Sustained Measurements of Crucial Ocean Currents

Teledyne RDI ADCPs Deliver Invaluable Time Series for Ocean Studies

Teledyne RD Instruments

Overview

Sustained, high-resolution measurements supply crucial information about the ocean and its processes. These long time series permit a unique view for clarifying the state of the ocean and how the marine system works.

Sustained observations can provide singular value for improving computer models, for quantifying trends in climate change, and for sorting out principal influences in ocean biogeochemistry. Furthermore, progress in new areas of research, such as physical-biological interactions and Arctic studies, will stem from high-resolution, long-duration measurements.

Strong currents move large volumes of warm water poleward from low latitudes, redistributing heat for the earth's climate system. On shorter time scales, they affect regional and local weather. These flows transfer organisms, nutrients, chemicals, debris, and pollutants that affect life in and out of the sea and along coastlines. And strong currents also affect maritime commerce by influencing ships' transit times.

Crucial ocean currents have been studied to measure their structure, transport, fluxes, and more recently, their seasonal and long-term changes.

Instruments

Products:
Self-contained ADCPs

Application:
Sustained observing of ocean currents

Organizations:
Research groups
Government agencies
Service companies

Product Line:
Teledyne RDI Marine Measurements

Sales Team:
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Paul Devine
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Location:
San Diego, CA

Long Ranger ADCP atop mooring for Agulhas System Climate Array (ASCA).

Credit: Jarred Voorneveld (SAEON) in Morris et al. (2017, https://goo.gl/Koi9kX) for South African Environmental Observation Network.

Measuring these currents has been challenging. To capture their extent, measurements need to reach deep. To resolve changes over time, measurements need to be sustained. And to survive, persistent measurement methods need to withstand the energy of these powerful currents. For example, surface drifters, floats, and gliders are quickly swept away in strong upper-ocean currents.

Researchers taking long-term measurements of important currents rely on resilient moorings. And for measuring strong currents in the upper ocean, these moorings carry Teledyne RDI ADCPs.

William Richardson, pioneer of Buoy Group at WHOI.

Credit: Nova Southeastern University. https://tinyurl.com/yb53ymp8

Origins

Almost 60 years ago at Woods Hole Oceanographic Institute (WHOI)[1], William S. Richardson launched the modern era of ocean-current metering. For studying deep-sea currents—notably, the Gulf Stream—he identified and invented two essential tools: a recording current meter and an unattended mooring. Richardson's intent for the mooring was to suspend current meters at several depths. The meters would record long time series of currents simultaneously. For studying currents across large areas, Richardson deployed several moorings.

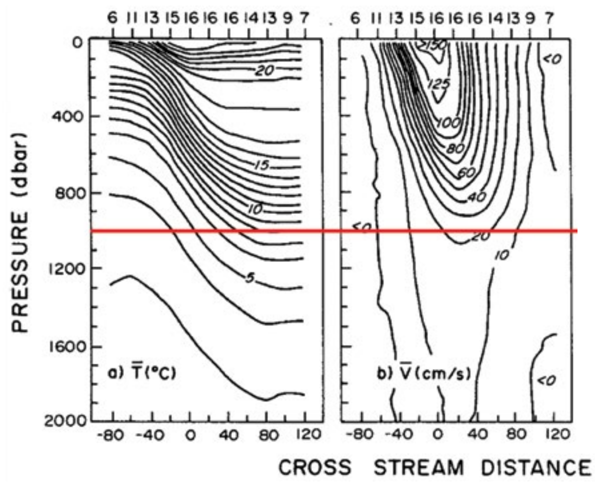
Over the next two decades, the WHOI Buoy Group at WHOI engineered this reality. Their impressive results were hard won in the harsh and unforgiving environment of the deep sea: https://www.whoi.edu/multimedia/i-50-years-of-the-whoi-buoy-group/.

Along the way, one key problem was mooring loss. A leading culprit was the large drag force caused by strong currents. The graph below shows a section of the Gulf Stream in the upper 2000 m. Speeds are directed along-stream. Notice the extreme current speeds in the upper ocean and the large spatial gradients.

For recording currents accurately, the meters need to hold position in three dimensions. The mooring must therefore be taut. To this end, substantial buoyancy is added to the mooring line. Yet, unavoidably, these buoyancy elements increase drag forces exerted by strong currents.

Gulf Stream currents and thermal structure. Distance: km, Current speeds: cm/s.

Credit: Halkin + Rossby, 1985. https://tinyurl.com/y9gw72fq



1. See Richardson et al. report (WHOI Ref: 63-1) http://bit.ly/2xPocwo

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Besides sweeping away moorings, strong drag forces caused mooring lines to separate or to blow over. The latter carried instruments and mooring elements in large vertical excursions: 300-500 m in a tall mooring.

These excursions made it hard to interpret the measurements. Worse, the mooring could sink when in-line buoyancy was crushed by high pressure at unplanned depths.

