Marine reserves: the best option for our oceans?

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Ideas and epidemics have intriguing similarities. Some die out quickly, while others linger but never become prevalent. Still others with the right combination of attributes at the right time experience explosive growth, with dramatic effects. The idea of protecting places in the sea is in a rapid growth phase. In contrast with temporary fishery closures, marine protected areas (MPAs) are permanently protected from at least one threat. Marine reserves are MPAs that are protected from all preventable threats.

National parks on land date from 1872 (Yellowstone), but intentional protection of places in the sea is more recent. Fort Jefferson National Monument in Florida, which contains important coral reefs, was designated in 1935, yet progress was still gastropodal when I started working on MPAs in 1978. Also, most MPAs were designated with little scientific basis. Pollution, especially oil pollution, was seen as the biggest threat, probably because oil floats, thereby making its effects more visible. Locations were chosen mainly because somebody liked them enough to work to secure nominal protection. Such MPAs could accomplish little beyond raising consciousness about what would soon be called biological diversity, but an outbreak of new thinking occurred in the late 1990s. By the time of the first Symposium on Marine Conservation Biology in Victoria, British Columbia, in 1997, nearly all the buzz concerned marine reserves. What had happened?

Before then, the prevailing science dealing with human impacts on marine organisms – fisheries biology – had generally treated the sea as being uniform. But new oceanographic tools, from satellite images of ocean productivity patterns to remotely operated vehicle photographs of benthic ecosystems, showed that the sea is heterogeneous and dynamic. Ecologists' realization that metapopulation and source–sink dynamics apply to species with planktonic larvae allowed us to better understand dispersal, recruitment, post-recruitment survivorship and reproduction – processes that, together, produce existing patterns. An obvious conclusion is that some places in the sea are particularly important.

Then, in 1998, 1605 marine scientists and conservation biologists from 70 nations released *Troubled waters: a call for action* (www.mcbi.org/AboutUs/TroubledWaters.pdf), an unprecedented statement that the sea is imperiled, that fishing is a major cause, and that a sizeable portion of the sea should be protected from threats. A landmark study by Pauly *et al.* (1998) showed that fishing greatly reduces the average trophic level of fish catches worldwide. Watling and Norse (1998) showed that trawling profoundly disturbs the seafloor on a vast scale. Jackson *et al.* (2001) and Myers and Worm (2003) confirmed that fishing threatens biodiversity and healthy fisheries on a global scale.

Clearly, prevailing management hasn't worked. In 1999, therefore, the National Center for Ecological Analysis and Synthesis (NCEAS) began a study to advance the theory of marine reserve design and to synthesize data on the performance of existing reserves (Lubchenco *et al.* 2003). The participating scientists concluded that reserves trigger lasting, often rapid increases in abundance, diversity, and productivity of marine organisms, and that reserve size matters. However, even small reserves have positive effects, reserve networks achieve benefits greater than isolated reserves, and full protection is necessary to achieve these benefits. Furthermore, in the few studies that examined effects outside reserves, size and abundance of exploited species increased, thanks in part to larval spillover. The NCEAS working group concluded that existing scientific information justifies immediate application of marine reserves as a central management tool. Superimposed on findings by the National Research Council panel on MPAs (Houde 2001), the NCEAS study provided a compelling case for establishing marine reserve networks.

The growing scientific consensus has evoked diverse responses. In 2000, President Clinton issued Executive Order 13158, calling for a national system of MPAs and the Bush administration is now implementing it, albeit slowly. Conservation organizations that had intermittently supported less protective MPAs were immediately energized, shifting their focus to fully protected marine reserves. Lobbyists for some commercial fishing interests oppose reserves, maintaining that the science is inconclusive. Hard-liners in the recreational fishing community either oppose reserves or argue that sportfishers (numbering perhaps 16 000 000 in the US) have such small impact that sportfishing should be allowed in reserves. In a move reminiscent of "scientific debates" on pesticides, cigarette smoking, and global warming, a sportfishing trade association commissioned a fisheries biologist to issue a critique of reserve theory (Shipp 2002), which was rebutted by ecologists who study reserves (Carr *et al.* 2002). In 2003, the blue-ribbon Pew Oceans Commission (including fishermen, environmentalists, and scien-

tists) recommended the establishment of a national system of marine reserves.

