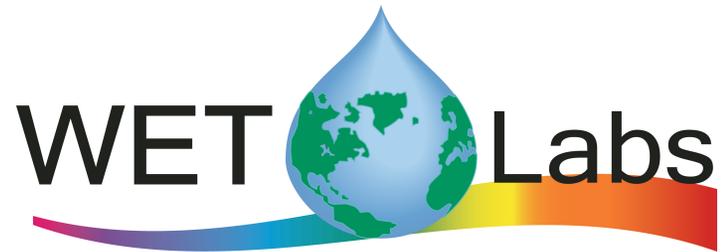


# Breakthrough Technology - Automated Moored Profiling on the Oregon Shelf





## Who We Are

- **Founded in 1992**
- **USA based**
  - **Oregon**
  - **Rhode Island**
- **Team of ~60 employees**
- **Now part of Sea-Bird Scientific**
  - **WET Labs**
  - **Sea-Bird Electronics**
  - **Satlantic**



# We create solutions for critical applications in ocean sciences and aquatic research



**Climate change and carbon sequestration**



**Environmental impact studies**



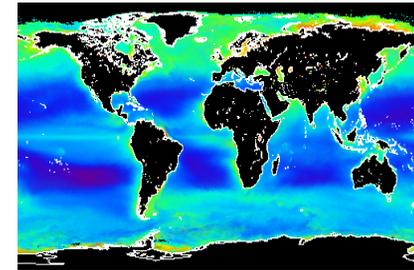
**Ocean observing systems**



**Underwater visibility and tactical assessment**

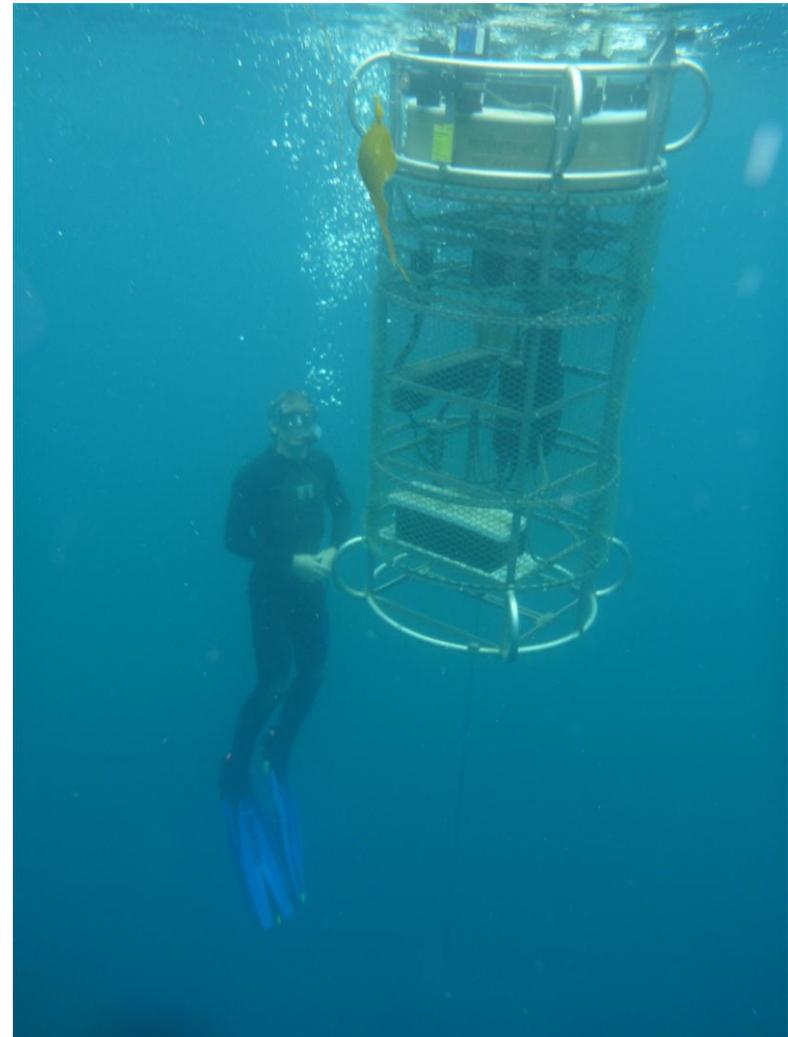
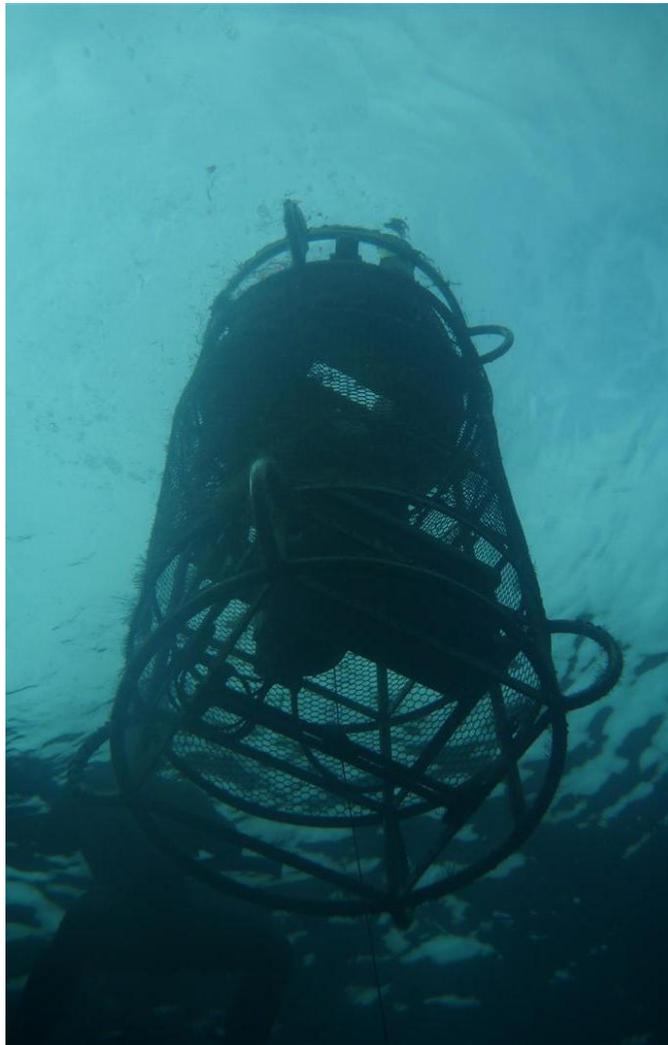


