The Heat Is On

The role of marine reserves in boosting ecosystem resilience to climate change

GREENPEACE

Introduction

"[The] arrival [of the grand shoal of herring] is easily announced, by the number of its greedy attendants, the gannet, the gull, the shark and the porpus. When the main body is arrived, its breadth and depth is such as to alter the very appearance of the ocean. It is divided into distinct columns, of five or six miles in length, and three or four broad; while the water before them curls up, as if forced out of its bed. [...] a field bespangled with purple, gold and azure. The whole water seems alive." (Oliver Goldsmith, Irish writer and physicist, marvelling in 1776 at the riches of Atlantic fisheries)

Spectacles such as this, described in 1776, are long since consigned to history. We have not looked after our seas and oceans, and are now paying the price. Among the many threats facing marine and coastal ecosystems, the impact of marine fisheries are of the greatest concern. Despite some changes to the way fisheries are managed, there is little ground for optimism: fishermen are bringing home smaller and smaller catches despite technological advances; fish size, abundance and genetic diversity has plummeted; high-value species are being replaced by so-called "trash" fish; and habitat degradation is widespread and increasing.[1] Destructive practices and overfishing have diminished the seas ability to renew its resources, with consequences for the more than one billion people in the world that rely on fish as their primary source of protein, and bringing economic hardship to coastal communities that once sustained a living by harvesting local fishing grounds.

We are now witnessing the consequences of our unsustainable use of the oceans further worsened by the impacts of climate change. The United Nations Intergovernmental Panel on Climate Change (IPCC) warned in 2001 that climate change will "affect the physical, biological, and biochemical characteristics of the oceans and coasts", and warned of "significant feedback on the climate system" of such changes.[2] Organisms in coastal zones and enclosed seas are most at risk from climate change, it warned.

The IPCC is updating its findings this year. In February, it revealed that our oceans have absorbed more than 80% of the heat added to the climate system and that average sea temperatures have as a result increased to depths of at least 3,000 metres.[3] At current levels, the oceans will continue to heat up for "more than a millennium", it predicted. In light of these findings, the Secretariat of the Convention on Biological Diversity (CBD) has advised that "genetically-diverse populations and species-rich ecosystems have a greater potential to adapt to climate change".[4] To help reduce the negative impacts of global warming, it thus recommends that fishing nations reduce pressures on fisheries and associated ecosystems.

In short, the experts warn that we have eroded the ocean's ability to cope with and mitigate the consequences of global warming. They recommend that we reduce our exploitation levels of marine fish and other maritime activities in order to improve the resilience of our seas and oceans and ultimately safeguard their role in stabilising the climate. Simply aiming at the sustainable use of sea-life is no longer a sufficient management strategy; marine protection has become an insurance policy for an unpredictable future, which will be hotter, stormier and more hostile.

It is beyond dispute that the health of our seas and oceans has first and foremost been compromised by the overexploitation of marine resources and marine pollution. In addition, however, we must consider the impacts of climate change to which we are committed as a result of greenhouse gasses already emitted into the planet's atmosphere.

This report considers how we might adapt management policies in order to account for these negative effects of climate change, bearing in mind that marine ecosystems are already severely degraded. It argues that a network of marine reserves, set aside from all extractive and destructive activities, will provide the necessary safety net to strengthen the resilience of marine ecosystems and limit the impacts of climate change. Marine reserves will provide sanctuaries for life, spaces for the ocean to recover and renew itself.

This report aims to progress the debate on marine protection in the context of attempts to implement ecosystem-based management and protect the oceans from a combination of pressures, including the cumulative impacts of severe overfishing and climate change. It is vital that, while every effort is made to reduce greenhouse gas emissions and eliminate unsustainable practices in oceans use, we also establish networks of large-scale marine reserves to help build up the resilience of ocean ecosystems and improve our understanding of the impacts of climate change on them.

Map showing areas in the Mediterranean, Baltic and North Seas proposed by Greenpeace as future marine reserves.

A marine reserve network covering 40% of European waters is needed to ensure a future for Europe's marine life and the people who depend on it.

