



## *Okeanos Explorer* CTD Supplemental Datasheet #1 for Cruise 12.02

This Supplement provides data that can be analyzed using techniques developed in the lesson, "Tools for Classroom Explorers – How to Use CTD Data" to investigate discoveries made during the NOAA Ship *Okeanos Explorer* Gulf of Mexico 2012 Expedition.

### Focus

CTD data and exploration activities during the NOAA Ship *Okeanos Explorer* Gulf of Mexico 2012 Expedition

### Grade Level

5-12 (Physical Science/Earth Science)

### Focus Question

How are CTD data used during exploration activities of the NOAA Ship *Okeanos Explorer* Gulf of Mexico 2012 Expedition?

### Learning Objectives

- Students explain the role of CTD data in the exploration strategy used during the NOAA Ship *Okeanos Explorer* Gulf of Mexico 2012 Expedition.
- Students interpret CTD data collected aboard the *Okeanos Explorer* during the Gulf of Mexico 2012 Expedition.

### Materials

- Copies of the *CTD Student Investigation Guide #1 for Cruise 12.02*; one copy for each student group
- Computers with Internet access

### Background for the Gulf of Mexico 2012 Expedition

Background information about the mission of the NOAA Ship *Okeanos Explorer* and its CTD system is provided in the lesson, *Tools for Classroom Explorers – How to Use CTD Data*.

The purpose of the Gulf of Mexico 2012 Expedition is to explore unknown and poorly known ocean areas in the Gulf of Mexico. Specifically, the northern West Florida Escarpment, the DeSoto Canyon in the northeastern Gulf, the vicinity of the Deepwater Horizon or Macondo Well, and deepwater shipwrecks (Figures 1 – 5). A major objective of the expedition is to use the *Okeanos Explorer's* state-of-the-art ocean exploration capabilities to investigate the diversity and



Image captions/credits on Page 2.

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distribution of deep-sea habitats and marine life in the target areas. Even after extensive investigations following the Deepwater Horizon blowout event in 2010, much of the Mississippi Canyon area where the event occurred remains unexplored. Throughout the deep Gulf of Mexico the situation is much the same: the ecology and even the basic distribution of seeps and deep-sea ecosystems remain poorly understood. For additional information about the Gulf of Mexico 2012 Expedition, please see the *Gulf of Mexico 2012 Okeanos Explorer Expedition Education Module* <http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/edu/edu.html>.

#### Images from Page 1 top to bottom:

Bobby Mohr, Tom Kok, and Jeff Williams discuss 'the plan' on the back deck. Image courtesy of the NOAA *Okeanos Explorer* Program.

<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/mar21-2-hires.jpg>

Anchor resting on the top of the Site 15429 wreck. *Lophelia* coral is also visible.

After a great first marine archaeology dive on March 27, everyone was excited about exploring a second target. Site 15429 was initially located in 2009 with the National Institute for Undersea Science and Technology's (NIUST) *Eagle Ray* autonomous underwater vehicle (AUV). The data showed a potential vessel resting on the seafloor. The remotely operated vehicle (ROV) dive confirmed what several members of the Science Team expected. The wreck appears to be a hotspot for *Lophelia* coral. It was a great day for both the marine archaeologists and the biologists. Image courtesy of NOAA *Okeanos Explorer* Program.

[http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/mar29\\_hires.jpg](http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/mar29_hires.jpg)

Image of gridded bathymetry shown as a wireframe and draped over gridded backscatter data. Ever since the Team on Leg I of the Gulf of Mexico expedition mapped the DeSoto Canyon area in early March 2012, there was lots of speculation about one specific seafloor feature in approximately 400 meters of water. Not only did the feature seem to be the one spot of significant relief in an otherwise fairly flat area, but it also showed up in the backscatter data as a very 'hard' target. Image courtesy of NOAA *Okeanos Explorer* Program.

