ICES CM 2013/L:14

OceanScope – Partnering with industry for the sustained and systematic observation of the oceans.

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Summary
A recent report 'OceanScope' (see link to report below) outlines in detail a proposed partnership with the global shipping industry to create a framework for expanded observation of the global water column. The partnership would also establish a framework to stimulate the development of novel sensors and instruments optimized for use on merchant marine vessels. To motivate and achieve the above requires scalability of operations that leads to improved coverage of the ocean on the one hand, and economic incentives on the other for investing in such initiatives. The initial phase of OceanScope would focus on the North Atlantic. Recent findings from vessels operating acoustic Doppler current profilers (ADCP) will serve to illustrate the power of repeat sampling.

Results and Discussion
The first example is that of the *Norröna*, a high-seas ferry that operates on a weekly schedule out of the Faroes to Hirtshals, Denmark and to Seydisfjördur, Iceland. Her route cuts across all water entering the Norwegian and Barents Seas enabling us to determine the rate of transformation of North Atlantic water into dense water, and thus the strength of the meridional overturning circulation (MOC). The detided average transports (to the north) between March 2008 and March 2011 across the two sections are 4.1±0.1 Sv (10^6 m^2s^{-1}) through the FSC and 4.4±0.25 Sv across the IFR (this excludes ~1.6 Sv circulating around the Faroes). These fluxes are consistent with albeit somewhat larger than previously published numbers, but it is too early to tell whether the differences reflect methods of measurement or temporal variations (Rossby and Flagg, 2012). The *Norröna* is now equipped with an automated XBT launcher (AXIS) so that we can determine the temperature field along both sections on a monthly basis. This will allow us to accurately determine heat flux and thereby lead to significantly improved integral estimates of heat loss in the Nordic Seas. The *Norröna* program is funded by the U.S. National Science Foundation and is ongoing.

The *Nuka Arctica* operation (1999-2002 and restarted in 2012 with a 75 kHz ADCP that reaches to >700 m) along 60°N reveals a striking pattern of poleward flow between Scotland and Greenland, with the topography of the Reykjanes Ridge and the Banks west of Scotland playing a defining role. A recently completed reanalysis of nearly 20 sections reveals a near-equal partition of poleward flow west (8.5 Sv) and east (8 Sv) of the Ridge, with the former principally feeding the Labrador Sea, and the latter the Nordic Seas. While flow towards the Labrador Sea is largely constrained to two parallel

flows north along the western slope of the Ridge, the Nordic Seas flow is concentrated to three paths: the Maury Channel, east of Hatton Bank and along the Scotland slope. The 8 Sv transport between the surface and 400 m between the ridge and Scotland accords quite well with the 8.5 Sv *Norröna* transport across the Iceland–Faroe–Scotland ridge. The repeat sampling also reveals a strikingly localized eddy kinetic energy maximum corresponding to the site of the PRIME eddy in the Maury Channel of the Iceland Basin (Chafik et al., 2013). The ADCP also records the strength of the backscattered acoustic signal. This gives us valuable insight into spatial and temporal variability of biomass in the water column. We illustrate this with two examples, first showing the difference in diurnal migration patterns between summer and winter, and the second showing average biomass content as a function of location across the ocean, time of year, and depth. One sees a striking maximum near-surface (30-90 m) maximum in backscatter in May-June in the Iceland Basin, but not in the Irminger Sea. The *Nuka Arctica* program is funded by the Institute of Marine Research in Bergen, and is ongoing.

The third example is that of the *Explorer of the Seas*, a Royal Caribbean Cruise Lines (RCCL) vessel. She transited an anticyclonic lens twice two weeks apart on her transit from the Caribbean to New Jersey. Equipped with a 38 kHz ADCP that reaches to 1100+ m depth we could analyze in considerable detail both the dynamical structure of the eddy and the embedded biomass distribution. The lens acts like a vorticity bottle meaning that there is very little exchange of material between its interior and the surrounding waters. A consequence of this that remains to be understood is a conspicuous lack of biomass at all depths (Rossby et al., 2011). The *Explorer of the Seas* program is ongoing and funded in part by the RCCL.

The above examples illustrate the power of repeat and sustained sampling. Repeat sampling means that the ensemble of sections creates its own framework or context for charting the mean state and variability of velocity, biomass or whatever variable is being monitored; sustained opens up the window for understanding how these fields vary over long time, including the possibility of underlying trends that would be difficult to tease out from only a few sections. It also allows for the capture and description of discrete features. The OceanScope report also discuss how partnering with the merchant marine can stimulate the development of sensors and technologies truly optimized for these vessels.

References

Chafik, L., T. Rossby and C. Schrum, 2013. On the spatial structure and temporal variability of poleward transport between Scotland and Greenland. Submitted to *Journal of Geophysical Research*

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OceanScope link: http://www.scor-int.org/Publications/OceanScope_Final_report.pdf