For more information see *www.oceans.greenpeace.org*:

- Rescuing the North and Baltic Sea.
- The Baltic Seas: a Roadmap to Recovery
- Marine Reserves for the Mediterranean Sea
- Roadmap to Recovery: A global network of marine reserves

Trouble beyond the shoreline

Europe's marine waters extend from the tide-swept beaches of its rugged shores to the deep crevices of the Northeast Atlantic, Mediterranean, Black and Baltic Sea basins. The tides cover the submerged margins of our continent, to a depth of approximately 200 metres. Beyond that, the ocean drops to 2,500 metres and more.

Once teeming with life, these seas have been put under pressure from overexploitation and are as a consequence even more vulnerable to climate change. The growing number of European fish stocks outside safe biological limits, the decline in top predators and the infamous blooms of toxic algae[5] are but three signs of ecosystems in severe distress.

Profound changes are being experienced in all parts of the world's oceans. In November 2006, new data brought the extent of marine degradation into stark relief. An international group of scientists, led by Professor Boris Worm, showed that the loss of marine biodiversity is drastically reducing the ocean's ability to produce seafood, resist diseases, filter pollutants and rebound from stresses such as overfishing and climate change. Consequences of biodiversity loss are felt in terms of the structure and functioning of ecosystems, the scientists warned, including their interactions with the water, carbon, nitrogen, and other major bio-geochemical cycles. In other words, the impacts of overfishing will be felt well beyond individual species' populations.[6]

As regards the impacts of climate change on marine and coastal biodiversity, the Intergovernmental Panel on Climate Change (IPCC) warned of:

- changes in the distribution and abundance of organisms;
- changes in productivity levels; and
- changes to the structure of communities and marine food-webs.

Generally speaking, these are the consequence of:[7]

- predicted increases in sea level, sea-surface temperature, wave climate and ocean circulation;
- predicted decreases in sea-ice cover; and
- predicted changes in the salinity and alkalinity of the water.

The IPCC's main findings regarding climate change impacts on marine and coastal biodiversity, supplemented by recent studies, are summarised in more detail in Box 1.

Take the impacts of overfishing and unsustainable practices and add the impacts of climate change, and we are unleashing processes of change that are without precedent. The ultimate scenario is one of negative feedback in which degraded seas cannot resist the impacts of climate change. Ocean currents will shift and weaken, sea levels will rise, and water temperatures and acidity will increase. As a result, the seas' ability to absorb excess CO_2 drops and the passage of heat from the equator to the poles is interrupted. In turn, the climate system is further destabilised, causing more species' extinction and so on.

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Box 1: Possible and predicted impacts of climate change on marine and coastal biodiversity and ecosystems

(a) Pole-ward shift and other changes in species distribution and abundance: The mean distribution of plankton and marine productivity in the oceans is likely to shift with projected changes in the sea-surface temperature, wind speed, nutrient supply, and sunlight, with consequences for the entire marine food web, including the abundance and distribution of commercial species.[8]

(b) Shrinking habitats: Reductions in Arctic and Antarctic sea-ice could alter the seasonal distributions, geographic ranges, migration patterns, nutritional status, reproductive success, and ultimately the abundance of marine mammals that depend on these ecosystems. Arctic sea-ice has decreased by about 8% over the past 30 years and some models indicate a complete ice-free summer Arctic Ocean by late this century.[9]

(c) Changing currents: Rising temperatures and changing salinity patterns are leading to changes in ocean currents. Increasing freshwater runoff into the Arctic Ocean north of Europe and Russia is weakening the Gulf Stream, the Atlantic Ocean's 'conveyor belt' that carries warm water north from the tropics. In November 2006, scientists reported that the Gulf Stream appears to have weakened by 30% in just 12 years.[10] Such changes are certain to affect marine life.

(d) Turning Sour: If global emissions of carbon dioxide (CO_2) from human activities continue to rise on current trends, the average pH of the oceans could fall by 0.5 units by 2100.[11] [12] Ocean absorption of CO_2 from the atmosphere causes chemical changes, making waters more acidic. Higher acidity is likely to be detrimental to the large number of marine organisms, such as phyto- and zoo-plankton, molluscs and corals, which rely on a process of calcification to produce external or internal skeletons made from calcium carbonate.[13]

(e) Rising sea levels and violent storms: Sea levels around Europe have risen at rates varying from 0.8 to 3.0mm/year.[14] Rising sea levels drive coastal ecosystems further onto land, increasing the possibility that important habitats, such as coastal meadows and lagoons, are squeezed or lost completely. In addition, increasingly destructive storms and hurricanes threaten many coastal areas.

