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THIS ISSUE

Human Activity in Deep Sea "Extending Ever Deeper"

"Human activity in the deep sea is extending ever deeper, with recent research showing that this environment is more sensitive to human and natural impacts than previously thought." So notes a review in the journal *Biological Conservation*.

The review, by Andrew J. Davies and J. Murray Roberts of the Scottish Association for Marine Science and Jason Hall-Spencer of the University of Plymouth in England, examines a number of emerging threats to deep-sea ecosystems around the world, among them:

- *Climate Change and Ocean Acidification:* Davies and colleagues write that although the deep sea was once considered to be buffered against the impacts of surface-driven cycles, modern research has shown otherwise. For example, changes in surface productivity, temperature or salinity could potentially influence deep-sea species distribution, abundance and behavior. Increasing fresh water input from terrestrial sources may disrupt thermohaline circulation, changing ocean circulation. Changes in the distribution of productivity on the surface may alter the distribution of species on the seafloor. And changes in ocean chemistry, including ocean acidification, while most likely initially affecting shallow water organisms, may have severe impacts on deep-sea life, most notably cold-water corals *(see following story)*.

- *Fisheries:* The authors note that since 1950, the mean depth of fishing in the North Atlantic Ocean has increased by approximately 100 feet per decade as fishermen "continually seek to fish unexploited areas, which usually lie in deeper waters." They also state that "many deep-sea fisheries have collapsed or are beginning to show warning signs of population decline" and that some deep-sea fish now meet IUCN criteria for being critically endangered.

  In addition, fishing methods in the deep sea are largely unselective, leading to a high amount of discarded bycatch. Further, unselective fishing gear can continue to have significant impacts over the long term, such as "ghost" fishing nets that continue to catch fish and marine wildlife for years, and bottom trawls that damage habitat and nontarget species.

- *Oil and Gas:* Oil and gas extraction has been undertaken in shelf seas for many years, but as production has started to diminish, some international hydrocarbon companies have begun to look elsewhere. Exploitation of deep-sea hydrocarbons began in 1979, with six producing wells by 1992. This had increased to 17 by 1997 and 118 by March 2006. According to the authors, the "lack of basic information on the biology and ecology of deep-sea species emphasizes the need for research on the impacts of hydrocarbon exploitation in deeper waters."

- *Carbon Capture and Storage:* One proposed response to increased atmospheric concentrations of carbon dioxide (CO_2) has been to capture and store the gas in underground geological formations or in deep-sea sediments. Although this technology remains expensive and difficult to implement, parties to the London Convention, which governs dumping of wastes and other matter at sea, have recently amended that convention's Annex 1 to permit the sequestration of CO_2 beneath the seabed. The authors argue that it "is likely that high concentrations of CO_2 at injection points would have the most profound effects on deep-sea organisms" and that any benefits gained by storing carbon dioxide in this way need to be "assessed in relation to the hazards it poses to deep-sea life."

The authors conclude by examining a variety of marine protection initiatives and approaches around the world. They assert that: "With so much of the earth affected by human activity, it is important to ensure that the deep sea, very probably the last great wilderness on earth, attains adequate protection to preserve it for future generations."

Source: Davies, A.J., *et al.* 2007. Preserving deep-sea natural heritage: Emerging issues in offshore conservation and management. *Biological Conservation* **138:** 299-312.

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Review Weighs Future of Deep-sea Corals in an Acidifying Ocean

High atmospheric carbon dioxide concentrations caused by emissions from the burning of fossil fuels are widely recognized to be the leading cause of anthropogenic climate change. But these emissions, notes a paper in the journal *Coral Reefs*, are also acidifying the ocean.

The ocean is a sink for atmospheric CO_2 and has already taken up half the atmospheric CO_2 humans have produced during the past 200 years. As a result, observe C.M. Turley of the Plymouth Marine Laboratory in England and colleagues, "ocean chemistry is changing." Ocean pH, they write, has already fallen by 0.1 unit, and "is set to fall another 0.3–0.4 units by the year 2100 and 0.67 by 2300 if we continue to burn fossil fuels at current rates." So great is this rate of change, say Turley and colleagues, that as early as 2050, ocean pH will be lower than it has been for about 20 million years.

In addition to a decline in surface seawater pH, this change will also lead to a substantial reduction in carbonate ion concentration. This poses a risk to marine calcifying organisms that require such carbonates to create shells and other structures—particularly, write Turley and co-authors, cold-water corals. Indeed, they write, such corals are perhaps "the most vulnerable marine ecosystems to the human dependence on burning fossil fuels."

