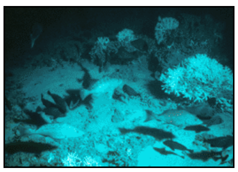
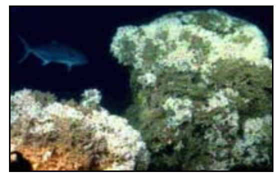
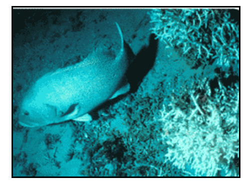
Summary Report

Treasures of the Deep –
Deep Water Corals of the South Atlantic and the Oculina Bank:
A Local Resource Workshop for Teachers

November 2005

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National Oceanic & Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
Deep Water Corals Education & Outreach Program

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I. Background

At the International Symposium on Deep Sea Corals (Erlangen, Germany; September 2003), the destruction of deep-sea coral beds by fishing gear impacts was dramatically illustrated (see http://www.geol.uni-erlangen.de/pal/isdsc/). "The situation is more serious than we feared," said Martin Willison, biologist at Dalhousie University in Halifax. "It's clear that corals are being damaged throughout the world. Fishermen are going deeper and deeper using ever-more destructive methods." A special session of the symposium highlighted the importance of outreach for the conservation of offshore resources. At the meeting, scientists from around the world singled out the *Oculina* Bank as an area that illustrates the plight of deep-sea corals and urgent need for more and better outreach.

The South Atlantic Fisheries Management Council (SAFMC) understands this priority and the need for a dedicated outreach plan for the *Oculina* Bank Habitat Area of Particular Concern (OHAPC). A 1996 brochure described the experimental reserve established in 1994; however, the brochure received minimal distribution and attention. As was noted by a member of the SAFMC Information & Education Committee at the recent Wrightsville Beach, North Carolina, Council meeting, "we need a fresh, new approach" to outreach for the *Oculina* Bank. Partners involved with OHAPC research and outreach over the past decade proposed development of such an approach.

While protection of the OHAPC certainly contributed to preservation of these ecosystems, trawlers still poach in the OHAPC, and they may continue to explore other new Deep-Sea Coral Ecosystem (DSCE) sites in the South Atlantic (e.g., deeper *Lophelia* reefs), with similar devastating results. Taking advantage of the momentum generated by the 2003 International Symposium of Deep-Sea Corals and by the recent Council meeting, the National Oceanic and Atmospheric Administration (NOAA) and SAFMC collaborated to formulate a comprehensive outreach plan for the OHAPC and Deep Sea Corals with input from local, regional, and national entities. Current efforts to implement this plan include:

- Creation of posters and rack cards for display in classrooms, bait and tackle shops, marinas, hotels, and restaurants;
- Development of a portable exhibit for display at outreach events, meetings, and symposia;
- Attendance at local area fishing tournaments and distribution of surveys and fact sheets about the OHAPC;
- Support for teacher professional development opportunities and distribution of education products for science, math, and technology teachers throughout the central eastern Florida region; and
- Execution of event-based outreach following the October 2005 research and monitoring cruise to the OHAPC, including Port Day, media excursions, press releases, and media packets.

On September 17, 2005 in Titusville, Florida at Dixie Crossroads Seafood Restaurant, NOAA, SAFMC, and Harbor Branch Oceanographic Institute sponsored a one-day teacher workshop entitled *"Treasures of the Deep – Deep Water Corals of the South Atlantic and Oculina Bank: A Local Resource Workshop for Teachers."* This workshop contributed towards accomplishing our goal of increasing awareness and appreciation of the OHAPC and DSCE sites among fishermen working in the area, citizens and visitors of central-eastern Florida, teachers and students, and the United States public. Twenty-one secondary school educators from three counties along the central eastern coast of Florida attended the workshop.

Participants learned about DSCE, the OHAPC, research and monitoring efforts, resource management, and received educational materials for classroom use. Additionally, workshop participants provided input on subsequent deep water coral outreach and education activities planned in conjunction with the October 2005 Ivory Tree Coral Expedition to the OHAPC (e.g. Port Day, web site interaction). Participants received new curriculum and multi-media educational resources, conducted activities related to oceanographic exploration, and gained further understanding of the importance of this unique deep water habitat.

II. Workshop Summary

Planning of the "Treasures of the Deep" workshop began in late June 2005 following two days of public meetings about the OHAPC in Cape Canaveral and Cocoa Beach, Florida. The overall goals for the teacher workshop included incorporation of DSCE and OHAPC research information into classroom curriculum; increasing partnerships between scientists, resource managers, educators, and students; and, increasing opportunities for educator and student participation in research and monitoring efforts along the *Oculina* Bank.

The first step in planning the workshop was selection of the target audience. The planning group decided the workshop would target secondary school science, math, and technology teachers of grades nine through twelve in three counties (i.e., Brevard, Indian River, and St. Lucie) along the central eastern coast of Florida. These counties are closest in proximity to the *Oculina* Bank and are home to many recreational and commercial fishermen that frequent the waters within and around the OHAPC. Additionally, the planning group decided that the number of workshop participants would be limited to thirty for easy facilitation and communication. Through early contact with the targeted school districts, the planning group obtained district approval for awarding participants with teacher re-certification credits.

Second, the workshop planning group drafted content for the teacher workshop materials binders, including lesson plans and additional educational resources, such as relevant scientific journal articles, which would be distributed to all workshop participants. This process included researching lesson plans already available, which could then be modified to meet the goals of the workshop and the needs of the target audience. Many of the final lesson plans included in the teacher packets were adapted from the NOAA Ocean Explorer website at http://oceanexplorer.noaa.gov/ (see Appendix A).

Last, the planning group outlined the workshop agenda, which included presentations, lunch, a keynote speaker, activities, and a question and answer period. In addition to the materials provided in the teacher packets, the planning group contacted various non-governmental organizations, governmental agencies, and academic institutions for donations of promotional items, such as brochures, newsletters, pens, bags, and t-shirts, for inclusion in the teacher "goodie bags." Each workshop participant received one of these bags (see Appendix B). Laurilee Thompson, of Dixie Crossroads Seafood Restaurant, generously donated the meeting space and lunch for the workshop. See Appendix C for an agenda of workshop activities.

a. Presentation Summaries

The planning group structured the presentation schedule such that it began broadly by focusing on deep-sea corals at the national scale and at the management level, then continuously narrowed down to the level of the OHAPC ecosystem. Jennifer Schull, of NOAA Southeast Fisheries Science Center, introduced the NOAA perspective on deep-sea corals in a presentation entitled "Deep-Sea Corals: NOAA Overview." Andy Shepard, the director of NOAA's National Undersea Research Center (NURC) at the University of North Carolina-Wilmington, focused on the *Oculina* Bank and "Evaluation Science"; and John Reed of Harbor Branch presented our keynote presentation during lunch: "Deep-Water Coral Reefs off Southeastern USA." In the afternoon, Laurilee Thompson of Dixie Crossroads Seafood Restaurant explained the history of the restaurant and the local rock shrimp fishery.

DEEP-SEA CORALS: NOAA OVERVIEW

JENNIFER SCHULL, NOAA SOUTHEAST FISHERIES SCIENCE CENTER

The major points of this presentation included an overview of DSCE locations, why they are important, and how they are being managed and conserved by NOAA. DSCE of several varieties are located all along the coastal waters of the United States, and they are important for several reasons not least of which is the incredible amount of biodiversity present and the protective habitat available for commercially important fish species.

Unfortunately, because of the depths at which DSC are found, they are subject to irreversible damage and/or complete destruction from human pressures. Human pressures include fishing using bottom trawls and oil and gas exploration and development. Natural pressures may include climate change, disease, and other unknown natural occurrences affecting the life cycles of these fragile, slow-growing corals.

NOAA's management responsibilities relative to DSCE include working with the eight regional fisheries management councils to address fishery impacts on essential fish habitat in addition to protecting DSCE under the National Marine Sanctuaries Program. Council management measures are increasingly including the closure of specific areas known to contain valuable DSC habitat to bottom trawling. In the South Atlantic region, the *Oculina* Experimental Closed Area prohibits fishing for snapper-grouper species in addition to the prohibitions of the OHAPC (i.e., bottom fishing, anchoring, fishing for rock shrimp, or possessing *Oculina* coral).

Current SAFMC management endeavors involve developing a Deep Water Coral Research and Monitoring Plan and evaluation plan for the *Oculina* Experimental Closed Area, consideration of more areas for designation as HAPCs in the South Atlantic, increased outreach efforts, and increased enforcement of OHAPC regulations. One advance in enforcing rock shrimp fishery regulations is the mandatory installment of Vessel Monitoring Systems (VMS) on all licensed rock shrimp vessels.

The topic of VMS stimulated questions from workshop participants. The following are examples of the types of questions asked:

- Are the fishers that fish near the OHAPC locally based?
- What about foreign fishing vessels? Are they monitored?
- What are the dates of the VMS data included in the graphic?
- Is there terrain on the southern end of the OHAPC that attracts fishers?

Overall, the presentation highlighted the growing international and national awareness of DSCE as valuable resources that require further protection, conservation, research, and monitoring via comprehensive ecosystem management plans, inter-agency cooperation and partnerships, and public engagement. Supporting this growing consciousness within NOAA is the development of a report on the *State of U.S. Deep-Sea Coral Ecosystems*; co-sponsorship of the third International Deep-Sea Coral Symposium in November 2005; the NOAA-NURP research and monitoring cruise to the *Oculina* Bank in October 2005; and, the NOAA-NURP/Ocean Explorer deep-sea coral cruise in the Georges Bank in late October 2005.

Oculina Bank "Evaluation" Science

Andy Shepard, NOAA National Undersea Research Center at UNC-Wilmington

Here, the geology of the Florida peninsula and the *Oculina* Bank was presented along with a gallery of photos illustrating the diversity of the ecosystem found along the Bank. Additionally, the technology, methodology, and applications of undersea science were described. The link between science and effective management of various important commercial fisheries (e.g. rock shrimp, grouper) also were explored and explained.

Beginning with a description of reefs and the process of reef building, the presentation explained the geologic morphology of Florida’s carbonate reefs and where reefs exist in the South Atlantic Bight today. The presentation of the geologic foundations of the *Oculina* Bank resulted in a couple of questions from teachers about the location of the *Oculina* Bank in relation to the continental slope. Other questions related to the location and structure of the Bank included:

- Does the Bank experience impacts from hurricanes?
- Does the Bank act as a steering mechanism for the Gulf Stream?

The Canaveral shelf was described as a “hotspot” for fisheries and ocean productivity because of the oceanographic features associated with the Florida Current. The slow-growing, reef-building form of *Oculina varicosa* is found only in the dynamic waters off the eastern central coast of Florida and thus at risk. The most obvious human impact on DSCE is fishing. The *Oculina* Bank traditionally supports several local commercial and recreational fisheries including grouper, pelagics (e.g., Wahoo, dolphin, tuna), Calico scallops, and rock and brown shrimp. Over the years, many of these local fisheries experienced a decline in stocks, if not a complete collapse (e.g. Calico scallops). This decline forced fishermen to move deeper and to use more damaging fishing gear (i.e. trawls). Trawling has an undeniable impact on fragile deep water corals. It completely decimates them to rubble, which is less desirable and productive fish habitat.

Two questions asked by workshop participants after discussion of fishing practices included:

- Whether fishermen were allowed to fish during spawning aggregations and,
- Whether rock shrimp utilized the Indian River Lagoon (IRL) for any portion of its life cycle (e.g. spawning, larval stages).

Additionally, another participant asked if rock shrimp might absorb chemicals and/or bioagents from the IRL, thereby depositing these chemicals/agents on the *Oculina* Bank reefs. Is there a possible link between the outflow of Lake Okeechobee, the IRL, and the *Oculina* Bank? One participant inquired whether there is a “recipe” or some sort of “starter kit” for growing *Oculina varicosa* and could this knowledge be used to restore damaged reefs.

The SAFMC recognizing that the *Oculina* Bank was essential habitat for the snapper-grouper complex and rock shrimp and in 1984, designated 315 square kilometers of the Bank as the *Oculina* Habitat Area of Particular Concern (OHAPC). This designation prohibited trawling and dredging within the OHAPC.

In 1994, the SAFMC made further restrictions within the OHAPC by prohibiting all bottom fishing, including trawling, and by creating the *Oculina* Experimental Closed Area within the OHAPC. The Experimental Closed Area has the same restrictions as the rest of OHAPC in addition to prohibiting fishing for or possessing any species of the snapper-grouper complex within that area. The SAFMC expanded the entire OHAPC to a total of 1029 km^2 in 2000. In 2003, the Council extended the restrictions of the OHAPC and the Experimental Closed Area indefinitely.

The restrictions set in place by the Council require several measures to be effective. Besides adequate law enforcement measures (i.e., VMS and increased on-the-water surveillance), outreach, research, monitoring, and assessment must occur. Thus, the SAFMC developed an *Oculina* Experimental Closed Area Evaluation Plan in 2005 for gauging the effectiveness of the restrictions over the next 10 years.

This plan included education and outreach efforts to inform the public about the existing OHAPC restrictions and to create a more substantial relationship with the public the Council serves. These efforts include teacher workshops, such as "Treasures of the Deep," at-sea experiences for educators and media, web interaction between researchers and educators, and increased visibility of the *Oculina* Bank in the media via documentaries and press releases.

Research, monitoring, and assessment of the *Oculina* Bank take place via ocean science. Performing ocean science on deep water coral reefs requires a variety of sophisticated technologies including occupied submersibles, remotely operated vehicles (ROVs), and autonomous underwater vehicles (AUVs) in addition to traditional tools such as geographic positioning systems (GPS), swath mapping echo sounders, and charts. Increasingly, geographic information systems (GIS) are used to map and manage data obtained from these technologies. GIS makes data access, sharing, and integration possible.

All of these technologies and methodologies combined are essential for evaluating the OHAPC and Experimental Closed Area and for conveying the results to stakeholders. For example, surveys using multi-beam echo sounders and GPS, combined with ground-truth video using ROVs allow researchers and resource managers to "see" the topography, substrate types, and biota.
These surveys also create a baseline habitat map for the managed area, which serves several purposes including guidance for research activities, baseline for assessing habitat condition over time and space, and meeting basic mandates of the SAFMC such as essential fish habitat description for the deep water snapper-grouper species complex. Questions from workshop participants in relation to habitat mapping and the technologies employed in ocean science research along the *Oculina* Bank included:

- What is the penetration of sonar and/or echo sounders?

∀ Do researchers at NOAA have access to Department of Defense nuclear submarine bottom topography/depth data?

Repeated mapping of the same area over time allows for effective monitoring and subsequently allows for better management. NOAA-NURP research expeditions over recent years have mapped approximately 50% of the entire OHAPC and greater than 90% of the *Oculina* coral bioherms within the entire OHAPC; however, much work remains and efforts must continue. Complementing the initiatives of the Council's Evaluation Plan is a NOAA-NURP research and monitoring expedition to the OHAPC in October 2005. Ultimately, the overriding issue affecting effective research, monitoring, assessment, and management is available funding for staff, supplies, and equipment. This prompted one workshop participant to comment that this "sounds like education" in that a plan is developed, yet no money is allocated to implement it.

DEEP WATER CORAL REEFS OFF SOUTHEASTERN USA

JOHN REED, HARBOR BRANCH OCEANOGRAPHIC INSTITUTE

This keynote presentation occurred during lunch and featured numerous images of the benthic flora and fauna found in DSCE of the Southeastern U.S. An overview of deep water coral reefs provided an explanation of how these reefs are classified and how and where they grow. Alternate terms used for DSCE reefs include bioherms, coral banks, or lithoherms. Deep water corals may build mounds (bioherms) or they may exist as beds of coral growing on rocks (lithoherms). These reefs exist in areas with relatively strong currents and upwelling, facilitating nutrient uptake by the coral.

Most of the information known about the *Oculina* Bank comes from nearly 20 years of research done in part by John Reed, Harbor Branch Oceanographic Institute, and colleagues using the Johnson-Sea-Link (JSL) submersibles. The four-person JSL submersibles are capable of dives to 914 meters and are outfitted with an array of photographic and collection equipment. Scientific divers made lockout dives from the JSL submersibles at depths of 80 meters for research on growth rates and animal communities of the *Oculina* reefs. Recent expeditions to the reefs funded by NOAA used NOAA-NURP's ROV, Phantom S2.

In addition to research on *Oculina varicosa*, which forms reefs comprised of numerous pinnacles and ridges at depths of 70-100 meters along the shelf edge of central eastern Florida, JSL submersibles also gather data on deep *Lophelia pertusa* reefs. These corals occur at depths of 500-850 meters and form pinnacles up to 150 meters tall along the Florida-Hatteras slope in the Straits of Florida.

