THE SKIMMER ON MARINE ECOSYSTEMS AND MANAGEMENT

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Managing for resilient ecosystems: Faced with limited budgets, should we protect the healthiest or restore the degraded?

When we say an ecosystem is *resilient*, we mean it is relatively able to resist change or recover from impacts - particularly the negative impacts caused by climate change. In the marine and coastal realms, such climate change-related impacts can include higher water temperatures and sea levels, lower ocean pH, and increasingly frequent and severe storms.

Generally, the more intact and less stressed an ecosystem is, the more resilient it should be (see the box at the end of this article "Ecosystem properties that confer resilience"). In that light, managing for resilience involves taking actions to foster intact, relatively unstressed ecosystems. There are two main ways of doing it: protecting ecosystems that are already healthy, and restoring degraded ecosystems to a state of better health.

However, in this era of decreased budgets and staffs for ocean and coastal management, prioritizing both of those strategies may not always be possible. Practitioners and agencies must focus instead on the activity that provides the higher return on investment.

To shed light on what to prioritize, MEAM polled several experts in the area of marine ecosystem resilience on this question:

> **Which of the following should be the top priority in planning for climate change resilience:**
>
> (a) Protecting relatively healthy ecosystems; or
> (b) Relieving stresses on (and/or restoring) degraded ecosystems in the hopes of increasing their resilience?

We received a variety of responses, below. From these responses, two key themes emerged:

- Planners and managers need a portfolio of management actions that they can tailor to the needs and circumstances of specific locations. A critical aspect of this portfolio is finding and protecting/restoring climate refugia - habitats to which species can retreat, persist, and potentially flourish under changing environmental conditions.
- Planners and managers should focus on locations or systems that provide the most critical ecosystem services to society, and should protect/restore these locations to sustain these services. In many instances, the most degraded ecosystems (which are often estuaries) may provide the greatest number and/or level of services.

[Note on this article: In the context of resilience, we recognize that there are more than just two kinds of areas in the ocean (i.e., protected vs. in need of restoration). It is a continuum: some areas are relatively intact without being under active protection. However, in light of the budgetary tightness so many managers face, and the costs associated with protection and restoration, we wanted to see how resilience experts would prioritize them. Do you have thoughts on the poll question? Let us know in the comments section below.]

Create a portfolio of different management actions

By Emily Darling, David H Smith Conservation Research Fellow, University of North Carolina, US

In addition to the reality of limited funding, ocean planners must also confront the inherent uncertainty of when and where climate impacts will occur. Addressing climate change is like looking into a crystal ball for conservation and management decisions. Instead of picking "winners" or "losers", our top priority should be to build portfolios of different management actions for different places.

Identifying natural climate refugia (i.e., places that can escape the worst impacts of climate change) is critical to this portfolio approach. Within areas of climate refugia, we can prioritize marine reserves to relieve other anthropogenic stresses on high diversity and climate-sensitive assemblages, or spend money to restore and recover degraded areas. To date, there is evidence that the northern Mozambique Channel (http://bit.ly/MozambiqueChannel) and sheltered bays of Palau (http://bit.ly/Palaubays) provide refuge for climate-sensitive coral reefs in the Indo-Pacific. A key focus for future research should be identifying more refugia and investigating the connectivity of refugia across regional scales.

On the other hand, there will be many areas of our oceans that are not refugia and will be hit hard by climate change. Here, investing in marine reserves or restoration might be counter-productive as climate change continues to reorganize ecosystems and swamp the benefits of conservation and management efforts. In these areas, we can focus on the sustainable management of climate-tolerant resources and ecosystem services, as well as protecting healthy ecosystems that show signs of climate adaptation or acclimation.

In my view, the top priority for planning should be to build current and future climate impacts into our conservation and management actions. The heterogeneity of climate impacts will undoubtedly call for different actions for different areas of our oceans. Such portfolio approaches that account for the real impacts of climate change will hopefully provide the best possible outcomes for both ecosystems and stakeholders.

Four considerations to guide decisions

By Paul Marshall, Manager, Climate Change Response Programme, Great Barrier Reef Marine Park Authority

Balancing investment of limited resources is a perennial challenge for ocean planners. Four considerations can guide our decisions.

First, what are our objectives? If we are hoping to support ecological resilience to underpin long-term biodiversity conservation then we should pick the ecosystem/patch with the highest resilience, irrespective of its current state. But if we aim to maximize delivery of ecosystem services for local communities, then identifying and protecting intact systems will bring the best results on timeframes that matter to people.

