlier station. *Chaetoceros socialis* had its maximum of 400 000 per liter at a depth of 20 m. *Peridinium minusculum* was the most numerous dinoflagellate, its maximum of 1500 per liter occuring at 1 m. The maximum values for oxygen now coincided with those for diatom population.

The composition of this diatom population indicates that the plankton of the spring maximum was for the main part autochthonous, consisting of species which were of no significance in the coastal waters outside. During the following weeks the situation gradually changed, the maximum being found at deeper levels, first at 5 m and later at 10 m. The populations at these levels were of a size similar to that of April 21st, but a succession of diatoms took place. *Chaetoceros gracilis* quickly fell off to moderate numbers, while *Chaetoceros Wighami* and *Ch. socialis* took the lead. *Sceletonema* also reached higher numbers than at the start of the spring outburst, its maximum being reached on May 7th with 5 645 000 per liter at the 10 m level.

In late May the diatom population had dwindled greatly, since the spring outburst was declining quickly towards a moderate population in early June. During this period the dinoflagellates *Exuviaella baltica* and *Gymnodinium spp.* were more numerous than before, the former reaching numbers of 40 000 per liter. *Sceletonema* was predominant among the diatoms, being accompanied by *Leptocylindrus danicus.*

In 1941 observations did not start until May 2nd. At this time the spring diatom outburst had passed, *Leptocylindrus danicus* being the leading diatom species with its maximum of 167 000 per liter at a depth of 5 m.

Comparing the conditions in Nordåsvatn in spring 1941 and 1942 with those of the coastal waters outside (GRAN 1927, 1929, 1930) the most striking feature is the late onset of the spring vegetation, obviously due to the poor light conditions caused by the ice covering the surface till late in April. In the coastal waters outside the spring diatom maximum occurs in March. Also the composition of the local plankton in Nordåsvatn is different from that known from other coastal waters of Norway.

Irregular changes in the phytoplankton population during summer.

From the middle of May, when the spring diatom vegetation had dwindled, until the middle of September, when a remarkable autumn increase in the diatom population was recorded, the phytoplankton showed irregular changes, probably due partly to a natural succession of populations and partly to influx of water from the outside. In addition, water transport within the surface layers of the area itself caused sequences of populations at the Marmorøy station which would explain some of the fluctuations recorded there.

Broadly speaking the summer conditions may be characterized by the following features:

1) Only small populations of diatoms, in which *Leptocylindrus danicus*, *Sceletonema costatum*, and at times, *Nitzschia closterium* and *N. seriata*, were predominant.

2) From late June increasing populations of coccolithophorids, mainly *Coccolithus* (*Pontosphaera*) *Huxleyi*. In August *Calyptrosphaera sphaeroidea* occurred in numbers up to 440 000 per liter.

3) The dinoflagellate population changed in composition from time to time. The ceratia had a seasonal distribution indicated in fig. 3. Maximum numbers for the three main species, *C. furca, fusus* and *tripos*, occurred in the middle of September.

Among the smaller autotrophic forms *Peridinium trochoideum*, *Prorocentrum micans, Oxytoxum mucronatum* and other species occurred in considerable quantities for short periods of time and then the populations decreased quickly. The same was the case with heterotrophic species like *Pronoctiluca pelagica.* Another remarkable feature during this period may be mentioned. At the time of a secondary diatom maximum recorded on July 11th large numbers of green fresh-water or brackish *Scenedesmus* occurred at the 1 m level, (S: 25.52 per mille), its 5 species totaling 730 000 cells per liter. At the same time the saprophytic flagellate, *Bodo marina,* reached its maximum of 138 000 cells per liter at the 10 m level. The situation at this date may be the result of water transport from the inner, more polluted part (Cf. page 15).

The autumn diatom maximum.

In 1941 a pronounced diatom maximum was recorded in the middle of September. Within a fortnight, from Sept. 5th to 18th, the diatom population showed a remarkable increase. The number of species recorded rose from 4 to 17, but only *Nitzschia closterium* reached extremely high figures (more than 2 millions per liter at the 2.5 and 5 m levels). The composition of the plankton indicates that some exchange with the waters outside may have taken place, since among the new species recorded several were oceanic. Also the dinoflagellate population had increased somewhat, while the coccolithophorids had fallen off in numbers, as might be expected at this season. The main bulk of the large diatom population, the *Nitzschias,* most probably originated in Nordåsvatn. The maximum at Marmorøy seems to be rather local since the two other stations, inside and outside, do not show increases in the oxygen values corresponding to that at the Marmorøy station.

