Detailed water properties of mesoscale vortex pairs in the Sea of Japan: direct observations using an underwater glider

*Taku Wagawa[1], Yusuke Kawaguchi[2], Yosuke Igeta[1], Naoto Honda[1], Takeshi Okunishi[3]

1. Japan Sea National Fishseries Research Institute, Japan Fisheries Research and Education Agency, 2. Japan Agency for Marine-Earth Science and Technology, 3. Tohoku National Fishseries Research Institute, Japan Fisheries Research and Education Agency

The Sea of Japan is a marginal sea bounded by the Asian landmass and the Japanese islands. Warm, saline Kuroshio waters enter the sea via the Tsushima Strait to form the Tsushima Warm Current. The Subpolar Front extends roughly along 40ºN to the Tsugaru Strait. Large horizontal density gradients across the front maintain a surface-intensified jet with a lateral scale of *O*(10 km) and speeds exceeding 0.5 m s^{-1}. The region offshore of Sado Island and the Noto Peninsula (i.e., along the southern margin of the central Sea of Japan) is characterized primarily by an eastward jet flows along the Subpolar Front and the Tsushima Warm Current and mesoscale eddies formed around the main currents. The anomalous intrusion of such currents and eddies into this region cause perturbations of temperature and salinity, which raise serious concerns for the set-net fisheries and aquaculturists in the region. Although earlier studies have investigated those synoptic-scale and mesoscale structures, their details remain unclear owing to insufficient in-situ data.

We successfully completed for the first time a spatially high-resolution survey with an underwater glider (Seaglider, Kongsberg Underwater Technology Inc.) along a Jason-2 satellite altimeter track #86 off Sado Island from 20 April through 2 June 2016. The Seaglider repeatedly profiled temperature and salinity from the ocean surface to roughly 900 m depth with an along-track profile separation 2–3 km, which is sufficient to resolve the mesoscale structures. A total of 257 profiles were obtained during a two-round-trip observation (four transects; referred to as “Transects 1–4”).

We applied principal component analysis using a time series of the absolute sea surface height (SSH) from 1993 to 2015 by AVISO and a correlation matrix method. Horizontal distribution of SSH of the first principal component are approximately in phase over the interested study domain with intraseasonal variations, whereas that of the second principal component (PC2) shows the existence of a vortex pair off Sado Island with primarily interannual variation.

A large variability of mesoscale frontal/eddy structures and water properties was revealed by the glider observations; Transects 1 to 4 were respectively characterized by a cyclonic eddy, a vortex pair, an anticyclonic eddy, and baroclinic jets (no eddies). We detected the vortex pair consisting of northern anticyclonic eddy and southern cyclonic eddy along Transect 2, almost corresponding to that of PC2. The paired anticyclonic and cyclonic eddies have distinct water properties and spatial structures. The anticyclonic eddy had a diffusive-convection favorable vertical structure near the surface layer (< 50 m depth) characterized by water being colder and fresher than those at the underlying subsurface layer. The counterpart of the cyclonic eddy was salt-fingering favorable which is warmer and more saline at the surface layer. In the cyclonic eddy, horizontal interleaving structures were also observed. With the horizontally high-resolution data obtained by the glider observations we will investigate the mixing processes and their spatial/temporal variability within the vortex pair system from statistical and quantitative approaches.

Keywords: underwater glider, vortex pairs, spatiotemporal change, subpolar front

