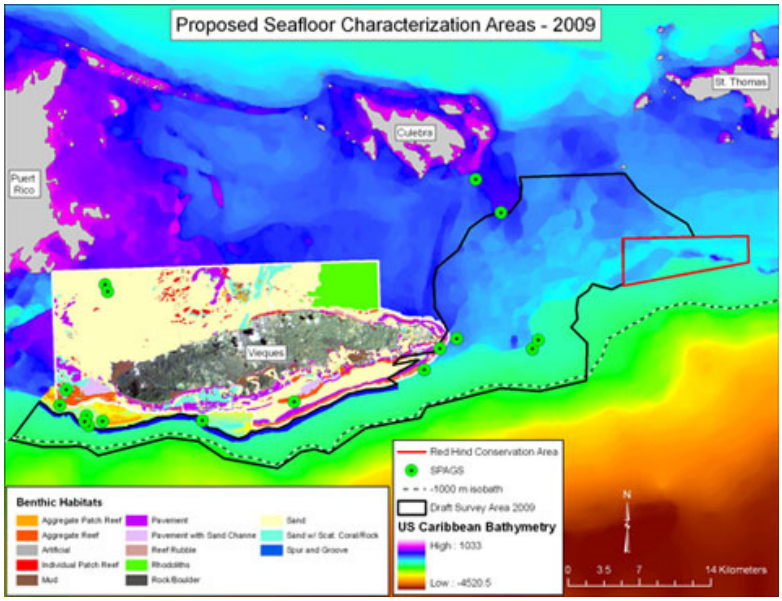
Web Update
Day 1: 03/27/2009

And We're Off

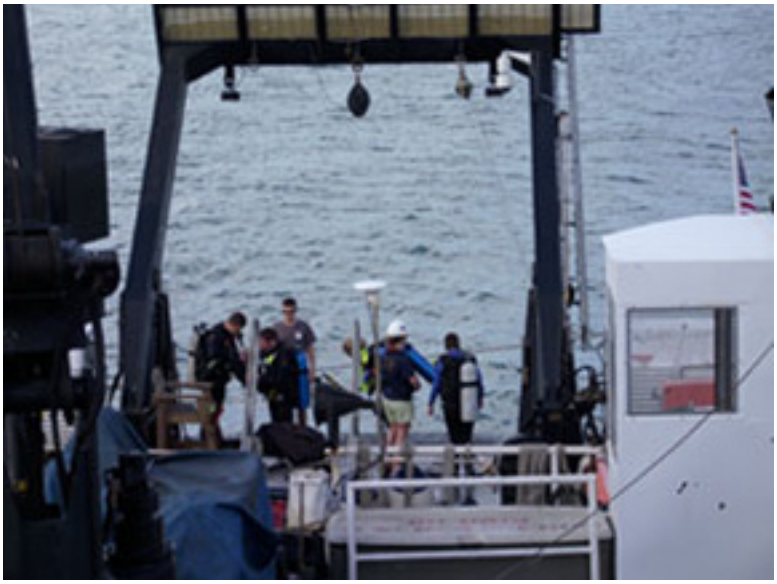
After nearly a week of delays the R/V Nancy Foster arrived at the U.S. Coast Guard Station in Old San Juan. This year, scientists from NOAA's Biogeography Branch and partners will explore nearshore habitats (10 to 300 m) off the coasts of Vieques. Vieques is an island just off the east coast of Puerto Rico. The surrounding waters contain several areas of biological importance including a number of fish spawning aggregation sites and coral reefs.



The 2009 survey area off the coast of Vieques, PR.

Before the science team and the crew of the Nancy Foster could start collecting data, they had to set up the high-tech tools used to conduct the work. First, the multibeam ecosounder used to collect bathymetric data was lowered into the water and installed by a team of divers to the bottom of the ship.

The multibeam unit is lifted over the side of the ship with the help of a winch



Divers ready themselves to mount the multibeam unit to the bottom of the Nancy Foster.

Meanwhile, the remotely operated vehicle that will collect real-time video imagery of the seafloor and the fish acoustic equipment used to map organisms in the water column were being calibrated and tweaked in preparation for arrival in the study area. Together this suite of biological and physical data will help the scientists paint a clearer picture of the underwater habitats off Vieques and the organisms inhabiting them. From there they can provide local resource managers tools, like habitat and seafloor maps, to help better manage the area's marine resources.

