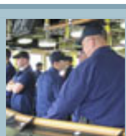
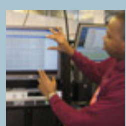
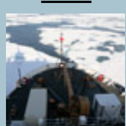

2010 Mission


Mission Plan


Law of the Sea


Continental Shelf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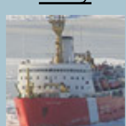
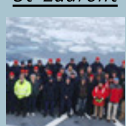
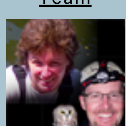

CCGS *Louis S. St-Laurent*


Healy's Science Team

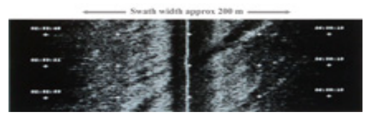

Teachers

Ice Gouges on the Beaufort Shelf, Plus an Alien Landing Site—
The Magic of Multibeam Sonar

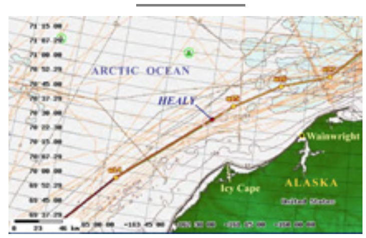
August 7, 2010

By Helen Gibbons, Web Coordinator, ECS Project

Date: August 7, 2010 ADT
(Alaska Daylight Time)
Time: 2030 hours
Latitude: 70°44.080’N
Longitude: 139°59.948’W
Air temperature: 3.27°C (37.89°F)
Sea temperature: 8.7°C (47.7°F)
Wind speed and direction: 24.9 knots from the northeast
Ship’s speed over the ground: 11.5 knots
Water depth: 1499 m



The dark bands cutting diagonally across the image are ice gouges, furrows gouged into the sediment of the seafloor by thick pieces of ice. This image was formed from acoustic backscatter data collected at 40-m water depth. Acoustic backscatter is one of three types of data collected by *Healy’s* multibeam echosounder, described below. Click image for larger view. **Credit**: Helen Gibbons, USGS/ECS Project.



Here is the ship’s position at the time we saw the ice gouges. (We have come considerably farther east and north since then.) Click image for larger view.
Credit: *Healy* Map Server/Steve Roberts, National Center for Atmospheric Research.

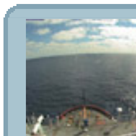
A couple of nights ago, on Thursday evening (August 5), we saw images of ice gouges in the sediment on the shallow seafloor north of Icy Cape, Alaska.

Ice gouges form when thick pieces of ice are pushed by the wind and their bottoms scrape through the sediment. They are commonly formed by icebergs—pieces of ice that have broken off ice shelves or glaciers and have deep drafts. Ice floes (pieces of frozen seawater) are not generally as thick as icebergs, but when ice floes collide, their edges buckle into pressure ridges above the water line and “keels”—downward projections of ice—below the waterline. Like icebergs, these keels can carve furrows into seafloor sediment. Ice gouges tend to be long and straight. The ones we saw on Thursday night were in water depths of about 40 m.

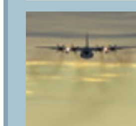
The ice-gouge images were brought to us by the multibeam echosounder, or “the multibeam” for short. The multibeam is a hull-mounted system that sends out a fan of sound energy perpendicular to the ship’s track.

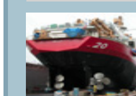
As the ship moves forward, the multibeam “ensonifies” a swath of seafloor. On our monitors for the bathymetric data, it looks as though someone is running a paint roller over the bottom. Because the fan of sound energy emitted by the multibeam widens toward the seafloor, the width of the swath increases as the water gets deeper.

