How Do Scientists Measure Ocean Characteristics

Scientific instruments are the tools scientists use to take measurements. Scientists on the SPURS cruise use just a few instruments to measure ocean salinity, temperature, depth, and turbulence. These instruments can be mounted on or deployed from stationary or mobile platforms, such as a vessel or an Autonomous Underwater Vehicle (AUV). Some of the most common instruments are the CTD Rosette, the UnderwayCTD, a microstructure profiler, and the ADCP. Here we give an outline of the specific instruments used on SPURS.

Featured Video: General Overview of Instruments

General Overview of Instruments
from **COSEE Ocean Systems** PLUS

08:24

Dr. David Fratantoni summarizes how data will be collected during the first SPURS cruise [view transcript]


Eularian or Lagrangian?
Dr. Andrey Shcherbina
[vimeo, 03:47]


Microstructure Instruments
Dr. Lou St. Laurent
[vimeo, 04:41]


Instruments, Biofouling, and Big Fish
Dr. Andrey Shcherbina
[vimeo, 01:16]

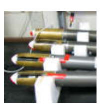

Flux Every Day
Dr. Tom Farrar
[vimeo, 00:51]

view all videos in this album [vimeo]

Types of Scientific Instruments
(Click images for enlarged views)

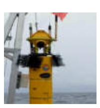
Conductivity, Temperature, and Depth (CTD) Rosette

What does it do? This instrument measures the conductivity and temperature of the water throughout the water column. Conductivity is a material's ability to conduct an electric current. Salt water has a higher conductivity than fresh water, and higher conductivity measurements indicate higher salt levels in the water. So, by measuring the conductivity of water, we can determine the salinity of the water. **How does it work?** The CTD sensor is located in the middle of the gray bottles (Niskin bottles) shown in the photo (above left). It is lowered to the desired depth from a stationary vessel on a cable. The instrument takes continuous measurements through the water column while the Niskin bottles collect water samples from specific depths to confirm the electronic data measured by the CTD sensor.



UnderwayCTD (U-CTD)

What does it do? The U-CTD allows the collection of salinity profiles through the water column while the ship is underway at relatively high speeds. This is helpful because scientists can get quick, continuous profiles of the water's characteristics over a large area. **How does it work?** The U-CTD is deployed from the stern of a vessel. There is a mounted piece of equipment consisting of an extending arm, which keeps the line away from the vessel, and a spool. Line is released from the spool that is set to deploy a certain length of line to get the U-CTD to the desired depth. When all of the line has been deployed, it is re-spooled to bring the instrument back in.



Microstructure Profiler

What does it do? This instrument measures extremely small-scale (cm) variations in vertical water turbulence, temperature, and salinity. **How does it work?** The profiler is deployed from the ship and contains ballast that allows it to free fall at a very slow speed. The profiler remains loosely tethered to the ship via a cable that is played out as it falls so as to not disturb the measurements.

Acoustic Doppler Current Profiler (ADCP)

While this instrument doesn't measure salinity directly, it does provide important ancillary/additional information on water current speed and direction over the water column to provide more insight into the data collected by the salinity sensors described above. **What does it do?** An ADCP measures how fast water is moving across an entire water column. It can be mounted on the bottom to measure upwards; horizontally on bridge pilings or seawalls to measure across currents; or on ships and surface moorings to take constant measurements. **How does it work?** Using a principle of sound waves called the Doppler effect, the ADCP transmits "pings" of sound at a constant frequency into the water, which ricochet off particles suspended in the water, and reflect back to the instrument. Sound waves that hit particles far from the profiler take longer to return than waves that strike close by. By measuring the time it takes for the waves to bounce back and the Doppler shift, the profiler can measure current speed at many different depths with each series of pings.

This material is based upon work supported by NASA under NASA Jet Propulsion Laboratory Subcontract No. 1459277. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

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Woods Hole Oceanographic INSTITUTION

Conductivity, Temperature, Depth (CTD) Sensors

Source: Ocean Instruments

What is it and why do we use it?

A CTD — an acronym for Conductivity, Temperature, and Depth — is the primary tool for determining essential physical properties of sea water. It gives scientists a precise and comprehensive charting of the distribution and variation of water temperature, salinity, and density that helps to understand how the oceans affect life.

How does it work?

The shipboard CTD is made up of a set of small probes attached to a large metal rosette wheel. The rosette is lowered on a cable down to the seafloor, and scientists observe the water properties in real time via a conducting cable connecting the CTD to a computer on the ship. A remotely operated device allows the water bottles to be closed selectively as the instrument ascends. A standard CTD cast, depending on water depth, requires two to five hours to collect a complete set of data.Water sampling is often done at specific depths so scientists can learn the physical properties of the water column are at that particular place and time.

Small, low-powered CTD sensors are used on autonomous instruments like the moored profiler, gliders, profiling floats and AUVs .

What platforms are needed?

There can be a host of other accessories and instruments attached to the CTD package. These include Niskin bottles that collect water samples at different depths for measuring chemical properties, Acoustic Doppler Current Profilers (ADCP) that measure the horizontal velocity, and oxygen sensors that measure the dissolved oxygen content of the water.

Advantages and limitations?

Advantages:

Remote sensing

Very accurate

Light weight (CTD only)

Can be used at depths up to several thousand meters

Disadvantages:

The small, low-powered CTD sensors that are used on autonomous instruments like the MP, gliders, profiling floats and AUVs are more complex to operate, the chief limitation is the need to calibrate the individual sensors. This is particularly true for autonomous instruments deployed for long time periods. (Ship-deployed CTDs are referenced with the water sample data which are not generally available with autonomous instrument deployments.) Therefore, the sensors must be stable for the period of deployment, or assumptions about the ocean water properties must be made and referenced to the sensor data. (For example, deep water properties are usually very stable, so autonomous sensor data is adjusted to match the historical water properties at depth. The danger of course is that we miss real changes in the ocean - ship based measurements are still required!)

Sources:

Encyclopedia of Ocean Sciences, vol. 1, p. 579-588

Last updated: August 17, 2007

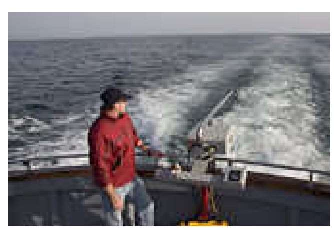
TELEDYNE OCEANSCIENCE
Everywhereyoulook™

UnderwayCTD

CTD Profiling from a moving vessel

- Achieve over 500m vertical profiles while underway at 10kts
- Convenience of expendables without the environmental impact
- High quality SeaBird Electronics freefall CTD data
- Compact and portable for deployment on multiple vessels

The Oceanscience UnderwayCTD provides research grade CTD (conductivity, temperature, and depth) profiles while underway at up to 20kts. The unique freefall profiler offers researchers vertical profiles even as the ship is moving away from the deployment location. The innovative deployment winch and re-spooling mechanism allows the probe to be recovered and re-launched time after time without ever needing to stop or slow down. Profiles are gathered quickly, allowing excellent spatial resolution for CTD transects. The UnderwayCTD can be installed on practically any vessel. The small footprint winch can be mounted on a post or rail, and can be set up and operated by one person. The UnderwayCTD components can be transported from ship to ship with ease, making the system ideal for gathering high quality data from vessels of opportunity.