Once the flurry of activity settled, the ship began the six hour steam from San Juan to Vieques.

A view of El Moro as we depart Old San Juan

Web Update
Day 2: 03/28/2009

Area Students Visit the Nancy Foster

Late Friday evening the R/V Nancy Foster reached the coast of Vieques. Following an all-night run of multi-beam and remotely operated vehicle (ROV) operations, the scientists and crew took a break from collecting data to welcome a group of 30 local students for a science education program. Students from Movimiento en Apoyo a Nuestros Tesoros Ambientales (MANTA) and Reach for Success boarded the ship at Moquito Pier to meet with scientists, discover the tools used in underwater data collection, learn about coral reef ecosystems, explore careers in marine science and take a tour of the Nancy Foster.

Students from MANTA meet at Mosquito Pier.

Chief scientist Tim Battista got the afternoon got off to an exciting start by explaining a bit about the mission, what kind of data his crew collects and showing the students a video of the Biogeography Branch's ongoing work in Buck Island (USVI).

Tim Battista greets the students.

For the remaining time, the groups of students cycled through three education stations: 1) coral reef ecosystems and fish, 2) research tools and 3) a ship tour. Charlie Menza met the group at the coral reef ecosystems and fish station where he gave the students an overview of fish and habitats, coral reef ecosystems and explained how each is connected to the other.

Charlie Menza takes the students on a tour of a coral reef ecosystem.

The students also discovered that in order to really understand underwater habitats, scientists need high-tech tools to collect data. Chris Taylor illustrated how sound waves can detect objects (i.e. fish) in the water column. This technique can even decipher the approximate size of the fish. Zach Hecht-Levitt explained how he uses a multibeam echosounder to collect bathymetric data and create 3-D images of the seafloor.

Chris Taylor explains how sound is used to detect fish in the water.

Lance Horn and Glenn Taylor gave the group a tour of the ROV while it was on deck and showed some examples of the detailed imagery it can collect. Finally, the students took a tour of the R/V Nancy Foster, exploring the ship's bridge, decks and corridors. They even practiced an abandon ship drill, donning hypothermia suits (also called Gumbi suits).

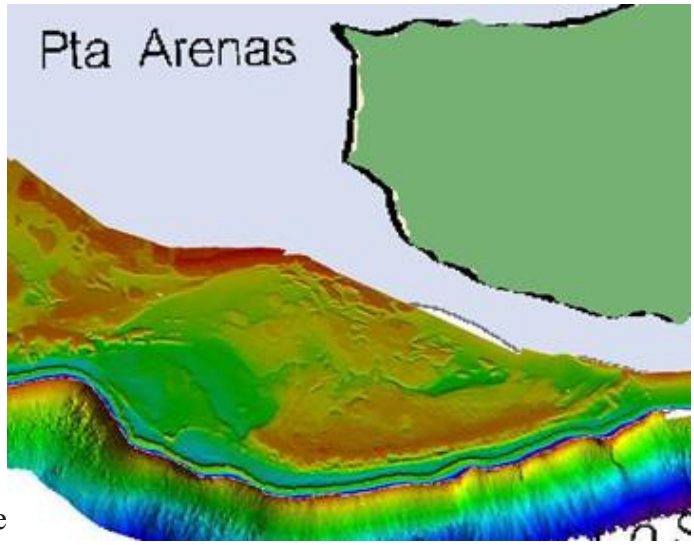
Lance Horn shows off the ROV.

Thanks to crew of the R/V Nancy Foster and the counselors from MANTA and Reach for Success help with coordinating this event!

Despite the hot weather these students are still smiling in their Gumbi suits.

Web Update
Day 3: 03/30/2009

One Seafloor, Two Sonars



Bathymetry map off Vieques, Puerto Rico, produced with the 100kHz sonar.