As probable causes for this autumn maximum may be mentioned: reduced grazing (cf. WIBORG 1944, BRAARUD 1944) and a spell of clear weather before the middle of September. The possibility of an effect of polluted water from the inner part can not be excluded.

The composition of the plankton.

The phytoplankton which was recorded from Nordåsvatn during this survey has a most heterogeneous composition. It consists of oceanic as well as neritic, cold-water as well as warm-water species. Pronounced brackish or fresh-water forms occur at the same time as clearly marine forms, although at different levels. This mixture of ecologically different forms is due to the characteristic hydrography of the waters: 1) the regular water exchange produced by the tidal currents flowing back and forth through the channel at the entrance, bringing into the area water from outside with the populations typical of the coastal waters near Bergen, 2) the fresh-water from rivers and rainfall leading to extreme stratification at least during summer, not only in salinity but also in temperature, 3) the contribution of nutrient salts from sewage creating possibilities for luxurious phytoplankton growth at times when conditions in regular coastal waters are unfavourable (certain ecological types which are subordinate or lacking in the waters outside may reach predominance in the plankton society of Nordåsvatn, changing the relative proportions within the population which has been introduced from outside), 4) the pronounced neritic nature of the habitat.

In tables 2, 3 and 4 the composition of the plankton from the quantitative samples is exemplified.

In a special publication floristic and taxonomic observations are given. The new species, *Oxytoxum mucronatum* Hope, is described there (HOPE 1952).

The Main Factors Influencing the Abundance of Phytoplankton.

Factors common to the coastal waters along the Norwegian coast.

As far as previous investigations along the Norwegian coast and our general knowledge of factors influencing phytoplankton abundance in the sea go, we may assume that the following factors are of importance in producing the seasonal distribution described above.

a) Supply of nutrient salts to the euphotic layer through vertical convection in winter. This is a prerequisite for the spring diatom outburst.

b) The shortage of light during winter and steadily improving light supply during spring.

c) Deficiency in nutrient salts after the spring maximum, the supply through local metabolism and turbulence sufficing for a moderate phytoplankton production only.

d) Grazing effecting an irregular and so far incalculable reduction of the phytoplankton population. In the Nordåsvatn there are indications that this factor is most variable. (WIBORG 1944, BRAARUD 1944).

A comparison between the changes in phytoplankton and zooplankton abundance indicates that the autumnal increase in phytoplankton resulting in a definite autumn diatom maximum, follows a pronounced decrease in the zooplankton population (BRAARUD 1944).

Local factors effective in Nordåsvatn.

Wind currents.

The seasonal changes which have been described above are recorded on the basis of observations at the Marmorøy station (b), in the middle of the basin. Wind currents which move the surface layers back and forth produce a sequence of societies (GRAN and BRAARUD 1935), an effect which interferes with the succession of populations at the point of observation. This is the case in coastal areas in general, but in Nordåsvatn the effect may be more pronounced, since the water masses in the northern part are fertilized through pollution with sewage. Some of the changes in the phytoplankton during the summer period may be due to transport of water from the northern part to the middle and vice versa. The occurrence of the remarkable *Scenedesmus* vegetation on July 11th may be caused by such an effect, since in early July a heavy rainfall and northern winds favoured transport in this direction.

A closer comparison between the populations at stations a and c with those at station b can not be made on the basis of the available records. Observations on May 2nd 1941, from b and c, show that at that time the qualitative composition of the plankton at the two localities was similar, although considerable differences seemed to exist in the quantities of the various species.

The effect of pollution.

Sewage which is being discharged into the surface layers in the inner (northern) part increases the supply of nutrient salts and at the same time reduces transparency so the euphotic layer becomes thinner. If BRAADLIE's figures for the average phosphorus content of river water for 7 Norwegian rivers (BRAADLIE 1931) are taken to be representative and the daily fresh-water discharge taken to be 300 000 cu.m, the phosphorus supply to the upper 5 m may be calculated to be 0.8 mg P_2O_5 per cu.m. Similar estimates of the phosphorus supplied by sewage being discharged into the inner part of Nordåsvatn would give 6 mg P_2O_5 per cu.m. When the rivers discharge more water than assumed, the supply from the rivers would be higher, but the nutrients would be distributed over a larger area. Sewage consequently seems to give a local fertilizing effect to the inner part and may be responsible for special conditions there. Our material does not admit any comparison between the population within the different parts of the basin during summer, when such an effect might be expected to be most clearly demonstrated.