The UnderwayCTD in Action

An evening on board the R/V Knorr with the UnderwayCTD

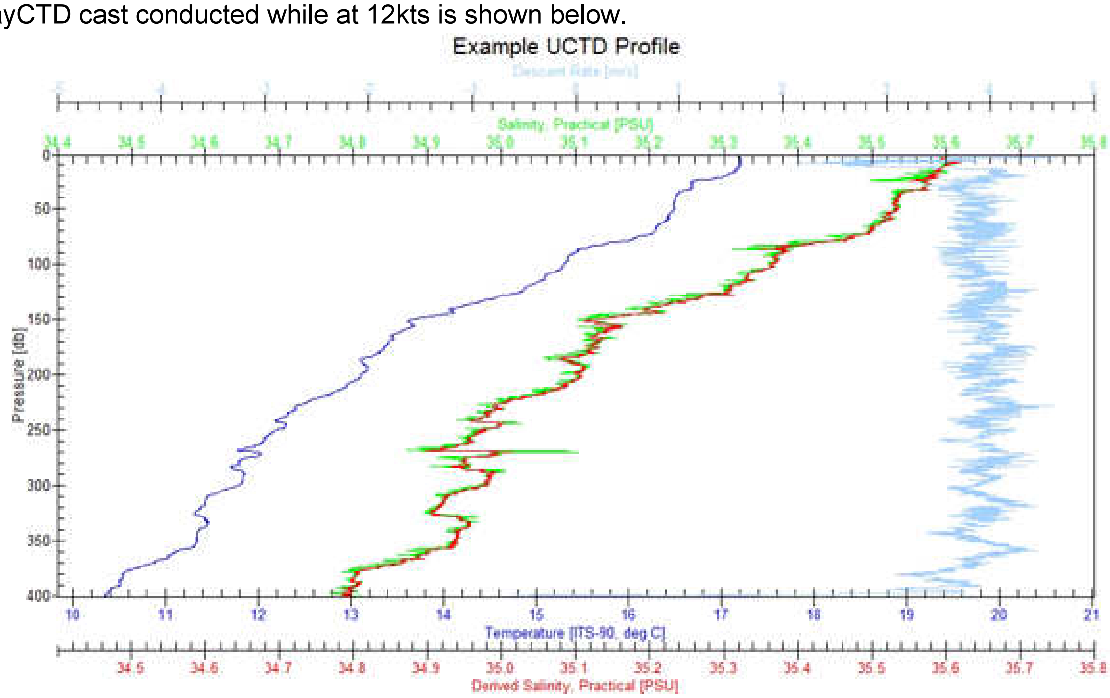
Deployment of the UnderwayCTD in 45 kt North Atlantic winds (April 2011). Courtesy of Dave Ullman, Mark Harris, and Emily Dougan (University of Rhode Island). Warning: not for the faint hearted.

An UnderwayCTD Deployment in the tropical Pacific with WHOI

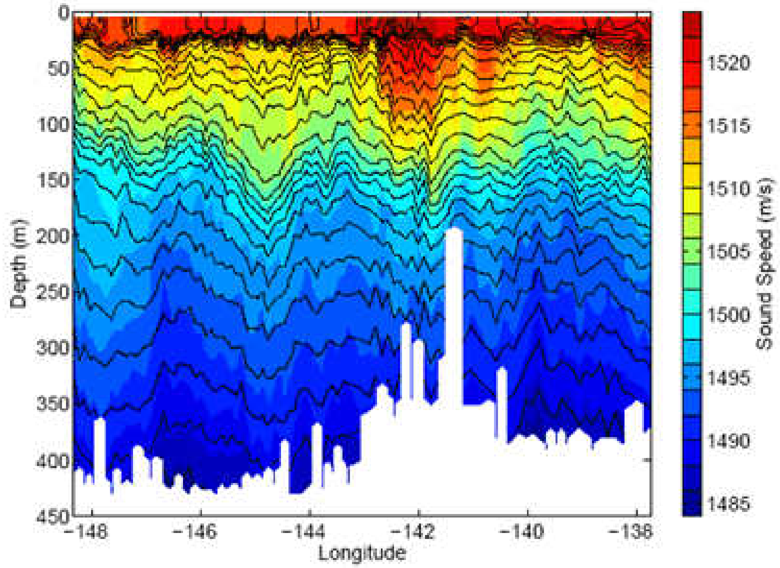
Researchers at Woods Hole Oceanographic Institution using the UnderwayCTD for the fourth straight year on STRATUS cruises (April 2011). Courtesy of Sean Whelan (WHOI).

UnderwayCTD Data Examples

The fast sampling rate and highly accurate sensors used in the UnderwayCTD probe generate excellent data adequate for the most exacting scientific research programs. Compared to expendable probes such as XBTs and XCTDs, the data are of significantly greater accuracy. A plot of raw, uncorrected data from a 400m UnderwayCTD cast conducted while at 12kts is shown below.



The fast turnaround between profiles allows extremely detailed CTD transects to be completed. A high resolution hydrographic section derived from CTD data gathered using the UnderwayCTD deployed at 10kts is shown below.



Extracted from Rudnick, D. L., and Klinke, J., "The Underway Conductivity-Temperature-Depth Instrument,"Journal of Atmospheric and Oceanic Technology, 2007.

Principle of Operation

The UnderwayCTD uses a freefall data-logging probe that is tethered to the ship by high strength line and not a conducting cable. To achieve deep vertical profiles, a special tail spool on the probe is pre-loaded with line from the UnderwayCTD winch before every cast. As the probe falls, the line on the tail spool is paid out at the same time as line is paid out from the winch on the ship, similar to the operation of an XBT or XCTD. As the probe drops with very little drag to slow it down, very deep profiles are possible even with the ship moving at over 10kts.

The UnderwayCTD deployment consists of four stages:

1. **Deployment**	Probe dropped from aft deck. Line simultaneously spools off the winch and the probe tail spool
2. **Recovery**	Probe recovered to the ship using high speed winch
3. **Respooling**	Line is reloaded onto the probe tail spool ready for the next cast
4. **Downloading**	Fast Bluetooth data transfer extracts data in seconds

Probe motion is completely decoupled from the ship throughout the downcast, leading to fast and highly accurate profiles.

LEARN MORE » Click here to learn more about how the Oceanscience Underway profilers work.

CTD Probe Specifications

The UnderwayCTD uses a custom freefall CTD probe manufactured by industry leader Sea Bird Electronics. Using field-proven and highly accurate conductivity, temperature, and pressure sensors, exceptional quality results are obtained. The internal electronics and exposed sensor components are carefully designed to withstand deployment and recovery at up to 20kts. Sampling at 16Hz, overall depth resolution of below 25cm is attained at a drop speed of about 4m/s. The specifications of the CTD probe sensors are shown below.

	Conductivity (S/m)	Temperature (C)	Depth (dbar)	Salinity (PSU)
Resolution	0.0005	0.002	0.5	0.005
Accuracy - Raw Data	0.03	0.01 - 0.02	4	0.3
Accuracy - Processed Data	0.002-0.005	0.004	1	0.02 - 0.05
Range	0 - 9	-5 - 43	0 - 2000	0 - 42

UnderwayCTD Configurations

Several configurations of the UnderwayCTD are available. The tether line thickness and length can be customized for each cruise requirement, and line sections are easily replaced as necessary. Longer line setups give deeper profiling for blue water oceanography; for shallow coastal work the UnderwayCTD can be configured with shorter lengths of thicker line for maximum probe security. For the available standard configurations, download the configurations options information sheet. The general purpose configuration is shown below.

	Profile Depth (m)							
Speed (kts)	300	400	500	600	700	800	900	1000
0								
2								
4								
6								
8								
10								
12								

LEARN MORE » Click here to download the configuration options information sheet.

UnderwayCTD Deployment in Shallow Water

Although developed for profiling in the open ocean, the UnderwayCTD has been adapted to allow successful use in the coastal environment. For profiling down to 250m or less, the tail spool reloading phase may be omitted and the probe simply dropped from the ship with line spooling off the main winch only. For shallow water deployment, this basic configuration represents a cost-effective means to gather high quality CTD profiles very rapidly.

