ADCPs See Action in OOI's Cabled Observatory

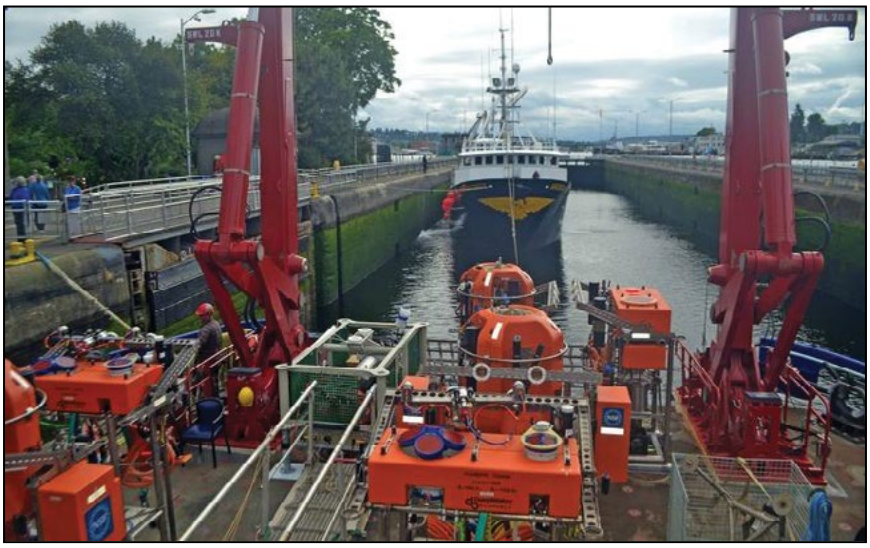
Sustained and Interactive Monitoring of NE Pacific Ocean

OVERVIEW

Thanks to a spirited cadre of marine scientists and engineers, high-tech ocean observatories are now operational. These sites provide a continuous presence in the ocean for sustained and interactive observing. Installed at various depths, these observatories exist worldwide in diverse marine environments. Some supply continuous real-time data via a cable connection to shore.

A prime example is the Cabled Array in the NE Pacific Ocean (https://goo.gl/EZJGTE). This observatory is part of the Ocean Observatories Initiative (OOI, https://goo.gl/rpVnLL), funded by the US National Science Foundation (NSF). Engineered by the Applied Physics Laboratory / University of Washington (APL / UW), the Cabled Array uses dedicated telecoms cables. They provide a high voltage supply and high-speed communication links to nodes as far as 500 km from shore.

Besides its high-tech infrastructure, the Cabled Array holds 150 instruments. Included are nine ADCPs operating at four different frequencies. They are installed in three different ways: (1) on shallow profiling moorings (2) inside benthic experiment packages (3) atop junction boxes in the power / comms network.



En route to sites off the Oregon coast, several ADCPs can be seen installed in the fixed platform of Shallow Profiler Moorings.

Credit: M. Elend, University of Washington, VISIONS'16 expedition. https://goo.gl/SpGo2y