Protected areas have become the last redoubts for many terrestrial species. In the sea they probably have the additional benefit of replenishing depleted populations outside their boundaries. Reserves cannot solve all marine conservation problems, and are likely to work best when integrated with temporary fishery closures, traditional fishery management methods, and buffer zones. Given the urgent need to protect and recover marine biodiversity, the case for reserves is so strong that it seems imprudent to wait until implacable opponents of marine conservation are convinced by the evidence.

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In his opening statement Norse writes, "Ideas and epidemics have intriguing similarities." So too, we believe, do epidemics and the sudden advocacy of (MPAs) as a panacea for the ocean's ills. Epidemic is exactly how we would describe the onslaught of information supporting the use of MPAs to save the imperiled seas from, among other things, the adverse effects of fishing (NRC 2001; Lubchenco *et al.* 2003). While we don't quibble with the assertion that, globally, the oceans are in dire need of increased protection, we would argue that some of the touted benefits of MPAs are controversial and have not been conclusively demonstrated.

Unfortunately, the debate concerning the use of MPAs to achieve sustainable fisheries has become polarized, and is rife with scientific advocacy and oversimplification (Lubchenco *et al.* 2003; Shipp 2003). Most egregious to us is the naiveté of some people regarding the accomplishments of fishery science. For example, Norse states that prior to 1997, "fisheries biology…had generally treated the sea as being uniform". Such a statement, at best, ignores the rich and long-standing contributions of fisheries science to our understanding of ocean ecosystems (Hjort, Cushing, Harden-Jones, and Sinclair) and, at worst, subliminally casts blame on fisheries science for bringing us to our current state of affairs. In fact, 50 years ago two pre-eminent fisheries biologists, Ray Beverton and Sidney Holt, modeled the impact of spatial closures on fishery yields (Guénette *et al.* 1998). As to the quality of government fishery science, several National Research Council studies (eg NRC 2002) concluded that US National Marine Fisheries Service (NMFS) stock assessment techniques are second to none among government fishery management agencies worldwide.

The justification that is most often cited for establishing domestic MPAs is that traditional fisheries management in the US is a failure. However, this is ill-informed. The present low levels of many fish stocks reflect poor management decisions made many years ago. A closer look at current exploitation rates reveals that current management is doing far better. Although many fisheries (eg cod in the northwest Atlantic and certain rockfish stocks along the west coast of the US) are in severe decline, many others, such as king mackerel in the Gulf of Mexico, summer and yellowtail flounder, Atlantic mackerel, and sea scallop along the US Atlantic coast, are at sustainable levels. In fact, of the 283 (25%) of 905 fish stocks managed by NMFS for which the status is known, only 15% are overfished and 39% are fished at or near their long-term potential yield (NRC 2002). Moreover, many US fisheries are already managed under severe spatial management regimes; for example, virtually the entire continental shelf of the west coast is presently closed to groundfishing.

While we are aware of evidence of the conservation benefits of biodiversity enhancement, population growth, attenuated size/age composition, and habitat recovery inside reserve boundaries, as well as adult spillover outside reserve boundaries, there are other critical scientific issues that are poorly understood. One simplistic generalization being touted by MPA advocates is that, at a minimum, 20% of a species' habitat needs to be protected to realize the benefits of an MPA (Agardy 2003). This figure is apparently based upon theoretical results showing that when fishing mortality is excessive, overall fishery yields could be enhanced by substantial area closures. However, many studies also show that traditional fishery management controls on fishing effort correspond directly to area controls, and that it is possible to manage fisheries optimally just using effort controls (Mangel 1998; Hastings

and Botsford 1999), which has been the general paradigm practiced within the US. Moreover, the claim has been frequently made that MPAs will promote sustainable fisheries and enhance fishery yields (Nowlis and Roberts 1998), but density-dependent theory tells us that per-capita production is lowest at carrying capacity (ie in the absence of fishing), and that compensation at lower population levels produces a surplus that can be sustainably harvested. How will overall stock dynamics (eg potential yield, spawning stock-recruitment relations, spawning biomass targets and rebuilding trajectories) be affected by declining compensation within reserve boundaries, and how will the time-delayed impact of MPAs affect ecological and stock dynamics both inside and outside the reserve? Equally important, how will fishing effort displaced by MPAs affect catch rates, yields, and habitats outside reserve boundaries?

