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Researchers Calculate Costs, Propose Benefits of High Seas Marine Reserves

A team of fisheries researchers at the University of British Columbia has called for the establishment of a network of no-take marine protected areas on the high seas. In a paper in the journal *Marine Ecology Progress Series*, the researchers provide what they say is the first global, economically supported analysis of the impact on fisheries of establishing such areas outside of territorially defined waters, and conclude that closure to fisheries of 20 percent of waters on the high seas might lead to the loss of only 1.8 percent of the current global reported marine fisheries catch.

In the paper, Ussif Rashid Sumaila and colleagues note that many of the fisheries in "crisis" today are located within countries' 200-mile Exclusive Economic Zones (EEZs). Fisheries outside of this zone, they say, have yet to reach the same state. However, as fisheries move further offshore in response to declining catches caused by overfishing or more restrictive quotas, overfishing is becoming evident on the high seas, particularly in deep waters.

Sumaila and colleagues state that logistical, legal and financial difficulties with monitoring and enforcement under current management regimes have prevented sustainable fishing on the high seas. Rather, the researchers propose that a portion should be set aside as marine reserves that are fully protected from fishing.

The researchers' data show that between 1989 and 2002, an average of 8.9 percent of the annual global marine fish catch was taken from the high seas. Therefore based on the values of catches and landings of global fisheries, the authors state, "closing 10, 20, 50, or 100 percent of the high seas to fishing may lead to losses of between 0.9 and 8.9 percent of current marine capture fisheries catch per year." Sumaila and colleagues further calculated that, in terms of total revenue, this loss would to amount to $1.35 to $13.5 billion a year, much of it in tuna, swordfish and small pelagic fisheries.

Despite such initial economic losses, the authors assert that their proposal contains several considerable benefits, including reduced likelihood of overfishing, insurance against management errors in fished areas and the protection of fish and habitat species for as yet unrealized nonconsumptive uses.

Even so, they recognize that the proposal would encounter challenges and obstacles, not the least of which is that, for many nations, concern over short-term losses would outweigh recognition of potential long-term benefits. An additional issue would be the question of which areas to close to fishing, although they propose that recent studies identifying large seamounts and clusters of seamounts globally, as well as evaluations of fishing efforts worldwide, could be used as a basis for "quantitative and rigorous" evaluations of prime candidates for high seas marine reserves.

Source: Sumaila, U.R., *et al.* 2007. Potential costs and benefits of marine reserves on the high seas. *Marine Ecology Progress Series* **345:** 305-310.

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Would "Evolutionary Impact Assessments" Help Protect Fish Stocks?

Environmental impact assessments are used widely to determine the potential ecological impacts of human activity.

A recent paper in the journal *Science* proposes that, particularly in regard to commercial fisheries, the concept should be expanded to "Evolutionary Impact Assessments," or EvoIAs.

Christian Jørgensen of the University of Bergen in Norway and 16 co-authors suggest that the impact of commercial fishing is so great that it is even affecting the evolution of some fish species, causing changes to occur in decades that under normal conditions would take millennia.

Jørgensen and colleagues observe that fisheries-induced mortality is now reckoned to exceed natural mortality by 400 percent and that increased mortality generally means fish will reach sexual maturity at a younger age and increase levels of reproduction. These trends are further exacerbated when fisheries selectively target larger or more mature individuals.

The authors cite several studies that indicate many fish species show changes in their size and age at maturation, reduced annual growth and loss of genetic diversity. Such changes affect more than these species, they say, because "predator-prey dynamics, competitive interactions, relative species abundances and other ecological relationships will systematically change over time." Furthermore, such fisheries-induced evolution may be slow to reverse, or even irreversible. As a result, they write, current management reference points are essentially "moving targets."

The authors admit that the concept of Evolutionary Impact Assessments is a challenging one. One hurdle would likely be in defining "evolutionarily enlightened management objectives" and then translating those into practice. However, they write, addressing fisheries-induced evolution is becoming critical: "Fisheries-induced evolution is likely to diminish yield and degrade ecological services within decades, having an impact on species, ecosystems, and societies."

Source: Jørgensen, C. *et al.* 2007. Managing evolving fish stocks. *Science* **318:** 1247-1248.

