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A NEW LOOK AT OCEAN LIFE

WHAT'S GOING ON DOWN THERE?

2,000 ocean scientists do the biggest, wettest census ever

BY SUSAN MILIUS

Researchers have taken clam digging to new extremes. To look for any mollusks or other creatures that live under several hundred meters of ice, scientists have just finished searching the ocean bottom off the Antarctic Peninsula. They cruised waters made more accessible when the Larsen A and B Ice Shelves shattered. For the exploration, they used a German icebreaker that pushes along at 5 knots through ice 1.5 m thick.

An earlier expedition to the area had videoed what looked like clams living there. That earlier expedition couldn't bring back samples, but the new cruise could. The team is scheduled to announce its findings—of any mollusks and other forms of life—this week. The team has hinted at success though; the weekly reports that it posted on the Internet include pictures of clamshells.

JELLIED FISH — A layer of natural goo covers the bottom-dwelling fish *Aphyonus gelatinosus*. One of the few recorded Atlantic sightings of this species took place on a Census of Marine Life cruise.

D. SHALE

The *Polarstern* expedition to Antarctica is part of a 10-year, international project called the Census of Marine Life. It started in 2000 with the mission to survey the biodiversity of the oceans. Some 2,000 researchers at schools, museums, and government agencies in more than 70 countries are developing new methods for studying marine life and are sampling the residents of both familiar and unfamiliar waters. All the projects address some aspect of three basic questions: What used to live in the sea? What lives there now? What will be there in the future?

Some general trends are already emerging, such as worrisome drops in some ocean species' populations as modeled by computer programs. Yet the current phase of the census emphasizes fieldwork over computer modeling, says Ron D'Or, the census' scientific coordinator. The *Polarstern* icebreaker cruise was the 20th sponsored by the census last year.

With all that searching of the seas, scientists have met some unexpected new underwater neighbors.

FRUSTRATED The marine census grew out of frustration, says D'Or, a marine biologist at Dalhousie University in Halifax, Nova Scotia. A 1995 report from the National Research Council in Washington, D.C., to several federal agencies warned that human activity is dramatically changing populations of sea creatures. To blunt such insults, the report concluded, marine biologists need to do much more research on the dynamics of marine biodiversity. Despite this call to action, no new government funding materialized.

So, Frederick Grassle, one of the drafters of the report, started talking to the New York City–based Alfred P. Sloan Foundation about private funding. The foundation agreed to put up money for marine biologists to get together, write grant proposals, and start ambitious ventures that might otherwise have remained daydreams.

"There were perfectly good reasons why people didn't know very much about the ocean," says D'Or. For example, standard winches on research vessels can take 8 hours just to lower a collecting contraption to the bottom, and then another 8 hours to haul a single sample back up. Because cruise time runs up big tabs in a hurry—the *Polarstern* costs about $77 a minute—deep-ocean samples are intellectual luxury goods. And only recently did remotely operated vehicles and underwater digital cameras become adept at collecting deep-ocean samples and images.

Originally, the planners discussed a "census of fishes," says D'Or. But the scope of work gradually expanded. D'Or specializes in squid and got involved in the project at a meeting unpoetically titled "Nonfish Nekton," or animals that aren't fish but can still swim better than plankton.

D'Or reports that the original census organizers "let us nonfish-nekton people in, and the plankton people, and the microbial people, and [then] everybody said, 'That's dumb—you can't just have a census of fishes. You have to have a census of marine life.'"

Now, the census has grown to 17 projects. One searches for historical records of sea life, such as fishing communities' tax records or church tithings, as measured in barrels of their catch. Another relies heavily on modeling to predict the future of marine populations. Fourteen projects focus on field studies of marine creatures—from albatrosses soaring over the water to microbes dwelling several kilometers deep.

The remaining census participants are creating the Ocean Biogeographic Information System (OBIS), which offers Internet access to 12.9 million records of 77,000 species from 200 databases.

Planners early on recognized that abyssal depths need special attention. Scientists' knowledge of marine life is, literally, shallow. Although the ocean bottom lies 4,000 m underwater on average and in places plunges much deeper, nearly 90 percent of the original entries into OBIS came from the top 100 m of water, and 99 percent came from the top 3,000 m. Nobody knows how many or what types of organisms live at lower depths, D'Or says.

