- **PL52A:** From WOCE Through CLIVAR to GO-SHIP: Results from Global Repeat Hydrographic Surveys II

As part of the global repeat hydrography effort, researchers from around the world have worked to measure vertical profiles of seawater properties with high spatial resolution, precision, and accuracy approximately once per decade. These measurements are made along pre-defined sections that cross the major ocean basins. The first detailed surveys were conducted by the 1990s World Ocean Circulation Experiment (WOCE). Major sections were repeated in the 2000s as part of the Climate Variability and predictability program (CLIVAR). Now, the Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP) is carrying this observation strategy into a third decade. Repeat hydrographic measurements have proven critical for revealing variability and long term trends in ocean heat content, freshwater cycling, anthropogenic and natural carbon storage, circulation patterns, acidification, nutrient distributions, and other natural and anthropogenic tracers.These cruises have also provided support for ancillary measurements and other observation programs (e.g. Argo and remote sensing).

In this session, we invite contributions from those who are interpreting these physical, chemical, and biological observations, or using them to construct or validate ocean circulation models or property estimation algorithms. Submissions from researchers who rely on repeat hydrography cruises for in situ sensor deployments or remote sensor calibration/validation are also invited.

**Friday, February 16, 2018**

**10:30 AM - 12:30 PM**

- *Oregon Convention Center*

- *- A107-A109*

### Primary Chair

- Richard A Feely
  - *NOAA Pacific Marine Environmental Laboratory*

### Co-Chairs

- Alison M Macdonald
  - *Woods Hole Oceanographic Institution*

- Leticia Barbero
  - *University of Miami*
- Toste S Tanhua
  - *GEOMAR Helmholtz Centre for Ocean Research Kiel*

## Moderators

- Leticia Barbero
  - *Cooperative Institute for Marine and Atmospheric Studies Miami*
- Alison M Macdonald
  - *Woods Hole Oceanographic Institution*

## Index Terms

- 1616 Climate variability
- 4215 Climate and interannual variability
- 4262 Ocean observing systems
- 4513 Decadal ocean variability

## Papers

- 10:30 AM**PL52A-01** Continued Warming Throughout the Abyssal South Pacific Ocean***Sarah G Purkey***, *Scripps Institution of Oceanography UCSD, La Jolla, CA, United States, Gregory C Johnson, NOAA Pacific Marine Environmental Laboratory, Seattle, WA, United States, Lynne D Talley, Scripps Institution of Oceanography, La Jolla, CA, United States, Bernadette Sloyan, CSIRO, Oceans and Atmosphere, Hobart, Australia and Susan Wijffels, Woods Hole Oceanographic Institution, Woods Hole, MA, United States*


  - Previous comparisons of repeated hydrographic sections between the 1990s and 2000s revealed a global pattern of deep and abyssal ocean warming in regions of the ocean fed by dense waters of southern origin. Here, we examine the next decade of repeat hydrography data collected through GO-SHIP in the South Pacific Ocean to evaluate regional deep ocean temperature and salinity trends over the whole time period. The deep South Pacific Ocean has continued to warm at a remarkably stable rate over the three decades. The strongest warming of 0.05 °C per decade is observed in the Ross Sea, directly downstream from bottom water formation sites, with smaller warming rates of 0.024 °C per decade to the east in

the Bellingshausen Basin and 0.011 °C per decade to the north in the Southwest Pacific Basin. These basin-average warming rates are consistent across all sections and occupations within each basin, demonstrating the deep warming is steady, basin-wide, and multi-decadal. In contrast, an abyssal water-mass freshening was observed only in the Ross Sea in the 2000s, but has expanded into parts of the Southwest Pacific Basin and the Bellingshausen Basin since then. This result indicates the freshening anomaly, stemming from strong shelf water freshening on the Ross Shelf, is being advected and mixed into deep basins on much slower timescales then the dynamically driven, wave-propagated warming signal. We quantify the relative contribution of the warming and freshening to local sea level, heat, and salt budgets.

- 10:45 AM**PL52A-02** Decadal variability in oxygen parameters in the subtropical South Pacific***Molly Martin*** *and Rana A Fine, University of Miami, Miami, FL, United States*

    - Climate models suggest that warming associated with greenhouse gases will lead to increased stratification and decreased solubility of gases in the ocean. Both increased stratification and decreased solubility will negatively impact the global ocean oxygen reservoir. To evaluate effects of variability on physical and biological processes for oxygen parameters, we use data from the South Pacific Ocean central subtropical gyre to the eastern Oxygen Minimum Zone (OMZ). The data span three decades: GEOTRACES (2013) along ~$12^0$ S ± $3^0$ as compared to WOCE (1990s), CLIVAR (2000s), and GO-SHIP (2010s) repeat hydrography programs. To compare data from different years at similar locations, practically at least 3 stations of data were averaged together to diminish the effects of bias from eddies and movement of fronts. Also, we concentrate on the lower thermocline, 26.5-27 sigma-theta, the range is within the OMZ. A new tracer $O_2^{*b}$, which is based on the Redfield $O_2^*$ semi-conservative tracer, is used to identify changes in biological activity. In the OMZ between 1993 and 2013, there is a decrease in oxygen concentration of ~5 µmol/kg or 0.25 µmol/kg/year. Of this decrease, most of it appears to be due to physical processes and not biological. The decrease is about two times greater than earlier work found looking over 50 years for $5^0$ S-$5^0$ N