We are certainly not opposed to the use of MPAs to attain the conservation benefits pointed out above to provide insurance against errors in traditional fishery management, and as natural research and reference areas. However, we believe there are important unresolved issues that need to be answered before claims that MPAs will improve fishery management can be fully accepted. In addition, managing fisheries with MPAs needs to be placed in the context of existing management controls, which requires a case-by-case consideration of all available options.

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Amidst the concerted rush of ecologists to push for the establishment of networks of MPAs, we need to brush off a little old-fashioned scientific skepticism and look carefully at the potential benefits and costs of MPA networks. As a conservation tool, MPAs move fishing effort out of some areas and shift it to others. It is not too surprising that abundance increases where fewer fish are removed, but the displaced fishing effort goes elsewhere. We need to ask whether the biodiversity benefits inside the protected area are more valuable than the biodiversity costs of additional fishing pressure outside. Once we realize that MPAs are effort-shifting programs, we recognize that the comparison of abundance inside and outside protected areas is flawed; the benefits estimated by comparing abundance inside and outside reserves, or before and after reserves are established (Halpern and Warner 2002) will be exaggerated.

Most MPA literature begins with a litany of the failures of fisheries management and MPA advocates have often used the fisheries management benefits of MPAs as a major selling point. MPAs can only benefit the yield of managed species if the species is overfished and if the movement rate of the spawning population is low enough relative to the size of the MPAs that spawning populations can build up inside them. Shipp (2002) points out that these two circumstances are rather unusual. Only 30% of the major fisheries in the US are classified as overfished, and for most of those species the movement of adults is great enough that only large MPAs would have much effect. Since current yield of US fisheries is over 80% of its potential yield (Hilborn *et al.* in press), there is little room for MPAs to increase fish yields.

For MPAs to be effective in increasing sustainable yield for a species, the sizes of the protected areas must be carefully matched to the movement of that species. If the MPAs are very large relative to movement, then yield is reduced because the fish are locked up. If the MPAs are too small, then there is insignificant buildup inside the reserves. No pattern of MPAs will be optimal, or even suitable, for all species; having different areas closed for different species would provide better yield and conservation benefits than blanket MPAs. Such areas are steps forward in the management of fisheries because they recognize the need for spatial management, but they are very blunt tools and we can do much better than one-size-fits-all networks if our objective is to maximize sustainable yield. Rather than broadly improving fisheries yields, a network of MPAs might improve yield in a few instances.

MPAs must be integrated into the fisheries management system. It is easily demonstrated that adding an MPA to a fishery regulated by catch quotas will generally require that the quota be reduced. While advocates argue that MPAs will increase fish yields (PISCO 2002), they rarely, if ever, do the quantitative work necessary to determine how regulations will need to change when an MPA is put in place.

Despite my skepticism, I believe that the establishment of MPAs is indeed a good idea, and when done with very specific objectives can benefit specific fisheries. I have no doubt that the abundance of many species will be higher in protected areas, and would like to see more marine areas protected in the same way that I wish more of the

terrestrial habitat had been protected in parks.

I do see MPAs having an important role in fisheries management. First, in some places it may be possible to enforce protected areas where other forms of fisheries regulation are not practical. Second, in the US and other intensively managed countries, the vast majority of species are not regulated. Several hundred species are caught in the west coast trawl fishery, yet fewer than 20 are assessed (Hilborn *et al.* in press.). The vast majority of species are generally not of major commercial interest, but conservation concern for all species is currently driving management regulations; the west coast fishery is largely closed at present to protect several species classified as overfished. I see that MPA networks can be established to protect the biodiversity of marine communities, so that exploitation of the commercially important and healthy species can take place outside reserves. Essentially, the reserves would guarantee the protection of overfished or unassessed species. This will probably mean less (not more) yield of the healthy species compared to their potential yield, but it would allow commercial exploitation to continue in some places while providing for protection of a broad range of species.

