Abstract

[Research Title]

Development of a High-Resolution Image Analysis System for Monitoring and Forecasting Plankton Dynamics in Lake Ecosystems

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Principal Investigator :	Jotaro Urabe
(PI ORCID) :	ORCID 0000-0001-5111-687X
Principal Institution :	Graduate School of Life Sciences, Tohoku University Sendai, 982-0011, JAPAN Tel: +81 22-795-6681 Fax: +81 22-795-6686 E-mail: urabe@tohoku.ac.jp
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This study consists of four sub-themes. Sub-theme 1 aimed to create a comprehensive image database of zooplankton with genetic information. Plankton samples were collected from 371 locations in 87 lakes and reservoirs in Japan. A total of 88,704 images of 211 taxa were obtained, representing 56.9% of the taxa known in Japan. The images of zooplankton taxa obtained from this sub-theme were provided to sub-theme 3 to test the AI-based plankton image recognition technology developed by them. In addition, DNA barcoding data were collected from these samples. Taxonomic re-evaluation was also performed based on DNA barcoding data (Makino et al. 2023, Ohtuski et al. 2022, Sioud et al. 2022, Suzuki et al. 2023).

In sub-theme 2, live phytoplankton were collected to produce isolated strains of cyanobacteria, diatoms, and green algae, totaling 422 strains. These were then imaged with genomic data. During this study, toxin-producing species and taxonomically questionable dominant species were analyzed (Tuji et al. 2022, 2023, Tuji and Nakagawa 2023). The images of phytoplankton collected in this study were also used in sub-theme 3 to develop plankton image recognition technology.

Sub-theme 3 established a series of AI-based image analysis methods for automatic classification and counting of planktonic organisms. A specialized method for plankton image classification, called Multi-Label Attention Branch Network (ML-ABN), was developed and demonstrated high accuracy and practicality in classification experiments (Ito at al. 2023).

Using long-term environmental data collected in Lake Biwa, sub-theme 4 developed non-linear predictive models to predict plankton dynamics in the next days to weeks. A model using water quality and variation data of other plankton species showed improved prediction accuracy for short-term (2 weeks) and medium-term (6 months) forecasts, The model was implemented as a web application using R and Shiny for public use. Additional analysis showed the usefulness of aggregating multiple species into a few taxonomic groups to improve prediction accuracy (Otomo et al. 2023, Iwashita et al. 2022).

The plankton image database, AI-based image analysis methods for automatic classification, and nonlinear prediction models developed in this study will be used as the core knowledge for building an efficient automatic plankton monitoring system in the future.

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