Effects on Phytoplankton Biomass, Succession and Composition in Lake 223 as a Result of Lowering pH Levels from 5.6 to 5.2. Data from 1980 to 1982

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EFFECTS ON PHYTOPLANKTON BIOMASS, SUCCESSION AND COMPOSITION IN LAKE 223 AS A RESULT OF LOWERING pH LEVELS FROM 5.6 to 5.2. DATA FROM 1980 TO 1982

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ABSTRACT

Findlay, D.L. 1984. Effects on phytoplankton biomass, succession and composition in Lake 223 as a result of lowering pH levels from 5.6 to 5.2. Data from 1980 to 1982. Can. Manuscr. Rep. Fish. Aquat. Sci. 1761: iv + 10 p.

This report documents changes in the phytoplankton community of Lake 223 during a decrease in pH levels from 5.6 to 5.2. It discusses changes in biomass, succession and composition over the three year period and documentsthe overall effects of acidification on the plankton community.

Key words: phytoplankton; acidification; Experimental Lakes Area; biomass; succession; diversity.

RESUME

Findlay, D.L. 1984. Effects on phytoplankton biomass, succession and composition in Lake 223 as a result of lowering pH levels from 5.6 to 5.2. Data from 1980 to 1982. Can. Manuscr. Rep. Fish. Aquat. Sci. 1761: iv + 10 p.

Le présent rapport décrit les changements survenus dans le phytoplancton du lac 223 lorsqu'on en a fait passer le pH de 5,6 à 5,2. Il explique les modifications apportées à la biomasse, succession et composition du phytoplancton, durant la période de trois ans qu'a duré l'expérience, et expose, avec données, l'action de l'acidification sur le plancton en général.

Mots-clés: phytoplancton; acidification; Région des Lacs Expérimentaux; biomasse; succession; diversité.

INTRODUCTION

Artificial acidification of Lake 223 began in 1976 and over the course of 7 years the pH has been decreased to 5.2 from 7. Earlier results summarized by Findlay and Saesura (1980) showed increased biomass, and dominance shifting from chrysophytes to chlorophytes. This report deals with data pertaining to 1980-1982 and discusses the effects on the phytoplankton community as pH levels decrease from 5.6 to 5.2.

METHODS

This is a continuation of an experimental acidification experiment started in 1976. The sampling and counting methods used are the same as described by Findlay and Saesura (1980).

RESULTS

LAKE 223

1980

Epilimnion (Fig. 1): Acidification continued to cause abrupt changes in the phytoplankton community. Chrysophyceae dominated throughout a large portion of the season (*Uroglena americana*, *Dinobryon* spp., *Chrysochromulina* spp. and several small flagellated species). The only period when they did not dominate was in early spring when chlorophytes (*Chlorella* cf *mucosa*) and cryptophytes (*Cryptomonas erosa*) were co-dominant. Cyanophyceae (*Chroococcus minutus*) were conspicuous throughout July and August. For the first time since the experiment began, Peridineae were prevalent throughout the season in large numbers.

Biomass increased from 800 to 3 400 mg•m^{-3} over the season with the largest estimate occurring in late fall.

Metalimnion (Fig. 2): Species composition was effected to a greater degree in the metalimnion than in the upper strata. Chlorophytes (*Chlorella* cf *mucosa*) were the dominant group from May until mid July giving way to chrysophycean (*Chrysochromulina* spp., *Uroglena americana*) dominance for the remainder of the season. Cryptophyceae were abundant in early May and Peridineae were present but not as prominent as in the epilimnion.

Biomass values were elevated over pre-acidification estimates 2 to 3 times ranging from 759 to 13 300 mg•m^{-3} in late July when *Chlorella* cf *mucosa* composed 85% of the standing crop (14 x 10^{6} cells•L^{-1}).

Hypolimnion (Fig. 3): The hypolimnion was sampled in 1980 from May to June; after this period the hypolimnion was below the 1% light level and any phytoplankton there were assumed to be non photosythetic.

As in the metalimnion, Chrysophyceae, Chlorophyceae and Cryptophyceae were the major groups constituting the plankton assemblage. Chrysophytes and cryptophytes dominated in May, with *Chlorella* cf *mucosa* dominating in June.

Biomass was increased over previous years ranging from 1 300 mg•m^{-3} to 9 200 mg•m^{-3}. The peak biomass occurred when *Chlorella* cf *mucosa* was dominant.

1981

Epilimnion (Fig. 1): The most drastic change in the epilimnetic phytoplankton occurred in 1981. Species composition was very different from that of previous years. Chrysophyceae (*Chrysosphaerella longispina*) dominated for a short period in early spring after ice-out, then decreased. Peridineae (*Peridinium Willie* and *Gymnodinium* sp.), for the first time, dominated the standing crop from May to late August. Cyanophyceae dominated in late August and again in mid September (*Chroococcus minutus*). Chlorophyceae were abundant in early spring, as were the cryptophytes.

Biomass estimates were higher than pre-acidification values fluctuating from 750 to 2 800 mg•m^{-3} and averaging 1 600 mg•m^{-3}.

