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Frontiers of Marine Science Stretched by Census Experts

Extreme Life, Marine Style, Highlights 2006 Ocean Census

Scientists intrigued by life around hottest-ever seafloor vent; Manhattan-sized school of fish off New Jersey coast; More new than familiar species on Antarctic seafloor

A host of record-breaking discoveries and revelations that stretch the extreme frontiers of marine knowledge were achieved by the Census of Marine Life in 2006, highlights of which were released today.

They include life adapted to brutal conditions around 407ºC fluids spewing from a seafloor vent (the hottest ever discovered), a mighty microbe 1 cm in diameter, mysterious 1.8 kg (4 lb) lobsters off the Madagascar coast, a US school of fish the size of Manhattan Island, and more unfamiliar than familiar species turned up beneath 700 meters of Antarctic ice.

Census of Marine Life, Year 6

Now in its 6th year, Census participants and their supporters pool talents and specialties, ships and laboratories, archives and technology in an unprecedented global scientific collaboration. Together, they are systematically recording the diversity, distribution, and abundance of global marine life. The most intense field work is taking place in 2006-8; the results will be analysed and synthesized in 2009-10 with the goal by 2010 of an initial census describing what lived, now lives, and will live in the oceans.

Census scientists mounted 19 ocean expeditions in 2006 (a 20th expedition underway in the Antarctic can be followed online at www.awi.de/MET/Polarstern/psobse.html). They inventoried nearshore biodiversity, where the number of active sampling sites grew exponentially from 30 to 128 in 2006 alone. And, using satellites, they followed across thousands of kilometers of ocean more than 20 tagged species - from sharks and squid to sea lions and albatross.

"Each Census expedition reveals new marvels of the ocean – and with the return of each vessel it is increasingly clear that many more discoveries await marine explorers for years to come," says Fred Grassle, Chair of the Census Scientific Steering Committee.

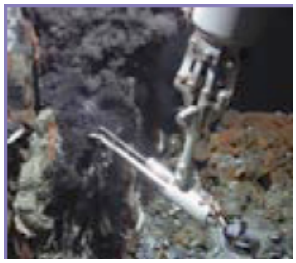
Each of 17 core projects produces a different dimension of knowledge. Two new associate projects were added in 2006, studying biodiversity in the Gulf of Mexico and along the seafloor of the Great Barrier Reef.

The Census Ocean Biogeographic Information System now publishes over 140 global databases, producing an online library of more than 10 million distribution records (up from 4 million just two years ago) of over 78,000 species.

A complementary library of short DNA sequences – barcodes for quick identification of marine animals – grew past 4,000, including 2,000 fish. Holes in the Census database define clearly the unknown ocean.

Extremes of Science

Hottest

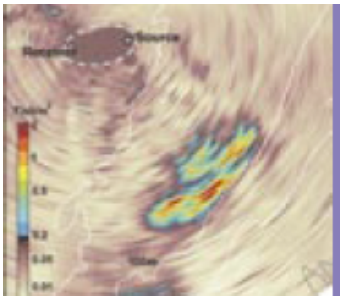


At a thermal vent 3 km below the surface in the equatorial Atlantic, Census researchers found shrimp and other life forms on the periphery of fluids billowing from Earth's core at an unprecedented marine recording of 407ºC, a temperature that would melt lead easily. Although the species resemble those around other vents, scientists want to study how, surrounded by near-freezing 2ºC water, their chemistry allows them to withstand heat pulses that approach the boiling point – up to 80ºC. Shrimp were seen on the walls of the vent chimney. Others in the habitat include mussels and clams. All somehow tolerate an environment of extreme temperature changes within a few centimeters and high concentrations of heavy metals from the vent fluids. (*ChEss photo credit: MARUM, University of Bremen © 2006.)*

Darkest

Southern Ocean census takers revealed an astonishing community of marine life shrouded beneath 700 meters of ice – 200 km from open water. Equally remarkable, sampling of this most remote ocean's depths during three lengthy cruises yielded more new than familiar species. (*CAML photo shows one of scores of species found, including a jellyfish, possibly Cosmetirella davisi, swimming with tentacles raised. Photo credit: AGAD, D. Rasch © 2006.)*