Rallying reserves against climate change

The growing perception that conventional fisheries management is failing and climate change impacts are growing has prompted widespread agreement on the need to adopt an 'ecosystem approach' to fisheries management and other human activities. Scientists and politicians agree that it is necessary to shift away from the conventional, single-stock management towards defining objectives that take the whole ecosystem as the starting point. This is reflected in a list of political commitments at national, regional and international level to implement an ecosystem-based approach, amongst which are the decisions, resolutions and recommendations of the Convention on Biological Diversity (CBD) and the European Regional Seas Conventions (HELCOM, OSPAR etc.). The Common Fisheries Policy (CFP) of the European Union (EU) incorporated in 2002 the binding objective to achieve "the progressive implementation of an ecosystem-based approach to fisheries management".[15]

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"The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way ... [and] is based on the application of appropriate scientific methodologies focused on levels of biological organisation, which encompass the essential structure, processes, functions and interactions among organisms and their environment."

The Convention on Biological Diversity

Although variously expressed, all definitions of ecosystem-based management take as a starting point a holistic consideration of the ecosystem and as their end point the sustainability of marine resources. The ecosystem approach requires consideration of whole ecosystems at scales that ensure that ecosystem integrity is maintained. In applying it, the conditions for sustainability must be met to ensure that ecosystems are not systematically degraded and that conditions required for the provision of human needs, future or present, are not undermined. Most or all definitions of the ecosystem approach additionally refer to the need for science or knowledge-based decision-making, embedded in adherence to the precautionary principle.

"The comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity."

European Seas Conventions OSPAR and HELCOM

The complexity of marine ecosystems and the difficulty of studying inaccessible ocean locations make it difficult, however, to fully understand and monitor ecosystem change. Studies often rely on models and predictions, which means that management decisions have to be taken in the context of unknowns. At the same time, there is a lack of intact ecosystems that could serve as "control sites" for assessing the value of protective measures.

"Generally speaking, the purpose of an ecosystem approach to fisheries is to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies without jeopardising the options for future generations to benefit from the full range of goods and services provided by marine ecosystems".

"Accordingly, an ecosystem approach to fisheries (EAF) strives to balance diverse societal objectives, by taking account of the knowledge and uncertainties of biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries"

UN Food and Agriculture Organisation (FAO) Technical Guidelines for responsible Fisheries

The above, as well as uncertainties caused by our incomplete knowledge of human behaviour patterns and rates of non-compliance, means that management must focus action where the control over the impact of the activity is most feasible and effective. Consequently, measures must be aimed at managing human activities, rather than attempting to manage the impacts or ecosystems themselves. In the case of climate change, measures are best aimed at climate-proofing maritime and marine conservation policies, while at the same time tackling the root causes of climate change.

Taking account of these uncertainties, implementation of the ecosystem approach requires a management strategy that:

- goes beyond a single or multi-species approach by considering the ecosystem as a whole;
- is aimed at protecting biodiversity and recovering ecosystems, not least with the aim to improve their resilience to global climate change;
- avoids overharvesting and ecosystem modifications;
- is based on the precautionary principle – i.e. conservation measures are taken even in the absence of full knowledge of the activities, impacts and ecological responses to these impacts;
- focuses on the 'up-stream' control of human activities, rather than on the control of impacts or ecosystems;
- is robust even in the light of uncertainties and management oversight; and
- can be applied with immediate effect.

In this context, the value of marine reserves as a conservation and management tool has been widely recognised. The European Commission's Joint Research Centre (JRC) advises that "protected areas contribute to the good health of the ecosystem which then could become relatively more resilient to environmental changes in comparison with those affected by additional anthropogenic pressure." [16] It consequently calls for the creation of new marine protected areas (MPAs) in Europe's seas, including fully protected no-take zones.

Marine reserves offer the highest level of protection, and are superior to areas with a limited number of restrictions.[17] Given the level of uncertainty in determining the effectiveness of individual ecosystem-based management measures, the establishment of permanent, legally defined and fully-protected reserves will be a vital component of implementing the ecosystem approach. For a detailed list of benefits of marine reserves please see Box 2.

