

CENSUS OF MARINE LIFE PEREPICbьMOPCKГO HACEЛEHIЯ 海洋生物の個体数調査 RECENSEMENT DE LA VIE MARINE CENSUS LIVET I HAVENE MANNTALL OVER MARINT DYRELIV MIPANGO YA VIFAA BAHARINI ZENSUS DES MARINEN LEBENS CENSUS VAN HET LEVEN IN ZEE 海洋生物大普查 CENSO DE LA VIDA MARINA ĀIREAMH NA BEATHA MHARA SENSO NG BUHAY SA DAGAT DAANĀIREAMH NA MARA CENSO DA VIDA MARINHA 해양생물개체수조사 CENSIMENTO DELLA VITA MARINA RECENSAMANTUL VIETII MARINE SAMUDRIJEEVAN KA GANAN مسج الحياة البحرى BANCIAN KEHIDUPAN MARIN RÉCENSMAN LA VIE MARIN RESANSMAN LAVI MAREN YFIRLIT YFIR LÍFRÍKI HAFSINS HAVSLIVSRÁKNINGEN MERE ELUSTIKU UURIMINE SENSUS VAN MARIENE LEWE DENİZ CANILARININ SAYIMI YVIRLIT YVIR HAVSINS DJÓRALÍV SENSUS BIOTA LAUT THÔNG KẾ SINH VẬT BIỂN สํารวจสิ่งมีชีวิตใน้ำทะเล مسح الحياة البحرى BANCIAN KEHIDUPAN MARIN RÉCENSMAN LA VIE MARIN RESANSMAN LAVI MAREN YFIRLIT YFIR LÍFRÍKI HAFSINS HAVSLIVSRÁKNINGEN MERE ELUSTIKU UURIMINE SENSUS VAN MARIENE LEWE DENİZ CANILARININ SAYIMI YVIRLIT YVIR HAVSINS DJÓRALÍV SENSUS BIOTA LAUT THÔNG KẾ SINH VẬT BIỂN สํารวจสิ่งมีชีวิตใน้ำทะเล CENSUS OF MARINE LIFE PEREPICbьMOPCKГO HACEЛEHIЯ 海洋生物の個体数調査 RECENSEMENT DE LA VIE MARINE CENSUS LIVET I HAVENE MANNTALL OVER MARINT DYRELIV MIPANGO YA VIFAA BAHARINI ZENSUS DES MARINEN LEBENS CENSUS VAN HET LEVEN IN ZEE 海洋生物大普查 CENSO DE LA VIDA MARINA ĀIREAMH NA BEATHA MHARA SENSO NG BUHAY SA DAGAT DAANĀIREAMH NA MARA CENSO DA VIDA MARINHA 해양생물개체수조사 BANCIAN KEHIDUPAN MARIN RÉCENSMAN LA VIE MARIN RESANSMAN LAVI MAREN YFIRLIT YFIR LÍFRÍKI HAFSINS HAVSLIVSRÁKNINGEN MERE ELUSTIKU UURIMINE SENSUS VAN MARIENE LEWE DENİZ CANILARININ SAYIMI YVIRLIT YVIR HAVSINS DJÓRALÍV SENSUS BIOTA LAUT THÔNG KẾ SINH VẬT BIỂN สํารวจสิ่งมีชีวิตใน้ำทะเล

AT THE LIMITS OF KNOWLEDGE

Discoveries of record-breaking extremes at the frontiers of knowledge highlighted the year. And six years into its ten-year program, the Census of Marine Life has gone fully global. The 17 core Census projects involve networks of researchers spanning all ocean realms. Affiliated projects added during 2006 in the Gulf of Mexico and along Australia's Great Barrier Reef bring the participants to more than 2,000 from 80 nations. Nine regional and national committees ensure that all areas of the global ocean are represented.