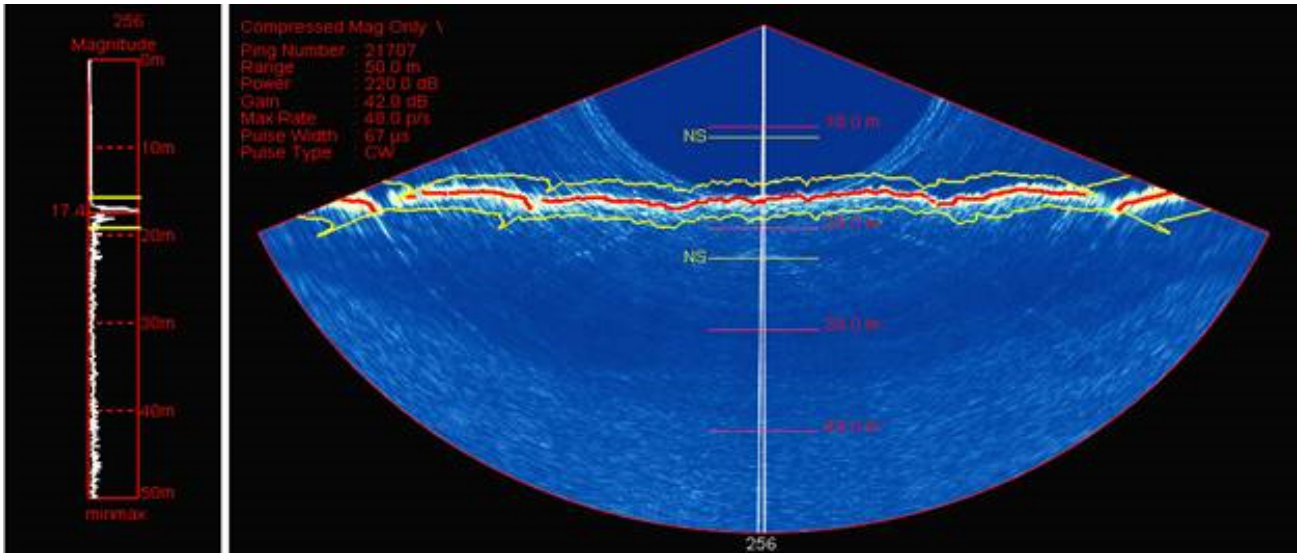
Mapping and monitoring land surface is a task that nowadays is done superbly well by satellites. A single polar-orbiting satellite can monitor swaths about 3,000 km wide in a single "flyover." Orbiting at about 850 km from the Earth's surface, these satellites can cover the entire planet 14 times in less than 24 hours. Mapping the seafloor, however, is a much more time-consuming and difficult task. It has to be done by ships instead of satellites, navigating much more slowly, and using sonars covering a small track at a time.

The depth to which the sonar can map is determined by the frequency of sound it produces. For instance, a lower frequency sonar (and longer wavelength) can penetrate deeper in the water column to retrieve information from the seafloor. The NOAA Nancy Foster R/V is fitted with a sonar (Simrad Em 1002) that uses a 100 kilohertz frequency to map the seafloor ideally from about 100-1,000 meters (that's very deep, especially when considering that a meter is more than 3 feet). While lower frequency sonars are useful for esonifying and mapping deep ocean habitats, the lower frequency also reduces the resolution of the features you are trying to detect. Therefore, if you are trying to produce seafloor maps in shallower waters, scientist prefer higher-frequency sonar system to provide very high resolution maps which lower frequency system would otherwise not be able to provide.

The Nancy Foster ship temporarily installed on an experimental basis a new sonar, the RESON 7125, to help map shallow water areas. This is an optimal sonar in that it has two sonar transducers (in this case, an instrument that uses electricity to emit and receive a very specific sound wave) with frequencies of 200 and 400 kHz. The optimum collection range for the 400 kHz system is at seafloor depths between 5 to 100 meters, and the 200 kHz from 100 to 400 meters. Both can produce high-resolution imagery of the shallow to moderate depth sea floor. With this, the Nancy Foster would be able to map almost the entire range where coral reefs exist, and would greatly increase its monitoring abilities. Any experimental and new equipment always requires calibrations, tweaks and adjustments; in this case, the positioning of the new sonar had to be adjusted so the signals could be accurately received. Ship divers ventured under the Nancy Foster to retrieve the sonar and, after modifications were made on a zodiac by the scientists, installed it back.

The sequence above shows the repositioning of the new sonar, with a cardboard diagram model for sonar alignment; divers reading to retrieve the sonar; and adjustments made on the zodiac.

