Improving the Quality and Accessibility of Current Profile Measurements in the Southern Ocean

BY ERIC FIRING, JULIA M. HUMMON, AND TERESA K. CHERESKIN

Like most modern oceanographic research vessels, RVIB *Nathaniel B. Palmer* and ARSV *Laurence M. Gould* are equipped with acoustic Doppler current profilers (ADCPs) for measuring the structure of ocean currents over a range of several hundred meters below the hull, both on station and while underway. It takes more than the ADCP itself, however, to yield good current measurements. The end result depends on how and where the sonar is installed; on the quality of ancillary information including position, heading, and, for some sonars, speed of sound at the transducer; on the data acquisition and processing techniques; and on ambient conditions of weather, ice, noise, and the availability of acoustic scatterers in the water (Firing and Hummon, 2010). In addition, the value of the measurements depends not only on their accuracy but also on their accessibility to scientific users both in near real time at sea and as a final product ashore.

The starting point is the instrumentation and its installation. Both the *Palmer* and the *Gould* continue to operate their original 150 kHz RD Instruments "narrowband" sonars (NB150), which provide nominal 8 m depth cells covering roughly the upper 300 m of the water column. Although the design dates back to 1984 and the manufacturer no longer supports it, these instruments still work remarkably well. For profiling the upper 1,000 m of the water column with nominal 12 m or 24 m depth cells, modern Teledyne-RDI Ocean Surveyor sonars operating at 38 kHz (OS38; Figure 1) were installed on the two ships at the end of 2004. All four sonars are mounted in wells filled with a glycol antifreeze solution, and they are protected from the ice by thick polycarbonate acoustic windows. The windows reduce the profiling range by perhaps 30%.

The biggest factor limiting the profiling range, however, is the ice or bubble-laden water that may be passing under the window. The *Palmer* acoustic windows are flush with the rounded hull, so when working in ice, or when steaming into heavy seas typical of the Southern Ocean, the combination of noise and sound absorption by bubbles or ice can completely block the sonar's function. On the *Gould*, in contrast, the sonars are mounted in a large, faired pod (Figure 2). This arrangement is highly effective in deflecting bubbles and ice, so the *Gould* sonars provide consistently

Figure 1. OS38 transducer, freshly installed on RVIB *Nathaniel B. Palmer*. A single panel of phased array elements generates four separate acoustic beams. The 1 m diameter transducer face is protected by a 5.1 cm thick polycarbonate (Zelux-W) acoustic window. *Courtesy of Teresa Chereskin*

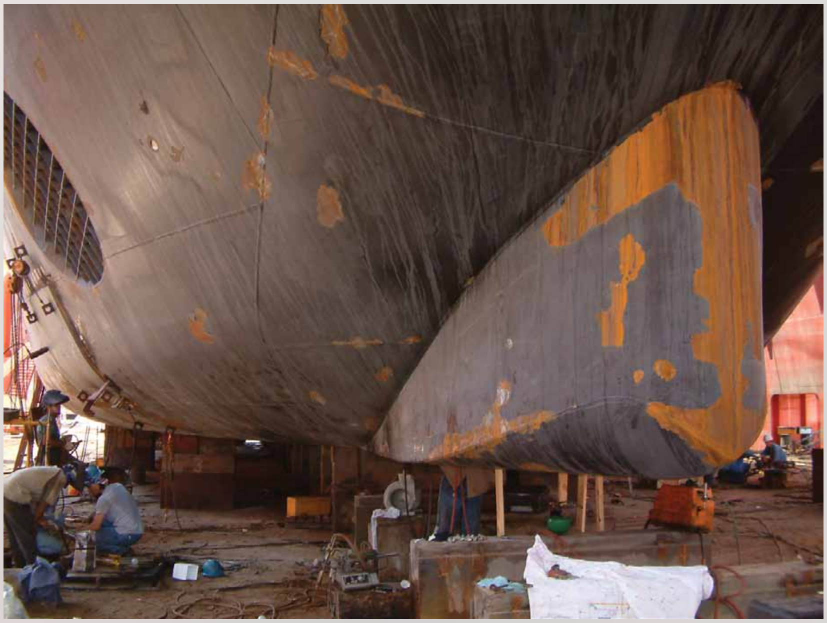

Figure 2. Sonar pod near the bow of ARSV *Laurence M. Gould*. It deflects ice and bubble-laden water away from the sonar transducers mounted on its underside, so the acoustic Doppler current profilers on the ship perform well even in the heavy seas of Drake Passage. *Courtesy of US Antarctic Program Marine Electronics Group*

good data while shuttling back and forth across Drake Passage (Sprintall et al., 2012, in this issue).

