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Report

Recent trend in seasonal periodicity of phytoplankton community in a small mountainous lake, Fukami-ike, Central Japan

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Abstract

In order to understand the present status of eutrophication of Lake Fukami-ike, seasonal periodicity of phytoplankton community was investigated from March 2013 to February 2014. Major species were *Cyclotella* sp. (Bacillariophyceae) and *Synedra rumpens* (Bacillariophyceae) in spring, *Aphanizomenon flos-aquae* (Cyanophyceae) and *Nitzschia* sp. (Bacillariophyceae) in summer, *Coelastrum sphaericum* (Chlorophyceae) and *Crucigenia tetrapedia* (Chlorophyceae) in autumn and *Synedra* sp. (Bacillariophyceae) in winter, respectively. The dominant species of the phytoplankton community in 1978-1979 were *Synedra acus* (Bacillariophyceae) in spring to summer, and *Aulacoseira ambigua* (Bacillariophyceae) in autumn to winter. However, propagations of *S. acus* and *A. ambigua* were not observed in this study. Furthermore, occurrence of cyanobacterial plankton was not seen in 1978-1979. From the results of this study, seasonal periodicity of the phytoplankton community seemed to change drastically in recent years. On the other hand, chlorophyll-*a* amounts in photic zone in 2013-2014 were only slightly higher than those in 1978-1979. Thus, progression of the eutrophication of the Lake Fukami-ike was not detected in this study.

Key words: Lake Fukami-ike, phytoplankton, seasonal periodicity

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Introduction

Lake Fukami-ike is a small monomictic and eutrophic lake, located in southern Nagano Prefecture in Central Japan; north latitude 35°32′55″77, east longitude 137°81′93″56, which has a small diameter: 150 m, a long diameter: 300 m, area 2.1 ha, volume 1.0 × 105 m^3 with a maximum depth of 7.8 m (Fig. 1). This lake has an outflow river and six inflow rivers which have water from paddy fields, orchards and surrounding house runoff into the lake. Circulation periods were from November to March, and stagnation periods were from April to October; the dissolved oxygen concentration was zero in about the 4 m to 5 m deeper layer in mid-summer (Yagi, 2009, 2010). Investigations of Lake Fukami-ike were begun from 1978, and are continuing roughly

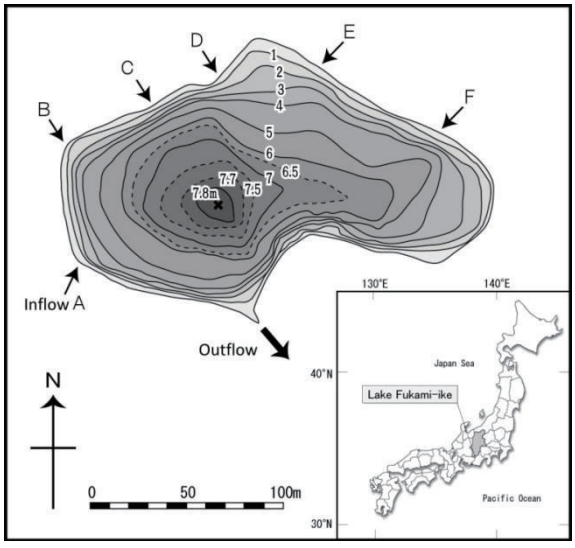

Fig. 1. Bathymetrical map of Lake Fukami-ike.

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once a month (Yagi *et al*., 1983). High chlorophyll-*a* concentration (357 μg L^{-1}) and low transparency (35 cm) were observed in the early 2000's. This phenomenon suggests that the lake environment is changing. The seasonal periodicity of the dominant species of the phytoplankton community is one of the signals indicating the state of lakes. However, information about the phytoplankton community in Lake Fukami-ike is never been reported in recent years. Thus, in order to understand the present status of eutrophication of Lake Fukami-ike, seasonal periodicity of phytoplankton community was investigated.

