Speed installation of system to monitor vital signs of global ocean, scientists urge

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A mooring with a suite of ocean acidification and other environmental sensors at Heron Island on the Great Barrier Reef is the latest tool in an expanding global network of ocean measurements, informing scientists of changes in ocean chemistry. Credit: Dr. Bronte Tilbrook, CSIRO, Australia

The ocean surface is 30 percent more acidic today than it was in 1800, much of that increase occurring in the last 50 years - a rising trend that could both harm coral reefs and profoundly impact tiny shelled plankton at the base of the ocean food web, scientists warn.

Despite the seriousness of such changes to the ocean, however, the world has yet to deploy a complete suite of available tools to monitor rising acidification and other ocean conditions that have a fundamental impact on life throughout the planet.

Marine life patterns, water temperature, sea level, and polar ice cover join acidity and other variables in a list of ocean characteristics that can and should be tracked continuously through the expanded deployment of existing technologies in a permanent, integrated global monitoring system, scientists say.

The Partnership for Observation of the Global Oceans (POGO), representing 38 major oceanographic institutions from 21 countries and leading a global consortium called Oceans United, will urge government officials and ministers meeting in Beijing Nov. 3-5 to help complete an integrated global ocean observation system by target date 2015.

It would be the marine component of a Global Earth Observation System of Systems under discussion in Beijing by some 71 member nations of the intergovernmental Group on Earth Observations.

The cost to create an adequate monitoring system has been estimated at $10 billion to $15 billion in assets, with $5 billion in annual operating costs.

Some 600 scientists with expertise in all facets of the oceans developed an authoritative vision of characteristics to monitor at a 2009 conference on ocean observations, (www.oceanobs09.net).

Furthermore, as documented in the forthcoming proceedings of the 2009 conference (to be published shortly by the European Space Agency), the value of such information to the world's financial interests and to human security would dwarf the investment required.

"Although the US and European Union governments have recently signaled support, international cooperation is desperately needed to complete a global ocean observation system that could continuously collect, synthesize and interpret data critical to a wide variety of human needs," says Dr. Kiyoshi Suyehiro, Chairman of POGO.

"Most ocean experts believe the future ocean will be saltier, hotter, more acidic, and less diverse," states Jesse Ausubel, a founder of POGO and of the recently completed Census of Marine Life. "It is past time to get serious about measuring what's happening to the seas around us."

The risks posed by ocean acidification exemplify the many good reasons to act urgently.

POGO-affiliated scientists at the UK-based Sir Alister Hardy Foundation for Ocean Science recently published a world atlas charting the distribution of the subset of plankton species that grow shells at some point in their life cycles. Not only are these shelled plankton fundamental to the ocean's food web, they also play a major role in planetary climate regulation and oxygen production. Highly acidic sea water inhibits the growth of plankton shells.

The Foundation says the average level of pH at the ocean surface has dropped from 8.2 to 8.1 units, "rendering the oceans more acidic than they have been for 20 million years," with expectations of continuing acidification due to high concentrations of carbon dioxide in the atmosphere.

Scientists explore on and beneath polar ice. Their aircraft remotely sense animals through properties of scattered light. Marine animals themselves carry tags that store records of their travels and dives and communicate with satellites. Fish carry tags that revealed their migration past acoustic listening lines. Sounds that echoed back to ships portray schools of fish assembling, swimming, and commuting up and down. Standardized frames and structures dropped near shores and on reefs provide information for comparing diversity and abundance. Manned and unmanned undersea vehicles plus divers photograph sea floors and cliffs. Deep submersibles sniff and videotape smoking seafloor vents. And nets and dredges catch specimens, shallow and deep, for closest study. Credit: E. Paul Oberlander / Census of Marine Life

Because colder water retains more carbon dioxide, the acidity of surface waters may increase fastest at Earth's high latitudes where the zooplankton known as pteropods are particularly abundant. Pteropods (see links to images below) are colorful, free-swimming pelagic sea snails and sea slugs on which many animals higher in the food chain depend. Scientists caution that the overall global marine impact of rising carbon dioxide is unclear because warming of the oceans associated with rising greenhouse gases in the air could in turn lead to lower retention of carbon dioxide at lower latitudes and to potential countervailing effects.