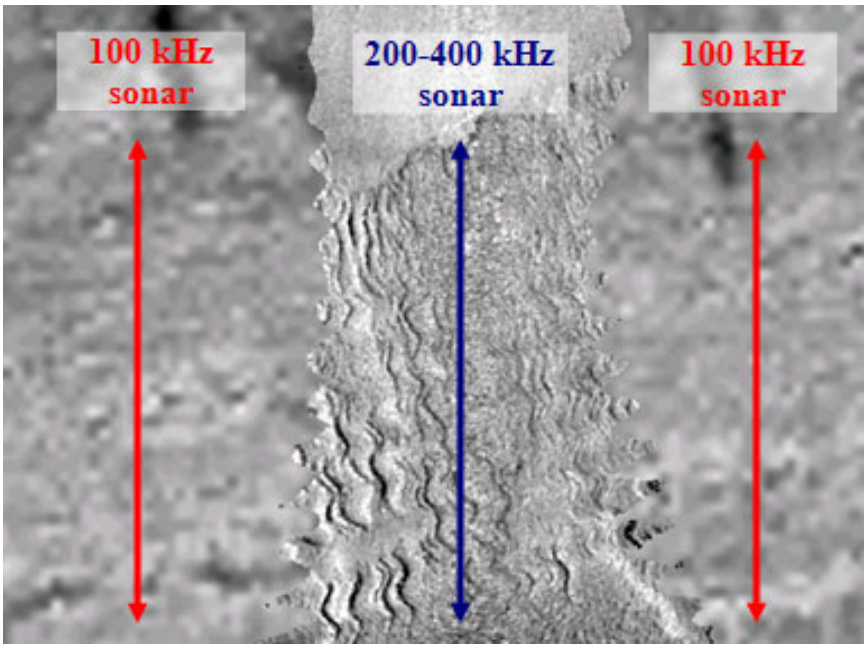
After successfully adjusting the new sonar, the ship spent time calibrating it, going over the same spot several times to compare the data it receives to make sure that it looks the same when it maps the same area of the ocean. The new sonar produces soundwaves dispersing at 128 degrees, as shown in the image below. Very much like a flashlight that illuminates within a circle that decreases as it gets closer to a wall, the size of the swath depends on how far the ship is from the seafloor. However, NOAA hydrographic charting standards require trimming the swath to a maximum of 3 times the depth (or up to 120 degrees), so mapping at about 40 meters as in the image below would produce a swath 120 meters wide (compare this to the swath of a satellite!).



The “pings” generated shallow-water sonar detect the sea floor, which shows up here as the red line.

What is gained after so much work of installing and calibrating a new sonar? A much more detailed map of the seafloor. The gains in resolution are significant - whereas the 100 kHz sonar can produce an accurate map of the depths and general contours of the seafloor, the map you get is very general, having a resolution of several meters. At optimal conditions, this shallow-water sonar can produce a map featuring details measuring centimeters, effectively going from a map where features are captured in yards to a map where details can be in inches. See the difference in the image below.

At the completion of the cruise, the 7125 sonar will be returned to RESON Inc. facilities, where they will calibrate the system in a controlled tank-testing environment. Upon the successful calibration, NOAA scientists will be able to accurately compare and analyze the acoustical signature return from the sonar, which will uniquely identify individual coral habitat types. This increase in the resolution opens up many uses for the maps generated. They can assist in monitoring the essential habitats found below, and it can even be used for observing important fish aggregations. We’ll talk more about that particular and innovative use in our next postings, so stay tuned!



One seafloor, two sonars: the left and right side of the image were generated by the 100 kHz sonar, while the center section was produced by the sonar being tested.

