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Vertical zoning of MPAs: When it is appropriate, when it is not, and how science is changing our understanding

For a marine protected area to be *effective* means it is successfully addressing threats to the features the MPA was designed to protect. So if an MPA is designed specifically to protect a certain benthic community — like a deep-sea coral reef — then it is effective if it minimizes or eliminates the threats to that community.

This raises the question, What is considered a threat? Sometimes it is direct and significant: say, a bottom trawl pulls up part of an important reef. In that case, bottom trawling is a threat to that reef. In other cases, the impact of various uses may be insignificant. In those instances, the uses might be considered compatible with a site's protection objectives.

One management strategy — vertical zoning — aims to apply such considerations to different sections of the water column. With vertical zoning, part of an MPA's water column is usually highly protected (no-take) while the rest remains open to some uses, typically fishing. Usually the no-take portion is the benthic area, where there may be coral reefs or other habitats that are particularly sensitive to bottom-contact fishing gear.

There are many examples around the world. Among the largest is New Zealand's 1.2 million-km^2 network of 17 benthic protection areas. MPA News reported on that network in 2007; the article also provided links to several other cases.

In more recent news, Canada and Mexico each designated significant MPAs that are vertically zoned. Canada designated the Hecate Strait and Queen Charlotte Sound Glass Sponge Reefs Marine Protected Area in February 2017, and Mexico designated the Mexican Caribbean Biosphere Reserve and Deep Mexican Pacific Biosphere Reserve in December 2016.

Importantly, for vertical zoning to be effective, it requires that ecosystem links between the area's benthic zone and the pelagic waters above it are relatively few or weak. The fewer or weaker the links, the less likely it is that pelagic fishing will compromise the health of the underlying benthic community. In contrast, in cases where there are significant 'benthic-pelagic linkages', vertical zoning is not as appropriate for maintaining benthic communities.

What is making vertical zoning increasingly tricky as a management tool is that, while the push in policymaking to balance conservation and fishing is often strong, science is discovering more about benthic-pelagic linkages. This month MPA News examines the evolving science of such linkages, including in the context of the new Mexican and Canadian MPAs.

The changing state of science on BP linkages

In 2005, the US National Marine Protected Areas Center convened a multi-stakeholder workshop on managing recreational fishing in MPAs through vertical zoning. At the time, the science on BP linkages was very young. In light of gaps in scientific knowledge, the workshop aimed to outline some general conditions under which benthic-focused MPAs could achieve conservation goals while allowing recreational fishing in the overlying water column.

"That period was a time of intense interest in the promise of MPAs, mirrored by widespread concerns among fishermen and others about the scientific rationale for MPA objectives, siting, size and levels of protection," says Charlie Wahle, who led the workshop and is Senior Scientist with the National MPA Center. "Stakeholders often assumed that proposed MPAs would necessarily be fully protected no-take areas, permanently excluding fishing of all types. These concerns were particularly acute among pelagic sport fishermen, whose activities were typically occurring well above protected benthic communities that are often the primary conservation targets of MPAs."

The workshop's participants — recreational fishers, ocean managers, scientists — outlined the state of the science at the time on BP linkages. Workshop leaders described the three main trends in an essay for MPA News in 2006:

- BP linkages can generally be expected to be stronger and more direct in shallow water habitats (i.e., seafloors 50-100m deep); among coastal pelagic fish species (e.g. jacks, mackerel, bluefish); in predictable spawning aggregations that feed heavily on the benthos; in upwelling zones and other areas of localized biophysical coupling; and in habitats with pronounced three-dimensional relief (e.g., coral reefs, shallow sea mounts, kelp beds).
- Second, BP linkages may be generally weaker and more indirect in deeper habitats where pelagic predators rarely encounter benthic prey and among oceanic pelagic species (e.g., tuna, sharks, marlin).
- Third, there are many circumstances in which ecologically important interactions are likely to be complex, unpredictable, and/or poorly understood. Local ecological factors contributing to complex BP linkages include multiple interactions within and among trophic levels (e.g., with mid-water forage or bait fish); complex behaviors and life histories among key local species; the ephemeral appearance of highly mobile predators; and/or the size of pelagic predator populations.