Products: Workhorse ADCPs: 75, 150, 300 kHz, and 5-beam 600 kHz

Application:
Real-time Monitoring of Currents

Project:
Cabled Observatory / Ocean Observatories Initiative

Organizations:
University of Washington

Principals:
Profs Deborah Kelley, John Delaney, and UW Cabled Array Team

Sponsor:
National Science Foundation

Data Collection Date:
Ongoing from Fall 2015

Location:
NE Pacific Ocean

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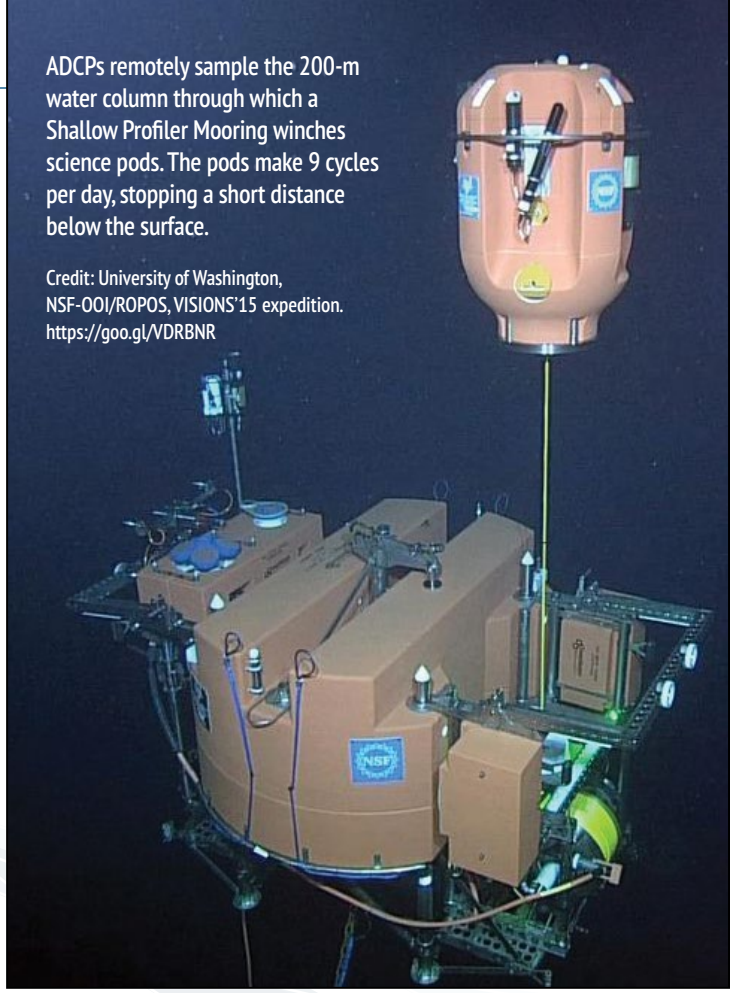


ADCPs remotely sample the 200-m water column through which a Shallow Profiler Mooring winches science pods. The pods make 9 cycles per day, stopping a short distance below the surface.

Credit: University of Washington, NSF-OOI/ROPOS, VISIONS'15 expedition. https://goo.gl/VDRBNR

SITUATION

One focus of the Cabled Array is water-column processes. Topics studied span all facets of ocean science. Some promote cross-discipline cooperation, such as biological-physical coupling, while others entrain citizen science. Sustained observing tackles understanding environmental impact and anticipated climate changes. Long-term observing at high sampling rates will reveal both rapid and slow-changing events. Potentially, this can provide the basis for early warning systems and lessons about adaption.

Currents observed with ADCPs transport important water properties. Examples include heat, momentum, salt, nutrients, plankton, and invertebrate larvae. Large-scale research using the ADCP data will range from the dynamics of eastern boundary currents to episodic events. Cross discipline studies will examine how water currents interact with the environment—from rough topography to ecosystems.

SOLUTION

Teledyne RDI won a $4.5M contract to supply more than 80 ADCPs to the Ocean Observatories Initiative (OOI) (https://goo.gl/JmwYc3). Several of these were earmarked for the Cabled Observatory. They equip a range of sites that span different depths, environments, and scientific objectives. These ADCPs are installed in three different ways: Shallow Profiler Moorings (SPM), Benthic Experiment Packages (BEP), and Seafloor Instrument Arrays (SIA).

Shallow Profiler Moorings

Besides the underlying power / comms infrastructure, a distinguishing innovation of the Cabled Array is the Shallow Profiler Mooring. Designed and installed by APL / UW, SPMs provide a large, stationary, instrumented platform at 200 m depth. The platform sits at the apex of a unique two-legged mooring. From here, a science pod is winched cyclically, nine times per day, through the upper ocean.

At two deep sites (1A,1C—about 3000 m), a pair of uplooking ADCPs are fitted to this large instrument platform. Also onboard are a digital still camera and a multi-discipline suite of probes for measuring water properties and bioacoustics.

The ADCPs are a 5-beam 600 kHz WorkHorse and a 150 kHz Quartermaster. The 600 kHz ADCP includes a beam directed vertically that complements the standard Janus configuration. The fifth beam measures vertical motions directly, ideal for studies of internal waves or the diel migration of zooplankton.