Metalimnion (Fig. 2): The metalimnetic standing crop was dominated throughout the season by chrysophycean species (*Chrysosphaerella longispina*, *Chrysococcus* spp., *Uroglena americana*, *Chrysochromulina parva* and *Dinobryon* spp.) except in early May when *Chlorella* cf *mucosa*, and *Gymnodinium* sp., a dinoflagellate, were co-dominant. Cyanophycean species *Chroococcus minutus* was co-dominant in late September with those chrysophytes mentioned earlier. Diatoms, mainly *Asterionella ralfsii*, were abundant in May and June and Peridineae were conspicuous throughout the season.

Biomass estimates decreased in 1981, averaging 1 200 mg•m^{-3} which is comparable to pre-acidification estimates.

Hypolimnion (Fig. 3): Changes in the hypolimnetic species composition were subtle in 1981 compared to 1980. Chrysophyceae (*Chrysococcus* sp. and *Chrysochromulina parva*) dominated for the entire season with large populations of chlorophytes (*Chlorella* cf *mucosa* and *Chlamydomonas* spp.) and diatoms (*Asterionella ralfsii*) being present. Peridinean species, *Peridinium aciculiferum*, was also common throughout the season.

Biomass estimates which ranged from 1 150 to 4 000 mg•m^{-3} were higher than those recorded prior to acidification but showed a decrease from previous years of acidification.

1982

Epilimnion (Fig. 1): Chrysophyceae (*Chrysococcus* sp. and *Dinobryon* sp.) dominated the plankton community in May and early June and continued to be abundant throughout the season. Chlorophytes (*Scenedesmus brevispina* and *Botryococcus Braunii*) were present throughout May, June and July, declining as an increase in Cyanophyceae occurred (*Chroococcus minutus* and

Merismopedia glauca). The most prominent species throughout the season was Gymnodinium sp., which was dominant throughout a large portion of the season, constituting up to 65% of the assemblage in July.

Biomass was slightly higher than pre-acidification estimates ranging from 600 to 2 800 mg•m^{-3} with a mean of 1 400 mg•m^{-3}. The highest estimate occurred when the Cyanophyceae were dominant.

Metalimnion (Fig. 2): In 1982 the species composition of the phytoplankton community was comparable to that seen prior to acidification. Chrysophyceae dominated for the entire season with Dinobryon sertularia var. protruberans, Dinobryon bavaricum var Vanhoeffenii and Uroglena americana constituting the major species. Synura sphagnicola (also a chrysophyte) was the dominant species from mid July on. Populations of cryptophytes existed in May and in late September with chlorophycean populations conspicuous throughout the season. Peridineae were nearly absent throughout the season.

Biomass estimates doubled over those recorded for 1981 averaging 2 300 mg•m^{-3}.

Hypolimnion (Fig. 3): The standing crop in the hypolimnion was dominated sequentially by cryptophytes in June (Cryptomonas rostratiformis, Cryptomonas ovata and Cryptomonas erosa) and chrysophytes in July (Synura sphagnicola, Dinobryon bavaricum var. Vanhoeffenii, Dinobryon bavaricum and Uroglena americana).

Biomass remained higher than pre-acidification estimates and those estimates for 1981, fluctuating from 2 300 to 6 900 mg•m^{-3} with an average of 4 000 mg•m^{-3}.

LAKE 224

1980

Epilimnion (Fig. 4): Lake 224 was sampled in 1980, three times during the ice-free season.

The standing crop was dominated by chrysophytes Uroglena americana, Dinobryon bavaricum, Stichogloea sp. and several small flagellated forms throughout the season constituting 50-70%. Cyclotella comta, a diatom, represented 30% of the biomass in early June but diminished by mid-July. Populations of cyanophytes, chlorophytes and cryptophytes were conspicuous, as were populations of Peridineae.

Biomass remained low declining from 1 000 mg•m^{-3} to 600 mg•m^{-3} for the remainder of the season.

Metalimnion (Fig. 5): The metalimnetic standing crop was dominated by the same species found dominating the epilimnion for the entire season. Stable populations of diatoms and cryptophytes existed throughout the season. Chlorophytes were present in early June and July, increasing in early September to represent 30% of the total with Botryococcus Braunii being the major species.

Hypolimnion (Fig. 6): The plankton assemblage in early June was 60% chrysophytes (Dinobryon bavaricum, Dinobryon cylindricum, Uroglena americana and Stichogloea sp.) and 20% chlorophytes (Botryococcus Braunii). In mid-July the previously mentioned chrysophytes and chlorophytes were co-dominant. Botryococcus Braunii continued to increase and by early September constituted 66% of the live biomass. Chrysophytes remained at 20%.

Biomass was very stable fluctuating from 1 200 to 1 300 mg•m^{-3}.

1981

Epilimnion (Fig. 4): Chrysophyceae dominated throughout the 1981 ice-free season with Dinobryon sertularia, Dinobryon bavaricum and Uroglena americana being the major species. Small pulses of diatoms, Peridineae and chlorophytes occurred in June, July and August respectively. Rhizosolenia eriensis was the most common diatom and Gymnodinium sp. were the most prominent Peridineae. The major chlorophytes causing an increase were Botryococcus Braunii and Glocococcus Schroeterii.

Biomass ranged from a high of 2 200 mg•m^{-3} in late May to a low of 500 mg•m^{-3} in mid-October.

Metalimnion (Fig. 5): The standing crop in the metalimnion was dominated by two chrysophycean species, Uroglena americana and Dinobryon bavaricum, for the entire season. In addition to the chrysophytes, populations of chlorophytes (Oocystis lacustris and Botryococcus Braunii) and diatoms (Cyclotella comta and Tabellaria fenestrata) were conspicuous.