To census the diversity, distribution, and abundance of marine life, participants pooled their talents and specialties, ships and laboratories, archives and technology. They sailed on 19 expeditions, for example, in the Southern Ocean bringing onboard more new species than species

already seen by centuries of explorers. Nearshore, the number of active sampling sites has grown exponentially from 30 to 128 in 2006 alone. Across the open ocean, Census participants tracked with satellites more than 20 species of animals from sharks and squid to sea turtles and albatross, distributing themselves through hundreds of thousands of kilometers of national and international waters. With sound waves, participants outlined schools of abundant fish spanning tens of kilometers of ocean, whose three dimensions could not be revealed previously by one-dimensional traverses. The now-proven effectiveness of the Census' unprecedented international links, coordination of work, and sharing of data in 2006 point toward a census by 2010 of what lived, now lives, and will live in the world's oceans.



**ChEss** Near a vent 3 km beneath the equatorial Atlantic, Census researchers, using equipment attached to the remotely operated vehicle *Quest*, found shrimp and other life forms. They were found living near a hydrothermal vent billowing chemical-laden water at an unprecedented 407° C, a temperature at which lead melts easily. It was the hottest marine temperature ever recorded.

MARUM, University of Bremen © 2006.


**CMarZ** In a zooplankton trawl 5 km below the surface of the Sargasso Sea, Census experts from 14 nations caught drifting, often menacing looking, animals such as the amphipod, a small prawn-like crustacean, the supposed inspiration for the movie *Alien*. They collected more than 500 species, likely including 12 wholly new species that eat each other or live on organic matter falling like snow from above.

R. Hopcroft, University of Alaska Fairbanks © 2006.

**Darkest**



**Oldest**



**CAML** A community of marine life shrouded beneath ice 700 m thick and 200 km from open water surprised Census Antarctic scientists, who filmed scores of species including a jellyfish, possibly *Cosmetirella davis*, swimming with tentacles raised.

AGAD, D. Rasch © 2006.

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

J. Groeneveld, Marine and Coastal Management, South Africa © 2006.

DISCOVERING DIVERSITY

Because species are the currency that measures the diversity of life, finding and naming a new one adds, while the extinction of an old one subtracts from the wealth of known biodiversity. Millennia of exploration and two centuries of naming species, combined with extinctions, might have diminished the chance of finding new ones. Instead, new technology, exploration of new regions, and new efficiencies of identifying and archiving are accelerating the discovery of species and expansion of known diversity.

**More new than old**

**CeDAMar** Discovering that wholly new species outnumber known ones exemplifies the acceleration of discovery. During three cruises of several months each, Census Antarctic scientists, trawling the depths of the remote

**Doubling zooplankton**

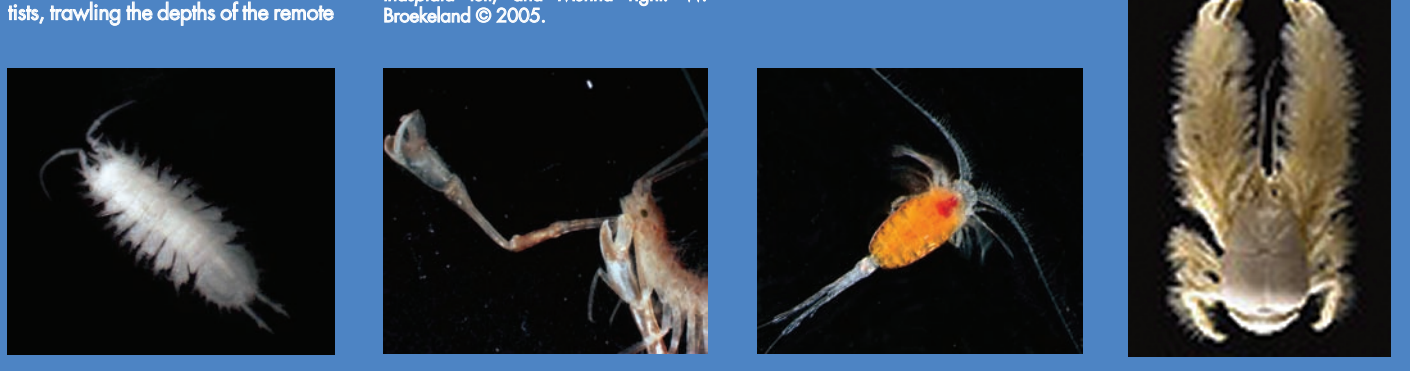
**CMarZ** Census zooplankton researchers discovered 3 new genera and 31 new species of copepods and mysids, small crustaceans, in South-east Asian, Australian, and New Zealand waters. Analysis of collections from biodiversity hotspots, the deep sea, and other unexplored regions is on track to double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

Below: *Lucicutia aurilla*, one of many copepod species being studied by Census scientists. R. Hopcroft, University of Alaska Fairbanks © 2006.

