Boundaries of Physical Structures in the Mid-latitude Northwest Pacific Ocean Identified based on Unsupervised Clustering

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The mid-latitude Northwest Pacific Ocean is a region where waters of subtropical and subarctic origin collide, and has been characterized by many boundaries of the spatial distribution of seawater properties, such as the Kuroshio Extension front. It is important to understand the nature of these boundaries correctly, because the location of these boundaries varies seasonally and interannually, and may lead to changes in property of atmosphere-ocean interaction and ecosystem. Until now, a boundary in the mid-latitude Northwest Pacific has been defined as a specific isotherm or isohaline over a specific depth plane, such as the 12˚C isotherm over a 300-m depth plane for the Kuroshio Extension. Such a boundary definition was defined about 40 years ago, when spatiotemporal distribution of ocean data was insufficient, so that the boundary could be determined from temperature and salinity information at only a specific depth, such as 100 or 300 m. Today, the marine environment is changing due to climate change, and the 40-year-old definition may not correctly identify the boundaries. In addition, with the expansion of Argo float array since 2000, a large amount of vertically multi-layered oceanic data is now evenly available in space and time, and it is now possible to identify the boundaries with new methods. In this study, we classified the ocean area using Profile Classification Model (PCM), a method for classifying profile shapes by applying unsupervised clustering, a type of machine learning, to Argo data, and aimed to identify the boundary by focusing on the border of these areas. PCM was developed by Dr. Guillaume Maze at the Ifremer. Previous research has shown that when this method is applied to Argo data for the North Atlantic and the Southern Ocean, the distribution of each class is concentrated in a specific region on the map. Therefore, it is possible to objectively investigate where the seawater with certain properties is located and where the boundaries where the properties of the seawater change are located. We used approximately 20 years of vertical temperature and salinity data from Argo floats in the mid-latitude Northwest Pacific (30-60˚N and 140-180˚E) at depths of 5-1000 m. As a result of performing PCM with the number of classes being set to 5~9, it was observed that each class constitutes a specific area in each case, and the area was subdivided as the number of classes increased. When the number of classes was set to 7, the locations of the borders of each class generally coincided with the four boundaries of the Kuroshio Extension, the Kuroshio Extension Northern Branch, Subarctic Boundary, and Subarctic Front. This suggests that PCM is an effective method to identify the boundaries.

Keywords: Mid-latitude Northwest Pacific Ocean, Kuroshio Extension front, Subarctic Boundary, Argo float, Unsupervised Clustering, Machine Learning

