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Can We "Save" the Ocean?

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From Unbounded Optimism to Overwhelming Despair

When people first settled the coasts, near the dawn of mankind, the ocean was both a source of food and a source of fear. With time, the fear decreased, the benefits grew, and the ocean became a great highway linking the continents, a source of great wealth as its riches were extracted, and a convenient rubbish dump. Throughout these many millennia it was inconceivable that humans could change the ocean through their activities – it was simply too vast. In 1884, Thomas H. Huxley wrote that "Probably all the great sea-fisheries are inexhaustible; that is to say that nothing we do seriously affects the number of fish….". Even as late as 1955, "The Inexhaustible Sea" was written by Francis Minot.

And vast the ocean still is, covering 71% of the earth's surface and representing perhaps 95% or more of the habitable biosphere, numbers that become achingly real when we try to find the remains of a jet lost on the ocean floor. Yet despite its almost incomprehensible size, the ocean is now a strikingly different place from that experienced by our distant and even more recent ancestors, thanks to our actions. Indeed, it is so different that we find it difficult to imagine how it once was – a place where cod could be scooped out in baskets and sailors could navigate by the sounds made by turtles. Our failure to recognize how much the ocean has changed is due to the phenomenon of shifting baselines – we redefine what was "normal" (and hence how much has changed) based on how the world was during childhood (Jackson *et al.* 2011).

It is only recently, thanks in part to the new field of historical ecology, that we have begun to grasp what we have lost. Today, in the era now known as the Anthropocene, we live with an ocean much diminished by our actions:

- The vast majority (perhaps 90%) of predatory fish have been taken from the ocean (Myers and Worm 2003). The consequences spread far beyond the fish – the loss of their vital roles in ecosystems have caused coral reefs to be smothered by seaweeds and seagrasses to succumb to disease (Jackson *et al.* 2001).

- Entire habitats are under threat, with 35% of mangroves (Valiela *et al.* 2001), 61% of living coral (Jackson 2008), 29% of seagrass beds (Waycott

et al. 2009), and 85% of oyster beds (Beck *et al.* 2011) severely damaged or gone.

- Thanks to nutrient pollution, dead zones so devoid of oxygen that almost nothing can live have proliferated around our coastal seas, at last count numbering more than 400 (Diaz and Rosenberg 2008).
- Invasive species brought to foreign shores by aquarists, aquaculture and ships have spread to all but 16% of marine ecosystems (Molnar *et al.* 2008), with lionfishes eating what few fish remain in the Caribbean, and smothering seaweeds taking over the Mediterranean.
- The oceans are getting inexorably warmer (0.4° C since the 1950s) thanks to the emissions of carbon dioxide, with consequences already seen in shifting species ranges and coral reefs that bleach and die (Doney *et al.* 2012).
- A substantial proportion of the carbon dioxide released to the atmosphere has already dissolved in the ocean, causing ocean acidity to rise by 26% (Doney *et al.* 2012), and studies suggest more profound changes will come in the future (Fabricius *et al.* 2014).
- Although complete extinctions have to date been limited in the ocean, perhaps no more than 21 species in total (del Monte-Luna *et al.* 2007), many species are effectively extinct in terms of the ecological roles that they play, and untold numbers may already be doomed due to "extinction debts".
- And last but certainly not least, human welfare has suffered, including an economic loss of 50 billion US dollars annually from mismanaged fisheries alone (World Bank and Food Agriculture Organization 2008).

The seemingly never ending onslaught of bad news about the ocean has led to a profound attitude shift in the public and even among many marine scientists over the last half century, from unbounded optimism to overwhelming despair. Indeed we seem to have gone from thinking that the ocean is too big to hurt to thinking that the ocean is too big, and too far gone to help.

Moving Beyond the Obituaries

A number of years ago, I founded the Center for Marine Biodiversity and Conservation at the Scripps Institution of Oceanography. The centerpiece of the educational program was a 10-week summer course, which

we kicked off with horror stories about the ocean. Year after year, we watched our eager young charges mentally (if not physically) slump in their chairs, as the scope of destruction was painted in grim detail.

Eventually I started to question the wisdom of what we were doing. The contrast between human medicine and conservation (or planetary medicine, if you will) was striking – medical students are taught how to make and keep people healthier while we were teaching our students how to write ever more refined obituaries of nature.