To maximize the value of the ADCPs we have developed a data acquisition, processing, distribution, and monitoring system called UHDAS (http://currents.soest.hawaii.edu/docs/adcp_doc/index.html). It provides a simple graphical user interface for starting and stopping data acquisition and for configuring the sonar data collection parameters—although we emphasize the benefits of picking a good default configuration and sticking with it. A single UHDAS instance logs the data from any number of ADCPs (two each on the *Gould* and the *Palmer*) and ancillary sensors (GPS position, gyro compass, high-accuracy GPS-based heading sensor, soundspeed sensor). Data processing is updated at 15-minute intervals: single-ping editing, vector averaging, compass error estimation and correction, and addition of the ship's velocity to yield five-minute averaged profiles of ocean velocity. The processed data are plotted, and both the plots and the data are served via a Web interface and file sharing over the ship's network. A daily email with extensive diagnostic information and a data sample is automatically parsed, plotted, and displayed on the Web ashore (http://currents.soest.hawaii.edu/uhdas_fromships.html). With this remote monitoring capability, we can detect problems promptly and work with the technicians on the ships to solve them.

Although the automated shipboard processing handles clean data sets well, finalization of the ocean current profile product requires the attention of a skilled analyst, particularly when the original measurements are less than ideal. For example, there may be glitches or gaps in the heading data, or subtle bias in the shallow velocity estimates. By routinely processing the data ashore, we can provide final shipboard ADCP data sets for use by the scientific community, and also continue to improve our data processing algorithms, including those used in the automated shipboard processing. The end results are the software we develop (http://currents.soest.hawaii.edu/hg) and the processed data. The latter are available from the National Oceanographic Data Center (http://ilikai.soest.hawaii.edu/sadcp), and are also presented as plots and in NetCDF format with corresponding predicted barotropic tides (e.g., http://currents.soest.hawaii.edu/nbpalmer).

UHDAS has proven useful beyond the *Gould* and the *Palmer*; to date it has been adopted by 13 UNOLS ships, three NOAA ships, and USCGC *Healy*.

ACKNOWLEDGEMENTS

This work has been supported by the National Science Foundation's Office of Polar Programs grants ANT-9816226/0338103/0838750 (Chereskin) and 9815156 /0337375/0838714 (Firing). Additional UHDAS development has been funded via annual NSF Technical Services grants to the University of Hawaii.

AUTHORS

Eric Firing (*efiring@hawaii.edu*) *is Professor of Oceanography, School of Ocean and Earth Science and Technology, University of Hawaii at Manoa, Honolulu, HI, USA.* **Julia M. Hummon** *is Research Associate, School of Ocean and Earth Science and Technology, University of Hawaii at Manoa, Honolulu, HI, USA.* **Teresa K. Chereskin** *is Research Oceanographer, Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, USA.*

REFERENCES

Firing, E., and J.M. Hummon, 2010. Ship-mounted acoustic Doppler current profilers. In *The GO-SHIP Repeat Hydrography Manual: A Collection of Expert Reports and Guidelines*. E.M. Hood, C.L. Sabine, and B.M. Sloyan, eds, IOCCP Report Number 14, ICPO Publication Series Number 134. Available online at: http://www.go-ship.org/HydroMan.html (accessed March 19, 2012).

Sprintall, J., T.K. Chereskin, and C. Sweeney. 2012. High-resolution underway upper ocean and surface atmospheric observations in Drake Passage: Synergistic measurements for climate science. *Oceanography* 25(3):70–81, http://dx.doi.org/10.5670/oceanog.2012.77.