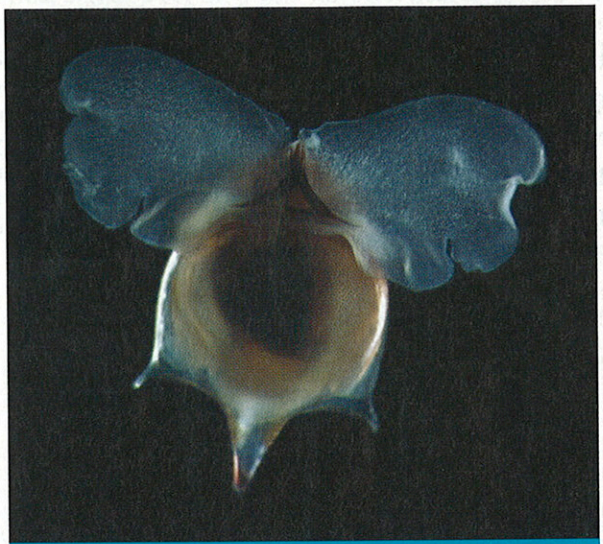
RED FISH, BLUE FISH With a wide variety of techniques, scientists are working to take a good look into the sea. Nicholas Makris and his fish-tracking research group at the Massachusetts Institute of Technology recently unveiled a sensor that can observe 10,000 square kilometers at a time over the continental shelf.

Older tracking systems for fish could cover just 100 square meters at a time. Those systems gave only rough ideas of the size of huge fish clusters that moved, spun off satellites, split, fused, and swerved this way and that. In a test off the coast of New Jersey, the new tool detected what may be the largest fish school ever recorded in one image, the researchers report in the Feb. 3, 2006 *Science*. It covered an area the size of Manhattan and included some 20 million fish.

On a very different scale, fish biologist Tracey Sutton has been considering the rare fish that he has pulled out of collecting nets lowered to the deepest waters of the Mid-Atlantic Ridge. Based at Harbor Branch Oceanographic Institution in Fort Pierce, Fla., Sutton has cruised on census expeditions along almost the entire length of the ridge. "It's a beautiful place," he says.

There he found tubeshoulders that when prodded squirt blue, luminescent clouds out of tubes on their shoulders. Sutton speculates that a fish living in velvet-black darkness might use a sudden blue glow to illuminate prey or to startle a predator.

On the ridge, Sutton found 10 or 20 tubeshoulders at a time instead of the one or two tubeshoulders that have shown up in samples from deep water elsewhere. He suggested at the Ocean Sciences conference in Honolulu last year that these supposedly nomadic loners gather at seamounts, which may be spawning grounds.



FOOT WITH WINGS — The snail *Cavolinia uncinata* swims with its foot's two broad flaps.

Sutton also collected hundreds of normally hard-to-find stoplight loosejaws (*Malacosteus niger*). These fish emit red light from a comma-shaped patch beside each eye, one of the few animals known to glow red. Despite having big fangs and a jutting jaw, the stoplight loosejaw feeds mostly on little crustaceans about as difficult to subdue as alphabet soup.

"I couldn't for the life of me figure out why it would do that," Sutton says. In the past 2 years, though, he and several other biologists have concluded that the wimpy diet of these loosejaws supplies them with the materials for the eye pigments that let them see red.

Seamounts and ridges may attract other deep-sea species that otherwise would be widely dispersed, Sutton speculates. If so, as state-of-the-art fishing fleets push into deep frontiers, fisheries managers need to watch out for damage to such exotic creatures.

The census is finding where fish aren't as well as where they are. Sharks don't seem to frequent the ocean's abyss, below 3,000 m, say Imants G. Priede of the University of Aberdeen in Scotland and his colleagues. They looked at world-wide fish-sighting records and their own sampling data from five cruises in the northeastern Atlantic. Shark species ply the waters down to 2,000 m, they report. In the depths though, sharks rarely appear, although bony fish live there. Sharks are "apparently confined to about 30 percent of the total ocean," the researchers reported in the June 7, 2006 *Proceedings of the Royal Society B*. That puts all of them within the reach of fishing fleets, so "sharks may be more vulnerable to over-exploitation than previously thought," the researchers concluded.