The geomorphology and structure of both the *Oculina* and *Lophelia* reefs are similar. Both corals form spherical, bushy colonies 10 to 150 centimeters in diameter. In shallow water, *Oculina* forms golden brown-colored colonies less than 30 centimeters in diameter with thicker branches and grows throughout the Caribbean to Bermuda. The deep water form has thinner branches, no zooxanthellae (making it pure white in color), and is known to exist only off the eastern coast of Florida. At a depth of 80 meters, *Oculina* grows at a rate of approximately 16 millimeters per year, which means that a large (1.5 meters) colony may be nearly a century old. At this point during the presentation, workshop participants asked the following questions:

- Does the deep water form of *Oculina* grow in a more fragile form because it grows below the disturbance of wave action?
- Does deep water *Oculina* grow faster than its shallow water form?
- How large is a mound?
- How tall does the coral grow?
- What is the tallest of all deep water coral species?

Lophelia only grows in deep water. It populates the depths of the western Atlantic Ocean from Nova Scotia to Brazil and the Gulf of Mexico. Additionally, it is found in the eastern Atlantic (off Norway and Scotland), the Mediterranean, the Indian, and Pacific Oceans at depths of 60-1270 meters. *Lophelia* grows at an estimated 6-25 millimeters per year and a core sample taken from a reef in Norway revealed that these reefs are ancient (~8600 years old). Additionally, the core sample revealed that the structure of these reefs consists of dead and dying coral, sediment, and rock. The core sample ignited more questions from the workshop attendees, including:

- How deep was the core sample?
- How deep was the location of the reef?
- How old was the reef?
- What is the difference between a bump, lump, or rock and how does one determine if it is a lithoherm or just a rock?

These deep water coral reefs support very rich communities of associated invertebrates and fish. Faunal diversity on the *Oculina* reefs is equivalent to many shallow water tropical reefs. Over 20,000 individual invertebrates live among the branches of *Oculina* colonies. Sea urchins, star fish, brittle stars, crabs, shrimp, and slipper lobsters abound on these reefs; however, unlike *Lophelia* reefs, larger sessile invertebrates such as sponges and gorgonians are not commonly found on *Oculina* reefs. The *Oculina* coral itself is the dominant component on these reefs.

The dense invertebrate community helps support the dense and diverse populations of fishes (greater than 70 species). The *Oculina* reefs form impressive breeding grounds for commercially important populations of gag (*Mycteroperca microlepis*) and scamp (*M. phenax*); nursery grounds for juvenile snowy grouper (*Epinephelus niveatus*); and feeding grounds for these and other fish. Spawning aggregations of scamp and gag appear to prefer the deep reef coral formations, but in recent years, the aggregation populations have dwindled immensely as commercial and recreational fishing pressures increased and habitat decreased. Evidence of fishing lines is common on many deep reefs and the removal of such apex predators as grouper, snapper, and sharks may have severe long-term repercussions on the ecology of these unique and fragile communities. Bottom trawling and dredging certainly cause severe mechanical damage to deep water reefs. In addition, most deep water fish communities are over fished or depleted.

The OHAPC was the first marine protected area in the world for deep water reefs. Recently, Norway enacted its own marine protected area legislation, which created the first MPA protecting *Lophelia* coral reefs. A proposal for a Northern Coral Forest MPA in Canada seeks to protect the deep water, soft coral habitats off Nova Scotia and in 1995, a deep water marine reserve was established on the continental shelf of Tasmania, protecting 370 square kilometers that contain 14 seamounts.

Following the Power Point presentation, Mr. Reed played two DVDs produced by Harbor Branch. The first, a twenty-minute documentary entitled “Deep Water Coral Reefs of Florida, Georgia, and South Carolina,” provided an overview of the DSCE found in the South Atlantic, including the Miami Terrace. Workshop participants asked if the Miami Terrace deep water coral bank could be included in the Florida Keys National Marine Sanctuary one day. Additionally, referring to the tilefish present in the DVD, one participant asked how deep the tilefish burrows went.

The second DVD, entitled “Oculina Reefs in Jeopardy: Deep-Sea Trawling Exposed,” was ten minutes long and presented the plight of the OHAPC, which still experiences the effects of poaching. Effective enforcement of the OHAPC regulations is one of the greatest challenges facing the longevity of the *Oculina* reefs. Teachers received copies of both DVDs for use in the classroom.

THE HISTORY OF DIXIE CROSSROADS AND THE LOCAL ROCK SHRIMP FISHERY

LAURILEE THOMPSON, DIXIE CROSSROADS SEAFOOD RESTAURANT

This informal talk occurred after lunch and prior to the break out sessions. Laurilee Thompson explained the genesis of Dixie Crossroads Seafood Restaurant and the history of the local rock shrimp fishery. In 1969, her father, Rodney Thompson, began trawling for rock shrimp off the east coast of Florida, along the *Oculina* Bank. To improve operating efficiency, Rodney invented a machine that could split the hard shell of the rock shrimp, making them easier to crack open for removal of a large sand vein. The shrimp could then be broiled within their shells, just like a lobster, making them a popular local and regional seafood delicacy.

Rodney established a processing plant at Port Canaveral, FL, called Ponce Seafood. For the next ten years, Ponce Seafood produced about 10 million pounds of processed rock shrimp a year. Ponce Seafood was the only fish house purchasing and providing rock shrimp. Other processing facilities operating at the time were reluctant to use rock shrimp because of the intense amount of hand labor required for cleaning them. Instead, the processors preferred using huge machines, called Lathrams, which peeled and de-veined brown and white shrimp. Peeled shrimp are popular in restaurants for use in stir-fry dishes, soups, salads, and Calabash bars.

In the mid-1980's Pascagoula Ice Company in Pascagoula, Mississippi became the first company to modify a Lathram machine, enabling it to peel rock shrimp. By increasing the diameter and adding heavier sandpaper to the rollers of the Lathram machines, Pascagoula Ice could crush the hard shells of rock shrimp, exposing the sweet lobster-like meats. The other processing companies quickly followed Pascagoula Ice's lead, and modified their Lathrams for rock shrimp processing.

The improved processing technology compelled dozens of trawlers from the Gulf of Mexico toward Florida's East Coast in search of rock shrimp. Some of the super-trawlers were quite large – 110 feet long and capable of dragging four 60 foot flat nets at one time. The bigger boats could catch and freeze more than 5000 pounds of shrimp a day. Fishing pressure on rock shrimp intensified. Catches peaked in 1991, when 40 million pounds of rock shrimp crossed the docks in Florida.

Consequently, rock shrimp catches declined at a rapid rate. The super-trawlers moved further south and east into the juvenile shrimp grounds, damaging the fragile *Oculina* reefs. Dragging nets with heavy chains, they created paths, called "goat trails," through the coral. Modern technology (plotters, GPS, and color scopes that showed the bottom contours more clearly than the old paper recorders) gave shrimpers the ability to drag safely in the same paths, reducing the chance of snagging, and losing, their nets in the coral.

Smaller shrimpers followed the super-trawlers into the nursery grounds. Operating ever closer to the time the juvenile rock shrimp first arrived each year, shrimpers shoveled thousands of pounds of small dead rock shrimp over the side as they culled the few marginally marketable ones to bring to shore. Rock shrimp disappeared off the Carolinas and Georgia, as it was impossible for the shrimp to slip through the gauntlet of boats to get there.

In 1994, recognizing that something must change before rock shrimp became extinct, Rodney, now the owner of Dixie Crossroads Seafood Restaurant, began campaigning for restrictions on destructive bottom trawling in the nursery grounds within the *Oculina* coral reefs and for implementation of a management plan for rock shrimp. Initially he met major resistance from captains, boat-owners, and owners of fish houses. Unable to procure enough rock shrimp to last all year, Dixie Crossroads began running out of them every spring. Catch rates continued crashing at an alarming rate, and in 2000, less than three million pounds of rock shrimp crossed the docks in Florida.

The decreasing catch rates inspired support for Rodney's management campaign among the people dependent on the rock shrimp fishery. In 2001, a new precedent was set when, under Rodney's guidance, all stakeholders sat down together to develop a management plan, which the SAFMC unanimously approved. This was a rare instance of a southern group of fishermen both agreeing that management was necessary and actively engaging in development of the resulting restrictions.

No longer can trawlers drag through the nursery grounds in the *Oculina* reefs. No additional boats may enter the rock shrimp fishery. Only time will tell whether their plan was implemented in time to save the rock shrimp stocks.

b. Break Out Session Summary

Following the presentations, participants divided themselves into five groups based on their primary interest in one of the five lesson plans provided in the teacher workshop materials binders. Participants chose the lesson that best suited their interests based on the summaries provided in the workshop agenda. Below are brief descriptions of each lesson plan and the name of the lesson plan facilitator.

- **Cool Corals** – Biology and ecology of shallow and deep water corals
  Facilitated by Sarah Heberling, University of Miami Rosenstiel School of Marine & Atmospheric Science
- **Who's Your Neighbor** –Benthic invertebrate groups associated with deep water coral reefs
  Facilitated by Jim Wharton, Smithsonian Marine Station at Ft. Pierce
- **Living in Extreme Environments** – Biological sampling methods
  Facilitated by Jocelyn Karazsia, NOAA-NMFS Habitat Conservation Division
- **Mapping the Bank** – Bathymetry of the *Oculina* Bank
  Facilitated by Andy Shepard, NOAA National Undersea Research Center at University of North Carolina-Wilmington
- **Spawn!** – Environmental needs of spawning reef fishes
  Facilitated by Jennifer Schull, NOAA Southeast Fisheries Science Center

The facilitators led each group through the lesson plan's background information, vocabulary, and activities and asked for feedback from the participants. At the end of the activities, the entire group of workshop participants reconvened. A member of each break out group was selected to summarize their group's lesson plan activities and comment to the rest of the workshop participants. The following is a summary of the comments made for each lesson plan.

Living in Extreme Environments	∀ This lesson plan teaches to FCAT Math. ∀ It covers the scientific method. ∀ It is an interdisciplinary lesson plan that is very adaptable. ∀ The materials required for the lesson plan activity are very affordable. ∀ This lesson plan utilizes the metric system and metric measurements. ∀ Writing a paragraph on the back of the Student Evaluation Sheet that describes how new knowledge of the deep sea might make a difference in the lives of students in 10 years might be too large a task for students, therefore another suggestion might be drawing a picture instead. ∀ Overall, this lesson plan is great and incredibly useful.
Cool Corals	∀ This lesson plan is very adaptable to the needs of middle school students and educators. ∀ This lesson plan utilizes questioning skills through the elaboration of questions. ∀ A suggestion for facilitating the lesson plan activity is using the DVDs from Harbor Branch for background information and as inspiration for inquiry question formation.
Mapping the Bank	∀ This lesson plan activity needs a pre-lesson for students that covers the background information (as provided), the concepts of latitude and longitude, vocabulary, and an overview of reading maps (e.g. legend, symbols, contours, etc.). ∀ This lesson plan needs additional vocabulary (glossary). ∀ This lesson plan needs a units/conversion table (including the number of feet in a statute mile and in a nautical mile). ∀ A suggestion for the materials needed for this lesson plan activity is: use appropriate maps that include keys on them; create digital copies of appropriate maps and post on Web, which can be printed out in black and white or color, and perhaps laminate them for repeated use in classroom; perhaps provide variety of maps from different locations (NOTE—hunting through Web resources does not work for this purpose and will require too much work for teachers)

	∀ This lesson plan should include an answer sheet with explanations for teachers. ∀ This lesson plan uses applied math skills well. ∀ This lesson plan provides excellent opportunities for interdisciplinary units (science, math, social studies, language arts, history—e.g., plot route of great explorer).
Spawn!	∀ This lesson plan covers ecology, evolution, and human impacts very well. ∀ This lesson plan provides the opportunity for an FCAT reading activity. ∀ This lesson plan provides great vocabulary words.
Who's Your Neighbor?	∀ This lesson plan teaches taxonomy, which is great. ∀ This lesson plan teaches of variety of organism characteristics, which is also great. ∀ This lesson plan requires many visual aids (e.g. photographs, etc.).

Participants did mention that they appreciated the web resources provided in each lesson plan; however, internet access in classrooms is limited and unreliable. Internet access in libraries and at the homes of students is better, but not always the best way of getting students to obtain information. Overall, the lesson plans proved useful and were adequate for the needs of teachers.

III. Workshop Participant Evaluations and Feedback

Prior to the workshop, the workshop planning group selected two types of evaluations that best reflected the goals, objectives, and themes of the workshop. The first evaluation tool was a self-assessment (see Appendix). The self-assessment included three different thematic areas in which participants would, prior to and following the workshop, rate their knowledge of specific content areas and their ability to use this knowledge in the classroom. The desired outcome of this evaluation was an improvement in the knowledge and abilities of each of the workshop participants.

The second evaluation tool was a post-workshop evaluation in which participants scored how well the workshop facilitators met the goals and objectives of the workshop (see Appendix). The participants responded to nine statements using a scale from "Strongly Disagree" to "Strongly Agree." The expected outcome of this evaluation was all participants responding that they "Strongly Agree" that the workshop met all of the goals and objectives provided. Additionally, participants had room allotted on the evaluation sheet for any other comments they wanted to provide.

a. Pre- and Post-Workshop Self-Assessments

The ratings given by participants in this evaluation were entered into a Microsoft Excel spreadsheet. For both the "content knowledge" and "ability to use this knowledge" categories, the average rating for each specific content area under each of the three thematic topics was calculated. These averages were charted on a bar graph (see Figures 1A-3B). Using the averages for each specific content area, the average pre- and post-workshop rating for all content areas under each thematic topic was calculated. Then, a simple two-tailed test (t-test) was performed on these comprehensive ratings averages. A confidence interval of 95% (0.05) was used for the calculations. All post-workshop mean evaluations were significantly greater than pre-workshop mean evaluations.

DEEP WATER CORAL ISSUES

The mean post-workshop self-assessment rating for participant content knowledge of "Deep Water Coral Issues" (μ_{post} = 3.12) was significantly greater than the mean pre-workshop self-assessment rating for participant content knowledge of "Deep Water Coral Issues" (μ_{pre} = 1.72), t(40) = 2.021, p = 0.3.

The mean post-workshop self-assessment rating for participant ability to use knowledge of "Deep Water Coral Issues" in the classroom (μ_{post} = 2.61) was significantly greater than the mean pre-workshop self-assessment rating for participant ability to use knowledge of "Deep Water Coral Issues" in the classroom (μ_{pre} = 1.24), t(40) = 2.021, p = 0.3.

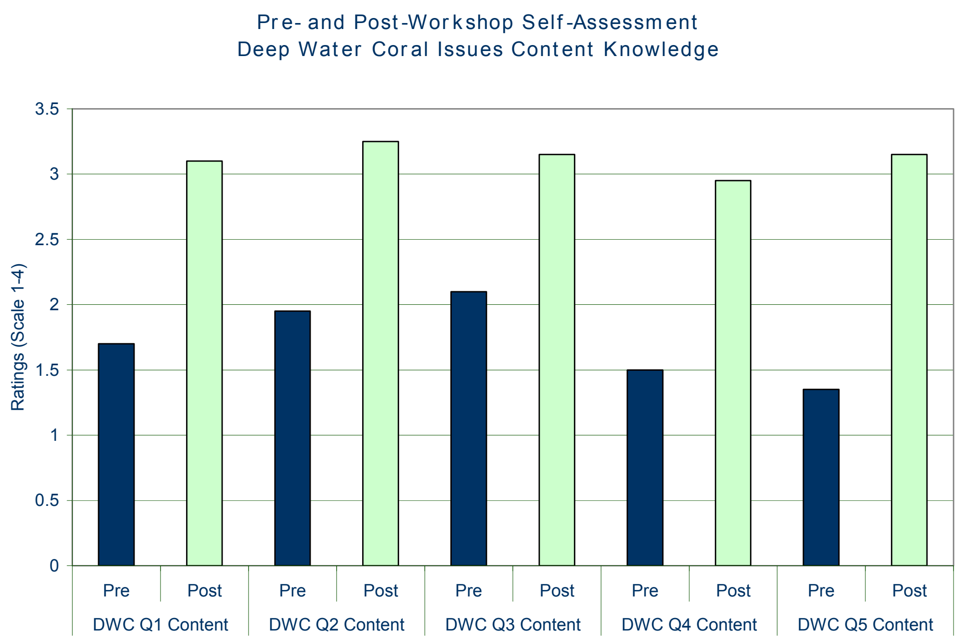


Figure 1A: Average pre- and post-workshop self-assessment ratings for participant "Content Knowledge" of each of the specific content areas under the thematic topic "Deep Water Coral Issues."