HIGHLIGHTS:

- The OOI's field sites combine innovative infrastructure with multi-discipline marine sensors
- NSF's Cabled Observatory uses dedicated fiber optic cables to permit interactive operation of distant instruments
- The Cabled Array holds nine ADCPs installed in three different ways from upper ocean to benthic regions
- The cabled connection makes ADCP data available in near real-time to shore-side observers
- Research using the ADCP data will range from the dynamics of eastern boundary currents to episodic events

The 150 kHz ADCP remotely profiles water currents from the depth of the platform to the sea surface. Thus it provides time series of the background flow within the 200-m water column sampled by the winched science pod.

The SPM's composite data set includes 18 instruments—platform and pod. Not only do they see a wide range of water properties but their simultaneous measurements have high resolution in time and space.

The ADCP data will inform diverse studies that range from the impacts of climate change to ocean acidification. Others include understanding biogeochemical processes and biological-rich thin layers.

The SPMs and their instrument suites (including the science pod) connect to the network of fiber optic cables. Each SPM has 1 Gbps bandwidth and 3000 watts power. As a result, live data are available on the Internet from sensors on the SPM platforms and their winched science pods (https://goo.gl/EZJGTE).

Within the Cabled Array, other projects use ADCPs to study the ocean near the seabed. We consider in turn the Benthic Experiment Packages (BEP) and the Seafloor Instrument Arrays (SIA).

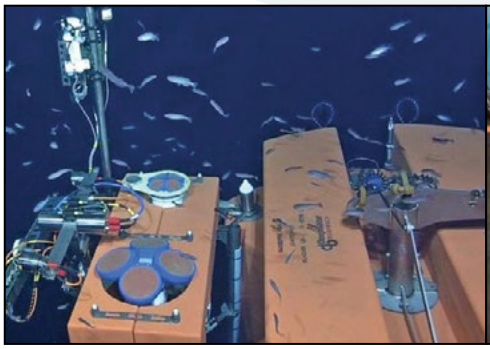
Benthic Experiment Packages

ADCPs are aboard a couple of Benthic Experiment Packages (BEP) installed on the Newport Line. It runs from shallow to deep water off Oregon. The deep offshore site (1C) sits at 600 m depth on the continental slope whereas the shallower inshore site (1D) is at 80 m on the continental shelf.

These ADCP data will be used to examine wide-ranging science questions. Examples include internal tides and the flow of currents onto the shelf. Others are hypoxia events and the release of methane from the seafloor. In each case, the ADCP frequency is selected to profile the full water column. Thus a 75 kHz Long Ranger sits at the deep site while a 300 kHz Sentinel is at the inshore location.

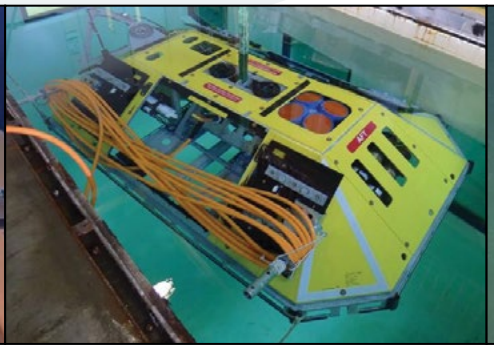
HIGHLIGHTS:

- Shallow Profiler Moorings include a pair of uplooking ADCPs fitted to a large, stationary platform held at 200 m depth
- The 150 kHz ADCP remotely profiles water currents in the 200-m water column sampled by the winched science pod
- Along the Newport line, a 75 kHz ADCP sits at the deep offshore site while a 300 kHz ADCP profiles the shallower inshore site
- Marine geologists are using ADCP echoes for long-term monitoring of bubble plumes due to methane seeps



Located at 200 m depth, two ADCPs (150 kHz, 5-beam 600 kHz) are installed on the fixed platform of a Shallow Profiler Mooring.

Credit: NSF-OOI/UW/ISS; Dive R1832, VISIONS'15 expedition. https://goo.gl/nKMkv1



A Benthic Experiment Package (BEP) hosts an ADCP and several smaller ocean sensors within a hazard-resistant frame. Also inside is a power / comms substation for the cabled network.

Credit: University of Washington. https://goo.gl/98tyyc

A BEP on the seafloor at 600 m depth off Oregon. At right is a 75 kHz ADCP. The cabled connection to the Internet extends from protective doors.