**Furry crabs**

**ChEss** Near Easter Island, Census vent explorers 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*.

Below: *Kiwa hirsuta*, the Yell crab. I. Bremer/A. Fifts © 2006.



**Squat lobsters**

**CenSeam** Scientists have found an abundance of squat lobsters inhabiting the seamount chains north of New Zealand. These creatures, when sitting on the ocean floor, often tuck their tails beneath them and assume a squatting position. Investigators have identified migration in only 200 days, the bird averaged a surprising 350 km per day. In some cases, a breeding pair made the entire journey together.

Below: Diverse Galatheids and Chirostylids. R. Webber, Museum of New Zealand Te Papa Tongarewa © 2006, specimens not to scale.

**A squid that chews**

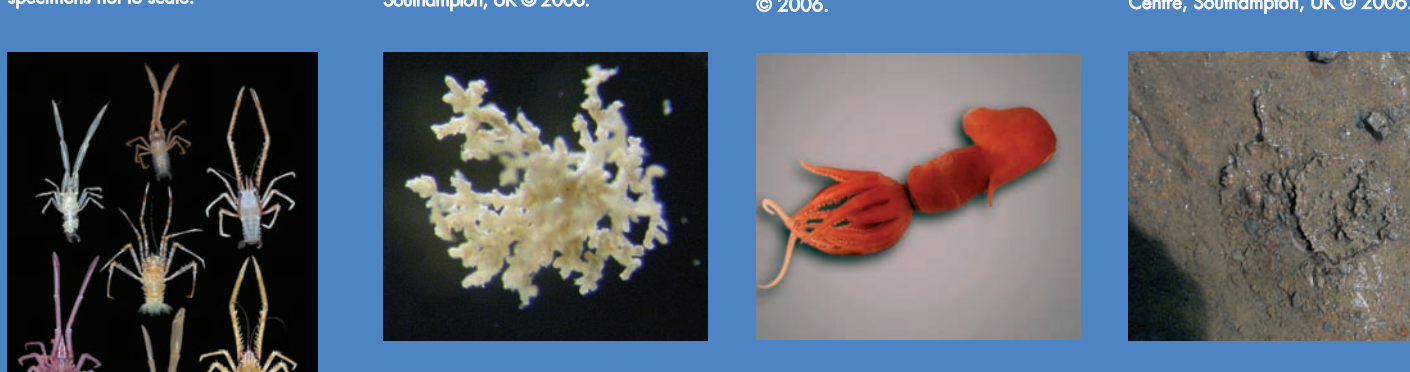
**MAR-ECO** Among the 80,000 organisms, encompassing 354 families, genera, and species that Census deep sea investigators collected from the Mid-Atlantic Ridge was the reference specimen or holotype for a new species of squid: *Promachoteuthis sloani*. Although collection easily damages the soft cephalopods,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

Below: *P. sloani*. MAR-ECO/R. Young © 2006.

**Macro microbe**

**COMARGE** 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.

Below: *Xenophyophore* in sediment. A. Gooday, National Oceanography Centre, Southampton, UK © 2006.



**GoMA** Eight million herring swimming in a school the size of Manhattan off the New Jersey coast qualified as most abundant. Focused sound, like the beam from a lighthouse, scans ocean areas 10,000 times larger than previously possible. Instantaneous and continuous updates reveal the extension and shrinking, fragmentation and merging of fish schools.