Cold-water corals are found throughout the ocean, usually at depths between approximately 650 and 3,300 feet. They can be long-lived, surviving for hundreds of years. They form reef structures that can persist for millennia and may cover a proportion of the ocean similar to, or even larger than, those of warm-water corals. Their slow growth and limited ability to recover make them especially vulnerable to anthropogenic activities, say the authors, and some deep-sea reefs have now been severely damaged by bottom trawling.

Turley and colleagues write that fossil evidence shows such corals have survived previous mass extinction events, all of them likely caused by perturbations in the carbon cycle that probably resulted in ocean acidification. However, in all such cases, the corals took several million years to recover. Furthermore, they conclude, "the extremely rapid release of anthropogenic CO_2 from fossil fuel deposits is unprecedented in geological history and risks fundamentally perturbing deep-water coral ecosystems before the scientific community has begun to map and understand them."

The *Coral Reefs* paper coincided with a review in the journal *Science*, in which 17 marine scientists from seven countries called for increased protection for corals against the impacts of global warming. Among the initiatives in place to encourage coral conservation is SeaWeb's Too Precious to Wear program, which is partnering with the fashion industry to promote alternatives to the use of precious corals in jewelry, fashion and décor.

This year has been designated the International Year of the Reef, a worldwide initiative to raise awareness of the importance of corals and coral reefs.

Source: Turley, C.M., *et al.* 2007. Corals in deep-water: Will the unseen hand of ocean acidification destroy cold-water ecosystems? *Coral Reefs* **26:** 445-448.

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For Further Information: Read about SeaWeb's Too Precious to Wear program at http://www.seaweb.org/programs/coral/home.php

Pacific Dolphin Numbers Fail to Recover from Depletion

Two dolphin populations, depleted by decades of mortality in the Eastern Tropical Pacific (ETP) yellowfin tuna fishery, are still not showing signs of recovery, despite substantial reductions in dolphin mortality rates in that fishery, reports a paper in the journal *Marine Ecology Progress Series*. However, the paper's authors were unable to conclude definitively whether the lack of recovery in dolphin numbers can be attributed to ongoing fishery impacts or to ecosystem changes.

From 1960 to 1972, purse-seine vessels fishing for yellowfin tuna in the ETP killed more than four million dolphins. At least three populations—northeastern offshore spotted dolphins, coastal spotted dolphins and eastern spinner dolphins—declined because of this mortality and were classified as "depleted" under the U.S. Marine Mammal Protection Act. A study conducted

in 2000 concluded that neither the northeastern offshore spotted dolphins nor eastern spinner dolphins had increased in abundance, despite significant reductions in their mortality in the tuna fishery. Using a combination of data and modeling, the new paper concludes that those two populations have been reduced to approximately one-fifth and one-third, respectively, of pre-fishery levels, and that their growth rates are as little as 1.4 percent a year.

Among the possible reasons for such suppressed recovery, the paper's authors—Paul R. Wade and colleagues from NOAA Fisheries—considered continued impacts from the fishery. Because schools of yellowfin tuna frequently swim beneath pods of dolphins, purse-seine vessels search for dolphins as a way of locating tuna; at the time of greatest dolphin mortality in the fishery, those vessels would then use their nets to encircle and capture both cetaceans and fish. They now attempt to eliminate dolphin mortality by "backing down" after encircling the dolphins, allowing the mammals to escape but trapping the tuna.

However, Wade and colleagues suggest that the pursuit of dolphins itself, even if leading to less direct mortality, may continue to impact their populations negatively. The authors suggest, for example, that because calves have less stamina and swimming ability than adults, calves and cows are more likely to be separated during fishing activities, particularly during the calves' first six months of life. They note in support of their contention that the proportion of calves declined in both northern offshore spotted and eastern spinner dolphin populations between 1993 and 2003; in addition, in the case of spotted dolphins, "the number of dolphin sets [i.e. the number of times in which purse-seine vessels set their nets around dolphins] negatively affected both the proportion of calves in the population and the length of time calves remained with their mothers."

In addition, they observe that fetal mortality rates are higher in these populations than for other marine mammals; however, they write, "whether this is natural or due to effects of chase and encirclement is not yet known." Furthermore, they state, the pelagic ecosystem in the ETP has changed during the five or six decades in which the purse-seine fishery has operated. These changes have generally not been linked to declines in the populations of eastern spinner and northern offshore spotted dolphins. Nonetheless, Wade and colleagues write, "The basic principles of ecology tell us that the physical and ecological environment ultimately determines how many dolphins can be supported by the pelagic ecosystem."

Source: Wade, P.R., *et al.* 2007. Depletion of spotted and spinner dolphins in the eastern tropical Pacific: modeling hypotheses for their lack of recovery. *Marine Ecology Progress Series* **343:** 1-14.