Methods

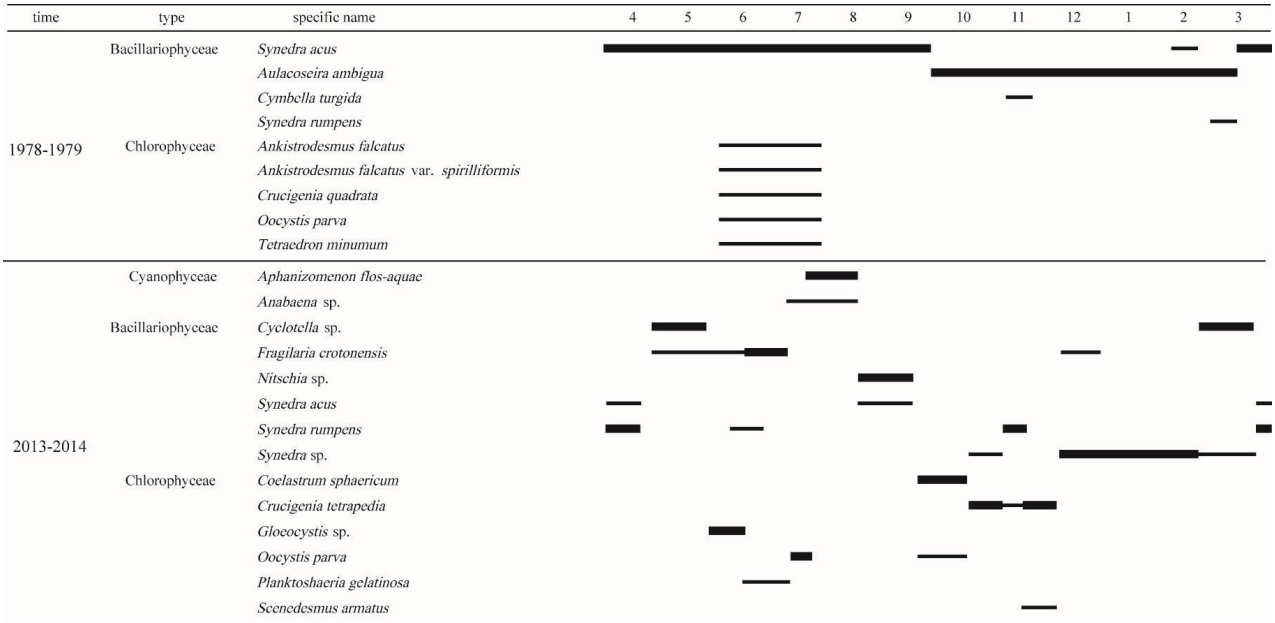
Surveys were carried out from March 2013 to February 2014. Plankton samples were taken with a *Van Dorn* water sampler (10L, Rigo Co., Ltd., Tokyo Japan) every 1 m from the upper to bottom layer. All samples were preserved in 1% formalin in the field immediately, then counted and identified using an optical microscope (BX51, OLYMPUS Optical Co., Ltd., Tokyo, Japan) in the laboratory. The cells of phytoplankton were counted using a ruled line glass slide. The greatest number of species counted was as dominant species, and the second most numerous of species was as subdominant species.

For chlorophyll-*a* analysis, lake water was collected at the deepest point with a hand-operation water pump connected to a polyvinylchloride tube from every 0.25 m depth during the period of water stratification from April to October or from every 50 cm-1 m depth in other months. A part of the water samples was filtered through a glass fiber filter (Whatman, GF/F, 47 mm) immediately after the sampling. Chlorophyll-*a* concentrations were measured by the fluorometric method (Holm-Hansen *et al*., 1965). Chlorophyll-*a* amounts were calculated by multiplying the concentration with the volume of the lake.

Results and Discussion

Dominant species of phytoplankton in 1978-1979 (Tanaka, 1992) and 2013-2014 (this study) were shown in Table 1. Major species in this study were *Cyclotella* sp. (Bacillariophyceae) and *Synedra* rumpens (Bacillariophyceae) in spring, *Aphanizomenon flos-aquae* (Cyanophyceae) and *Nitzschia* sp. (Bacillariophyceae) in summer, *Coelastrum sphaericum* (Chlorophyceae) and *Crucigenia tetrapedia* (Chlorophyceae) in autumn and *Synedra* sp. (Bacillariophyceae) in winter, respectively. The dominant species of the phytoplankton community in 1978-1979 were *Synedra acus* (Bacillariophyceae) in spring to summer, and *Aulacoseira ambigua* (Bacillariophyceae) in autumn to winter. However, propagations of *S. acus* and

Table 1. Seasonal periodicity of phytoplankton in the Lake Fukami-ike. thick lines: dominant species, thin lines: subdominant species 1978-1979: June 1978-May 1979（Tanaka, 1992）.