Biomass ranged from 500 to 1 900 mg•m^{-3} with the largest estimate occurring in late spring when Uroglena was dominant.

Hypolimnion (Fig. 6): The standing crop in the hypolimnion was dominated by the same species which dominated the metalimnion from May until mid-August. At this time Botryococcus Braunii became dominant. Also present throughout the season was a population of dinoflagellates dominated by Gymnodinium.

Estimates for biomass ranged from 1 000 to 1 500 mg•m^{-3}.

1982

Epilimnion (Fig. 4): Uroglena americana, Dinobryon bavaricum and Dinobryon bavaricum var. Vanhoeffenii dominated the plankton assemblage in the epilimnion for the entire ice-free season averaging over 50% of the live biomass. Co-existing were populations of chlorophytes (Botryococcus braunii), diatoms (Rhizosolenia eriensis and Cyclotella stelligera) and cyanophytes (Lyngbya sp.).

Biomass ranged from 750 to 1 250 mg•m^{-3}.

Metalimnion (Fig. 5): As in the epilimnion, the metalimnion was dominated by chrysophyceans (Dinobryon bavaricum, Dinobryon bavaricum var.

Vanhoeffenii and Uroglena americana). Diatomeae with Synedra acus constituted 36% of the biomass in early spring and remained conspicuous. Chlorophyceae dominated the latter portion of the season as Botryococcus Braunii became abundant constituting 54% of the crop.

Biomass was low ranging from 700 to 1 500 $mg \cdot m^{-3}$.

Hypolimnion (Fig. 6): In 1982 the hypolimnion was sampled from mid-June through early September. Chrysophyceae (Dinobryon bavaricum, Dinobryon sertularia and Uroglena americana) were found to be the dominant group except in late August and early September. During this period the standing crop was dominated by chlorophytes (41%) represented mainly by Botryococcus Braunii. Throughout August and early September the diatom Rhizosolenia eriensis, was prominent, constituting up to 20% of the assemblage.

Biomass was low for the majority of the season ranging from 900 to 1 600 mg/m^3 except in mid-July when it increased to a maximum of 7 400 $mg \cdot m^{-3}$. This increase was due to Uroglena americana.

DISCUSSION

Since acidification began in 1976 the phytoplankton community in Lake 223 has undergone significant changes, most occurring below pH 5.5.

Community structure has gone through several phases of dominance, shifting from chrysophytes, to chlorophytes to cyanophytes and lastly to Peridineae. The appearance of Peridineae at low pH agrees with the literature (Yan and Stokes 1978). In addition, a large population of the diatom (Asterionella ralfsii W. Smith) appeared in Lake 223 in 1980. This species was not previously reported from ELA lakes. Although its cell volume is small and it does not form a significant portion of the biomass, it was numerically abundant. Its appearance in Lake 223 correlates with a drop of silica (Fig. 7). In previous years there have been large pulses of diatoms but they had no effect on silica concentrations. Asterionella ralfsii appears to have a high assimilation for silica. In view of its appearance in the Experimental Lakes Area and its ability to exist in low pH it could be considered acidophilic making it a possible indicator of acidification in future experiments.

Lowering the pH has also affected the biomass. Contrary to the Scandinavian literature which hypothesizes an oligotrophication effect, biomass has remained the same with a possible trend of a slight increase occurring in the last 3 years (Fig. 1,2,3). In comparison Lake 224 has not increased at all (Fig. 4,5,6).

It has been documented that nutrients, mainly phosphorus, nitrogen and carbon, influence species composition and biomass. There has been no increase in the major nutrients (Schindler and Turner 1982). Therefore these increases could be caused by changes in metal concentrations such as copper, aluminum, and zinc. This relationship requires further study.

It appears that Lake 223 is reaching a critical pH level in regard to the phytoplankton community. Further studies will be required to assess the total effect of acidification on this part of the food chain.