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Researchers Question Endangered Status of Western Arctic Bowheads

The western Arctic population of bowhead whales now exceeds 10,000. Therefore, concludes a recent study in the journal *Biological Conservation*, based solely on their numbers, they no longer meet the criteria for listing as endangered under the U.S. Endangered Species Act.

According to the study's authors—Leah Gerber and A.C. Keller of Arizona State University and Doug DeMaster of NOAA's Alaska Fisheries Science Center—the extant populations of bowheads worldwide vary significantly in their abundance and status. The Okhotsk Sea population, for example, numbers in the "few hundreds," while that in the eastern North Atlantic comprises just a "few tens." The status of bowheads in the eastern Canadian Arctic is unknown and under review. However, the western Arctic population, also known as the Bering-Chukchi-Beaufort population, is universally acknowledged to be recovering from severe depletion to the point that it now numbers in excess of 10,000 whales and is continuing to increase by approximately three percent per year.

Using data gathered from 11 abundance estimates conducted during the past 23 years, Gerber and colleagues calculated the likelihood that the western Arctic bowhead population would become extinct in the foreseeable future. "If the population model indicated a greater than 5 percent chance that the population would fall below the quasi-extinction level in the next 10 years, listing as endangered would be warranted," they write. "Similarly, a 5 percent chance of such a decline occurring over 35 years would be consistent with listing as threatened. A recommendation to delist (i.e., remove a population from the List of Endangered and Threatened Wildlife) would be consistent with a finding that it was unlikely the ... population would fall below 500 animals in the foreseeable future."

They concluded that the population would need to undergo an annual decline of 25 percent to decline to 500 whales within 10 years, and of approximately 8 percent to reach that level within 35 years. They point out that, given the observed increase in abundance in the population over the last 23 years, "declines of this magnitude appear to be extremely unlikely."

In addition, because of the species' life history characteristics, including delayed maturation and extreme longevity, the authors also examined the probability that the population would fall below the 500 animal threshold within 100 years. Results from this analysis were then applied to determining the population's status based on listing criteria of the World Conservation Union (IUCN).

Those criteria stipulate that for a population to be classified as endangered, the probability of extinction within 20 years or five generations, whichever is longer, must be 20 percent; for it to be listed as vulnerable, the probability of extinction in 100 years must be at least 10 percent. Gerber and colleagues conclude that the population does not meet either of these criteria.

Although the authors do recommend that the National Marine Fisheries Service undertake a status review of the population, they acknowledge risk of extinction is just one of five factors involved in determining listing status under the Endangered Species Act, the others being overexploitation, lack of regulations, disease, predation and habitat destruction. They recognize that uncertainty over the future environment of bowhead whales, primarily as a result of the impact of global warming on arctic sea ice, would most likely be raised as an objection to any delisting. In addition, the Alaska Eskimo Whaling Commission, which regulates subsistence whaling on the population, may also resist downlisting or delisting because such a step might diminish protection of bowheads from offshore oil and gas development.

Source: Gerber, L.R., *et al.* 2007. Ten thousand and increasing: Is the western Arctic population of bowhead whale endangered? *Biological Conservation* **137:** 577-583.

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Sandy Beaches "At the Brink"

Sandy beaches dominate the world's open coastlines; as prime sites for human recreation, they underpin many coastal economies. However, point out the authors of a recent study in the journal *Diversity and Distributions*, "beaches are not just piles of sand, they support a range of under-appreciated biodiversity." A single beach can harbor several hundred species of invertebrates, for example. Beaches also provide ecological services, such as filtering large volumes of seawater, recycling nutrients, supporting coastal fisheries and providing critical habitats for endangered species such as sea turtles and birds.

However, observe Thomas A. Schlacher of Australia's University of the Sunshine Coast and colleagues: "These unique ecosystems are facing escalating anthropogenic pressures, chiefly from rapacious coastal development, direct human uses—mainly associated with recreation—and rising sea levels. Beaches are increasingly becoming trapped in a 'coastal squeeze' between burgeoning human populations from the land and the effects of global climate change from the sea."

Schlacher and colleagues argue that the limits of scientific understanding of how sandy beaches respond to the plethora of human threats are "emerging as crucial impediments for the conservation of these threatened systems." They propose a number of broad research areas that they contend are critical to address those limits of scientific understanding. They conclude by arguing that innovative and interdisciplinary approaches, as well as public outreach, will be required for the conservation of sandy beaches worldwide.

Source: Schlacher, T.A., *et al.* 2007. Sandy beaches at the brink. *Diversity and Distributions* **13** (5): 556-560. DOI: 10.1111/j.1472-4642.2007.00363.x

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About Ocean **Update**

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