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Lophelia II 2010:
Cold Seeps and Deep Reefs

Van to the Ocean Floor

Image captions/credits on Page 2.

lesson plan

Focus
Deep-sea exploration

Grade Level
9-12 (Life Science/Technology)

Focus Question
How can scientists and interested citizens obtain data from *Jason II* missions?

Learning Objectives
- Students will discuss the advantages and disadvantages of remotely operated vehicles for ocean exploration.
- Students will describe the general features of the *Jason II* robot.
- Students will obtain data from *Jason II* missions, and analyze these data.

Materials
- ❑ Copies of *Jason Virtual Van Inquiry Guide,* one copy for each student group.

Audio-Visual Materials
- ❑ (Optional) Video projection or large screen monitor for showing downloaded images (see Learning Procedure, Step 1)

Teaching Time
One or two 45-minute class periods, plus time for student research

Seating Arrangement
Groups of 2-4 students

Maximum Number of Students
30

Key Words
Gulf of Mexico
Cold seep
Lophelia
Deepwater coral

Jason
Medea
Remotely Operated Vehicle (ROV)
Virtual Van

Background Information

NOTE: Explanations and procedures in this lesson are written at a level appropriate to professional educators. In presenting and discussing this material with students, educators may need to adapt the language and instructional approach to styles that are best suited to specific student groups.

Around 10:00 pm CDT on April 20, 2010, about 40 miles southeast of the Louisiana coast, a gas explosion occurred on the mobile offshore drilling unit Deepwater Horizon. The explosion killed 11 workers, injured 17 others, ignited an intense fire that burned until the Deepwater Horizon sank 36 hours later, and resulted in a massive release of crude oil that is now considered the greatest environmental disaster in U.S. history. The total volume of oil released into the Gulf of Mexico is estimated to have been 205 million gallons (4.9 million barrels), dwarfing the 11-million-gallon *Exxon Valdez* spill of 1989. Ecological impacts of the released oil have received extensive media attention, particularly those affecting beaches, marshes, birds, turtles, and marine mammals; but other, less visible, organisms may be affected as well. Many scientists are particularly concerned about the unusual and biologically-rich deep-sea ecosystems on the Gulf of Mexico seafloor.

These ecosystems are often associated with rocky substrates or "hardgrounds." Most of these hardbottom areas are found in locations called cold seeps where hydrocarbons are seeping through the seafloor. Two types of ecosystems are typically associated with deepwater hardgrounds in the Gulf of Mexico: chemosynthetic communities and deep-sea coral communities. Hydrocarbon seeps may indicate the presence of undiscovered petroleum deposits, so the presence of these ecosystems may indicate potential sites for exploratory drilling and possible development of offshore oil wells. At the same time, these are unique ecosystems whose importance is presently unknown.

For the past four years, NOAA's Office of Ocean Exploration and Research (OER) has sponsored expeditions to locate and explore deep-sea ecosystems in the Gulf of Mexico. These expeditions were targeted toward broad questions that included:

- Where are cold-seep and deepwater coral communities associated with hard-bottom environments in the deep Gulf of Mexico?
- What organisms are characteristic of cold-seep and deepwater coral communities in the deep Gulf of Mexico?
- What are the relationships between coral communities and artificial and natural substrates?

Images from Page 1 top to bottom:
Lophelia pertusa on the seafloor. Note extended polyp on the right. Image courtesy of Ian MacDonald, NOAA.
http://oceanexplorer.noaa.gov/explorations/09lophelia/logs/sept1/media/lophelia_insitu_close.html

Video monitors inside *Jason* control van allow scientists and *Jason* crew to see all seafloor operations. Tim Shank (right) records observations using the "Virtual Van" software. Image courtesy Troy Kitch, NOAA.
http://oceanexplorer.noaa.gov/explorations/09lophelia/logs/aug31/media/controlvan.html

Preserved specimens collected during *Lophelia* II 2009. Image courtesy Troy Kitch, NOAA.
http://oceanexplorer.noaa.gov/explorations/09lophelia/logs/aug23/media/species_jar.html

