Using Autonomous Underwater Gliders to Observe Continental Margins and Oceanic Boundary Currents

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Coastal Upwelling Ecosystems

California Current

Canary Current

Humboldt Current

Benguela Current

1% of surface area, but > 20% of wild caught seafood
Seasonal cycle of winds

Sea-surface temperature

upwelling

spring transition
wind-driven upwelling drives ocean productivity

chlorophyll

temperature

Courtesy of Ted Strub (OSU)
Off Oregon, hypoxia develops on the open continental shelf
Subsurface ocean observations off Newport for the last ~60 years

N ~ 4000 hydrocasts

Chan et al. (2008, Science)
Autonomous Underwater Vehicle Gliders

cross-margin transect twice per week since April 2006

CTD
dissolved oxygen
chlorophyll fluorescence
CDOM fluorescence
light backscatter
depth-averaged velocity
Autonomous Underwater Glider

- GPS, Iridium and Freewave Antennae in tail fin
- Aanderaa Optical Dissolved Oxygen sensor
- Glider Control and more batteries
- Science Bay
- Pitch Batteries
- CTD
- Air bladder
- Optical Sensors (Chl, CDOM and Backscatter)
- Displacement Pump

7 ft long
100 lbs in air
Seaglider: A Long-Range Autonomous Underwater Vehicle for Oceanographic Research

Charles C. Eriksen, T. James Osse, Russell D. Light, Timothy Wen, Thomas W. Lehman, Peter L. Sabin, John W. Ballard, and Andrew M. Chiodi
Glider operations from just about any size boat

OSU’s 16-m R/V Elakha

from a rowboat off Chile
Horizontal resolution

How the glider works

1. Diving: Glider runs on very small amounts of power, using change of buoyancy and weight to propel itself. Battery packs move forward shifting more weight to the front and water is pumped into the vehicle causing it to dive. The wings convert some of the vertical motion into forward motion.

2. Rising: Batteries are moved backward and water is pumped out of the vehicle causing it to point upward and rise.

3. Surfacing: Every six hours the glider surfaces. An air bag in the rear inflates, allowing a satellite phone in its tail to call into a computer, get instructions, and send data. Then the air bag deflates and the vehicle dives back down.

4. Recharge: After a month in the ocean, the glider is retrieved by researchers and brought to the lab to install new batteries.

The glider's tools

Sonar: Keeps the vehicle from hitting the bottom.
Optics: A light measures concentrations of phytoplankton.
Oxygen: A sensor measures oxygen levels to monitor "dead zones" (data graph shown at right).
Debris: A light measures dissolved organic material.
Depth: A sensor measures the temperature, salinity and density at various depths.

Currents: Because gliders aim toward a GPS position, researchers can estimate ocean currents by calculating how far it has been swept off course.
OSU Glider Operations

April 2006–Sep 2014
3485 glider-days
260,190 vertical profiles
82,000+ km

Over twice around the Earth!
Salinity

T (°C)

Chlorophyll (μg/L)

Light Backscatter (1/m)

A temperature & salinity “front”

A “hotspot” for phytoplankton

Barth et al. (in prep)
Dissolved Oxygen from glider

Hypoxia

July 2006

Barth et al. (in prep)
glider “bob” in the January 18-19, 2012 storm

NOAA Buoy 46050

November 28, 2001

Yaquina Bay Bridge (AP photo)

wind speed (knots)

wind height (feet)

50 knots
25 m/s

30 feet
~10 m
glider “bob” approaches shore and gets carried north in the January 18-19, 2012, storm

Barth, Shearman, Erofeev (OSU)
oceanographic data from across the shelf in 30-foot (~10 m) seas!

Barth, Shearman, Erofeev (OSU)
Let’s take a closer look at freshwater forcing.

Siletz River, central Oregon coast

Eel River, northern CA - USA (1974).
(http://www4.ncsu.edu/~elleitho/)

Photo by J. Barth
Columbia River – largest river on US west coast

Barnes et al. (1972)
The Oregon Coastal Current (OCC)

Columbia R.
S. Coastal R.
N. Coastal R.

Mazzini et al. (2014)
Example glider lines: summer vs. winter

Mazzini, Barth, Shearman and Erofeev (JPO, 2014)
Fit: \( h(x) = H[1 - e^{-\left(\frac{x + W_p}{R}\right)}] \), finding \( W_p, R \) and \( H \).
Wind effects width and shape of front/current

Mazzini, Barth, Shearman and Erofeev (JPO, 2014)

Lentz and Largier (2006)
Glider measurements from around the US

New Trinidad Head Line
Starting October 2014
Ocean Observatories Initiative (OOI)
Installing observing arrays off the Pacific Northwest 2010-2015
(operate for 25-30 years)
Using Gliders to Explore Boundary Currents

- high spatial and temporal resolution
- cost effective
- physical, bio-optical, chemical measurements
- use in combination with moorings and ship-based work
- future work: additional sensors (e.g., bioacoustics)

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