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Elliot Norse's depiction of MPAs as the saviors of our marine environment does not ring true for the situation here in Chile. Perhaps this is because his ideas were formulated with the US in mind rather than an international perspective. However, even within the context of the US, Norse's views seem too narrow. Most troubling is the unquestioning advocacy of MPAs as "the central management tool" with "full protection necessary". One can come to a different conclusion if one begins with different assumptions, definitions, and goals for conservation. The conclusions reached regarding MPAs depend to a large extent on how we begin with definitions of biodiversity and conservation.

The oceans face serious conservation problems, with the state of the world's fisheries indicating resource overexploitations and a failure of existing management tools (Botsford *et al.* 1997). It follows that a new set of policies needs to be implemented to improve the situation. However, the establishment of marine reserve networks is just one of those tools. We should not fool ourselves into believing that by simply protecting or conserving coastal and open sea sites from "all preventable threats", problems will be solved. The situation is more complex, and the regulation of fishing effort is one critical aspect of it.

Furthermore, scientists and agencies cannot agree on the exact meaning of "marine conservation", and the role of MPAs. The US National Research Council (2001) suggested that one of the main priorities for MPAs was to "protect biodiversity". It has been argued that "if society were forced to await the satisfaction of all economic interests before protecting their resources, it is improbable that much protection would ever occur, and the resources supporting the economic concerns would continue their collapse" (Sala *et al.* 2003). On the other hand, Sanchiro *et al.* (2003) have argued that MPA analysis should strive to better represent the complex ecological, sociocultural, and economic dimensions by including variables that are sufficient to capture the range of human activity (O'Connor *et al.* in press). These disagreements can go on forever. There are many possible options and I believe the best one is to first clarify the concept of biodiversity and then encourage the direct participation of fishermen, users, organizations, and governments.

The UN Convention on Biological Biodiversity defines biodiversity as "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems". Clearly, biodiversity includes not just the species that reside in an area, but also functioning ecosystems; biodiversity can be seen as a structural feature of ecosystems. Therefore, a comprehensive approach to marine problems should embrace an ecosystem services perspective, rather than focus mainly on species richness. Ecosystem services are those conditions and processes through which natural ecosystems, and the species that comprise them, sustain and fulfill human life; they maintain biodiversity and the production of goods (Daily 1997); and represent the benefits human populations derive, directly or indirectly, from ecosystem functions (Costanza *et al.* 1997). This does not mean that society should await the resolution of all economic concerns before protecting its resources. We must act immediately, using rational, comprehensive, and innovative approaches that include humans as part of ecosystems. In fact, the first preamble clause of the Convention on Biodiversity refers to "the intrinsic value of Biological Diversity", but also to "the ecological, genetic, social, economic, scientific, educational, cultural, recreational, and aesthetic values". Ecosystem services can be classified into: provisioning (eg food, genetic resources), regulating (eg water, detoxification control), cultural (eg identity, educational values)

and supporting (eg primary production, provision of habitats) (MEA in press).

Thus we need to integrate into the concept of "marine reserve networking" a richer set of objectives than simply sequestering species in no-take areas. I suggest that marine management and marine conservation be melted into one enterprise. For example, artisanal fisheries are important components of coastal ecosystems throughout South America; marine conservation must include these fishing communities and the economic and production services they rely on, as well as species richness. In Chile, a mix of local, community-based management units and marine protected areas (Castilla 2000) promises the greatest hope for the marine environment. In general, we cannot expect any approach or solution to work in all countries. We need adaptive and multi-approach plans with strategies adapted to countries, states, regions, governance, and idiosyncrasies.