Moored ADCPs

By the mid-1980s, the designs of both moorings and current meters had evolved substantially. Decreasing drag on the mooring was a principal design goal to reduce losses. Major currents have strong near-surface speeds. Considering that drag increases with the square of speed, moorings that terminated subsurface were developed. Many were topped with large spherical buoys that provide the same buoyancy for less drag than smaller options.

ADCPs provided a new solution for measuring strong upper-ocean currents. Among other advantages, including on-board data processing, ADCPs could measure water currents remotely by sending out sound waves. Echoes generated successively along the path of the sound waves report water speeds at increasing distances from the ADCP.

Scientists realized that an ADCP looking upward could be used to measure strong surface currents while deployed in slower waters below. This placement helped reduce drag on the mooring yet still captured the vital upper-ocean measurements. To this end, ADCPs were installed inside large flotation buoys and mounted atop subsurface moorings. Pioneers of this approach were Friedrich Schott and William Johns (University of Miami) who applied it in the Gulf Stream and in the Somali Current (off East Africa).

A moored ADCP records time series of velocity profiles through the water column at one location. Likewise, an array of moored ADCPs can capture such information across the spatial extent of strong currents. In fact, ADCP arrays provide a unique solution for measuring narrow, deep, and energetic currents—such as those found off the eastern seaboards of continents.

Teledyne RDI ADCPs mounted in top buoys of an ASCA mooring array.

Credit: SAEON Egagasini Node. http://asca.dirisa.org/

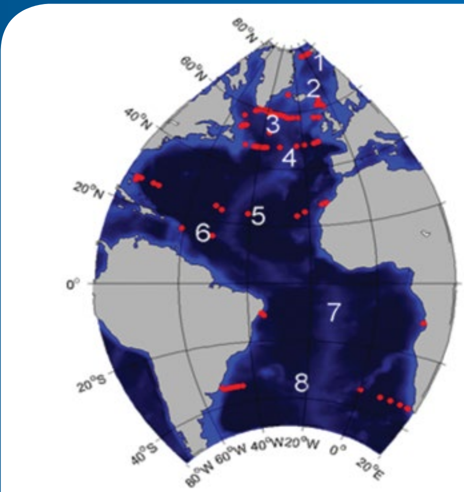
Teledyne RDI Long Ranger
75 kHz ADCP

Sustained Ocean Time Series

During the last two decades, several transoceanic observational sections have been installed in the Atlantic Ocean. (See graphic on the right.) These long-term sections support a push for better understanding of changes in the Atlantic Meridional Ocean Circulation (AMOC). Theoretical and computer models link AMOC variability to pronounced and widespread changes in environmental conditions: from changing temperatures and sea levels to altered intensity of storms, rainfall, and droughts.

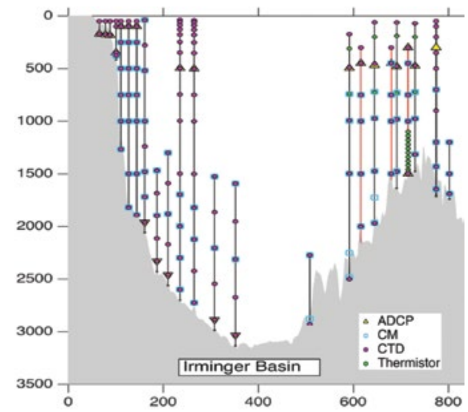
Indirect current measurements can be reliably calculated from hydrographic data in the ocean interior. At the western margin of these transoceanic sections, however, the dynamic balance of forces is more complex. Direct current measurements are needed.

These sections include moored ADCPs where strong, narrow currents can make key contributions to total transport. Some sections also add direct current measurements where steep seabed changes can steer currents, such as the Mid-Atlantic Ridge.



Transport mooring arrays in the Atlantic.

Credit: AtlantOS page on OceanSITES web site. http://bit.ly/2L4Yo8k



Current moorings along part of OSNAP section near 60N. Depth (m), Distance (km)

Credit: OSNAP web site. http://bit.ly/2L4aL4d

Some of these transoceanic sections (16 N, 26.5 N) have been in place for extended periods. Unexpected findings included large short-term changes in AMOC transport and a strong seasonal signal. These pointed to the need for continuous monitoring. Furthermore, low north/south coherence between AMOC transport fluctuations at these sections motivated other transoceanic lines.

An impressive recent addition is the *Overturning in The Subpolar North Atlantic Program* (OSNAP) near 60 N that includes myriad moorings, many carrying Teledyne RDI ADCPs. (See figure on this page.)

Measuring sustained ocean time series underpins efforts to clarify long-term changes of the global environment. Although a mix of methods is needed to capture large-scale connections, moored arrays of Teledyne RDI ADCPs deployed in crucial ocean currents provide an essential ingredient.

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