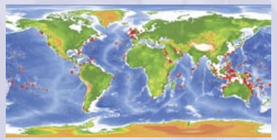
MAKING OCEAN LIFE COUNT

In 2005 the accelerating work and discoveries of the Census of Marine Life furnished gratifying highlights. In only one year, the number of scientists participating has doubled to 1,700 from 73 nations. In five years, unprecedented international links have formed and begun producing results from 17 Census projects. This acceleration points toward delivery of the first global census of marine life in 2010.

Census researchers have established the capability to sample all ocean realms and have linked 50 databases of millions of records that show the distribution of tens of thousands of marine species. The capability spans sizes from microbes to whales, water from near-shore to mid-ocean, and depths from along the abyssal plains to above the polar ice. They have explored down to submerged edges of continents, along the seamounts that traverse the ocean's floor, and around diverse coral reefs. At the bottom of the planet, Census scientists are sampling unexplored regions of the wild and unpredictable Southern Ocean. Matching the global span of exploration, the 10 regional data collection nodes established this year—from sub-Saharan Africa to the Indian Ocean to China—make it easier to collect, assimilate, and access data in local languages from around the world.

The Census nearly doubled the number of its expeditions to previously unexplored regions from 8 in 2004 to 14 in 2005, and it has planned many more through 2010. In 2005 the rapid rate of species discovery promises that the Census will continue to amplify the inventory of biodiversity. The exemplary global cooperation, data, and analyses of the Census will expand for years to come the knowledge of the diversity, distribution, and abundance of what lived, now lives, and will live in the world's oceans.

More than 50 linked databases now contain five million records on the distribution of 40,000 marine species. For example, the occurrence of more than 400 stony coral species can be mapped through the Census online portal based on 16,000 records. Several hundred more known and new stony coral species are likely to be added.

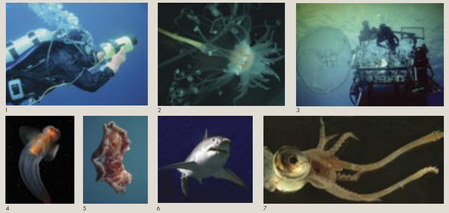


OBIS: The world-wide distribution of 400 species of stony coral (in red) was mapped in 2005.

CoML: Stony coral of the genus *Acropora* was found in the Egyptian Red Sea. Photo: N. Hobbs, 2005.

Caccia Fotografica

Caccia fotografica is an Italian phrase that means "photographic hunting." It aptly describes the way that many Census scientists capture images of animals as they move around marine environments. Using high-definition video and still cameras, often attached to remotely operated vehicles (ROVs) and optical landers, scientists are creating an aquarium-like view into the world below the water's surface. The images reveal behavior in nature and show species that might be destroyed if raised to the surface. By "hunting" without harm, *caccia fotografica* enables researchers to expand the knowledge of how creatures live in their natural habitats.



1. AnCOD: An under-ice SCUBA diver films marine life in the high Arctic Canada Basin. NOAA photo: K. Iken, 2005.
2. AnCOD: Among the animals discovered in the deep Arctic Canada Basin was this as-yet-unidentified crinoid. NOAA photo: B. Bluhm & K. Iken, 2005.
3. CMarZ: A jellyfish of the genus *Aurelia* swims in front of the Johnson-SeaLink submersible. Photo: S. Haddock, 1999.
4. AnCOD: *Clione limacina*, a pelagic snail, lives in the water column of the Arctic Canada Basin. NOAA photo: K. Raskoff, 2005.
5. CMarZ: The Spanish dancer nudibranch, *Hexabranchus sanguineus*, is a common inhabitant of Pacific Ocean coral reefs. NOAA photo: M. Delley, 2003.
6. TOPP: The white shark, *Carcharodon carcharias*, is at the top of the pelagic food chain in ocean waters. Photo: R. Wildner, 2005.
7. MAREECO: The deep-sea squid, *Gonatus antarcticus*, inhabits the waters of the Mid-Atlantic Ridge. Photo: R. Young, 2005.