LITTLE GUYS Gauging the diversity of smaller creatures isn't necessarily straightforward under water. The tropics have long been hailed as rich in species, yet sea spiders may be most diverse in, of all places, Antarctica. "Some of the most amazing species live there, like those with one or two extra body segments," says Claudia Arango of the Queensland Museum in South Bank, Australia.

The sea spiders, or pycnogonids, arise from an ancient lineage of arthropods and look like their sister group of terrestrial spiders. The sea spiders have some social skills, such as male parenting, Arango notes. She says that she's looking forward to using samples collected from census expeditions to clarify sea spiders' evolutionary history.

The census also stumbled upon a new species of the so-called Jurassic shrimp. To the trained eye, like that of the creature's discoverer Bertrand Richer de Forges, that shrimp looks impossibly ancient, as if a small, pinkish dinosaur had come to life.

Crustaceans such as this may have given rise to modern decapod crustaceans, including lobsters and crabs as well as shrimp. Scientists had assumed that the lineage went extinct some 50 million years ago. But in 1908, a U.S. research vessel in the Philippines caught a single shrimp that belonged to this group. This living fossil sat generally unnoticed in a museum of the Smithsonian Institution for 67 years before two French scientists recognized what it was. Biologists have since collected only about two dozen more specimens.

In October 2005, Richer de Forges of the Institute of Research for Development in New Caledonia led a cruise to the Coral Sea as part of the Census of Marine Life. A collecting net slowly trawling a rocky, uncharted surface at a depth of 400 to 500 m brought up another shrimp with the ancient characteristics. "We immediately recognized the very special shape," Richer de Forges says.

He described it as a new species in the March 31, 2006 *Zoosystema*. Since then, another systematist has given it a genus of its own, and it's now called *Laurentaeglyphea neocaledonica*.

Even smaller animals are providing surprises for the census, says Russell Hopcroft of the University of Alaska, Fairbanks. He studies zooplankton, animals that are weak swimmers and so are swept along with ocean currents. In this category, there's "incredible diversity," Hopcroft says.

The group includes members from at least 15 or so animal phyla, the big categories just below kingdoms. "It's much easier to find new species than it is to find time to work up the descriptions," says Hopcroft.

For example, one cruise in the Arctic doubled the known diversity of comb jellies there, from 5 species to 10. Comb jellies have the same diaphanous look as jellyfish but aren't closely related to them. Ranging in size from a few millimeters to perhaps a third of a meter for rare oceanic species, they move by beating rows of tiny paddles and prey on other jellylike animals.

When Hopcroft goes on a cruise, he makes special efforts to collect frail plankton with filmy tissues. Jellyfish may be the most widely known examples, but plenty of other kinds of sea animals, such as salps, have jellylike bodies. To find them, Hopcroft drags an extrafine mesh, extra gently, through the water.

His photographs of a typical catch show translucent shapes shimmering under artificial lights. The creatures range from a few millimeters to a few centimeters in length and may be shaped like barrels, bells, or bananas with wings. Few people have seen even preserved specimens, Hopcroft says, and even fewer have seen them moving naturally.

HOPCROFT

The winged-banana group consists of snails that gave up crawling for a life of swimming through open water. The snail foot evolved into various gauzy flaps, some paired like wings. Some of the snails breaststroke through the water, others undulate their panels in birdlike flying motions, and still others row themselves along.

D'Or speculates that marine snails in general "may turn out to be the beetles of the ocean." In species number, beetles far overwhelm other land animals. Census participant Philippe Bouchet of the National Museum of Natural History in Paris sampled coral reefs near three New Caledonian islands. He found several thousand species of microsnails at each site, and as few as 20 percent of the species overlapped between islands.

JURASSIC SHRIMP — This new species of shrimp, *Laurentaeglyphea neocaledonica*, belongs to a lineage once thought to have vanished 50 million years ago. The species, discovered in the Coral Sea, is the second modern example of the lineage.