Box 2: The benefits of marine reserves

The American Association for the Advancement of Science (AAAS) summarises the benefits of marine reserves as follows:[18]

A) Benefits within the reserve boundaries

- long lasting and rapid increases in abundance, diversity and productivity of organisms attributable to decreases in mortality, habitat destruction and to indirect ecosystem effects; and
- reduced probability of extinction of marine species.

B) Benefits outside reserve boundaries

- the size and abundance of exploited species increase in areas adjacent to reserves, although this finding is based on relatively few studies; and
- increasing evidence that reserves replenish populations regionally through larval export.

C) Positive effects of reserve networks

- increasing evidence that networks of reserves are more effective than a single reserve at buffering environmental variability and that they provide greater protection for marine communities.

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In fact, marine reserves are as old as fishing itself. The oceans seemed a limitless resource only because our catches were replenished from areas that we could not reach. Now that technological limitations no longer exist, managers must purposefully create the sanctuaries that once helped to replenish our oceans and seas.

There is a growing body of evidence to suggest that the establishment of a network of marine reserves can lead to enhanced yields in adjacent fishing grounds. This can be the result of either the spillover of adults and juveniles across reserve boundaries or from the export of larvae or eggs from unfished to fished areas.

A recent study of fisheries management, loosely based on experience from Iceland, concluded that closed areas must be part of a cod management strategy, if we are to save the species.[19] North Sea and Baltic Sea cod are feeling the heat of the combined pressures of overfishing and climate change (see Box 3). Existing EU recovery plans are failing, not least because politicians are ignoring the scientific recommendations for a moratorium on cod fishing. The authors conclude that protected areas should be large and exclude all principle gears, to protect against mortality during crucial life phases (e.g. during spawning or in nursery areas).

In addition to boosting the oceans' capacity to rally its own reserves, ocean sanctuaries act as valuable reference areas that can guide complementary management measures and recovery targets in areas beyond the reserves' boundaries, so underpinning the ecosystem approach.

The role of marine reserves as an integral part of the implementation of the ecosystem approach has been recognised by the American Association for the Advancement of Science (AAAS), amongst others. The AAAS notes that a larger reserve size confers more ecological benefits than a small reserve, and that networks must span large geographic distances to protect against catastrophic and climatic events. The design of a marine reserve network will become increasingly important in so far as conservation efforts are to account for the predicted latitudinal shift in species distribution in response to global climate change. Reserves may, for instance, be selected to include 'cold spots' to which organisms could retreat from rising temperatures. These include deeper waters, areas of cold water up-welling and areas at the pole-ward range of a species.

Box 3: Feeling the heat - North Sea cod ... going, going, gone

Cod stocks in the North Sea have been considered at risk of collapse since 1990. Current management is based on annual quotas set at levels well above those recommended by scientific advice, leading to persistent overfishing. Cod is also illegally fished and taken as by-catch in other North Sea and Atlantic fisheries. This means that even if scientific advice was being adhered to, and a zero Total Allowable Quota was set for North Sea cod, the species would still be caught in other nets.

Besides the severe impacts of overfishing, stock projections and recovery plans have not considered the impact of other environmental factors, including climate change. The relationship between cod populations, different fishing practices and climate change is a complex one. This is not adequately taken into account in the management of North Sea cod, and models predict that at current levels of exploitation, populations are likely to decline more markedly than predicted by conventional fisheries management models.[20]

It is known, for example, that changes in the occurrence of planktonic species in the North-East Atlantic and in the North Sea have resulted from climate change and are affecting the cod population. Warm water plankton species have replaced cold water species, but occur in far fewer numbers or display different seasonal peaks than equivalent cold water species.[21] As a result of the changes in the composition and abundance of plankton, larval cod is finding it difficult to find food.[22] It further seems that the reproductive success of cod is also hampered by the warmer environment, as the number of one-year-old fish entering the population decreases with increased sea-surface temperatures in the previous spring.[23]

While continuing to cut global greenhouse gas emissions, the best the European Union can do in the short to medium term is adapt its fisheries and marine management policies to take into account climate change, including by designating marine reserves.

Thinking big

EU Member States are already obliged to protect areas of sea under the EU's Habitats and Birds Directives. However, these Directives are principally directed at the protection of nature on land. Their implementation in the marine environment is many years behind schedule and insufficient to protect the wider marine ecosystem from activities such as fishing. Meanwhile, measures taken under the Common Fisheries Policy have failed to prevent or mitigate the impacts of fishing on slumping stocks, non-target species and habitats.