Discovering Diversity

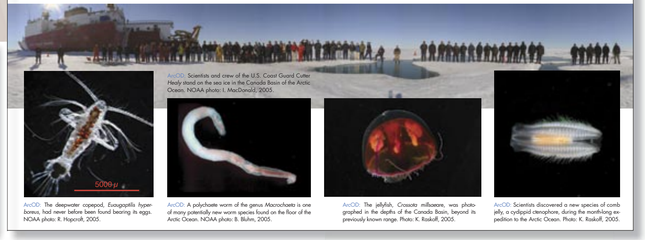
Although scientists have already named and described more than 200,000 marine species, further exploration and streamlined identification could increase this number by hundreds of thousands. Because Census scientists often sample previously unexplored regions with new techniques, they have quickened the rate of discovery of new species.

MAREECO: *Aphyonus gelatinosus*, a strange bottom-dwelling fish covered by a gelatinous layer, has only been recorded twice. Photo: D. Shale, 2004.

MAREECO: This red penisgone sea cucumber, one of four species new to science, was photographed on the Mid-Atlantic Ridge. Photo: A. Gebruk, 2004.

During expeditions along the northern Mid-Atlantic Ridge, researchers documented several new and rare species. These include a variety of odd deep-sea fish, two possibly new species of squid, and at the sea bottom, at least four new species of sea cucumbers.

In the frigid Canada Basin of the Arctic Ocean, Census scientists and others on a historic expedition uncovered a surprising amount of marine life and biodiversity. No one before had observed some of the species encountered, including squid, octopuses, and bottom-dwelling worms, in the icy waters of the Canada Basin. In all, possibly 12 species were found well outside their previously known range.



AnCOD: Scientists and crew of the U.S. Coast Guard Cutter *Healy* stand on the sea ice in the Canada Basin of the Arctic Ocean. NOAA photo: I. MacDonald, 2005.

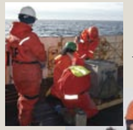
AnCOD: The deepwater copepod, *Euaugaptilis hyperboreus*, had never before been found bearing its eggs. NOAA photo: K. Hopcroft, 2005.

AnCOD: A polychaete worm of the genus *Macrochaeta* is one of many potentially new worm species found on the floor of the Arctic Ocean. NOAA photo: B. Bluhm, 2005.

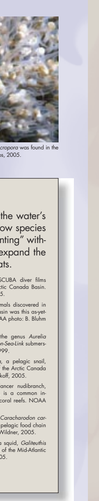
AnCOD: The jellyfish, *Crossota millaresae*, was photographed in the depths of the Canada Basin, beyond its previously known range. Photo: K. Raskoff, 2005.

AnCOD: Scientists discovered a new species of comb jelly, a cydippid ctenophore, during the month-long expedition to the Arctic Ocean. Photo: K. Raskoff, 2005.

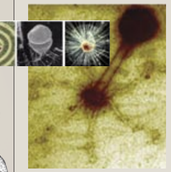
Unexpected biodiversity surprised scientists on two expeditions to the abyssal plains and basins of the South Atlantic Ocean and Southern Ocean. At least 30 percent of all species in their samples were new to science. Among the most intriguing creatures were small unicellular animals constructing fragile shells from sediment grains. Sponges with calcareous skeletons living much deeper than expected also surprised the researchers.



CaDAMar: Scientists on a cruise to the Southern Ocean prepare a box corer for deployment and process a collected sediment sample. The bucket contains many organisms from more than 1,000 meters depth. Photos: B. Hilbig, 2005.

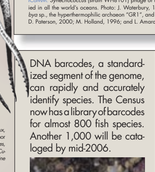


The giant squid, *Architeuthis dux*, was drawn by Richard Ellis, author of the new book, *Singing Whales, Flying Squid, and Swimming Cucumbers: The Discovery of Marine Life*, 2005.



