Measuring the Effects of Marine Reserves on Fisheries: The Dilemmas of Experimental Programs

In theory, no-take marine reserves hold benefits for nearby fisheries: the reserves allow target species to grow older and larger, produce more young, and ultimately replenish fished areas with larvae and/or adults. While evidence of benefits to fisheries has appeared in scientific literature, some researchers argue that most science on reserves has not involved sufficiently rigorous experimental design, including the use of control sites. As a result, they say, there is an urgent need for experimental programs to clarify the fisheries benefits - and costs, for that matter - of marine reserves.

But conducting rigorous experiments on reserves brings an array of challenges that have hindered such research to this point. This month, MPA News interviewed several scientists about the fisheries benefits of reserves, why carefully controlled studies are rare, and how managers should communicate with stakeholders in light of the scientific uncertainty.

Skepticism of reserves’ benefit to fisheries

The crux of the issue is whether the establishment of a marine reserve will have a negative or positive impact on a fishery and on those who depend on the fishery for their livelihood. According to Ray Hilborn, a fisheries biologist at the University of Washington (US), few studies have addressed that issue adequately.

"It is being argued that reserves will protect both biodiversity and increase fish yields," said Hilborn. "But the scientific data used to support these claims have internal biases. First, the protected areas used in the research were almost certainly selected for protection because of their higher productivity" - thus making comparisons with outside areas unfair - "and, second, the effort that was excluded from the protected areas would have been redirected to the unprotected areas." Together, these factors frustrate attempts to measure the effects of the closures. In short, says Hilborn, most studies have no rigorous control sites - that is, fished sites that are otherwise equivalent to closed areas - against which to evaluate reserves.

Although Hilborn sees value in reserves as scientific reference areas or as tools to protect biodiversity, he is skeptical of their usefulness in increasing catches. In part, he says, it is simply too difficult to create a closure that would boost more than one fish species at a time. "In theory, the size of a [reserve] needs to be finely tuned to the dispersal pattern of a species, and one size won't fit all," he said. And, he added, reserves do not solve the problems of enforcement or races for fish - the latter of which, in his view, should be the top priority for managers to solve. "We should be embarking on an experimental program to determine whether MPAs have fisheries benefits or not," he said. "My gut feeling is that, for biodiversity reasons, we should probably go ahead and lock up a good portion of the sea, but not pretend like it'll benefit fishermen."

Wendy Craik, chair of the board of directors for the Australian Fisheries Management Authority and former executive director of the Great Barrier Reef Marine Park Authority, agrees on the need for well-designed studies of reserves. Most research programs on the benefits of reserves, she says, are set up after the site has already been designated rather than as part of the site’s planning process. This hinders the selection of adequate control sites.

"MPAs have generally been put in place by environmental management agencies without necessarily a high degree of consultation with fisheries management agencies," said Craik. At the same time, she added, fisheries managers have been experimenting more with other management tools than with reserves. These events have conspired to make experimental programs on reserves rare.

Like Hilborn, Craik sees value for reserves as scientific reference areas and, probably, as protection for biodiversity. She believes there will eventually be empirical evidence of benefits from reserves to some - but not all - fisheries. Asked whether fisheries managers would be right to promise benefits to fishermen from reserves, she said, "I think managers should say that they are looking at marine reserves as options. Without empirical evidence to say that reserves would enhance fisheries, to say otherwise would be courageous."

Challenges in evaluating reserve benefits

According to Trevor Ward, former program manager for environmental research in the Division of Fisheries at Australia’s Commonwealth Scientific and Industrial Research Organization (CSIRO), the benefits and costs of reserves are unclear from a fishing perspective. To a large extent, he says, convincing stakeholders of the potential of marine reserves still depends on theoretical or logical arguments based on researchers' basic knowledge of marine ecology.

Ward co-authored "The Role of Marine Reserves as Fisheries Management Tools: A Review of Concepts, Evidence and International Experience" (see box at end of article), which details the myriad challenges involved in evaluating reserve benefits to fisheries. They fall into three basic categories: methodological (including lack of control sites and time-series data); ecological (including the influences of predation, large-scale oceanographic or climatic events); and managerial (including lack of enforcement).

Coupled with the limited global history and experience with the use of MPAs, these challenges mean there are no well-tested approaches that can be used "off-the-shelf" by researchers and managers to evaluate the benefits of reserves with confidence, according to the report.

Speaking to MPA News, Ward said the lack of empirical evidence should not imply a failure of reserves to deliver benefits to fisheries. "Fisheries enhancement should not be considered to mean only an increase in catch rates," he said. "The responsible approach to this matter is to describe reserves to fishers as [given adequate design and management] potentially being able to make an important contribution to solving a number of key problems in the management of many fisheries." Among these solutions, he said, were providing insurance against overfishing and helping to conserve species and habitats that would otherwise be affected negatively by fishing.

"Reserves will best fulfill their potential for supporting fisheries if they are adopted and incorporated into the toolkit of fishery managers in the same way as any other new opportunity to improve fisheries management: that is, systematically, progressively, and with constant vigilance and review, modification, and improvement," said Ward.

He believes there will eventually be empirical evidence that properly designed reserves provide benefits for all fisheries. "The main arguments in favor of this lie in the role of reserves as insurance against environmental unpredictability and weaknesses in management systems," said Ward. "This translates directly into long-run economic viability."

Neilie Barrett, a fisheries biologist at the Tasmanian Aquaculture and Fisheries Institute of the University of Tasmania (Australia), says reserves are best viewed as fisheries management information tools - with the emphasis on information. "If the information that we are able to obtain on natural populations within an MPA is applied to a fishery with the capacity for flexible management, then clearly reserves can help to maximize yields," he said. That is, by better understanding the potential size of a fish stock, managers may grow the population back toward a point of higher optimal yield, which would benefit fisheries in the long term. Like Ward, Barrett believes there will eventually be empirical evidence of the benefits of well-designed reserves to all fisheries.