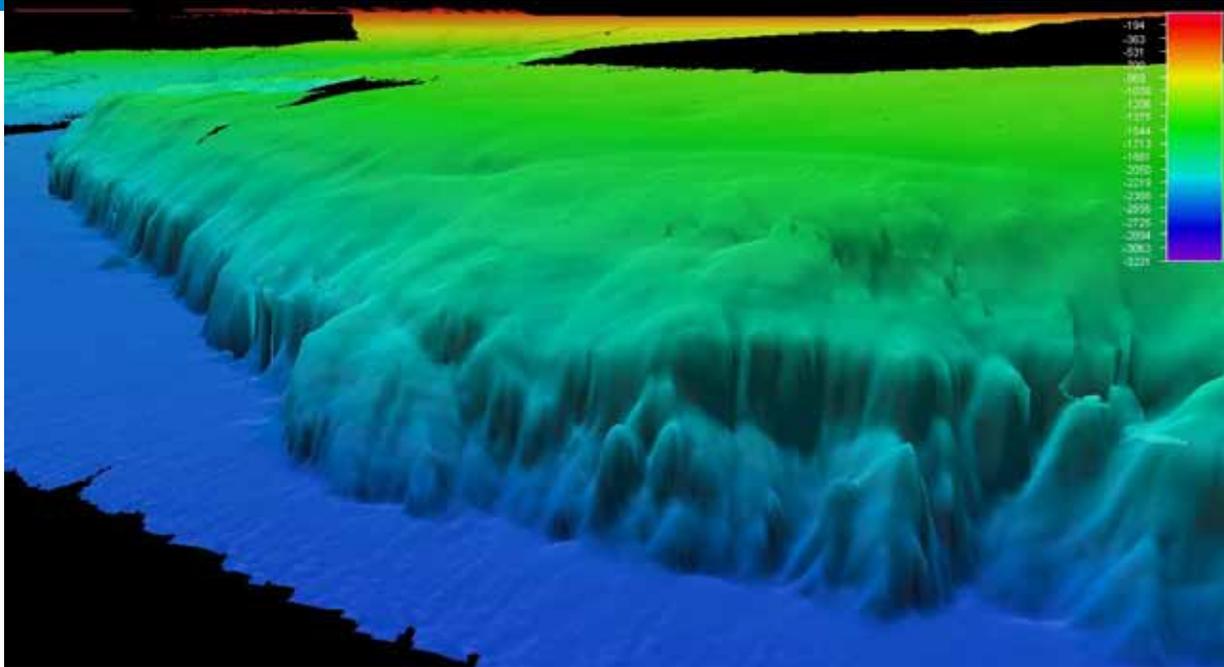
[http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/mar28\\_update\\_hires.jpg](http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/mar28_update_hires.jpg)

Through the power of technology, scientists on the ship and on shore are able to view and learn about the complex ecosystems in the Gulf of Mexico. Deep-sea corals flourish in the dark depths of the Gulf of Mexico, providing foundations that attract lush communities of other animals, including brittle stars, anemones, crabs, and fish. This diversity of life on the seafloor may be out of sight, but it is has been squarely on the minds of scientists seeking to determine the short- and long-term ecological impacts of the Deepwater Horizon oil spill. Image courtesy of the NOAA *Okeanos Explorer* Program.

<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/logs/hires/mar24-2-hires.jpg>