Viosca Knoll Wreck: The stempost of the wreck is covered in *Lophelia*, stalk barnacles, *Acesta* clams and anemones. A little *Eumunida picta* is also evident in the lower corner. Image courtesy Stephanie Lessa, NOAA.
http://oceanexplorer.noaa.gov/explorations/09lophelia/logs/sept6/media/7_biostem.html

NOAA Ship *Ronald H. Brown* at sunrise in the Gulf of Mexico. Image courtesy of Dana Mancinelli, NOAA, *Lophelia* II 2009.
http://oceanexplorer.noaa.gov/explorations/09lophelia/logs/aug27/media/ronbrownship.html

Jason II on the deck of the NOAA Ship *Ronald H. Brown*. Image courtesy of Sheli Smith, NOAA, *Lophelia* II 2009.
http://oceanexplorer.noaa.gov/explorations/09lophelia/logs/sept6/media/1_jason_ll.html

CTD rosette on deck ready for deployment. Image courtesy of NOAA, *Lophelia* II 2009.
http://oceanexplorer.noaa.gov/explorations/09lophelia/logs/sept1/media/ctd_on_deck.html

- What processes control the occurrence and distribution of cold-seep and deepwater coral communities in the Gulf of Mexico?

Working from NOAA Ship *Ronald H. Brown*, the *Lophelia* II 2010: Cold Seeps and Deep Reefs Expedition is a continuation of exploration efforts to answer these questions, as well as a new question that has been added to the list:

- What impacts, if any, have occurred in deep-sea communities as a result of the Deepwater Horizon blowout?

This expedition depends heavily upon two key technologies: a standard instrument for oceanographic studies known as a CTD (see the *Where's the Oxygen?* lesson for more information), and a remotely operated vehicle (ROV) named *Jason II/Medea*.

Jason II/Medea is a two-part system: *Jason II* is a mobile platform that carries sonar and video imaging equipment as well as manipulator arms for collecting samples. *Jason II* gives scientists a 'virtual presence' in deep ocean waters at depths up to 6,500 meters. A 35-meter cable connects *Jason II* to a second ROV named *Medea*, which is connected to the surface ship by a 10-kilometer fiber optic cable. This arrangement allows *Medea* to buffer *Jason II* from movements of the ship, and provides a second platform that allows scientists to observe *Jason II* during seafloor operations.

The advantage of the *Jason II/Medea* system is that it allows much longer observation periods than are possible with manned submersibles; the average *Jason* dive is 21 hours (compared to *Alvin* dives which are six to ten hours), though dives as long as 71 hours have been made on some occasions. The system is designed, built, and operated by the Deep Submergence Laboratory of Woods Hole Oceanographic Institution. See http://oceanexplorer.noaa.gov/technology/subs/jason/welcome.html for more information.

The *Jason II/Medea* system is operated from a control van that is loaded aboard the host ship along with the ROV. Additional equipment and supplies are carried in tool and rigging vans. To make it easier for scientists and the interested public to obtain information from *Jason II* operations, Woods Hole Oceanographic Institution provides an online Virtual Control Van system that automatically captures information in the control van during ROV operations and makes this information immediately accessible and searchable via a Web browser. The Virtual Control Van is available to scientists and the public via the Internet. For more information, visit http://4dgeo.whoi.edu/jason.

This lesson is intended to introduce students to the *Jason* Virtual Control Van, and to provide a realistic impression of a typical *Jason II* mission.

Learning Procedure

1. To prepare for this lesson:
   - Review introductory essays for the *Lophelia* II 2010: Cold Seeps and Deep Reefs Expedition at http://oceanexplorer.noaa.gov/explorations/10lophelia/welcome.html. You may also want to consider showing students some images of deep-sea ecosystems from http://oceanexplorer.noaa.gov/explorations/09lophelia/logs/photolog/photolog.html. You can find a virtual tour of a cold-seep community at http://www.bio.psu.edu/cold_seeps.
   - Review procedures and questions on the *Jason Virtual Van Inquiry Guide*.

