

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."

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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, below left), 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 and 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.

Report available on role of reserves as fisheries management tools

Trevor Ward co-wrote the 192-page report *The Role of Marine Reserves as Fisheries Management Tools: A Review of Concepts, Evidence and International Experience* with Dennis Heinemann of the US National Marine Fisheries Service and Nathan Evans of the Australian Department of Agriculture, Fisheries, and Forestry. It is available for free online in PDF format at http://www.affa.gov.au/corporate_docs/publications/pdf/rural_science/fisheries/brs_marine_report.pdf.

The report suggests five classes of evidence, at a minimum, that will provide defensible 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.

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."

Neville 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 contour favored by grouper. By May 2003, researchers must report to the council their

preliminary findings on the reserve effects; the council will decide then whether to reopen the closures to fishing in 2004 or continue them.

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 reprioritized 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 Koenig of Florida State University (US), re-routed one of its airborne homeland-security patrols to fly over the closures each day 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] as word has spread that the daily overflights are occurring," said David. Despite the improved compliance, 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 — an 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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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 recommendations 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.pmmc.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.piscoweb.org.

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Australia Designates World's Largest No-Take Area

In a move to protect the waters of one of the most remote places on Earth, Australia has designated a giant marine reserve around an island group just outside the Antarctic Circle. At 65,000 km², the Heard Island and McDonald Islands Marine Reserve is the world's largest no-take area – roughly the size of Belgium, the Netherlands, and Luxembourg combined.

The Australian territory of Heard Island and McDonald Islands (HIMI) lies equidistant from Australia and South Africa in the southern Indian Ocean. Licensed fishing there by Australians started in 1997, trawling for Patagonian toothfish and mackerel icefish. Although management has been restricting the fishery to three boats to limit environmental impacts, unlicensed fishing activity by non-Australian vessels — including longliners — has been widespread. (It has been estimated that in 2001-2002 within the HIMI exclusive economic zone, the illegal catch of toothfish was equal to 89% of the total allowable catch for the legal fishery.) With the new marine reserve, government discussions are underway on how to strengthen surveillance and enforcement of the fishing restrictions.

The HIMI marine reserve incorporates a pre-existing wilderness reserve that stretched from the islands' shorelines out to 12 nautical miles. Fishing within that protected area, as well as an adjacent 1-nm buffer zone, has been off-limits for several years. Managers do not expect the new HIMI marine reserve to have a significant negative impact on the licensed trawl fishery, as the terrain within the reserve is not ideally suited for bottom trawl gear and areas outside the reserve have yielded good catches.

Heard Island is home to Australia's only active volcano, as well as large numbers of penguins and seals. McDonald Island, the major island in the group, has such steep shores that just two successful landings by boat have occurred since the island's discovery a century ago. The uninhabited islands, which have no species introduced by humans, were transferred from the United Kingdom to Australia in 1947, and were inscribed on the World Heritage List in 1997.


Protecting spawning habitat

Margaret Moore, senior marine policy officer for WWF Australia, an NGO, said the new reserve would play a crucial role in protecting spawning habitat for fish and foraging areas for rare seabirds and marine mammals. "This is one of the most significant conservation decisions taken by Australia," said Moore. "It acknowledges Australia's responsibility to manage remote areas of our oceans."

Negotiations on details of the reserve designation took two years and involved government officials, scientists, NGOs, and the fishing industry. Peter Taylor, director of the marine protected areas program for Environment Australia, said industry agreed to the new reserve because fishermen saw the value in protecting likely spawning and nursery areas for their target fish. "There was mutual interest in protecting these areas," said Taylor. "The licensed fishers of this region are high-profile and known for their conservation interests."

The industry has complained about illegal fishing activity for years, and licensed operators have supplied intelligence and surveillance to officials. Government enforcement operations, including vessel arrests, have reportedly reduced the level of illegal activity occurring in the region since 2000, although patrols have been sporadic. Officials are discussing additional measures to strengthen enforcement, including the use of satellite-based monitoring similar to systems used by military operations, said Taylor.

Patagonian toothfish, often marketed as Chilean sea bass, has experienced intense fishing pressure around the world in the past decade. Quentin Hanich, oceans campaigner for Greenpeace Australia, applauded the move by Australia to designate the new HIMI reserve, but said that stopping pirate fishing for toothfish in the reserve and elsewhere would require international efforts. He called for the intergovernmental Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) to establish an independent, centralized vessel-monitoring system to verify all catch documents and ensure that only legally caught fish are traded worldwide. He also called for CCAMLR to support the nomination of toothfish under the Convention on the International Trade in Endangered Species.

The size of the new no-take zone surpasses another Australian marine reserve, the 58,000-km² Macquarie Island reserve off Australia's southeast coast. 