Most



Census fish counters' observation off the New Jersey coast of 20 million fish swarmed in a school the size of Manhattan Island qualifies as most new abundance found. Sound emitted by a new ship-based technology illuminates life in an oceanic area tens of thousands times larger than previously possible. It updates instantaneously and continuously, revealing the extension and shrinking, fragmentation and merging of the island-sized swarms as a person might watch schools of minnows swimming in a brook beneath a bridge. *Photo credit: N. Makris © 2006.)*

Deepest

Sampling 5 km below the surface in the Sargasso Sea, deploying a unique trawl configuration that filtered large volumes of water for rare-but-diverse zooplankton living in the ocean's deepest depths, Census experts from 14 nations caught these drifting, often soft and elusive animals in a sophisticated net, the MOCNESS. They collected more than 500 species, including 12 likely new species, eating each other at the great depths or living on organic matter falling like snow from above. (*CMarZ photo of menacing-looking, animals such as this amphipod, a small prawn-like crustacean, the supposed inspiration for the movie Alien. R. Hopcroft, University of Alaska, Fairbanks © 2006.)*

Oldest

Census seamount researchers found a shrimp, believed extinguished 50 million years ago, alive and well on an underwater peak in the Coral Sea. *Neoglyphea neocaledonica* was nicknamed "Jurassic shrimp" by its discoverers, who say it rivals the find in South Africa and Indonesia of the coelacanth, a prehistoric fish previously known only through fossils. (*CenSeam photo credit: Neoglyphea neocaledonica. B. Richer de Forges © 2006.)*

Richest

In the sense that biodiversity is richness, Census microbe hunters found 20,000 kinds floating in a single liter of sea water. Samples were taken from the Atlantic and Pacific, including from an eruptive fissure 1,500 meters deep on a seamount in the Pacific a few hundred kilometers west of Oregon, USA. Revealed by DNA studies, most of the different kinds of bacteria were unknown and likely rare globally. The richness of the diversity invites speculation about what rare species contribute to their biosphere and an estimate that the kinds of bacteria in the oceans exceed five to 10 million. The researchers also began assembling the best-ever video of protists (mostly microscopic organisms that are neither animals, plants, or fungi) and to pioneer optical and genetic techniques to extend the limits of knowledge. *(The video is available for media at the embargoed media materials URL. Credit: Jeremy Pickett-Heaps)*

Farthest

Tracking tagged sooty shearwaters by satellite, Census researchers mapped the small bird's 70,000 km search for food in a giant figure eight over the Pacific Ocean, from New

Zealand via Polynesia to foraging grounds in Japan, Alaska and California and then back. Making the longest-ever electronically-recorded migration in only 200 days, the bird averaged a surprising 350 km daily. In some cases, a breeding pair made the entire journey together.

Largest

Among the many new species discovered by Census participants during 2006, a 1.8 kg (4 lb) rock lobster that Census explorers found off Madagascar may be the largest. Named *Palinurus barbarae*, the main body spans half a meter.

Discovering diversity: More new species

New technology, the exploration of new regions, and new efficiencies of identification are accelerating discovery and recording of new species. Among the most remarkable finds:

Macro microbe

The protozoan that Census explorers of the continental margins discovered in the Nazare Canyon off Portugal differs from the usual protozoans seen swimming in a drop of water under a microscope. The single cell of this fragile new species of *Xenophyophore,* found at 4,300 m depth, is enclosed within a plate-like shell, 1 cm in diameter, composed of mineral grains.

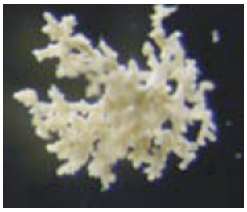
Furry crab

Near Easter Island, Census researchers discovered a crab so unusual it warranted a whole new family designation, Kiwaidae. Beyond adding a new family to the wealth of known biodiversity, its discovery added a new genus, *Kiwa*, named for the mythological Polynesian goddess of shellfish. Its furry or hairy appearance justified its species name, *hirsuta*.