**Fisheries management and aquaculture**



**Ocean color validation**

# THETIS - Autonomous Moored Profiler





# Current Technologies

## Current Technologies

- UAVs
  - Gliders
  - Propellered
- UVs
  - Towable
  - Self-motivated, ship cabled
- Moorings
- Wire Crawlers

## Gaps

- Floor to surface measurements
- Thin-layer resolution
- Instrument payload
- ***Survivability***
- Longer deployment lengths
- Ship time and size
- Serviceability
- Expense



# Architecture of Thetis Design

- Large payload for physical, biological, chemical and optical instruments.
- Sub-meter scale vertical resolution from 1-2 m above the water floor to the surface.
- Precise control of the profiler's vertical position and speed within the water column.
- Survivability in heavy seas



# Addressing Some of the Difficulties with the Thetis Design

- Modular, self-contained.
  - Integrated control, power, and telemetry systems
- On-board winch-driven platform.
- Expansion ports for up to a total of 8 instruments.
- Independent instrument control.
- Break-away detection.
  - Integrated GPS
  - Independent GPS beacon
- “Wave Height Estimation”
  - Ability to determine if surface is “safe”

# Survivability and Longevity

Robust control system:

Instrument I/O, platform control, power supervision, remote communications, data storage

“Intelligence”:

Winch drive algorithm for rough ocean conditions (waves and currents)

