

# Upper Ocean Hydrography and Currents in the Japan Sea

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## LONG-TERM GOAL

The long-term goal of this project is to better understand the properties of the upper portion of the water column in the Japan Sea. It is important to understand the seasonal cycle in the upper 800-1000 m of the Japan Sea: how the Sea stratifies in spring and summer and how it forms a mixed layer in fall and winter, sometimes with deep convection occurring, and the location and strength of the major features of the mid-depth circulation.

## OBJECTIVES

I want to be able to study the circulation and hydrography of the upper 800-1000 m of the Japan Sea over at least a few complete seasonal cycles in order to understand the process of mixed-layer formation and destruction there. In some ways the Japan Sea behaves as a subtropical ocean, and in other ways it is more like a subarctic one; as a result, it is a useful laboratory for studying many oceanographic processes that occur throughout the world ocean. I have deployed 36 PALACE floats in the Japan Sea in this study, and the work discussed here fits into a larger program in the Japan Sea with about 20 PIs.

## APPROACH

I deployed 36 PALACE floats in the western Japan Sea during the summer of 1999. These floats were deployed from the Russian research vessel *Professor Khromov*, from the FERHRI laboratory in Vladivostok. These floats are cycling between the sea surface and 800 m depth at approximately 7 day intervals and collecting profiles of temperature and salinity during their ascent phase on each cycle. So far, nearly 3000 profiles have been collected in this way in the Japan Sea, including data from all seasons of the year. All of the results are being made available in real-time via the ARGOS system and a web page. I am presently doing similar work in several other experiments, and the all results can be viewed on the web at <http://flux.ocean.washington.edu>. Locations of the floats at the end of September 2001 are included in Figure 1 at the end of this document.

## WORK COMPLETED

The floats have now been in the water for over two years. Most are still operational and returning good data. Two floats were inadvertently picked up by Japanese fishermen and, eventually returned to UW. The sensors on these floats were recalibrated by SeaBird Electronics, Inc., and found to be

operating well within the stated specifications for the instrument, even well after deployment. At this time most of my effort is centered on data analysis, specifically the estimation of the absolute velocity field at all depths above 800 m from the data. This is being done by producing objectively-analyzed maps of relative geostrophic velocity at depths above 800 m, from a knowledge of the dynamic height field inferred from the temperature and salinity measurements on the floats, in conjunction with maps of the 800 m velocity field inferred from the float drifts. This has worked quite well and has allowed for estimation of the absolute geostrophic velocity field in the Japan Sea as a function of time since the summer of 1999.

## **RESULTS**

The absolute geostrophic flow maps can be used in a variety of studies of the Japan Sea circulation. The coverage of the data is best in the western Japan Sea, north of about 30 °N, and the seasonal structure of the western boundary currents in this region has been well-elucidated by this method. The data show that the circulation is strongest in winter, with 2 clearly formed gyres (an anticyclonic subtropical gyre and a cyclonic, subpolar gyre), separated at about 39 °N, at all levels of the water column above 800 m. In the summer, the circulation is much weaker, and the southern gyre is nearly non-existent in this region. The flow is strongly surface intensified. At deeper levels, there is a single deep boundary current extending from the coast of Russia south along the N. Korean coast. In the eastern Japan Sea, the eastern branch of the Tsushima Current is strongest at the surface, especially in winter. A plot of the wintertime geostrophic circulation in the western Japan Sea, with sites where deep convection has been observed by the floats in the winters of 2000 and 2001, is shown in Figure 2 at the end of this document.

## **IMPACT/APPLICATION**

This work will provide the best depth-dependent estimate of the large-scale circulation of the Japan Sea that is presently in existence. The results provide a useful comparison for numerical models of the region, and the data are being used in data assimilation studies of the Japan Sea circulation in both the US and Japan. In addition, a number of PIs on other projects in the US ONR Japan Sea Initiative are using these observations in conjunction with their own data analyses.

