MPA news

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Using Multibeam Sonar to Map MPAs: Tool of the Future for Planning and Management?

The seafloor — sandy or rocky; flat or sloped; seamount or canyon — provides the foundation for multiple processes within MPAs, including the distribution of flora and fauna. However, MPA practitioners have generally had only patchy knowledge, at best, of what lies at the bottom of their protected sites, based on information gathered from fishermen, divers, and rough bathymetric data from nautical charts. With an inexact understanding of what's "down there", planners and managers face a real challenge of drawing appropriate boundaries and protecting the habitats they want to protect.

Under such conditions, multibeam sonar may be the tool of the future for MPA practitioners. Used now at a small number of MPAs in North America, this mapping technology provides resource managers with the ability to envision the seabed as they never have before. Practitioners are using it to pinpoint boundaries, streamline research costs, identify and reduce ecosystem impacts from fishing, and more. This month, MPA News examines the technology of multibeam sonar and how resource managers are adapting it to fit their needs.

The basics of multibeam sonar

Maps of the seafloor made over the past century vary widely in accuracy. Older navigation systems resulted in features being mapped several hundred meters or even kilometers from their actual geographic locations. Systems to measure depth resulted in errors of tens to hundreds of meters. Depending on the spatial resolution of the mapping system, objects less than a certain size — even undersea mountains, in some cases — could fail to appear at all.

US military researchers developed multibeam sonar in the 1960s to address these problems. Mounted on a ship's hull, the sonar sends a fan of sound energy toward the seafloor, then records the reflected sound through a set of narrow receivers aimed at different angles. Declassified for civilian use in the 1980s, the technology has since advanced to the point where it can detect features as small as one meter across and locate them to within one meter of their true geographic location. It provides users with two kinds of data: bathymetric (depth) data, and "acoustic backscatter". The latter, which records the amount of sound returned off the ocean bottom, helps scientists identify the geologic makeup — sand, gravel, mud — of the seafloor.

In the 1990s, government hydrographic agencies appropriated the technology to improve the accuracy of their nautical charts, particularly in harbors subject to sediment shifting and other navigation obstacles. Oil and gas companies seized on multibeam sonar to help explore the seabed in their search for hydrocarbon deposits. And by the late 1990s, some MPA managers began to see the possibilities offered by the technology for studying seafloor habitats. Jim Gardner, a marine geologist with the US Geological Survey, said, "Multibeam sonar gives managers, for the first time, a very clear view of the bathymetry and backscatter of their MPA — it's really the first time they've seen what they're protecting."

One question that the technology helps practitioners to answer is, Where should an MPA be sited? "A lot of people just draw a polygon on a map, and that becomes their marine protected area," said John Hughes Clarke, a marine geologist at the University of New Brunswick, Canada. But drawing an arbitrary line fails to consider the hydrographic forces — such as currents — that affect a site, or its topography. Notably, the Canadian government has expressed interest in using multibeam sonar to help it redraw the boundary for its exclusive economic zone, which officials aim to extend beyond the current 200-nm range in areas where the continental shelf stretches beyond that line.

Hughes Clarke believes that Canada's Department of Fisheries and Oceans (DFO) should take account of the seabed whenever designating MPAs. His team of researchers is mapping the Musquash Estuary, a shallow, partly intertidal area in New Brunswick that DFO is considering for formal MPA designation. In the estuary, he is using a series of multibeam surveys to map erosion, sediment deposition, and other surface-sediment changes over time — factors to consider when drawing up a management plan for the site.

Robert Rangeley, marine program director for the Atlantic regional office of World Wildlife Fund Canada

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Website with multibeam sonar images

To learn more about multibeam sonar and view seafloor images of MPAs and other marine sites, go to

http://walrus.wr.usgs.gov/pacmaps

This is the website of the Pacific Seafloor Mapping Project, operated by the US Geological Survey.

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For more information

Jim Gardner, US Geological Survey MS-999, 345 Middlefield Road, Menlo Park, CA 94025, USA. Tel: +1 650 329 5469; E-mail: *jvgardner@usgs.gov*.