Others working in the field of conservation have also come to the conclusion that messages of doom and gloom do not, on their own, motivate people to behave in a more nature-friendly fashion (Knight 2013) – recognition of a problem needs to be coupled with ideas or examples of solutions. Nevertheless, it is doom and gloom that still dominates too much of the conservation conversation. This is perhaps unsurprising in the public realm, where "if it bleeds, it leads" remains the prevailing dictum in the newsroom. It is perhaps more surprising that even professionals in the field of ocean conservation are often unaware or at least silent on the subject of the many successes that have occurred. Indeed, at times it seems as if a reverse form of the shifting baselines syndrome is at work, where we forget how bad things once were.

And so began the "Beyond the Obituaries" project, collecting stories of success in ocean conservation, and it is a sampling of these that I wish to share with you today. These stories of success are important not only as a source of inspiration and guidance for those who wish to bring the ocean back to health. One critical lesson we have learned is that because the ocean suffers from multiple stressors, tackling those that can be addressed now, in particular local problems such as overfishing and pollution, can provide a measure of resilience to those threats that are tougher in the short term to reduce, in particular the rising concentrations of carbon dioxide in the atmosphere.

So while I am by no means oblivious to the enormous threats that still face ocean life and ecosystems, I would prefer to focus on elements of the positive. Perhaps most importantly for this particular gathering, some of the most striking examples of success come from small groups of people with little money succeeding through the power of community in bettering the health of the ocean and their own well-being. Below I review some of the strategies being used to protect and restore the health of the ocean.

Protecting Species

Hunting and fishing of ocean life was the first way humans substantially affected the ocean, and harvesting remains the most influential of all human

impacts (Jackson *et al.* 2001). In our history we have first sought out big creatures, and because big creatures often reproduce slowly, they are very vulnerable to humans with spears, harpoons and guns. Some did not survive the onslaught – the great auk, the sea mink, and the Caribbean monk seal are no longer with us. Steller's sea cow was exterminated a mere 27 years after its discovery (Turvey and Risley 2005).

Yet some of most striking success stories concern these large charismatic species (Lotze *et al.* 2011). There are numerous examples of success stories in groups as diverse as whales, turtles, seabirds and sharks, although as Lotze and colleagues stress, recovery can take decades in long-lived species and complex ecosystems, some species fail to recover in response to conservation measures, and only rarely have "pristine" numbers been regained. In some cases harvesting has been largely or entirely banned because numbers were so critically low or because public attitudes about hunting specific types of organisms shifted (e.g. marine mammals, some shorebirds).

Most recently, wildlife scarcity has shifted the economics of harvesting such that organisms are now much more valuable alive than dead (e.g. Anderson *et al.* 2011, although with some unfortunate counter examples in highly prized fishes like the bluefin tuna). Where hunting is inadvertent and species are being killed accidentally as bycatch, changes in fishing technologies can help, although good relationships among fishers, scientists and managers, monitoring and enforcement are required for success (Cox *et al.* 2007).

We are currently in the midst of a fascinating change in the attitudes toward and actions associated with the protection of sharks. Shark numbers have been decimated, in large part associated with the lucrative trade in shark fins, made worse by the fact that sharks, unlike fishes, typically have very slow reproductive rates. Fins were once de rigueur for any high-prestige Asian banquet, but alarm at plummeting numbers and disgust with the practice of dropping finless-but-still-living sharks back into the ocean to slowly die is creating an environment of rapid change. Bans in shark fishing, shark finning, and the sale of shark fins have been increasing around the world. Particularly on coral reefs where tourism dollars can dominate the economy of developing countries, sharks have been shown to be far more valuable swimming than in a net (a single shark in a popular dive site has been estimated as worth $35,000 annually, and in the Maldives shark-based ecotourism contributes >30% to the Maldive's GDP; Gallagher and Hammerschlag 2011). But even in areas where shark tourism is not a major activity, appealing to environmental ethics has been a powerful tool at a variety of scales, ranging from cities to countries.

Protecting Spaces

Marine Protected Areas, or more broadly ocean zoning, is a key component of many if not most marine conservation plans. The general logic is relatively straightforward, although the details often are not. But put simply, the concept is that just as on land, in the ocean we need to protect some places completely and regulate human activities in others. The problems stem from 1) trying to determine the best mixture of activities for what areas, 2) getting local cooperation, without which enactment and compliance is effectively impossible, and 3) determining how to make such plans financially sustainable. It remains the case that only a small fraction of the world's ocean habitat is truly protected, and about 60% of the ocean remains outside of any Exclusive Economic Zone (EEZ) (Orbach 2003). Yet this is an area of many successes as well.