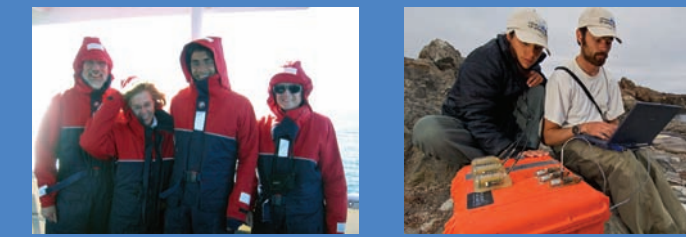
N. Makris © 2006.

**Researchers world wide**

**CoML** Participants at a Scientific Steering Committee meeting in Reykjavik, Iceland. J. Audet © 2006.

**TOPP** Biologists download information from tags retrieved from seals. J. Bradley, www.bradleyphotographic.com © 2006.

**CRReefs** Teams that discovered scores of new species on the French Frigate Shoals, Hawaii. NWHMNM © 2006.



CHARTING DISTRIBUTION

New and extended techniques let scientists collect and tag creatures in order to follow their movements. Marine animals themselves are recruited as oceanographers, mapping their travels in the world's oceans. With their help, the Census is meeting the challenge of picturing the present and shifting distribution of global marine life.

**Wider ranges**

**ArxOD/MAR-ECO** 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 under sampled. During 2006, counts rose to 31 species in the Arctic outside

**Needles in haystacks**

**CeDAMar** The span from schools of countless herring 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.

Below: Southern Ocean isopod, *Munopsis*. W. Broekeland © 2005.

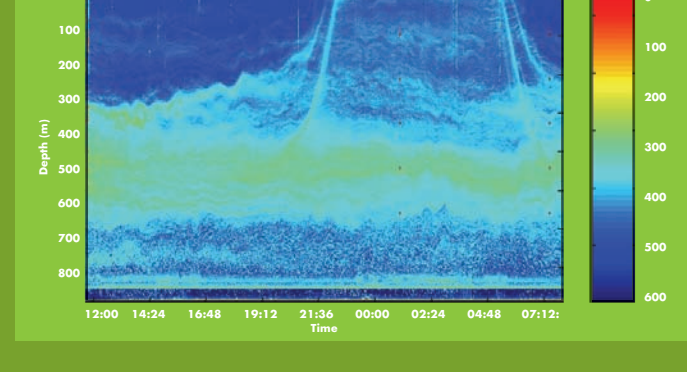


**A nightly commute**

**MAR-ECO** At dusk above the 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 prepared food.

Below: 18 hours of data from an upward-looking echo sounder moored 1,000 m deep near the Mid-Atlantic Ridge showing plankton and fish in light blue rising about 9 pm and descending about 6 am. MAR-ECO © 2006.

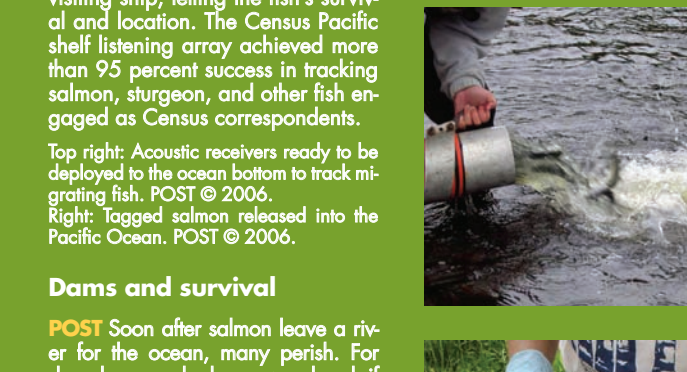


Top right: Acoustic receivers ready to be deployed to the ocean bottom to track migrating fish. POST © 2006.

Right: Tagged salmon released into the Pacific Ocean. POST © 2006.

**Salmon cellphone coverage extended**

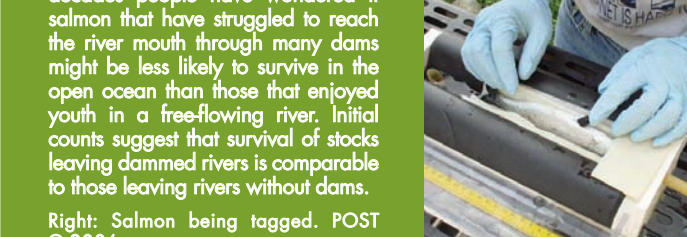
**POST** When 2,600 fish left rivers during the early summer of 2006 for a career in the North Pacific, they carried tiny acoustic transmitters. These could be detected for years by the Census using an array of 252 receivers on the continental shelf, reaching outward from shore and stretching along the Pacific migration route to over 2,000 km in 2006. 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.