For deployment in 15-100m water depth, the "Slow-Fall" profiler option can be specified. Properly selected buoyancy modules are simply installed on the tail spool to slow the probe descent rate from 4m/s to 1m/s.

Deployment of the "Slow-Fall" UnderwayCTD profiler

A slower descent rate maximizes data quality and offers safe use of the UnderwayCTD in shallow water, even estuaries.

UnderwayCTD Cruise Reports

Oceanscience customers are generating unique datasets with the UnderwayCTD in all of the major world oceans. Some information about particularly interesting projects is included in the application notes below.

NOAA National Data Buoy Center Deep-ocean Assessment and Reporting of Tsunamis (DART) Program

NOAA Breaks Record Research Grade Profile Depth in Only 50 minutes with the UnderwayCTD - 2,041m!

Woods Hole Oceanographic Institution

Four years of UnderwayCTD Success Stories

University of Washington, Applied Physics Lab

Record-breaking 3,000 UnderwayCTD Profiles Completed in 20 days!

EMAM (Portugal)

First UnderwayCTD Cruise Completed

Frequently Asked Questions

LEARN MORE »

Have a question about the UnderwayCTD? If frequently asked, the answer will be in the FAQ!
Click here for the FAQ Page

Download

- **PRODUCT INFORMATION SHEET - UnderwayCTD**
- **PRODUCT INFORMATION SHEET - UnderwayCTD Freefall Probe**
- **PRODUCT INFORMATION SHEET - UnderwayCTD Configuration Options**
- **APPLICATION NOTE - WHOI UCTD 2011**
- **APPLICATION NOTE - ITOP UCTD 2011**
- **APPLICATION NOTE - EMAM UCTD 2010**
- **APPLICATION NOTE - NOAA NDBC SET RECORD IN NORTH PACIFIC 2012**
- **TECHNICAL PAPER - Rudnick and Klinke, 2007**
- **TECHNICAL PAPER - WHOI Technical Note 2007**
- **TECHNICAL PAPER - Eddies in the South East Pacific 2009**

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Thursday, January 29, 2015

Turbulence Profilers

Instrument	Description	Application
VMP 250 	Light-weight turbulence profiler with internal data acquitistion system. Carries two shear probes and one thermistor. 500m depth rating (1000 m option).	Coastal-zone measurement on ships with limited deck space or minimal electrical facilities.
VMP 500 	Tethered microstructure profiler for measurement of dissipation-scale turbulence. Carries shear probes, thermistors, and CTD sensors. Depth rating up to 1500 m.	Coastal-zone and shelf region measurement. Suitable for deployment from small vessels.
VMP 750/2000 	Tethered microstructure profiler for measurement of dissipation-scale turbulence. Contains shear probes, thermistors, CTD, and other sensors. 2000 m depth rating.	Vertical profiler for shelf region and open ocean measurement.
VMP 6000 	Internally recording profiler for deep ocean measurement of turbulence microstructure. Carries turbulence sensors, CTD, accelerometers, and 1 GB solid state disk. Instrument will return to the surface after reaching a programmed depth. 6000 m depth rating.	Vertical profiler for full ocean-depth measurement.
XMP 	Expendable profiler with fibre optic cable. Measures two components of small scale velocity shear, temperature, and depth. 6000 m depth rating.	Single-use vertical microstructure profiler for measurement of the bottom or deep ocean.

Woods Hole Oceanographic INSTITUTION

Acoustic Doppler Current Profiler (ADCP)

Source: Ocean Instruments

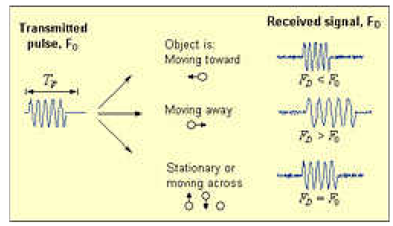
What is it and why do we use it?

An Acoustic Doppler Current Profiler, or Acoustic Doppler Profiler, is often referred to with the acronym ADCP. Scientists use the instrument to measure how fast water is moving across an entire water column. An ADCP anchored to the seafloor can measure current speed not just at the bottom, but also at equal intervals all the way up to the surface. The instrument can also be mounted horizontally on seawalls or bridge pilings in rivers and canals to measure the current profile from shore to shore, and to the bottoms of ships to take constant current measurements as the boats move. In very deep areas, they can be lowered on a cable from the surface.

Acoustic Doppler Current Profiler (ADCP)

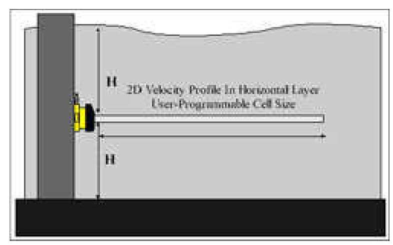
How does it work?

The ADCP measures water currents with sound, using a principle of sound waves called the Doppler effect. A sound wave has a higher frequency, or pitch, when it moves to you than when it moves away. You hear the Doppler effect in action when a car speeds past with a characteristic building of sound that fades when the car passes.



HOW THE ADCP WORKS: A Sontek figure showing what happens to the frequency of sound waves when they reflect off of moving objects. (Courtesy of Sontek)

The ADCP works by transmitting "pings" of sound at a constant frequency into the water. (The pings are so highly pitched that humans and even dolphins can't hear them.) As the sound waves travel, they ricochet off particles suspended in the moving water, and reflect back to the instrument. Due to the Doppler effect, sound waves bounced back from a particle moving away from the profiler have a slightly lowered frequency when they return. Particles moving toward the instrument send back higher frequency waves. The difference in frequency between the waves the profiler sends out and the waves it receives is called the Doppler shift. The instrument uses this shift to calculate how fast the particle and the water around it are moving.



HOW THE ADCP WORKS: A Sontek cartoon of an ADCP being used to measure a horizontal current profile. (Courtesy of Sontek)

Sound waves that hit particles far from the profiler take longer to come back than waves that strike close by. By measuring the time it takes for the waves to bounce back and the Doppler shift, the profiler can measure current speed at many different depths with each series of pings.

What platforms are needed?

ADCPs that are bottom-mounted need an anchor to keep them on the bottom, batteries, and an internal data logger. Vessel-mounted instruments need a vessel with power, a shipboard computer to receive the data, and a GPS navigation system (so the ship's own movements can be subtracted from the current data). ADCPs have no external read-out, so the data must be stored and manipulated on a computer. Software programs designed to work with ADCP data are available.

Advantages and limitations?

Advantages:

- In the past, measuring the current depth profile required the use of long strings of current meters. This is no longer needed.
- Measures small scale currents
- Unlike previous technology, ADCPs measure the absolute speed of the water, not just how fast one water mass is moving in relation to another.
- Measures a water column up to 1000m long

Disadvantages:

- High frequency pings yield more precise data, but low frequency pings travel farther in the water. So scientists must make a compromise between the distance that the profiler can measure and the precision of the measurements.
- ADCPs set to "ping" rapidly also run out of batteries rapidly
- If the water is very clear, as in the tropics, the pings may not hit enough particles to produce reliable data
- Bubbles in turbulent water or schools of swimming marine life can cause the instrument to miscalculate the current
- Users must take precautions to keep barnacles and algae from growing on the transducers.

Sources:

- Frank Bahr, research specialist in the Physical Oceanography Department at WHOI
- Jim Culter, program manager of the Benthic Ecology Department at Mote Marine Laboratory
- SonTek: www.sontek.com/princop/adp/adppo.htm
- RD Instruments: www.rdinstruments.com/products.html - particularly the ADCP (BroadBand) Practical Primer

Last updated: February 24, 2007

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How Do Scientists Collect Measurements at Different Depths?