## **TRANSITIONS**

All of the data collected by this project are put immediately on the GTS for use by other interested parties. The data have been used in modeling and assimilation studies by investigators at the NRL in the US and at several institutions in Japan. Additionally, we have continued to help investigators at the Naval Oceanographic Office to begin the Navy's own float program. The UW float group was the first to carry out air-deployments of profiling floats (a technique now routinely used by NAVO scientists), and we have helped the NAVO investigators to set up a data acquisition system for their floats using the ARGOS system. In addition, we have provided web-hosting for the NAVO float program. Their float data can be viewed on the site <http://flux.ocean.washington.edu/navo>, which is maintained on a server at UW.

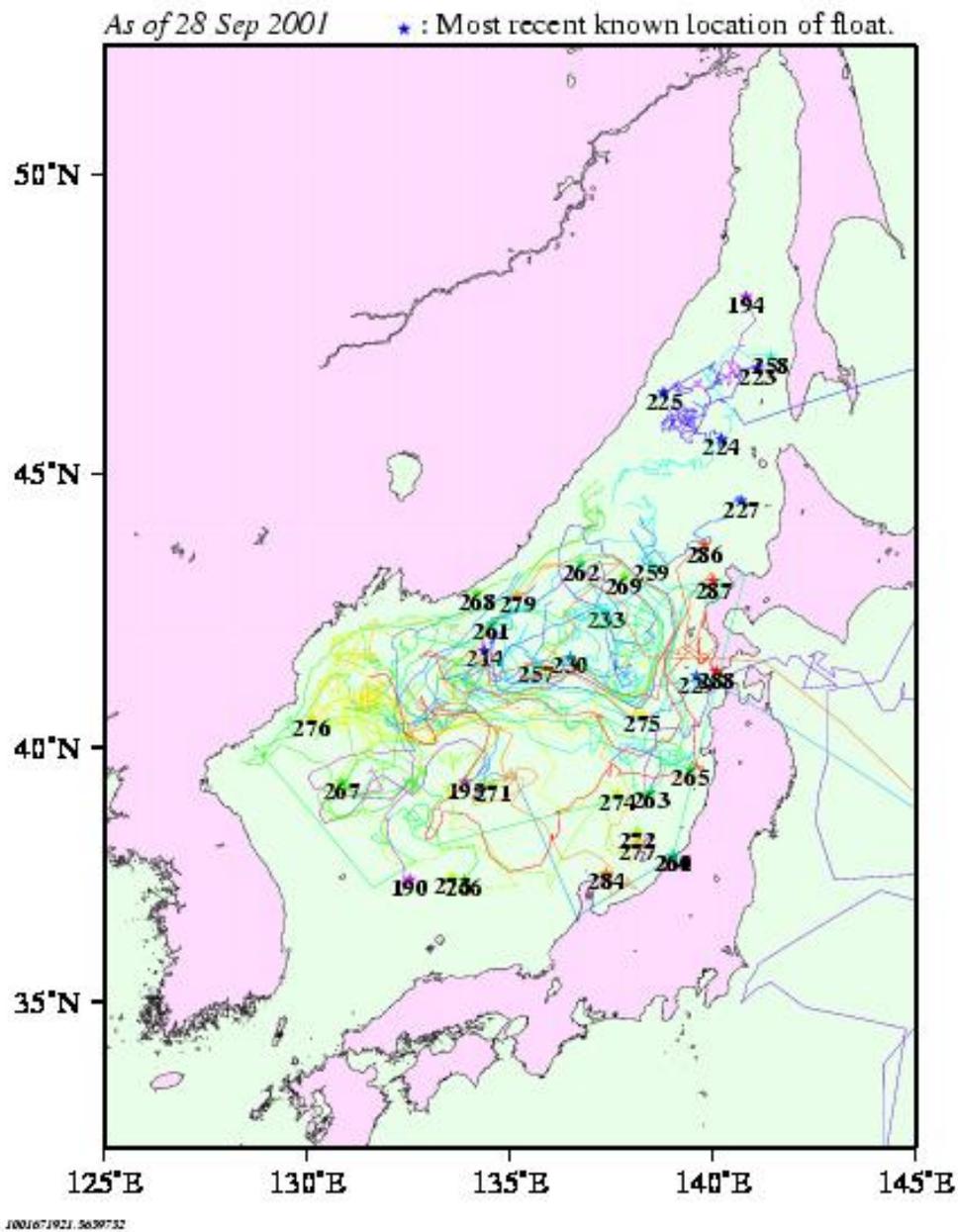
## **RELATED PROJECTS**

For the past 2 years I have been one of 3 float providers for the ARGO program. Beginning ARGO has required the procurement, construction, and