**Dams and survival**

**POST** 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.

Right: Salmon being tagged. POST © 2006.



ASSESSING ABUNDANCE

Although every living individual will never be counted, rational appraisal of hazards and effective management requires not anecdotes but the reliable data the Census obtains. Such new technology as that employed to observe island-sized schools of herring plus novel mining of historical and data archives advanced the global network toward a reliable census by 2010.

**Proportion of protected coral reefs**

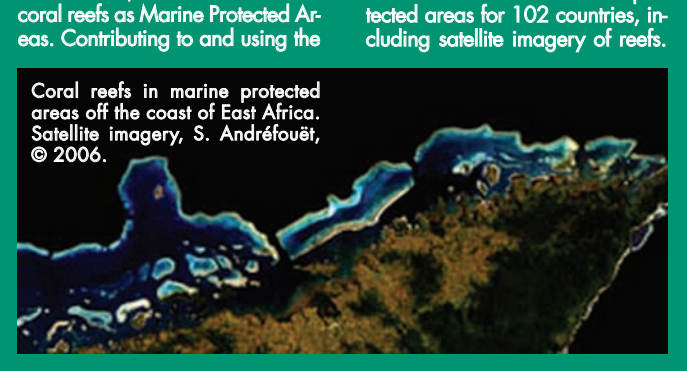
**FMAR/CReefs** Analysts in the Census network concerned with the future of marine animal populations compiled the first-ever global assessment of the extent, effectiveness, and omissions of coral reefs as Marine Protected Areas. Contributing to and using the

**Assessing abundance demands efficiency**

**CReefs** Expanding knowledge of diversity with a new species requires one specimen, charting distribution requires several, but counting abundance demands examining many. During 3 explorations of coral reefs, Census experts expedited determination of many of the 1 to 9 million species of animals that inhabit reefs, using new molecular techniques allowing rapid processing of large samples.

Below: Barcode (expanded horizontally) of the frigate tuna, *Auxis thazard*. FishBOL © 2006.

Vials of copepods ready for sequencing. M.D. Allison, WHOI © 2006.



**Degradation and recovery in estuaries**

**FMAR** In archives such 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 the 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**

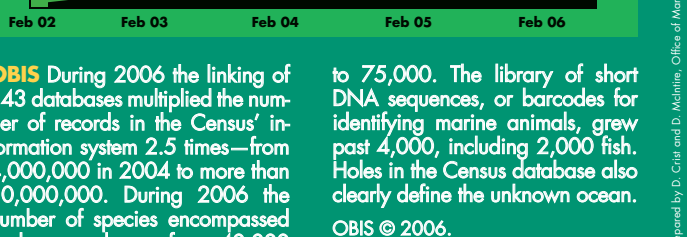
**MAR-ECO** Although energetic exploration by the Census may uncover species long unseen, the appearance of a longtime absentee may be a clue to rising abundance. An expedition to the Mid-Atlantic Ridge, for example, captured 300 fish species. Several fishes captured had not been seen since a

1910 expedition, and others considered rare were found common. The change in abundance could reflect removal of predators or limited sampling in the past.

Below: A proposed new species of eel out of the genus *Lyodon* collected on the Mid-Atlantic Ridge. P.R. Waller © 2006.

**Absent in space**

**MAR-ECO** Absence is the lower limit of abundance. Census researchers discovered that 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.



**OBIS** During 2006 the linking of 143 databases multiplied the number of records in the Census' information system 2.5 times—from 4,000,000 in 2004 to more than 10,000,000. During 2006 the number of species encompassed and mapped rose from 40,000

to 75,000. The library of short DNA sequences, or barcodes for identifying marine animals, grew past 4,000, including 2,000 fish. Holes in the Census database also clearly define the unknown ocean.

OBIS © 2006.

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