The Great Barrier Reef (GBR) of Australia is often touted as the gold standard of ocean zoning. The product of years of negotiations with stakeholders, in 2003 a zoning plan that protected more than 33% of the marine park from all fishing was announced. In many ways the GBR is a success story (McCook *et al.* 2010). In particular, devastating outbreaks of crown of thorns starfish are lower, and numbers of fish and abundance of coral has increased in no-take areas. Yet despite the large area protected (exceeding the 30% that is often cited as an optimistic goal for the world as a whole), there are still signs of trouble, particularly in areas close to human populations. Notably, there has been a 50% loss of live coral cover between 1985 and 2012 due to a large extent to cyclones, coral bleaching, and predation by crown of thorns starfish, the latter probably fueled by nutrients from agricultural runoff (De'Ath *et al.* 2012). This illustrates that particularly in areas with large rainfall, linkages between land and sea require that adjacent lands be managed as well. Recent controversial approval of an expanded coal port within the park also illustrates how successes need constant support, as there is always the potential for things to get worse again.

The story of Cabo Pulmo, Mexico presents an interesting counterpoint to the story of the GBR (Aburto-Oropeza *et al.* 2011). In this case a small village banded together thanks to the visionary leadership of a local leader, who became convinced that unsustainable fishing was destroying their future. The Cabo Pulmo Marine Park was established in 1995, and by 2009 fish biomass had increased by 463%; notably, during the same time interval there were no increases in fish biomass for the federally managed marine parks. These biological outcomes were accompanied by a substantial increase in local income as well. The latter was driven primarily by small-scale tourism, which in 2006 generated 18,000 USD per capita for the 30 people involved,

an amount significantly above the per capita Gross National Income of Mexico. Now a UNESCO World Heritage Site, it still remains, like the Great Barrier Reef, vulnerable, ironically in this case due to its own success, with continuing pressure to build mega-resorts in the immediate vicinity.

Replicating the successes of these marine protected areas is a widely held goal in marine conservation. The biggest challenge is often determining how to weather the initial declines in local incomes associated with protection before the benefits of recovered fish populations and tourism are established. Fortunately, the benefits often exceed the costs within as little as five years (Sala *et al.* 2013), with benefits derived from both increased catches and tourism; the latter typically exceed the former where dive-related tourism is feasible.

Harvesting for the future

Although protecting species and the places where they live from human harvesting are important strategies for marine conservation, they cannot be the only solution. The sea is a critical source of protein for over two billion people, and managing that harvest sustainably is an essential challenge to meet. Here too there are welcome examples of success.

Fisheries experts have long known that harvesting at moderate rates yields higher returns and a stable future. The problem has been achieving these sustainable harvest levels through mechanisms that are broadly acceptable to fishing communities. One approach has been the issuing of individually owned fishing rights, often referred to as catch shares, much as taxis are regulated in some cities through the issuance of taxi medallions. A wide-ranging review of this strategy suggests that catch shares can have substantial beneficial effects (Costello *et al.* 2008). There are, however, governance challenges associated with such things as setting the appropriate prices and numbers of permits based on stock assessments.

In developing countries, centrally controlled efforts to manage fishing levels are often less successful, and data are also often inadequate (Costello *et al.* 2012). In such cases Territorial Users Rights for Fishing (TURFs) and fisheries cooperatives have in a number of cases proved remarkably successful. A well-documented example is that of the Chilean fisheries for locos, a small but highly prized intertidal snail that became severely overfished. With the establishment of locally managed fisheries, however, numbers have rebounded and are indeed as high in areas managed by TURFs as they are in no-take areas (Gelcich *et al.* 2010). Moreover, other aspects of ecosystem health have improved as well.

Making fishing less destructive is also a strategy for conservation success. Sea floor trawling is the poster child of destructive fishing, and many chal-

lenges remain (Puig *et al.* 2012). However, the selective banning of gill nets in the near shore waters of coastal California has led to several impressive recoveries (Pondella and Allen 2008). The use of fish traps in tropical waters that allow small or narrow fish to escape or for traps to decompose if lost (to eliminate ghost fishing) has considerable potential (e.g. Johnson 2010).

On land, we have largely replaced hunting and gathering with agriculture, and in the ocean aquaculture is an increasingly important source of marine food, providing close to 50% of the world's seafood. Unfortunately, many of the initial aquaculture efforts caused considerable problems of their own, including local pollution and overfishing of food for aquacultured species. Now, however, methods in many places have greatly improved, with the potential to safely reduce pressure on wild stocks. This has led to calls to use a variety of methods to encourage aquaculture sustainability (Bush *et al.* 2013).

