Development and future of global ocean observing systems

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In this talk, I like to talk about the development and future of global ocean observing systems in relation to observational studies of surface water masses. During the late 1990s when I was a graduate student, data in the interior ocean were obtained mainly by research vessels, and research on water masses were conducted by using climatological data for seasonal variations and limited repeat sections and points for year-to-year variations. Argo initiated in 2000, becoming a mature global observing system after 6-7 years, and more than 10 years have passed since then. Along with satellite-altimeter sea surface height observation that has lasted since 1992 for more than 25 years, large-scale temperature and salinity variations shallower than 2000 m depth now can be studied using internet, wherever you are. In my research, for example, decadal variability of formation and subduction of Subtropical Mode Water (STMW; Oka et al., 2015, 2019) in relation to that of the Kuroshio Extension system (Qiu and Chen, 2005) was revealed. 10-year time series of STMW using Argo data greatly impressed me 5 years ago when I first draw it, but it might not be surprising at all for younger generations.

Now that we obtained physical ocean observing systems, it is a matter of course that we develop chemical and biological observing systems. In association with the decadal variability of STMW subduction, that in dissolved oxygen, nutrients, and carbonate system parameters was observed at the 137E repeat hydrographic section of the Japan Meteorological Agency. This finding relied greatly on the existence of 137E that has lasted for more than 50 years (Oka et al., 2018). If we are to examine similar biogeochemical variability in other regions, we are overwhelmed by the paucity of historical data (Stramma et al., 2020). Since Argo decided to extend its coverage to layers deeper than 2000 m and biogeochemical parameters (Roemmich et al., 2019), we shall be able to examine biogeochemical as well as physical variability in 10 years. Argo floats with biogeochemical sensors have been intensively deployed in the Southern Ocean under the US’ s SOCCOM project. In the STMW region, 13 floats equipped with oxygen and pH sensors are going to be deployed at the beginning of JFY2020 as a part of the “Mid-latitude ocean-atmosphere interaction hotspots under the changing climate” project started in 2019.

Needless to say, global observing systems like Argo are not only for large-scale studies but also for meso to micro-scale ones. To examine the relation between the formation of Central Mode Water (CMW) and fronts/eddies in the Kuroshio-Oyashio Extension region, we occupied two zonal high-resolution hydrographic sections using R/V Hakuho-maru in 2013 and 2016. These sections revealed that two or three CMWs with slightly different densities vertically overlapped each other commonly in three neighboring anticyclonic eddies. Although it is not easy to infer the formation mechanism of this structure from the shipboard observations only, fortunately an Argo float equipped with an oxygen sensor had been trapped in one of these eddies. Its time series indicated that in association with merging and splitting of eddies, low-potential vorticity water seemed to be exchanged between eddies or between an eddy and the ambient region, suggesting a new subduction mechanism in relation to the eddy-to-eddy interaction. Thus the development of multidisciplinary global observing systems will also contribute to understanding of smaller-scale phenomena.

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