Web Update
Day 4: 03/31/2009

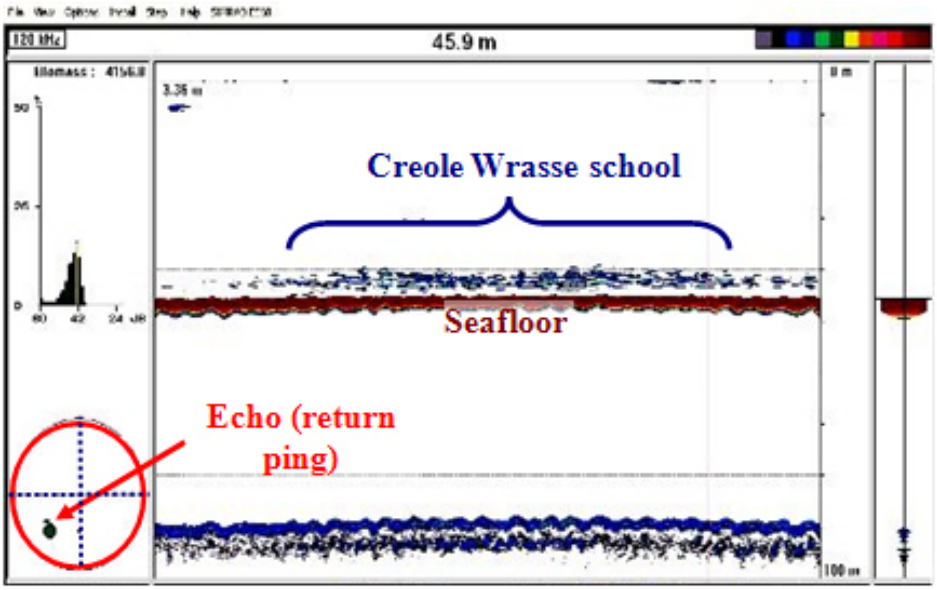
Of Fish and Sonars

Fish move. Fish hide. Fish don't answer questions. Counting fish outside a tank is never a straight forward process. So the best we can do is make educated guesses based on sound science – sound science as in acoustics. So instead of devising a census questionnaire, we develop sonars to gain a sneak peek at the fish world below.

A school of Creole wrasse swimming over a reef area. Figuring out the best way to count them is not easy.

One sonar in particular, the split-beam echosounder, is an effective tool used to detect fish. The echo-sounder aboard this NOAA ship is sort of a very powerful and accurate version of the simpler fish finder found in some fishing boats. The split-beam gets its name because it sends a single "beam" of sound straight to the sea floor, but return signals (the echoes from the ping) are received by a transducer split (hence the first part of the name) along quadrants, each one receiving the echo at a slightly different time. The beam is emitted for a very short time, lasting just 120 microseconds; but often, repeating every 1/10 to 1/5 of a second. The beam that's emitted is a very narrow one – just 7 degrees of a circle, or 0.12 of the water depth (compare this to the 3 times water-depth, 128-degree swath of the other sonars on this ship!). This translates to a diameter of just 5.5 meters when the ship is at 45.9 meters, as in the sample image below (circle in lower left corner).

The echosounder can accurately locate fish in depths from 2 to 200 meters by emitting a low-power pulse of 120 kHz. This frequency is far beyond the hearing range for humans (which is between 20 and 20,000 Hertz), and also beyond the hearing capacity of most fishes. However, we are not the only mammals to use sonar to locate fish – dolphins can emit their "clicks" at a similar frequency (or lower) to locate and catch their fish. The physics behind both echosounders are similar: based on the return times, the echosounder can accurately locate the fish in the water column. The strength of these return signals

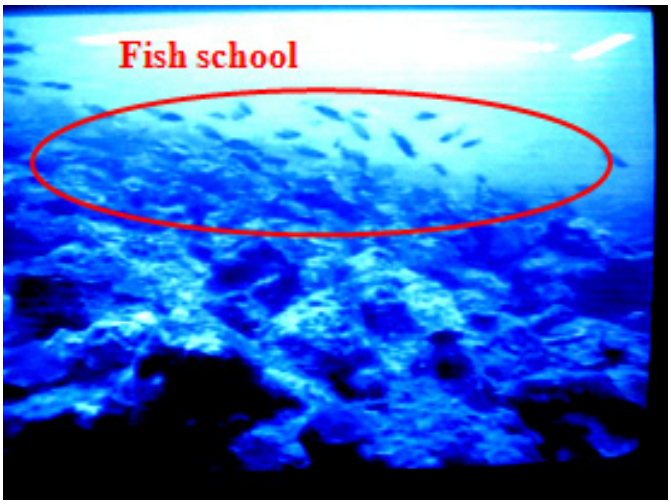


Data from the split-beam echosounder. Here, the echo from the emitted ping comes from the school of fish.

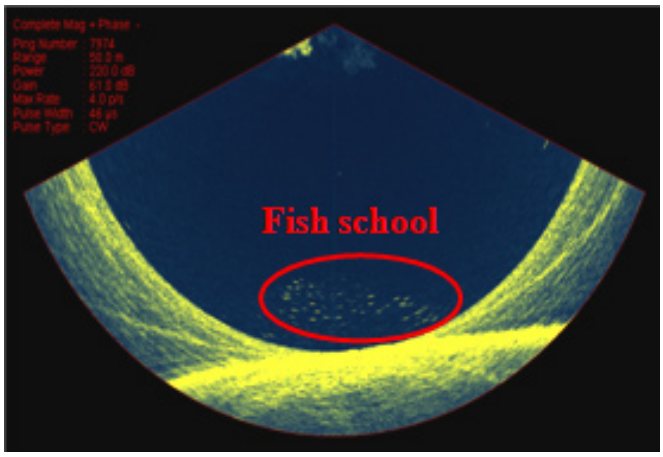
can give us a general idea of the size of the fish – small, medium, or large. But in order to get a better idea of the size of a school of fish, or the actual species found, we need other tools.