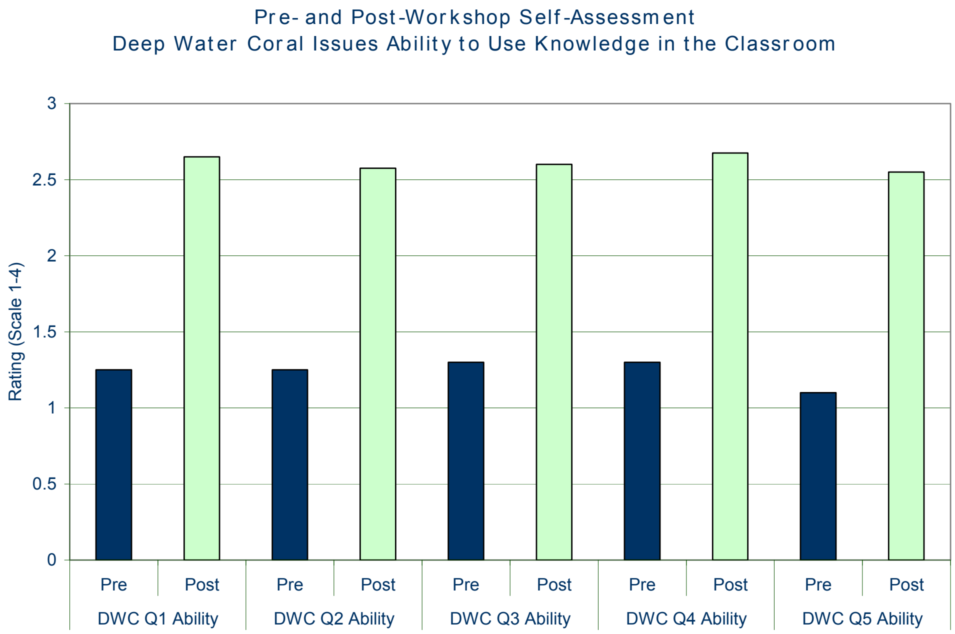


Figure 1B: Average pre- and post-workshop self-assessment ratings for participant "Ability to Use This Knowledge in the Classroom" of each of the specific content areas under the thematic topic "Deep Water Coral Issues."

OCULINA BANK

The mean post-workshop self-assessment rating for participant content knowledge of the "*Oculina* Bank" (μ_{post} = 3.16) was significantly greater than the mean pre-workshop self-assessment rating for participant content knowledge of the "*Oculina* Bank" (μ_{pre} = 1.26), t(40) = 2.021, p = 0.4.

The mean post-workshop self-assessment rating for participant ability to use knowledge of the "*Oculina* Bank" in the classroom (μ_{post} = 2.71) was significantly greater than the mean pre-workshop self-assessment rating for participant ability to use knowledge of "*Oculina* Bank" in the classroom (μ_{pre} = 1.16), t(40) = 2.021, p = 0.3.

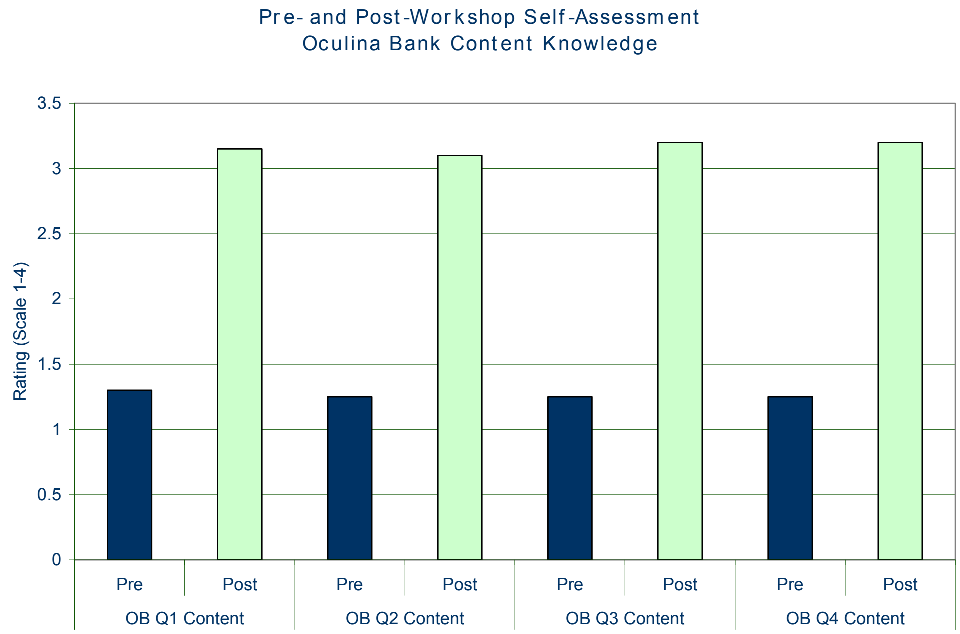


Figure 2A: Average pre- and post-workshop self-assessment ratings for participant "Content Knowledge" of each of the specific content areas under the thematic topic "*Oculina* Bank."

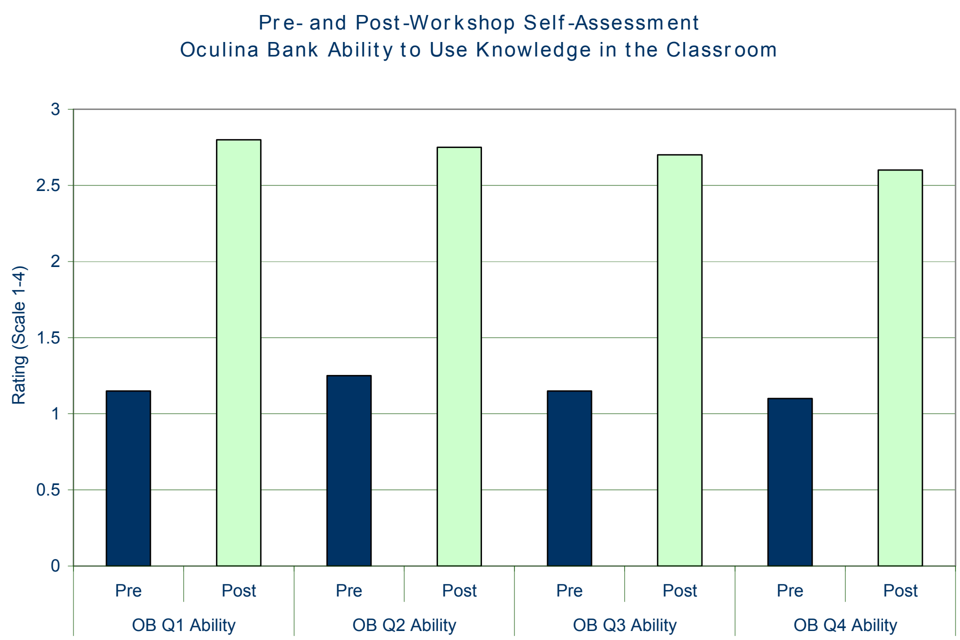


Figure 2B: Average pre- and post-workshop self-assessment ratings for participant "Ability to Use This Knowledge in the Classroom" of each of the specific content areas under the thematic topic "*Oculina* Bank."

<u>SCIENTIFIC RESEARCH</u>

The mean post-workshop self-assessment rating for participant content knowledge of the "Scientific Research" (μ_{post} = 3.16) was significantly greater than the mean pre-workshop self-assessment rating for participant content knowledge of the "Scientific Research" (μ_{pre} = 1.65), t(40) = 2.021, p = 0.3.

The mean post-workshop self-assessment rating for participant ability to use knowledge of the "Scientific Research" in the classroom (μ_{post} = 2.97) was significantly greater than the mean pre-workshop self-assessment rating for participant ability to use knowledge of "Scientific Research" in the classroom (μ_{pre} = 1.43), t(40) = 2.021, p = 0.3.

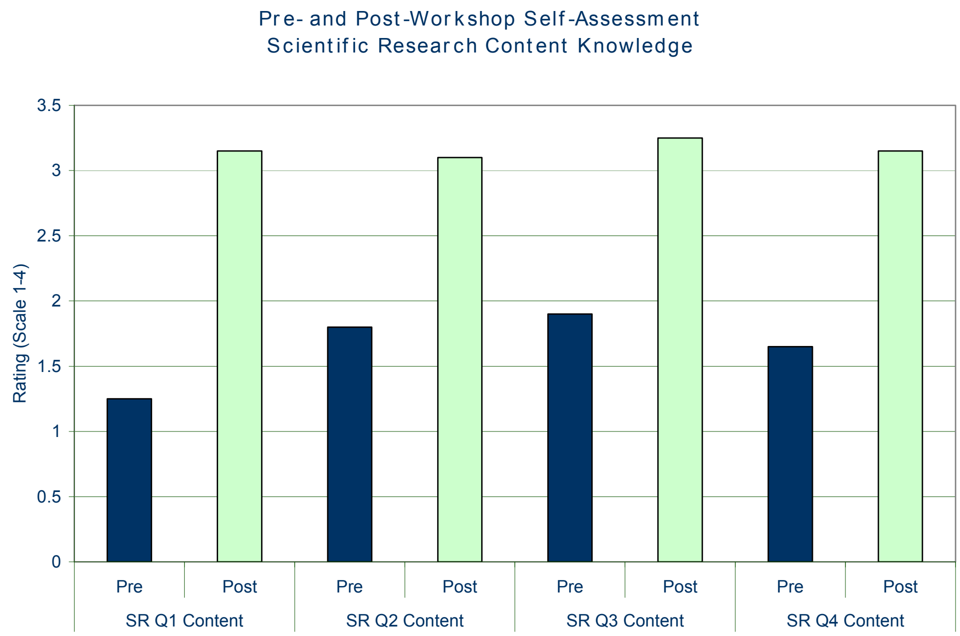


Figure 3A: Average pre- and post-workshop self-assessment ratings for participant "Content Knowledge" of each of the specific content areas under the thematic topic "Scientific Research."

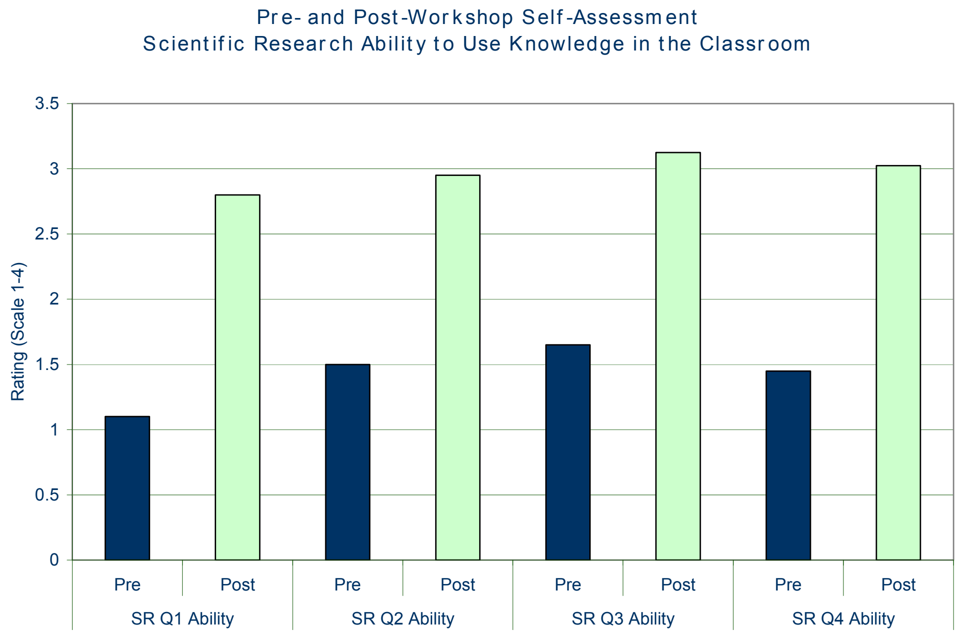


Figure 3B: Average pre- and post-workshop self-assessment ratings for participant "Ability to Use This Knowledge in the Classroom" of each of the specific content areas under the thematic topic "Scientific Research."

Clearly, within each specific content area of all thematic topics, workshop participants gained knowledge and experience, and the ability to apply this knowledge and experience in the classroom. The greatest increase in any of the areas assessed was for participant content knowledge of the "*Oculina* Bank;" however, participants gained the least ability to apply knowledge of "Deep Water Coral Issues" in the classroom as compared with any of the other assessment areas.

b. Post-Workshop Evaluation

The scores from each of the nine statements (see below) of this evaluation were counted manually. Then, the total number of participant responses for each of the four different scores was entered into a Microsoft Excel spreadsheet. The percentage of participants that responded with "Strongly Agree" for each of the nine statements was calculated (see Table 1).

Eight of the ten statements resulted in 80% or more of participants responding with "Strongly Agree." The only statement that resulted in less than 80% of participants responding with "Strongly Agree" was the sixth statement, "Networking with other workshop participants will be beneficial." 51% of participants, however, did "Agree" with this statement.

The responses indicate that, overall, the workshop was useful, engaging, educational, and appreciated. 100% of the participants would recommend this workshop to colleagues.

Statement 1: The workshop met my expectations and needs.
Statement 2: I can find deep water corals and ocean sciences curriculum and resources for use in my classroom.
Statement 3: I can develop at least one new activity for my students based on the workshop.
Statement 4: The workshop instructors presented materials in a clear and understandable way.
Statement 5: I plan to participate in events and activities related to the upcoming research cruise to the Oculina Bank.
Statement 6: Networking with other workshop participants will be beneficial.
Statement 7: I can integrate relevant estuarine, coastal and ocean issues in my classes.
Statement 8: I learned much new information about ocean science research and how scientists work.
Statement 9: I would recommend this workshop to my colleagues.

Statement	Strongly Disagree	Disagree	Agree	Strongly Agree	% that Strongly Agree
1	0	0	3	18	86
2	0	0	2	19	90
3	0	0	1	20	95
4	0	0	1	20	95
5	0	0	4	17	81
6	0	0	11	10	48
7	0	0	3	18	86
8	0	0	4	17	81
9	0	0	0	21	100

All comments written on these evaluations are below.

- *"Great job and thanks for the food and rock shrimp history!"*
- *"Great job. Thank you for the information!"*
- *"I would like a workshop on chemical/physical oceanography, ocean/atmosphere interface chemistry, and pollution effects on coastal water."*
- *"Loved the lunch, but hard to concentrate with the extra noise [from the adjoining dining room]."*
- *"Excellent workshop – much useful information."*
- *"This was a wonderful workshop. I truly appreciate the work NOAA is doing."*
- *"I appreciate the lesson plans and I look forward to further developing them and integrating them into the curriculum."*
- *"Need to start out with some more basic information on the species that are referred to often [in the presentations]."*
- *"Great workshop. DVD will be helpful."*

IV. Conclusions and Future Outreach Activities

As part of concluding activities at the workshop, Andy Shepard led a group discussion about planned outreach activities, particularly about the Ivory Tree Coral Expedition Port Day planned for October 12, 2005. Participants were asked if there was interest in such activities as viewing the research vessel (R/V *Liberty Star*), experimenting with the controls of an ROV, touring the enforcement vessel the *C.T. Randall*, and viewing other exhibits related to research and monitoring within and around the OHAPC.

Participants discussed a number of logistics issues including:

- Security restrictions and regulations surrounding student access to Port Canaveral docks and the NASA-owned R/V *Liberty Star*;
- Field trip costs for participating classrooms;
- Selection and notification process for participating classrooms; and
- Location of Port Day activities, including dock space for the R/V and enforcement vessel.

Participants were asked also to provide suggestions of activities, related to the Ivory Tree Coral Expedition research and monitoring cruise, they would like included in the outreach and education efforts. The suggestions provided by participants follow below.

- Provide a virtual tour of the R/V *Liberty Star* on-line.
- Provide a video from the expedition to teachers and classrooms.
- Allow students to email scientists onboard the R/V.
- Provide a daily web log of at-sea activities onboard the R/V.
- Provide real-time datasets from the ROV transects, including coordinates, temperature, depth, salinity, date, and time.
- Provide educators with a cruise plan/agenda.
- Provide images from a fixed camera.
- Provide chemical analysis data.

Last, participants were asked if interest in an excursion to the R/V *Liberty Star*, via the C.T. Randall existed. If so, interested participants contacted Jocelyn Karazsia with their preferred excursion day and contact information.

Following the day's activities and discussions, the workshop concluded with some participants remaining to have discussions with the workshop facilitators. Many participants reiterated the pleasure of attending the workshop. One participant noted that "this was one of the best workshops I have been to in a while." Others hoped for another, similar workshop and all (participants and facilitators) walked away extremely satisfied.

In the weeks following the workshop, Port Day activities and participants were confirmed, including exhibitors and selection of attending classrooms. Three classrooms from three different schools and several members of the media attended the Port Canaveral Port Authority docks on October 12, 2005. Additionally, the logistics of the CT Randall excursion were finalized. Inclement weather, unfortunately, prevented the CT Randall excursions to the R/V *Liberty Star*.

A follow-up email with photographs, a participant list and this summary will be sent to all participants and facilitators.

V. Appendices

Appendix A – Workshop Lesson Plans

Appendix B – Workshop “Goodie Bags” Contents

Appendix C – Workshop Agenda

Appendix D – Pre- and Post-Workshop Self-Assessment

Appendix E – Post-Workshop Evaluation

Appendix F – Workshop Announcement and Application

Appendix G – Workshop Certificate of Participation

Appendix A – Lesson Plans

Cool Corals

FOCUS
Biology and ecology of shallow and deep water corals

GRADE LEVEL
9-12 (Life Science)

FOCUS QUESTION
What are the similarities/differences between shallow- and deep water corals?

LEARNING OBJECTIVES
- Students will design inquiry questions to help them answer the focus question.
- Students will research the biology and ecology of shallow- and deep water corals.
- Students will compare and contrast the biological and ecological data on both types of corals.
- Students will organize their findings to present the information related to the inquiry questions upon which they based the conclusion to the focus question.