Introduction of populations from outside.

Tidal currents transport considerable quantities of water back and forth each tidal period, the tide in this region amounting at an average to about 1 m. Water from the outside is brought in and mixed with the local water, and phytoplankton is in this way regularly brought in and mixed with the local vegetation. The occurrence of oceanic species, which in summer constitute an important part of the population gives evidence of this effect. Even when ice is covering the surface an abundant vegetation of the regular spring diatom population of the coastal waters outside is brought in. This factor is mainly responsible for the heterogeneous nature of the population.

Grazing.

The special hydrographical features due to the sill at the entrance, influence zooplankton distribution. In the deep layers sulphuretted hydrogen is found during summer and the zooplankton stays in the upper layer and constantly grazes upon the actively growing phytoplankton; consequently the effect of the grazing factor may be more pronounced here than in coastal waters outside.

The ice cover.

In 1941 and 1942, which were severe winters, ice and snow covered the surface during winter and early spring. This special feature is of outstanding importance for the onset of the spring diatom vegetation. The spring diatom maximum may be delayed for several weeks.

In other years, when the winter is milder, ice may not stay for such a long period or be so thick and snow-covered. The effect of the ice cover changes from year to year, and consequently the time of the spring maximum may be expected to vary considerably from one year to another, according to meteorological conditions.

Summary.

1. Quantitative phytoplankton records for 1941 and 1942 from Nordåsvatn near Bergen were used for a discussion of the annual phytoplankton cycle of this land-locked fjord.

2. Ice covered the surface till late in April 1942 and retarded the onset of the spring diatom vegetation, which reached its maximum in early May, while in the coastal waters outside it occurs in March.

3. Between the spring diatom maximum and an autumnal increase in the diatom population in the middle of September, irregular changes in the phytoplankton population took place. These were due partly to succession, partly to influx of water from the outside.

4. The summer plankton consisted of a few diatoms, coccolithophorids in increasing numbers from June (mainly *Coccolithus Huxleyi* and *Calyptrosphaera oblonga*) and dinoflagellates. The ceratia had their maximum in the middle of September, while other dinoflagellates (*Peridinium trochoideum*, *Prorocentrum micans* and *Oxytoxum mucronatum*) occurred in considerable quantities at various times.

5. The causes of the heterogeneous composition of the phytoplankton as to ecological types are discussed.

6. The main factors influencing phytoplankton abundance in the fjord are enumerated, including local factors which are effective in Nordåsvatn, such as pollution by sewage, ice cover and currents.

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Table 1. Nordåsvatn. List of observations at the three localities, a, b, c. (cf. fig. 1).

Locality a.

St.nr.	Date	0 m	1 m	5 m	10 m	25 m
78	1/12–41	×		×	[1]×	
81	10/4—42	×	×	×	×	×

Locality b.

St.nr.	Date	0 m	1 m	2.5 m	5 m	10 m	25 m	50 m	80 m
2	2/5—41	×		×	×	×	×	×	
8	16/5	×				×			
15	30/5	×		×	×	×	×		
22	13/6		×			×			
29	27/6		×	×	×	×	×		
34	11/7		×			×			
40	25/7		×	×	×	×	×		
46	8/8		×			×			
52	22/8		×	×	×	×		×	
58	5/9		×			×			
64	18/9		×	×	×	×	×		
70	3/10		×			×	×		
76	24/10		×	×	×		×		
79	12/12		×		×	×	[1]×		
82	21/4—42	×	×		×	×	[2]×	×	×
85	29/4		×		×	×	×	×	×
88	7/5	×	×		×	×	×	×	×
94	22/5		×			×	×		
100	12/6		×			×			

Locality c.

St.nr.	Date	0 m	5 m	10 m	25 m
3	2/5 —41	×	×	[1]×	×
9	16/5	×			
16	30/5	×			
20	6/6	×		×	

[1] 15 m. [2] 20 m.