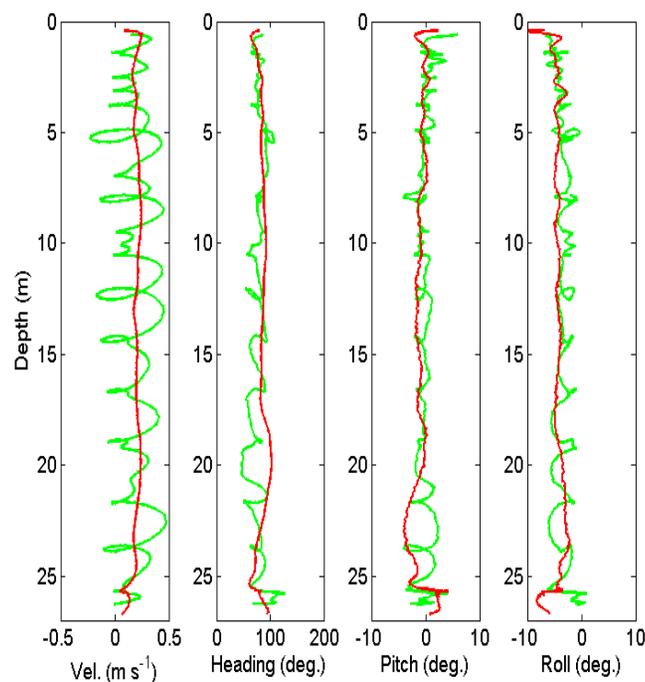
➤ WL Patent - #8382540

United States Patent		8,382,540
Bernard, et al.		February 26, 2013
Method and apparatus for controlling the motion of an autonomous moored profiler		
Abstract		
A method and apparatus for controlling the motion of a subtidal autonomous moored profiler. The profiler includes one or more buoyant members for buoying the profiler in the field, a winch, and a feedback controller for controlling the winch. The winch includes a spool, a drive providing for varying rates of turning of the spool, and a flexible cable for winding onto and unwinding from the spool. A line end of the cable is carried by the profiler. The controller monitors an indication of the tension in the cable and controls the drive to respond thereto.		
Inventors: Bernard, Andrew B. (Corvallis, OR); Bhattach, Bruce K. (Corvallis, OR); Karples, Eli; John, N. (Corvallis, OR); Dyer, Alan R. (Dad Rock, OR); Moore, Casey (Corvallis, OR); Whitman, David R. (Philomath, OR); Daugherty, Perry L. (Clatskanie, OR); Sulzbren, James M. (Clatskanie, OR)		
Applicant: Name City State-Country Type		
Bernard, Andrew B. Corvallis OR US		
Bhattach, Bruce K. Corvallis OR US		
Karples, Eli John N. Corvallis OR US		
Dyer, Alan R. Dad Rock OR US		
Moore, Casey Corvallis OR US		
Whitman, David R. Philomath OR US		
Daugherty, Perry L. Clatskanie OR US		
Sulzbren, James M. Clatskanie OR US		
Assignee: Wet Labs, Inc. (Philomath, OR)		
Famfile ID: 3000294		
Appl No: 13,998,409		
Filed: November 26, 2007		

Diagnostics:

Battery voltage/power consumption, tilt/roll, cable tension, speed, distance traveled

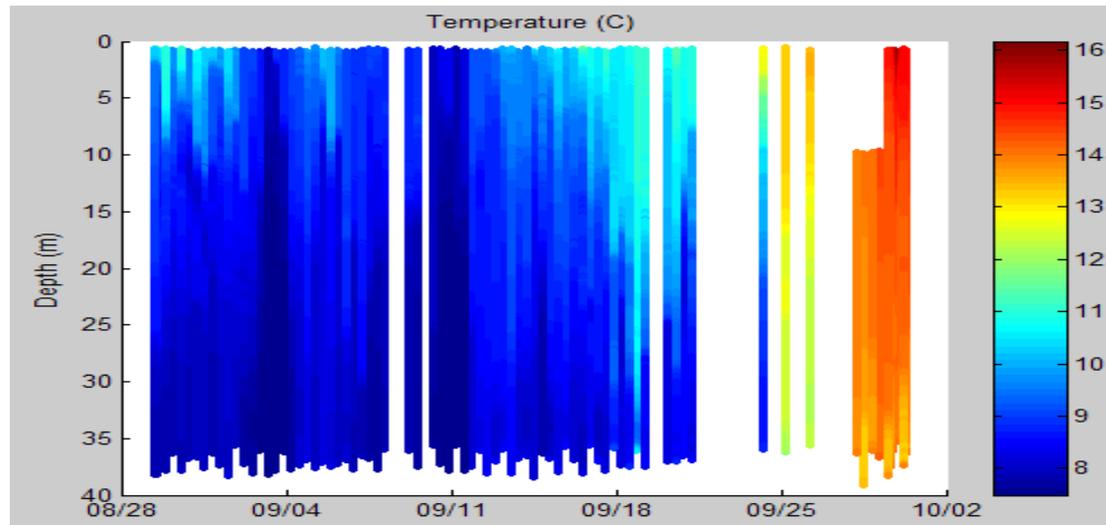
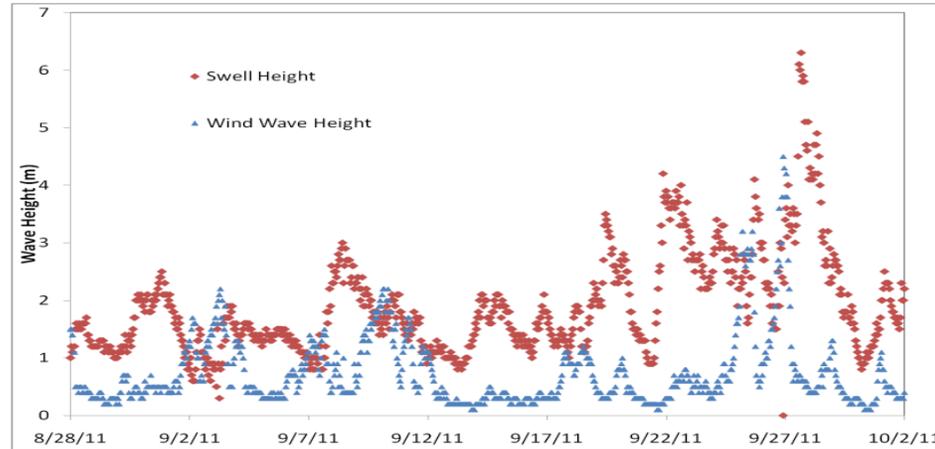
## Winch control