Says Foundation Director Dr. Peter Burkill: "Ocean acidification could have a devastating effect on calcifying organisms, and perhaps marine ecosystems as a whole, and we need global monitoring to provide timely information on trends and fluxes from the tropics to the poles. Threatened are tiny life forms that help the oceans absorb an estimated 50 gigatonnes of carbon from Earth's atmosphere annually, about the same as all plants and trees on land. Humanity has a vital interest in authoritative information about ocean conditions and a global network of observations is urgently needed."

Ocean conditions that require monitoring can be divided into three categories:

- Chemical - including pollution, levels of oxygen, and rising acidity;
- Physical / Geological - including sound, tide and sea levels, as well as sudden wave energy and bottom pressure changes that could provide precious minutes of warning before a tsunami; and
- Biological - including shifts in marine species diversity, distribution, biomass and ecosystem function due to changing water conditions.

Benefits of the comprehensive ocean system envisioned include:

- Improved short-term and seasonal forecasts to mitigate the harm caused by drought, or by severe storms, cyclones, hurricanes and monsoons, such as those that recently put one-fifth of Pakistan temporarily underwater and left 21 million people homeless or injured. International lenders estimate the damage to Pakistan's infrastructure, agriculture and other sectors at $9.5 billion. Improved weather forecasting would also enhance the safety of the fishing and shipping industries, and offshore operations such as wind farms and oil drilling. Sea surface temperature is a key factor in the intensity and location of severe weather events;
- Early identification of pollution-induced eutrophication that spawns algal blooms responsible for health problems in humans and marine species, and harm to aquaculture operations;

- Timely alerts of changes in distributions of marine life that would allow identification of areas needing protective commercial re-zoning, and of immigration by invasive species;

- Minimized biodiversity loss on coral reefs, the importance of which, for species diversity, is comparable to that of the planet's rainforests.

Says Dr. Suyehiro: "What happens in the world's oceans profoundly affects the success of life throughout the Earth. We now have remarkable and proven ground-based, ocean-drifting, air-borne and space-based technologies to measure and report changing ocean conditions quickly, often in real-time. The right kind of data streams from the ocean will help us forecast regime shifts in weather patterns over continents and their consequences for agriculture, fisheries, tourism and other sectors. The value of the knowledge within our reach - to human health, security and commerce - is overwhelmingly large relative to its cost."

"The situation of scientists today is akin to that of a doctor schooled in the range of technologies that could record a patient's vital signs, sound an alarm when required, and suggest remedial options - if only we would make the investment."

Says Tony Knap, Director of the Bermuda Institute of Ocean Sciences and a leader of POGO: "The top three meters of the oceans hold as much heat as Earth's atmosphere and changes in marine conditions are felt on land in profound ways. To obtain clear warning of weather-related disasters, we need to monitor oceans in an integrated, continuous and systematic manner. It will not be cheap, but it has to be done."

Elements of the ocean monitoring system in place today include:

Chemical

- A scientific instrument with a suite of environmental sensors, recently deployed at Australia's Heron Island to observe changes in the acidity of waters covering the Great Barrier Reef, among other data gathered. The instrumentation also includes carbon dioxide sensors developed with the long-term aim of building a global network of carbon dioxide observations at sea. The Heron Island site is the newest in a growing network of 25 moorings through the Pacific and Atlantic valued at about $20 million. Other moorings are planned for the Great Barrier Reef and the Australian coast in the next year as part of the nation's Integrated Marine Observing System.

Physical

- Underwater cabled observatories: long lines of cable on the seabed dotted with nodes of instruments relaying insights into underwater volcanic eruptions and earthquakes that can cause tsunamis.
  Installed by Japan at a cost of roughly $100 million, the Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET / www.jamstec.go.jp/jamstec-e/maritec/donet), coupled with a national warning system, can avoid an estimated 7,500 to 10,000 (of 25,000) fatalities and about $10 billion (of $100 billion) in estimated economic losses if and when another major (M8) earthquake occurs in the waters off central Japan.

