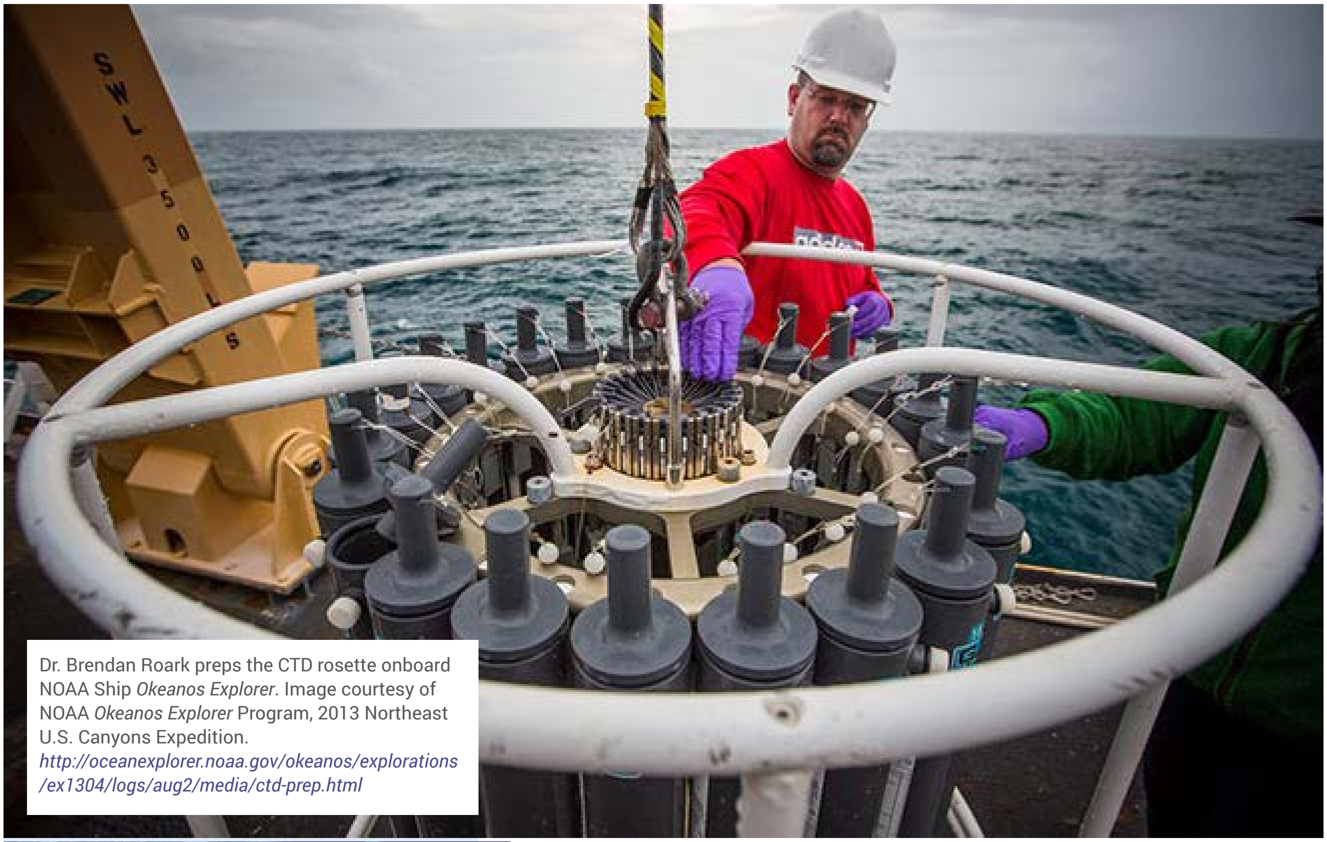
Introduction to Water Column Investigations

The "water column" extends from the ocean surface to the seafloor. The water column usually refers to the volume of water underlying a specific area of Earth's ocean. In the broadest sense, the water column may mean the entire volume of water in the ocean, from coast to coast. Because the ocean covers 71% of Earth's surface with an average depth of nearly 4 km, the water column is the largest habitat for life on this planet. A variety of technologies are used to explore the water column, including:

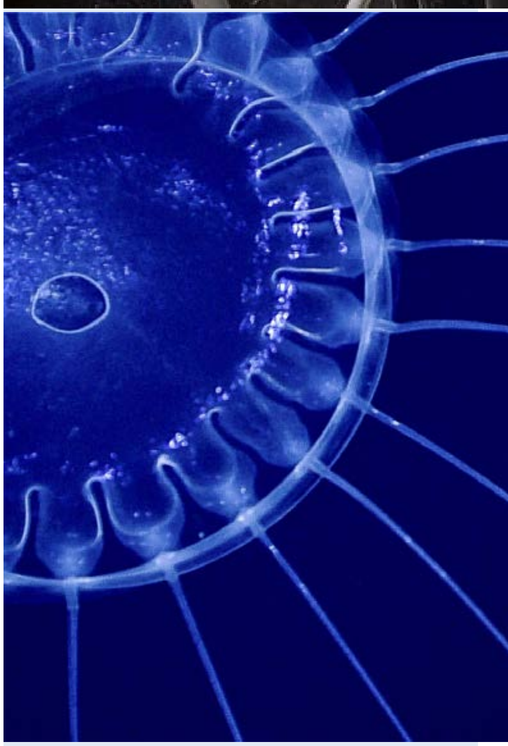
Nets and other devices to capture living organisms -- Animals in the water column were first studied using trawl nets, which is still a primary technology for obtaining specimens of animals large enough to be captured in the net. Plankton nets have a much smaller mesh than trawl nets, and are used to capture phytoplankton (microscopic plants) and small zooplankton (including larvae of many species as well as animals that are very small for their entire lives). Other capture devices include pumps combined with mesh filters, and various types of sampling bottles designed to collect water samples from specific depths. The latter method has been widely used to collect phytoplankton.

Sonar -- SOund NAvigation and Ranging (sonar) systems consist of transmitters that send pulses of sound energy through the water and receivers that detect return signals (echoes) that are reflected back from the seafloor or other objects. Modern ocean exploration vessels use several types of sonar for mapping, detecting smaller objects (fish-size to bubble-size) objects in the water column, measuring the speed and direction of ocean currents, and to obtain details about sediment layers below the seafloor.
For additional details, please see the *Introduction to Sonar and Multibeam Mapping* *http://oceanexplorer.noaa.gov/okeanos/edu/collection/media/hdwe-MMBkgnd.pdf*.

Water samples are collected from the Niskin bottles on the CTD. All 20 Niskin bottles take water samples from various depths, starting near the seafloor and ending close to the surface. Photo courtesy of Caitlin Bailey, GFOE, The Hidden Ocean 2016: Chukchi Borderlands.
http://oceanexplorer.noaa.gov/explorations/16arctic/logs/july24/media/shipton.html



Dr. Brendan Roark preps the CTD rosette onboard NOAA Ship *Okeanos Explorer*. Image courtesy of NOAA *Okeanos Explorer* Program, 2013 Northeast U.S. Canyons Expedition.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1304/logs/aug2/media/ctd-prep.html



Solmissus jellyfish observed during midwater transects during Dive 17 of the Deep-Sea Symphony: Exploring the Musicians Seamounts expedition. Image courtesy of the NOAA Office of Ocean Exploration and Research, Deep-Sea Symphony: Exploring the Musicians Seamounts.
http://oceanexplorer.noaa.gov/okeanos/explorations/ex1708/dailyupdates/media/sept23-2.html

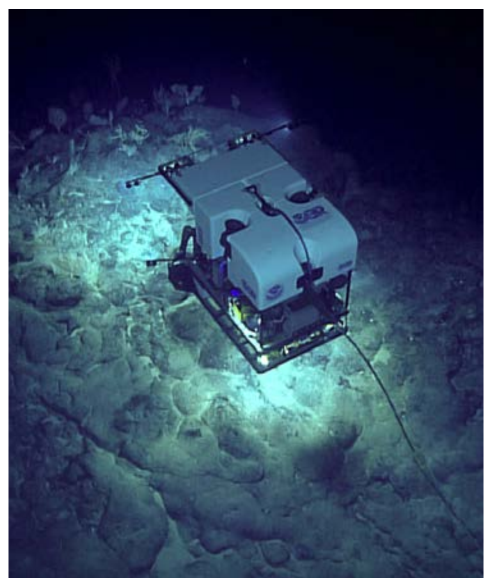
CTDs and Electronic Sensors -- Just as bathymetry of the ocean floor is essential knowledge for ocean explorers, it is equally important to know the physical and chemical properties of the water column. Scientists use the term “water mass” to describe a parcel of water that has similar properties. By measuring certain physical and chemical properties of seawater, oceanographers are able to identify and track water masses to understand how water circulates around the ocean. Temperature and salinity are the two main properties used to identify water masses, and are probably the most common measurements made in the ocean.