Moorings are stationary platforms that can carry multiple instruments to collect data both above and below the ocean surface. One of the major goals of SPURS is to deploy an array of three oceanographic moorings; a single Woods Hole Oceanographic Institution (WHOI) surface flux mooring and two Pacific Marine Environmental Laboratory (PMEL) Prawler moorings. These moorings will be deployed for one year, collecting information on the central part of the study area.

Each mooring is made up of two parts: a surface buoy and a subsurface mooring wire. The surface buoy measures meteorological parameters like wind speed, solar radiation, and humidity, which indicate how the ocean is interacting with the atmosphere. Multiple instruments are attached to the subsurface mooring wire for collection of data throughout the water column. Visit WHOI for videos and interactive multimedia on moorings and buoys.

Featured Video: Why the Top Centimeter Matters

Why the Top Centimeter Matters

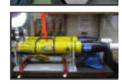
from **COSEE Ocean Systems** PLUS

02:22

Dr. Eric Lindstrom explains the importance of the top centimeter in understanding the whole ocean
[view transcript]


Setting the Properties of the Ocean
Dr. Tom Farrar
[vimeo, 04:55]


Sampling the Ocean Surface
Dr. David Fratantoni
[vimeo, 01:41]


Getting a Complete Picture
Dr. David Fratantoni
[vimeo, 01:31]

view all videos in this album [vimeo]

Types of Stationary Platforms
(Click images for enlarged views)

WHOI Surface Flux Mooring

What does it do? Surface flux moorings collect surface measurements of atmospheric parameters, radiation, turbulence, evaporation, waves, and precipitation and subsurface measurements of current direction and speed, temperature, and salinity. **How does it work?** The surface buoy is made up of an Air-Sea Interaction METeorology (ASIMET) System, consisting of seven sensors that measure how energy and water move between the ocean and atmosphere (read more about the ASIMET System here). The ASIMET system sits in a large foam float, which is attached to the subsurface mooring line. The subsurface mooring line has multiple instruments attached to take measurements down to 500m below the surface.

Prawler (Profiler + Crawler = Prawler) Mooring

What does it do? A Prawler mooring obtains a vertical profile of conductivity, temperature, and depth using a single sensor. **How does it work?** The Prawler part of the mooring is a single, subsea instrument that uses wave-powered technology to move up and down a mooring line. After the Prawler reaches its pre-programmed bottom depth, a ratcheting mechanism harnesses the wave motion to crawl up the mooring line to the top before starting the process over again. Click here for a schematic of the Prawler mooring and instrument.

This material is based upon work supported by NASA under NASA Jet Propulsion Laboratory Subcontract No. 1459277. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

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Mooring Deployment

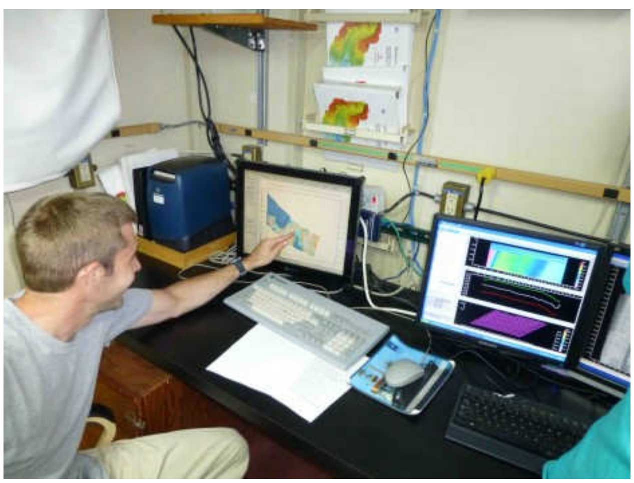
September 17th, 2012 by Maria-Jose Viñas

By Eric Lindstrom

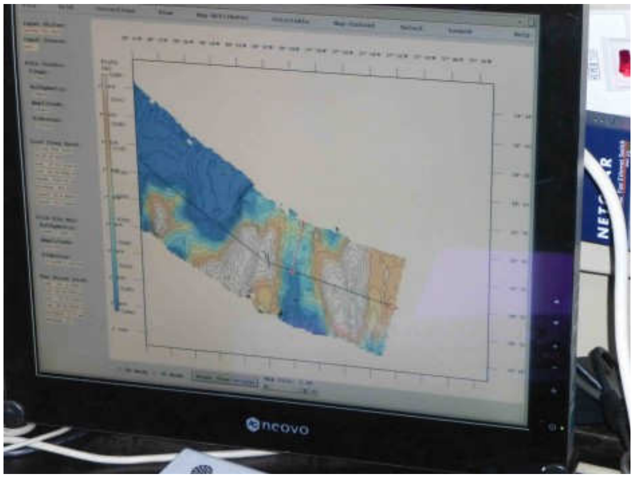
Your SPURS blogger, Eric Lindstrom, showing off the NASA logo on the surface buoy.

The central mooring at the SPURS site is a critical piece of gear. It will provide us with a time series of upper ocean properties at one location over the entire year. We'll build the other SPURS measurements around this spot on this and future voyages. We'll "fly" the gliders in patterns centered on this location.

Our first order of business is to survey the bottom depth in the vicinity of the proposed mooring location (near 25N, 38W). The water depth we are aiming for is near 17,390 feet (5,300 meters).



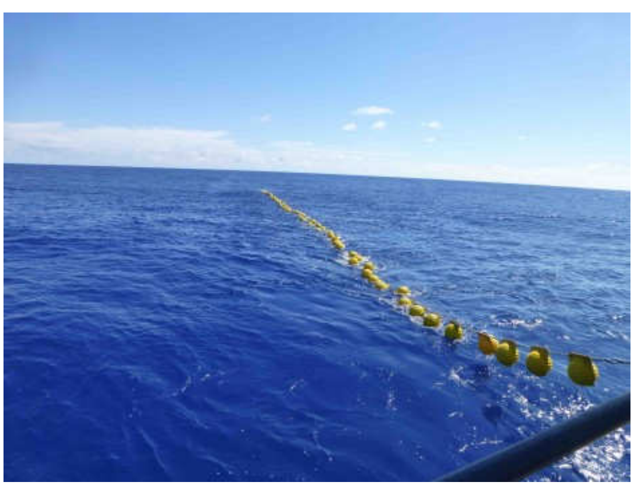
Tom, working on the survey of bottom depths prior to mooring deployment.



Seabeam maps the bottom along a swath 8 miles wide.

The mooring is anchored to the bottom (with a 10,000 pound anchor). A large, heavily-instrumented buoy at the surface holds the entire string of instruments below. Just above the anchor is an acoustic release mechanism that can disengage the mooring from the anchor on command from the ship next year. Above the release are 80 glass floats (inside hardhats) that serve to float the bottom of the mooring to the surface after release.

80 glass floats in hardhats go at the bottom of the surface mooring.



The glass floats at the bottom of the WHOI mooring, trailing behind the R/V Knorr.