in the eastern Pacific. It is not surprising that our calculated rate of oxygen decrease is larger, as we expect the effect of climate change to greater for recent years. From the 1990s to 2010s, there are no discernable changes in oxygen parameters in the central gyre region. Also, stratification data will be compared in both regions. Oxygen minimum zones located adjacent to subtropical gyres have been shown to be effected by climate change; however, here we present work that adds to understanding and quantification of processes affecting these changes.

- 11:00 AM **PL52A-03** Two decades of Pacific anthropogenic carbon storage changes assessed along 10+ repeat hydrography sections ***Brendan Carter***, *NOAA Pacific Marine Environmental Laboratory, Seattle, WA, United States and Richard A Feely, NOAA PMEL, Seattle, WA, United States*
- **PL52A-04** Trends in Antarctic Circumpolar Current Transport of Volume and Properties from 25 Years of Annual Repeat Hydrography on SR1b

*ABSTRACT WITHDRAWN*

- 11:30 AM **PL52A-05** Decadal Changes of Anthropogenic, Biogenic and Total Carbon in the Atlantic ***Reiner Steinfeldt***[1], *Dagmar Kieke*[2] *and Monika Rhein*[2], *(1)University of Bremen, Institute of Environmental Physics, Bremen, Germany, (2)MARUM, University of Bremen, Bremen, Germany*
- 11:45 AM **PL52A-06** Initial results from the A02 GO-SHIP repeat hydrography expedition CE17007 in the North Atlantic: International collaboration supports Ireland's entry into GO-SHIP and basin scale ocean observing ***Peter L Croot***[1], *Margot Cronin*[2], *Caroline Cusack*[2], *Evin McGovern*[3], *Triona McGrath*[4], *Christian Mohn*[5], *Ute Schuster*[6], *Andreas M Thurnherr*[7], *Daniel J Torres*[8] *and Douglas Wallace*[9], *(1)iCRAG (Irish Centre for Research in Applied Geosciences), National University of Ireland Galway, Galway, Ireland, (2)Marine Institute Ireland, Oranmore, Ireland, (3)Marine Institute, Ireland, Marine Environment and Food Safety Section, Galway, Ireland, (4)National University of Ireland Galway, Galway, Ireland, (5)Aarhus University, Department of Bioscience, Aarhus C, Denmark, (6)University of Exeter, Exeter, United Kingdom, (7)Lamont-Doherty Earth Observatory of Columbia University, New York, NY, United States, (8)WHOI, Woods Hole, MA, United States, (9)Dalhousie University, Halifax, NS, Canada*
- 12:00 PM **PL52A-07** On the variability of the basin-scale inorganic nutrient transports and budgets in the North Atlantic ***Lidia I. Carracedo***[1], *Elaine McDonagh*[2], *Herle Mercier*[3], *Peter Brown*[2], *Gabriel Roson*[4], *Richard Sanders*[2], *C Mark Moore*[2], *Sinhue Torres-Valdes*[2,5], *Fiz F Pérez*[6] *and Molly O'Neil*

*Baringer[7], (1)University of Vigo, Ourense, Spain, (2)National Oceanography Centre, Southampton, United Kingdom, (3)CNRS, LOPS, Ifremer, Plouzané, France, (4)University of Vigo, Vigo, Spain, (5)Alfred Wegener Institute Helmholtz-Center for Polar and Marine Research Bremerhaven, Bremerhaven, Germany, (6)CSIC, IIM, Vigo, Spain, (7)NOAA/AOML/PHOD, Miami, FL, United States*

- 12:15 PM**PL52A-08** On the Spatial Variability of Ocean pH and its Primary Drivers***Siv Lauvset**, Uni Research, Uni Climate, Bergen, Norway, Liqing Jiang, National Centers for Environmental Information, Silver Spring, MD, United States, Richard A Feely, NOAA PMEL, Seattle, WA, United States, Brendan Carter, NOAA Pacific Marine Environmental Laboratory, Seattle, WA, United States, Are Olsen, University of Bergen, Geophysical Institute, Bergen, Norway, Steven van Heuven, University of Groningen, Centre for Isotope Research, Groningen, Netherlands, Anton Velo, Instituto de Investigaciones Marinas de Vigo, CSIC, Vigi, Spain, Robert M Key, Princeton Univ, Princeton, NJ, United States and Geoffrey Gebbie, Woods Hole Oceanographic Inst., Woods Hole, MA, United States*