To census microbes, the tiniest of marine species, the Census launched an array of online resources that allows researchers to manage geo-spatial, molecular, environmental, and taxonomic information about marine microbes. This includes an online database where researchers can cross-check the identity of collected microbes against known species by comparing lipid compositions.

ICoMM: Synechococcus (strain WH8101) phage of the family Myoviridae is one of many microbes being studied in all the world's oceans. Photo: J. Waterbury, 1990. Inset: Filaments of the marine cyanobacterium *Lyngbya* sp., the hyperthermophilic archaeon "GR1", and the planktonic foraminiferan *Neogloerina pelagica*. Photos: D. Peterson, 2000; M. Holland, 1996; and L. Amaral-Zettler, 1995.



DNA barcodes, a standardized segment of the genome, can rapidly and accurately identify species. The Census now has a library of barcodes for almost 800 fish species. Another 1,000 will be cataloged by mid-2006.

CoML: Amphiprion clarkii, found off Hawaii, is one of several clown fish species with unique barcodes that aid identification. Photo: J. Randall, 2005.

In a cooperative effort to explore near-shore biodiversity, scientists and volunteers are now working at 80 official Census sites around the world. These sites encompass more than three-quarters of the world's coastlines.

NaGISA: A Japanese high school biology club samples the Shirahama rocky shore. Photo: T. Kato, 2005.

CaDAMar: An Antarctic researcher stands near the Perennial Acoustic Observatory in the Antarctic Ocean. Photo: H. Klinck, 2005.

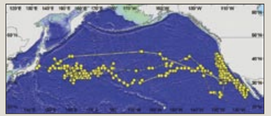
For the first time, scientists are continuously studying the pulsed calls and tonal sounds that make up the acoustic repertoire of whales and seals in an environment nearly undisturbed by humans. An autonomous listening station on the Antarctic shelf ice edge is recording the sounds of these animals at the top of the marine food chain, and so revealing their distribution.

CMar: ABE, the Autonomous Benthic Explorer, and TOBI, a sidescan sonar instrument, were used to image the southern Mid-Atlantic Ridge where newly discovered hydrothermal vents were found. Photos: C. German, 2005 (left); E. Ramirez, 2005.

An international team of researchers, towing autonomous and remotely operated vehicles to explore the Mid-Atlantic Ridge south of the equator, encountered the first known hydrothermal vents in the South Atlantic Ocean. Comparison of animals found near these vents with those found on distant vents provide clues about how vent animals disperse. Vent animals live in dynamic ecosystems where super-heated water at temperatures of 350° C flows from black smokers.

Charting Distribution

Determining how marine life distributes itself throughout the vast, deep, dark, and interconnected oceans challenges the Census. Nevertheless, with an array of techniques from visual and acoustic sampling, to collecting with specialized equipment, to tagging creatures that traverse the world's oceans, Census researchers are creating a picture of how marine life is distributed and changes with time.



TOPP: Data recently recovered from a tagged bluefin tuna, *Thunnus orientalis*, shows it made a remarkable trans-Pacific migration (shown in yellow) three times in 600 days, traveling a distance of 40,000 kilometers, a distance greater than the circumference of the globe. Map: S. Benson, 2005.

To trace where animals travel, Census scientists have so far tagged more than 2,000 animals—21 different species of large pelagic animals—in the Pacific Ocean, including a variety of sharks, bony fish, birds, and seals and sea lions. This year a new website allows the public, as well as scientists, to track some of these creatures in real time as they migrate across the Pacific.

Curtains of underwater listening stations arrayed along the Northeast coast of the Pacific Ocean tracked nearly 4,000 tagged fish last year. New equipment for arrays was field-tested to track the path and survival of individual fish of virtually any species year-round as they migrate up and down the west coast shelf of North America. Furthur construction of this and compatible arrays in other parts of the world will be completed by 2010, creating a global listening network.