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Suppose there was no overfishing – that all fished species were perfectly managed to yield a sustained take – would there still be a need for any fully protected marine reserves? On the surface, this seems, perhaps, a foolish question, because reserves protect against the local damage caused by overfishing. But even in an imaginary world where fished species were not disappearing, there would still be powerful reasons to create reserves.

Impacts from exploitation can be felt even in the absence of overfishing. Fisheries species can be considered healthy even though they persist at only one-third of their former abundance, and many important fishing species are far rarer, at about 10% of historic levels. Reducing species to these levels can still yield sustainable fisheries, but such reductions in abundance can have dramatic impacts on marine ecosystems. Reserves can help to buffer these impacts.

Three aspects of fishing can generate impacts, even if fished species are sustainable. First, sustainable mechanized fishing can disturb bottom habitats, removing biological architecture species such as oyster reefs (Brooks 1891), dredging seabed structures that provide juvenile protection, or disturbing spawning grounds. Because even low intensity dredging can dramatically alter the seafloor for years (Peterson and Estes 2001), reserves play a key role by creating areas free of this impact.

Second, removal of a large part of a population – even when no physical habitat is disturbed – can result in extreme disruption of an ecosystem. This disruption is called ecological overfishing (Palumbi 2003) and an example is found in lobster harvesting. Low numbers of lobsters result in sea urchin booms and loss of kelp beds in New Zealand and California (Babcock *et al.* 1999; Laferty unpublished). Ecological overfishing of cod in New England led to the rise of dogfish communities. Removal of oysters in the Chesapeake Bay has helped muddy the US's largest estuary (Brooks 1891). Lessons like these show that even heavily managed fisheries can deplete species so dramatically that their normal ecological role is lost. As a result, these ecosystems may be nothing like their natural state.

Third, fishing is now a diverse enterprise in which many species are exploited; there are few parts of the US where fishing concentrates on just one species. When we fish entire ecosystems, removing two-thirds to nine-tenths of the biomass of many different species, we can end up with a situation in which no species is technically overfished, but the whole ecosystem is depleted and nonfunctional.

When exploitation reaches every corner of the sea, these fisheries impacts become universal. Managers in previous centuries did not face this problem because there were always places in the sea where the technology of fishing could not reach (Bohnsack 1996). However, dredges can now navigate rocky seabeds that would previously have shredded nets, and the hunger of a populous world leaves few corners of the ocean untouched.

It is crucial to leave some parts of the sea unperturbed by these activities, so that in some places natural marine communities can thrive, grow, and persist. A strategy to establish reserves in every major marine habitat solves the problem of pervasive impacts of exploitation, at least in local protected areas. Reserve science has shown that many components of marine communities respond strongly to reserve protection, so this management device can help promote crucial conservation goals that are otherwise unattainable.

Naturally, these fully protected areas do not serve all conservation or management goals, and it is imperative that they be joined by other types of marine management schemes that allow access to the sea and its resources by diverse user groups (Agardy *et al.* 2003). As part of a

wider system of recreational, subsistence, and commercial use of coastal areas, reserves have been integrated in broader zoning schemes in Australia and the US, and play a key role in biodiversity and conservation, even in places where fisheries management is successful.

Just as the US has invested in a series of magnificent National Parks and Wildlife Refuges on land to preserve the nation's natural grandeur and wildlife, a system of marine wilderness areas in the oceans would preserve a legacy of ecosystem vigor. In a make-believe world without overfishing, reserves would still be a national priority. In the real world, where the entire ocean is open to the scramble of fisheries overexploitation, they are even more important.

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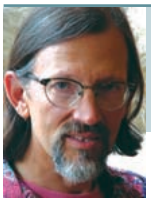

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Elliot Norse would have managers unleash a virtual epidemic of MPAs, but not just any strain. His prescription calls for a particularly virulent genus: "marine reserves", also known as "no take zones" (NTZs). As Tundi Agardy (2003) wrote, "The enthusiastic prescription of simplistic solutions to marine conservation problems risks polarization of interests and ultimately threatens bona fide progress in marine conservation. The blanket assignment and advocacy of empirically unsubstantiated rules of thumb in marine protection creates potentially dangerous targets for conservation science."