February 2012
January 2012
December 2011
November 2011
October 2011
September 2011
August 2011
May 2011
April 2011
March 2011
February 2011
August 2010
July 2010
June 2010
April 2010
March 2010
February 2010
September 2009
August 2009
July 2009

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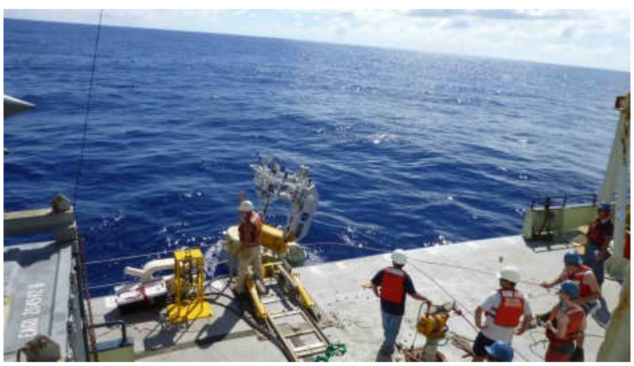
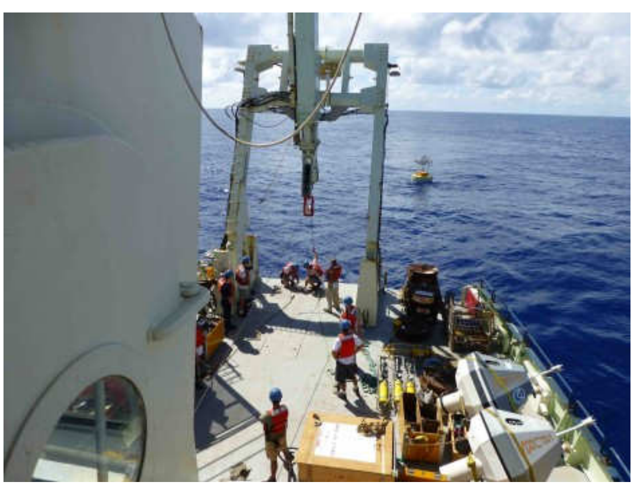
It's a process of many hours to deploy the mooring. The ship will position itself some miles from the proposed anchoring site (depending on wind and currents) and start steaming toward the spot very slowly. The length of mooring and gear are then deployed over the stern starting with the top of the mooring, the surface buoy. After that various current meters, salinity and temperature sensors are attached in turn with various lengths of chain and shackles. As they are joined, they are in turn lowered over the stern and the surface buoy begins to distance itself in the ship's wake. About 8 hours after the start of the deployment, the 16,000 feet of mooring is laid out on the surface behind the ship, and all that's left on deck is the anchor.

At this point, location is everything. If timed correctly, the ship will be some distance past the location mooring intended to land on the bottom (say 10 percent of the water depth). If so, it is time to drop the anchor. As it falls, the length of mooring will drag it back toward the spot it will finally come to rest. We will see the surface buoy begin to rush swiftly back toward the ship (hopefully finishing up at its intended target location).

Lifting the WHOI buoy for deployment.



The buoy is away!



The mooring wire and equipment are gradually added.

Such work has been done thousands of times over the decades, but every deployment presents its own challenges of ocean bottom topography, wind, currents, and equipment. The length of the mooring needs to precisely cut for the water depth in which it is anchored. If it is too long, the mooring swings around too much at the surface. If it is too short, the mooring may be under too much stress or snap.

Tags: Atlantic, buoy, mooring, salinity, SPURS

This entry was posted on Monday, September 17th, 2012 at 10:57 am and is filed under Salinity Processes in the Upper Ocean Regional Study (SPURS). You can follow any responses to this entry through the RSS 2.0 feed. Both comments and pings are currently closed.

4 Responses to "Mooring Deployment"

Phoebe Jekielek says:
September 18, 2012 at 9:37 am

Hi Eric! So exciting that the moorings are being deployed, congrats to all of you! I have a question about the floats…why use glass floats protected in hard hats? Why not just make some sort of plastic float/buoy? Just interested. Thanks!

Eric Lindstrom says:
September 18, 2012 at 12:19 pm

Hi Phoebe,
That is an excellent question. Let me explain the role of the 80 glass floats in hard hats.

The glass floats are at the bottom of the ocean (~17000 feet) just above the release mechanism. The idea is to have enough buoyancy at the bottom of the mooring to bring the bottom end to the surface in case the surface buoy is lost and for ease of recovery if things go well (the bottom end is where you would like to start recovery operations).

The surface buoy is the part most at risk from weather, ship strike, vandalism, etc. And the most likely place for the mooring to break is right under the surface buoy where wave action keeps parts moving and wearing. IF the surface buoy is lost, ALL the instruments suspended below the surface buoy (mostly in the top 1000 feet of ocean) will fall to the sea bottom. They can still be recovered later because of the glass floats in hard hats are at the bottom of the string. All the instruments on the mooring are built to withstand the pressures found at the ocean bottom, so data collected before the loss of the surface buoy is recoverable.

Why hard hats? The glass floats are precision-built spheres designed to withstand great pressure. Any scratch or imperfection could lead to their implosion at depth. The force of one imploding is known to be enough of a disturbance to cause other nearby floats to fail. However, loss of a few glass floats will not deter recovery operations. The hard hats provide secure points to chain the glass floats together as well as much needed protection during their lifetime of service.

I hope that answers your question!
Eric

Alba Ragone says:
September 19, 2012 at 6:11 am

Date: 18/09/2012

Hello and thank you for the opportunity to communicate with interested parties and experts on the SPURS project and scientists on board the Knorr research vessel.

I am Alba Ragone, a research scientist in the department of Civil Engineering, at Glasgow Strathclyde University in Scotland UK. Working on a project called "link between seawaters salinity changes and Octanol-water partition coefficient for POPs".

Therefore, I am following SPURS progress and data update with absolute interest; and as your project is collecting actual, site-specific data (salinity, pH and temperature changes) in Marine waters. Consequently, I would like to ask the following questions.

1) Is the SPURS project, is analyzing Persistent Organic Pollutants (POPs) levels in your Seawater samples?

2) If sampling for these compounds is outside SPURS' agenda, is it possible for the SPURS project to collect water samples and send these to us for analysis, at Glasgow Strathclyde University.

Analyzing actual Sea and Oceanic-water, sampled at different locations for the presence of POPs, would help further environmental research on the trans-boundary dispersion of POPs by means of the Sea and Oceanic waters currents'. Therefore, the SPURS expedition to the Atlantic Ocean "Saltiest Spot"; and program for sampling and data collection, together with the subsequent expedition in 2015 to areas of "low saltiness" is a very important, and could facilitate collection of additional data.

I thank you very much for your kind attention and look forward to your correspondence.

Yours sincerely,

Alba Ragone

Eric Lindstrom says:
September 19, 2012 at 5:02 pm

Alba,
Thank you for your interest in SPURS. Its not very often that a research vessel gets out to study the saltiest water in the North Atlantic! In the spirit of scientific cooperation and opportunity, we are interested in helping you. However, we will need to know more about the sampling requirements and protocol and thereafter assess our ability to meet the need and return useful samples. I will be in contact via email for further discussion of the details.
Eric

Notes from the Field
« Seaglider #189 Away! Plastic Ocean »

National Oceanic & Atmospheric Administration For more information: (206) 526-6239 // pico@noaa.gov

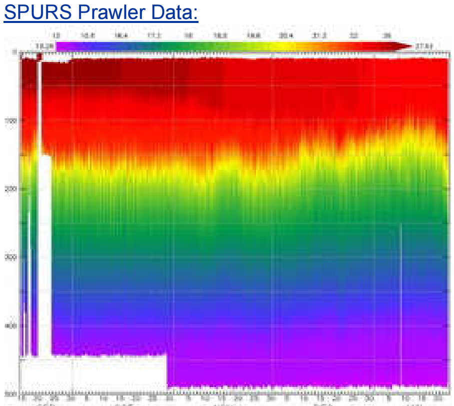
PICO Platform and Instrumentation for Continuous Observations

Technology

PICO is the evolution of over 30 years of experience at PMEL with deep ocean moorings. Its primary components include:

1. Anchor and Mooring Line: The patented* compound synthetic mooring line has several unique elements that are seamlessly manufactured in one continuous piece. It's then spooled onto a steel reel under tension and placed in a steel box that serves as a bobbin holder, a pallet, and anchor for the buoy. During deployment, the line is drawn off the outside of the reel, through a path of sheaves, and out the center of the anchor. As the anchor falls to the ocean floor, the line is spooled out automatically and without kinks and hockles. Typical mooring scope is between 1.10 to 1.45 depending on the mission, water depth and oceanic conditions.
2. Buoy: The octagonal buoy hull is a simple fabrication with a galvanized steel framework, structural foam core and tough polyurea skin. It has solid sea keeping characteristics due to a strong righting moment and sharp chines, and a stealthy, vandal resistant cowling. Electronics are housed in a large central fiberglass well.
3. Prawler: The Prawler (Profiler + Crawler) is a wave-powered subsea instrument that eliminates the need for multiple sensors on the mooring line. Prawler is housed inside the buoy during shipping and is automatically released after the system is dropped into the water. During descent, it makes a CTD profile and communicates those via inductive modem to the surface buoy. Once reaching the pre-determined bottom depth (~500m) a micro-processor activates a ratcheting mechanism and harnesses the wave motion to crawl up the mooring line.

