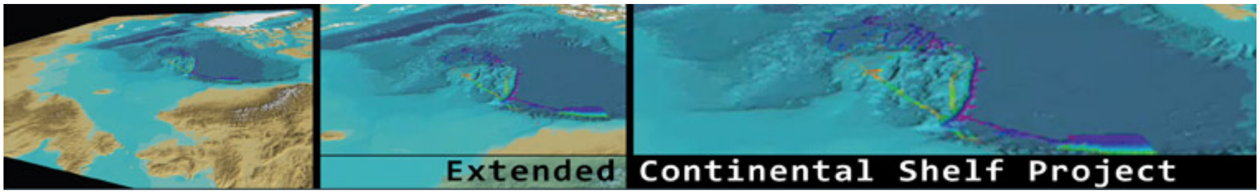
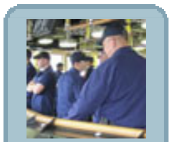



2010 Mission


Mission Plan


Law of the Sea


Continental Shelf


USCGC *Healy*


CCGS *Louis S. St-Laurent*


Healy's Science Team


Teachers

Deep CTD Cast, Part 2
Speed of Sound in Seawater

August 23, 2010

By Helen Gibbons, Web Coordinator,
ECS Project

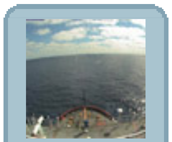
Date: August 23, 2010
Time: 1400 hours Pacific Daylight Time
Latitude: 79°04.67'N
Longitude: 144°04.54'W
Air temperature: 0.6°C (33°F)
Sea temperature: -1.7°C (29°F)
Wind speed and direction: 5 knots from the north-northeast
Ship's speed over the ground: 8.7 knots
Water depth: 3,807 m


24-bottle CTD rosette about to be lowered into the water. (From a CTD cast on August 9, 2010.) Click image for larger view. **Credit:** Helen Gibbons, USGS/ECS Project.

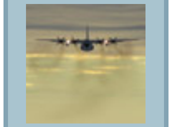

Package of CTD electronics and sensors (arrow) is mounted below a ring of water-collecting bottles. Click image for larger view. **Credit:** Helen Gibbons, USGS/ECS Project.

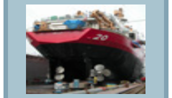
Two days ago, on August 21, we lowered a CTD rosette nearly to the floor of Canada Basin in the Beaufort Sea, about 360 nautical miles northeast of Barrow. It took almost an hour and a half to lower the rosette to a depth of 3,750 m, in a spot where the water depth was about 3,800 m. (The depths have been very monotonous as we map the abyssal plain of the Canada Basin, changing by only a few meters over a period of days—as Dale Chayes [Lamont-Doherty Earth Observatory, Columbia University] says, "It's flatter than a pool table.")

"CTD" stands for conductivity (used to calculate salinity), temperature, and depth—variables that sensors mounted at the bottom of the frame measure continuously as it is lowered through the water. The CTD package used on August 21 also has sensors to measure dissolved oxygen in the water and the fluorescence of the biota in the water. "Rosette" refers to a ring of large water-collecting bottles called Niskin bottles. The bottles, which have caps at both ends, are sent down open. As the rosette is winched back up, the scientists send signals down the winch wire (made of armored electrical cable) to trigger the bottles to close at selected depths, typically chosen on the basis of the CTD data collected on the way down.


Hourly Photos from *Healy's* Aloft Conn

USCG Logs


Photos of the Day


Sep 05 Log


Aug 29 Log

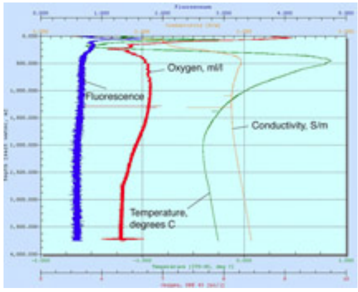

Aug 28 Log


Aug 25 Log


Aug 24 Log

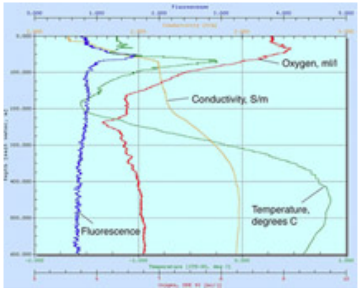

Aug 23 Log


Aug 22b Log

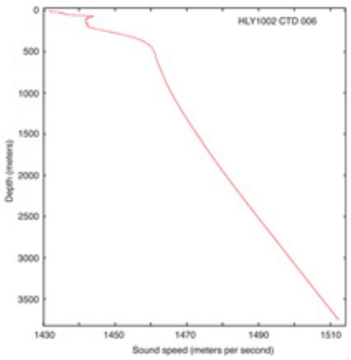


Plot of data collected by the CTD package as it was lowered to about 3,750-m water depth on August 21. In addition to conductivity, temperature, and depth, this CTD package recorded dissolved oxygen and fluorescence (a measure of chlorophyll activity). Scientists can watch the data in real time, as measurements are transmitted up the conducting cable to monitors onboard. ml/l, milliliters per liter; S/m, Siemens (a measure of electrical conductivity, the inverse of Ohms) per meter; ITS-90 refers to a standard way of reporting temperature; SBE 43 is the dissolved oxygen sensor. Click image for larger view. **Credit:** Dale Chayes, Lamont-Doherty Earth Observatory of Columbia University.

