

Analysis of Changes in Fish Community Structure in Response to Variations in the Flow Path of the Kuroshio Extension

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Introduction

The waters off the eastern coast of Japan are highly productive and host a diverse assemblage of organisms originating from both warm and cold current systems. The eastward-flowing Kuroshio Extension (KE) plays a crucial role in shaping the regional marine environment and ecosystems. Under normal conditions, the KE flows eastward around 35–36°N. However, since 2022, it exhibited a pronounced northward meander, reaching approximately 40°N—representing the largest northward deviation observed to date. By 2025, this prolonged meandering had subsided. This study examined how such large-scale variability in the KE influences fish community structure in coastal waters along the eastern coast of Japan, using environmental DNA (eDNA) analysis.

Methods

Surface seawater samples were collected from coastal areas ranging from Hokkaido to offshore of the Boso Peninsula aboard the Hokkaido University training vessel *Oshoro Maru* in June 2024 and June 2025. In addition, surface water has been sampled monthly off Sanriku aboard the Ro-Ro vessel *Mashu* since September 2022. After onboard filtration, DNA was extracted in the laboratory, and eDNA metabarcoding was conducted to estimate fish species composition.

Results and Discussion

Analyses of the 2025 data revealed higher fish diversity in southern waters compared to northern waters, with a pronounced contrast across the Kuroshio Front. Cluster analysis based on detected species composition classified the sampling stations into four groups: high-latitude, mid-latitude, low-latitude, and coastal clusters. Distance-based redundancy analysis (db-RDA) indicated that water temperature was a primary driver of community structure, while salinity contributed to cluster differentiation, particularly in coastal zones.

Notably, warm-water species such as southern frigate tuna and round herring were detected north of 40°N during the northward extension of the KE in 2024. In contrast, after the termination of the meandering phase in 2025, these species were detected only south of 36.5°N, corresponding to the position of the Kuroshio Front. These findings demonstrate that variability in the flow path of the KE exerts a strong influence on fish community structure along the eastern coast of Japan.

As global warming progresses, ecosystem responses are likely to be driven not only by rising seawater temperatures but also by changes in the dynamics of major warm currents such as the Kuroshio. Continued monitoring of these physical–biological linkages is therefore essential for understanding and predicting future changes in marine ecosystems.

Keywords: Kuroshio extension, bio-diversity, environmental DNA, fish community