2. Briefly introduce the *Lophelia* II 2010: Cold Seeps and Deep Reefs Expedition, and describe cold-seep and deepwater coral communities. If desired, show images from the Web page referenced in Step 1. Lead a brief discussion about the Deepwater Horizon blowout, highlighting the potential importance of deep-sea biological communities that may have been adversely affected by this event. Point out that many questions remain to be answered about such impacts, and ask students how scientists can investigate ecosystems that are thousands of meters deep. Human-occupied submersible vehicles are likely to be mentioned, as well as robotic vehicles. Highlight some of the advantages of unoccupied vehicles, which include greatly reduced costs and risks to human life.

3. Tell students that their assignment is to learn about how they can retrieve information from *Jason II* ROV missions. Provide each student group with a copy of the *Jason Virtual Van Inquiry Guide*. Point out that the primary purpose of this inquiry is to become familiar with techniques for retrieving information from *Jason II* missions that include many little-explored regions of Earth's ocean.

4. When students have answered all questions on the *Inquiry Guide*, lead a discussion of their results. The following points should be included:

Part A. Background About ROV *Jason*

See Background Information, above.

Part B. Dive With *Jason*!

3a. Dive J2-466 lasted 23 hours, 44 minutes, and 1 second.

3b. The maximum depth reached by the ROV during Dive J2-466 was 502.08 m.

3c. The *Jason* Virtual Van for dive J2-466 contains 2165 records.

6a. At Event 18749, *Jason II* was 480.33 m deep.

6b. At Event 18749, *Jason II* was 28.28 m off the bottom.

6c. At Event 18749, *Jason II* was not horizontal; it was 11 degrees down from horizontal

6d. If the ROV began its descent immediately following the last Event entry, its rate of descent was 0.441 m/sec.

6e. The temperature difference between Events 18748 and 18749 was 19.387° C.

6f. The interval between ASNAPs was 1 minute.

7a. The video displays for Event 18876 show a shark.

7b. At Event 18876, the ROV was 3.39 m above the bottom.

8a. At Event 18960, Video Monitor 1 shows a crab.

8b. The video displays for the next three events show that the crab is eating a fish.

9. The fish observed in Event 20136 are *Berex splendens*.

10a. At Event 20612, a fish being eaten.

10b. About 3 minutes 26 seconds were needed for this activity to be completed.

11. Events 20389 through 20410 involve push core sampling.

12. During Events 20637 through 20648, an octocoral *Callogorgia* sp., and two types of brittle stars, *Astrogomphus* sp. and *Asterochema* sp. are being collected.

13. An orange antipatharian (antipatharians are black corals) is being collected in Event 22115.

14. Tubeworms are conspicuous in Events 22441 through 22443.

15. Reasons for deep-sea exploration include:
- Potential for finding new sources of energy;
- Pharmaceuticals and other biological products that can be useful and important to humans;
- Understanding possible connections between deep-sea ecosystems and other systems that are directly important

to humans; and
- Understanding interactions between the deep ocean and Earth's climate.

The BRIDGE Connection

www.vims.edu/bridge/ - Click on "Gulf of Mexico" in the "Search" box on the left for resources and links about the Gulf.

The "Me" Connection

Have students write a brief essay about how underwater robots might be of personal benefit.

Connections to Other Subjects

English/Language Arts, Earth Science, Physics

Assessment

Students' answers to *Inquiry Guide* questions and class discussions offer opportunities for assessment.

Extensions

1. See the "Resources" section of *Lessons from the Deep: Exploring the Gulf of Mexico's Deep-Sea Ecosystem Education Materials Collection* Educators Guide for additional information, activities, and media resources about deepwater ecosystems in the Gulf of Mexico.

2. Build your own underwater robot! See *ROV's in a Bucket* and books by Harry Bohm under Resources.

Multimedia Discovery Missions

http://oceanexplorer.noaa.gov/edu/learning/welcome.html - Click on the links to Lessons 3, 5, and 6 for interactive multimedia presentations and Learning Activities on Deep-Sea Corals, Chemosynthesis and Hydrothermal Vent Life, and Deep-Sea Benthos.