**Figure 1 – Google Earth map showing general priority areas for the Gulf of Mexico 2012 Expedition.**



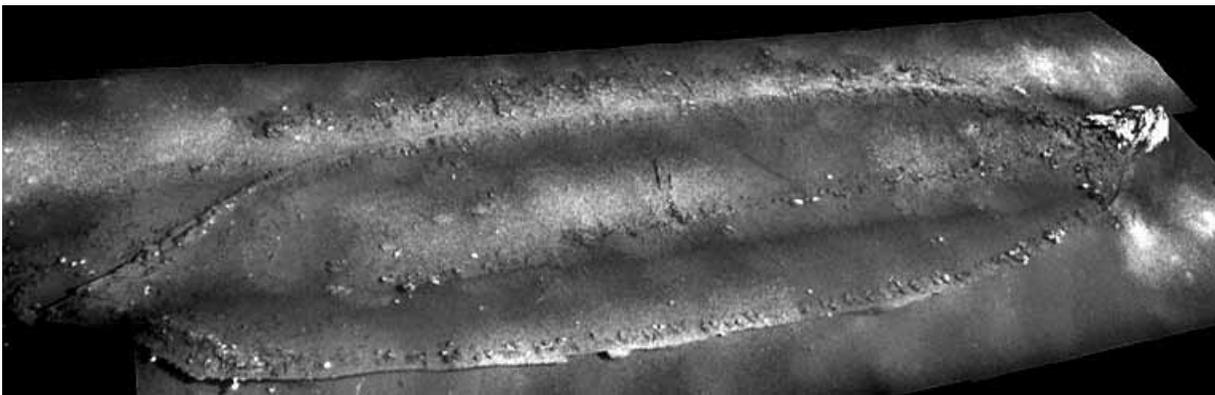
**Figure 2 – Bathymetry of the West Florida Escarpment.** The base of the escarpment (2,600 meters depth) is shown in blue with the upper rim more than 600 meters above. The expedition will identify at least four dive sites that cover the diverse soft sedimented and hard carbonate rock bottom between 2,300 and 400 meters to explore the physical structure of the seafloor and biodiversity on soft and hard bottom habitats (Multibeam data from EX1105, EX1106, and this expedition, EX1202). Image courtesy of the NOAA *Okeanos Explorer* Program. [<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/hires/science-1-hires.jpg>]



**Figure 3 – Bamboo corals (with an attached crinoid) on a scarp wall in the DeSoto Canyon area (2,055 meters depth).** Image courtesy of the NOAA *Okeanos Explorer* Program. [<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/hires/science-3-hires.jpg>]



**Figure 4 – Corals and associated animals** living with them in the vicinity of the Deepwater Horizon oil spill (within 11 kilometers) as captured by a time-lapse camera image. Image courtesy of C. Fisher and T. Shank, Woods Hole Oceanographic Institution. [<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/science/media/science-2-600.jpg>]



**Figure 5 – Mosaic of the Ewing Bank Wreck** at 621 meters depth in the Gulf of Mexico. This three-dimensional perspective of the Ewing Bank Wreck was produced by “draping” the photo mosaic over the multibeam bathymetry. The photos and multibeam data were collected with the C-Surveyor autonomous underwater vehicle. Image courtesy of C & C Technologies, Inc.; video courtesy of *Lophelia II* 2009: Deepwater Coral Expedition: Reefs, Rigs, and Wrecks Exploration. [<http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/hires/science-4-hires.jpg>]

### Procedure

1. To prepare for this activity:
  - a. Ensure that students are familiar with procedures described in the lesson, *Tools for Classroom Explorers – How to Use CTD Data*.
  - b. Make copies of *CTD Student Investigation Guide #1 for Cruise 12.02* for each student group.
  - c. Download the data file EX1202\_ctd\_1.xls from [http://oceanexplorer.noaa.gov/okeanos/edu/resources/media/ex1202\\_ctd\\_1.xls](http://oceanexplorer.noaa.gov/okeanos/edu/resources/media/ex1202_ctd_1.xls), and install this on computers that students will use to complete the *Investigation Guide* activities.