SPURS Prawler Data:



PICO Buoy and Anchor Assembly

Watch the PICO advantage in action

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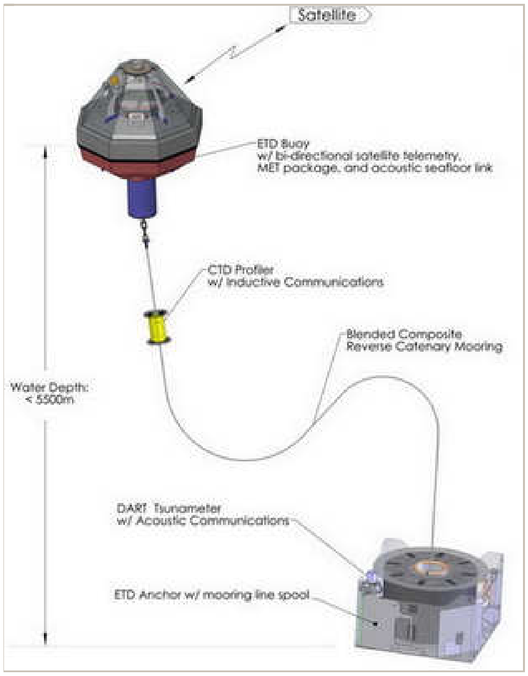
NOAA's Strategic Plan for 2005-2010 calls for "development of ...an integrated global-to-local environmental and ecological observation ... system that will continually monitor the ... ocean, atmosphere and land."

PICO Buoy and Anchor Assembly



PICO - FLEXIBLE LOW-COST OCEAN OBSERVATONS

Water column profiling with wave-powered instrumented mooring line prawler

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How Do Scientists Collect Measurements in Different Areas?

SPURS has a number of free-drifting platforms that carry instruments to measure salinity, temperature, density, and the velocity of ocean currents. After deployment, some of these platforms drift along at the surface, while others adjust their buoyancy to move up and down the water column. All move about at the mercy of the currents.

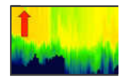
Featured Video: Communicating With Floats

Communicating With Floats

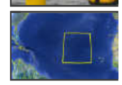
from **COSEE Ocean Systems** PLUS

00:37

Jesse Anderson discusses how researchers are able to remotely modify the sampling strategies of ARGO floats [view transcript]


ARGO Float Modifications
Jesse Anderson
[vimeo, 01:28]


Sampling Around
Dr. Andrey Shcherbina
[vimeo, 01:31]


From Millimeters to Kilometers
Dr. David Fratantoni
[vimeo, 01:13]

view all videos in this album [vimeo]

Types of Free-Drifting Platforms
(Click images for enlarged views)

Lagrangian Drifter

What does it do? A Lagrangian drifter measures radiation, conductivity, and temperature in deep (50-100m) and shallow (upper 10m) water. They can also be programmed to stay within a certain body of water to measure vertical turbulence and energy fluxes. **How does it work?** Like the Argo floats, a Lagrangian drifter modifies its buoyancy to collect vertical measurements. Extra drogues allow it to drift freely in the ocean, thereby collecting data in the horizontal direction as well. (A drogue is a device on a drifter that acts like an underwater sail. When pushed by an ocean current, the drogue helps a drifter move with the flow of water. Without a drogue, drifters become subject to wind and wave action.)

Surface Drifter

What does it do? Surface drifters measure salinity, temperature, air pressure, wind speed, and direction, and track currents at depths up to 100m. In SPURS, they are being used to track large scale ocean currents and eddy fields. **How does it work?** Each drifter is made up of three parts: the drogue, the surface float, and a connecting tether. A GPS tracking unit and the scientific instruments are be found in the float, which remains at the surface. The connecting tether or line connects the float to the drogue. The drogue hangs down from the tether and creates drag in order to anchor the drifter to the desired parcel of water to be measured. The deeper the water to be measured, the longer the drogue.

Profiling Float

What does it do? Profiling floats continuously measure the temperature, salinity, and velocity of currents in the upper ocean. These floats form part of the Argo global program, an international collaborative of 3,000 free-drifting profiling floats that measure the upper 2000m of the ocean. Twenty six floats will be deployed during SPURS, each containing two CTD sensors for high-resolution readings and novel acoustic sensors for measuring rainfall and surface wind. **How does it work?** Profiling floats are battery-powered autonomous vehicles that modify their buoyancy to move vertically through the water column. Once deployed to a target depth, the drifting float will adjust its bouyancy to ascend, taking measurements along the way. At 10-day intervals, the float rises to the surface to transmit its data to a satellite before beginning the process again.

This material is based upon work supported by NASA under NASA Jet Propulsion Laboratory Subcontract No. 1459277. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

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SVP LAGRANGIAN DRIFTERS

SVP drifters track currents at depths of 2 to 50 meters, and are equipped to accommodate a range of additional sensors.

Standard drifter sensor configurations include sea surface temperature, air pressure, wind velocity, and salinity

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SVP Specification Sheet (PDF)

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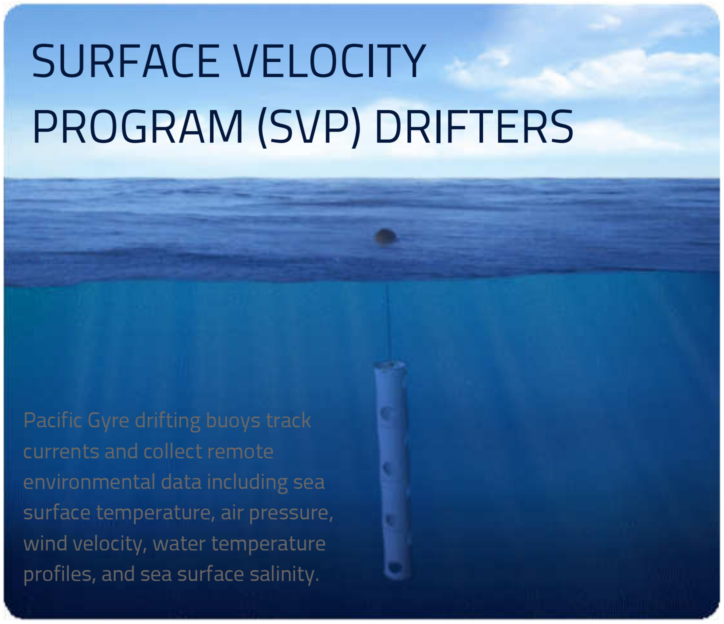

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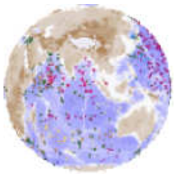

Argo

How Argo floats work

part of the integrated global observation strategy

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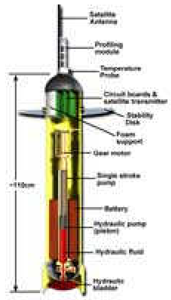
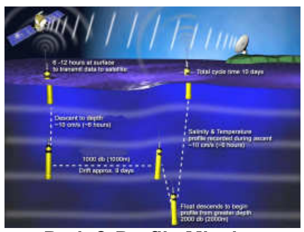
Argo Steering Team



Float Design



Park & Profile Mission Operation

Argo Floats

Argo is an international collaboration that collects high-quality temperature and salinity profiles from the upper 2000m of the ice-free global ocean and currents from intermediate depths. The data come from battery-powered autonomous **floats** that spend most of their life drifting at depth where they are stabilised by being neutrally buoyant at the "parking depth" pressure by having a density equal to the ambient pressure and a compressibility that is less than that of sea water. At present there are several models of profiling float used in Argo. All work in a similar fashion but differ somewhat in their design characteristics. At typically 10-day intervals, the floats pump fluid into an external bladder and rise to the surface over about 6 hours while measuring temperature and salinity. Satellites or GPS determine the position of the floats when they surface, and the floats transmit their data to the satellites. The bladder then deflates and the float returns to its original density and sinks to drift until the cycle is repeated. Floats are designed to make about 150 such cycles.