Other Resources

The Web links below are provided for informational purposes only. Links outside of Ocean Explorer have been checked at the time of this page's publication, but the linking sites may become outdated or non-operational over time.

http://oceanexplorer.noaa.gov/explorations/10lophelia/welcome.html – Web site for the *Lophelia* II 2010: Cold Seeps and Deep Reefs Expedition

http://oceanexplorer.noaa.gov/edu/guide/gomdse_edguide.pdf – *Gulf of Mexico Deep-Sea Ecosystems Education Materials Collection Educators' Guide*

http://oceanexplorer.noaa.gov/edu/development/online_development.html – Online professional development opportunities, including *Lessons from the Deep: Exploring the Gulf of Mexico's Deep-Sea Ecosystems*

http://celebrating200years.noaa.gov/edufun/book/welcome.html#book - A free printable book for home and school use introduced in 2004 to celebrate the 200th anniversary of NOAA; nearly 200 pages of lessons focusing on the exploration, understanding, and protection of Earth as a whole system

http://www.restorethegulf.gov/ – The official federal portal for public information about the Deepwater BP oil spill response and recovery

http://response.restoration.noaa.gov/deepwaterhorizon – NOAA Web site on Deepwater Horizon Oil Spill Response

http://docs.lib.noaa.gov/noaa_documents/NESDIS/NODC/LISD/Central_Library/current_references/current_references_2010_2.pdf – Resources on Oil Spills, Response, and Restoration: a Selected Bibliography; document from NOAA Central Library to aid those seeking information concerning the Deepwater Horizon oil spill in the Gulf of Mexico and information on previous spills and associated remedial actions; includes media products (Web, video, printed and online documents) selected from resources available via the online NOAA Library and Information Network Catalog (NOAALINC)

http://www.gulfallianceeducation.org/ – Extensive list of publications and other resources from the Gulf of Mexico Alliance; click "Gulf States Information & Contacts for BP Oil Spill" to download the Word document

http://www.darrp.noaa.gov/southeast/deepwater_horizon/index.html – Information about damage assessments being conducted by NOAA's Damage Assessment Remediation and Restoration Program

http://www.noaa.gov/sciencemissions/bpoilspill.html – Web page with links to NOAA Science Missions & Data relevant to the Deepwater Horizon/BP Oil Spill

http://www.geoplatform.gov/gulfresponse/ – An online tool developed by NOAA, EPA, U.S. Coast Guard, and the Department of Interior that provides a "one-stop shop" for spill response information

http://www.education.noaa.gov/Ocean_and_Coasts/Oil_Spill.html - "Gulf Oil Spill" Web page from NOAA Office of Education with links

to multimedia resources, lessons & activities, data, and background information

Coastal Response Research Center. 2010. Deepwater Horizon Dispersant Use Meeting Report May 26-27, 2010. Coastal Response Research Center, University of New Hampshire. June 4, 2010; available online at www.crrc.unh.edu/dwg/dwh_dispersants_use_meeting_report.pdf

Fisher, C., H. Roberts, E. Cordes, and B. Bernard. 2007. Cold seeps and associated communities of the Gulf of Mexico. *Oceanography* 20:118-129; available online at http://www.tos.org/oceanography/issues/issue_archive/20_4.html

Kellogg, C. A., 2009, Gulf of Mexico deep-sea coral ecosystem studies, 2008–2011: U.S. Geological Survey Fact Sheet 2009–3094, 4 pp. available at http://pubs.usgs.gov/fs/2009/3094/

Sulak, K. J., M. T. Randall, K. E. Luke, A. D. Norem, and J. M. Miller (Eds.). 2008. Characterization of Northern Gulf of Mexico Deepwater Hard Bottom Communities with Emphasis on *Lophelia* Coral - *Lophelia* Reef Megafaunal Community Structure, Biotopes, Genetics, Microbial Ecology, and Geology. USGS Open-File Report 2008-1148; http://fl.biology.usgs.gov/coastaleco/OFR_2008-1148_MMS_2008-015/index.html

National Science Education Standards

Content Standard A: Science As Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard C: Life Science

- Interdependence of organisms

Content Standard E: Science and Technology

- Abilities of technological design
- Understandings about science and technology

Content Standard F: Science in Personal and Social Perspectives

- Science and technology in society

Content Standard G: History and Nature of Science

- Nature of science

Ocean Literacy Essential Principles and Fundamental Concepts

Essential Principle 1.
The Earth has one big ocean with many features.
Fundamental Concept h. Although the ocean is large, it is finite and resources are limited.