- d. Ensure that Microsoft Excel® or compatible software is installed on computers that students will use to complete the *Investigation Guide* activities.
  - e. Review the Mission Plan and Background Essays for the Gulf of Mexico 2012 Expedition (linked from <http://oceanexplorer.noaa.gov/okeanos/explorations/ex1202/background/welcome.html>). You may also want to review Daily Updates and Mission Logs, and consider assigning these as the basis for short student reports to give a more complete impression of the expedition's activities.
  - f. Adaptations for grades 5-8: Depending upon students' skill level, you may want to provide a simplified data set that can be graphed by hand. The overall pattern of salinity and temperature changes with depth will still be discernable, and discussions can focus on how these parameters change with increasing depth, and how variable they are in deep ocean habitats.
2. Briefly review the purpose of the Gulf of Mexico 2012 Expedition. If assigned, have students present their reports based on Daily Updates and Mission Logs.
  3. Provide each student group with a copy of *CTD Student Investigation Guide #1 for Cruise 12.02*, and have them complete the activities described in the *Guide*.
  4. Discuss students' answers to *Investigation Guide* questions. Key points include:
    - Students' graphs should resemble Figures 5 and 6.
    - The entire ROV dive required about 9.5 hours to complete.
    - The maximum depth recorded by the CTD during the dive was 2,144.7 m.
    - Points on the graphs are much closer together at deeper depths because the ROV was moving slowly as it explored the bottom, so the location did not change as rapidly as it did when the ROV was on its way to or from the bottom. Also, temperature and salinity were not as variable at deeper depths.
    - Temperatures recorded during the dive ranged from 24.86 °C to 4.29 °C. The maximum temperature was recorded at the shallowest depth (49.83 m) and the minimum temperature was recorded near the bottom at 2,086 m. The greatest change in temperature took place in the depth range 0 - 500 m. The major reason for this pattern is that solar warming is greatest at the surface, and very little warm surface water is mixed with colder deep waters at depths below about 1,300 m.
    - Salinity values recorded during the dive ranged from 34.89 PSU to 36.64 PSU. The maximum salinity value was recorded at a depth of 86.25 m, and the minimum value was recorded at 672.57 m. The greatest salinity changes occurred near the surface in depths less than 100 m.