Argo Mission

The standard Argo mission is a **park and profile mission** where the float descends to a target depth of 1000m to drift and then descends again to 2000m to start the temperature and salinity profile. In the beginning of 2014, 80% of floats profile to depths greater than 1500m. Another 12% profile to between 1000 and 1500m.

Argo Float Models

The Argo array is currently comprised of several float models: the **PROVOR** and the **ARVOR** built by NKE-INSTRUMENTATION in France in close collaboration with IFREMER, the **APEX** float produced by Teledyne Webb Research, the **SOLO** float designed and built by Scripps Institution of Oceanography, USA and the **S2A** float built by MRV Systems in the USA.

The ARVOR is a new generation PROVOR float and the S2A is a new generation SOLO float. The **NAVIS** is a new float being built by Sea-Bird in the USA.

The **SBE** temperature/salinity sensor suites is now used almost exclusively. In the beginning, the **FSI** sensor was also used. The temperature data are accurate to a few millidegrees over the float lifetime. For discussion of salinity data accuracy please see the **Data FAQ**.

Argo Data Transmission

As the float ascends, a series of about 200 pressure, temperature, salinity measurements are made and stored on board the float. These are transmitted to satellites when the float reaches the surface. For floats using high speed communications with more bandwidth capabilities, measurements are taken more frequently, often up to every 2db, resulting in several hundred measurements per profile.

For 70% of floats in the Argo array the data are transmitted from the ocean surface via the **Système Argos** location and data transmission system. The data transmission rates are such that to guarantee error free data reception and location in all weather conditions the float must spend between 6 and 12 hrs at the surface. Positions are accurate to ~100m depending on the number of satellites within range and the geometry of their distribution.

An alternative system to Argos using positions from the Global Positioning System (GPS) and data communication using the **Iridium** satellites now comprises 30% of the Argo array. Iridium is becoming a more attractive option as it allows more detailed profiles to be transmitted with a shorter period at the surface and even two-way communication. In 2013, 60% of floats were been deployed with Iridium antennas and 40% with Argos antennas.

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How do scientists measure ocean characteristics?

How do scientists collect measurements at different depths?

How do scientists collect measurements in different areas?

How are robots used to study salinity?

How do scientists use models to study ocean salinity?

How are Robots Used to Study Salinity?

There are four different types of robotic autonomous underwater vehicles (AUVs) to be used on SPURS. All of them have the ability to take multi-scale measurements of ocean temperature, salinity, and other water properties. Three of them take these measurements at various depths below the ocean surface, while the fourth remains at the surface. The advantage of these autonomous platforms is that it allows scientists to magnify what can be done from a research vessel. Humans are not able to stay on site in the middle of the ocean for a year, but these robots can! All of the information from these sensors is fed back to shore where it is integrated into a coherent picture of what the ocean is doing, on scales ranging from the entire Atlantic to a single cubic centimeter.

Featured Video: Seagliders and Profilers

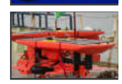
Seagliders and Profilers

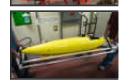
from **COSEE Ocean Systems** PLUS

02:54

Dr. Lou St. Laurent discusses seagliders (with a comparison to the Slocum glider) and the vertical microstructure profiler (VMP) [view transcript]


Slocum Gliders
Dr. Lou St. Laurent
[vimeo, 01:32]


Eco_Mappers and Wave Gliders
Dr. David Fratantoni
[vimeo, 02:13]


How Gliders Work
Dr. Andrey Shcherbina
[vimeo, 01:08]

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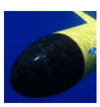
Types of Robotic AUVs

(Click images for enlarged views)

IVER 2/Eco-Mapper

What does it do? The Eco-Mapper carries the instruments that measure the spatial structure of the upper ocean. **How does it work?** The Eco-mapper is similar to a small submarine. Unlike other gliders, it is propeller driven and uses energy stored on board in the form of batteries. The propellers drive the vehicle forward at 3-4 knots for 3-4 hours while the on-board instruments collect high-resolution measurements of temperature, salinity, and other water properties at scales ranging from a few kilometers to a few tens of meters.



Slocum Glider

What does it do? These gliders carry microstructure sensors that measure very fine-scale changes in salinity and temperature. They will remain in the water for several weeks while the *R/V Knorr* is in the SPURS study region and will be recovered as scientists leave the area. **How does it work?** A Slocum glider is buoyancy driven and uses very little battery power. To rise, it expels water from an inside chamber (this increases buoyancy); to sink, it takes water into the chamber (this decreases buoyancy). They have rigid wings on the side to help the glider sink slowly at an angle, and no external moving parts. Data is transmitted at the surface via an iridium antenna.

Seaglider

What does it do? Seagliders carry instruments that collect continuous measurements of temperature and salinity. Three will be deployed for six months at SPURS, then recovered and replaced with three new gliders. **How does it work?** The Seaglider works similarly to a Slocum glider, changing its buoyancy to move up and down in the water column and transmitting data at the surface via antenna. Different from the Slocum, these gliders use oil, rather than water to manipulate buoyancy. Because they will be out for so long, they will provide a continuous one-year record of temperature and salinity over a 100-150 kilometer square area of the middle Atlantic Ocean. Read more about Seagliders and the first Seaglider launch on the SPURS cruise blog.

Wave Glider

What does it do? A wave glider measures temperature and salinity while floating at the ocean surface. **How does it work?** The wave glider is an environmentally powered vehicle: surface waves provide all of the energy for forward propulsion while the electronics, sensors, and communication needs on board are powered by batteries recharged by solar cells. Wave gliders consist of a surface platform connected to fins that dangle approximately 20 feet below the surface. These gliders will operate in the SPURS region for about a year, with minimal course corrections applied from land. The gliders call in via satellite phone about every five minutes thereby providing real-time data on near-surface ocean temperature and salinity on a continuous basis. Watch a video of a wave glider here!

This material is based upon work supported by NASA under NASA Jet Propulsion Laboratory Subcontract No. 1459277. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

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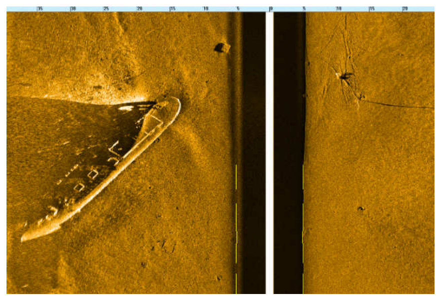
OceanServer
IVER2 Autonomous Underwater Vehicle

OceanServer builds the first commercially developed family of low cost Autonomous Underwater Vehicles (AUVs), Iver, ideal for coastal applications such as sensor development, general survey work, sub-surface security, research and environmental monitoring. These modern AUVs are single man-portable and feature simple point and click mission planning.