No one benefits from sound fisheries management more than those dependent upon commercial, subsistence, and sport fishing. Good management requires finding the right tool for the job. What is missing from the current MPA/NTZ campaign is the critical need to carefully define the problem before reaching for a tool.

If overfishing is the problem, then as Andrew Rosenberg (2003) said in this journal, "The only way to end overfishing is to fish less." In Alaska, as the Chairman of the Pew Commission acknowledged, we've seen the wisdom in that all along (Panetta 2002), which is perhaps why we have no overfished groundfish stocks.

Time and gear closures of huge tracts of ocean have long been facts of life in the North Pacific. In the Bering Sea, year-round bottom trawl closures encompass about 30 000 square nautical miles, an area larger than Indiana. Trawl closures in the Gulf of Alaska encompass 60 000 square nautical miles. Large expanses of the North Pacific are closed seasonally for bycatch reduction or to protect marine mammal habitat and feeding areas. Together, these closures comprise some 25% of the continental shelf. More importantly, catch and bycatch are limited and closely monitored through an observer program – without a network of permanent NTZs. In Alaska, in short, fisheries management already proceeds from the assumption that the entire ocean should be a marine protected area.

Despite our experience in Alaska, Norse concludes, "the case for reserves is so strong that it seems imprudent to wait until implacable opponents of marine conservation are convinced by the evidence". As an implacable supporter of marine conservation – though a skeptic on the value of NTZs as tools for fisheries management – I prefer policy based on evidence.

So what is the evidence? Norse dismisses a study by Shipp (2002) because it was funded by sport fishers. If funding is an appropriate criterion for assessing validity of scientific research, Norse's conclusions as a Pew-funded author, citing a Pew commission report that cites Pew-funded scholars, including himself, are also suspect. In any case, let's review their evidence. The Pew Commission's report on marine reserves (Palumbi 2003) cites a variety of studies indicating that:

- proof of augmented reproductive capacity via larval transport is rare, except with extremely over-exploited species
- there are few US studies of NTZs (except for "boutique-size" closures)
- most studies are mathematical models
- effort control can achieve the same purposes
- reserve networks are poorly studied
- studies of reserves show beneficial results in specific circumstances, where there are heavily exploited species, that the benefits are stronger within reserve borders, and that the effect is clearer for sedentary species.

The evidence that NTZs offer substantial incremental benefit to well-managed fisheries outside the NTZ is less than compelling. In advocating NTZs, supporters should clearly differentiate between NTZs as a fisheries management tool and NTZs as parks. Where NTZs can be

demonstrated to increase yields at a lower cost to fishers than other management tools, fishers will accept the price of lost fishing grounds. However, were the public to decide that it wanted to create a new national park in the grasslands of Iowa, we wouldn't simply evict the farmers. Society as a whole would shoulder the cost.

Scientifically-based closures, carefully designed to accomplish specific goals, are part of a broader set of management tools that together provide sustainable fish populations and sustainable fisheries with the economically important jobs they provide. But habitat protection measures are not simple; there are endless gradations between totally open and completely closed. From the perspective of the fishing community, any measure should meet four critical tests. MPAs must be scientifically justified, have clearly articulated goals, incorporate provisions for continued monitoring to ensure that those goals are being achieved, and their creation must take into account existing closures.

The Northwest Indian Fisheries Commission (Franks 2003) and Pacific Coast Federation of Fishermen's Associations (PCFFA 2002) have thoughtful online policy statements on MPAs, NTZs, and sustainable fisheries, which articulate the concerns of the broader fishing community. Due to space restrictions, I have posted links to their sites and further discussion of the fishing community's perspective on MPAs and NTZs at www.olympus.net/personal/dfraser/mpalinks.htm.

"For every complex problem", wrote HL Mencken, "there is an answer that is clear, simple, and wrong". Properly considered, researched, and implemented, various types of MPAs adapted to specific circumstances may prove useful. Applied broadly without meaningful participation by stakeholders in the fishing community and other interest groups, they will engender conflict and resistance. Let's get it right before we unleash an epidemic of NTZs.