At regional seas level, EU coastal states have agreed to protect areas of the sea by 2008, and to complete a joint network of marine protected areas by 2010 in the North and Baltic Seas. Similarly, Mediterranean coastal states have agreed to protect, preserve and manage in a sustainable and environmentally sound way coastal and sea areas of particular natural or cultural value.

In 2004, echoing pledges taken at the World Summit on Sustainable Development, all EU Member States committed to the establishment of a global network of marine protected areas by 2012 in the context of the Convention on Biological Diversity's 7th Conference of the Parties. Notwithstanding the above, little more than 2% of Europe's seas have been granted some form of protection;[24] even less has been turned into marine reserves.

A review of 40 studies into the coverage that is necessary to achieve conservation and fisheries management goals concludes that 20-50% of the ocean should be protected.[25] The World Parks Congress, in 2003, recommended that at least 20-30% of marine habitats be included in networks of marine reserves, while the UK Royal Commission on Environmental Pollution (RCEP) in 2004 called for 30% of the UK's EEZ to be designated as no-take zones to reverse the impact of fisheries on the marine environment. In 2005, the United Nations Millennium Project called for 10% of the oceans to be covered by marine reserves in the short to medium term, with a long-term goal of 30%.

In relation to the need to preserve marine biodiversity and strengthen ocean resilience in light of climate change, the German Advisory Council on Global Change (WBGU) advised that at least 20–30 % of the area of marine ecosystems should be protected.

Greenpeace advocates that some 40% of marine areas globally should be designated as fully protected marine reserves. EU Member States are first and foremost responsible for designating reserves in the waters under their jurisdiction. In addition, the EU should, as it has done in the past, use its clout in international negotiations to make progress towards the establishment of a network of marine reserves in international waters.

Conclusions

Our oceans and seas are in a perilous state: 77% of all fish stocks are now either fully or over-exploited.*[26] Placing large areas of ocean 'off limits' is vital to protect marine life, the complexity of which we still do not fully understand, and is crucial to underpin the ecosystem approach.

Human-induced global climate change has profound implications for both marine ecosystems and the many people who depend on them. In order to protect our oceans we must reduce greenhouse gas emissions, eliminate unsustainable practices in ocean use and establish networks of large-scale marine reserves, which will help build the resilience of ocean ecosystems and improve our understanding of the impacts of climate change on marine systems.

Changes to the oceans and marine life are likely to be highly complex, including changes in sea temperature, sea level, currents and ocean chemistry. Moreover, negative feedback between climate change impacts and other human activities, particularly fishing pressure, will likely exacerbate climate-induced changes to marine ecosystems. In April 2007, the UN's Intergovernmental Panel on Climate Change (IPCC) is expected to issue its most urgent warning yet of the impacts of climate change on ecosystems. It is likely to link this warning to a call for action to reduce the negative impacts of global warming on marine ecosystems.

Through the forthcoming adoption of the EU's proposed Marine Strategy Directive, the European Union (EU) has a unique opportunity to lay the basis for a long overdue, coherent and dedicated instrument for marine protection, providing a first real chance to translate global and regional commitments into real action.

The proposed Directive will add to a number of existing EU laws that contribute to, or help regulate, aspects of marine protection. With a view to up-dating and consolidating these rules, the Directive should build on the advice and commitments that exist in relation to the implementation of the ecosystem approach, the designation of marine reserves and the need to 'climate-proof' conservation policies.

As a minimum, it should include provisions for the use of large-scale marine reserves as a mandatory component of regional strategies for marine protection and an integral part of the implementation of the ecosystem approach, as has already been suggested by the European Parliament. It should further ensure the sustainable management of all marine resources, whether protected by marine reserves or not. To be effective in this regard, it must address all the human-induced pressures on the marine environment, including impacts of fishing, pollution and shipping. The content and timing of the provisions must be set ambitiously, and ultimately implemented by all EU Member States without delay.

For further and detailed recommendations for the Marine Strategy Directive, please see http://www.greenpeace.eu/issues/oceans.html.

* The UN's Food and Agricultural Organisation 2007 report on the State of the World's Fisheries and Aquaculture states that 52% of fish stocks are fully exploited, 17% overexploited and 7% depleted. Merely 1% of fish stocks are recovering.

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