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MPA Perspective: Challenges in Planning Protected Areas in Jamaica, and the Co-Management Role of NGOs

By Peter Espeut

Protected areas based on sound science, created with a robust legal framework, and backed by a good management team are an effective mechanism for the conservation of biodiversity. In less-developed countries where poverty and lack of opportunity are factors in conservation planning, protected areas can be a particularly useful concept. Efforts can be focused on environmental conservation, while human and material resources can be brought to bear on local human development problems.

Jamaica is an island nation with rich biodiversity and pockets of extreme poverty that originate in the skewed distribution of land resources and other social benefits, characteristic of post-slave societies in the New World. Global and regional assessments paint a worrying picture, with the highest rate of deforestation in the world, the second highest rate of endemic plant species in danger of extinction, and Jamaican waters being the most overfished in the Caribbean Community.

Unsustainable fisheries and forest-use practices threaten plant and animal biodiversity, and create a socioeconomic context in which poverty persists from generation to generation. Against this background, natural resource management must include improving personal self-image, empowerment of residents, diversifying the local economy to provide new economic niches, and changing cultural practices toward more sustainable natural resource use.

Jamaican society, although democratic, is highly polarized by two strong political parties; government departments are perceived as arms of whichever party is in power. In this context, natural resource management efforts by the state alone could be counter-productive since they will not receive the support of all, and may lead to high levels of non-compliance with management measures.


The Jamaican government has committed itself to create 14 terrestrial, marine and integrated protected areas, representing fully 25% of its land area and about 50% of its shallow shelf (20 meters in depth or less). Wisely, in light of the political situation, the government has created space in this process for non-governmental organizations (NGOs) to play an important role. In fact, there are no plans for a national agency to manage the new protected areas; rather, national policy provides for the delegation of management authority to qualified NGOs. While the government will provide the necessary legislative framework for each protected area, an NGO with proper consultation with stakeholders will prepare an approved management plan, source the

necessary funding, hire staff, do enforcement, conduct the necessary biophysical and socioeconomic baseline surveys, and involve the local community in implementation.

So far, management responsibility for the Blue and John Crow Mountain National Park has been delegated to the Jamaica Conservation and Development Trust, and the Montego Bay Marine Park Trust has been given a mandate to manage the Montego Bay Marine Park. The delegation of the management of the Negril Marine Park, the Negril Environmental Protection Area and the Portland Bight Protected Area to local NGOs is imminent.

The experience has not been an unqualified success. Not all NGOs have risen to the task with equal vigor and thoroughness, and the government has been slow to fulfill its side of the bargain. But the approach has the potential to achieve the desired environment and development goals.

The Jamaican government's plans to implement the system of protected areas have been slowed because of the shortage of suitable NGOs to which to delegate management responsibility. While many NGOs exist, very few are equipped with the necessary skills and experience for natural resource management. Some are excellent members' clubs with a particular interest, such as SCUBA diving or bird-watching; many biophysically-focused NGOs possess good natural science skills but lack training in the human sciences which are essential since natural resource management is essentially a social science; some NGOs are politically motivated, while others have limited goals and vision. What is required is the emergence in Jamaica of non-partisan NGOs with a clear vision of natural resource management and sustainable development, possessing both natural and social science skills.

It is early days yet, and the challenges of funding and gaining the confidence and collaboration of the resource-users appears immense; the waters are largely uncharted. Once there are success stories, once the incumbent NGOs demonstrate that the co-management approach is workable, new NGOs will emerge to fill the void. 

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Editor's note:

Peter Espeut, author of the adjoining perspective piece, is executive director of the Caribbean Coastal Area Management Foundation (C-CAM), a nongovernmental organization in Jamaica. C-CAM is preparing to accept management responsibility from the Jamaican government for the Portland Bight Protected Area, an integrated marine and terrestrial protected area. MPA News has adapted this perspective piece from material that Espeut originally posted to the online discussion forum "Wise Coastal Practices for Sustainable Human Development", maintained by UNESCO.

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Letter to the Editor

Dear MPA News:

Two things caught my eye in reading the article on human dimensions of MPAs in the July issue of MPA News (4:1).

First, in the section on the Florida Keys National Marine Sanctuary, Superintendent Billy Causey's comments about fisheries in the sanctuary being better than elsewhere in the region suggest that this is because of closed areas within the sanctuary, perhaps apart from or in combination with other sanctuary efforts to protect marine resources (e.g., water quality). However, the section on Indonesia makes a critical point that I think has not been explicitly addressed in the Florida Keys case: that is, when a community experiences social change following the designation of an MPA, researchers must determine whether the change occurred because of the MPA or as a result of another factor, or some combination of factors. In the Florida Keys, both the lobster trap reduction program implemented in the region by fishery managers in the early 1990s and other fishery management actions (e.g., Florida's subsequent gillnet ban) may have played a role. Although the lobster trap program is noted in some discussions of the case, its relevance to observed changes in use patterns and outcomes is largely dismissed. Closed areas may indeed make a valuable contribution to fisheries, but that contribution must be explicitly evaluated in the broader context of environmental, regulatory and social change.