The primary reason for the August 21 CTD cast was to acquire salinity, temperature, and pressure data for constructing a “sound speed profile” (a graph of the speed of sound at different depths in the water column), which is used to calibrate our multibeam mapping system (see August 7 log). In general, sound speed increases with increasing water temperature. Because sound travels faster in a denser medium, sound speed also increases with increasing salinity and increasing pressure (depth). To calculate the combined effect of these influences, Steve Roberts (National Center for Atmospheric Research) uses a formula called the Chen-Millero algorithm. The results for the August 21 CTD cast are graphed below:



Expanded view of the top 600 m of the water column, in which the trends are more complicated than in deeper water. Steve Roberts (National Center for Atmospheric Research) says that he sees profiles like this year after year in the Arctic. Note the low values for conductivity (directly related to salinity) near the surface, where the melting ice makes the water fresher. A layer of warm water, which reaches a maximum temperature of approximately +0.8°C at about 450-m water depth, has higher conductivity (salinity) than the water above it; its salinity makes this water dense and helps to keep it from rising and mixing with surface waters, which would melt the ice. Steve says, “It’s all about salinity in the Arctic.” Click image for larger view. **Credit:** Dale Chayes, Lamont-Doherty Earth Observatory of Columbia University.



Plot of speed of sound versus water depth calculated from data collected during the August 21 CTD cast. Sound speed increases with increasing water temperature, increasing salinity, and increasing depth. Click image for larger view. **Credit:** Steve Roberts, National Center for Atmospheric Research.

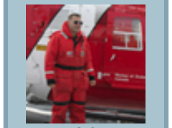
The sound speed profile is entered into our multibeam system in the form of a two-column table, with depth on the left and sound speed on the right. The multibeam system uses this information to determine water depths from the angles and travel-times of the beams of sound energy reflected back to it from the seafloor.

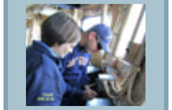
It took nearly three hours for the CTD rosette to make the trip to 3,750 m and back, with the ship stopped on station a little longer. When we want to calibrate the multibeam system without interrupting mapping, we use an expendable bathythermograph, or XBT. This device provides a vertical profile of temperature from the surface to the seabed while the ship is underway. The XBT has two main parts: a protective shell that remains on the vessel after launch, and the probe itself, which falls through the water and passes data back to the vessel along a thin wire composed of two copper strands. The probe has a hydrodynamically shaped body (think “torpedo”), with a weighty metal nose cone attached to a lightweight plastic tail equipped with fins. A thermistor in the probe tip measures temperature as the probe descends, and the depth for each measurement is calculated from time of descent using an empirical equation. (XBT information from *Encyclopedia of Ocean Sciences*, 2001, Academic Press).

As the name implies, an XBT measures only temperature data, rather than the suite of


Aug 22a Log


Aug 21 Log

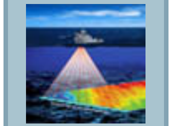

Aug 20 Log

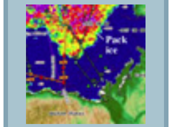

Aug 18 Log


Aug 17 Log


Aug 11 Log


Aug 08 Log


Aug 07 Log


Aug 06 Log

Aug 04 Log


Aug 03 Log


Photo Log

data collected by our CTD sensors. To turn the XBT data into a sound-speed profile, Steve makes some assumptions about the missing parameters—pressure and salinity—on the basis of data from recent CTD casts, from a conductivity meter in *Healy's* flow-through seawater system (which circulates near-surface water through the chemistry lab), and from compilations of historical data. The XBT is a good compromise when we want to balance the need for calibrating the multibeam system's sound speed profile against the need to maximize ship time spent collecting multibeam data.

Of course the geochemists aboard *Healy* are particularly happy when we stop to do a CTD cast, because the rosette of water-collecting bottles provides them with seawater samples from throughout the water column. Read more about that in the August 25 log, "Deep CTD Cast, Part 3, What Do We Do with All This Water? Ocean Acidification in the Arctic."

Expendable bathythermograph (XBT) probe (a faulty one that was never launched). As this torpedo-shaped probe falls through the water, a thermistor in the tip continuously measures temperature. The thin wire that passes data back to the ship is barely visible on the left. Click image for larger view. **Credit:** Helen Gibbons, USGS/ECS Project.

MST3 Daniel Purse prepares to launch an XBT off *Healy's* stern. The black wire connects the launcher to a computer in the Aft Conn, a control room overlooking the stern of the ship. Click image for larger view. **Credit:** Helen Gibbons, USGS/ECS Project.

The probe is in the water and falling toward the seafloor. A thin wire (not visible in this photo) connects the probe to the launcher. With his left hand, Dan holds the connecting wire away from the railing while he watches MST3 Marshal Chaidez in the Aft Conn for the signal that the probe has reached the seafloor. At Marshal's signal, Dan will snap the connecting wire and bring the launcher back inside the ship. The probe stays on the seafloor. Click image for larger view. **Credit** Helen Gibbons, USGS/ECS Project.

U.S. Extended Continental Shelf Project

Revised December 03, 2010 | Contact Us | Report Error On This Page | Site Map
Web site hosted by: National Ocean Service | National Oceanic and Atmospheric Administration | U.S. Department of Commerce | USA.gov
Disclaimer | Privacy Policy | Freedom of Information Act (FOIA) | Information Quality
http://continentalshelf.gov/missions/10arctic/logs/aug23/aug23.html

12/9/15 9:59 AM