Next, we have to think about why one area is "healthy" while the alternative is degraded. If this is just because of good luck (i.e., differences in exposure to largely random events, such as hurricanes), then it would pay to place our eggs in the healthy basket. But if one is degraded because of exposure to chronic stresses (such as pollution), then it would make sense to invest in reducing risk of damage to the more pristine ecosystem. It gets tricky when a patch is currently healthy but is predicted to face increasing risk of exposure to acute disturbances that managers can't control, such as thermal stress events or hurricanes. If the degraded site happens to be in an area with less future exposure risk, then the best long-term investment may well be to fix up the sources of chronic stress.

Third, let's get real about what we can and can't achieve with our intended "protection" regime. Too often we talk about protecting an area as if its declaration erases all stress on the chosen ecosystem/patch. Lines on maps don't increase resilience.

Finally, we have to think about relative cost effectiveness. Especially for restoration, we need to be sure the cost of actions, adjusted for probability of long term success, is built into our analysis of options.

The skeptic and the optimist

By Joachim Claudet, Researcher, National Center for Scientific Research, CRIOBE (www.criobe.pf)

There are two ways to tackle this question: a skeptical one and an optimistic one. Both tend to lead to the same conclusion.

The skeptic will first question the hypothesis underlying the poll question - namely, that protection can increase resilience to climate change (including resilience to thermal stress, species invasion, and ocean acidification). Evidence that protection could confer such benefits is very limited, and expected effects are still controversial in the literature. The skeptic would also question the specific benefits of protecting relatively healthy (often remote) ecosystems. In the great majority of cases, those places are healthy because they are not threatened. So what would they be protected from?

The skeptic would now tend to be cynical and think that we are more worried about climate change's effects on us (humans) rather than on natural systems. This would translate into prioritizing investment into conserving ecosystem services and therefore into protecting/restoring ecosystems that are already degraded because of our uses. The cynic wants the seawater to continue to buffer the negative effects of terrestrial run-off and sewage outfalls, and he wants to continue to bring his son to fish where his father brought him. All this should happen where it has always happened (at the temporal scale of a generation life span), which means where ecosystems are already degraded.

The optimist, based on his belief that climate change is reversible and that humans can change, will not question the fact that people and governments can reduce their ecological footprint, therefore limiting stresses that induce climate change. The faith he has in humanity and especially in the fact that humans are rational beings will make him invest his efforts into relieving stresses on degraded ecosystems in the hopes of increasing their resilience.

Benefit-cost ratios for protection and restoration

By Raphaël Billé, RESCCUE (Restoration of Ecosystems Services against Climate Change Unfavorable Effects) Project Coordinator, Secretariat of the Pacific Community

With budgetary crises hitting so many countries, it seems legitimate to look for the most efficient ways to protect marine biodiversity.

One simple approach is to compare the benefit-cost ratio of protecting vs. restoring a hectare of a given habitat: unsurprisingly, with few exceptions, protection comes out much cheaper than restoration. Marine and coastal ecosystem restoration is still in its infancy, but recent research shows that restoring coastal ecosystems such as coral reefs, seagrass meadows, estuaries, rocky shores, beaches and wetlands presents significantly smaller benefit-cost ratios than restoring most terrestrial ecosystems (http://onlinelibrary.wiley.com/doi/10.1111/cobi.12158/abstract). While little information is available on the cost of restoring deep-sea ecosystems, it will probably be several orders of magnitude higher than for shallow ones (www.nature.com/news/ecology-protect-the-deep-sea-1.14547) - if it is even feasible. However depending on the timeframe, costs and benefits considered, it is possible to demonstrate that both (a) and (b) actually pay for themselves. Therefore, in principle, costs and limited budgets should not be a problem.

But is the return on investment an appropriate criterion to favor any one option? In general, no, because marine conservation is a socio-political process undertaken by and for real people, not a scientific optimization protocol. Therefore wondering how best to prioritize spending in general is a theoretical question. Prioritization is about strategy, and strategy is necessarily context- and agency-specific. Tell me which agency has decisions to make and a strategy to develop, what means it has, and what its geographic or sectoral scope is, and we may be able to work out an answer to the poll question - including by using elements of costs and benefits.