MATERIALS
- KNL Chart Handouts
- Web and print resource list for information on shallow- and deep water corals

AUDIO/VISUAL MATERIALS
- Chalkboard, marker board, or overhead projector with transparencies and markers for group discussion

TEACHING TIME
Two 45-minute class periods, plus time for student research

SEATING ARRANGEMENT
Groups of 4-6 students

MAXIMUM NUMBER OF STUDENTS
30

KEY WORDS

Continental shelf	Continental slope
Hard bottom	*Oculina varicosa*
Deep water coral	Polyp
Zooxanthellae	Symbiosis
Anthropogenic	Turbidity
Coral reef	Coral bleaching
Bioherm	Remotely Operated Vehicle

BACKGROUND INFORMATION

Coral reefs are the most luxuriant and complex of all benthic communities; and they are found all around the world. In the continental United States, however, Florida is the only state to have extensive shallow coral reef formations near its coasts. These reefs extend from near Stuart, on the Atlantic coast, to the Dry Tortugas, west of Key West, in the Gulf of Mexico. The most prolific reef development occurs seaward of the Florida Keys. Florida's reefs are spectacular and rival those of many Caribbean areas. Approximately 6,000 coral reefs are found between Key Biscayne and Dry Tortugas (from http://www.dep.state.fl.us/coastal/habitats/coral.htm).

Corals are colonial animals, and individual coral animals are called polyps. A coral polyp is very similar to a tiny sea anemone, but extracts calcium carbonate from the water and forms a calcareous skeletal cup. Large numbers of these polyps grow together in colonies of delicately branched forms or rounded masses. Most shallow-water coral colonies also have symbiotic algae, called zooxanthellae, living in their skeletons. The coral provides protection and access to light for the algae and, in turn, algae provide nutrients for the polyps from photosynthetic activity. These shallow-water reef-building corals require warm, clear, shallow, clean water and a hard substrate to which they can attach. Shallow-water corals require water temperatures above 18°C and the optimum temperature is 23°C to 25°C. Therefore, their growth is restricted to tropical water between 30 N latitude and 30 S latitude and away from cold water currents. Waters at depths greater than 50-100 m are too cold for significant secretion of calcium carbonate. Also, reefs are not usually found in turbid waters where sediments limit light penetration, which affects the efficiency of photosynthesis in zooxanthellae (from A.C. Duxbury and A.B. Duxbury, 1997, "Introduction to the World Oceans", 5th edition, William C. Brown Publishing Co., Tropical Coral Reefs, p. 460-477).

Corals, however, do not only grow in shallow tropical waters. For centuries, humans have known about deep water corals, but until recently, few knew about the widespread distribution and incredible diversity of deep water coral structures. Deep water corals live in cold, deep waters beyond the reach of sunlight; however, like shallow corals, they require a hard surface on which to settle and grow. Colonies of deep water corals come in a variety of shapes and sizes, including mounds, conical-shaped reefs, or delicately branching trees.

Some of the largest structures are several centuries old, making deep water corals among the oldest living organisms on Earth! Moreover, recent research indicates that deep water coral reefs are more abundant than their better-known shallow-water relatives (from A. Rogers, "The Biology, Ecology and Vulnerability of Deep Water Coral Reefs" http://www.iucn.org/themes/marine/pdf/AlexRogers-CBDCOP7-DeepWaterCorals-Complete.pdf).

Incredibly, not only is Florida home to shallow coral reefs, it is the only place *in the world* to have extensive populations of the deep water coral *Oculina varicosa*. Off the central eastern coast of Florida, between Cape Canaveral and Ft. Pierce, at depths of 70-100 m along the edge of the continental shelf, *O. varicosa* forms a unique and complex habitat called the *Oculina* Bank. Here, branches of living coral grow on mounds of dead coral branches that can be several meters high and hundreds of meters long. Unlike corals that produce reefs in shallower waters, *O. varicosa* does not have symbiotic algae and receives nutrition from plankton and particulate material captured by its polyps from the surrounding water. *O. varicosa* mounds alter the flow of currents and provide essential habitats for a variety of invertebrates and recreationally and commercially important fishes and crustaceans.

Because the deep *Oculina* reef habitat exists nowhere else in the world, it provides an excellent opportunity for scientific studies. On-going research strives to learn more about the biology, population status, and ecological role of these unique and vulnerable deep water corals and the ecosystem these unique corals support. In an effort to protect these fragile corals from human activities such as trawling and dredging, fishery managers designated 300 square miles of the *Oculina* Bank as a Habitat Area of Particular Concern (OHAPC). This designation prohibits the use of habitat damaging fishing gear such as trawls, fish traps, or bottom long lines to help protect the fragile coral. Additionally, the southern area of the OHAPC has been closed to bottom fishing, creating an Experimental Closed Area for studies of the snapper and grouper species associated with the coral while providing additional protection from fishing gear.

The 2005 *Ivory Tree Coral Expedition* will continue research and monitoring objectives within the OHAPC, including further mapping of the OHAPC and quantification of fish and invertebrate populations. In this activity, students will research basic information on shallow- and deep water corals and compare the similarities and differences between the two.

LEARNING PROCEDURE

1. Engage students in a discussion of corals reefs by writing the focus question, "*What are the similarities and differences between shallow- and deep water corals?"* on the board.
2. Using the KNL (Knowledge, Needs, and Learned) Chart Handout, encourage students to share what they know about these marine communities, and about the organisms that create and live in them.

3. Tell students that they will research shallow-water and deep water corals. Divide the class into two groups and assign each group one of the types of corals.
4. Divide each of the two groups into the following subjects: Corals Up Close, Coral Communities, and Threats to Coral Reefs.
5. Groups will then design questions based on what they need to know in order to answer the focus question. *(*Alternatively, the teacher can assign a question to each group.) Examples of questions include, but are not limited to:

   Corals Up Close
   - What are the different morphological forms of corals?
   - Do physical characteristics differ between shallow and deep water corals?
   - How does each type (shallow/deep) reproduce?
   - How does each type (shallow/deep) eat?
   - When do they eat?
   - How do they grow?
   - How are coral reefs created?

   Coral Communities
   - Where are shallow and deep water coral reefs found?
   - What physical conditions are needed for each type type (shallow/deep) of coral to grow?
   - Are shallow and deep coral reefs found in Florida?
   - Approximately how many species of plants and animals (or percentage of the world's species) live among each of these reefs?
   - Why do so many animals inhabit coral reefs?
   - How do specific species use coral reefs?
   - What is the symbiotic relationship between coral polyps and zooxanthellae?

   Threats to Coral Reefs
   - What are some of the natural threats to coral reefs?
   - What are some of the human threats to coral reefs?
   - What is trawling?
   - How does overfishing affect coral reef communities?
   - How do land-based human activities affect coral reefs?
   - How might a boater or diver affect coral reefs?
   - How can we protect coral reefs?
   - Do threats differ between shallow and deep coral reefs?
   - Should we protect coral reefs, and if so, how?

6. Once the groups have developed the inquiry questions, assign one or two questions to each group member.

7. Students will research the answers to the assigned inquiry question(s) developed by the class using internet, library, and printed handout materials.
8. Each subgroup will organize their data and make a presentation to the class, which includes sources, vocabulary, and the inquiry questions addressed. Allow time for students to ask questions.

THE "ME" CONNECTION
Have students write a short essay on how both deep and shallow coral reefs are important to their own lives.

CONNECTIONS TO OTHER SUBJECTS
English/Language Arts; Earth Science

EVALUATION
Students will be assessed in the gathering, translating, and presentation of facts.

EXTENSIONS
- Have the students participate in a debate on issues surrounding threats to deep and shallow coral reefs and efforts to conserve them.

RESOURCES
Visit HBOI's @Sea website (http://www.at-sea.org/) for more information on the 2005 *Ivory Tree Coral Expedition*.

Deep Water Corals:
Reed, J.K., 2002, "Deep water *Oculina* coral reefs of Florida: Biology, impacts, and management", *Hydrobiologia*, 471, p. 43-55.

http://www.uncwil.edu/oculina/Sections/coral_biology.htm – for more background on *Oculina* reefs.

http://www.coris.noaa.gov/about/deep/deep.html - NOAA's Coral Reef Information System

http://pubs.usgs.gov/fs/fs108-99/ - the geology of the *Oculina* Bank

http://oceanica.cofc.edu/Oculina2003/ProjectOverview.htm - more on the *Oculina* Bank from Project Oceanica

http://www.bio.fsu.edu/ifre/ifre_research_oculina.html - Studies in the Experimental *Oculina* Research Reserve off the Atlantic Coast of Florida

http://oceanexplorer.noaa.gov/explorations/islands01/log/sab_summary/sab_summary.html - web logs from NOAA's 2001 *Islands in the Stream Expedition* http://oceanexplorer.noaa.gov/explorations/deepeast01/background/corals/corals.html - background information on deep water corals from NOAA's 2001 *Deep East Expedition*

http://map.mapwise.com/safmc/Default.aspx?tabid=60 – information system for the South Atlantic ecosystem including deepwater coral and the *Oculina* Bank from the South Atlantic Fisheries Management Council (SAFMC)

http://ocean.floridamarine.org/efh_coral/ims/viewer.htm - SAFMC's Internet Mapping System for Coral and Benthic Habitats including the *Oculina* Bank

http://www.cool-corals.de/ - on the left hand navigation bar, click on "ACES" (Atlantic Coral Ecosystem Study) for more information on deep water coral communities

http://www.ices.dk/aboutus/pressrelease/coral.asp - International Council for Exploration of the Sea (ICES)

Roberts, S. and M. Hirshfield. Deep Sea Corals: Out of sight but no longer out of mind.
http://www.oceana.org/fileadmin/oceana/uploads/reports/oceana_coral_report_final.pdf

Rogers, A. "The Biology, Ecology and Vulnerability of Deep Water Coral Reefs"
http://www.iucn.org/themes/marine/pdf/AlexRogers-CBDCOP7-DeepWaterCorals-Complete.pdf

Shallow Water Corals:
http://www.dep.state.fl.us/coastal/habitats/coral.htm - information on Florida's coral reefs from the Florida Department of Environmental Protection

http://www.fknms.nos.noaa.gov/coraleducation.html - Florida Keys National Marine Sanctuary

http://www.coralreef.noaa.gov/outreach/welcome.html - coral reef information and resource list from NOAA's Coral Reef Conservation Program

http://www.coralreef.org/coralreefinfo/about.html - International Coral Reef Information Network

http://www.seaworld.org/infobooks/Coral/home.html - information from the Sea World Education Department

http://mbgnet.mobot.org/salt/coral/indexfr.htm - biomes of the world http://www.oceanoasis.org/fieldguide/cnidaria.html - Ocean Oasis Field Guide

SUNSHINE STATE STANDARDS

Processes that Shape the Earth

- ∀ (SC.D.2.4)

Processes of Life

- ∀ (SC.F.1.4)
- ∀ (SC.F.2.4)

How Living Things Interact with Their Environment

- ∀ (SC.G.1.4)
- ∀ (SC.G.2.4)

The Nature of Science

- ∀ (SC.H.3.4)

ACKNOWLEDGEMENTS
This lesson plan is a modified version of the one available at
http://school.discovery.com/lessonplans/programs/BP_coralseas/

Student Handout
KNL Chart

Concept, Term, or Diagram	What do I KNOW?	What do I NEED to know?	What have I LEARNED?

Living in Extreme Environments

FOCUS
Biological sampling methods

GRADE LEVEL
9-12 (Life Science)

FOCUS QUESTIONS
1. What are the characteristics of an extreme environment in the deep ocean?
2. Explain what YOU would need in order to survive in this environment.
3. Why do people want or need to study and learn more about extreme environments in the deep ocean?
4. What three things must all populations of organisms be capable of doing in order to survive?
5. What types of data will scientists be collecting in the extreme environments visited during the 2005 Ivory Tree Coral Expedition and how will they collect it?

LEARNING OBJECTIVES
- Students will understand four methods commonly employed by scientists to sample biological populations.
- Students will understand how to gather, record, and analyze data from a scientific investigation.
- Students will begin to think about what organisms need in order to survive (collect food, grow, protect themselves, and successfully reproduce).
- Students will understand the concept of interdependence of organisms.

MATERIALS
For each group of 3 or 4 students:
- ☐ String (40 cm in length), round paper dots (from waste bin of a 3-hole punch), 4 toothpicks, glue
- ☐ "*Oculina* Reef Photo Sheet"
- ☐ Descriptions of the four sampling methods and instructions on how to use them
- ☐ "Key to Organisms Sheet"
- ☐ "Procedure Data Sheet" (one for each student in each group)
- ☐ "Student Evaluation Sheet" (one for each student in each group)
- ☐ Ecology textbooks to use for reference
- ☐ Metric rulers
- ☐ Masking tape
- ☐ Colored fine point marker or pen
- ☐ Clear transparency paper

AUDIO/VISUAL MATERIALS
Chalkboard, marker board, or overhead projector with transparencies and markers for group discussion

TEACHING TIME
One or two 45-minute class periods

SEATING ARRANGEMENT
Groups of 3-4 students

MAXIMUM NUMBER OF STUDENTS
30

KEY WORDS
Baseline
Biomass
Core samples
Infauna and epifauna
Interstitial
Line transect
Metabolism/metabolic pathways
Methodology
Octocorals
Random Point survey
Quadrat
Remotely Operated Vehicle (ROV)

BACKGROUND INFORMATION
In order to survive, organisms must: 1) have access to some source of energy for metabolism (food, light, chemicals), 2) successfully defend themselves against predators and environmental stress, and 3) make more of their own kind or reproduce. How do they accomplish these requirements? Even thousands of years ago, before explorers had access to what we consider primitive instrumentation and ocean-going vessels, these questions were being raised.

The deep water benthos comprises a large and important marine habitat that we know relatively little about. The type of substrate strongly influences the species composition of a benthic community. Today, we have sophisticated technological capabilities that have made the ocean more “visible” and more accessible than it has ever been before. As a result of “new technological eyes,” hundreds of new species and new ecosystems have been discovered. Some of these new discoveries may hold the keys to the origin(s) of life on Earth, cures to life-threatening diseases, and knowledge about presently unknown metabolic pathways for obtaining and using energy to support life on Earth.

During the 2005 Ivory Tree Coral Expedition, scientists will be collecting information on several sites within and adjacent to the *Oculina* Bank Habitat Area of Particular Concern (OHAPC) including Jeff’s Reef and the Experimental *Oculina* Research Reserve (EORR). Cruise objectives include: 1) documenting grouper spawning activities on a living *Oculina* reef, and 2) monitoring and comparing live coral cover, fish populations, and biodiversity in and outside of the OHAPC. Researchers on the Ivory Tree Coral Expedition will primarily utilize transect sampling to compare areas in and outside the OHAPC in regards to: 1) coral cover, 2) fish populations, and 3) benthic (bottom) diversity in habitat type and biodiversity. Transects will be captured on video with a camera mounted onboard an unmanned, submersible Remotely Operated Vehicle (ROV).

These data are important because after making baseline descriptions of a community to use as a standard for comparison, it is necessary to collect the same kinds of information over a period of months or years for scientists to determine if changes in size, class, density, and distribution of populations have taken place. Only then will we know if something might be affecting that ecosystem. For example, if we find there are fewer or smaller coral colonies in the same place than recorded earlier, this could indicate some type of disturbance (fishing gear, waste disposal, or slumps) to the older and larger colonies, replacing older with younger (smaller) corals. Is a disease or new predator affecting the coral bed, and if so, why?

The 2005 Ivory Tree Coral Expedition is a continuation of previous research and monitoring efforts within the *Oculina* Habitat Area of Particular Concern (OHAPC), including mapping of the OHAPC and quantification of fish and invertebrate populations. In this activity, students will learn to use transects and other common sampling techniques employed by researchers like those on the 2005 Ivory Tree Coral Expedition.

LEARNING PROCEDURE

1. Teacher will divide the class into groups of 3 or 4 students each.
2. Teacher will hand out one "*Oculina* Reef Photo Sheet," a transparency, and a "Key to Organisms Sheet" to each group. A "Procedure Data Sheet" and "Student Evaluation Sheet" will be given to EACH student. Each student will fill out their own Data Sheet and individually answer the questions on the Student Evaluation Sheet.
3. Each group will read about the four different methods of sampling populations (Line Transect, Core Sample, Quadrat, and Random Point Survey).
4. Groups will use each of the different sampling methods on the photo. One method (Core Sample) will not be used. Students will follow the procedure for each sampling method on the photo.
5. Students will record the method, names, and numbers of organisms observed during "sampling" for each of the 3 trials (raw data).
6. Students will average the three trials to get an average set of data and record the average on the "Procedure Data Sheet." To obtain the average, total the number of each species for each trial, then divide by the number of trials (3). If no individuals of a species are observed in a trial, use a zero for that species number.
7. Students will generate a chart or graph for the data, giving it a title and all other appropriate labels and keys. Three charts or graphs may be

generated or a group may choose to combine all data into one chart or graph.