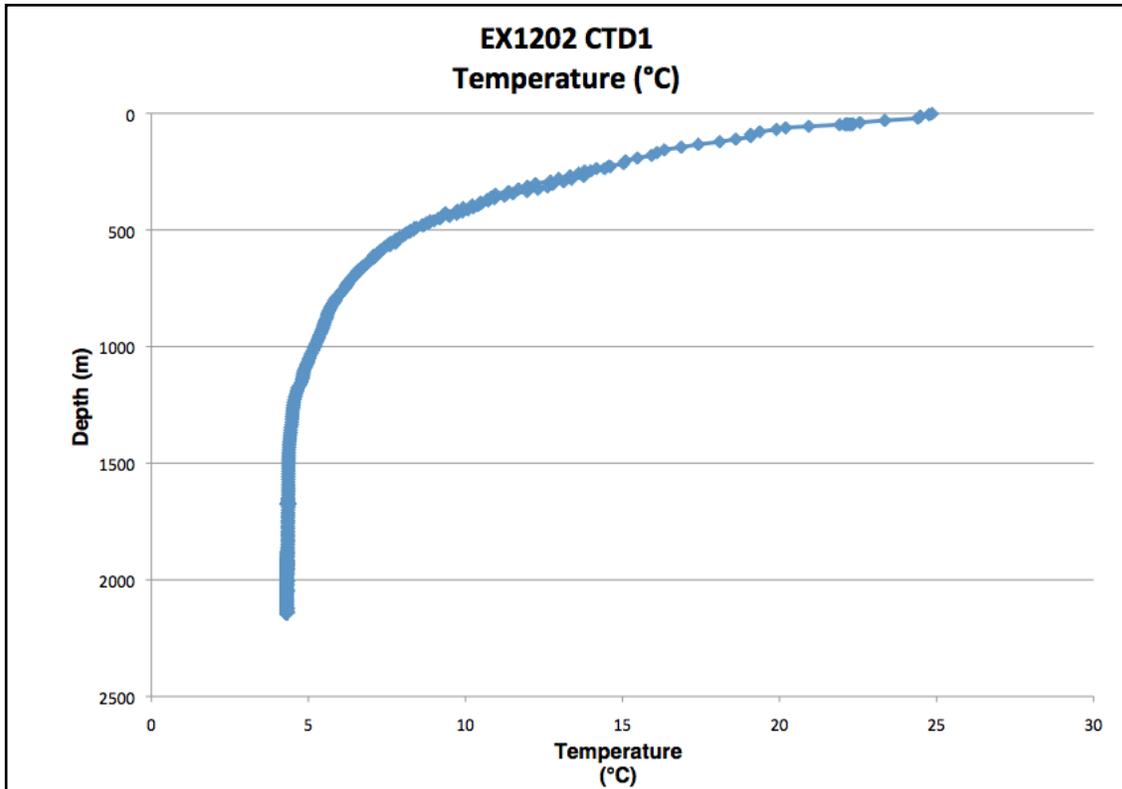


Figure 5

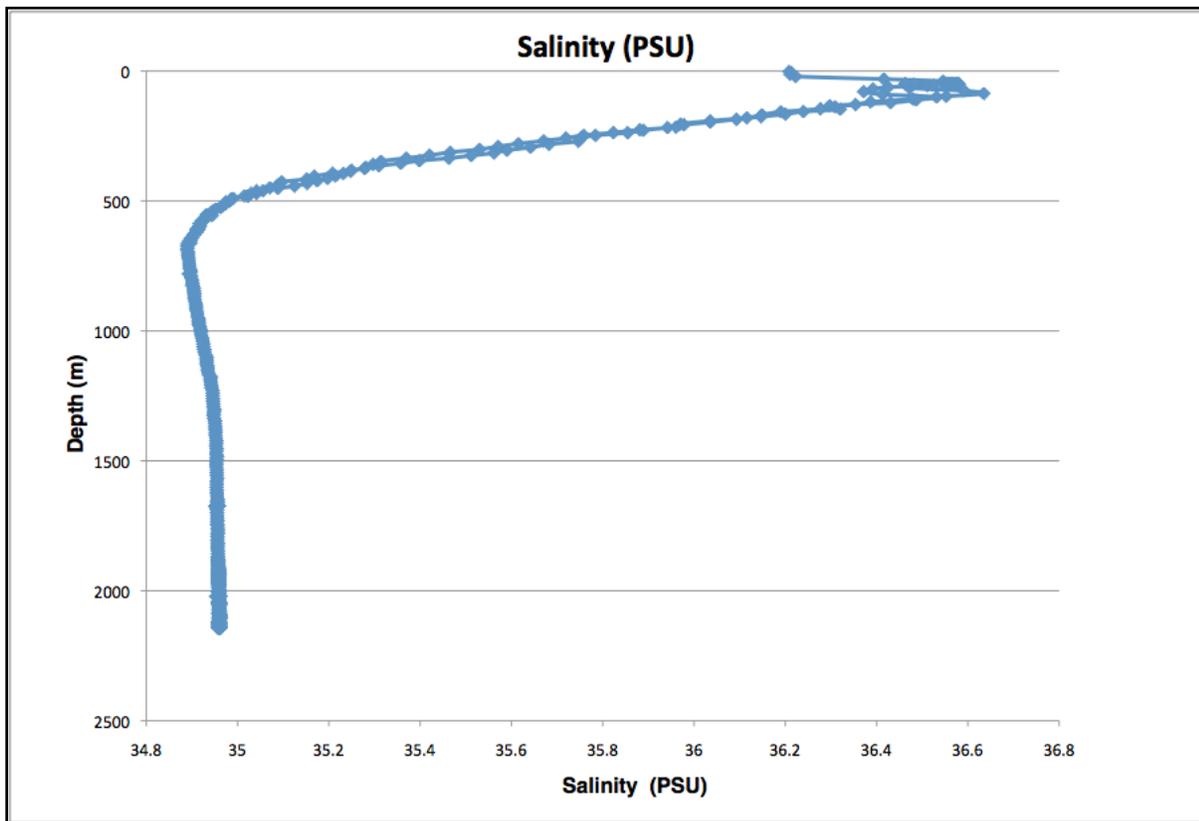


Figure 6

- The salinity graph suggests that salinity values in this depth range increased initially, then decreased, then increased again to the maximum value, and then steadily declined to a depth of about 700 m. This is a good example of why it is important to understand the overall process that produced these data. The apparent variations are really the result of recording salinity values at various depths as the ROV descended to the bottom, and then recording them again as the ROV returned to the surface. If students do not immediately recognize this point, direct their attention to the portion of the graph where salinity is approximately equal to 35.5 PSU. Here, the graph contains two lines, which should lead students to recognize that the graph includes data collected during ascent as well as descent. Examining the data values in the file, it is clear that the data for the descending portion of the dive begin at 48.74 m, and that values from the shallowest depths were recorded during the ascent. If data from ascent and descent are separated, most of the sharp fluctuations disappear.
- Even if ascent and descent data are plotted separately, salinity values still appear to increase with increasing depth near the surface, then decline steadily to a depth of about 700 m, then increase slightly and remain almost constant at depths below 1,300 m. This pattern is most likely due to the effects of evaporation at the surface, which causes salinity to increase. Increased salinity also increases density, which causes the more saline water to sink. Students should notice that the range of temperature variations is much larger than the range of salinity variations, and should also realize that decreasing temperature also increases density, so colder water tends to sink. Since the greatest change in temperature took place in the depth range 0 - 500 m, the effect of temperature on density overcomes the effect of salinity at depths below about 100 m. So, even though deeper waters have lower salinity values, these less saline waters tend to sink because the effect of colder temperatures has a greater impact on density than the slightly lower salinity values.
- Based on their graphs, students should predict that temperature and salinity have very low variability in deep bottom habitats in this part of the Gulf of Mexico.
- You may want to point out that the dataset used for these calculations has been simplified to include measurements at 30 second intervals. The CTD carried aboard *Little Hercules* makes measurements at intervals of 1/16th second, so the original dataset contained more than 546,000 lines of data!