Based on those trends, the workshop developed a set of practical 'rules of thumb' for planners and stakeholders on how to consider BP linkages in the design and management of benthic-focused MPAs. In short, vertical zoning made sense in areas with weak or indirect BP linkages. It made less sense to consider in areas with strong or direct linkages. And in areas where the extent of linkages was unclear, a precautionary and adaptive approach to MPA design would be appropriate. (The rules of thumb were fleshed out and illustrated in this 2008 paper in *Fisheries* journal. Wahle adds that the guidance could apply just as well to commercial fishing in multiple-use MPAs after accounting for inherent differences in gear, scale, intensity, and other factors.)

With the newness of science on BP linkages at the time, the recommendation of a precautionary approach was wise. Since then, the science of BP linkages has become more robust. Wahle notes there have been several notable advances, including in our understanding of:

- The patterns, timing, and local ecological effects of the movements of highly migratory pelagic species;
- The critical ecological roles played by mid-water forage fish;
- The structure and implications of complex food webs and the impacts of their disruption; and
- The trophic importance of regular vertical migrations of key species in many habitats. The nightly vertical migration of copepods and other species to surface waters to feed, then back to deeper waters by day, is one example.

In addition, the ecosystem role of deadfall in the ocean — when the carcasses of pelagic species sink to the bottom — is gaining in appreciation, including in the context of the emerging study of 'fish carbon'.

"My sense is that these findings will continue to both inform and underscore the importance of incorporating benthic-pelagic linkages into place-based marine planning like MPAs," says Wahle.

In Mexico, knowledge of BP linkages informed new deep-sea MPAs

Such scientific advances were taken into account in the planning of Mexico's new deep-sea biosphere reserves — the 57,541-km^2 Mexican Caribbean Biosphere Reserve in the Caribbean Sea, and the

577,862-km^2 Deep Mexican Pacific Biosphere Reserve in the country's Pacific waters.

Both sites effectively have vertical zoning and host important commercial fisheries:

- The Caribbean reserve has a multiple-use zone from sea level down to 100m that allows fishing. Below that, portions of the lower water column include three no-take core zones.
- The Pacific reserve has several no-take core zones that extend from 800m below the sea surface to the seafloor (which is as deep as 6700m, Mexico's deepest seabed area). The water above 800m is not technically part of the MPA but effectively operates as a de facto multiple-use zone.

Juan Bezaury Creel of The Nature Conservancy's Mexico and Northern Central America Program was involved in designing the new biosphere reserves with Mexico's Natural Protected Areas Commission (CONANP). He acknowledges that the science on BP linkages still has many gaps. "Our mostly incomplete understanding of how benthic and pelagic systems and species interact, and the ways surface or mid-water fisheries may negatively impact the integrity of benthic communities below, represent real problems in MPA design," he says.

Planning of the two MPAs incorporated what information was available. This focused largely on existing modeling of carbon 'detrital flux' at 500m below sea level. (The modeling was provided by Andrew Yool from the UK's National Oceanography Centre through Elva Escobar at National University in Mexico City.) Detrital flux is the movement of carbon nutrients up and down in the water column. The greater the amount of flux, the greater the degree of vertical intermixing. This is a surrogate for BP linkages.

"The Deep Mexican Pacific Biosphere Reserve presented mostly high values [for detrital flux], with medium values to a lesser extent, suggesting a significant benthic-pelagic environmental linkage," says Bezaury. "The Mexican Caribbean Biosphere Reserve presented only low values, thus suggesting a lower benthic-pelagic environmental linkage."

These data were incorporated into a Marxan analysis that, together with mapping of various targeted habitat types (submarine canyons, ocean ridges), ultimately informed the biosphere reserves' designs. (For observant readers: Yes, the Caribbean reserve, which was believed to have less BP linkage, ended up with a shallower multiple-use area than the Pacific reserve, which has greater BP linkage. The Pacific reserve was sited deeper due to the presence of an important tuna fishery in the overlying waters.)