Credit: NSF-OOI/UW/CSSF, Dive 1747, VISIONS'14 expedition. https://goDvxZRz

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Housed in a hazard-resistant frame, the BEP plays a twofold role. It is a mounting for the ADCP and several smaller sensors. It also holds some of the power / comms infrastructure that connect these instruments to the cabled network. The sensors measure chemical signatures in the ocean: acidity (pH), carbon dioxide, salinity and oxygen concentrations. Probes installed nearby address the physics of the bottom boundary layer. As well, a hydrophone sits outside the frame to act as a benthic ear.

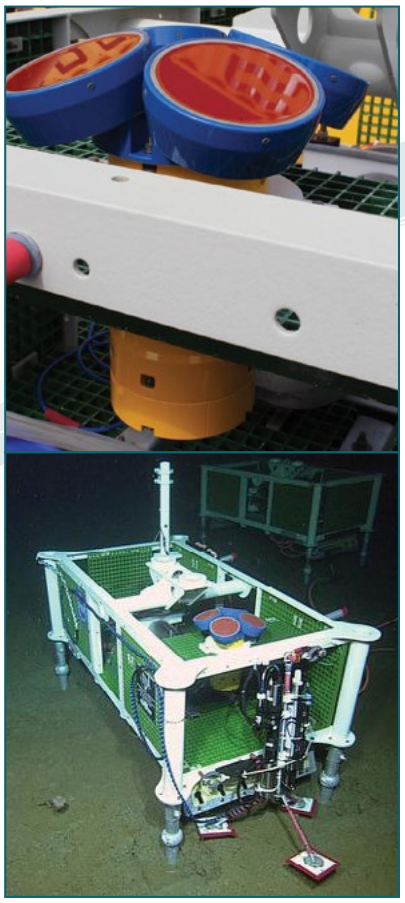
Seafloor Instrument Arrays

The cabled Seafloor Instrument Arrays (SIA) permit study of near-bottom and water-column processes. There are three of these arrays (Sites 1A, 1B, 3A). They too carry a suite of instruments. Two SIAs, deployed at 3 km depth (1A, 3A), are fitted with 150 kHz Quartermaster ADCPs. These sites are co-located with SPMs; nearby is a wire-crawler mooring. A third SIA (1B), on the continental slope at 800 m, carries a 75 kHz Long Ranger ADCP.

You can see in the Figures that the ADCP sits atop a junction box for the power / comms network. Due to the cabled connection, these ADCP data are available in near real-time and for a long duration—two years so far. This has led to innovative use of the ADCP data.

One example is a bio-geological study at the Southern Hydrate Ridge (1B). Marine geologists at the University of Washington are using the ADCP's returning acoustic echoes to see bubble plumes of methane. The plumes seep from gas hydrate deposits in the seabed. Gas hydrates are a solid ice-like form of water that contains methane molecules. These deposits support biological communities on and within the sediments. The ADCP profiles show bubble plumes through much of the water column. One hypothesis is that these rising plumes of methane might boost biological productivity in the overlying ocean.

NSF's Cabled Observatory is planned to operate for 25 years. Owing to its unique power / comms infrastructure, this networked array will permit interactive monitoring of diverse ocean sites—from upper ocean to benthic depths. The remote sampling capability of ADCPs deployed throughout the array will extend the reach of observers through the water column. And thanks to the fiber optic connection to the Internet, these data will be available in near real-time for a global community of users.



Top: A 150 kHz ADCP is mounted atop a junction box, prior to deployment at 2900 m. Bottom: Part of a Seafloor Instrument Array, this 150 kHz ADCP sits at 3 km depth near Axial Seamount.

Top Credit: M. Elend, University of Washington. https://goo.gl/Cfumqx
Bottom Credit: NSF-OOI/UW/CSSF; Dive R1735; VISIONS'14 expedition. https://goo.gl/XeiP7q

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NSF's Cabled Array: A wired tectonic plate and overlying ocean

Deborah S. Kelley, John R. Delaney, Cabled Array Team

School of Oceanography, University of Washington, Seattle, USA

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www.teledynemarine.com/rdi

14020 Stowe Drive, Poway, CA 92064 USA
Tel. +1-858-842-2600 • Email: rdisales@teledyne.com

Les Nertieres 5 Avenue Hector Pintus 06610 La Gaude France
Tel. +33-49-211-0930 • Email: rdie@teledyne.com