Essential Principle 3.
The ocean is a major influence on weather and climate.
Fundamental Concept f. The ocean has had, and will continue to have, a significant influence on climate change by absorbing, storing, and moving heat, carbon and water.

Essential Principle 5.
The ocean supports a great diversity of life and ecosystems.
Fundamental Concept c. Some major groups are found exclusively in the ocean. The diversity of major groups of organisms is much greater in the ocean than on land.
Fundamental Concept d. Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (such as symbiosis, predator-prey dynamics and energy transfer) that do not occur on land.
Fundamental Concept g. There are deep ocean ecosystems that are independent of energy from sunlight and photosynthetic organisms. Hydrothermal vents, submarine hot springs, and methane cold seeps rely only on chemical energy and chemosynthetic organisms to support life.

Essential Principle 6.
The ocean and humans are inextricably interconnected.
Fundamental Concept b. From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.
Fundamental Concept g. Everyone is responsible for caring for the ocean. The ocean sustains life on Earth and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.

Essential Principle 7.
The ocean is largely unexplored.
Fundamental Concept a. The ocean is the last and largest unexplored place on Earth—less than 5% of it has been explored. This is the great frontier for the next generation's explorers and researchers, where they will find great opportunities for inquiry and investigation.
Fundamental Concept b. Understanding the ocean is more than a matter of curiosity. Exploration, inquiry and study are required to better understand ocean systems and processes.

Fundamental Concept d. New technologies, sensors and tools are expanding our ability to explore the ocean. Ocean scientists are relying more and more on satellites, drifters, buoys, subsea observatories and unmanned submersibles.

Fundamental Concept f. Ocean exploration is truly interdisciplinary. It requires close collaboration among biologists, chemists, climatologists, computer programmers, engineers, geologists, meteorologists, and physicists, and new ways of thinking.

Send Us Your Feedback

We value your feedback on this lesson.
Please send your comments to:
oceanexeducation@noaa.gov

For More Information

Paula Keener, Director, Education Programs
NOAA's Office of Ocean Exploration and Research
Hollings Marine Laboratory
331 Fort Johnson Road, Charleston SC 29412
843.762.8818 843.762.8737 (fax)
paula.keener-chavis@noaa.gov

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Jason Virtual Van Inquiry Guide

A. Background About ROV *Jason*

Use the Internet or other resources provided by your teacher to answer the following questions:

1. What is *Jason II*?

2. What is the maximum depth that can be explored with *Jason II*?

3. What instruments are normally carried aboard *Jason II*?

4. What is *Medea*?

5. What are the advantages of using *Jason II* in combination with *Medea*, rather than having *Jason II* operate alone?

6. What is the *Jason* Control Van?

B. Dive With Jason!

During a typical *Jason II* dive, a tremendous amount of data is collected from a variety of sensors including video imagery from multiple cameras, information about the location and depth of the ROV, and measurements from scientific instruments. All of these data are recorded, but unless an observer is actually inside the control van during a dive it can be very difficult to obtain a sense of the "big picture" from many different data sets.

To deal with this problem, engineers at Woods Hole Oceanographic Institution developed the *Jason* Virtual Control Van, which is a Web-based application based on a series of snapshots that record events that occur during a *Jason II* mission. During a typical *Jason II* dive, a member of the science team creates an electronic record of events that take place during the dive, such as when a specimen is collected, something interesting is observed, or a specific measurement is made. Each of these events is recorded in the Virtual Control Van. In addition, an automatic record of sensor readings, video displays, and navigation information is made at regular intervals (every 0.5 – 2 minutes). Each automatic record is called an autosnap (ASNAP), and is also recorded in the Virtual Control Van.

In this part of your inquiry, you will use the *Jason* Virtual Control Van to re-create the discovery made with *Jason II* during the *Lophelia* II 2009 Expedition to the Gulf of Mexico.

1. Read the log entry for September 3, 2009, "A Closer Look Reveals an Exciting New Discovery!" by Dr. Chuck Fisher at http://oceanexplorer.noaa.gov/explorations/09lophelia/logs/sept3/sept3.html. You may also want to look at the videos linked to this page: http://oceanexplorer.noaa.gov/explorations/09lophelia/logs/sept3/media/movies/lophelia_abundance_video.html, and http://oceanexplorer.noaa.gov/explorations/09lophelia/logs/sept3/media/movies/diverse_reef_video.html.