A new multibeam system is being used on *Healy* this year, a Kongsberg


Hourly Photos from *Healy’s* Aloft Conn

USCG Logs


Photos of the Day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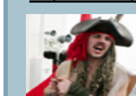
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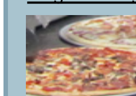
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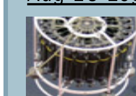
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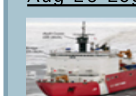
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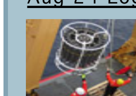
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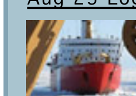
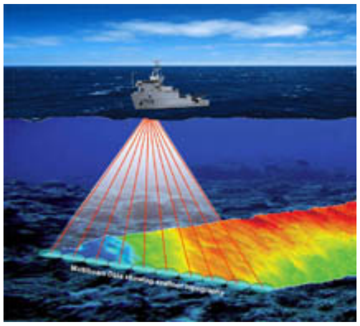
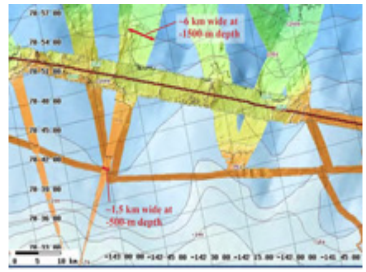

Aug 22b Log

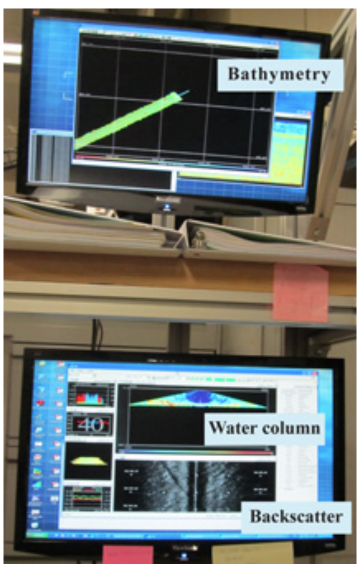


Ship using multibeam echosounder to map a swath of seafloor. Click image for larger view. **Credit:** Fisheries and Oceans Canada.

EM122, installed and run by science systems guru Dale Chayes (Lamont-Doherty Earth Observatory of Columbia University) and software engineer Steve Roberts (National Center for Atmospheric Research). This system records three types of data: bathymetric data, as shown in the colorful swaths above; "acoustic backscatter" from the seafloor, as shown in the image of ice gouges; and returns (or echoes) from reflectors in the water column. This third type of data is a new capability on *Healy* and probably not pertinent to this cruise.



Swaths of multibeam bathymetric data compiled on the ship's Map Server. The swath collected during this mission trends east-southeast and has a dark line (the ship's track) down the middle. The other data swaths were collected during earlier missions. The data are color-coded; in this view, orange tones indicate shallower water and green tones indicate deeper water. Note how the swaths widen with increasing depth. One of the swaths trending north-northeast in this view widens from about 1.5 km at 500-m water depth to about 6 km at 1,500-m water depth. Click image for larger view. **Credit:** *Healy* Map Server/Steve Roberts, National Center for Atmospheric Research.



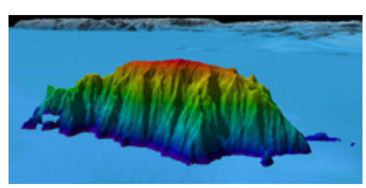
Monitors in the computer lab displaying multibeam data: bathymetry on top monitor, reflectors from the water column in upper half of bottom monitor, and acoustic backscatter in lower half of bottom monitor. Click image for larger view. **Credit:** Helen Gibbons, USGS/ECS Project.

Bathymetric Data

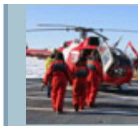
Water depth, or bathymetry, is calculated from the time it takes the sound energy to travel to the seafloor and back (measured by the multibeam system), and the speed of sound in seawater along the path that the sound travels, which varies with temperature, salinity, and pressure and is monitored by the scientists. The simple equation is:
1/2 (travel time to seafloor and back) X (speed of sound in water) = water depth

During this mission, we will mostly collect long swaths of multibeam data while *Louis* collects seismic-reflection profiles (images of sediment layers beneath the seafloor) along the same tracklines. The multibeam system can also be used to map large areas of seafloor by sailing the ship back and forth to collect overlapping swaths of data, a process commonly referred to as "mowing the lawn." Combining the swaths of bathymetric data produces striking images of the seafloor.