A squid that chews

Among the 80,000 organisms – encompassing 354 families, genera and species – that Census deep-sea investigators collected from the Mid-Atlantic Ridge was the reference specimen or holotype for a new species of squid: *Promachoteuthis sloani*. Although collection easily damages the soft cephalopods, the hard beaks are unique to each species, including that of the new squid, which looks quite capable of chewing its food. (*MAR-ECO photo credit: P. sloani. R. Young © 2006.)*

Komoki in Antarctic waters



Komokiaceae or "komoki" dominate deep-sea foraminifera, protozaons with false feet used for locomotion and food collection. In the Weddell Sea, where ice crushed the ship of Antarctic explorer Shackleton in 1915, Census polar researchers found 59 komoki and komoki-like species, at least 42 unknown to science. *(Photo credit: A. Gooday, National Oceanography Centre, Southampton, UK © 2006)*

Doubling Zooplankton

Census zooplankton researchers discovered 3 new genera and 31 new species of copepods and mysids, small crustaceans, in Southeast Asian, Australian, and New Zealand waters. Analysis of collections from biodiversity hotspots, the deep sea, and other unexplored regions is on track to double the number of known zooplankton species

Charting distribution

New and continuously improving techniques also let scientists collect and tag creatures in order to follow their movements. Marine animals themselves are thereby recruited as oceanographers, mapping their travels in the world's oceans. With their help, the Census is creating new insights into the present and shifting distribution of global marine life.

Salmon cellphone coverage extended

When 2,600 fish left rivers in early summer, 2006 for a career in the North Pacific, they carried tiny acoustic transmitters. These could be detected for a year or more by the Census using an array of 252 receivers on the continental shelf, reaching outward from shore and stretching along the Pacific migration route for over 2,000 km in 2006 – from California through Canada to Alaska. When a fish passes an acoustic receiver, its unique identity is stored and later transmitted to a visiting ship, telling the fish's survival and location. The Census Pacific shelf listening array achieved more than 95 percent success in tracking salmon, sturgeon, and other fish engaged as Census correspondents.

Wider ranges

When studying distribution, the surprise of finding a species in a new place is as exciting as the discovery of a new species. A species in a new place may indicate the species adapted, the environment changed, or the area was seriously undersampled. During 2006, counts rose to 31 species in the Arctic outside their known range, plus 60 species never

before seen over the Mid-Atlantic Ridge between Iceland and the Azores. Meanwhile, Census seamount researchers found an abundance of squat lobsters, so named because they appear to squat on the ocean floor, inhabiting seamounts off the New Zealand coast, some of which researchers believe may never have been found before on seamounts.

Needles in haystacks

The span from schools of countless herring and other fish down to single animals of a species among thousands collected typifies the range of scale challenging Census' charting. The rich diversity of the isopod crustaceans includes common species and others rarely observed. In its exploration of Antarctic seas, the figurative haystack, Census researchers found many new species, especially isopod species, represented by only a single animal, the figurative needle, among thousands of specimens collected. (*CeDaMAR photo credit: Southern Ocean isopod, Munnopsis. W. Broekeland © 2005)*

Dams and survival

Soon after salmon leave a river for the ocean, many perish. For decades people have wondered if salmon that have struggled to reach the river mouth through many dams might be less likely to survive in the open ocean than those that enjoyed youth in a free-flowing river. Initial counts suggest that survival of stocks leaving dammed rivers is comparable to those leaving rivers without dams.

The most complete registry

During 2006, experts in the Gulf of Maine released the most comprehensive list ever created of known species in this ecosystem: 3,317 in all. Researchers continue to refine and add to the registry, which includes marine life from microscopic phytoplankton up to right whales, and from seasonal migrants to year-round residents. The database is one tool in a larger effort to describe patterns of biodiversity and their contributions to the functioning of a regional system.

Assessing abundance

Degradation and recovery in estuaries

"The historical studies of the CoML agree with recent studies showing steep declines of most wild populations of marine animals that people eat," says Dr. Grassle. "The past richness of the oceans in many near shore regions is hard for people today to believe."