POST: Researchers release a tagged green sturgeon, *Acipenser medirostris*, later detected by the listening curtain. Photo: Yurok Tribal Fisheries Programs, 2003.

Seafloor ruptures that contributed to the deadly December 26, 2004 Indonesian tsunami were photographed at a depth of 4,500 meters. Photo: Dorlove Smithson Productions, 2005.

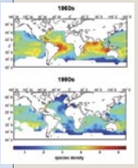
Sometimes what's most interesting is what isn't found. Census biologists on the first scientific expedition to the epicenter of the deadliest tsunami in recorded history found no deep-sea animals in the disturbed area five months after the incident. The lack of life at the site was "unprecedented in 25 years of deep-sea sampling."

Measuring Abundance

While a precise counting of all individual marine organisms may be impossible, management to improve conditions for marine life and assessment of harmful influences cannot be accomplished without a reliable census—a goal of the Census of Marine Life. New uses of archival data and innovative technology in 2005 have helped scientists to make great strides toward accomplishing this goal by 2010.

By extending trends backward from the baseline of the present, archives give a head start to detection of future trends. The lessons of past causes and effects also can be used today. Extensive study of historical data, for example, revealed that multiple human impacts caused severe losses of whales, seals, birds, large fish, and oysters over the past 500 years in the Wadden Sea, a part of the North Sea bordering Denmark, Germany, and the Netherlands. Scientists also documented that recent conservation efforts such as hunting bans and habitat protection have benefited seals as well as some birds.

HMAP: The European market for sturgeon was at its height more than 100 years ago, before over-exploitation collapsed the fishery. Illustration: H. Petersen, 1885.

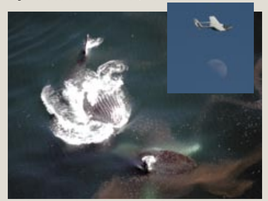


TOPP: Yellowfin tuna, *Thunnus albacares*, is one of many species affected by intense global fishing over the past several decades. Photo: R. Wildner, 2005.

HMAP: The number of tuna and billfish caught by standard longline fishing fell significantly between the 1960s and the 1990s. Maps: B. Worm, *et al.*, 2005.

Census scientists studying records of fish hooked on longlines in the world's open oceans found that both the abundance and species diversity of large pelagic fish have rapidly shrunk over the past 50 years. Large hotspots of key pelagic predators such as tuna, marlin, and swordfish decreased dramatically around the world.

In 2005 a joint operation of scientists aboard surface ships and in airplanes above documented major fluctuations in the abundance of feeding whales, pelagic fish, and plankton in the Gulf of Maine. Biological "hotspots," areas teeming with marine organisms across the food web, were found.



GoMA: Researchers in a small seaplane document hotspots in the Gulf of Maine. Here, two humpback whales feed on red krill. Photo: P. Sievick, 2005. Inset photo: H. McRae, 2005.

CMarZ: The larvacean *Oikopleura labradoriensis* and the copepod *Neocalanus plumchrus* exemplify the vast diversity of marine zooplankton around the world. Photos: R. Hopcroft, 2005.

Nineteen research projects joined together under the banner of the Census to learn the abundance of microscopic zooplankton in the global seas. Molecular analysis of samples from numerous collection expeditions around the world identified species of the 15 phyla of zooplankton and established DNA barcodes for nearly 500 species, with hundreds more to come.

AnCOD: Sea cucumbers such as *Kolga hyalina* dominated sea floor fauna at several stations during the summer expedition to the Canada Basin. NOAA photo: B. Bluhm & K. Iken, 2005.

What has become predictable about the Census of Marine Life is that because the ocean has been explored so little, scientists are regularly surprised by what they find in the field. Nowhere is this better demonstrated than in the expedition to the Canada Basin in the Arctic Ocean in 2005, where scientists found abundant sea cucumbers. The surprising multitude of these animals, and others, invites further scientific inquiry to learn why and how they thrive in the icy Arctic waters.