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(Iver AUV Product Information)

Slocum Glider

Conceived by Douglas C. Webb and supported by Henry Stommel and others, the class of Slocum Gliders is named after Joshua Slocum, the first man to single-handedly sail around the world.

The Slocum Glider is a uniquely mobile network component capable of moving to specific locations and depths and occupying controlled spatial and temporal grids. Driven in a sawtooth vertical profile by variable buoyancy, the glider moves both horizontally and vertically.

The long-range and duration capabilities of Slocum gliders make them ideally suited for subsurface sampling at the regional scale. Carrying a wide variety of sensors, they can be programmed to patrol for weeks at a time, surfacing to transmit their data to shore while downloading new instructions at regular intervals, realizing a substantial cost savings compared to traditional surface ships.

The small relative cost and the ability to operate multiple vehicles with minimal personnel and infrastructure will enable small fleets of gliders to study and map the dynamic (temporal and spatial) features of subsurface coastal waters around the clock and around the calendar.

» More about Slocum
» Slocum Electric Glider
» Slocum Thermal Glider

SEAGLIDER

APPLIED PHYSICS LABORATORY
University of Washington

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Electronic and Information Systems Dept.
Applied Physics Laboratory
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Seagliders fly through the water with extremely modest energy requirements using changes in buoyancy for thrust coupled with a stable, low-drag, hydrodynamic shape. Designed to operate at depths up to 1000 meters, the hull compresses as it sinks, matching the compressibility of seawater.

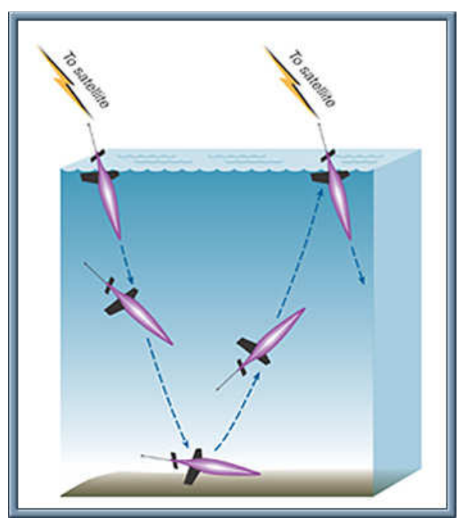
The autonomous underwater vehicle (AUV) Seaglider is the result of a collaborative effort between APL-UW and the UW School of Oceanography. These small, free-swimming vehicles can gather conductivity-temperature-depth (CTD) data from the ocean for months at a time and transmit it to shore in near-real time via satellite data telemetry.

Seagliders make oceanographic measurements traditionally collected by research vessels or moored instruments, but at a fraction of the cost. They can survey along a transect, profile at a fixed location, and can be commanded to alter their sampling strategies throughout a mission.

Seaglider's cylindrical hull is a series of arched anodized aluminum panels separated by ring frames. The hull is surrounded by a fiberglass fairing to give it a low drag shape.

After each dive Seaglider dips its nose to raise its antenna out of the water. It determines its position via GPS, calls in via Iridium data telemetry satellite, uploads the oceanographic data it just collected, then downloads a file complete with any new instructions.

Seaglider is 1.8 m long and weighs 52 kg—a size and weight that allow easy launching and recovery by two people from a small boat.



Seaglider can travel at slopes as gentle as 1:5 or as steep as 3:1. At gentle glide slopes the vehicle transits most efficiently, while steeper slopes are used to maintain position and act as a "virtual mooring."

LIQUID ROBOTICS

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"Our world makes progress through the invention of simple, yet game-changing technologies. Liquid Robotics is one of these game-changers."

- Dr. Marv Langston, former deputy assistant secretary of defense, USDOD

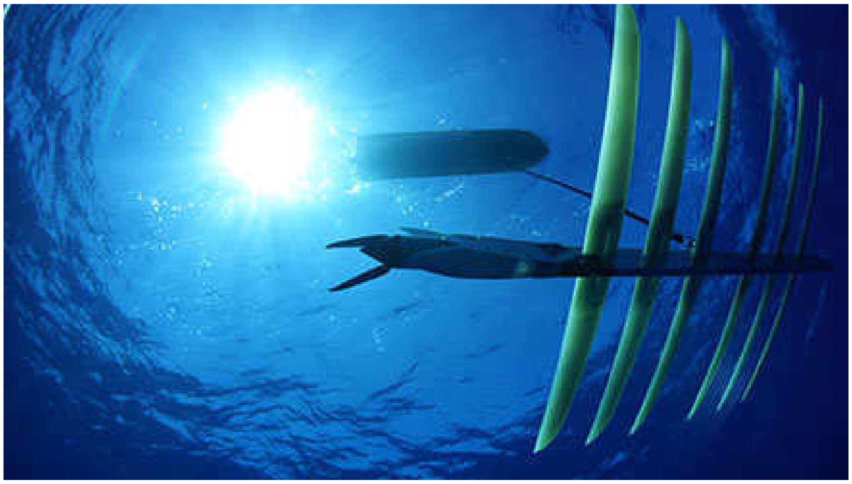
Converting wave motion to propulsion

Wave motion is greatest at the water's surface, decreasing rapidly with increasing depth. The Wave Glider's unique two-part architecture exploits this difference in motion to provide forward propulsion.

A little bit of extra get-up-and-go.

The Wave Glider SV3 leverages the design principle of the highly successful Wave Glider SV2 platform, while adding a hybrid power and propulsion system that uses both wave-powered and stored solar energy to navigate challenging ocean conditions (doldrums, high currents, and hurricanes/cyclones) in which it was previously too challenging or costly to operate.

The Wave Glider SV3's auxiliary vectored thruster is used for extra speed to address difficult ocean conditions, or to quickly accommodate changes in mission operations.



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Drones Come to the High Seas

CNN Money
April 11, 2013

Where data is concerned -- that is, where usable, potentially profitable data -- the world's oceans are somewhat akin to black holes...

Cleantech 100 Case Study

The Guardian
October 9, 2013

Manned ocean exploration is dangerous and expensive, so Liquid Robotics created an emission-free robot to survey the sea for government and commercial customers...

Bright Ideas for a Brighter Future

Time Magazine
September 11, 2012

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Patents

Liquid Robotics holds 5 U.S. and 14 foreign patents relating to its technology. These include:

Chile (48.628); China (2011 101405179); Egypt (25194); Indonesia (P0027767); Israel (192828); Japan (2009533257); New Zealand (570562 and 592743); Singapore (144487); South Africa (200806769); United States (7,371,136; 7,641,524; 8,043,133 and 8,287,323).

Additional U.S. and non-U.S. patent applications pending.

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Live Chat

How Do Scientists Use Models to Study Ocean Salinity?

Computer models are used by scientists to make predictions about certain oceanographic processes. For the SPURS cruise, oceanographers use these models to observe salinity changes along the cruise track and they also use them as a forecast, much like weather forecasts, to know exactly where certain water features will occur (for instance, predicting the location of an eddy they want to locate). The models are powered with years of collected data, that allow scientists to make comparisons over time and gives them the ability to track changes in ocean events.

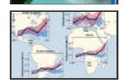
Featured Video: Forecasts and Nowcasts

Model Forecasts and Nowcasts
from **COSEE Ocean Systems** PLUS

01:44

Dr. Fred Bingham discusses how SPURS data are used in models to produce forecasts and nowcasts
[view transcript]


How the Source Affects the Sink
Dr. Lisan Yu
[vimeo, 04:11]


Near Real Estimates of Fluxes
Dr. Lisan Yu
[vimeo, 01:46]

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