A CTD is a package of electronic devices that measure conductivity, temperature, and depth. Devices to measure other parameters also may be included, but the package is still called a CTD. Conductivity is a measure of how well a solution conducts electricity and is directly related to salinity, which is the concentration of salt and other inorganic compounds in seawater. Salinity is one of the most basic measurements used by ocean scientists. When combined with temperature data, salinity measurements can be used to determine seawater density, which is a primary driving force for major ocean currents. CTDs are often attached to a much larger metal frame called a rosette, which may hold water sampling bottles that are used to collect water at different depths. Additional sensors may be included on a CTD, such as dissolved oxygen, fluorescence (used to measure chlorophyll concentration and color dissolved organic matter including oil), pH, optical backscatter (a measure of suspended particles), and many other chemical compounds. A traditional CTD-rosette system is typically lowered to depth just once at each station while the ship is stationary. CTD sensors and sonars can also be included on other types of platforms such as underwater vehicles and moorings.

Some localized water column areas are of particular interest. For example, fronts are areas where two different water masses come together. Fronts often coincide with large aggregations of animals from small zooplankton up to large fishes and marine mammals. Another example is water in the vicinity of hydrothermal vents (see *https://www.pmel.noaa.gov/eoi/PlumeStudies/plumes-whatis.html* for additional details). One way to detect hydrothermal vents is the "tow-yo" technique in which a CTD package is lowered to near the bottom, then the package is moved up and down from just above the seafloor to a few hundred meters above the ocean bottom as the ship slowly moves over the area being studied. Sudden changes in temperature or other chemical properties can signal the presence of hydrothermal vents (see *https://www.pmel.noaa.gov/eoi/PlumeStudies/WhatIsACTD/tow-yo-method.html* for additional details). In the past, NOAA Ship *Okeanos Explorer* has conducted tow-yo operations to detect anomalies in the water column, particularly in areas where scientists think there may be hydrothermal vents.

The forward-facing high-definition camera is the most commonly seen view from ROV *Seirios*. Image courtesy of NOAA OER, Deep-Sea Symphony: Exploring the Musicians Seamounts. *http://oceanexplorer.noaa.gov/okeanos/explorations/ex1708/logs/sept26/media/camera.html*

Underwater Vehicles -- Since the 1930's manned submersibles have been used to observe animals in the water column, though most submersible developments have focused on the seafloor. Today, remotely operated vehicles (ROVs) have almost entirely replaced manned submersibles as the primary means to directly access the deep sea. Advances in ROV technology have improved our understanding of water column animals by facilitating observations of animal behavior, enabling collections of live specimens in pristine condition, conducting manipulative experimentation, and assessing community composition. Technologies exist to collect delicate animals like jellyfish intact and conduct experiments on them underwater. Autonomous underwater vehicles (AUVs) are another type of unmanned underwater vehicle. Unlike ROVs, which are attached to a support vessel by a cable or tether, AUVs can operate without any direct connection to a ship. This independence means that AUVs can be programmed to accurately survey an underwater area for many hours without continuous human support. Underwater vehicles can be equipped with video photography equipment, sonars, CTDs, and a variety of other instruments. Please see the *Introduction to Remotely Operated Vehicles and Autonomous Underwater Vehicles* *http://oceanexplorer.noaa.gov/okeanos/edu/collection/media/hdwe-URintro.pdf* for additional details.



Much like its namesake, ROV *Seirios* acts as a brilliant source of light in the "night sky" of the ocean, providing illumination and a wide-angle view from above for its counterpart ROV *Deep Discoverer*. Image courtesy of NOAA OER Deep-Sea Symphony: Exploring the Musicians Seamounts. *http://oceanexplorer.noaa.gov/okeanos/explorations/ex1708/logs/sept26/media/dd2.html*

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