Reducing Pollution

Pollution is often the first thing that comes to mind when people are asked about threats to the environment. Oil spills, because of the spectacular scenes of death and destruction that result, are often listed by the public as the number one threat to the ocean. Similarly, photographs of dead seabirds whose guts are filled with cigarette lighters, ignite widespread disgust and increasing attention to the problem of plastic marine debris (Derraik 2002). Beach clean-ups are popular activities, but clearly this is a problem that needs to be addressed at the source. In 2002 in Ireland, a 15 Euro cent tax was introduced and resulted in a 90% reduction in the use of plastic bags, as well as associated reductions in litter, and has been popular with the public as well (Convery *et al.* 2007). Plastic bag bans or taxes are increasingly spreading throughout the US and elsewhere.

DDT was once one of the most damaging pollutants globally, but it is now banned in many parts of the world. The toxic crisis caused by this pesticide was described by Rachel Carson in *Silent Spring*, a book that in many ways launched the environmental movement in the United States. Birds at the top of the food chain suffered catastrophic nest failures because accumulated DDT caused thinning of eggshells. The power of Carson' book led to a banning of the use of DDT in the US in 1972, and with it the recovery of many birds, including the magnificent fish-eating osprey (whose recovery was also aided by other restoration efforts) (Henny *et al.* 2010). These birds are so common now that they are unremarkable, and today many people are unaware of how perilously dire their situation once was.

One of the biggest pollutants in coastal seas are things that in small amount aren't harmful at all, namely nutrients. The widespread application

of large amounts of fertilizers even far from the ocean has led to eutrophication and dead zones. These are places where nutrients fuel an explosion of single celled algae in the plankton that then die and become food for bacteria, which in turn suck all the oxygen out of the water. Around the world the numbers of dead zones – places where oxygen is so low that no complex animal life can survive – is currently tallied at over 400 (Diaz and Rosenberg 2008). Though the numbers of dead zones continues to increase, there are moves afoot to limit the flow of nutrients into rivers and hence the sea. One particularly simple strategy is to plant strips of forest along rivers and streams, where they suck up the nutrients before they get to the water (Committee on Environment and Natural Resources 2010).

Restoring Habitats

Marine communities are often structured by what are called ecosystem engineers, the large organisms that create the three-dimensional structure upon which other organisms depend. When organisms like seagrasses, shellfish, mangroves, or corals disappear or are greatly reduced, meaningful conservation depends on restoring these critical organisms. Once restored, the rest of the community can often rebound unaided. This may seem simple, but untold millions have been spent on failed restoration efforts. The first rule of thumb is that whatever was responsible for the loss of the engineers in the first place must be eliminated first. In some cases, conditions must even be hyper-restored (that is made more favorable than they were previously) or restored in a large scale fashion, because a state change has occurred that impedes recovery.

For example, elimination of oysters results in large, silty expanses that can be easily stirred up, smothering any new oysters that naturally recruit or are placed in restoration efforts. As a consequence, restoration must be done on a large scale, creating substantial three-dimensional structure in order to overcome the changed situation (Schulte *et al.* 2009). After decades of decline, genuine success in oyster and other shellfish restoration is being seen. These efforts have the advantage of not only returning a complex habitat but also filtering and cleaning seawater that flows over these biogenic reefs. Restoration typically depends on not only replacing the organisms that have been lost, but also restoring the conditions that favor their growth and reproduction. Pollution abatement and fishing controls are thus often components of restoration efforts.

Sometimes habitat restoration involves not rebuilding depleted species but rather eliminating invasive ones. This is hard to do, unfortunately, and essentially impossible once invasive species have become established. The

overwhelming of native seagrass beds in the Mediterranean by the invasive alga *Caulerpa*, and the rapid establishment of the invasive lionfish throughout Caribbean waters are but two examples. An ounce of prevention is worth a pound of cure.

Why Reducing Local Impacts Now Matters

I have focused in this paper on threats that can be reduced by local actions. This is not to demean the extraordinary severity of global threats, in particular the consequences of increasing concentration of carbon dioxide in the atmosphere. But reducing local threats makes it easier for organisms and communities to deal with the effects of global change, either by increasing resistance or resilience. For example, unstressed coral reefs appear to be better able to resist disease and to have larger numbers of juvenile corals, suggesting higher potential recovery rates from disturbances that cannot be prevented (Sandin *et al.* 2008). Thus local actions buy marine organisms, communities, and the humans that depend on them valuable time, while the global community slowly coalesces around the challenges associated with switching from a carbon-based economy. The more we can encourage taking such local actions, the more time we will have. In the end, then, this is a matter of replicating small solutions to achieve a global scale. Entities that work at local scales have an enormous role to play in facilitating this process, so that conservation becomes a global passion rather than an elite pastime.

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