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Climate Change Affecting Fisheries

A recent review in the *Proceedings of the National Academy of Sciences* states that current research on global climate change indicates "strong interactions between the effects of fishing and the effects of climate." Keith Brander of the International Council for Exploration of Seas (ICES) writes "fishing reduces the age, size, and geographic diversity of populations and the biodiversity of marine ecosystems, making both more sensitive to additional stresses such as climate change."

Brander discusses several studies that have examined actual or potential effects of climate change on fisheries, among them:

- *Metabolic Stress from Increased Water Temperature:* Changes in the distribution of common eelpout in the southern region of the North Sea have been linked to decreased oxygen in the water during summer hot spells. Salmon in the Fraser River in Canada suffered enhanced mortality when temperatures in the summer of 2004 exceeded levels previously recorded during a 60-year time period.
- *Species and Ecosystems Close to Their Physiological Tolerance Limits:* Atlantic cod is the principal demersal fish species in the Baltic Sea. However because of the sea's relatively low salinity levels, this species is "close to the extremes of its physiological tolerance in this area," writes Brander. Mild winters with westerly winds, above-normal rainfall and reduced inflow of saltwater from the Skaggerak (the strait that connects the otherwise land-locked Baltic with the North Sea) have become the norm since the mid-1980s. As a result, the Baltic may be approaching a condition in which, according to experimental studies, cod spermatozoa cannot survive.
- *Past Warming Periods as Analogues for Climate Change:* A long warming period from the mid-1920s until the 1960s affected many parts of the North Atlantic. Cod and several species of marine mammals and benthos expanded their ranges. Some species, including cod, were caught that had previously either been present only in restricted coastal fiords or, such as haddock and herring, entirely absent. Brander writes that this demonstrated that redistribution of species, and indeed replacement of species and whole ecosystems, can take place quite rapidly.
- *Regional Climate Variability and Regime Shifts:* Regional climate variability affects many major fisheries. For example, "regime shifts"—fairly abrupt changes in physical oceanography and biology that persist for at least a decade—characterize North Pacific ecosystems. El Niño, or ENSO, events, in which anomalously warm water appears in the coastal and equatorial ocean off Peru and Ecaudor for periods of 6 to 18 months, adversely affects Peruvian anchovy production in the eastern Pacific Ocean. However, says Brander, "decadal anomalies appear to have greater long-term consequences for the food web than the short periods of nutrient depletion during ENSO events."

Although such comparative studies can provide a degree of illumination of some of the likely impacts on fisheries as a result of climate change, Brander writes, any predictions can be made only with low confidence. Local and regional forecasts are likely to be more accurate than a global forecast because the latter requires consideration of special factors (such as sea-ice loss in higher latitudes) and greater variables. Fundamentally,

fish production is reliant on net primary productivity (NPP) in the ocean, notes Brander. He observes: "NPP depends on the availability of light and nutrients, which in turn are governed by runoff, atmospheric dust deposition, ocean mixing processes, cloud cover and the solar cycle. Satellite measurements of ocean color over the past two decades show changes in global NPP but with large regional differences that can be related to changes in upper-ocean temperature gradients, wind stress, and atmospheric iron deposition."

Because of such complexity and regional variability, Blander concludes that providing detailed adaptation strategies for fisheries management in a world affected by climate change is difficult. However, certain attributes of management would likely be helpful: flexibility, adaptability to new information about marine ecosystems, reflexivity (i.e., continuous evaluation of the consequences of management decisions) and transparency. Meanwhile, he writes, the best way to reduce the impacts of climate change on fisheries is to reduce catches in the majority of fisheries, which are currently fully exploited or overexploited.

Source: Blander, K.M. 2007. Global fish production and climate change. *Proceedings of the National Academy of Sciences* **104**(50): 19709-19714.

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Ship Emissions Linked to 60,000 Deaths Annually

Particulate emissions from marine shipping may cause approximately 60,000 deaths annually, according to a study in the journal *Environmental Science & Technology*.