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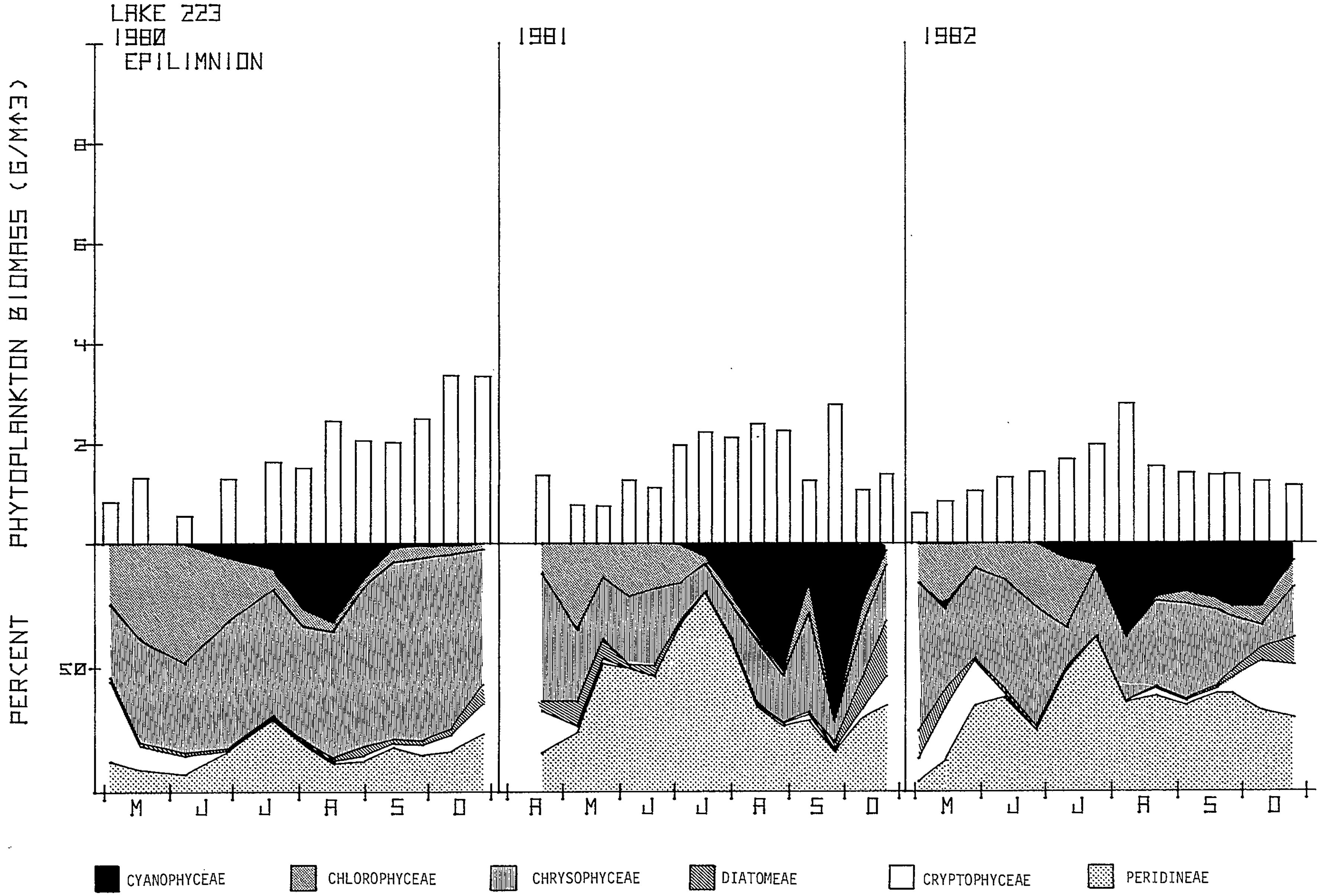


Fig. 1. Average phytoplankton volume in the epilimnion of Lake 223 in 1980-1982, and accumulative percent composition.

