Technological revolutions in sensors, robotics, and telecommunications allow new views of ocean

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Scientists find undersea mountains, discover new species, and spy on fish

Scientists can now visualize the ocean floor in remote areas of the Arctic, observe rockfish hideouts, and see live images of coral cities thousands of meters under the sea's surface. Soon their robots will be able to "live" on the bottom of the ocean - monitoring everything from signs of tsunamis to the effects of deep sea drilling.

"We have very complex problems in the ocean, but we've been looking at things through a narrow straw," explains James Bellingham of the Monterey Bay Research Institute. "We're trying to expand this view - this is about turning the ocean transparent."

In an American Association for the Advancement of Science press conference on February 19th at 2 PM, scientists will discuss innovations in underwater research and how they are advancing both science and management.

"For every tool we have to explore outer space - space stations, tethered missions, rovers, mapping - we have a comparable tool for ocean exploration," says James Lindholm of the Pfleger Institute. "This suite of technologies allows us to study an environment that is equally hostile to human life."

"It's exciting," adds Les Watling of the University of Maine. "There hasn't been this level of true exploration in the ocean for a hundred years."

New Powers of Mapping

In the past, seafloor maps were constructed based on individual depth measurements, taken laboriously at discreet points in the sea. These points formed a connect-the-dots type picture that scientists could use to draw maps, but that was as good as it got. "You can connect the dots and get an outline, but this is like the difference between a dot-to-dot outline of someone's face and a photograph of the person," says Larry Mayer of the University of New Hampshire.

Today, multi-beam sonar sprays sound waves to scan the ocean floor, revealing everything from 3 centimeter sand ridges to 4,000 meter undersea mountains - from gun barrels off the coasts of Normandy to the contours of a favorite fishing ground. The technology for this detailed mapping has been around for several years, but, as Mayer explains, "Every time we go out there, we find tons of surprises, features we didn't know were there."

"Over 90% of U.S. imports come in by ship," adds Mayer. "If these ships run aground or have a spill it's a problem - detailed maps can prevent these accidents. It's important for safety and for the environment."

Mayer and his group are currently mapping unexplored areas of the Arctic. In 2003, his team found a seamount rising 3,000 meters from the ocean floor - a navigational hazard that wasn't on any of the charts, despite high sub traffic in the area. The importance of this finding was highlighted last month, when the USS San Francisco - a Navy attack submarine - ran aground on an uncharted sea mount, killing one crew

member and injuring dozens.

Mayer's team also uses 3D visualizations of the ocean floor to help managers, fishermen, and conservationists find new solutions for protecting resources. They brought scallop fishermen into their labs to "fly them through" a 3D, underwater image of their fishing grounds. "They'd known these areas for years, but now they could finally see it," says Mayer. The best of these fishermen recognized the seafloor they had been mentally visualizing, calling out pet names of familiar bumps where fish and shellfish congregate. Ironically, the new technology takes away the competitive edge of these experienced fishermen and makes it easier for a population to be overfished, but it can also create win-win situations. Fishermen can place their rakes exactly where the scallops are, reducing the number of damaging trawls along the bottom and allowing them to use lighter, more environmentally safe gear. They can also catch their quota in one quarter of the time, which could lead to fewer ship and fuel costs.

Managers can also make use of multi-beam sonar to monitor fishing activity in areas that are closed or protected from specific gear. With the detailed mapping systems, scientists can see trawl marks across the seafloor. New studies are examining the staying time of such marks so that the maps can be used to uncover illegal fishing practices.

Live in Color From the Bottom of the Sea

Les Watling uses state of the art ROVs and cameras to investigate life on seamounts. His team travels hundreds of miles offshore, maps an area with the multi-beam sonar, and then sends down small robots to explore mountainsides never before seen by the human eye.

"We see everything from little tiny, two-inch corals to ones that are 12 feet high, and sponges of all shapes, sizes, and design," says Watling.

"You can go along and find something that is totally bizarre. It's important for understanding biodiversity, making a record of life on earth."

Last summer in waters off Alaska, Watling's group discovered a predatory sponge standing 1.5 feet tall and acting like a fly-trap flower to catch crustaceans. The only similar species known to the world was found in a cave in the Mediterranean and stands only 3 to 4 inches. They also discovered worms that induce corals to form tunnels in their skeletons, and a unique association in which shrimp use a specific type of deep sea coral as a hiding place when they are carrying eggs. Now they are documenting corals across the Atlantic, trying to understand deep sea processes that allow these animals to disperse well below the busy Gulf Stream highway that many animals use for transport.

Based in part on Watling's work, last week the North Pacific Fisheries Management Council protected more than 370,000 square miles off the coast of Alaska from trawling. Watling hopes his research on the associations of deep sea corals, fish, and other species will continue to inform conservation decisions.

"We know that these corals are all really long lived - anywhere from a couple hundred to a couple thousand years old - but we don't know how quickly we could force them to go extinct," says Watling. "When it comes to deep water invertebrates, we barely know who they are."

Manned Missions

Mary Yoklavich of NOAA Fisheries and other scientists who travel to the deep sea in submersibles recently found a new species of coral just 20 miles off the coast of Los Angeles. Published in the February 8th issue of Zootaxa, these "Christmas Tree Corals" live 100-225 meters under the sea in bushy colonies of pink, white, and red. The scientists

suspect that the corals have remained healthy because of the low level of bottom trawling in the area.