The Biogeography branch of NOAA's Center for Coastal Monitoring and Assessment is using other tools, such as the 100 kHz and 200/400 kHz sonars (described in the previous posting) and ROV to map and monitor the benthic habitat. But these instruments are used not only to map the seafloor, but also to help us get a better understanding of fish that live there. And things start getting interesting when data from these instruments are combined.

We recently had a chance to get three different views of the same school of fish, using three different instruments in combination. While navigating less than 50 meters away from the ship, the Remotely Operated Vehicle came across a school of Creole Wrasse (Clepticus parrae), a medium-sized fish often found in open water by drop-offs or in deeper reefs. They're often on the move, and found in groups of varying sizes. We saw the school in the TV screen that receives the live video feed from our aquatic rover, and this image allowed us to identify the particular fish species. Later, as the ship went directly above the same school, the echosounder picked them up. Its narrow view allowed us to quantify the density of the school and general size of individual fish within, along with an accurate 3-D location of each fish. At the same time, the 200/400 kHz sonar gave us the wide view, a "flying-fish eye" perspective if you will, of the entire school at once, allowing us to measure its total size. The ROV for visual species identification, the multibeam for school size, and the echosounder for fish location and individual specimen size: one school of fish, three instruments.



Species Identification (ROV): TV display video camera from the ROV while it's being guided, and gliding, through the school of fish ahead of the ship

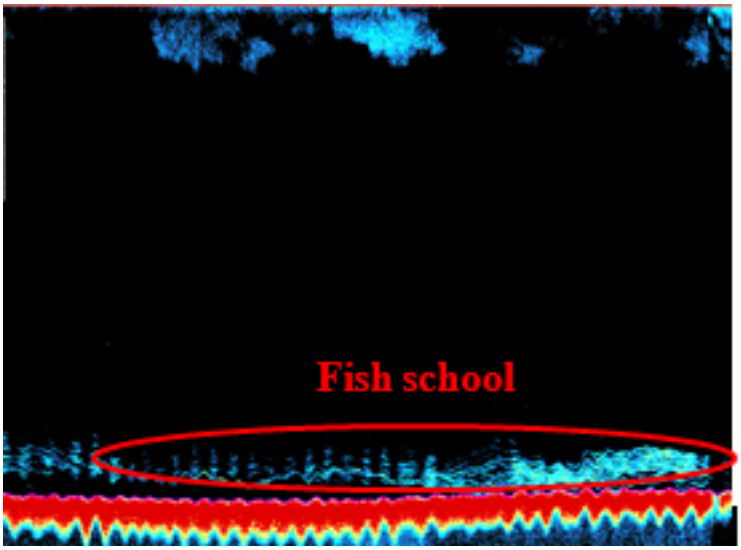


School Size (200/400 kHz Sonar): Image from the 200/400 kHz sonar. The school of fish is seen moments later as the yellow dots in the lower middle section (seafloor is the solid yellow arch).

Why is it important to track fish? With all these data, we can track and monitor important spawning aggregations of key fish species, such as yellow tail snapper and red hind, and answer basic questions about local fish populations: are they being depleted? Have they moved elsewhere? If known spawning sites are protected for overfished species, we can monitor if and how these are recovering. We'll follow this topic up in our next posting tomorrow. Armed with our arsenal of fish-finding tools, we begin to answer ourselves the questions that fish keep quiet about.

* Short clip that shows Creole Wrasse school observed, with the 3-D animation of each fish position in the water column.

* A 34-sec clip of echosounder data as it is received. The dots appearing and disappearing in lower left circle represent fish detected.



Fish Size and Location (Echosounder): Completed image of the split-beam echosounder - the same school of fish is detected here, moments after the ROV came across it.