## CTD Student Investigation Guide #1 for Cruise 12.02

NOTE: The following instructions are for Microsoft Excel®2008. Other versions of Excel or other spreadsheets will require slightly different procedures. See user documentation for how to import text files and make graphs from these files. If you have difficulty opening the file referenced in Step 1 and are using an older version of Excel®, you may need the Office Compatibility Pack. This can be downloaded from: <http://www.microsoft.com/download/en/details.aspx?displaylang=en&id=3>. If you would like to open the file in a newer version of Excel, be sure that you have turned on "Compatibility Mode". If you only want to look at Excel® files, you may want to try the Excel® Viewer (<http://www.microsoft.com/download/en/details.aspx?id=10>), but this will not allow you to graph or edit the data.

1. Open the "EX1202\_ctd\_1.xls" file in Microsoft Excel®. These data were collected by a CTD carried by the ROV *Little Hercules* on March 23, 2012. The first row shows the contents of each column: Date, Time; Latitude in decimal degrees; Longitude in decimal degrees; Elapsed time since the start of the cast in seconds; Depth in meters; Temperature in °C; Conductivity in milliSiemens per centimeter; Salinity in Practical Salinity Units; and Depth (again). Columns for optical backscatter and oxidation-reduction potential used in the lesson, *Tools for Classroom Explorers – How to Use CTD Data* are not included in this file because these sensors were not used on the CTD carried by *Little Hercules* for this dive.
2. How much time was needed to complete the entire ROV dive?
3. What was the maximum depth recorded by the CTD?
4. Make graphs of Temperature and Salinity as a function of Depth. Construct the graph so that Depth is on the y-axis and the greatest depths are at the bottom of the plot. Be sure to title the graphs, label both axes, and include units in the labels.
5. On both graphs it is possible to identify individual points at shallow depths, but points are much closer together at deeper depths. Why?
6. What was the range of temperature recorded during the dive? Where were the maximum and minimum temperatures recorded? Where did the greatest change in temperature take place? How do you account for these observations?
7. What was the range of salinity values recorded during the dive? Where were the maximum and minimum salinity values recorded? Where did the greatest change in salinity take place? How do you account for these observations?
8. Based on these graphs, how variable would you expect temperature and salinity to be in deep bottom habitats in this part of the Gulf of Mexico?