8. Each group will have five minutes to prepare and one minute to present a summary of its findings to the entire class.
9. Teacher will lead a discussion on whether groups had similar or differing conclusions, with possible explanations for results generated by the students.
10. Students will individually answer evaluation questions on the "Student Evaluation Sheet" in class or for homework.

THE "ME" CONNECTION

The discovery of new life forms may hold the keys to the origin(s) of life on Earth, cures to life-threatening diseases, and knowledge about presently unknown metabolic pathways for obtaining and using energy to support life on Earth.

CONNECTIONS TO OTHER SUBJECTS

Mathematics; English/Language Arts; Physical, Earth, and Biological Sciences; Art/Design

EVALUATION

Use Student Evaluation Sheet

EXTENSIONS

∀ Ask students to write a story based on the lesson, projecting themselves into the storyline.
∀ Ask students to act as if they were the pilot operating a deep water submersible.
∀ Ask students to investigate technologies of the past used in previous ocean exploration initiatives.
∀ Ask students to investigate career opportunities as ocean explorers, ocean scientists, and others whose careers support ocean science research and exploration.
∀ Log on to http://www.at-sea.org/ to keep up to date with the latest 2005 Ivory Tree Coral Expedition discoveries, and to find out what researchers are learning about deep-water hard-bottom communities

RESOURCES

Deep Water Corals:

Reed, J.K., 2002, "Deep water *Oculina* coral reefs of Florida: Biology, impacts, and management", *Hydrobiologia*, 471, p. 43-55.

http://www.uncwil.edu/oculina/Sections/coral_biology.htm – for more background on *Oculina* reefs.

http://www.coris.noaa.gov/about/deep/deep.html - NOAA's Coral Reef Information System http://pubs.usgs.gov/fs/fs108-99/ - the geology of the *Oculina* Bank

http://oceanica.cofc.edu/Oculina2003/ProjectOverview.htm - more on the *Oculina* Bank from Project Oceanica

http://www.bio.fsu.edu/ifre/ifre_research_oculina.html - Studies in the Experimental *Oculina* Research Reserve off the Atlantic Coast of Florida

http://oceanexplorer.noaa.gov/explorations/islands01/log/sab_summary/sab_summary.html - web logs from NOAA's 2001 *Islands in the Stream Expedition*

http://oceanexplorer.noaa.gov/explorations/deepeast01/background/corals/corals.html - background information on deep water corals from NOAA's 2001 *Deep East Expedition*

http://www.cool-corals.de/ - click on "ACES" on the left-hand navigation bar for information on the Atlantic Coral Ecosystem Study (ACES)

http://www.ices.dk/aboutus/pressrelease/coral.asp - International Council for Exploration of the Sea (ICES)

Roberts, S. and M. Hirshfield. Deep Sea Corals: Out of sight but no longer out of mind.
http://www.oceana.org/fileadmin/oceana/uploads/reports/oceana_coral_report_final.pdf

SUNSHINE STATE STANDARDS

Processes that Shape the Earth
- (SC.D.2.4)

Processes of Life
- (SC.F.1.4)

How Living Things Interact with Their Environment
- (SC.G.1.4)
- (SC.G.2.4)

The Nature of Science
- (SC.H.1.4)
- (SC.H.2.4)
- (SC.H.3.4)

ACKNOWLEDGEMENTS
This lesson plan is a modified version of the one available at:
http://oceanexplorer.noaa.gov

Student Handout
Line Transect Sampling Methodology

Line Transect (Linear Point-Intercept Transect):
Line Transects (more technically referred to as linear point-intercept transects) are used to determine what organisms are found on an ocean bottom or in a substrate. Several lines are laid to ensure maximum characterization of the study area. Suppose the leader of a far away galaxy told her astronauts to go to planet Earth and bring back a sample of what Earth is like. If they brought back a sample from only one or two different locations on Earth, would the leader have a good picture of what the Earth is really like? (Think: ocean, coral reef or deep water coral communities, mud flat, city, desert, ice cap, mountain top, pine forest, redwood forest, river, lake, beach, parking lot, sewage pond, suburb, amusement park, football field, and a golf course). Often the data are inaccurate even though many samples are taken to get a more accurate picture of what is there. Inaccuracies may occur due to lack of direct access to the environment, problems with the sampling methods, or difficulties identifying the organisms.

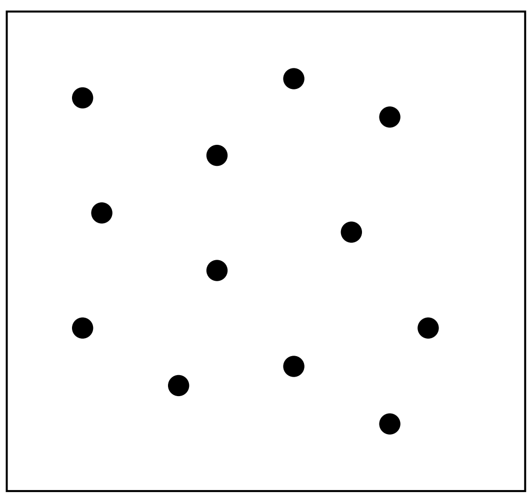
To Make a Line Transect Instrument:
1. Cut a piece of string 40 cm long (string may be pre-cut by teacher).
2. Using a metric ruler, mark regularly spaced points every 2 cm along the string where each observation will be made.

To Use a Line Transect on the Transparency Covering the Photo:
1. Place a clear transparency over the photo and tape it in place.
2. Place the marked string across the photo left to right, 4 cm from the top of the photograph, taping it on the ends outside the picture with masking tape.
3. Using the colored pen or marker, place a dot on the transparency over the photograph by each marked 2 cm on the string.
4. Using the Key for Organisms, identify and record the name of each organism directly beneath the dot marked on the transparency over the photograph. Record as raw data on the "Procedure Data Sheet."
5. Repeat Steps #1- 4 two more times placing the starting and ending points of the string 4 cm lower on the photo each time keeping the string parallel to its previous location. You will end up with data for three trials of the Line Transect crossing different areas on the photo.
6. Average the three trials for a more accurate set of data. Record the average on the "Procedure Data Sheet" (see #7 under Learning Procedure).

Student Handout
Random Point Methodology

Random Point Survey:
A random point survey uses randomly-selected points in a study area to characterize a site. The more points surveyed, the more accurate the data.

Procedure to Conduct a Random Point Survey:
1. Obtain 12 punched out dots from the three-hole punch waste bin.
2. Hold each dot about one foot above the chosen photo and drop it. If it does not fall on the photo, try again. When you are done there should be 12 dots randomly scattered across the photo. (Be careful not to breathe hard on the dots until the spots are marked on the photo!)
3. Mark the position of each dot with the colored pen or marker.
4. Using the "Key to Organisms Sheet," identify and record the name of organisms found under each dot. Record as raw data on the "Procedure Data Sheet."
5. Repeat Steps #2 – 4 two more times to finish the three trials of the Random Point Survey.
6. Average the three trials for a more accurate set of data. Record average on the "Procedure Data Sheet" (see #7 under Learning Procedure).



Student Handout

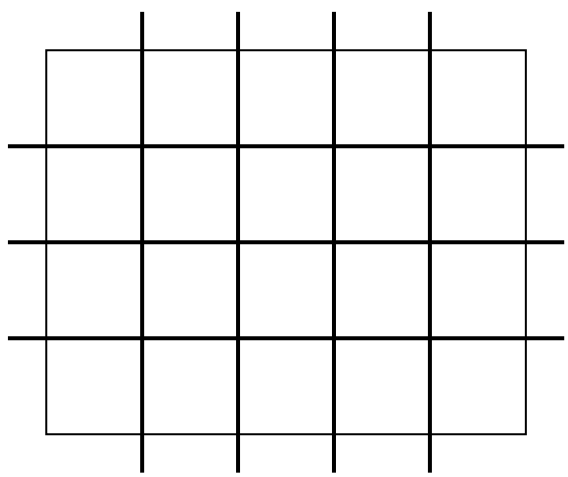
Quadrat Survey and Core Sampling Methodologies

Quadrat Survey:

A quadrat survey is another systematic approach to characterizing a study area. The study area is separated into smaller equal sections or quadrat. The investigator will record all organisms found in a specified number of sections of each quadrat.

Procedure to Conduct a Quadrat Study:

1. Divide the study area into squares of 2 cm each.
2. Randomly choose 3 squares for study. You may drop dots, label each quadrat with a number and randomly choose numbers, or devise your own method for random choice.
3. Using the "Key to Organisms Sheet," identify and record the names of all organisms found in each of the three quadrats. Record as raw data on the "Procedure Data Sheet."
4. Repeat Steps #2 – 3 two more times to finish the three trials of the Quadrat Survey.
5. Average the three trials for a more accurate set of data. Record the average on the "Procedure Data Sheet" (see #7 under Learning Procedure).



Core Sample: (no exercise provided)

A core sample is obtained by inserting a hollow tube-shaped device into the bottom sediments to retrieve a tube full of sediment with its accompanying organisms. Animals small enough to live between individual grains of sediment are called the interstitial community. Organisms like worms, crustaceans, bacteria, and protozoans are found here. Larger organisms also live at or below the surface of the sediment, many with some type of structure that protrudes above the surface of the sediments to collect food, dispose of wastes, respire, and/or reproduce. To collect a core sample, scientists push the Core Sampler into the sediment to the desired depth. The core sampler is retrieved. Scientists analyze the sample (usually using a microscope) and record data.

Student Handout
Procedure Data Sheet

Line Transect Sampling Methodology

	Live *Oculina* (yes/no)	Sponges (# species)	Fish (total #)	Urchins (total #)
Trial One -				
Trial Two -				
Trial Three -				
Average of 3 Trials	n/a			

Random Point Survey Sampling Methodology

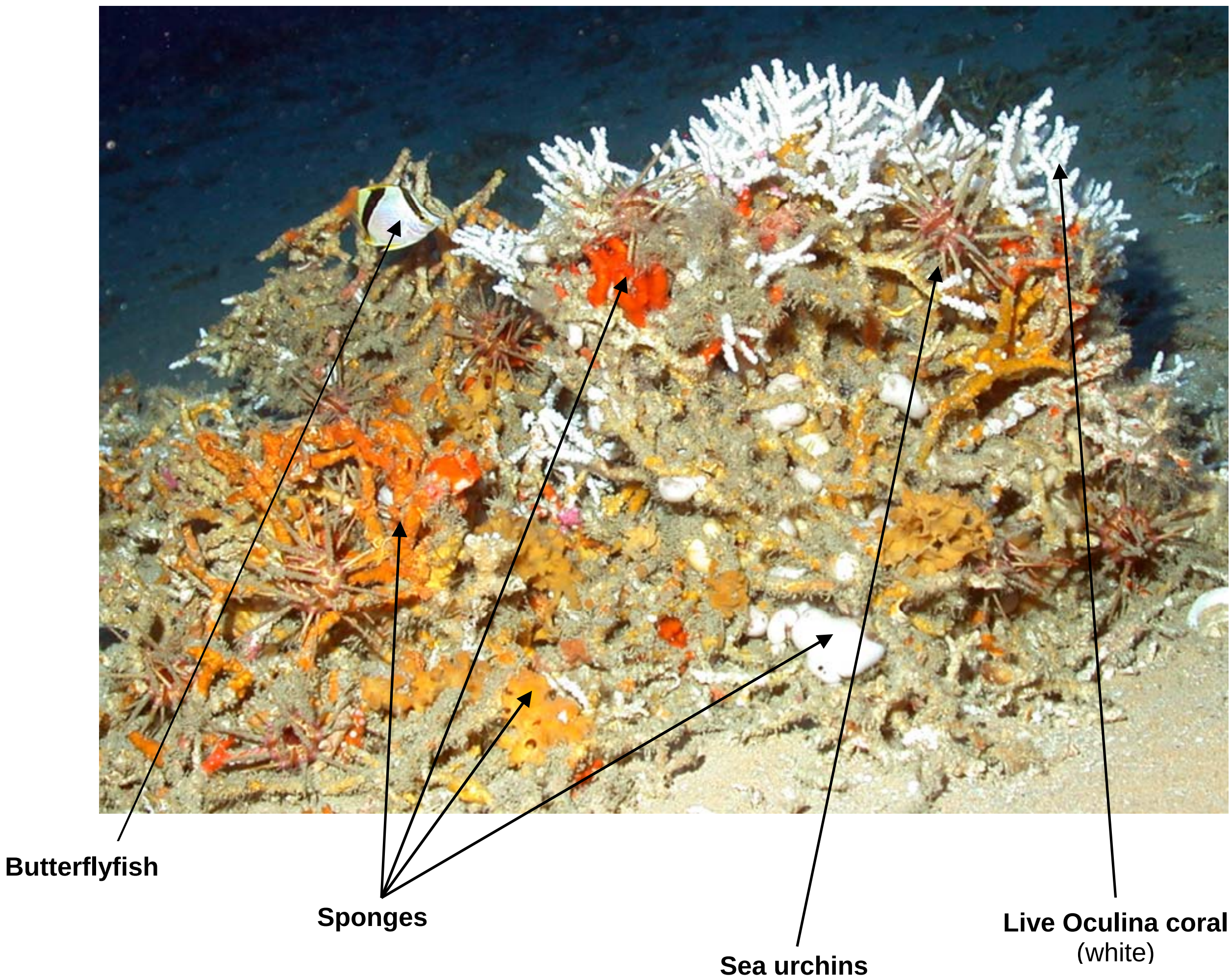
	Live *Oculina* (yes/no)	Sponges (# species)	Fish (total #)	Urchins (total #)
Trial One -				
Trial Two -				
Trial Three -				
Average of 3 Trials	n/a			

Quadrat Survey Sampling Methodology

	Live *Oculina* (yes/no)	Sponges (# species)	Fish (total #)	Urchins (total #)
Trial One -				
Trial Two -				
Trial Three -				
Average of 3 Trials	n/a			

Student Handout
Oculina Reef Photo Sheet

Student Handout
Key to Organisms Sheet



Student Handout
Student Evaluation Sheet

1. What three things must all populations of organisms accomplish successfully in order to survive?

____

____

2. Why do scientists always perform three or more trials when gathering data?

____

____

3. What are some of the problems associated with studying deep water organisms?

____

____

4. What are some of the problems you might encounter bringing a deep water organisms to the surface for study? Be specific.

____

____

5. Why are species of organisms found in one location and not in another? Why are no plants found in deep water environments?

____

____

6. Do you think environmental change tends to increase or decrease diversity? Why?

____

____

7. Do you think organisms found in high or low diversity environments would be more likely to survive change? Explain your reasoning.

____

____

8. Write a paragraph on the back of the page (5-7 sentences) based on what you have learned in this activity, describing how your newly acquired deep sea knowledge about the deep sea might make a difference in your life 10 years from now.

Student Evaluation Sheet

Teacher Answer Key

1. To get food or other energy necessary for metabolism and growth, defend themselves from predators, and successfully reproduce.

2. To try to get more accurate data.

3. Sampling tool must be functional, incorrect estimates of individuals and/or diversity of individuals, how to determine exact location of studied sample site, expense, too deep for SCUBA, etc. Accept all reasonable answers.

4. How to catch it, how to transport it, pressure change, temperature change, keeping it alive, food for it, etc. Accept all reasonable answers.

5. a. Different species have different requirements for food, temperature, substrate, light, and other factors. Accept all reasonable answers.
   b. Because plants need light in order to photosynthesize to make food.

6. It depends on the type of environmental change.

7. High diversity environments offer more survival strategies. Answers will vary.

8. Answers will vary.

Mapping the Bank

FOCUS
Bathymetry of the *Oculina* Bank

GRADE LEVEL
9 – 12 (Earth Sciences and Technology)

FOCUS QUESTION
What are the differences between bathymetric maps and topographic maps?

LEARNING OBJECTIVES
- Students will be able to compare and contrast a topographic map to a bathymetric map.
- Students will investigate the various ways in which bathymetric maps are made.
- Students will learn how to interpret a bathymetric map.

MATERIALS
Part I:
- ☐ 1 *Oculina* Bank Bathymetry map transparency
- ☐ 1 local topographic map

Part II:
- ☐ 1 local topographic map per group
- ☐ 1 *Oculina* Bank Bathymetry map per group
- ☐ 1 *Oculina* Bank Bathymetry map transparency
- ☐ Contour Analysis Worksheet

Part III:
- ☐ Library Books and Resources

AUDIO/VISUAL EQUIPMENT
Overhead Projector

TEACHING TIME
Two 45-minute periods

SEATING ARRANGEMENT
Cooperative groups of 2 to 4

MAXIMUM NUMBER OF STUDENTS
30

KEY WORDS
Topography
Bathymetry
Map
Bank
Contour lines
SONAR
Side-scan sonar
Multi-beam echo sounder
Fathometer

BACKGROUND INFORMATION
A map is a flat representation of all or part of Earth's surface drawn to a specific scale (Tarbuck & Lutgens, 1999). Topographic maps show elevation of landforms above sea level, and bathymetric maps show depths of landforms below sea level. The topographic elevations and the bathymetric depths are shown with contour lines. A contour line is a line on a map representing a corresponding imaginary line on the ground that has the same elevation or depth along its entire length (Tarbuck & Lutgens, 1999).