John Hughes Clarke, Ocean Mapping Group, Department of Geodesy and Geomatics Engineering, University of New Brunswick, P.O. Box 4400, Fredericton, NB E3B 5A3, Canada. Tel: +1 506 453 4568; E-mail: *jhc@omg.unb.ca*.

Leslie Burke, Department of Fisheries and Oceans, Regional Director's Office, Scotia-Fundy Fisheries, P.O. Box 1035, Dartmouth, Nova Scotia B2Y 4T3, Canada. Tel: +1 902 426 9962; E-mail: *burkel@mar.dfo-mpo.gc.ca*

Andrew David, National Marine Fisheries Service, 3500 Delwood Beach Road, Panama City, FL 32408, USA. Tel: +1 850 234 6541 x208; E-mail: *andy.david@noaa.gov*.

G.P. Schmahl, Flower Garden Banks National Marine Sanctuary, 216 W. 26th Street, Suite 104, Bryan, TX 77803, USA. Tel: +1 979 779 2705; E-mail: *george.schmahl@noaa.gov*.

Jim Galloway, Canadian Hydrographic service, Institute of Ocean Sciences, 9860 West Saanich Road, Sidney, BC V8L 4B2, Canada. Tel: +1 250 363 6316; E-mail: *gallowayj@pac.dfo-mpo.gc.ca*.

(an NGO), said multibeam sonar benefits seafloor conservation in a number of ways. "First, the better we know the distribution of bottom types, the better we can map out both distinctive and representative habitats for protection," he said. "Second, we can better understand the relationships between patterns in benthic habitats and patterns in the distributions of benthic organisms. And third, by limiting bottomfishing to those areas with high fisheries yield, the area of seafloor that is impacted by bottom gear — and the diversity and abundance of bycatch — can be reduced."

Use of multibeam in marine protected areas

The number of marine protected areas that have been mapped using multibeam sonar is very small. The technology remains unfamiliar to many practitioners, and the cost to deploy it can be fairly high (see box *Questions and answers on multibeam sonar*). Nonetheless, planners and managers of several sites have incorporated it in their work, illustrating a mix of potential applications:

Sable Gully Area of Interest, Canada Sable Gully is a large undersea canyon off the coast of Nova Scotia. In 1998, DFO designated it as an Area of Interest, the first step in a process that could lead to formal designation as a marine protected area under Canada's Oceans Act, and funded a two-year research program to study the ecosystem. Included in the study was a multibeam mapping project — a joint effort among DFO, Natural Resources Canada, and the petroleum industry — to survey both the deep-water portions of the canyon and adjacent bank areas. The imagery proved to be invaluable for guiding subsequent benthic and deep-sea coral surveys. As well, it shed light on physical processes that drive the canyon system: for example, the multibeam survey offered insights to the role of smaller "feeder" canyons that carry materials from the surrounding area into the main Gully channel. Protection of the canyon's core habitat depends on the health of these feeder canyons. DFO will incorporate these and other findings into the upcoming management plan for the area, including boundary considerations. "We revisited the proposed boundaries in a number of ways, based on our improved understanding of the Gully system," said Leslie Burke, regional director of fisheries management with DFO.

Grouper fishery closures, US Threatened by overfishing, gag grouper have been the focus of efforts by the (US) Gulf of Mexico Fishery Management Council to help the commercially valuable stock rebound. In June 2000, the council designated two four-year fishery closures around sites that it determined could be valuable spawning aggregation sites — each roughly 10 nm by 10 nm along the 100-meter depth contour favored by grouper. Although the choice of sites was made without the benefit of multibeam sonar (coarse bathymetric data and fishermen's knowledge were used instead), follow-up multibeam studies of the closures in 2001 indicated the precise spots and seabed morphology where grouper tended to aggregate. Now that researchers can go straight to these spots, the cost of studying aggregations within the closures has dropped significantly from what it was prior to the multibeam mapping, according to biologist Andrew David of the National Marine Fisheries Service. "It allows us to maximize our research impact from the funds we have," said David. "It's well worth the investment."