Table 2. Nordåsvatn. Locality b. 27 June 1941. Cells per liter.

Depth in metres	1	2.5	5	10	25
Number of ml. examined	2;50	2;50	2;50	2;50	2;50
Chaetoceros compressus		300	140		160
— curvisetus					4000
— laciniosus		1500			
— sp.		3000			
Coscinosira polychorda	60		240	600	
Navicula sp.		40	40		
Nitzschia closterium	1000	500	12500	18500	24500
— delicatissima					2500
Pleurosigma sp.					20
Rhizosolenia imbricata			20	20	
Sceletonema costatum		12000	1260		60
Ceratium furca	1400	3020	380	20	
— fusus	280	140	220	40	
— macroceros		20			
— tripos	80	100	120	20	
Dinophysis norvegica				20	
Exuviaella baltica	1500		3500	20	
Goniaulax spinifera		20			
Gymnodinium 1	22000	53500	1500		
— Lohmanni			160	40	
— pseudonoctiluca	40				
— sp.	4000	80	1000	2500	
Oxytoxum mucronatum		20		120	
Peridinium brevipes		60	40		
— conicum		20			
— depressum			180	60	
— globulus f. ovatum	20	40	120		
— — f. quarnerense		80	140	80	
— minusculum	280	1500	20		
— pallidum		40			
— triquetrum		80	500	1500	
— trochoideum	1500	1000	1000	2000	
Phalacroma rotundatum	60	20			
Pronocticula pelagica		500			
Prorocentrum micans	80	100			
Bodo marina	4000	13000	45000	10000	8500
Eutreptia Lanowii				120	
Phaeocystis Pouchetii	c				
Pontosphaera Huxleyi	8500	1500	8500	7500	5000
Scenedesmus arcuatus		6000			
— bijuga	8000	41500			
— granulatus	20000				
— quadricauda	10000	24500	6000	4000	
— sp.			2000		
Syracosphaera sp.		1000			

Table 2 (Cont.).

Depth in metres Number of ml. examined	1 2;50	2.5 2;50	5 2:50	10 2;50	25 2;50
Ciliata indeterminata		60			
Favella sp.		40			
Helicostomella fusiformis	20				
Laboea conica		60			
— cornuta			20	20	
— emergens		40	20		
— sp.	40	80		20	
Lohmanniella oviformis		100		240	
— spiralis	20		100		
Parafavella sp.	80	100	60	40	
Strombidium oblongum				120	
Tintinnopsis sp.	20	20			
Copepods		80			

Table 3. Nordåsvatn. Locality b. 22 August 1941. Cells per liter.

Depth in metres Number of ml. examined	1 2;50	2.5 2;50	5 2;50	10 2;50	50 2;50
Asterionella sp.				40	
Leptocylindrus danicus	4000				
— minimus	46000			1500	
Nitzschia closterium	31500	75000	42500	5500	40
— delicatissima	8000	8000	21500	1000	
— seriata					160
Rhizosolenia alata	220		120		
— fragilissima				80	
Sceletonema costatum		4500	3500	3000	
Cysts				4500	
Ceratium furca	100	560	60		
— fusus		20	740	220	
— lineatum	20		80		
— *longipes*		20	20		
— macroceros	120	120	20		
— tripos	260	40	520	140	
Dinophysis acuminata	120	180	60		
— acuta	20	60	80		
Exuviaella apora	200	100			
— baltica	280		20		
Glenodinium lenticula		40			
— sp.			80	100	
Goniaulax spinifera	80	40			
— tamarensis			40		
— triacantha				60	
Gymnodinium 1		500	500		
— Lohmanni	7280	4380	700	240	
— m.	780	1360	360		
— pseudonoctiluca	280	20			
— sp.	37500	120	4500	1000	
Oxytoxum mucronatum	100	60	80		
Peridinium brevipes	40	100			
— conicum	40	20			
— crassipes	80	80	20	200	
— depressum	40				
— divergens			20		
— globulus f. ovatum			20		
— globulus f. quarnerense	60	240	80	160	
— minusculum		500			
— pellucidum	200	140			
— sp.		60	20		
— Steinii	40			20	
— trochoideum	2500	2000	3000	40	
Phalacroma rotundatum		60	40		

Table 3 (Cont.).

