University of BRISTOL

Cabot Institute

Living with global uncertainty

2050: Sustainable oceans in a changing climate

Cabot Institute Position Paper

Authors: Tom Appleby (Law, University of the West of England), Philippa Bayley (Cabot Institute, University of Bristol), Martin Genner (Biological Sciences, University of Bristol), Erica Hendy (Earth Sciences and Biological Sciences, University of Bristol), Alice Hooker-Stroud (Public Information Research Centre), Fanny Monteiro (Geographical Sciences, University of Bristol), Margherita Pieraccini (Law, University of Bristol), Steve Simpson (Biological Sciences, University of Bristol).

Correspondence: Stephen.Simpson@bristol.ac.uk

The world's oceans are a potentially hugely productive resource. Against a backdrop of climate change, ocean acidification, population growth and poor governance and regulation, it is vital that we change our management strategies to maximise marine resources now, as well as for future generations. Policy and legislation must be more responsive to scientific evidence and reinforce sustainable and efficient practices.

The problem

Ocean ecosystems, historically, have been quietly undervalued and aggressively overexploited, yet healthy oceans are prerequisite for the welfare of people and planet.

CO_2-driven acidification and warming will gradually change ocean ecosystems over century-long timescales. These changes will likely have gained momentum by 2050 such that their impacts will be strongly felt for centuries. Biodiversity and habitat loss are already evident and will continue to degrade ocean ecosystems, while eutrophication and toxic plankton will continue to have localised, dramatic effects on ocean health.

While ocean ecosystems are set to degrade, the inefficiencies of current fisheries practice means we get only a fraction of what we could get from the ocean. Humans only benefit from a small proportion of the ocean's primary productivity - on land we eat herbivores, but we eat top-end predators from the marine environment. Poor and inconsistent regulation of the marine environment means we have also diminished ocean populations to the point where their inherent resilience and productivity is low.

Population growth, especially the disproportionate growth of those who depend heavily on fisheries to underpin their livelihood (directly and indirectly), will make the issue of fisheries and fishery management more pressing over the next few decades.

The Cabot contribution

Within the Cabot Institute, initiatives such as the Bristol Research Institute for the Dynamic Global Environment bring together expertise in climate modelling and biogeochemical cycling over a range of timeframes (deep, quaternary and recent times) from Earth Sciences, Geography and Biology.

Substantial involvement in the Intergovernmental Panel on Climate Change (IPCC) process helps develop global models to predict future climates and biological and ecosystem responses.

Cabot scientists generate new, and analyse existing, long-term datasets recording past climates, environmental conditions and measures of ecosystem function and composition. Combining these datasets allows us to detect the effects of climate change on the marine ecosystems, and better predict future ecological and evolutionary responses to climate change. For example, new research has revealed the effects of recent warming (last 100 years) on European fisheries, leading to predictions for future fisheries (Simpson et al. 2011 *Current Biology*). Analysis of biogeography relating to species ranges and community composition is also now being used to predict future distributions and patterns of connectivity at global and regional scales.

Researchers in the School of Biological Sciences are revealing the ways that environmental change impacts all scales of organisation, from molecules and cells to whole ecosystems. Combined with studies of speciation related to climate change, this is leading to an understanding of evolutionary responses to climate change.

.New legislation, such as the Marine and Coastal Access Act 2009 in the UK and the 2008/56/EC Marine Strategy Framework Directive, reflects the increasing governmental awareness that our seas need managing. Colleagues within the Cabot Institute have taken a leading role in the legal and stakeholder engagement processes which led up to this legislation, enabling us to comment reliably on the effectiveness of current marine management and to explore ways in which to develop future managerial solutions in line with an environmental justice perspective. Besides, socio-legal experts within the Cabot Institute create a much needed bridge between the functional focus of law and the analytical and methodological advances of other social sciences, thereby rendering the legal analysis of rights and governance more attentive to the social effects of regulatory solutions. More precisely, by linking doctrinal analysis with ethnographic methods, socio-legal experts are able to explore issues of marine governance from an interdisciplinary and innovative viewpoint,

Additional expertise from Departments of Economics and Nutrition could help to give a more complete prescription of what is required to shift ocean use to a more sustainable footing.

What does the future look like in 2050?

The overwhelming evidence from all contemporary climate change models suggests ocean temperatures will increase almost everywhere over the next century – though some areas will warm more than others. The Arctic may become ice-free and the Antarctic Ice Shelf reduced. The tropics could experience regular (annual?) spikes in sea temperatures, leading to bleaching of coral reefs, with temperatures hostile to many of the existing biological communities. Warming will bring about reorganisation of existing communities, with migration of species away from the tropics, and only if suitable habitat is available elsewhere. The timing of important life-history events (phenology, e.g. spawning, egg maturation, migrations) will change, often leading to match-mismatch between trophic levels (e.g. zooplankton and larval fish) with consequences on whole ecosystems and bioresources (e.g. fisheries).

Sea level is unlikely to change dramatically in the next 50 years, but shallow water nursery/feeding areas may change, as may chemical signals emanating from shallow water environments.

Ocean acidification will continue, with potential implications for phytoplankton productivity (especially calcifying phytoplankton, e.g. coccolithophores), exoskeleton growth in molluscs and corals, and stress levels and sensory ecology of fish.

Weather may become more destabilised, with more intense rainfall and resulting runoff from rivers, increased prevalence and intensity of cyclone/hurricanes (and possible changes to currents, El Niño cycles, Western Boundary Currents). Warming will result in lower gas dissolution into the ocean and greater stratification of the upper ocean with less mixing between layers. Increased release of CO_2 and oxygen will lead to increases in anoxic zones and microbial activity in surface waters.