deployment of a relatively large number of profiling floats over a fairly short time. The ARGO data are being treated in a fashion similar to the Japan Sea data, and there is a great deal of information and expertise sharing between the two projects.

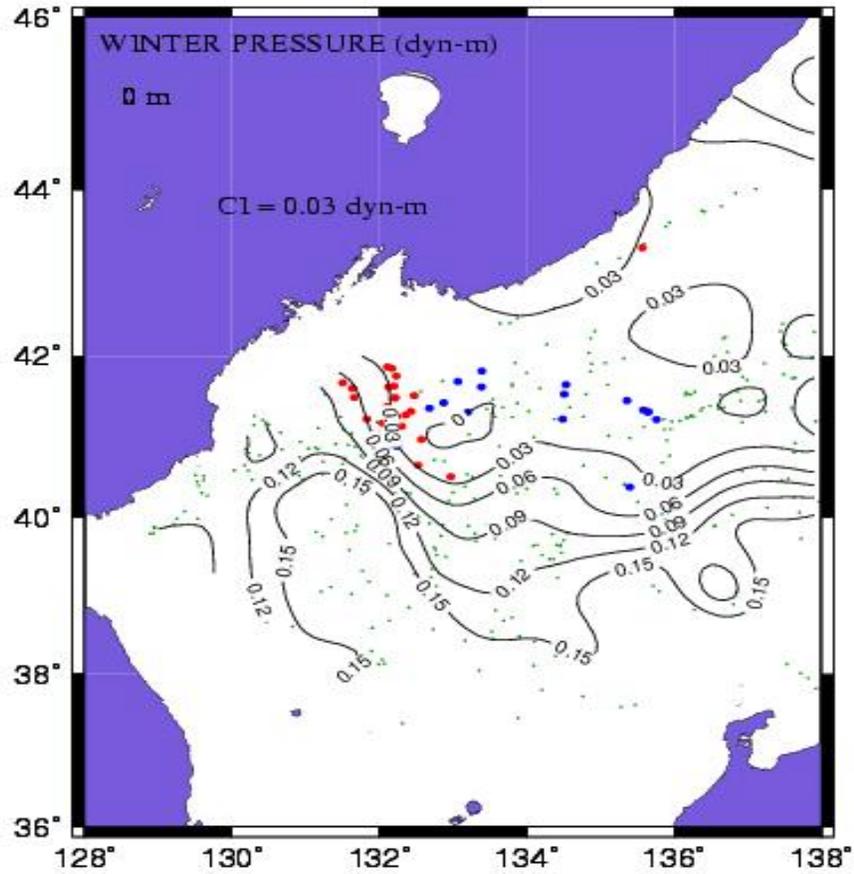
## **PUBLICATIONS**

Riser, S.C. (2001) Long-term measurements of salinity from profiling floats. Submitted to *Journal of Atmospheric and Oceanic Technology*.

Riser, S.C. (2001) The geostrophic circulation of the Japan/East Sea. Proceedings of the 3rd Research Institute of Oceanography (Seoul National University)/Research Institute of Applied Mechanics (Kyushu University) Joint Symposium on Circulation of the Adajacent Seas of Korea.



*Figure 1. The locations of all 800 m profiling floats in the Japan Sea as of 28 September, 2001.*



*Figure 2. A map of the wintertime geostrophic flow at the surface of the Japan Sea inferred from profiling float data, with locations of observed deep convection shown in red (winter of 2000) and blue (winter of 2001).*