The study, by James J. Corbett of the University of Delaware and colleagues, notes that the marine transport sector "contributes significantly to air pollution, particularly in coastal areas." The authors report that, annually, ocean-going ships are estimated to emit 1.2 to 1.6 million metric tons of particulate matter, 4.7 to 6.5 million metric tons of sulfur oxides and 5 to 6.9 million metric tons of nitrogen oxides. Recent studies estimate that around 15 percent of global nitrogen oxide emissions and 5 to 8 percent of global sulfur oxide emissions are attributable to ocean-going ships. "Given nearly 70 percent of ship emissions occur within 400 km [about 250 miles] of land, ships have the potential to contribute significant pollution in coastal communities," write Corbett and colleagues.

Additionally, numerous studies have linked air pollution to human health impacts such as asthma and heart attacks. Indeed, an estimated 800,000 deaths each year worldwide are attributed to it.

Corbett and his co-authors sought to ascertain how much of this mortality could be linked to ship emissions. They did this by first determining pollutant emissions from ships and applied atmospheric transportation and chemistry models to estimate what the increased concentrations were due to ships. They then could estimate increased risk to those populations exposed to these additional concentrations and calculate what additional mortalities could be due to that increased risk.

They concluded that exposure to shipping-related emissions resulted in 19,000 to 64,000 cardiopulmonary and lung cancer mortalities annually in 2002, and that those mortalities would increase by approximately 40 percent by 2012 because of trade-driven growth in ship emissions. In other words, approximately 3 to 8 percent of all such mortalities each year are attributable to marine shipping.

These mortalities were concentrated in distinct regions. Between 20 and 40 percent occurred in the European and Mediterranean region; 20 to 30 percent in East Asia, including China and Japan; and 15 to 30 percent in South Asia, including India and Indonesia. As expected, those regions reflect the areas where both shipping concentrations and coastal population levels are high.

The authors further observe that although they concentrate on cardiopulmonary and lung cancer mortalities, regions where ships contribute most to mortality effects—such as concentrated population areas with high shipping-related particulate matter emissions—should be expected to suffer other related health impacts. They conclude that mitigating ship emissions from engine combustion and exhaust pollutants could result in significant health benefits.

Source: Corbett, J.J. *et al.* 2007. Mortality from ship emissions: A global assessment. *Environmental Science & Technology* **41**(24): 8512-8518.

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E. coli Found for First Time in Antarctic Wildlife

"There is growing international concern about harmful pathogens being introduced accidentally into Antarctica by human activities," note the authors of a paper in the journal *Polar Biology*. "Such microbial pollution could result in infectious disease outbreaks and high mortality among sensitive, colonial-breeding Antarctic wildlife."

In recent years, surveys in the region have detected pathogens such as *Salmonella* in Antarctic wildlife. Jorge Hernandez of the University of Kalmar in Sweden and colleagues collected rectal

swabs from 33 Antarctic fur seal pups at a rookery in the South Shetland Islands, just off the Antarctic Peninsula. Samples from two of the pups showed the presence of *Escherichia coli*—both the first such recorded presence in Antarctic wildlife and the first in pinnipeds.

The authors propose a number of pathways by which the pathogen could have been introduced into a seemingly pristine Antarctic environment. It could have spread from contaminated food or sewage from land runoff or from cruise ships and fishing vessels that frequent the area. Previous studies have found *Salmonella* and *Campylobacter jejuni* bacteria in wildlife breeding sites close to scientific bases. The Antarctic Treaty requires treatment of human waste and sewage, but only for populations greater than 30 people. Once a population has become infected, humans can spread the infection unwittingly. For example, fecal pathogens can be transported by footwear that has been in contact with fecal material from an infected population.

They also propose that seabirds breeding in proximity to fur seals might feed in enriched waters near sewage outlets and bring the infection back with them, spreading the pathogen by foraging and defecating in the fur seal colonies. Additionally, individual fur seals and seabirds might wander to lower latitudes near South America and introduce the microorganism on their return.

The authors state that nothing indicates that either Antarctic fur seals or any Antarctic species would likely suffer higher mortality as a result of *E. coli* infection. However, they conclude that the organism's discovery "in this remote, relatively pristine wilderness is distressing, for it suggests that the nations of the world are still not doing enough to protect Antarctic wildlife from exotic pathogens."

Source: Hernandez, J., *et al.* 2007. Enteropathogenic *Escherichia coli* (EPEC) in Antarctic fur seals *Arctocephalus gazelle. Polar Biology* **30:** 1227-1229.

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About Ocean **Update**

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