Observations from NDBC Station 46050 STONEWALL BANKS - 20NM West of Newport, OR

- 1.5 m Significant wave ht
- 12 sec dominant wave period
- 8 sec average wave period
- 2.5 m/s average wind speed

# “Duck and Cover”



# Instrument Suites

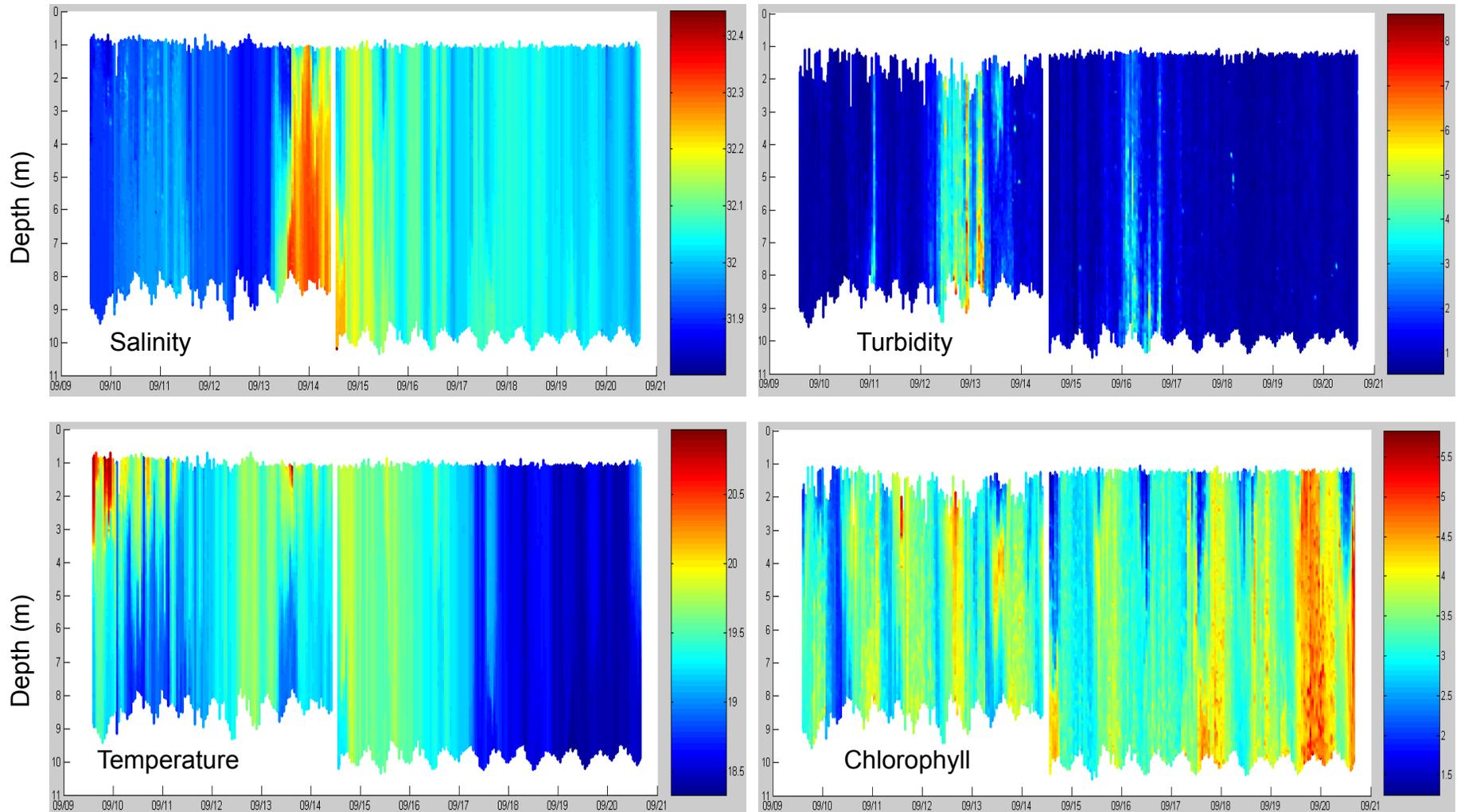
## Standard Instrument Suite:

- SBE 49 CTD
- BBFL2W
  - 700nm  $b_b$ , CHL-a, CDOM
- PARs
  - light field in the photosynthetic available radiation band

## Additionally Supported:

- ECO family
- C-Star
  - Total attenuation
- ACS
  - spectral absorption and attenuation.
- SBE43/63
  - Dissolved oxygen
- OCR/HOCR
  - Ocean color irradiance and radiance
- SUNA
  - Optical nitrate
- Nortek Aquadopp
  - Free stream water velocity

# Data from Marthas Vineyard



# Broad Dissemination of Technology



OOI is funded by the National Science Foundation



OOI is managed and coordinated through the Consortium for Ocean Leadership



## A MEGA-OCEAN OBSERVATORY

The US Ocean Observatories Initiative includes one sea-floor cable observatory (called Regional Scale Nodes), four deep-sea sites, and two coastal arrays of instruments; but together, this covers only a fraction of a per cent of the world's oceans.

### STATION PAPA

- 4,250 m water depth
- 1 full-depth profiler
- 2 subsurface moorings
- 3 gliders

★ Historic site with records dating back to 1949

### IRMINGER SEA

- 2,800 m water depth
- 1 surface mooring
- 1 full-depth profiler
- 2 subsurface moorings
- 3 gliders

★ Productive fisheries area



### ENDURANCE ARRAY

- 25-600 m water depth
- 2 mooring lines
- 6 gliders

★ Coastal upwelling important for fisheries

### PIONEER ARRAY

- 130 m water depth
- 10 moorings
- 6 gliders
- 3 autonomous underwater vehicles

★ Gulf Stream boundary currents; array can be moved to other sites in future

- Deep-sea site
- Coastal array
- ★ Science highlight

### REGIONAL SCALE NODES

- 800-2,900 m water depth
- 925 km of cable
- 7 sea-floor terminals

★ Earthquakes, volcanoes, methane hydrates

### SOUTHERN OCEAN

- 4,800 m water depth
- 1 surface mooring
- 1 full-depth profiler
- 2 subsurface moorings
- 3 gliders

★ Region absorbs significant amount of carbon dioxide.

### ARGENTINE BASIN

- 5,200 m water depth
- 1 surface mooring
- 1 full-depth profiler
- 2 subsurface moorings
- 3 gliders