Flower Garden Banks National Marine Sanctuary, US Also located in the Gulf of Mexico, the coral-laden Flower Garden Banks National Marine Sanctuary was first mapped with multibeam sonar in 1997. Now those maps form the basis for several of the MPA's programs, including its current effort to build a detailed habitat map of the entire site: management is currently "ground-truthing" areas of the sanctuary to check the multibeam map's assumptions of seabed habitat. As an education tool, said Sanctuary Manager G.P. Schmahl, the multibeam maps do a great job of showing stakeholders the unique geology of the site. "The maps go a long way toward explaining what the Flower Garden Banks are," he said. They have also helped in rapid-response situations: when a tie-off buoy from a nearby oil-drilling rig drifted into the sanctuary, management was able to overlay the buoy's coordinate with the multibeam map to gauge what type of ecological community it was on and how the buoy might affect that ecosystem.

Race Rocks Area of Interest, Canada The rugged Race Rocks archipelago off the province of British Columbia is on the verge of formal, federal designation as a marine protected area. Researchers have conducted a series of seabed surveys of the site — with multibeam sonar and other technologies — resulting in detailed imagery of rock outcrops, small sand waves, sediments located in depressions in rocky zones, and more. "The definition of the seabed assists in estimating the degree of uniqueness of this area, a fundamental requirement for designation as an MPA," said Jim Galloway, head of sonar systems for the Canadian Hydrographic Service. "Similarly these baseline surveys contribute to our knowledge of nursery locations within the boundary, thereby giving us the means to protect species and habitat appropriately." As it has done for Flower Garden Banks, the multibeam mapping has also contributed to community education efforts. "The dramatic imagery and definition greatly assisted stakeholders in their appreciation of the suitability of Race Rocks to be assigned MPA status," said Galloway. Incidentally, the Canadian Hydrographic Service is located within the Department of Fisheries and Oceans, which is responsible for designating MPAs in Canada. This co-location of responsibilities helped ease the process of executing the seabed surveys at Race Rocks and reduced operational costs, said Galloway.

Using multibeam sonar to reduce the seabed impacts of fishing

Off the Atlantic coast of Canada, the offshore scallop industry is using a multibeam sonar database to help its boats catch their quota of scallops in far less time. In doing so, the industry is dramatically reducing its impacts on the seabed.

The partnership between industry and the Canadian government began in 1996, when scallopers noticed a set of multibeam maps the Canadian Hydrographic Service (CHS) had created. The maps happened to show scallop grounds, with sediment types indicated. Knowing that scallops prefered light (or "pea") gravel, the scallopers quickly recognized that this map of sediment could be their route to better harvests. "Where you find pea gravel, you're likely to find scallops," said Eric Roe, director of government relations for Clearwater Fine Foods, an offshore scallop company.

Within two years, the six companies of Canada's Atlantic offshore scalloping industry had teamed with CHS and Natural Resources Canada (NRCan, another federal agency) to outfit a retired scallop vessel with a multibeam sonar system. Then, with technical expertise provided by CHS and NRCan, the industry proceeded to map three entire undersea banks. The cost to industry was more than CDN $3 million (US $1.9 million) over two years. "It was the largest industry-funded program of its nature in Canadian fisheries history, and potentially the largest of its kind anywhere," said Roe.

For the scallopers, it has been worth the investment. Scallop vessels now leave port with a computerized map showing exactly where to expect to find their target. Follow-up research has determined that the maps are nearly perfect (94% accurate) in identifying the presence of scallops. "It has changed from a hunting process to a gathering process," said Dick MacDougall of CHS.

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Questions and answers on multibeam sonar

Q: How much does multibeam sonar cost to operate?

A: Mapping the seabed using multibeam sonar requires a specially outfitted vessel and trained personnel. As a result, it can cost a significant amount:

- The US National Marine Fisheries Service spent roughly US $350,000 to map a set of fishing closures, totalling about 1130 km^2 in area, in the Gulf of Mexico.
- The offshore scallop industry on the Atlantic coast of Canada spent roughly CDN $3 million (US $1.9 million) to map three undersea banks at an estimated cost of CDN $1000/nm^2 (equivalent to US $625/nm^2, or US $180/km^2). The Canadian government also contributed technical expertise to this effort.
- The Department of Fisheries and Oceans in Canada spent roughly CDN $80,000 (US $50,000) on vessel time, contracts, and staff mapping the Race Rocks Area of Interest, which measures less than 1 nm^2 in area.