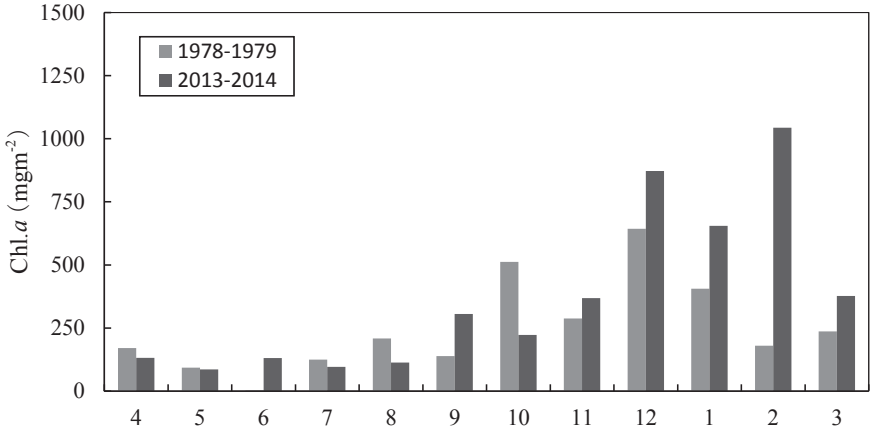


Fig. 2. Seasonal variations of Chlorophyll-*a* amounts in the photic zone in 1978-1979 (Yagi, unpublished data) and 2013-2014.

A. *ambigua* were not observed in this study. Furthermore, occurrence of cyanobacterial plankton was not seen in 1978-1979. From the results of this study, seasonal periodicity of phytoplankton community seemed to change drastically in recent years.

Seasonal variations of chlorophyll-*a* amounts in the photic zone in 1978-1979 (Yagi, unpublished data) and 2013-2014 (This study) were shown in Fig. 2. The value was low in the stagnation period (spring-summer) and high in the circulation period (autumn - winter). This trend was reported in the previous study (Yagi *et al*., 1983). Total annual amounts of chlorophyll-*a* were 4,401 mg m^{-2} in 2013-2014, and 3,004 mg m^{-2} in 1978-1979. Chlorophyll-*a* amounts in 2013-2014 were only slightly higher than those in 1978-1979. Thus, progression of the eutrophication of the Lake Fukami-ike was not detected in this study.

Major species of the phytoplankton community changed, but chlorophyll-*a* amounts and the daily production rate did not change in Lake Biwa, affected by TN/TP ratio, trace elements, and noxious chemicals (Nakanishi *et al*., 2001). Sakamoto (2010) reported that only the species of phytoplankton composition has changed, but chlorophyll-*a* amounts did not change in Lake Biwa. Kishimoto *et al*. (2013) reported that phytoplankton biovolume decreased about one fifth from 1980s to 2000s in long-term succession in Lake Biwa. The upward flux of nutrients was suppressed by global warming intensified thermal stratification and limited light for phytoplankton growth by water mixing in epilimnion. Cyanophyceae were characteristically in strongly competition for nutrients because they have N_2 fixation typically. Homma *et al*. (2005) reported *Microcystis* species which also belongs to Cyanophyceae dominant in Lake Suwa under a NO_3-N-limited condition. Further analyses are required to elucidate changes of the phytoplankton community of Lake Fukami-ike about environmental factors that influence the change.

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摘　要

深見池における植物プランクトン群集の最近の傾向

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横山亜希子[3)]・八木明彦[1)]

深見池の富栄養化の現状を理解するために，植物プランクトン群集の季節的な周期性を2013年3月から2014年2月にかけて調べた。主な植物プランクトンは，春季に珪藻 *Cyclotella* sp. と *Synedra rumpens*，夏季にシアノバクテリア *Aphanizomenon flos-aquae* と珪藻 *Nitzschia* sp.，秋季に緑藻 *Coelastrum sphaericum* と *Crucigenia tetrapedia*，そして冬季に珪藻 *Synedra* sp. であった。1978年から1979年の優占種は，春季から夏季が珪藻 *Synedra acus*，秋季から冬季が珪藻 *Aulacoseira ambigua* であった。しかしながら，本研究では，これら2種類の珪藻の増殖は観察されなかった。加えて，1978～1979年にはシアノバクテリアの出現も見られなかった。本研究の結果からは，植物プランクトン群集の季節的な周期性が，近年，大きく変化しているであろうことが示唆された。一方で，有光層内のクロロフィル *a* 量は，1978～1979年の値よりわずかに高いのみであった。したがって，深見池の富栄養化の進行は，本研究では検出できなかった。

キーワード：深見池，植物プランクトン，季節的な周期性

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