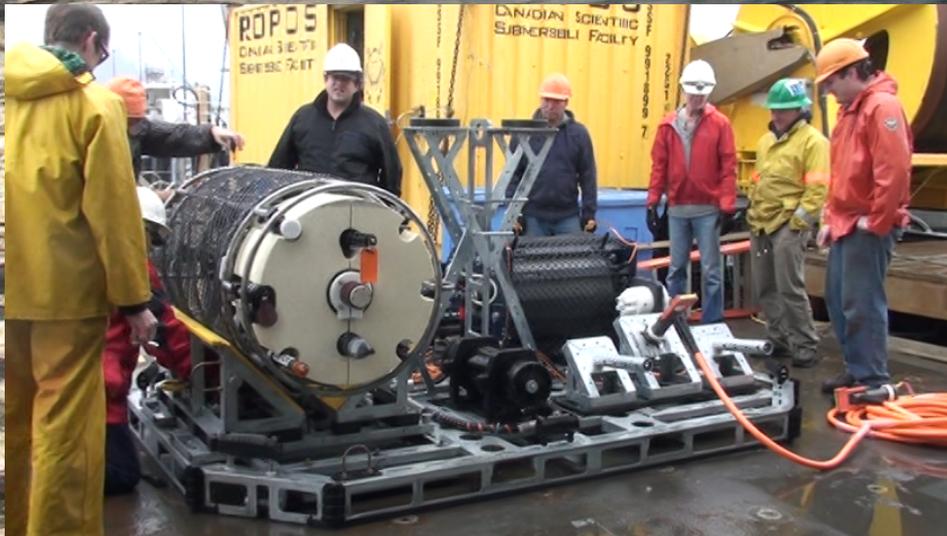
★ Closes a gap in the global seismic network

- 5 Profiler systems delivered for OOI
  - Being deployed at the Endurance and Pioneer Arrays
  - 3 more systems to be ordered
- 6 month deployment cycles

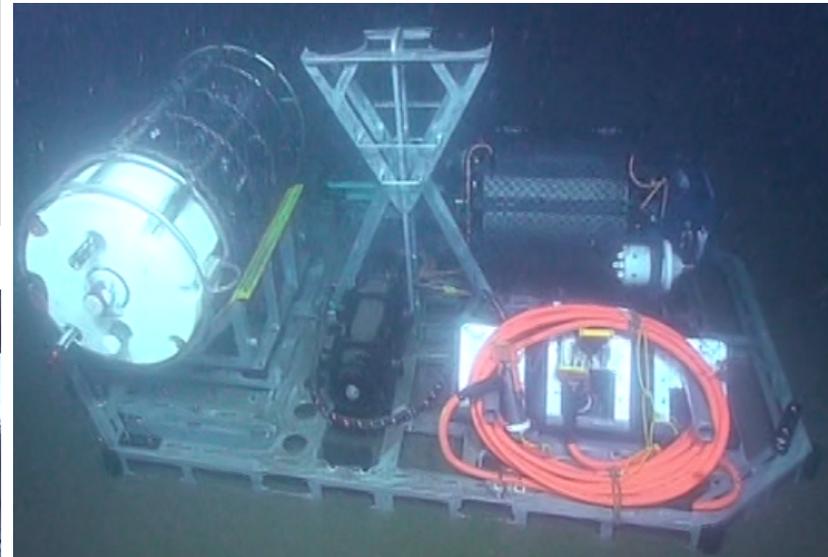
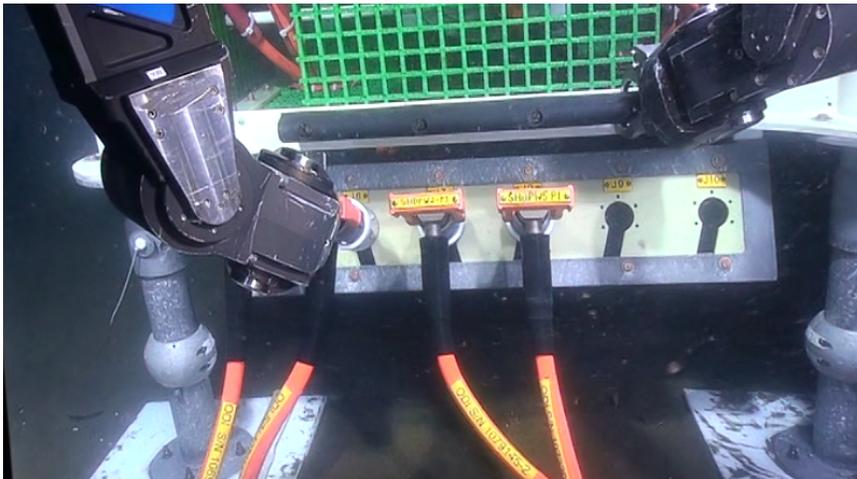
# Continuing Development

## Winch on Bottom Profiler

- OOI/NSF sponsored development between:
  - WET Labs (Profiler)
  - MacArtney (Winch)
  - OSU (Control)
- First article deployed and plugged into Endurance array September 29<sup>th</sup>, 2014.



# Plugging IN





# Questions?

A



SEA-BIRD  
SCIENTIFIC

Company