Many governments, including in developing nations, are applying multibeam to their undersea charting work. As such, this technology may be available to MPA managers who develop contacts with their national hydrographic agencies: the MPAs could be offered as a place for agencies to test new multibeam equipment.

For an MPA manager without access to such funds, multibeam sonar may be out of reach. However, according to Jim Gardner of the US Geological Survey, many governments — including in such developing nations as India, Indonesia and China — are applying multibeam sonar to inform their hydrographic charts. As such, this technology may be available to MPA managers who develop contacts with their national hydrographic agencies: there may be opportunities, for example, for managers to offer their MPAs as a place for agencies to test new multibeam equipment. This is how the Flower Garden Banks National Marine Sanctuary, in the US, came to be mapped with multibeam.

Q: What is the difference between multibeam sonar and sidescan sonar?

A: Multibeam sonar and sidescan sonar both provide photograph-like images of the seafloor and information on the geologic makeup of the ocean bottom. However, they have some important differences. Sidescan sonar, for example, does not provide data on depth. And because it is towed behind a research vessel — rather than attached to the ship's hull, like multibeam sonar — scientists must make assumptions about the location of the towed device to determine the geographic location of mapped areas. The data collected by multibeam sonar, in contrast, are firmly tied to the ship's position, and compensations can be made for the ship's roll and other movements. As a result, multibeam sonar maps are usually more geographically accurate than sidescan images.

For more information

Eric Roe, Clearwater Fine Foods, 757 Bedford Highway, Halifax, NS B4A 3Z7, Canada. Tel: +1 902 457 2343; E-mail: *eroe@cffi.com.*

Dick MacDougall, Canadian Hydrographic Service, Bedford Institute of Oceanography, 1 Challenger drive, Dartmouth, NS B2Y 4A2, Canada. Tel: +1 902 426 3497; E-mail: *macdougallr@mar.dfo-mpo.gc.ca.*

Leslie Burke, Department of Fisheries and Oceans, Regional Director's Office, Scotia-Fundy Fisheries, P.O. Box 1035, Dartmouth, Nova Scotia B2Y 4T3, Canada. Tel: +1 902 426 9962; E-mail: *burkel@mar.dfo-mpo.gc.ca*

Robert Rangeley, Atlantic Regional Office, World Wildlife Fund Fund Canada, Suite 1202, Duke Tower, 5251 Duke St., Halifax, NS B3J 1P3, Canada. Tel: +1 902 482 1105; E-mail: *rrangeley@wwfcanada.org.*

MPA News

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Direct correspondence to: MPA News, School of Marine Affairs, Univ. of Washington, 3707 Brooklyn Ave. NE, Seattle, WA 98105, USA. Tel: +1 206 685 1582; Fax: +1 206 543 1417; E-mail: *mpanews@u.washington.edu.*

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One metric ton of scallops used to take the fishermen more than six hours to harvest; now it takes less than two and a half hours. The industry, managed under an individual quota system with total-allowable-catches, reaches its quotas in a fraction of the time it used to take, resulting in lower crew and fuel costs and less wear on gear. With captains focusing on the high-yield areas, the amount of seafloor dragged in pursuit of scallops has been reduced by as much as 70%. "As long as there is a scallop fishery, there is going to be an impact [on the seabed]," said Clearwater's Roe. "It is incumbent upon us to reduce that impact as much as possible."

Fishery managers have incorporated the new information. "We're able to observe almost bed-by-bed productivity for the scallops," said Leslie Burke, regional director of fisheries management with the Canadian Department of Fisheries and Oceans (DFO). "A more optimal total-allowable-catch will be the expected result." Multibeam mapping could spur a revolution in the management of more than just scallops. "The interest in multibeam from other fisheries will grow over time," said Burke.

However, two factors make the offshore scallop industry especially well-suited to the technology: 1) Scallops can be mapped reliably because they are relatively sedentary and found in high association with a particular substrate; 2) The industry's quota system under DFO assures the fishermen a secure level of access, thereby providing a strong incentive for industry to invest in science, mapping, and other activities with long-term benefits. "The Canadian offshore scallop industry has a history of working cooperatively on a range of science issues that would be of mutual benefit," said Roe. "We have a vested interest in maintaining and possibly growing the resource pie."