Web Update
Day 5: 04/01/2009

The Little ROV Explorer: In celebration of a diver that needs no decompression

The diver aboard the Nancy Foster R/V that has logged most underwater hours measures just under two feet in height, has gone deeper than any of the other talented NOAA divers, and is not afraid of sharks: meet our Remotely Operated Vehicle, ROV. It does, however, need a little help getting in the water: to deploy it, crew and scientists don helmets, safely attach themselves to the ship (to avoid becoming unwilling ROV passengers) and lower it in the ocean with a large crane.

ROV operator Lance Horn directs deployment. Heading straight for the beach, this ROV is well trained.

A tether cable always keeps the ROV connected to the ship, bringing back the images and giving it power. Our ocean rover has four electrical motors that allow it to turn either way, climb, and descend, or just glide along. At full throttle, it attains plankton-speeds of up to one knot (!) and can go as deep as 1000 feet (unless the cable were to get accidentally and tragically get cut, in which case, it could go down up to 6.78 miles.) Controlling all of these movements is done in a panel that looks very much like an arcade game. But in this case, no quarters are needed, just lots of training.

The ROV serves as our eyes, with a live-feed video camera and a high-definition still camera. There are several serious and important uses for this camera. The rich visual data allows us to monitor and assess ecosystems – for instance, we can quickly determine live coral cover over large areas. Here in Vieques, we have seen some areas with rich and healthy coral reef environments with over 80% coral cover. We can use this imagery to ground-truth and complement data obtained by other methods, especially sonars. We can also use it to identify individual fish species, something you cannot do with sonars, and check on spawning aggregations. The camera also offers good entertainment: being miles off shore, TV reception aboard the ship is spotty, so this video feed serves as our own Discovery Channel: the ROV daily Ocean Show: it's live, and unedited nature TV, and there's always an excitement in not knowing exactly what or who you'll see next.

ROV operator Glenn Taylor carefully maneuvers across a reef.

The ROV is also an ROB - a remotely-operated bucket: a cylinder in the front with a door that opens up on command and can bring back bottom samples (that's the part you see protruding on the forefront in the "inspirational ROV" picture at the beginning of the story). A sort of ROV's right hand, always extended and ready to shake, the seafloor.

Where there's a TV on, there's a crowd.

Also an accomplished nature photographer - bottom pictures taken by the ROV.

Web Update
Day 6: 04/02/2009

Parting Thoughts

After many sunsets, we have reached San Juan, Puerto Rico, our mission has been completed, and soon we'll be leaving the ship – a place that has a most contemplative deck chair where we've taken turns to sit down and ponder what would result from all of this research, and the age-old question of why we're here.

The big chair at the stern of the boat.

It turns out we're here because of federal funding and coordination with the local fisheries council. Last year, NOAA's Biogeography Branch met with Caribbean Fisheries Management Council (CFMC) and a number of other partners, including the University of Puerto Rico, the local government's Division of Natural Resources, and NOAA Fisheries. Corals were made one of the key priority areas to monitor, and there was overwhelming consensus that El Seco, off Vieques, Puerto Rico, should be atop the list of places that needed to be mapped and characterized. El Seco is a productive fisheries area that is home to several spawning aggregations of commercially important reef species, such as red hind, yellow-tail snapper and tiger grouper, but scientific data from this area has been very sparse.

But while we are refining our understanding of the reef area and mature fish (since emphasis has been on spawning aggregations and large schools), the formation of these populations via larval dispersal, still remains unknown. Towards this end, we are collaborating with the University of the Virgin Islands to study larval distribution patterns and the related oceanographic processes that influence fish abundance and distribution in the Virgin Passage, the channel between (and possibly linking) Vieques and the nearby St. Thomas, USVI. This future research would help understand the many complex physical processes that support the rich biological activity found there.

A sepia sunset off Vieques.

Returning to our first question, what comes out of all of this research? The result is a better understanding of location, sizes, times, and associated trends of spawning aggregations, fish populations, and habitat health. This information can help inform management of the local marine resources, and determine if special protection for these areas is needed. We find examples of research informing management not only here, but also in nearby (and biologically connected) areas. Ongoing research in two important spawning aggregations in the Virgin Islands, the Red Hind Marine Conservation District and the Grammanik Bank MPA, is assessing the effectiveness of these protected areas, and if their size is sufficient to protect the spawning aggregations.

The CFMC has started conducting in-situ, diving-based work to monitor the ecosystem, while Biography Branch has been conducting mapping and ecosystem characterization for the past several years. Information collected from these combined efforts will serve to better inform research managers in making and conserving commercially important species, and providing them with an assessment of the status of tiger grouper population, size and frequency distribution of large, elusive and commercially exploited fish, as well as a bathymetry map of El Seco. And these are, after all, very good reasons to be here, and to come back again.