Bezaury notes that the waters above each new MPA are also whale refuge areas under a 2002 Mexican law that protects all large whales in Mexico´s EEZ. This contributes to ensuring a natural rate of 'whale falls' (the descent of whale carcasses to the seafloor) that create ephemeral but important habitats for deep-sea communities.

Considering the presence of important pelagic commercial fisheries at the Pacific reserve and important international shipping lanes at the Caribbean reserve, it seems doubtful that absolute protection of the entire water column would have been achievable. Bezaury acknowledges the disadvantages of vertical zoning. Aside from potential impacts on BP linkages, such zoning can make enforcement more challenging. "It is much more difficult to monitor vessels for compliance in an MPA that allows a pelagic fishery than to monitor when fishing vessels are completely excluded," he says. This problem can be addressed through satellite tracking of the fishing fleet. Mexico already tracks the tuna fishery above the Deep Mexican Pacific Biosphere Reserve, for example.

Bezaury says the potential downsides are worth it. Vertical zoning provided an opportunity to achieve protection for the sites' deep-sea areas, of which many — due to their great depth — had not yet been fished or mined. (A similar proposition — that benthic conservation objectives could be achieved without negatively impacting fishing — was made by advocates of New Zealand's benthic protection areas.)

"Since currently there are no public or private stakeholders using deep-sea resources in Mexican marine zones, this is precisely what makes the creation of a system of deep-sea MPAs so timely," he says. "Why wait for conflicts to emerge in order to create such system? The Mexican Caribbean and Deep Mexican Pacific Biosphere Reserves now provide protection to over one-fifth of Mexico´s deep-sea habitats."

In Canada, vertical zoning and glass sponge reefs

The 2410-km^2 Hecate Strait and Queen Charlotte Sound Glass Sponge Reefs Marine Protected Area provides protection for three globally unique and ancient glass sponge reef complexes, off Canada's Pacific coast. With skeletons made of silica, the glass sponges have reef structures estimated to be thousands of years old. Glass sponge reefs of this size — once abundant during the Jurassic Period — were believed to be extinct before these colonies were discovered in the 1980s.

In the 1990s, scientists noticed areas of damage to the reefs, mainly from bottom trawling but also from trap fishing and long-line gear. (Gear from mid-water trawling around the reefs was also known sometimes to contact the seafloor, based on the presence of groundfish in some catches.) The observed damage led scientists and conservation groups to call for protection of the reefs. In 2000, local fishermen instituted a voluntary closure for bottom trawling, and that was formalized into a legally designated fishing closure in 2002. But the reefs remained at risk from other bottom and mid-water fisheries, as well as activities like cable-laying, anchoring, and mining. So in 2010, Canada identified the reefs as an Area of Interest for potential future designation as a marine protected area. That MPA was finally designated in February 2017.

The MPA comprises three non-adjacent areas that encompass distinct reef sites. Within each area are different management zones with varying levels of protection:

- A Core Protection Zone contains the sponge reefs, seabed, and subsoil as well as the water column from the seabed to a minimum of 40m from the highest point of each reef;
- A Vertical Adaptive Management Zone (VAMZ) is designed to mitigate risks of direct impacts to the reefs, and extends above the horizontal extent of the Core Protection Zone to the sea surface; and
- An Adaptive Management Zone (AMZ) surrounds the Core Protection Zone horizontally and is designed to mitigate risks of indirect impacts to the reefs.

All fisheries are prohibited in the Core Protection Zones. All commercial bottom-contact fishing activities for prawn, shrimp, crab, and groundfish, as well as mid-water trawl for hake, are prohibited in the AMZ and VAMZ. (Effectively this prohibits commercial fishing in the AMZ, whereas some commercial fishing in the VAMZ remains.) All recreational fishing activities are allowed. The MPA's full regulations are here.