Application of multibeam mapping to an open-access fishery would likely have different long-term results: stocks could be quickly wiped out. The rarity of multibeam data relevant to open-access stocks has kept this from becoming a problem so far. Paradoxically, the inavailability of multibeam data could pose a separate problem, say some conservationists. That is, keeping multibeam maps proprietary — for use by industry and government only, for example — could give industry an enormous advantage. Said Robert Rangeley, marine program director for the Atlantic regional office of World Wildlife Fund Canada, "A proprietary regime does not allow the broader community of researchers and conservation advocates access to the data and the benefits for ocean resource planning and siting of MPAs."

Notes & News

No-take zones in Solitary Islands Marine Park (Australia) take effect

No-take zones comprising 12% of the 710-km^2 Solitary Islands Marine Park in New South Wales (NSW), Australia, took effect August 1, 2002. Initial government proposals for the zoning scheme had set the no-take percentage at 7%, but that figure was increased in response to public comments and meetings with stakeholders. These "sanctuary zones" will prohibit all fishing activity, including recreational; scuba diving is still allowed. Criteria used in the selection of these areas included representation of habitat type, biodiversity, and various natural or cultural features.

The sanctuary zones will be buffered by "habitat protection zones" that encompass a further 54% of the park and allow for the use of certain types of commercial fishing gear (trawling is prohibited). Roughly one-third of the park will serve as a general use area, where most types of commercial fishing will be allowed. Recreational anglers, prohibited from the sanctuary zones, will have access to the remaining 88% of the park. The zoning scheme is the first comprehensive plan for any NSW-run marine park.

Under state law, the main objectives of NSW marine parks are to conserve marine biodiversity and habitats, and maintain ecological processes. Where consistent with the above objectives, management plans are also to provide for the sustainable use of fish and opportunities for public appreciation and enjoyment. The NSW government announced an AU $4 million (US $2.1 million) initiative to buy out 30 commercial fishermen from the Solitary Islands Marine Park to ensure that the zoning plan does not cause an unsustainable shift in commercial fishing to other areas of the park.

Also in New South Wales, a new zoning plan for the state-run Jervis Bay Marine Park will take effect on October 1. Roughly 20% of the 220-km^2 park will be no-take zones.

For more information: Libby Sterling, Marine Park Manager, Solitary Islands Marine Park, PO Box J297, Coffs Harbour Jetty, NSW 2450, Australia. Tel: +61 6652 0910; E-mail: *libby.sterling@npws.nsw.gov.au*; Web: *www.nationalparks.nsw.gov.au/npws.nsf/Content/Marine+parks.*

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www.mpanews.org

MPA Perspective Mitigating the Effects of Coastal Development on the Sian Ka'an Biosphere Reserve: A Case Example from Mexico

By Juan E. Bezaury Creel

In the state of Quintana Roo, Mexico, along the Meso-American Reef, lies the Sian Ka'an Biosphere Reserve. A World Heritage Site, the reserve covers 1.6 million acres (6500 km^2) of coastal and marine habitats, from tropical rainforest to mangroves and coral reefs. Recognized worldwide for its biodiversity, the site contains some areas that have been zoned off-limits to humans under the reserve's management plan, which controls land use and activities in public properties and waters.

However, several businesses and private coastal properties remain within the reserve from before its designation in 1986. Under Mexican law, land tenure within a protected area is not necessarily altered when the area is designated. Until this past May, there was no plan to mitigate environmental effects from uncontrolled development of these private parcels in Sian Ka'an, the single-most important threat to the biological integrity of the site.

Upon its publication on May 24, 2002, the environmental zoning plan (EZP) for the reserve became the legal instrument that controls land use over the private properties within the site. Representing a 10-year, joint governmental and NGO effort, the Sian Ka'an EZP features a system of "transferable development easements". These easements allow for limited development transferability by property owners. In contrast to "transferable development rights" — with which planners have experimented in other areas of the world — the easements are not as freely marketable, allowing for easier enforcement.