* Short 3-D animation showing newest bathymetry data for El Seco region, off the Vieques coast, Puerto Rico (no sound).
* Tiger grouper courtship behavior filmed by ROV camera off Vieques, Puerto Rico, at about 110 feet underwater. Notice the change in coloration in the underside of these fish during courtship.

Web Update
April 3: Mission Summary

to Photo Gallery
to 3-D Video

All Good Things Must Come to an End

After seven days at sea, the 2009 Vieques seafloor characterization mission came to an end. Despite only a week in the field, the NOAA researchers collected an impressive body of data for analysis, and also took a break to connect with local students. Below is a summary of the mission highlights. Click on the button above to view the 2009 Seafloor Characterization: Vieques photo gallery.

Remotely Operated Vehicle Observations
The remotely operated vehicle (ROV) footage yielded some rather interesting finds, particularly during observations around El Seco, PR. El Seco is a region that is well known for attracting aggregations of many species of fishes during the spawning season. A pair of tiger grouper was observed in courtship behavior. At times the two were seen swimming side-by-side and at one point on of the fish swam upside down near its potential mate. Both had white belly patches indicating courting or mating was taking place.

ROV footage also revealed the presence of several uncommon schools of fish, including, white margate and trunkfish. Typically these species are seen as individuals in shallow coral reefs, but the observation of hundreds of individuals suggests they were at El Seco to spawn or to take advantage of other fish (i.e., eating eggs) that were also spawning.

The team also observed a very deep zooxanthellate coral at 95 m. Although this is not the record, which is 119 m at Bahamas, this is exceptionally rare, noteworthy and indicates exceptional water quality.

Acoustic Data Collection
While surveying at El Seco the team demonstrated the first use of splitbeam and multibeam sonar to detect and image reef fish schools and aggregations. They successfully detected and mapped the distribution of two large aggregations of fishes. The mapped locations of the schools were used to pinpoint an ROV dive that provided the species identification: an aggregation of greater than 100 adult white margate, and a very large school of Creole wrasse that measured greater than 20 m across and nearly 100 m long! Many fishes aggregate around the full moon to spawn. A full moon occurred on March 10, so the team probably missed the most intense spawning activity. But the cruise did demonstrate the utility of these sonar technologies for assessing reef fishes and coral reef ecosystems. High-resolution multibeam and splitbeam sonar mapping provided a detailed picture

of the geological and habitat features, in addition to the distribution of fishes that utilize the region. Abundance at El Seco was higher than other sites around Vieques that were surveyed on previous cruises and emphasizes the importance of this region for fish populations and overall ecosystem health.

Multibeam Data Collection

Over the course of the mission the group collected about 28 km2 of bathymetric data down to 910 m off the south shore of Vieques, and about 19 km2 of data down to 289 m for El Seco. Once the raw multibeam data is cleaned and processed, Biogeography scientists will serve it to the public in the form of downloadable images and GIS raster datasets. In the coming months the next step will be to analyze the ROV footage and attempt to match what is seen in the video with what is seen on the sonar imagery. Ultimately, correlating changes in the ROV footage with changes in the bathymetric and backscatter data will allow the team to create detailed benthic habitat maps of the surveyed area.

Education and Outreach

Once the R/V Nancy Foster arrived in Vieques the scientists and ship crew took a break from collecting data to welcome a group of 35 area students for a science education program (see day two's posting, 3/28/2009, for a full description of the event). Students from Movimiento en Apoyo a Nuestros Tesoros Ambientales and Reach for Success boarded the docked ship to meet NOAA and partner scientists, learn about NOAA's work in the area, discover the tools used in underwater data collection, explore coral reef ecosystems and experience life aboard a science research vessel. The group cycled through the following three 40-minute education stations: 1) coral reef ecosystems and fish, 2) research tools and 3) a ship tour. The education and outreach component of the mission was organized to build and strengthen ties with the local community and promote various aspects of marine science as a career.

Many thanks to the captain and crew of the R/V Nancy Foster for their support!

* This one minute video shows a short survey track (green line) using multibeam sonar. The complex shape of a large school of fish (creole wrasse) is shown as a "cloud" of points in 3-D near the shelf break of El Seco.