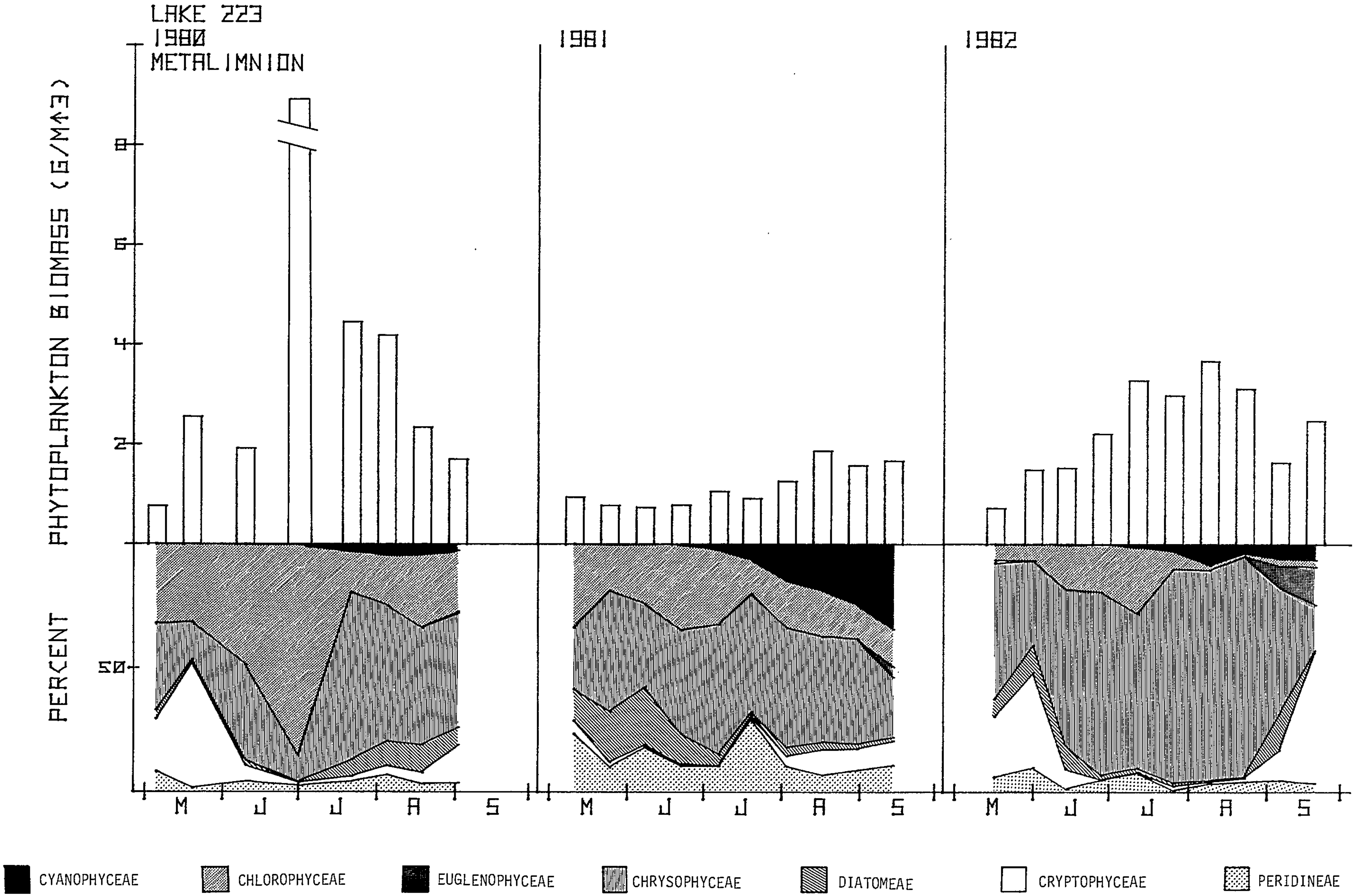


Fig. 2. Average phytoplankton volume in the metalimnion of Lake 223 in 1980-1982, and accumulative percent composition.

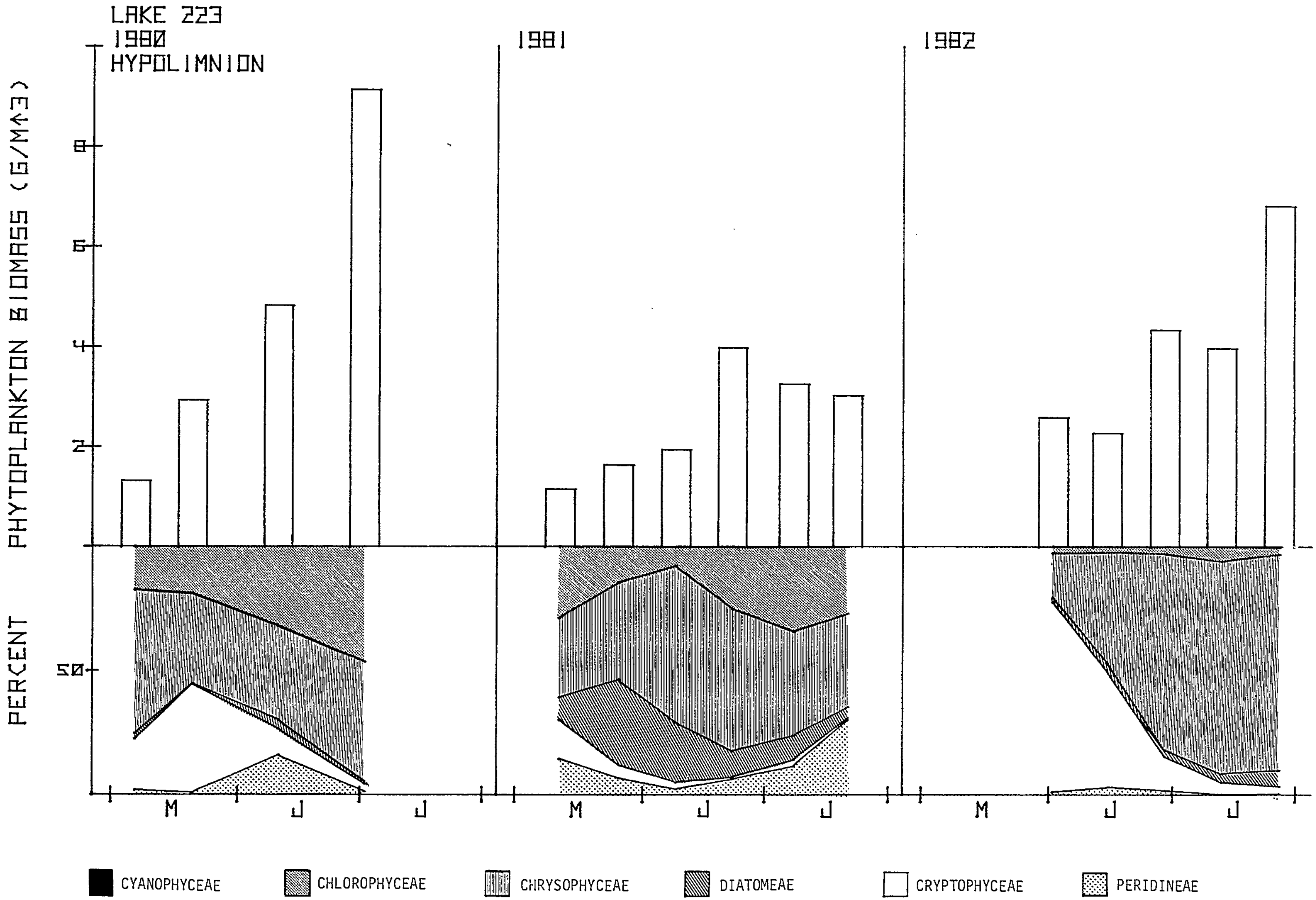


Fig. 3. Average phytoplankton volume in the hypolimnion of Lake 223 in 1980-1982, and accumulative percent composition.