Since the ocean floor is not visible to us, it is difficult to map. Scientists use various techniques to gather data for a bathymetric map. In the early 1800's, mariners took depth records in shallow waters with a weight on a line. Then in 1854, a depth-sounding device was attached to the line instead of the weight. This made determining when the line hit the bottom of the ocean easier; however, recording a small section of the ocean was time-consuming.

During World War II, when submarine warfare was at its height in the Atlantic and Pacific Oceans, sonar developed rapidly. Sonar devices use sound echoes to determine the distance to or size of objects underwater, or to measure ocean depth (Metzger, 1999). The frequency of the return signal also can reveal information about the hardness of the seafloor (e.g. soft-bottom vs. hard bottom). After World War II, with the increased use of sonar, suspicions of a featureless seafloor where dispelled. Scientists were able to map ocean trenches, ridges, plains, and submerged islands. These maps were the critical first steps in the ocean age of discovery in the 1960s and 1970s, when the theory of plate tectonics was developed and proven.

Today, scientists are working on advances to make sonar more efficient and accurate. The first fathometers sent a single beam of sound to the seafloor and measured the depth at that one point – surveys with high resolution took many passes of the platform across the bottom. Side-scan sonar sends out a few wide beams of sound that scan a swath of bottom beneath and to the sides of the support platform, and although the depth measurements are less accurate, a high-resolution picture of the bottom structure and hardness can be done relatively quickly. Multi-beam echo sounders are essentially an array of over 100 fathometer beams that ping a swath across the bottom, providing accurate depths and information on bottom hardness. Even with all of these new advances in bathymetric mapping, only a limited portion of the vast seafloor actually has been mapped.

LEARNING PROCEDURE

Part I:

1. Introduce topographic maps and bathymetric maps to the students.

Part II:

1. Have student groups gather the following materials:
    a. 1 local topographic map per group
    b. 1 *Oculina* Bank bathymetry map per group
    c. 1 Contour Analysis Worksheet per student
2. Have students observe and analyze the two different maps using the Contour Analysis Worksheet.

Part III:

1. Have student groups research and give presentations on the different techniques used to collect depth data for bathymetric mapping.
2. Topics could include:
    a. Fathometer echo sounder
    b. Seismic reflection profiles
    c. Multi-beam echo sounder
    d. Sounding lines and weighted wires
    e. Sonar
    f. World War II and sonar

CONNECTION TO OTHER SUBJECTS

Mathematics, Language Arts, History

EVALUATIONS

∀ Students will write a paragraph summarizing what they learned about the bathymetry of the *Oculina* Bank.
∀ Teacher will review each student's Contour Analysis Worksheet.
∀ Teacher will review presentations given by students on the various techniques used to map the bottom of the ocean floor.

EXTENSIONS

∀ Ask students to write a short essay comparing the Appalachian Mountains to the *Oculina* Bank.
∀ Make a clay model of the *Oculina* Bank.
∀ Ask students to identify all of the deep water coral banks and seamounts found along the Atlantic Coast.
∀ Visit the @Sea Web Site at http://www.at-sea.org/ for more information on the 2005 *Ivory Tree Coral Expedition*.
∀ Visit the Ocean Exploration Web Site at www.oceanexplorer.noaa.gov
∀ Visit the joint NOAA and USGS demonstration project web-page for a GIS fly-through of Tampa Bay, FL at http://nauticalcharts.noaa.gov/bathytopo/spatialvis.html

RESOURCES:

http://pubs.usgs.gov/of/1999/of99-010/ - Kathryn M. Scanlon, Peter R. Briere, Christopher C. Koenig. 1999. Oculina Bank: Sidescan Sonar and Sediment Data from a Deep-Water Coral Reef Habitat off East-Central Florida

http://www.uncw.edu/oculina - *Oculina* Bank Geographic Information System (GIS)

http://erg.usgs.gov/isb/pubs/booklets/topo/topo.html - USGS topographic mapping page

http://chartmaker.ncd.noaa.gov/staff/faq.htm - NOAA coast survey FAQs on navigational charting

http://mrib.usgs.gov/ - USGS Marine Realms Information Bank

http://www.gis.com/whatisgis/ - What is a Geographic Information System?

http://www.ccom.unh.edu/education.html - opportunity/curriculum for graduate degree in Ocean Mapping

http://pubs.usgs.gov/fs/fs039-02/fs039-02.html - USGS Fact Sheet: Mapping the Sea Floor

http://woodshole.er.usgs.gov/operations/sfmapping/default.htm - general information on how USGS maps the seafloor

REFERENCES:

Maddocks, Rosalie F., 2000, Introductory Oceanography Lecture 4A: The Ocean Floor. Department of Geosciences, University of Houston.

Metzger, Ellen P., 1999, "Submarine Mountains Teachers Guide." (www.ucmp.berkeley.edu/fosrec/Metzger2.html)

Tarbuck, E.J., and Lutgens, F.K., 1999, EARTH *An Introduction to Physical Geology* (6th ed.): Prentice Hall, Inc., Upper Saddle River, New Jersey, p. 450-452

SUNSHINE STATE STANDARDS

Earth and Space:

- (SC.E.1.4)

The Nature of Science:

- (SC.H.1.4)
- (SC.H.2.4)
- (SC.H.3.4)

ACKNOWLEDGEMENTS

This lesson plan is a modified version of the one available at http://oceanexplorer.noaa.gov

CONTOUR ANALYSIS WORKSHEET

1. Collect the following materials from your teacher:
   a. 1 local topographic map
   b. 1 bathymetric map of *Oculina* Bank
2. What is the scale on the topographic map?
3. What is the scale on the bathymetric map?
4. Why do you think the scales are so different?
5. What is the contour interval on the topographic map?
6. What is the contour internal on the bathymetric map?
7. What do the two contour intervals indicate?
8. What do the colors represent on a topographic map?
9. What do the colors represent on a bathymetric map?
10. Why do these color schemes differ?
11. What is the highest feature on the topographic map? What is its elevation?
12. What are the latitude and longitude coordinates of this feature?
13. Locate *Oculina* Bank on the bathymetric map. What is the depth of the deepest part?
14. What are the latitude and longitude coordinates of the *Oculina* Bank?
15. Why is it important for submarine or remotely operated vehicle (ROV) pilots to know the bathymetry and bottom type before diving?
16. Write a two-paragraph summary comparing and contrasting topographic maps to bathymetric maps.

Spawn!

FOCUS
Environmental needs of spawning deep water reef fishes

GRADE LEVEL
9-12 (Biology)

FOCUS QUESTION
What environmental conditions are necessary to ensure the success of spawning deep water reef fishes?

LEARNING OBJECTIVES
- Students will understand that the ability of certain deep water reef fishes to spawn successfully is dependent on numerous environmental conditions.
- Students will be able to list the critical factors needed by deep water reef fishes in the *Oculina* Banks Habitat Area of Particular Concern to spawn successfully.

MATERIALS
- ☐ Card stock paper
- ☐ Six decks of "Spawn" cards

TEACHING TIME
One 45-minute class period, plus time for student research

SEATING ARRANGEMENT
Groups of 4 students

MAXIMUM NUMBER OF STUDENTS
24

KEY VOCABULARY WORDS

Evolve	Larvae
Reef	Hatching
Habitat	Estuary
Territorial	Upwelling
Spawning	Aggregation
Solitary	Fertilized
Abundance	Survival
Chlorophyll densities	Coral thicket
Current	Deep water coral
Hard bottom habitat	*Oculina varicosa*

Phytoplankton	*Oculina* Banks
Limestone ridges	Pinnacles
Gag grouper	Scamp
Eddies	Gyres
Relief	Florida Current/Gulf Stream
Detritus	Habitat Area of Particular Concern
Mangrove wetlands	Haremic spawning

BACKGROUND INFORMATION

Like all species, the deep water reef fishes of the *Oculina* Bank, such as gag and scamp groupers, are dependent on the environment where they live. Groupers are solitary, territorial fishes that claim a spot on a reef habitat and can remain there almost the entire year. Though living alone in a territory provides these fishes with enough resources, it does not provide the opportunity for congregating with large numbers of individuals of the same species for reproduction and genetic exchange. To address this need, groupers and other territorial reef fishes will leave their territories at approximately the same time each year to come together into large spawning aggregations. Populations of these fishes will meet at the same site and at the same time each year to release eggs and milt into the water for external fertilization. These aggregations can include hundreds or thousands of fish because bringing many fish together, all releasing thousands or even millions of eggs and sperm into the water, improves the chances of successful fertilizations. Scientists believe that these spawning aggregations only occur in places where certain environmental conditions are conducive to the survival of newly-released eggs and sperm, the resulting fertilized eggs, and hatching larvae. Another spawning strategy used by fishes living on the *Oculina* Bank is haremic spawning. This occurs when one male and several females come together in a small group to reproduce.

Groupers and other reef fishes (for example, snappers) tend to spawn on rocky reef habitats generally located in or near a current that will carry the eggs and larval fishes to an area suitable for their growth into juveniles and adults. It is well known that shelf edge reefs, such as the deep water *Oculina* reefs, are important habitat for grouper spawning. In the *Oculina* Banks, scamp and gag groupers form spawning aggregations around high-relief *Oculina* pinnacles. However, intensive fishing and habitat damage since the 1970s have nearly eliminated these aggregations.

There are several theories why the fishes depend on reef habitats while spawning, one hypothesis is that as currents flow in the vicinity of these reefs, eddies and gyres are sometimes formed that will carry the eggs to areas where the tiny larval and juvenile fishes have a better chance of finding food and shelter. Most of the reef fishes in the *Oculina* Banks spawn near the Florida Current, which is considered the “official” beginning of the Gulf Stream System. The Florida Current is generally defined as the section of the system that stretches from the Florida Straits up to Cape Hatteras. The Florida Current was first reported by the Spanish explorer Ponce de Leon in 1513 when he discovered Florida (Galstoff, 1954).

Some groupers spawn in the gyres and eddies that spin off the Florida Current/Gulf Stream towards shore. These currents lead to areas of high food production, either to inshore estuaries and mangrove wetlands or to the Gulf Stream. Estuaries and wetlands provide nursery, foraging, and refuge habitat for juvenile fishes. They also produce and export detritus (decaying organic material), which is an important component of marine and estuarine food chains. Nutrients enter the estuaries, thus providing a nutrient-rich environment in which phytoplankton (microscopic plants) and seagrasses grow. These plants, producing their own food, can in turn support a large community of animals from tiny herbivores to large predators, including the larval and juvenile offspring of spawning snappers and groupers. By spawning in currents that bring them inshore, these young fishes can find plenty of food and have a better chance of survival.

Young fishes also can find plenty of food in the Florida Current. The Florida Current is a current that spins inshore, affecting successful spawning of reef fishes off of the Gulf Stream. The gyres and eddies carry the warm water of the Gulf Stream into the colder waters above the continental shelf. When warm water comes in contact with cold water, upwelling occurs. The colder, denser water sinks below the warm water. When it does, it stirs the nutrients on the ocean floor that are left behind by decomposed marine organisms. These nutrients are carried to the surface as they are displaced upward by the colder, denser water. Near the surface waters, they are available to phytoplankton, and can support a large population of these microscopic plants. Like the plants in estuaries, the phytoplankton that result from upwelling can support a large community of animals. In some gyres, like the Charleston Gyre, upwelling is constantly occurring, and as a result, it is one of the highest areas of food production in the South Atlantic Bight. The larval reef fishes that spawned in the Gulf Stream in the South Atlantic Bight are spun into the gyres where the abundance of food offers a better chance of survival.

High relief shelf edge habitats generally occur in depths from 50-100 m. The *Oculina* Bank is an area near the western edge of the Florida Current that extends from Cape Canaveral to Fort Pierce, Florida. The habitat consists of a series of clustered limestone pinnacles that range from 5-30 m in height and are separated by flat, soft-bottom sediment. The pinnacles are topped with ivory tree coral, *Oculina varicosa*, which grows in spherical heads 1 to 2 m in diameter and provides the primary habitat structure of the reefs in this area (Reed, 1980).

To spawn successfully, reef fish need hard bottom habitats in strong currents that can carry eggs and larvae to areas of high food production. To ensure successful spawning, all of these characteristics have to be available to these fishes. This is important because the protection of ecologically and economically important fishes such as snappers and groupers cannot be guaranteed just through regulations such as setting catch and size limits. As they are dependent on many factors of their environment, entire ecosystems need to be protected for their continued survival.

Because the deep *Oculina* reef habitat exists nowhere else in the world, it provides an excellent opportunity for scientific studies. Little is known about the biology, population status, or ecological role of these unique deep water corals and the fishes supported by this unique habitat. The rarity of deep water corals also makes them vulnerable to human activities such as trawling and dredging.

The 2005 *Ivory Tree Coral Expedition* will continue research and monitoring objectives within the *Oculina* Habitat Area of Particular Concern (OHAPC), including documenting grouper spawning and other reproductive activities on a living *Oculina* reef.

In this activity, students will learn that the ability of certain deep water reef fishes to spawn successfully is dependent on numerous environmental conditions. Students will also learn the factors needed by deep water reef fishes in the *Oculina* Banks HAPC to spawn successfully. Additionally, students will learn about some fish species found at the *Oculina* Bank and the methods they use to spawn.

LEARNING PROCEDURE

1. Print “Spawn” cards onto card stock and cut out each individual card. Print enough sets that the class can be divided into groups of four and each group can receive a deck of cards.
2. Discuss with the students how organisms adapt to their environment and how they become dependent on certain features of their environment in order to ensure their survival. Explain that the reef fishes of the *Oculina* HAPC are an example of this. Explain that fishes, such as snappers and groupers, are solitary and live on reef habitats. However, when they spawn, they come together in groups of hundreds or even thousands over reef habitats in currents that can carry eggs to areas that have an abundance of food. Explain that without these conditions, the resulting fertilized eggs and hatching larvae may not be in an environment suitable for survival.
3. Tell the students that they will be playing the card game “Spawn.” Divide students into groups of four. Give each student group a deck of the “Spawn” cards and explain the rules. The object of the game is to have a hand that includes a card listing a reef fish, a card listing a rocky reef habitat, a card that lists a current, and a card that lists a nearby habitat with high food production. When all of these cards are in hand, the student has a successful “Spawn” and wins the game. The rules are very similar to those of “Gin.” Cards are shuffled and each student is dealt four

cards. The rest of the deck is placed face down in the center of the students. The top card is flipped over and laid face-up next to the deck. The student to the left of the dealer goes first by taking the flipped over card or the card at the top of the deck. A student will finish his/her turn by discarding one card from his/her hand and placing it face up on the flipped over card. Students will keep the cards that make the best hand (those that together provide the conditions necessary for a reef fish to have a successful spawning) and should discard all other cards (such as non-reef fish, non-reef habitats, oceanic conditions without currents and nearby habitats with low food production), as these will not produce a winning hand. When the student has all four cards needed, the student will lay them face down, say "Spawn!" and be declared the winner. If all the cards in the face-down deck have been drawn and no one has successfully "spawned" (i.e., won), shuffle the cards in the face-up deck, place this deck face-down, flip the top card over to make another face-up deck, and continue playing.

4. Have students play a few hands to allow them to learn the connection between spawning reef fishes and the environmental conditions they need to spawn successfully.
5. Follow up the card game by leading students in a discussion using the following discussion questions:
    a. Why do fish aggregate to spawn?
    b. What other methods do fish use to reproduce?
    c. What impact does fishing and/or habitat destruction have on spawning aggregations?
    d. Why do some spawning aggregations form at the same place and the same time every year?
    e. How do fish find a spawning aggregation?
    f. How can humans protect spawning aggregations?

THE "ME" CONNECTION

Have students collect menus from local seafood restaurants. How many of the fishes discussed in the activity show up on the menu? Discuss with students how these fishes might not be on the menu if some of the environmental factors necessary for the successful spawning of snappers and groupers were some how disturbed.

CONNECTIONS TO OTHER SUBJECTS

Social Studies, History, and Language Arts

EVALUATION

Based on everything they have learned about the environmental needs of spawning reef fishes, have each student write a description of a fisheries management plan that would protect both the fishes and their environmental needs.

EXTENSIONS

- Social Studies – Mapping. Have students search the Internet to find maps that show currents and chlorophyll densities (food production) and have them map potential places for reef fishes to spawn so that currents will carry their young to a food source.
- Language Arts - Have students read the sections of Song for the Blue Ocean by Carl Safina on spawning groupers. Have them write a response to these sections, describing what they think about what man has done to grouper populations.

RESOURCES

Visit http://www.at-sea.org/ for more background information about the 2005 Ivory Tree Coral Expedition.

http://fwie.fw.vt.edu/WWW/macsis/fish.htm - Detailed information on the life histories of fishes, including many of the reef fish found in the South Atlantic Bight.

http://www.scrfa.org – official web site for the Society for the Conservation of reef fish aggregations

http://www.scaquarium.org/curriculum/iexplore/sixth_eighth/units/reefs/reefs_back.htm - Detailed information on reefs and reef fishes of the South Atlantic Bight.

http://www.fishbase.org/search.cfm - Detailed information on the life histories of fishes, including many of the reef fishes found in the South Atlantic Bight.