As it does for all islands in the reserve, the EZP bans development along a total of 35.5 km, or 28%, of the reserve's coastline. These areas contain the most ecologically important coastal ecosystems and a representative system of the area's coastal vegetation assemblages. The development potential of any private parcels on these lands can be transferred to less ecologically sensitive coastal properties within the reserve.

Over the remaining 102 km of coastline without total protection, limited development may occur. One vacation home is permitted on each existing lot, and further subdivisions to lots with less than a 100-m sea frontage are prohibited. The most-likely "balanced development" scenario could include a mixture of vacation homes and hotels for a total of around 450 homes (average 4.41 houses per km of coastline) and around 750 hotel rooms (average 8.9 rooms per km of coastline). Under the EZP, basic hotel densities within the reserve's 1,580 hectares (15.8 km^2) of private coastal property range from 0.35-0.5 hotel rooms per hectare. These densities could be increased somewhat as incentives for owners of large parcels to not subdivide their property, or for owners within the no-development zones when they transfer their rights to less sensitive areas.

Allowed development, even if planned at a very low level of intensity, will certainly increase pressures on the resources of the Sian Ka'an coast. Depending on the balance reached between vacation homes and hotels, the average daily number of tourists in the reserve could fluctuate from 3,000 to 4,200 and the resident population of the reserve — now close to 1,000 — could fluctuate between 4,500 and 5,700. The balanced scenario described above would result in 8,400 m^3/day of water that would need to be pumped out from a very limited aquifer, captured from rainfall or trucked in. After use, the 6,200 m^3/day of waste water would need to be treated. Garbage generated could add up to 2,160 metric tons per year, and additional fisheries pressure from the local population for home consumption could represent demand for 415 metric tons of extra fish products per year.

Nevertheless the most important challenge is the establishment of procedures, systems and controls that allow for adequate monitoring and enforcement of the EZP. EZPs are still relatively weak tools, mainly due to the lack of human and financial resources for enforcement. As a result, enforcement comes mainly from public outcry and pressure. The concept of "environmental white guards" — being developed by Amigos de Sian Ka'an for an adjacent portion of the coast — might prove to be a model that provides the Sian Ka'an EZP with a good set of teeth. This model integrates a non-official operative network of NGOs, interested individuals and government officials. When a network participant observes an act of noncompliance, he coordinates with other participants to inform the government agency in charge of solving the noncompliance problem. Capacity allowing for public broadcasting efforts, and/or direct legal action to resolve the noncompliance issue, is also created within the network.

The Sian Ka'an EZP does not represent by itself a magic solution but — used in conjunction with the site's management plan, administrative capacity and a good measure of strategic social support — it can become an innovative way to mitigate the effects of uncontrolled coastal development.

Editor's note:

Juan Bezaury Creel, author of the adjoining perspective piece, is an environmental policy associate for The Nature Conservancy - Mexico, an NGO. In this piece, he describes an innovative effort in Mexico to protect the Sian Ka'an Biosphere Reserve from the effects of uncontrolled shoreline development. Underlying the site's protection is an environmental zoning plan (EZP), published in May 2002. In Mexico, EZPs are the legal instrument allowing for integrated coastal management.

For more information

Juan Bezaury Creel, Mexico Operative Unit, The Nature Conservancy, 4245 North Fairfax Drive, Suite 100, Arlington, VA 22203-1606, USA. Tel +1 703 841 4881; E-mail: *jbezaury@tnc.org*.

Letters to the Editor

The letter writers

John R. Clark is co-author of *Marine and Coastal Protected Areas: A Guide for Planners and Managers* (2000, IUCN).

Graeme Kelleher is a former chairman and chief executive of the Great Barrier Reef Marine Park Authority, and has edited and authored several MPA-related publications, including IUCN's *Guidelines for Establishing Marine Protected Areas* (1999).

Dear MPA News:

Bill Ballantine's attempt to clarify terms for marine area conservation falls short of the mark (MPA News 4:1). Terminology has already been pretty much worked out in the past decade. To use the term "reserve" to mean only a fully protected area is not helpful. An area designated a marine reserve in many countries may include a mix of uses within its scope.