In terms of promising benefits to fishermen, said Barrett, the argument for reserves may be most compelling in subsistence fisheries with no conventional management and severe overfishing. "In that case, reserves may be the only management option that is presently available," he said. This is not the case, he added, for large commercial fisheries in developed countries. "There is a reasonable argument that perhaps, in countries capable of doing so, fisheries and their impacts are best managed by appropriate conventional strategies such as input and output controls, gear restrictions, etc., and if provided with sufficient information these fisheries could be optimized without closed areas," he said.

Case example of an experimental program

A study on the fishery effects of reserves is underway in the northern Gulf of Mexico. In 2000, the US Gulf of Mexico Fishery Management Council designated two four-year closures encompassing potential spawning aggregation sites for gag grouper, a commercially valuable stock threatened by overfishing. Researchers with the US National Marine Fisheries Service (NMFS), responsible for studying the no-take areas, selected a control (fished) site adjacent to one of the closures. The year-round closures and the control are each roughly 10 nautical miles by 10 nautical miles along the 100-meter depth
Andrew David, a biologist with NMFS, is studying the closures and control, and has had to confront many of the challenges inherent in reserve research. The greatest one, he says, has been enforcing the no-take regulations. "Of the two closures, the closer one to land is 50 miles offshore," said David. "The only way to enforce it is with Coast Guard patrols." But vessel patrols in the area were infrequent; in addition, the Coast Guard in the past year prioritized its activities in light of national security concerns, sending its vessels elsewhere. As a result of the lack of patrols, each time David and his team visited the closures, they saw violations taking place.

The situation is improving, though. Earlier this year the Coast Guard, following consultation with grouper researcher Chris Koering of Florida State University (US), re-routed one of its airborne homeland-security patrols to fly over the closures on a randomly timed basis. The patrol is able to take georeferenced photographs of violators, including the vessels' permit numbers that often appear in large font on decks and roofs. "The violation rate has decreased significantly in the latter portion of 2002," he said. Despite this improvement, the research team still must determine how to account for the past illegal fishing in its study calculations, factoring in how many fish may have been removed by violators. "It's one of the sticky issues that we'll have to deal with in the report," said David.

Another major challenge for the study is the short time period within which it must draw conclusions. The closures and control have been in place only since 2000, and the research team will have just two full years of data to present to the council this coming May. "After only two years, it's hard to say how much of any effect is due to fishing or not fishing," said David. Add to this the fact that gag grouper do not reach sexual maturity for several years, making the real recruitment impacts of the closures somewhat unclear until 2010 or beyond. "We'll have a two-year dataset to answer a decadal problem," he said. "The grouper lifecycle provides a good rationale for extending the closures to 10 years." That extension option will be one that the council will consider.

In selecting appropriate areas to serve as closures, the council considered up to 30 candidate locations. The main selection criterion was that the closures must incorporate known or suspected gag grouper spawning aggregation sites. Fishermen viewed the two chosen sites as being somewhat depleted as productive fishing areas, which ensured fewer complaints during the site selection process, says David. In choosing the control, researchers picked a site near one of the closures so it could be sampled relatively easily, and would be subject to the same supply of juvenile fish and other environmental variables, such as storm events and upwellings.

Preliminary results from the study indicate more gag grouper are present in one closure than in the adjacent, open-to-fishing control site or other closed area. The latter closure has attracted red grouper instead of the once-unforeseen result, although David says a difference in bottom structure there is the most likely cause for the predominance of reds. He says it is too early to draw conclusions on whether any fisheries benefits have accrued from the closures.

Notably, the council has made no secret of where the control site is. This is despite the fact that such knowledge could, at least theoretically, lead fishermen to purposely skew the study results by avoiding fishing in that control area. If the control site, for example, were found to have just as many fish as the closures, that would suggest the closures were having little effect. "They're fishing the control site, though," said David. "I think the vast majority in the industry have an interest in perpetuating the stocks, and would like to see it remain a productive industry. Once they understand what we're doing in our research, they support it."

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BOX: Report available on role of reserves as fisheries management tools

The report suggests five classes of evidence, at a minimum, that will provide defendable evidence of a successful reserve performance for fisheries purposes:

1. Enhanced conservation of fishing-affected species or habitats either inside or outside the reserve;
2. Stock enhancement within the reserve;
3. Stock enhancement overall or outside the reserve;
4. Improved overall fisheries yields; and
5. Improved socio-economic outcomes for local communities.

BOX: New media available on MPAs
The Pacific Marine Conservation Council, a US-based NGO, has released a CD-ROM of its “Fishermen’s Forum on Marine Protected Areas”, held in January 2002. The forum invited commercial fishermen from the US Pacific coast to recommend ways to improve communication on MPAs among managers, scientists, and the fishing community. Attendees also gained a working knowledge of MPA science and policy and an update on MPA initiatives along the coast. The CD-ROM features presentations from participants and video footage of presentations, including by scientists, NGO representatives, and fishermen. It is available for US $10 from the Pacific Marine Conservation Council (www.pmmco.org).

PISCO, an ocean-focused consortium of scientists from four US universities, has released a video and booklet on the current state of knowledge about marine reserves. Titled The Science of Marine Reserves, the materials explain several concepts - including larval export and adult spillover - and provide case studies. The materials are for use by resource managers, scientists, and other stakeholders. To order the video and booklet, or to download them directly from the web, go to the PISCO website at www.piscomarine.org.