Islands in the Stream, Editor, George Sedberry. A collection of scientific papers on reef and reef fishes in the South Atlantic Bight.

Galstoff, P.S., 1954: Historical Sketch of the Explorations in the Gulf of Mexico, Galstoff, P.S., (ed.), In Gulf of Mexico and Its Origin, Waters, and Marine Life, Fishery Bulletin of the Fish and Wildlife Service, 55, 3-36.

Koenig, C.C., F.C. Coleman, C.B. Grimes, G.R. Fitzhugh, K.M. Scanlon, C.T. Gledhill, and M. Grace, 2000, "Protection of fish spawning habitat for the conservation of warm-temperature reef-fish fisheries of shelf-edge reefs of Florida." *Bulletin of Marine Science*, 66(3), p. 593-616.

http://oceancurrents.rsmas.miami.edu/caribbean/florida.html - for more information on the Florida Current.

Reed, J.K., 1980, "Distribution and structure of deep-water *Oculina varicosa* coral reefs off central east Florida *Bulletin of Marine Science,* 30, p. 667-677.

Reed, J.K., 2002, "Deep water *Oculina* coral reefs of Florida: Biology, impacts, and management", *Hydrobiologia*, 471, p. 43-55.

http://www.uncwil.edu/oculina/Sections/coral_biology.htm – for more background on *Oculina* reefs.

http://www.coris.noaa.gov/about/deep/deep.html - NOAA's Coral Reef Information System

http://pubs.usgs.gov/fs/fs108-99/ - the geology of the Oculina Bank

http://oceanica.cofc.edu/Oculina2003/ProjectOverview.htm - more on the Oculina Bank from Project Oceanica

http://www.bio.fsu.edu/ifre/ifre_research_oculina.html - Studies in the Experimental Oculina Research Reserve off the Atlantic Coast of Florida

http://oceanexplorer.noaa.gov/explorations/islands01/log/sab_summary/sab_summary.html - web logs from NOAA's 2001 *Islands in the Stream Expedition*

http://oceanexplorer.noaa.gov/explorations/deepeast01/background/corals/corals.html - background information on deep-sea corals from NOAA's 2001 *Deep East Expedition*

SUNSHINE STATE STANDARDS

How Living Things Interact With Their Environment

- SC.G.1.4
- SC.G.2.4

ACKNOWLEDGEMENTS

Activity developed by Kevin Kurtz, South Carolina Aquarium, Charleston, SC

This lesson plan is a modified version of the one available at http://oceanexplorer.noaa.gov

Spawn Cards

Reef Fish

Gag Grouper

Reproductive Method: Collects seasonally in large groups at *Oculina* Bank for spawning. Releases eggs and milt

Reef Fish

Scamp

Reproductive Method: Collects seasonally in large groups at *Oculina* Bank for spawning. Releases eggs and milt

Reef Fish

Black Sea Bass

Reproductive Method: Collects seasonally in groups comprised of one male and several females for spawning.

Fish

Clearnose Skate

Reproductive Method: Female and male come together for internal fertilization. Larval skates released in egg cases.

Fish

Oyster Toadfish

Reproductive Method: Female and male come together. Female attaches eggs to hard surface and male fertilizes externally and then guards eggs until larvae hatch.

Reef Fish

Blue Angelfish

Reproductive Method: Collects seasonally in groups comprised of one male and several females for spawning.

Fish

Sand Tiger Shark

Reproductive Method: Female and male come together for internal fertilization. Embryo stays inside female and is born fully developed.

Fish

Seahorse

Reproductive Method: Female and male come together. Female lays eggs in a pouch on the male's stomach. Male carries and protects eggs until after they hatch.

Habitat

Oculina Bank

Habitat *Oculina* Bank	Habitat *Oculina* Bank	Habitat Low- Relief Hard Bottom
Habitat **Muddy Bottom**	Habitat **Sandy Bottom**	Habitat Destroyed *Oculina* **Rubble from trawling activities**
Oceanic Condition **Gulf Stream Current**	Oceanic Condition **Gulf Stream Current**	Habitat **Open Ocean**

Oceanic Condition **No Current**	Oceanic Condition **Gyre Current Off of the Gulf Stream**	Oceanic Condition **Eddie Current Off of the Gulf Stream**
Oceanic Condition **No Current**	Oceanic Condition **No Current**	Oceanic Condition **No Current**
Productivity of Nearby Habitats **Salt Marsh** Nutrients from freshwater rivers support abundant phyto-plankton production and marsh grass production.	Productivity of Nearby Habitats Mangrove Wetlands **Nutrients from detritus and freshwater rivers support abundant**	Productivity of Nearby Habitats Seagrass Beds **Nutrients from detritus and freshwater sources support abundant**

Productivity of Nearby Habitats

Offshore Sand Bottom

Offshore sand bottom does not have enough nutrients for abundant phytoplankton

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Productivity of Nearby Habitats

Offshore Sand Bottom

Offshore sand bottom does not have enough

Productivity of Nearby Habitats

Open Ocean

The open ocean does not have enough

Habitat

***Oculina* Bank**

Oceanic Condition

No Current

Productivity of Nearby Habitats

Florida Current

Upwelling brings nutrients to the surface to support abundant phytoplankton production.

Fish

Red Porgy

Reproductive Method: Collects seasonally in large groups for spawning. Releases eggs and milt in water for external fertilization.

Productivity of Nearby Habitats

Open Ocean

The open ocean does not have enough nutrients for abundant phytoplankton production.

Productivity of Nearby Habitats

Open Ocean

The open ocean does not have enough nutrients for abundant phytoplankton production.

Who's Your Neighbor

FOCUS
Benthic invertebrate groups associated with deep water coral reefs

GRADE LEVEL
9-12 (Life Science)

FOCUS QUESTION
What kinds of animals are found in the benthic communities associated with deep water corals, and how may these animals interact?

LEARNING OBJECTIVES
- Students will be able to recognize and identify some of the fauna groups found in deep water coral reef communities.
- Students will be able to describe common feeding strategies used by benthic animals in deep water coral reef communities.
- Students will be able to discuss relationships between groups of animals in deep water coral reef communities.

MATERIALS
- ☐ "Data Summary Sheet," copied onto an overhead transparency or onto a marker board or flip chart
- ☐ Copies of "Some Fauna Associated with Live and Dead *Oculina varicosa* Corals," one copy for each student group
- ☐ 1 map of the *Oculina* Bank Habitat Area of Particular Concern (OHAPC) and the adjacent coast, including bathymetry

AUDIO/VISUAL MATERIALS
Chalkboard, marker board, or overhead projector with transparencies and markers for group discussion

TEACHING TIME
One 45-minute class period, plus time for student research

SEATING ARRANGEMENT
Groups of 4-6 students

MAXIMUM NUMBER OF STUDENTS
30

KEY WORDS

Continental shelf
Continental slope
Deep water coral
Fauna
Snapper-grouper complex
Oculina varicosa
Hard bottom
Habitat
Invertebrate

BACKGROUND INFORMATION

For hundreds of years, thousands of fishermen have fished U.S. coastal waters of the Atlantic Ocean and Gulf of Mexico. Yet, the marine habitats of the adjacent outer continental shelves and slopes are poorly studied and in many cases completely unknown. Until recently, most scientists assumed that these habitats did not support large or productive biological communities. Although no one had actually visited the edges of the continental shelves for a first hand look, they believed that the extensive commercial fisheries depended upon migrations from other areas and/or nutrients carried in from deeper or coastal waters. Once they actually began exploring the area more thoroughly, scientists found many diverse and thriving benthic communities.

Offshore North Carolina and Florida, several unique habitats are found where the topography of the outer continental shelf is extremely rugged and swept by the powerful currents of the Gulf Stream. Hard or “live” bottom habitats support diverse biological communities that include important fish and invertebrate resources. On the edge of the continental shelf where depths range from 80 to 250 m, hard bottom communities provide the foundation for the food web of many commercially important species. While scientists have studied many shallow-water hard bottom communities (within the range of SCUBA gear), little is known about the ecology of deep water coral reef communities.

Off the central eastern coast of Florida, between Cape Canaveral and Ft. Pierce, at depths of 70-100 m along the edge of the continental shelf, *O. varicosa* forms a unique and complex habitat called the *Oculina* Bank. Here, branches of living coral grow on mounds of dead coral and can be several meters deep and hundreds of meters long. Unlike the reef-building corals found in shallower waters, *O. varicosa* does not have symbiotic algae. Conversely, *O. varicosa* receives nutrition from plankton and particulate material captured by its polyps from the surrounding water. *O. varicosa* mounds alter the flow of currents and provide essential habitats for a variety of invertebrates and recreationally, commercially, and ecologically important fishes and crustaceans.

Because the deep *Oculina* reef habitat exists nowhere else in the world, it provides an excellent opportunity for scientific studies. On-going research strives to learn more about the biology, population status, and ecological role of these unique and vulnerable deep water corals. In an effort to protect these fragile corals from human activities such as trawling and dredging, fishery managers designated 300 square miles of the *Oculina* Bank as a Habitat Area of Particular

Concern (OHAPC). This designation prohibits the use of habitat damaging fishing gear such as trawls, fish traps, or bottom long lines to help protect the fragile coral. Additionally, the southern area of the OHAPC has been closed to bottom fishing, creating an Experimental Closed Area for studies of the snapper-grouper complex associated with the coral while providing additional protection from fishing gear.

The 2005 *Ivory Tree Coral Expedition* will continue research and monitoring objectives within the OHAPC, including further mapping of the OHAPC and quantification of fish and invertebrate populations. In this activity, students will research information on the ecology of faunal groups found on the *Oculina* Bank, and make inferences about the role of these groups in the deep water reef community.

LEARNING PROCEDURE

1. Review the general geographic location and form of the continental shelf adjacent to Florida's Atlantic coast. Tell students that very little is known about the ecology of the edge and slope of the shelf, but that recent explorations have found diverse and thriving benthic communities.
   - For more background information about the 2005 *Ivory Tree Coral Expedition*, visit http://www.at-sea.org/.
   - For more background on the *Oculina* Bank, visit: http://oceanexplorer.noaa.gov/explorations/islands01/background/islands/sup6_oculina.html
2. Provide each student group with a copy of "Some Fauna Associated with Live and Dead *Oculina varicosa* Corals." Tell students that these data were obtained by examining 42 small *Oculina* colonies. Colonies were collected by placing a fine-mesh bag over the colonies so that all macroscopic fauna on and within the colony would be collected. Each colony was photographed, measured, broken into small pieces, and put through a fine mesh so that all boring, free-living, and "epizoic" animals (those that live on other animals) might be collected.
3. Assign each student group one or more of the fauna groups listed in the table. Have each student group prepare a brief report on the assigned group(s) using library and/or internet resources. Each report should include (a) a description of the animal, including size range; (b) habitat; (c) food source(s) and feeding habits; (d) an illustration, if possible. The following websites may assist in their research the necessary information:
   - http://library.thinkquest.org/26153/marine/animalia.htm
   - http://tolweb.org/tree?group=Animals&contgroup=Eukaryotes
   - http://virtual.yosemite.cc.ca.us/randerson/Marine%20Invertebrates/index.htm

4. Have each student or group present their report to the entire class, and fill in the appropriate cells in the "Data Summary Sheet."
5. Lead a discussion of how faunal groups associated with *O. varicosa* may interact in deep reef communities, with particular emphasis on habitat and feeding strategies. The "Data Summary Sheet" should reflect a variety of potential habitats including the reef surface, variously-sized spaces between living or dead coral branches, sediment, and the skeletons of dead (and sometimes living) corals.
6. Ask students to distinguish between motile and sessile organisms, and relate this to feeding habits. Students should realize that most of the organisms are suspension feeders like *O. varicosa*, and many are sessile. This implies that current flow could be important to maintaining a steady supply of food, and may explain why *O. varicosa* reefs are found an area with strong currents. Some groups may have several possible feeding strategies. In this study¸ 29% of the mollusks collected were filter feeders (as suspension feeders and using mucous webs), 23.9% were parasitic carnivores, 16.8% were non-parasitic carnivores, 15.5% were herbivores, 6.7% were detritovores, 4.2% were scavengers and 3.8% were corallivores (feeding on coral). Similarly, crustaceans may also be predators, or may feed on detritus.
7. Students should also realize that the primary source of food for benthic organisms is primary production that occurs in shallower waters and that organic material and nutrients are transported out of these environments when organisms die and settle to the bottom. Feeding activities by benthic organisms return some of these materials to other realms of the ocean environment. Ask students why they think there are so many different kinds of animals in these benthic communities, and why this diversity is important.

THE "ME" CONNECTION

Have students write a brief essay on why diverse but relatively unknown groups like those studied in this activity might be important to their own lives.

CONNECTIONS TO OTHER SUBJECTS

English/Language Arts; Earth Science

EVALUATION

Reports prepared in Step 2 provide opportunity for assessment.

EXTENSIONS

- Log on to http://www.at-sea.org/ to keep up to date with the latest 2005 Ivory Tree Coral Expedition discoveries, and to find out what researchers are learning about deep water hard bottom communities
- Compare to similar faunal community studies on *Lophelia* reefs—another deep water coral. See: Jensen, A. and R. Frederiksen. 1992. "The fauna

associated with the bank-forming deepwater coral *Lophelia pertusa* (Scleractinia) on the Faroe Shelf." *Sarsia* 77:53-69.

∀ Explore other methods for studying and collecting invertebrates of this ecosystem.

RESOURCES

http://oceanica.cofc.edu/activities.htm – Project Oceanica website, with a variet of resources on ocean exploration topics

http://pubs.usgs.gov/of/of01-154/index.htm – U.S. Geological Survey Open-File Report 01-154 "Sea-Floor Photography from the Continental Margin Program"

Reed, J.K., 2002, "Deep water *Oculina* coral reefs of Florida: Biology, impacts, and management", *Hydrobiologia*, 471, p. 43-55. – The technical journal article upon which this activity is based

http://www.uncwil.edu/oculina/Sections/coral_biology.htm – for more background on *Oculina* reefs.

http://www.coris.noaa.gov/about/deep/deep.html - NOAA's Coral Reef Information System

http://pubs.usgs.gov/fs/fs108-99/ - the geology of the *Oculina* Bank

http://oceanica.cofc.edu/Oculina2003/ProjectOverview.htm - more on the *Oculina* Bank from Project Oceanica

http://www.bio.fsu.edu/ifre/ifre_research_oculina.html - Studies in the Experimental *Oculina* Research Reserve off the Atlantic Coast of Florida

http://oceanexplorer.noaa.gov/explorations/islands01/log/sab_summary/sab_summary.html - web logs from NOAA's 2001 *Islands in the Stream Expedition*

http://oceanexplorer.noaa.gov/explorations/deepeast01/background/corals/corals.html - background information on deep water corals from NOAA's 2001 *Deep East Expedition*

http://www.cool-corals.de/ - click on "ACES" on the left-hand navigation bar for more information on the Atlantic Coral Ecosystem Study (ACES)

http://www.ices.dk/aboutus/pressrelease/coral.asp - International Council for Exploration of the Sea (ICES)

SUNSHINE STATE STANDARDS

The Nature of Science

- ∀ (SC.H.1.4)
- ∀ (SC.H.2.4)

How Living Things Interact with Their Environment

- ∀ (SC.G.1.4)
- ∀ (SC.G.2.4)

ACKNOWLEDGEMENTS

This lesson plan is a modified version of the one available at http://oceanexplorer.noaa.gov/

Student Handout
Data Summary Sheet

	Size Range	Habitat	Food Source(s)	Feeding Habits
Phylum Mollusca				
Class Bivalvia				
Class Cephalopoda				
Class Gastropoda				
Class Polyplacophora				
Class Scaphopoda				
Phylum Arthropoda				
Class Octracoda				
Class Pycnogonida				
Subclass Copepoda				
Order Amphipoda				
Order Decapoda				
Order Isopoda				
Family Tanaidae				
Phylum Echinodermata				
Phylum Annelida				
Class Polychaeta				
Phylum Sipuncula				
Phylum Nemertea				

Student Handout

Some Fauna Associated with Live and Dead *Oculina varicosa* Corals

Information from (Reed, 2002)

Group	Number of Species	Number of Individuals
Phylum Mollusca	230	5132
Class Gastropoda	155	*
Class Bivalvia	68	*
Class Polyplacophora	5	*
Class Cephalopoda	1	*
Class Scaphopoda	1	*
Phylum Arthropoda	*	*
Order Decapoda	50	2300
Order Amphipoda	47	*
Class Pycnogonida	15	*
Class Octracoda	*	*
Subclass Copepoda	*	*
Order Isopoda	*	*
Family Tanaidae	*	*
Phylum Echinodermata	21	*
Phylum Annelida	*	*
Class Polychaeta	*23 families*	*
Phylum Sipuncula	*	*
Phylum Nemertea	*	*
Total:	*	20,000+

* data not available

Other Faunal Facts:

- The 2,300 decapod crustaceans included 15 families, 35 genera and 50 species.
- The most common decapods were two species of hermit crabs (*Pagurus carolinensis* and *P. piercei*), one species of porcelain crab (*Megalobranchium soriatum*) and a galatheid crab (*Galathea rostrata*).
- These species seemed to prefer the dead, rather than the live coral areas, as their numbers were positively correlated with the relative size of the dead versus live patches of the *Oculina* colonies sampled.
- The 230 molluscan species came from 111 genera in 74 families.
- Three gastropod species and three bivalve species made up 51.5% of all mollusks collected.
- Twenty-nine percent of the mollusks collected were filter feeders (as suspension feeders and using mucous webs), 23.9% were parasitic carnivores, 16.8% were non-parasitic carnivores, 15.5% were herbivores, 6.7% were detritovores, 4.2% were scavengers, and 3.8% were corallivores (feeding on coral).

