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Shipboard physical oceanographic observation in the Argo era

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Physical oceanography has almost changed its morphology from a pure science to a practical one that aims more quantitative assessment of the ocean circulation's role in climate and fishery resources variations. The modern physical oceanography is supported by high-resolution numerical models and global observation systems. As for observations, satellite altimeter enabled us to monitor vertically-integrated current structures since early 1990s, which has grew understanding of large-scale ocean circulation variability as well as the influence of mesoscale variability of ˜100 km scale to large-scale one. Furthermore, a global observation network by autonomous Argo profiling floats has been built since 2000, which made it possible to monitor three dimensional structures of temperature and salinity down to 2000-m depth with a horizontal resolution of ˜300 km. Further accumulation of data in the future will lead to clarifying long-term variability of ocean interior and its effect on climate and fishery resources.

On the other hand, the current Argo network cannot monitor phenomena of mesoscale and smaller scales (including sub-mesoscale, turbulence) nor deep layers below 2000-m depth. Also, the float sensors other than temperature and salinity ones are still in the test phase, and the Argo network has not yet exercise its power in investigating the relation of physical oceanography to biogeochemistry or meteorology. In these research fields, shipboard observation still has a crucial role. As an example, I would like to introduce our ongoing research. In recent years, analyses of satellite altimeter data have demonstrated that the Kuroshio Extension current flowing east of Japan has two states alternately on decadal timescales: an unstable state accompanied by high mesoscale eddy activity and a stable state with low eddy activity. This eddy activity variability is expected to influence structures of temperature, nutrients, etc. in broad areas through the formation of winter oceanic mixed layer in the Kuroshio Extension region, but specific influences and the associated processes have not been clarified yet. To clarify eddies' role in the water mass and nutrient distributions in areas north of the Kuroshio Extension, we plan to conduct two high-resolution physical and biogeochemical observations using *R/V Hakuho-maru* in FY2013 and FY2015.

Further development of physical oceanography requires both monitoring type observations represented by ones performed by the Japan Meteorological Agency and bottom-up type observations for process studies such as ones planned by us. As for bottom-up type observations, two research vessels *Hakuho-maru* and *Tansei-maru*, which are currently handled by the Japan Agency for Marine-Earth Science and Technology for operations and the Atmosphere and Ocean Research Institute, the University of Tokyo for cooperative research, have played an important role in conducting observations proposed by scientists across the country for nearly 50 years. The current two vessels are both old. The currnet *Tansei-maru*, which has performed coastal observations for 30 years, stops its operation in FY2012, and turns over its role to the incoming vessel from FY2013. The currnet *Hakuho-maru* is also close to the end of its durable period. For further clarification of ocean's role in global environment, another incoming vessel for *Hakuho-maru* and the adherence of cooperative research system are strongly desired.

Keywords: physical oceanography, research vessel, Argo