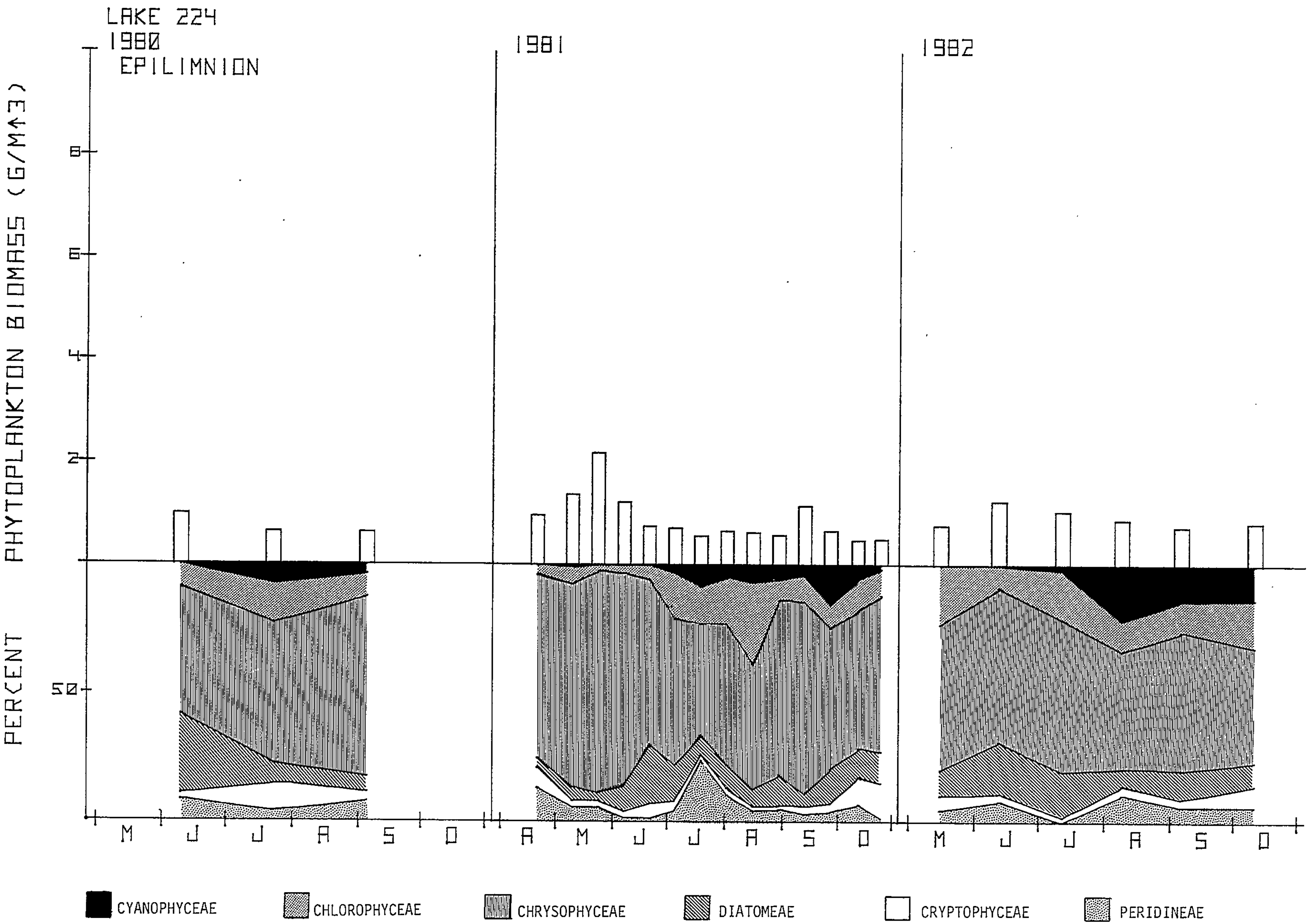
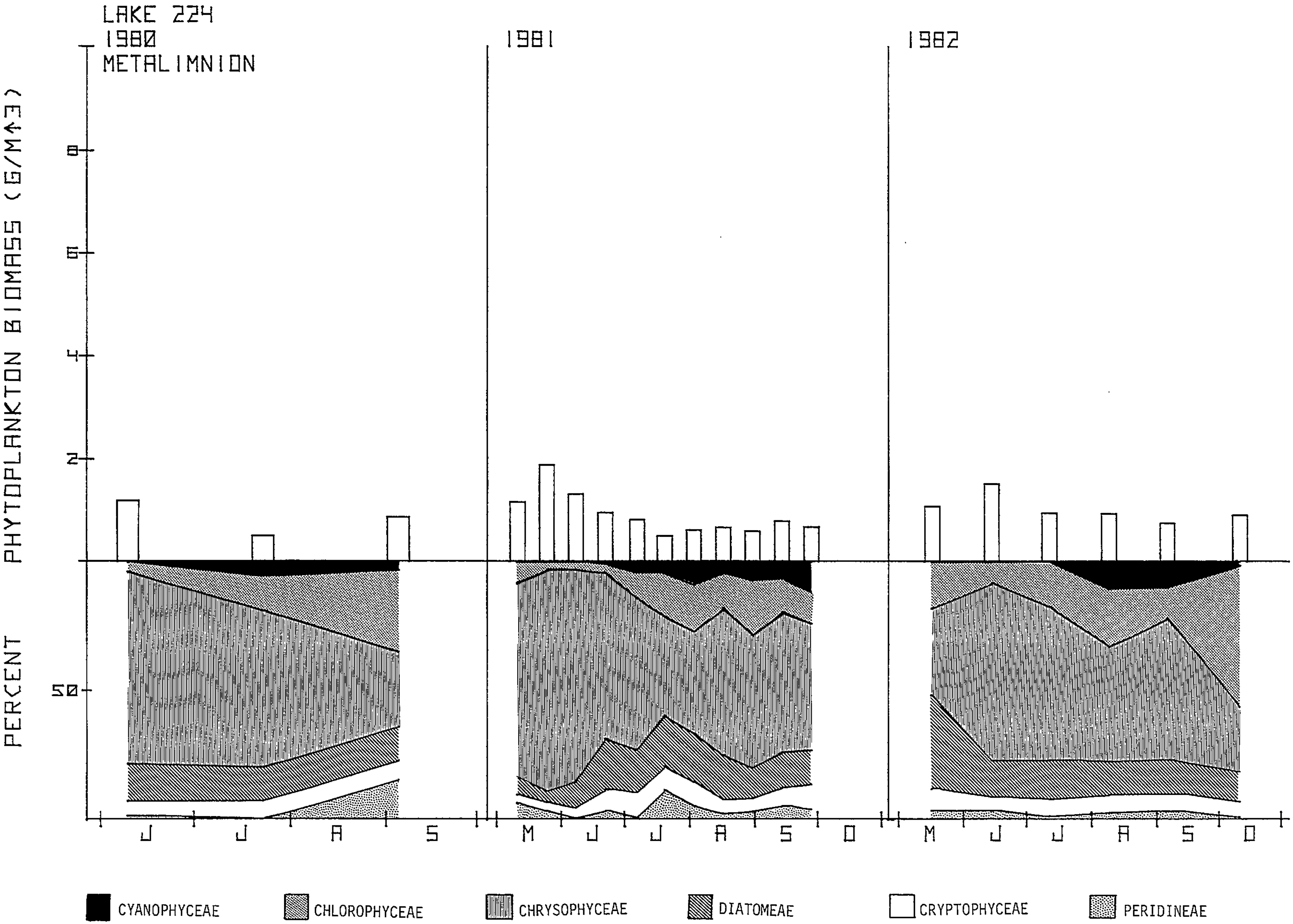