Second, regarding the section on Canada's study of socioeconomics prior to setting MPA regulations, it is important to note that the approach used in that case is not so different from what is mandated by US law (federal, though not necessarily state). The US National Environmental Policy Act requires environmental impact assessment — including evaluation of impacts on the human environment — for any federal action that will affect the biophysical environment. Environmental impact assessment of a proposed action is required before the proposed action is taken, and is supposed to document the status quo and evaluate potential changes to the human as well as the biophysical environment. As I read it, the Canadian example is striking in its explicit attention to this matter as an integral step in the MPA process, rather than as a necessary, if inconvenient, task or box to be checked off.

Carrie Pomeroy, Ph.D.

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Notes & News

In memoriam: Bob Johannes Robert (Bob) Johannes, a champion for the inclusion of traditional knowledge in marine resource management, died on 2 September from a long illness. He was 66 years old. A marine ecologist who spent as much time studying people as fish, Johannes was a pioneer in the integration of traditional resource-management systems with Western-based science, particularly in the context of tropical fishing societies. He was an inspiration to many in the MPA field with his work to involve all stakeholders in effecting positive change. For more information on his life and where to send condolences, go to http://www.pewmarine.org/PewFellows/pf_JohannesRobert_tribute.html.

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Prosecutions pursued for misdeeds on Great Barrier Reef Two men — the master and assistant fisherman of a commercial fishing vessel — have been fined AU \$27,500 (US \$15,000) and AU \$6000 (US \$3300), respectively, for fishing illegally in a no-take zone within Australia's Great Barrier Reef Marine Park (GBRMP). It was the first prosecution under new federal provisions increasing penalties for illegal fishing in the marine park. The maximum fine for "intentionally or negligently using or entering a no-take zone of the GBRMP for the purpose of fishing" is AU \$220,000 (US \$120,000) for individuals and AU \$1.1 million (US \$600,000) for companies. In a separate case, enforcement officials in September seized a fleet of three fishing boats and twelve tenders observed allegedly within a GBRMP no-take zone, raising this year's number of fishing vessel seizures in the park to 30. **For more information:** Tom Baxter, Legal Officer, Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville Qld 4810, Australia. Tel: +61 7 4750 0705; E-mail: t.baxter@gbmpa.gov.au.

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Mapping project proposed for Norwegian seafloor A national, interagency project to produce multibeam sonar maps of Norway's seafloor, including its deepwater coral reefs, is now in the planning stage. Among other information, the MAREANO project would provide a detailed database of the location of coral reefs in Norwegian waters, enabling fishermen to avoid trawling such areas. Project planners also suggest the improved maps could help reduce fishing time and related seafloor disturbance by bottomfishermen, similar to the results of an ongoing multibeam-based project off the Atlantic coast of Canada (MPA News 4:2). Deepwater coral reefs consist mainly of hard, branching *Lophelia pertusa*, earlier this year off the Norwegian coast, researchers discovered what may be the world's largest *Lophelia* reef, measuring 35 km in length. The Norwegian environment ministry is currently reviewing nearly 50 candidate areas for MPA status, including the newly discovered reef. **For more information:** Terje Thorsnes, Geological Survey of Norway, 7491 Trondheim, Norway. Tel: +47 73 904275; E-mail: terje.thorsnes@ngu.no.

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Canada to designate new national marine conservation areas Canada will designate five new national marine conservation areas (NMCAs) under a plan announced this month, adding at least 15,000 km² to the NMCA system. Awaiting designation after the completion of necessary consultations and negotiated agreements are two sites in waters off British Columbia on the Pacific coast (Gwaii Haanas and the southern Strait of Georgia) and a freshwater site in western Lake Superior. The two remaining sites are yet to be selected. Designation of all five sites is expected to come within five years. Parks Canada, which will oversee the new NMCAs, holds a long-term goal of representing each of Canada's 29 marine bioregions with at least one national marine conservation area. Earlier this year, the Canadian parliament passed legislation to provide a formal framework for the NMCA program (MPA News 4:2). **For more information:** Doug Yurick, Chief, Marine Program Unit Coordination, Parks Canada, 25 Eddy, 4th Floor, Hull, Quebec. Tel: +1 819 997 4910; E-mail: doug.yurick@pc.gc.ca.

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