"It's amazing," says Yoklavich. "They're right off the largest urban area of the west coast, in an area with lots of boating and fishing and activity - yet this spectacular species has gone unnoticed," says Yoklavich. "And these are not just tiny colonies - these are 8 foot tall trees, sometimes 10-20 feet wide."

Scientists first viewed the corals while doing rockfish surveys from the small confines of the manned submersible, Delta. Lying sideways in the nose of the sub, researchers wrap their legs around the pilot's chair, peering out the portholes and calling out species as they pass by.

Yoklavich uses the Delta to observe rockfish in the deep rocky habitat they call home - areas where traditional net surveys are not effective. The 60 plus species of rockfish have been the bread and butter of coastal communities along the US west coast for nearly 75 years, but populations are now dwindling. Direct observation on the sea floor is the only way to discern links among corals, rockfish, and other deep sea creatures - information critical to developing effective protection measures.

"It's a different experience," explains Yoklavich. "You're in the medium, in the habitat, getting first hand experience. We took a commercial fisherman down to the sea floor - he'd been fishing since he was four years old, but it was a different world than what he understood from his nets." Yoklavich is convinced that anyone working with the ocean should have the chance to travel to the bottom of the sea.

Cindy Lee Van Dover, a deep sea ecologist and former Alvin pilot from the College of William & Mary, agrees. "The importance of being there cannot be underestimated," she says. "No amount of watching videos of

the seafloor environment prepares one for the view and insight to be gained from that first look through a viewport at depth. Your heart will race, your breathing will pause, and you will say to yourself: 'Now I understand'."

For more than 40 years, Alvin pilots have ferried hundreds of scientists to the seafloor at depths of up to 4500 meters. "Deep sea dives in Alvin have changed the way we think about plate tectonics, the formation and fate of the seafloor, as well as constraints on the nature and evolution of life - on this planet and others," says Van Dover. A new submersible, capable of diving to 6500 meters and providing access to more than 90% of the ocean, is slated to replace Alvin in 2008.

Ocean Aquanauts

Aquarius, the only undersea "space" station in the world, allows researchers to do more than just visit the seafloor: scientists stay on 10 day missions, not to Mars, but to "inner-space" off the coast of Florida.

"You actually live underwater with the fish. You can watch them while you take a shower, on your bunk, or eating dinner," says Lindholm, who is preparing for his third underwater research trip this fall.

Aquarius sits approximately 15 meters under the sea, where the pressure on divers is 2.5 times what we experience on land. It enables scientists to conduct dives for as long as 7 hours Ц opening the door to research and observations not possible with surface diving.

"Immediately following a storm during one of our trips, we saw herds of hundreds and hundreds of fish moving across the reef - fish that are typically solitary or paired," says Lindholm. "We would never have seen this if we weren't there."

Lindholm's group works with popular reef fish Ц grouper, snapper, and parrotfish Ц surgically implanting acoustic transmitters to track fish movements so that managers can better understand the impact of closing areas to fishing.

"Working on the fish in their natural environment is incredibly advantageous," says Lindholm. "We reduce stress on the fish during surgery and can watch recently tagged fish for several days to makes sure they return to normal behavior - it's vital to our research."

Once the animals are tagged and acoustic receivers are placed on the reef, Lindholm and his team can track individual fish long after the mission has concluded - at three-minute intervals for as long as five years. So far, their results show that these reef fish are staying close to home across seasons, implying that relatively small reserves may provide significant long-term protection for these populations.

Point and Click Oceanography

Scientists will soon be able to monitor the deep-sea full time from the comfort of their own living rooms. A test system, scheduled for Monterey Bay this fall, will use a cable the size of an average garden hose to bring power and Internet connectivity to the ocean. These new power outlets in the sea will allow complex instruments and robotic vehicles to stay in the water and "plug in" - sending data back to shore in real time without being connected to the surface. Scientists and engineers hope that this new technology will allow us to wire the entire ocean basins in the future.

"It's hard to understand how important it is until you compare it with how we work in the oceans today," says Bellingham. "We go to sea on ships and visit particular places for short periods of time. But what shapes the ocean are highly episodic events that are fast and intense -

algal blooms, upwelling events, deep oceanic convection. We need to be very, very lucky to be at the right place at the right time to see these events."

Monitoring devices at sea take away this element of luck, allowing around-the-clock observations and the real time connectivity needed to study short-lived and often unpredictable events. Many of the "high energy events" go hand in hand with hazardous sea conditions. "When the weather is worst is when these things are best to study, and that's when it's not safe to be out there," explains Bellingham.

There are other advantages too. In recent test experiments on the effects of carbon dioxide sequestration, scientists found that chemical reactions proceeded quite differently in the lab than on the seafloor. With the new system, scientists studying everything from ocean floor ecology, to whale migrations, to seismic activity and tsunamis, will be able to conduct ocean experiments at depth. "It's going to be an era of point and click oceanography," says Bellingham.

"Every time we've found a new way of working in the ocean we've made new discoveries, but we don't know what we're going to see," he adds. "Galileo didn't say, 'there must be sunspots and craters on the moon so I'll make a telescope'."

Plus, explains Mayer, who was once a finalist candidate to be an astronaut, "It's just really fun to explore the unknown."

Source: SeaWeb

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