2. The dive mentioned in Dr. Fisher's essay was made by the *Jason II* remotely operated vehicle (ROV). Now let's use the *Jason* Virtual Control Van to find out more about this discovery...

   Open the *Jason* Virtual Van System home page at http://4dgeo.whoi.edu/jason/. In the menu on the left side of the page, the headings under **Jason VVan System** link to additional information about the system. If you click on the arrow next to a year, a list will appear of the *Jason* missions for that year that are included in the Jason Virtual Van system. Click on the arrow next to **2009** then click **Lophelia II-3 [rb-09-05]**.

3. A new window appears titled **ROV JASON Lophelia II-3 CruiseID rb-09-05**. The upper part of the window provides the Cruise Objective and general statistics about the cruise. If you click **Virtual Van** on the lower left of the upper window, a new window will open showing the Jason Virtual Van window for the first record for the first lowering of

the *Jason II* ROV Cruise rb-09-05. Don't press this button right now (if you already pressed it, close the new window and return to the window that has the cruise statistics).

The lower portion of the window is titled **Jason VVan rb-09-05 Lowering Statistics**. This window lists each dive (called a lowering) of the *Jason II* ROV during the cruise. For each lowering, the start time, end time, duration, maximum depth, and number of Virtual Van records for that dive are listed. We are interested in the lowering that took place on September 3, 2009. Scroll down the Lowering Statistics window to find the entry for Lowering J2-466.

a. Dr. Fisher says that the entire dive lasted approximately 24 hours. Exactly how long was this dive?

_____

b. What was the maximum depth reached by the ROV during this dive?

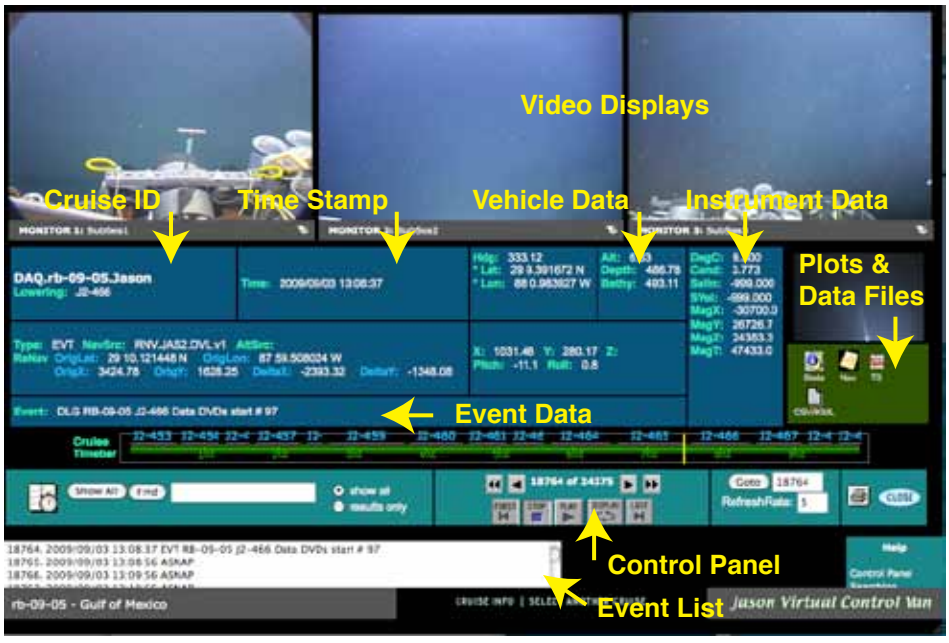
_____

c. How many records are contained in the *Jason* Virtual Van for this dive?

_____

4. Now click **Virtual Van** on the lower left of the upper window. A new window will open showing the Jason Virtual Control Van window for the first record for the first lowering of Cruise rb-09-05. Figure 1 shows how the window is set up.

Figure 1.