Sabine Jessen is National Oceans Program Director for the Canadian Parks and Wilderness Society (CPAWS) and was among the first advocates for designating an MPA to protect the reefs. Jessen was a representative of the conservation sector on the stakeholder committee that advised the MPA's designation process. She says the vertical zoning — with some commercial fishing remaining in the VAMZ — was a considerable, but necessary, compromise. "If we had not agreed to it, we would not have been able to get the horizontal buffer zone [the AMZ] with no fishing activities," she says. "We felt the latter was absolutely critical to protecting the sponge reefs from sedimentation and accidental damage caused by bottom-contact fishing gear."

Notably, draft regulations for the MPA in 2015 proposed allowing mid-water trawling to continue within the VAMZ despite indications that such trawling occasionally contacted the bottom. In response to conservationists' concerns, the government — now under a different prime minister and political party — applied a more restrictive approach in its final regulations, prohibiting mid-water trawling unless no impact to the reefs from such gear can be demonstrated.

"So while we had to concede to vertical zoning to get the MPA in place, we have continued to voice our concerns about it," says Jessen. "We are just starting to discover the important role of the reefs as nutrient cyclers and carbon sinks, as well as the details of the biology and ecology of the reefs. The more we are learning, the more apparent the benthic-pelagic connections are becoming."

Although much remains to be known about the mysterious glass sponges, some of their basic characteristics have been determined. The sponges feed on marine snow (the slow shower of organic material falling from upper waters to the benthos) and sediments lifted by currents. They have the ability to shut off flow through their vascular cavities, and there is evidence that they do this to limit dense sediment loads. (A 2013 study of the biological effects and impacts of sediment to the sponge communities is available here.)

Jim McIsaac is Pacific region vice-president for the Canadian Independent Fish Harvesters' Federation and also executive director of the T. Buck Suzuki Environmental Foundation, which works to protect fish stocks and fish habitats. He served on the same stakeholder advisory board for the glass sponge reefs MPA as Jessen. McIsaac says the key to ensuring the welfare of sponge reefs and fishermen is not so much about balancing conservation and fisheries as about recognizing the need for their *co-existence* — conservation and an economy, conservation and livelihoods, conservation and food.

"Vertical management zones for the sponge reefs MPA were proposed as a way to protect that co-existence: the sponge reefs at depth (150m-240m) and fishing in the water column above (0-100 m)," he says.

He acknowledges that co-existence will bring some impacts. "Of course there are interactions from current, noise, vibration, and other possible impacts," he says. "We don't know them all, nor do we know all the risks. We do believe impacts can be avoided." McIsaac says that as long as the risks to the reefs are small, co-existence has value, particularly in light of the importance of food production for society.

"Food is a fundamental human need," he says. "We are all part of the problem. We must all be part of the solution."

BP linkages and the precautionary approach

As scientists learn more about BP linkages, it remains to be seen whether MPA regulations will grow stricter and less open to vertical zoning. Or perhaps interest in finding a co-existence between conservation and fisheries will continue to steer planners toward it, at least in some cases.

Returning to the rules of thumb from the 2005 workshop on vertical zoning (mentioned earlier), which attempted to bring some clarity and objectivity to the MPA debate, the nature and extent of protections in any given MPA should reflect its fundamental purposes and objectives. If it is focused solely on conserving benthic communities, and if those communities are known to be largely independent of events occurring in the overlying water column, then vertical zoning could provide an effective management solution acceptable to many.

If, on the other hand, the area has strong BP linkages or is simply a place that warrants total protection due to its vulnerability or legacy value, then vertical zoning is clearly not appropriate.

For the areas where we just do not know, it may come down to taking a precautionary approach. The question then becomes, How precautionary are MPA planners willing or able to be?

IUCN has already stated its opposition to such zoning:

> "IUCN's position is a strong presumption against vertical zoning. It often does not make ecological sense, as how benthic and pelagic systems and species interact is not yet fully known, and surface or mid-water fisheries may in fact impact on the benthic communities below…. We are only just beginning to develop a scientific understanding of the vertical ecological connections that exist in marine ecosystems." (See page 26 in this document.)

Yet the drive for co-existence between conservation and fisheries is likely to continue. As is the interest — particularly in areas with a strong fishing presence — in achieving some level of protection rather than perhaps no MPA at all. Designing each MPA from its fundamental objectives "up" is a good way to find that balance.

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