Fig. 4. Average phytoplankton volume in the epilimnion of Lake 224 in 1980-1983, and accumulative percent composition.



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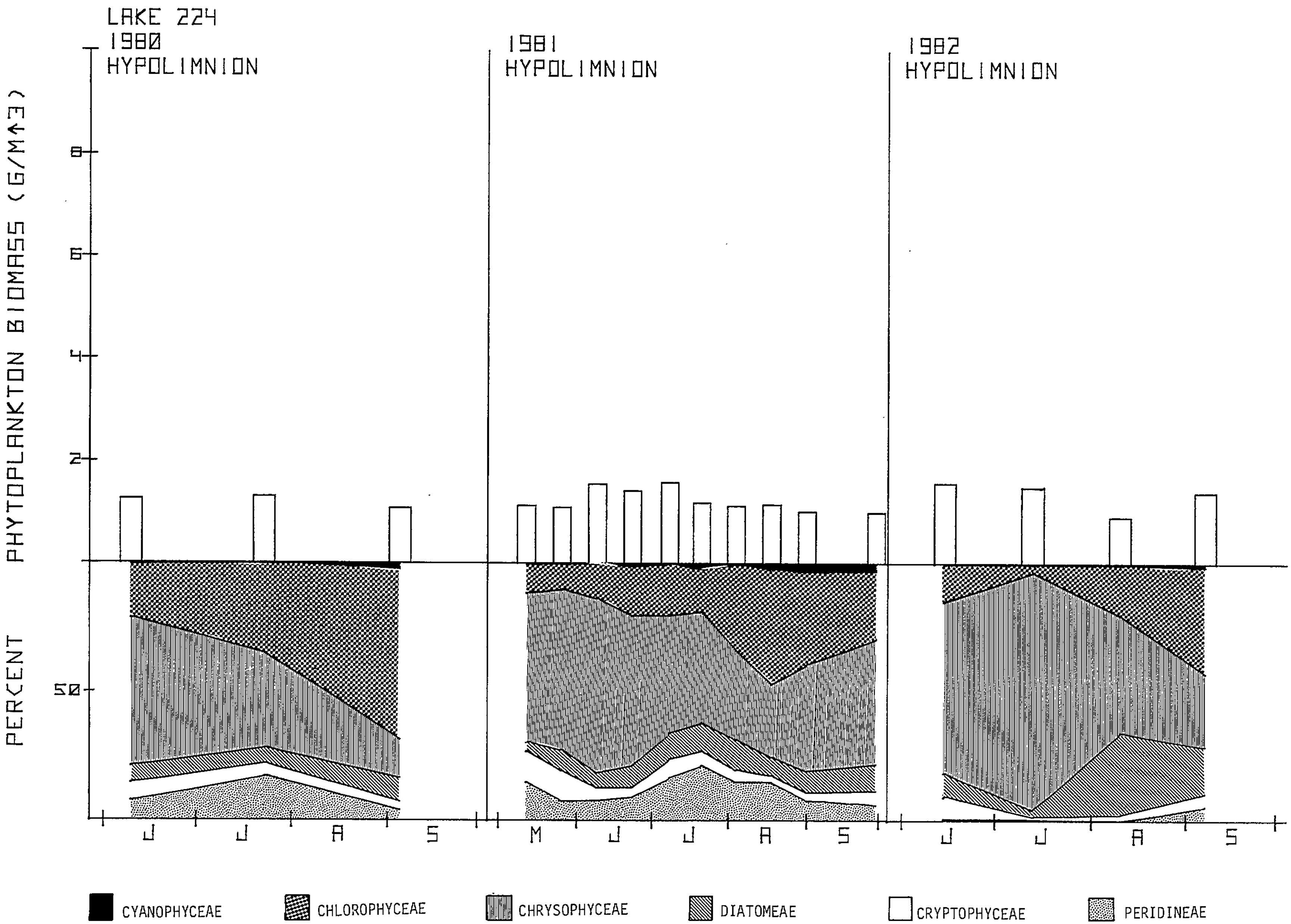