In such archives as taxes on salt to cure fish, Census historians reconstructed the changing abundance of marine life in 12 estuaries and coastal seas around the world. In archives from Roman times in the Adriatic Sea, the medieval era in Northern Europe, to Colonial times in North America and Australia, they confirmed the fears that exploitation and habitat destruction depleted 90 percent of important species. They also confirmed elimination of 65 percent of seagrass and wetland habitat, a 10 to 1,000-fold degradation of water quality, and accelerated species invasions. More happily, they also found signs of transitions from degradation to recovery where conservation was implemented during the 20th century.

Scarce in time

An expedition to the Mid-Atlantic Ridge captured 300 fish species, several of them not seen since a 1910 expedition, while others considered rare were found common. The change in abundance could reflect removal of predators, limited sampling in the past, or a change in the weather.

Absent in space

Census researchers discovered 70 percent of the world's oceans are shark-free. In an extensive study of the vast abyss below 3,000 m, deep-sea scientists found sharks were almost entirely absent and sought physiological and other explanations. Although many sharks live down to 1,500 m, they fail to colonize deeper, putting them more easily within reach of fisheries and thus endangered status.

Assessing abundance demands efficiency

Expanding knowledge of diversity with new species requires one specimen, charting distribution requires several, but counting abundance demands examining many. During three explorations of coral reefs, Census experts expedited determination of many of the 1 to 9 million animal species that inhabit coral reefs, using new molecular techniques allowing rapid processing of large samples.

The Census zooplankton team performed the first DNA barcoding of plankton on a ship at sea, telescoping what formerly took three years of work into just three weeks, an approach that may revolutionize the way researchers expand the boundaries of knowledge.

Other marine life dimensions

Marine rush hour commuters

At dusk above Mid-Atlantic Ridge, Census researchers encountered a rush hour, when animals rise to the surface to feed as if returning home for supper, and measured the traffic precisely. Using the world's first long-term, full ocean-depth echo sounder, the scientists observed a daily vertical commute of up to 400 m (higher than the Eiffel Tower) between the twilight or mesopelagic zone, about 500 m down, and the surface layer, where sunlight and photosynthesis prepare food.

Proportion of protected coral reefs

Analysts in the Census network concerned with the future of marine animal populations compiled the first-ever global assessment of the extent, effectiveness, and omissions of coral reefs as Marine Protected Areas. Contributing to and using the Census' information system, they found that less than 2 percent of coral reefs worldwide are protected from extraction, poaching and other major threats. They built their worldwide database of protected areas for 102 countries, including satellite imagery of reefs.

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About 2000 researchers from 80 countries now participate in the Census.

"The vast expanse of the oceans, the rarity of some animals, their movements, and fluctuations challenge Census researchers. Happily, the astonishing progress of the past six years shows the community will create the first-ever Census of Marine Life in 2010," says Jesse Ausubel, a program manager for the Sloan Foundation, a Census sponsor.

Adds Ron O'Dor, CoML Senior Scientist: "Together, we can see the wonders of the ocean and excite the world to preserve and increase them."

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About the Census of Marine Life

Support for the Census of Marine Life comes from government agencies concerned with science, environment, and fisheries in a growing list of nations as well as from private companies and foundations A complete list of sponsors is available at www.comlsecretariat.org/Dev2Go.web?id=302846&rnd=27644 The Census is associated or affiliated with several intergovernmental international organizations including the Intergovernmental Oceanographic Commission of the UN, the Food and Agriculture Organization of the UN, the UN Environment Programme and its World Conservation Monitoring Centre, the Global Biodiversity Information Facility, the International Council for the Exploration of the Seas, and the North Pacific Marine Science Organization. It is also affiliated with international non-governmental organizations including the Scientific Committee on Oceanic Research and the International Association of Biological Oceanography of the International Council for Science. The Census is led by an independently constituted international Scientific Steering Committee, whose members serve in their individual capacities, and a growing set of national and regional implementation committees.