Depth in metres Number of ml. examined	1 2;50	2,5 2;50	5 2;50	10 2;50	50 2;50
Porella perforata			40	60	
Pronoctiluca pelagica	160				
Prorocentrum micans	1160	540	240	120	
Protoceratium reticulatum		320			
Pyrocystis lunula				80	
Acanthoica quattrospina			500		
Calyptrosphaera sphaeroidea		14000	444000	44500	
Coccolithus Huxleyi	620000	902000	160000	185000	
Meringosphaera sp.	4500		2000	45500	
Carteria sp.	10500			500	
Distephanus speculum				20	
Scenedesmus bijuga		14000		2000	
— quadricauda	880		10000	110000	160
— sp.			2500		
Bodo marina	31000	18500	5000	9500	
Pterosperma Moebiusii				20	
Trochischia sp.	500			100	
Copepods	?	100	240	200	
Ciliata indeterminata	80	40			
Laboea compressa	60				
— conica	60	100	100		
— emergens	60	100	180		
— ovalis	20				
— strobila		20			
— vestita				40	
Lohmanniella spiralis	20				
Mesodinium rubrum	80				
Parafavella sp.		80	180	180	
Strombidium sp.			40		
Tintinnopsis sp.		20	20	60	

Table 4. Nordåsvatn. Locality b. 21 April 1942. Cells per liter.

Depth in metres	0	1	5	10
Number of ml. examined	20	2;50	2;50	2;50
Asterionella sp.	150			
Chaetoceros constrictus				40
— debilis				
— gracilis	7354000	1047000	466000	3000
— holsaticus		2500		
— socialis		12500	33000	43000
— sp.				5500
— Wighami	4000		10500	
Coscinodiscus sp.				20
Navicula sp.	100			40
Nitzschia closterium				100
— delicatissima				160
— seriata				1620
Rhizosolenia fragilissima				340
— imbricata var. Shrubsolei				40
Sceletonema costatum	79000	26000	5500	24500
Thalassionema nitzschioides				80
Thalassiosira gravida				540
Cysts		1000		3000
Ceratium intermedium		40		
Dinophysis acuminata		80		40
— norvegica		40		
Exuviaella sp.				60
Glenodinium rotundum		60		
Gymnodinium Lohmanni		640	100	80
— m		20		
— sp.		580	40	60
Peridinium brevipes		60	20	
— globulus f. quarnerense		20		
— minusculum		1500		
— subinerme			20	
— trochoideum		40	20	
Phalacroma rotundatum		20		
Bodo marina		9500	500	
Chlamydomonas sp.	384000			
Monads	19000	45000	6000	2500
Ciliata indeterminata		100	40	
Laboea conica		320	60	
— strobila		100		
Lohmanniella oviformis	9800	120		
— spiralis		60		
Mesodinium rubrum	850	480	440	80
Strombidium sp.		60		20
Tintinnopsis sp.			20	
Copepods			100	20

(see next page also).

Table 4 (Cont).

Depth in metres Number of ml. examined	20 2;50	50 20
Asterionella sp.		
Chaetoceros constrictus		
— debilis	69000	
— gracilis	1500	
— holsaticus		
— socialis	402000	950
— sp.		
— Wighami		
Coscinodiscus sp.	20	
Navicula sp.	80	100
Nitzschia closterium	40	150
— delicatissima	80	800
— seriata		
Rhizosolenia fragilissima		
— imbricata var. Shrubsolei	20	
Sceletonema costatum	4500	36600
Thalassionema nitzschioides		100
Thalassiosira gravida		50
Cysts		
Ceratium intermedium		
Dinophysis acuminata		
— norvegica		
Exuviaella sp.	100	
Glenodinium rotundum		
Gymnodinium Lohmanni	40	
— m		
— sp.	20	
Peridinium brevipes		
— globulus f. quarnerense	20	
— minusculum		
— subinerme		
— trochoideum		
Phalacroma rotundatum		
Bodo marina		
Chlamydomonas sp.		
Monads		250
Ciliata indeterminata		
Laboea conica		
— strobila		
Lohmanniella oviformis		
— spiralis		
Mesodinium rubrum		
Strombidium sp.		
Tintinnopsis sp.		
Copepods		50