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Marine conservation lags behind terrestrial conservation in funding, science, and implementation. The sluggishness with which we have come to focus on marine conservation is inexcusable. However, there is some advantage to not being first. In particular, we can learn from the successes and failures associated with longstanding systems of parks and wildlife preserves on land. As we race to establish MPAs, we should pause to consider the following ten lessons that are gleaned from our experience with terrestrial conservation.

- Terrestrial parks have often been located in the wrong places – typically those that are of little economic value (Scott *et al.* 2001). For example, in the US we have many national parks in areas of snow and rock, with little productivity or biodiversity. If we take a similar approach to marine conservation, and place MPAs where political forces offer the least resistance, we will end up with an ill-designed reserve network.
- Many supposedly protected terrestrial areas are in fact no more than "paper parks", in which a lack of enforcement results in poaching, illegal logging, and even mining. Enforcement will probably be an even greater challenge in the marine realm.
- Global climate change is real and represents a serious challenge to the design of any reserve network. Parks that are fixed in space therefore risk becoming obsolete. Clearly, consideration of resilience in the face of climate change should be a part of any plan for MPAs (West and Salm 2003).
- Invasive species are the greatest threat to terrestrial reserves, but have not figured prominently in discussions of marine conservation. However, invasive species often dramatically alter marine ecosystems (Simberloff 2000). Marine reserves will require as much protection against non-indigenous species as against harvest or other human disturbances.
- All too often, terrestrial conservation has focused on collecting long lists of species, with little attention paid to the maintenance of critical ecological processes. In terrestrial systems these processes include natural disturbances such as fires and floods. In marine systems they could include freshwater inputs and recolonization following large disturbances such as hurricanes. Whereas a relatively small area may capture many species within its borders, it usually takes a much larger area to protect ecological processes.
- On a related note, a myopic focus on the accumulation of long lists of species within the smallest possible area (biodiversity hotspots) can fail to protect the diversity of ecosystems and ecosystem services (Christensen 2003; Kareiva and Marvier 2003). A focus on species protection will typically lead to a very different alloca-

tion of conservation effort than would a focus on the conservation of ecosystem diversity. Both species protection and ecosystem protection should be considered in plans for marine conservation.

- Corridors and connections between terrestrial reserves are widely embraced in theory, but poorly documented with data (Simberloff *et al.* 1992). The same mismatch between theoretical appeal and empirical support is evident in marine discussions of "connectivity". Before rushing to invest in marine corridors, we should await some convincing evidence of their effectiveness.
- The ecological status of the matrix in which terrestrial reserves are embedded can be as important as the integrity of the parks themselves (Daily 1999). It may be impossible to achieve our conservation goals if we focus too narrowly on marine reserves to the neglect of the surrounding human-dominated landscapes and seascapes.
- Wide-ranging species such as caribou, salmon, and migratory birds have posed special challenges to conservation planners in terrestrial settings (Groves 2003). These same challenges will apply to the many wide-ranging marine species, and will require a much more complicated strategy than just networks of biodiversity reserves.
- No nature reserve system can be sustainable without also making sure that local human populations are provided for (UNCED 1992). This principle will certainly hold for coastal fisheries, which many local communities rely on for livelihood and food.

Much is made of the unique challenges posed by marine conservation. While marine systems have extraordinary biological nuances, many of the lessons learned from terrestrial conservation will surely apply equally well in a marine setting. The critical difference between marine and terrestrial conservation has less to do with biology than with the policy context and political justifications used when arguing that marine areas should be set aside as reserves. Specifically, advocates of MPAs commonly argue that the spillover of fish from within these areas can supplement harvest in surrounding zones, and hence provide a win–win conservation tool (protected biodiversity and greater harvest). Meanwhile, on land, no one asks that terrestrial protected areas produce a surplus of wildlife that spills over and supports surrounding hunting communities. Perhaps we should think about MPAs in the same way we think about terrestrial parks – simply as secure havens for biodiversity. The real challenge for marine conservation may well lie in the management of non-reserve areas, which we risk neglecting in our fondness for MPAs.

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