The confusion over terms and practices can be minimized by designated "zoning", which has been practiced for many years to address multiple use. With use zoning, certain areas within an MPA are selected for full protection. This is rational and simple, plus it provides space for general conservation surrounding the fully protected part — which Ballantine terms "reserve" and others call "no-take zone". IUCN terms such areas (zones) "strictly protected".

A discussion of zoning and terminology for multiple use areas and fully protected areas appears in "Zoning — lessons from the Great Barrier Reef Marine Park" (*Ocean and Coastal Management*, Vol. 45, Nos. 2&3, 2002, by J.C. Day).

John R. Clark

P.O. Box 420-313, Ramrod Key, FL 33042, USA. Tel: +1 305 872 4114; E-mail: *JohnRClarkX@cs.com*.

Dear MPA News:

I read and strongly agreed with Tundi Agardy's contribution (MPA News 3:11) and I agree with the substance of Bill Ballantine's article in the July 2002 issue (4:1). However, there are two points I'd like your readers to know — in relation to nomenclature and scale — so that they understand Tundi's points.

1. The definition of MPAs used by IUCN, the World Commission on Protected Areas (WCPA), the World Conservation Monitoring Centre (WCMC), etc. has seven categories. One of these, Category Ia, totally excludes "take" [i.e. is a no-take MPA]. The other, Cat Ib, allows only limited take by indigenous, traditional communities. The term "reserve" is often used to mean "no-take" but, like MPA, can mean a less protected area. Tundi was using the term MPA in its intended way, to include but not be limited to no-take MPAs or reserves.

2. Readers should be aware that, while Bill Ballantine's figure of 4.5% of the Great Barrier Reef Marine Park is no-take, this amounts to more than 16,000 km^2. It would therefore be wrong to conclude that this amount is insignificant, since it exceeds by a great margin the total area of no-take MPAs in nearly any other country. As well, readers should be aware that trawling — perhaps the most damaging of fishing techniques — is prohibited in 50% (172,000 km^2) of the MPA.

Graeme Kelleher

12 Marulda Street, Arenda, Canberra ACT 2614, Australia. Tel: +61 2625 11402; E-mail: *g.kelleher@gbrmpa.gov.au*.

Notes & News

Canada passes law to help create representative system of marine parks

In June, Canada passed a bill to facilitate creation of a representative system of "national marine conservation areas", or NMCAs, to be overseen by Parks Canada, the federal parks agency. Although the concept of NMCAs existed previously under national parks law, the new legislation provides clearer guidance for establishing and managing these protected areas.

NMCAs are designed to be models for sustainable use. Among the new law's provisions are a ban on mineral and hydrocarbon development in NMCAs, and a requirement that each site include at least one zone that fully protects special features or sensitive ecosystem elements. The law instructs that NMCA management plans be based on principles of ecosystem management and the precautionary principle; this would include potential limits on fishing inside NMCAs.

Parks Canada is charged with creating a system of NMCAs to represent the range of ecosystems found in Canada's Atlantic, Arctic, and Pacific Oceans, as well as its Great Lakes. The first two NMCAs to be designated under the law are expected to be in Western Lake Superior (in the Great Lakes) and off the Queen Charlotte Islands on the Pacific coast, adjacent to the Gwaii Haanas National Park Reserve.

Under Canadian law, NMCAs are differentiated from "Marine Protected Areas". The latter term refers specifically to protected sites overseen by Canada's Department of Fisheries and Oceans that are designated to protect specific marine resources and habitats. Francine Mercier, a senior planner for Parks Canada, said the two agencies are collaborating to ensure protection of a full representation of Canada's marine habitats. "These will be complementary systems," she said.

For more information

Susan Katz, Director of Legislation and Policy, Parks Canada, 25 Eddy, 4th Floor, Hull, Quebec K1A 0M5, Canada. Tel: +1 819 994 2691; E-mail: *susan.katz@pc.gc.ca*.

Doug Yurick, Chief, Marine Program Unit, Parks Canada, 25 Eddy, 4th Floor, Hull, Quebec K1A 0M5, Canada. Tel: +1 819 997 4910; E-mail: *doug.yurick@pc.gc.ca*.