In addition to their practical value (the data we collect will help determine the outer limits of the "continental shelf" in this region, as defined in the United Nations Convention on the Law of the Sea), multibeam bathymetric data have tremendous scientific value. A marine geologist can learn a great deal about processes shaping the seafloor, for example, just by examining multibeam bathymetry. Here are a few examples, courtesy of Steve Roberts, who gave us a virtual tour of some of the data from past cruises compiled on the Map Server



3D view of seamount rising from the abyssal plain at a depth of more than 3,800 m to a least depth of 2,622 m, constructed from overlapping swaths of multibeam data collected during the 2009 U.S.-Canada joint mission. View toward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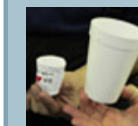
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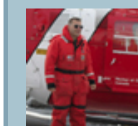
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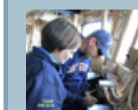
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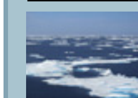
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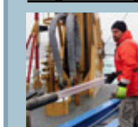
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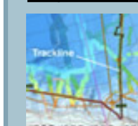
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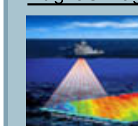
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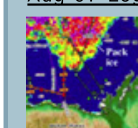
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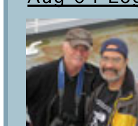
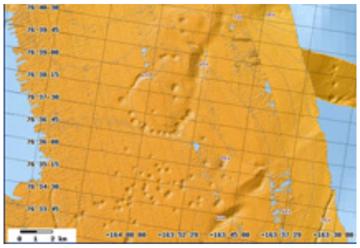

Aug 03 Log

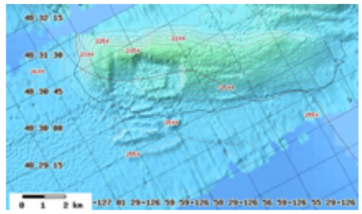
Photo Log

he created for *Healy's* science intranet.

southwest. Click image for larger view. **Credit**: CCOM/JHC University of New Hampshire.



Although Steve likes to call this an alien landing site, the pockmarks are probably the result of hydrocarbon seeps on the seafloor. This image is from the Chukchi Plateau, about 130 km east of the U.S.-Russia border. (Data collected during previous *Healy* missions HLY0302, HLY0703, and HLY0905.) Click image for larger view. **Credit**: *Healy* Map Server/Steve Roberts, National Center for Atmospheric Research.



Submarine landslides on the seafloor about 185 km southwest of the mouth of the Strait of Juan de Fuca, which separates Washington State (U.S.) from Vancouver Island (Canada). Data collected during a *Healy* transit, HLY06TI. Click image for larger view. **Credit**: *Healy* Map Server/Steve Roberts, National Center for Atmospheric Research.

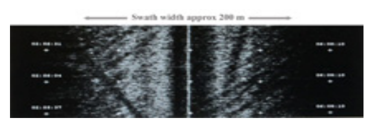
Sediment waves on the seafloor along the Alpha-Mendeleev Ridge, about 500 km south of the North Pole. The largest sediment waves in this view measure nearly 1 km from crest to crest, indicating unusually strong water flows for this depth (about 2,000 m). Data collected during previous *Healy* mission HLY0503. Click image for larger view. **Credit**: *Healy* Map Server/Steve Roberts, National Center for Atmospheric Research.

Acoustic Backscatter

The multibeam system also measures "acoustic backscatter": the strength of the echoes returned to the system from the seafloor. Backscatter reveals information about the material on the seafloor. At the frequencies emitted by the EM122 multibeam, for example, echoes from mud will typically be weaker than echoes from more reflective seafloor materials, such as rock or sand. The backscatter data also reveal irregularities on the seafloor: echoes will be stronger from a surface that is nearly perpendicular to the approaching sound than from a surface at a low angle to it. Some features on the seafloor, a large rock, for example, will block sound energy from reaching the seafloor beyond them, casting sound "shadows."

The ice gouges we saw on Thursday evening were particularly striking in the images produced by the backscatter data.

Both the bathymetric and the backscatter data will be digitally processed during and after the mission. This processing will reveal even more information than we observed on the monitors in real time.



More ice gouges imaged in multibeam acoustic-backscatter data; lighter areas indicate stronger echoes. This image was produced from data collected at 40-m water depth. Click image for larger view or here for a high resolution image. **Credit**: Helen Gibbons, USGS/ECS Project.