The human population will have risen to 9+ billion, with a disproportionately high demand for marine protein in the diets of the world's poorest in coastal, usually tropical, countries. Energy demands will likely require far more offshore energy extraction, competing with current forms of exploitation.

Possible solutions and responses – what's needed?

To deal with these pressing issues which we know are coming, certain fundamental changes are required in our attitudes toward the ocean, as an environment with which we interact and rely on. Our vision of an attitudinal shift that would result in necessary change cover six key areas:

1. Governance

- Adaptive co-management strategies will be developed to cope with the rapid impacts of climate change upon the oceans.
- There will be a **binding** requirement for nation states' governments to stay within safe environmental limits.
- Governance structures will be transparent to ensure public accountability of the management process and to limit undue lobbying.
- There will be well-established networks of marine protected areas (MPAs) globally to protect biodiversity and to secure fisheries benefits.
- The diversity of ownership patterns of marine spaces and resources will continue to increase, as recreational activities, communities, conservation groups, offshore and wind/wave farms enter the marine environment in competition to traditional activities of fishing and navigation. Within fisheries there will be a practice of collective and individual property rights allocated to fishers on more certain terms than has been the practice to date, and in response to an increase in the development of aquaculture. Greater regard will be placed on the overall public nature of marine resources and the need to justify and account for the terms of any such privatisation properly.
- The practice of operating vessels under flags of convenience to avoid regulation will be outlawed.

2. Science

- Scientists will be trained to provide solutions for dealing with the marine impact of climate change through interdisciplinary collaboration and application of scientific research.
- Improved scientific modelling will allow a better understanding of the complexity and connectivity of the marine environment, so more accurate predictive models can be developed.

- Model results will be tested against past climate change information to improve the predictions of future climate change.
- To safeguard against regulatory capture, the independence of scientific expertise will be rigorously maintained.

3. Industry / aquaculture responses

- The most obviously harmful industrial practices, such as scallop dredging, will be banned as a result of a mixture of regulation and consumer awareness campaigns. There will be an increase in science-led fisheries management, with more sustainable practices being rewarded through market forces but bad practice penalised through price and regulation.
- The price of remote monitoring of the industry will continue to fall as technologies develop to enable better compliance with regulations.
- Alternative protein sources will become available for feed used in aquaculture.

4. Economics

- Markets will be optimised to give the best productivity/food security over price, stopping the wasteful practices of liberal discards of bycatch and farming expensive top-end predators over more nutritious alternatives.
- Changes will be made to subsidy structures to enable the true cost of fish to be reflected to consumers, pushing up the price of fish at the counter but reducing the overall tax burden.

5. Public participation

- The ocean will become a more accessible space with greater public engagement, e.g. through leisure activities.
- There will be a greater range of interests reflected in the management and ownership of the sea.
- In line with the Aarhus Convention 1998, early and effective opportunities to participate in environmental decision-making should be given to the public.

6. Justice

- It will be Illegal for richer nations to undermine other poorer nations' ability to access their own marine resources.
- Within countries, fisheries will be managed to reflect the best social benefit, such that the financial rewards are spread throughout coastal population. The industry will focus on developing a skilled workforce with an equitable share of wages.
- Distributive justice considerations should be integrated in governance solutions.

The Isle of Arran No Take Zone – a case study

The Isle of Arran sits in the middle of the Firth of Clyde in Scotland, an area which was once Europe's finest fishery. Today there are no commercially viable white fish stocks in the Clyde and, with the exception of a small inshore potting fleet, the only fishermen left use destructive bottom fishing techniques to catch prawns and scallops. Arran is an island famous for its tourism, and visitors used to be attracted there for its sea angling, but since the collapse of the white fish in the early 1990s, the sea angling festival on the island has been cancelled. This made local people wonder what was the cause

of the stock collapse, and after a visit to Leigh marine reserve in New Zealand, islander Don MacNeish realised that the widespread use of bottom towed fishing gear was likely to be the culprit. So Don and a number of other locals established the Community Of Arran Seabed Trust (COAST) whose aim was to create a small experimental No Take Zone (NTZ) to help restock the Clyde, and test the effectiveness of Marine Protected Areas as a management tool. The creation of the no take zone was a difficult task because it forced Government to look at fisheries in a different way. Until that point Government had been focussed on the declining numbers of active fishermen. With a shrinking pool of fishermen those consulted became less and less representative of the public. This was a real issue for the Scottish government as COAST had discovered early on that the right to fish was public property. The rights of the industry had to be weighed alongside the rights of everyone else. After a fraught campaign COAST established their no take zone in 2008 and it is now being regularly monitored by scientists and the local community to test its benefits. Early indications are positive; the no take zone contains maerl beds which act as a nursery area for juvenile fish. This is still only a very small area though in the context of the whole Clyde and remains the only no take zone in Scotland.

Perceived next steps and research questions?

Explore relationship between fishing and nutrient content of the oceans – can we model this?

Explore the relationship between the public's rights to the seabed and fish stocks and whether these are being managed in the public interest.

External Partners involved

Marine Conservation Society (suggested as peer reviewer for future documents)

Ocean 2012 (additional reviewers)

New Economics Foundation

Other NGOs: WWF, RSPB, Community of Arran Seabed Trust, Blue Marine Foundation

Fishermen's Organisations: Under Ten Metre fishermen's association

Wind Energy Association / Department of Energy and Climate Change

Hugh's Fish Fight

Government organisations: The Crown Estate, Defra, the Marine Management Organisation, Natural England, Marine Science Scotland, Countryside Council for Wales, Environment Agency

Additional expertise within the Cabot Institute:

Rich Pancost – esturine changes

Richard Evershed

Archaeologists – historic patterns of resource use (e.g. East African middens)

Economists

Ecosystem Services analysis Dr Mark Everard – Environment Agency

Historians – Caroline Williams – views of the sea