EVEN SMALLER STUFF For single-celled life, the oceans appear even more diverse. According to genetic analysis of samples from the Atlantic and the Pacific Oceans at various depths, 1 liter of seawater can contain more than 20,000 kinds of bacteria. Mitchell Sogin of the Marine Biological Laboratory at Wood's Hole, Mass., and his colleagues reported this tally in the Aug. 8, 2006 *Proceedings of the National Academy of Sciences*.

In more news of single-celled organisms, researchers announced last year a new species of what might be know as a giant microbe. It's the newest example of a group of deep-ocean creatures, known as xenophyophores, that live inside gritty particle casings. The casings of specimens of the new species range from shirt-button to coat-button size.

This encased single cell was the discovery of the European project HERMES, which shares personnel with census projects. During a cruise of the Nazaré Canyon off the coast of Portugal, the ship had lowered a device that grasps a chunk of the sea bottom. After sampling at a depth of 4,300 m, scientists found flat disks of xenophyophores on the surface of their recovered block of ocean floor.

"They're quite thin, like a crepe," says Andrew Gooday of the University of Southampton in England. The disks also break easily, so Gooday had to nudge a bit of paper under the casings to remove them from the chunk's surface.

The 50 or so known species of xenophyophores have a wide variety of shapes. They can look like flat plates, tubes, rocklike lumps, and even thin, floppy sheets that Gooday says remind him of "a piece of damp cloth." The largest species form cases some 10 centimeters in diameter. Figuring out the dimensions of the cell inside is tricky, since it threads throughout a network of passageways. Some of the space inside also goes to storage for pellets of the cell's waste.

Cruises like the ones that turned up these creatures will continue through 2008, explains D'Or. Then, the census participants are scheduled to put together their findings into a report due in 2010.

They hope that all this new research will help humanity shepherd changing ocean resources. That's always been a challenge, says D'Or. He recalls a fisheries manager summing up the difficulty: "Fisheries management is like forestry management—except that everything moves and you can't see it." ■

DE FORGES

OF NOTE

BEHAVIOR

Two dimensions of mind perception

Scientists want to figure out how individuals can tell whether someone or something else has a mental life. Controversial studies have addressed whether chimpanzees and children with autism are capable of making such an inference about others.

However, investigators shouldn't assume that organisms perceive another's mind as a single entity, assert psychologist Heather M. Gray of Harvard University and her colleagues. Instead, people attribute to others two distinct dimensions of mental activity, Gray's team reports in the Feb. 2 *Science*.

The researchers dub one dimension of mind perception "experience," meaning a capacity for feeling hunger, fear, pain, rage, desire, pride, embarrassment, and joy. This dimension also implies the presence of self-awareness and a distinctive personality.

The other dimension, "agency," refers to a capacity for self-control, morality, memory, emotion recognition, planning, communication, and thought.

The researchers surveyed 2,399 people via the Internet. Participants rated pairs of characters described on the survey on one of 18 mental capacities, for example, deciding which member of the pair was more able to feel pain. The pair members were also rated in six other ways, such as which was the more likable character. Characters included a frog, a chimpanzee, a human fetus, a baby, a 5-year-old girl, a man in a persistent vegetative state, an adult woman, God, and a robot that interacts with people.

Volunteers' responses often broke down along the two mind-perception dimensions. For instance, participants felt that characters rated high in agency—such as the active adults—deserved punishment for a misdeed, but participants most wanted to avoid inflicting harm on the characters ranked high in experience, such as the young girl.

Participants perceived God as having much agency but little experience. —B.B.

ASTRONOMY

Tiny shutters for new observatory

With the Hubble Space Telescope's sharpest camera no longer working and its repair uncertain, the spotlight falls on the orbiting observatory's successor. Scheduled to fly in 2013, the infrared-sensing James Webb Space Telescope (JWST) is designed to record the first stars and galaxies that flamed into existence.

NASA engineers now report that they have demonstrated that a set of small but critical electronic devices developed for the new telescope can withstand the rigors of launch and can travel into deep space. With those devices, known as microshutters, the