Here are some tips to help you use the *Jason* Virtual Control Van window:

a. The **Event** entry on the middle left side shows which event is recorded in the video and data displays. The **Event List** on the bottom left shows all of the events that were recorded during the lowering.

b. The **Control Panel** allows you to step through the **Events** one at a time, or to have them "play" at the interval set in the **Refresh Rate** window. You can also use the **Goto** window to skip to a specific **Event**.

c. The **Vehicle Data** section gives information about the ROV's location, including:
- Heading (compass course)
- Latitude and Longitude
- Altitude (distance above the bottom)
- Depth (distance the ROV is from the surface)
- Bathymetry (depth of the bottom)
- X, Y, and Z coordinates (sometimes it is more convenient to establish a "local" coordinate system to describe the ROV's position rather than use latitude, longitude and depth)
- Pitch (how much the ROV is pointed up or down; a negative pitch means the ROV is pointed downward; a pitch equal to 0 means the ROV is horizontal)
- Roll (how much the ROV is tilted to the left or right)

d. The **Instrument Data** section shows measurements provided by various sensors carried aboard the ROV, including:
- DegC (temperature in degrees Celsius)
- Cond (conductivity in Siemens/meter)
- Salin (salinity in Practical Salinity Units)
- SVel (sound velocity in meters/second)
- MagX, MagY, MagZ, MagT (outputs from an onboard magnetometer)

Note that a value of -999.000 means that a measurement has not been recorded.

e. In the **Plots & Data Files** section different buttons allow you to:
- **Stats** button – Create a table showing lowering statistics for each lowering during the cruise (same as the window discussed in Step 3)
- **Nav** button – Create a two-dimensional plot of the ROV's track during the lowering; longitude is on the x-axis and latitude in on the y-axis
- **TS** button – Create a time-series plot of selected data (such as depth, conductivity, etc) for the entire lowering
- **CSV/KML** button – Download a comma-separated file of all data for every event during the lowering; you can open this file in a spreadsheet and create graphs, scan event descriptions for particular occurrences, etc.; you can also download a KML file of these data for use in an application such as Google Earth

5. Now let's use the *Jason* Virtual Control Van to find out more about the *Jason II* dive in the Gulf of Mexico on September 3, 2009.

   Open the *Jason* Virtual Control Van window as described above, and enter "j2-466" in the window next to the **Find** button. Press the **Find** button, and the first entry in the **Event List** should be:

   18747. 2009/09/03 12:32:16 EVT RB-09-05 J2-466 Jason Jason in water

   As you know from question 3a, this is the first event in **Lowering J2-466**. Two of the video displays show the greenish color typical of shallow water in the Gulf of Mexico, while the third display shows the deck of the ship.

6. Using the **Go To** button, skip ahead to **Event 18749**.
   a. How deep is *Jason II* at this point?

   _____

   b. How far off the bottom is the ROV?

   _____

   c. Is the ROV horizontal?

   _____

   d. If the ROV began its descent immediately following the last Event entry, what was its rate of descent?

   _____

   _____

   _____

   e. What is the temperature difference between **Events 19748** and **18749**?

   _____

   f. Scroll down the **Event List**, and you will see a long series of autosnaps (ASNAPs). What is the interval between these ASNAPs?

   _____

7. Skip to **Event 18876**.
   a. What do you see in the video displays?

   _____

   b. How far above the bottom is the ROV?

   _____

8. Skip to **Event 18960**.
   a. What does **Video Monitor 1** show?

   b. Look at all three video displays for the next three events. Can you tell what is happening?

9. What kind of fish are observed in **Event 20136**?

10. **Event 20612** is noted as a "Best of Video."

    a. What is happening?

    b. How long did it take for this activity to be completed?

11. What is going on during **Events 20389** through **20410**?

    You can see more video of this technique here:
    http://oceanexplorer.noaa.gov/explorations/09lophelia/logs/aug26/media/movies/pushcore_video.html

12. What is being collected in **Events 20637** through **20648**?

13. What is being collected in **Event 22115**?

14. What organisms are conspicuous in **Events 22441** through **22443**?

15. While underwater robots such as *Jason II/Medea* are much less expensive to operate than human occupied submersibles, deep-sea exploration is still expensive. Why is this sort of exploration important?