Fig. 6. Average phytoplankton volume in the hypolimnion of Lake 224 in 1980-1983, and accumulative percent composition.

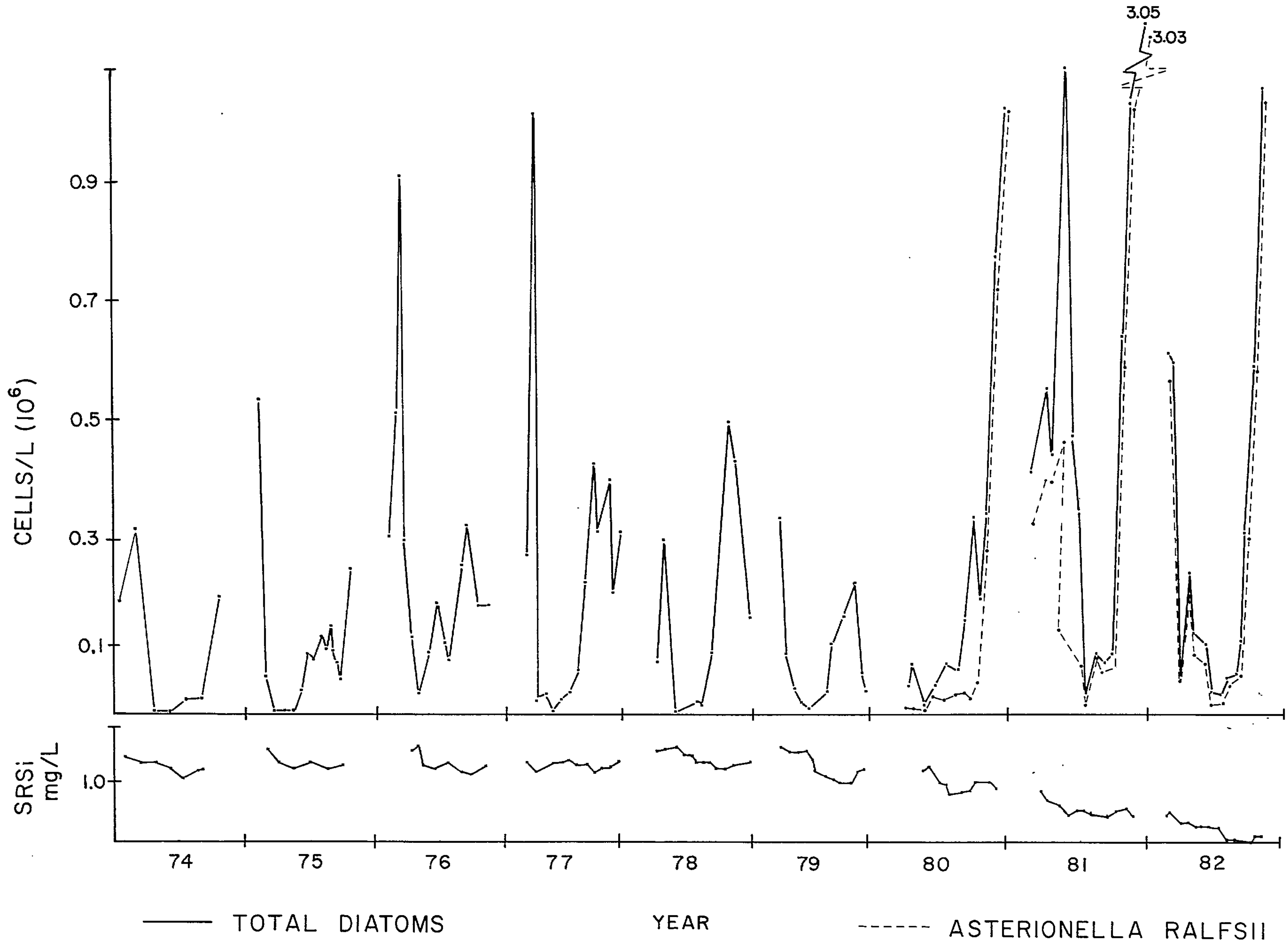

Fig. 7. A comparison of total diatoms to Asterionella ralfsii W. Smith in relation to SrSi in Lake 223.

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