- The recently completed North-East Pacific Time-Series Underwater Networked Experiments cabled observatory system (NEPTUNE / www.neptunecanada.ca) off Canada's west coast will take continuous measurements on the seafloor, equipped with such gadgets as a Doppler ocean current profiler, multi-beam SONAR to reveal masses of life in the water, microbial life samplers, sediment traps, plankton recorders, hydrophones and high resolution video and still cameras.

- A robotic navy of some 3,000 small, drifting "Argo" probes (www.ARGO.net), deployed at a cost of $15 million per year to measure pressure, salinity and temperature at depths down to 2 km and return to the surface every 10 days to transmit readings via satellite. POGO officials say up to 10 times as many floats are needed to produce a high-resolution global picture of shifting marine conditions, incorporating biological and optical measurements;

- Three Equatorial moored buoys, each valued at $5 million, to measure temperature, currents, waves and winds, salinity and carbon dioxide.

- Some 60 globally-distributed reference stations (www.oceansites.org), each valued at $1 million, measuring the oceans' physical, chemical and biogeochemical properties throughout the water column;

- Deep Ocean Assessment and Reporting of Tsunamis (DART / www.ndbc.noaa.gov/dart/dart.shtml) stations, consisting of a surface buoy and a seafloor bottom pressure recorder that both reports water temperature and detects tsunamis. When a potential tsunami is detected, the buoy reports measurements every 15 seconds for several minutes, followed by 1-minute averages for 4 hours. The US array, completed in 2008, totals 39 stations in the Pacific Ocean, Atlantic Ocean, and Caribbean Sea. Australia, Chile, Indonesia, India and Thailand have also deployed tsunami warning systems.

Biological

- An expanding global Ocean Tracking Network (http://oceantrackingnetwork.org), currently valued at $150 million, which allows scientists to follow the migrations of tagged salmon and other animals.
- Thousands of pelagic "animal oceanographers" spanning 50 species -- elephant seals, tunas, white sharks, leatherback turtles, squid and others -- equipped with electronic tags that record the light, depth, temperature and salinity conditions they pass through, while revealing their speed, heart rate, biodiversity hotspots, nurseries, and migratory routes that need protection (www.topp.org);
- At-sea DNA sequencing of microbial, bacterial, and planktonic life forms, yielding real-time marine equivalents of "pollen counts";
- The Continuous Plankton Recorder Survey (www.sahfos.ac.uk), which has been monitoring the Atlantic for almost 80 years. At a current cost of $6 million per year, the survey recently extended into the Arctic and Pacific, with plans underway to monitor plankton worldwide;
- A growing network, NaGISA (www.nagisa.coml.org), of more than 200 sites around the world using standardized protocols to measure near-shore biodiversity and changes that climate and pollution could cause.

To embrace the challenge of monitoring ocean life, world experts are formally puzzling through a recommended installation sequence; in other words, what, where and how many "life gauges" are top priorities in the proposed system.

Moving forward

The parts of the system now installed represent only a fraction of what's required for authoritative accuracy and global perspective, according to POGO. Needed are expansion of the array of the technologies above as well as:

- So-called 'air-clippers': atmosphere and ocean surface sensors tethered to balloons with which scientists have achieved concurrent atmospheric and ocean measurements from within the eye of a strong cyclone where the balloons become trapped;

- A suite of novel "Autonomous Reef Monitoring Structures," valued at $50 million -- dollhouse-like structures into which animals migrate for collection and analysis later. The ARMS devices allow for standardized global comparisons and monitoring of reef life and benthic biodiversity;

- A Chlorophyll Globally-Integrated Network (ChloroGIN / www.chlorogin.org), which aims to monitor the coastal ecosystem using in situ and satellite techniques, at a cost of $5 million per year.

- Merchant marine and research vessels programs to make observations along their routes. The cost of instituting the global programs is estimated at, respectively, $50 million and $75 million per year.

The in situ observations would complement a suite of satellite-borne devices tracking sea-surface roughness, temperature, currents, ice cover and shifting distributions of marine plants. Satellites provide wide aerial coverage, but provide little information from deep within the ocean; hence the need for both types of observations.

Provided by Partnership for Observation of the Global Oceans