Appendix B – Workshop “Goodie Bags” Contents

Canvas tote bag from Marine Conservation Biology Institute (MCBI)

1. Teacher Workshop Materials Binder
2. NOAA Southeast Fisheries Science Center informational brochure
3. NOAA plastic bag
4. NOAA National Undersea Research Center at the University of North Carolina-Wilmington t-shirt
5. NOAA National Undersea Research Program pen
6. Wildlife guide for the Space Coast of Florida
7. Year Round Outdoor Adventure Guide for Florida’s Space Coast
8. Brevard Zoo Teacher Resource Guide
9. Rosenstiel School of Marine and Atmospheric Science (RSMAS) sticker
10. RSMAS informational brochure
11. RSMAS pencil
12. RSMAS keychain
13. University of Miami Seafood Watch Guide
14. Habitat Newsletter from the Environmental Learning Center (ELC) in Vero Beach, FL
15. ELC program brochure
16. ELC informational brochure
17. Dixie Crossroads Seafood Restaurant informational brochure
18. Smithsonian Marine Station at Ft. Pierce (SMS) event and school program schedule
19. SMS Newsletter
20. SMS informational brochure
21. SMS bookmark
22. SMS brochure
23. SMS brochure
24. National Marine Educators Association bookmark
25. North Carolina Sea Grant Newsletter, *Conch Shell*
26. South Atlantic Fisheries Management Council brochure and information
27. NC Sea Grant periodical, *Coastwatch*
28. National Marine Educators Association periodical, *Current: The Journal of Marine Education*
29. Harbor Branch Oceanographic Institute (HBOI) CD-ROM, *Sea Profiles*
30. Workshop Presentations and Teacher Resources CD-ROM
31. HBOI DVD, *Oculina Reefs in Jeopardy*
32. HBOI DVD, *Deep Water Coral Reefs of Florida, Georgia, and South Carolina*
33. HBOI Bulletin

Treasures of the Deep -
Deep-Water Corals of the South Atlantic and the Oculina Bank:
A Local Resource Workshop for Teachers

WORKSHOP AGENDA

8:30 – 8:45	Workshop Registration
8:45 – 9:15	Welcome Jocelyn Karazsia, NOAA Fisheries Habitat Conservation Division
	Introductory Remarks Laurilee Thompson, Dixie Crossroads Seafood Restaurant
	Workshop Overview Jocelyn Karazsia
9:20 – 9:40	Overview of Deep Water Corals Presented by Jennifer Schull, NOAA Southeast Fisheries Science Center
9:40 – 10:00	Overview of the *Oculina* Habitat Area of Particular Concern (OHAPC) Presented by Andy Shepard, NOAA Undersea Research Center
10:00 – 10:40	Overview of October 2005 *Ivory Tree Coral Expedition* Presented by Andy Shepard
10:40 – 10:50	Questions
10:50 – 11:00	Break
11:00 – 11:30	Review teacher packet information Organize into breakout groups
11:30 – 12:30	Video presentation and Keynote speaker John Reed, Harbor Branch Oceanographic Institution **Lunch provided by Dixie Crossroads Seafood Restaurant**

(continued on back)

12:30 – 2:15	Breakout groups commence lesson plan activities

- ∀ **Cool Corals** – Biology and ecology of shallow and deep water corals
  Facilitated by Sarah Heberling, University of Miami Rosenstiel School of Marine & Atmospheric Science
- ∀ **Who's Your Neighbor** –Benthic invertebrate groups associated with deep water coral reefs
  Facilitated by Jim Wharton, Smithsonian Marine Station at Ft. Pierce
- ∀ **Living in Extreme Environments** – Biological sampling methods
  Facilitated by Jocelyn Karazsia
- ∀ **Mapping the Bank** – Bathymetry of the *Oculina* Bank
  Facilitated by Andy Shepard
- ∀ **Spawn!** – Environmental needs of spawning reef fishes
  Facilitated by Jennifer Schull

2:15 – 2:25	Break
2:25 – 3:40	Breakout groups report out Group Discussion
3:40 – 4:00	2005 *Ivory Tree Coral Expedition* Port Day Discussion
4:00 – 4:30	Questions and Comments Evaluations

September 17, 2005

2005 Deep Water Corals of the South Atlantic Workshop

This self-assessment instrument is designed to compare what you know now in contrast to what you know after today's activities. Recognizing that each person at this workshop brings a different set of experiences, we are interested in your personal gains in understanding deep water coral communities, the *Oculina* Bank Habitat Area of Particular Concern, applicable research methods, and your ability to teach the concepts presented.

Next to the phrases associated with Deep Water Coral Issues, *Oculina* Bank, and Scientific Research, write the number in the box that corresponds to your perception of your current content knowledge and also to your current ability to use this knowledge in the classroom and your teaching.

Content Knowledge
1. No knowledge about this topic
2. Little knowledge about this topic
3. Some knowledge and experience with this topic
4. Considerable knowledge and understanding about this topic

Ability to apply this knowledge in the classroom
1. Never taught this topic
2. Have touched on this topic with students
3 This topic is part of my curriculum teaching, with few activities
4. This topic is very important to students, I have lessons and activities

	Content Knowledge	Ability to use this knowledge in the classroom
Deep Water Coral Issues	**1-4**	**1-4**
Natural factors affecting Deep Water Coral Ecosystems (DWCE) health		
Natural resources that rely on healthy DWCE		
Human factors affecting DWCE health		
Management options for conservation of DWCE and associated resources		
Scope of DWCE in the United States		
***Oculina* Bank**		
The *Oculina* Bank Habitat Area of Particular Concern (OHAPC) and Experimental Closed Area		
Ecosystem management efforts along the *Oculina* Bank		
Changes and causes of change in the OHAPC over time		
Interaction of the OHAPC with coastal areas		
Scientific Research		
Major research initiatives along the *Oculina* Bank		
Experimental design in deep ocean science research		
Use of ocean technology to map, characterize, and understand deep ocean ecosystems		
Types of research important to deep ocean ecosystems		

September 17, 2005

Evaluation of the 2005 Deep Water Corals Workshop
At Dixie Crossroads Seafood Restaurant – Titusville, FL

Please answer the following questions to help the National Oceanic and Atmospheric Administration evaluate the effectiveness of its programs in relation to the goals and objectives of this project. For each of the following questions (#1-10), please fill in one circle that best reflects your level of agreement. If you have difficulties deciding on an answer, give the answer that best represents your thoughts. Please remember that there are no wrong answers.

		Strongly Disagree	Disagree	Agree	Strongly Agree
1.	The workshop met my expectations and needs.	○	○	○	○
2.	I can find deep-water corals and ocean sciences curriculum resources to use in my classroom.	○	○	○	○
3.	I can develop at least one new activity for my students based on the workshop.	○	○	○	○
4.	The workshop instructors presented materials in a clear and understandable way.	○	○	○	○
5.	I plan to participate in events and activities related to the upcoming research cruise to the Oculina Bank.	○	○	○	○
6.	Networking with other workshop participants will be beneficial.	○	○	○	○
7.	I can integrate relevant estuarine, coastal and ocean issues in my classes.	○	○	○	○
8.	I learned much new information about ocean science research and how scientists work.	○	○	○	○
9.	I would recommend this workshop to my colleagues.	○	○	○	○

Please use the space below or the back of this page to provide any comments or suggestions.

Thank you very much for your time and effort.

Treasures of the Deep -

Deep-Water Corals of the South Atlantic and the Oculina Bank:

A Local Resource Workshop for Teachers

Target Group: Science, math, and technology teachers (grades 9-12) from St. Lucie, Indian River, and Brevard counties

Description: In this one-day workshop, participants will learn about deep-water coral ecosystems, the Oculina Bank Habitat Area of Particular Concern (OHAPC), research and monitoring efforts, and educational materials for classroom use. Additionally, this workshop solicits educator input on various deep-water coral outreach and education activities, including possible teacher and student participation in upcoming research and monitoring cruises via classroom curriculum materials, World Wide Web interaction, Port Day events, and possible day-at-sea visits to the research ship. Participants will receive new curriculum and educational resources, conduct activities relating to oceanographic exploration, and gain a further understanding of the importance of this unique deep-water habitat.

When: Saturday, September 17, 2005
8:30 AM to 5:00 PM
(Lunch provided free of cost by Dixie Crossroads.)

Where: Dixie Crossroads Seafood Restaurant
1475 Garden Street
Titusville, FL
For directions go to http://www.dixiecrossroads.com/

Deadline for application submission: Friday, August 26, 2005
Announcement of Selections: Friday, September 2, 2005

***NOTE*: Teachers can earn district in-service re-certification credits by attending this workshop.**

For more information about this workshop, please contact either:

Jocelyn Karazsia
NOAA National Marine Fisheries Service
Email: Jocelyn.Karazsia@noaa.gov
Phone: 561.313.2038

Sarah Heberling
NOAA Southeast Fisheries Science Center
Email: SHeberling@rsmas.miami.edu
Phone: 305.365.4109

Sponsors: NOAA-Southeast Fisheries Science Center, NOAA-National Undersea Research Center, South Atlantic Fishery Management Council, NOAA Coral Reef Conservation Program, Harbor Branch Oceanographic Institution

Why Deep-Water Corals?

In October 2005 and May 2006, the National Oceanic and Atmospheric Administration (NOAA), together with the Harbor Branch Oceanographic Institution and the South Atlantic Fisheries Management Council, are conducting a research and monitoring cruise on-board the NASA ship *Liberty Star* to the Oculina Habitat Area of Particular Concern (OHAPC). The cruises focus on monitoring and comparing live coral cover, fish populations and reproduction, and biodiversity inside and outside the OHAPC.

This September's deep-water corals workshop is part of the on-going education and outreach efforts sponsored by NOAA's Coral Reef Conservation Program. Deep-water coral reefs are more abundant than their better-known shallow-water relatives, and exist all around the coast of Florida off the continental shelf edge; however, many people are unaware of their presence and value. The Oculina Bank is a series of deep coral reefs found in 200 to 350 feet of water, about 25 miles offshore, extending along the edge of the continental shelf from Ft. Pierce to Daytona Beach. Though little sunlight can reach the reefs, their biodiversity nonetheless rivals that of shallow Caribbean reefs mainly because the Gulf Stream delivers nutrients and the larvae of countless animal species.

Since the discovery of the Oculina Bank in 1975 by scientists at Harbor Branch, concentrations of healthy coral and schooling fish have declined dramatically; however, a NOAA-funded 2003 spring research cruise to the area's deep-water reefs gathered new information that bodes well for the future of this vital habitat. While remotely operated vehicles surveyed approximately 35 miles of habitat during the expedition, revealing disturbing swaths of coral reduced to rubble; researchers also observed thickets of standing live and dead coral, giving hope for recovery. Only through public outreach and education can we generate a better understanding, appreciation, and acceptance of the need to protect for these remote, valuable natural resources. Education in the classroom is critical for reaching this objective.

Specific Workshop Objectives Include:

- Introduce teachers to deep-water corals (i.e. ecology and biology), to issues specific to the OHAPC (including management efforts), to ocean exploration technology, and to experimental design.

- Promote familiarity and new partnerships between teachers and deep-water coral researchers.

- Promote inquiry learning through existing curricular and educational resources, aligning with the Sunshine State Standards.

- Facilitate development, exchange, and implementation of curriculum and lessons in the participant's classrooms.

- Promote interest in and development of various levels of interactive education components related to research and monitoring cruises and management efforts.

- Provide opportunities for feedback and evaluation between workshop sponsors and participants.

- Provide opportunities for participants to demonstrate leadership skills.

OHAPC Focus Questions:

- Why was the OHAPC given an HAPC designation status?
- How has the OHAPC changed over time and what are the causes of change?
- How does the OHAPC interact with coastal areas?
- How is the OHAPC and surrounding area studied and monitored for change?
- What resources rely on healthy deep-water coral ecosystems?
- How do deep-water corals differ from shallow-water corals?

Education Focus Questions:

- How can teachers engage students in deep-water coral science?
- How can real data from deep-water coral research and monitoring be used in the classroom?

Measurable Objectives:

- Review existing deep-water coral curriculum that has been modified specific to the OHAPC and further developed for use in classrooms
- Plan and execute a Port Day and other interactive activities
- Participate in evaluation exercises

DRAFT WORKSHOP AGENDA

8:30 – 9:00	Welcome & Introductions Workshop overview and purpose
9:00 – 9:20	Overview of Deep-Water Corals
9:20 – 9:40	Overview of the Oculina Habitat Area of Particular Concern
9:40 – 10:20	Overview of the October *Liberty Star* research and monitoring cruise to the OHAPC, including a review of related education and outreach efforts and objectives
10:20 – 10:30	Questions
10:30 – 10:45	Break
10:45 – 11:15	Review Teacher Packet information
11:15 – 12:00	Breakout Sessions Commence
12:00 – 1:00	Video presentation and keynote speaker, *Dr. John Reed, deep-water coral expert and ocean explorer, Harbor Branch Oceanographic Institution* **Lunch provided *free of cost* by Dixie Crossroads Seafood Restaurant**
1:00 – 3:30	Breakout groups continue and report out
3:30 – 4:30	Group discussion
4:30 – 5:00	Questions/Comments/Evaluation

Treasures of the Deep -

Deep-Water Corals of the South Atlantic and the Oculina Bank:

A Local Resource Workshop for Teachers

APPLICATION

Due on or Before **August 26, 2005**
Selection* Announced **September 2, 2005**

Name: ______________________________

Home Address: ______________________________

City, State, Zip: ______________________________

Home Phone: ______________________________

Preferred Email (*Please print clearly*): ______________________________

Name of Principal/Supervisor and School: ______________________________

Work Address: ______________________________

City, State, Zip: ______________________________

Work Phone: ______________ Fax: ______________

Position: ______________________________

Subjects Taught: ______________________________

Years Teaching: ______________________________

Grade Level: ______________________________

Email or fax your completed application by **Friday, August 26, 2005** to Sarah Heberling at sheberling@rsmas.miami.edu or (305) 361-4478.

* *The basis for attendance selection is first come, first served. Preference will be given to teachers from Indian River, St. Lucie, and Brevard counties.*

Treasures of the Deep -
Deep-Water Corals of the South Atlantic and the Oculina Bank:
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This certifies that I, ___________________________________, participated in a ____ hour workshop on Deep Water Corals of the South Atlantic at Dixie Crossroads Seafood Restaurant in Titusville, FL on Saturday, September 17, 2005.

Participant Signature: ____

Workshop Coordinator Signature: _______________________________________

Workshop agenda on back.

WORKSHOP AGENDA

8:30 – 8:45	Workshop Registration
8:45 – 9:15	Welcome Jocelyn Karazsia, NOAA Fisheries Habitat Conservation Division Introductory Remarks Laurilee Thompson, Dixie Crossroads Seafood Restaurant Workshop Overview Jocelyn Karazsia
9:20 – 9:40	Overview of Deep Water Corals Presented by Jennifer Schull, NOAA Southeast Fisheries Science Center
9:40 – 10:00	Overview of the *Oculina* Habitat Area of Particular Concern (OHAPC) Presented by Andy Shepard, NOAA Undersea Research Center
10:00 – 10:40	Overview of October 2005 *Ivory Tree Coral Expedition* Presented by Andy Shepard
10:40 – 10:50	Questions
10:50 – 11:00	Break
11:00 – 11:30	Review teacher packet information Organize into breakout groups
11:30 – 12:30	Video presentation and Keynote speaker John Reed, Harbor Branch Oceanographic Institution **Lunch provided by Dixie Crossroads Seafood Restaurant**
12:30 – 2:15	Breakout groups commence lesson plan activities ∀ **Cool Corals** – Biology and ecology of shallow and deep water corals Facilitated by Sarah Heberling, University of Miami Rosenstiel School of Marine & Atmospheric Science ∀ **Who's Your Neighbor** –Benthic invertebrate groups associated with deep water coral reefs Facilitated by Jim Wharton, Smithsonian Marine Station at Ft. Pierce ∀ **Living in Extreme Environments** – Biological sampling methods Facilitated by Jocelyn Karazsia ∀ **Mapping the Bank** – Bathymetry of the *Oculina* Bank Facilitated by Andy Shepard ∀ **Spawn!** – Environmental needs of spawning reef fishes Facilitated by Jennifer Schull
2:15 – 2:25	Break
2:25 – 3:40	Breakout groups report out Group Discussion
3:40 – 4:00	2005 *Ivory Tree Coral Expedition* Port Day Discussion
4:00 – 4:30	Questions and Comments Evaluations