

Environmental Monitoring and Integrated Analysis of Multi-Dimensional Data for Marine Phytoplankton Community Dynamics on the Sanriku Coast

*Toyonobu Fujii^{1,2}, Minoru Ikeda^{1,2}, Yuichi Aoki^{3,4}, Tomoko Hamabata^{2,3}, Takeshi Obayashi^{2,3}

1. Onagawa Field Centre, Graduate School of Agricultural Science, Tohoku University, 2. Advanced Institute for Marine Ecosystem Change (WPI-AIMEC), Tohoku University, 3. Graduate School of Information Sciences, Tohoku University, 4. Tohoku Medical Megabank Organization, Tohoku University

Amid the escalating global pressures on marine environments driven by human activities, coastal areas are increasingly confronted with a range of challenges that threaten the sustainability of fisheries resources. The Sanriku coast is a region characterized by active aquaculture of species such as scallops, oysters, and sea squirts, which rely entirely on naturally occurring phytoplankton production for food. In addition, fisheries targeting rocky reef/seaweed-bed associated resources, such as sea urchins, abalone, wakame seaweed, and demersal fish, are widely practiced in the area. The region also hosts numerous seagrass beds, which serve as critical nursery habitats for coastal fish species.

In this study, we conducted environmental monitoring in Onagawa Bay, located along the Sanriku coast, focusing on observations of key coastal primary producers (i.e., phytoplankton, macroalgae, seagrass) and physical parameters such as water temperature, salinity, nutrient concentrations, and current pathways (Oyashio and Kuroshio currents). By integrating these observations with a range of historical survey data and open-access datasets, we performed a comprehensive analysis to understand the temporal dynamics of the Onagawa Bay coastal ecosystem with particular reference to changes in phytoplankton community structures over the past 20 years.

Our findings indicate that changes in the phytoplankton community structure exhibited significant long-term periodic variation, primarily influenced by seasonality and spatial gradients between the inner bay and the outer mouth. However, under recent intensified warming trends, we observed shifts toward novel community structures across the entire bay. Further, during the hot summer in 2024, phytoplankton communities, observed exclusively in the surface layer throughout the bay, differed markedly from those recorded at any other depths or seasons. Analysis of the relationships between these occurrence patterns and environmental variables identified physical factors including nutrient concentrations, water temperature, and salinity as significant explanatory variables, which were potentially influenced by the recent behavior of the Oyashio and Kuroshio currents. It is imperative to deepen our understanding of the processes driving the dynamics of primary productivity in the Sanriku coastal ecosystem as a whole and thereby elucidate how these processes are in turn linked to the productivity of fishery resources, the disappearance of rocky reef algal communities (known as "isoyake"), and mass mortality events in aquaculture. Such insights will be vital for developing scientifically grounded solutions to the increasingly complex challenges facing coastal societies.

Keywords: phytoplankton community, coastal ecosystem dynamics, environmental monitoring, socio-ecological system, Oyashio and Kuroshio currents