Find ecosystems with capacity to survive, then manage them strictly

By Tim McClanahan, Senior Conservation Zoologist, Wildlife Conservation Society, Kenya

An immediate need of planners and managers is to find marine ecosystems that have the capacity to survive with minimal change in the coming era of increasing climate disturbances. Then they should apply the strictest forms of management that are socially acceptable in these locations. Other ecosystems with less capacity to remain unchanged need to be managed to reduce their vulnerability to losses of function and therefore maintain their sustainability for human resource use. These principles should be applied to all ecosystems - not just some on a triage basis.

Given the history of environmental change in the ocean, there are locations that have been refuges for species and ecosystems from past historical disturbances. It is likely that these same locations will provide similar roles in the future. These are often habitats with high species richness or regions containing rare taxa. It is likely that past and current stability of the environment has been critical in maintaining this refuge - current levels of biodiversity often reflect this stability but not always. Stability is, however, not just the lack of change but more a change that does not exceed far beyond the envelope of conditions that are deadly to many species. Some environmental variability that creates the potential for acclimation and adaptive responses is good, but change that is rapid and exceeds tolerable levels is bad.

Consequently, there is a need to examine the historical and current environmental variability and find locations with the properties of high species richness, uncommon taxa, and some but constrained environmental variability. Once found, all efforts should be made to insure human resource use does not undermine the irreplaceable potential of these biodiversity refuges.

Climate impacts will require active restoration

By Jeff Benoit, President, Restore America's Estuaries

My choice as top priority should be no surprise. We need to focus on relieving stresses on - and/or restoring - degraded ecosystems with the goal of increasing their resilience.

Sea level rise and increased temperature and acidification in coastal waters are among the most significant climate change impacts on coastal ecosystems. Addressing these impacts on coastal ecosystems requires a focus on your poll's second option (actively managing and restoring natural systems) as opposed to the first option (protecting relatively healthy ecosystems), which is also important, but is a more passive approach.

Funding large-scale restoration is challenging. As a way to attract private sector investment in restoration projects, Restore America's Estuaries is currently advancing the concept of Blue Carbon - i.e., using salt marshes, seagrass meadows, and mangroves to sequester atmospheric carbon and generate carbon credits. This wetlands restoration work will not only help to reduce greenhouse gas emissions; it will help shorelines adapt to changing conditions, including sea level rise, and will promote resilient coastal ecosystems.

BOX: Ecosystem properties that confer resilience

A recent publication in the *Annual Review of Marine Science* describes three ecological properties that underlie resilience, as well as management strategies for promoting each property:

Diversity, which increases the variety of responses to disturbance and the likelihood that species can compensate for one another. To promote diversity: limit overharvest and place reserves in areas of high species diversity and high habitat complexity.

Connectivity (including connectivity among species, populations, and ecosystems), which enhances capacity for recovery by providing sources of propagules, nutrients, and biological legacies (organisms and organic material that persist through disturbance and are incorporated into the recovering ecosystem). To promote connectivity: distribute extraction across trophic levels or limit extraction; create reserve networks; restore degraded habitats; limit land-based nutrient pollution; and protect climate refugia and areas with reproductive individuals that provide a propagule source.

Adaptive capacity, which includes a combination of organism-level adaptability, species range shifts, and rapid evolution of traits better suited to new conditions. To promote adaptive capacity: protect climate refugia and dispersal corridors; place networks of reserves along climate gradients; and protect landward edges of wetlands to facilitate landward migration.

Source: Bernhardt, J.R. and H.M. Leslie. 2013. Resilience to Climate Change in Coastal Marine Ecosystems. *Annual Review of Marine Science*. http://blogs.brown.edu/leslie-lab/files/2009/09/Bernhardt-and-Leslie-2013.pdf

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BOX: More sources on ecosystem resilience

Reef Resilience Toolkit
www.reefresilience.org

Coastal Resilience Tool
www.coastalresilience.org

Mumby, P.J., I. Chollett, Y.-M. Bozec, and N.H. Wolff. 2014. Ecological resilience, robustness and vulnerability: How do these concepts benefit ecosystem management? *Current Opinion in Environmental Sustainability*
www.sciencedirect.com/science/article/pii/S1877343513001838

Fujita, R., J.H. Moxley, H. DeBey, T. Van Leuvan, A. Leumer, K. Honey, S. Aguilera, and M. Foley. 2012. Managing for a resilient ocean *Marine Policy*
http://bit.ly/Fujitaresilience
