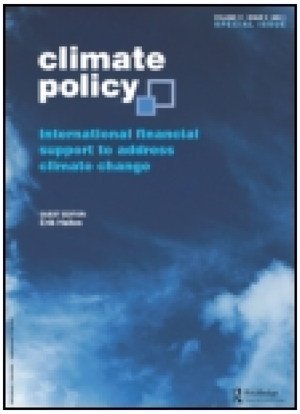

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The ocean and climate change policy

Grantly Galland [a], Ellycia Harrould-Kolieb [b] & Dorothée Herr [c]

[a] Center for Marine Biodiversity and Conservation, Scripps Institution of Oceanography, University of California at San Diego, La Jolla, CA, 92083-0202, USA

[b] Melbourne School of Land and Environment, University of Melbourne, Melbourne, Australia

[c] Global Marine and Polar Programme, International Union for Conservation of Nature, 1630 Connecticut Ave NW, Suite 300, Washington, DC, 20001, USA

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■ outlook: insight

The ocean and climate change policy

GRANTLY GALLAND[1]*, ELLYCIA HARROULD-KOLIEB[2], DOROTHÉE HERR[3]

[1] Center for Marine Biodiversity and Conservation, Scripps Institution of Oceanography, University of California at San Diego, La Jolla, CA 92083-0202, USA
[2] Melbourne School of Land and Environment, University of Melbourne, Melbourne, Australia
[3] Global Marine and Polar Programme, International Union for Conservation of Nature, 1630 Connecticut Ave NW, Suite 300, Washington, DC 20001, USA

The ocean plays a major role in regulating Earth's climate system, and is highly vulnerable to climate change, but continues to receive little attention in the ongoing policymaking designed to mitigate and adapt to global climate change. There are numerous ways to consider the ocean more significantly when developing these policies, several of which offer the co-benefits of biodiversity protection and support of marine-dependent human communities. When developing forward-thinking climate change policy, it is important to understand the ways that the ocean contributes to global climate and to fully inventory the services that the ocean provides to humans. Without more inclusive consideration of the ocean in climate policy, at all levels of governance, policy makers risk weaker than necessary mitigation and adaptation strategies.

Keywords: climate policy; marine conservation; marine ecosystems; ocean–climate interactions; oceans; UNFCCC

L'océan joue un rôle majeur dans la régulation du système climatique de la planète, tout en étant aussi très vulnérable au changement climatique, mais cependant continue de ne recevoir que peu d'attention au sein de l'élaboration actuelle des politiques visant à atténuer et à s'adapter au changement climatique. Nombreuses sont les manières de bien prendre en compte les océans dans l'élaboration de ces politiques, certaines d'entre elles offrant des co-bénéfices en matière de protection de la diversité et soutien aux communautés humaines dépendantes des zones marines. Il est important de comprendre, dans l'élaboration de politiques climatiques prévisionnelles, les façons dont les océans contribuent au climat planétaire et de pleinement inventorier les services que l'océan fournit à l'homme. En l'absence d'une prise en compte inclusive des océans dans les politiques climatiques, à tous les niveaux de gouvernance, les décideurs risquent une mise en œuvre de stratégies de mitigation et d'adaptation plus faibles qu'il ne le faut.

Mots clés: politique climatique; conservation marine; écosystèmes marins; interactions océan-climat; océans; CCNUCC

1. Introduction

The ocean is a vital component of the global climate system and helps to regulate climate through its immense capacity to store heat and gases, including CO_2. The ocean currently absorbs close to 30% of all anthropogenic CO_2 emissions (Sabine et al., 2004) and 90% of the heat being added to Earth's climate system (Bindoff et al., 2007), thereby substantially reducing the effects of global climate change. However, this service does not occur without consequences. Absorbed heat and CO_2 is causing the ocean to warm, rise, and become more acidic. These physical and chemical changes threaten to alter substantially the abundance and distribution of life throughout the ocean (Brierley and Kingsford, 2009) and will probably affect millions of humans who rely on the ocean and its life for their sustenance and livelihoods. It is clearly necessary to consider the ocean's role in regulating climate and vulnerability to climate change when negotiating – at all levels of governance – the best ways to mitigate and adapt to this global problem. In this article, three topics regarding

■ *Corresponding author. *E-mail*: ggalland@ucsd.edu

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the ocean's inclusion in climate change discussions are addressed:

- Why it is important to consider the ocean during climate change policy creation and implementation.
- Whether the ocean is already sufficiently considered in these policies or if it is undervalued.
- If the ocean is undervalued, how climate change policy makers might begin to significantly address this issue.

2. Why worry about the ocean in a climate forum?

The ocean plays an important role in creating and regulating the regional climates around which human societies are organized. The Earth's climate is driven by interactions within and between the ocean, the atmosphere, and the continental landmasses, contributing to cloud formation, precipitation, and both constant and seasonal winds that drive important weather events, such as monsoons (Talley et al., 2011). The ocean also acts as a heat distribution pump, moving huge volumes of warm water and air towards the poles and cold water and air towards the tropics (Talley et al., 2011), supporting mild climates in places like New Zealand, Western Europe, and California.

The ocean is the planet's largest active carbon sink and plays an important role in buffering changes within the climate system by absorbing large amounts of CO_2 (Sabine et al., 2004) and heat (Bindoff et al., 2007) from the atmosphere, preventing more drastic changes to the Earth's climate system. However, this service has limits, and continued emissions of CO_2 are overburdening the ocean and weakening its buffering capacity (Fung et al., 2005; Le Quéré et al., 2007). Furthermore, this substantial absorption of CO_2 and heat alters the physical (i.e. temperature; Levitus et al., 2005) and chemical (i.e. pH and carbonate ion concentration; Caldeira and Wickett 2003) properties of the ocean, threatening marine ecosystems and biodiversity, as well as the people who rely on them.

Rising sea level (Domingues et al., 2008), an increasing incidence of extreme weather events (Webster et al., 2005; Hoyos et al., 2006), and potential changes to oceanic water masses and currents (Stocker and Schmittner, 1997) are all physical alterations to the ocean associated with ongoing warming. The resulting flooding, saltwater intrusion, and changing oceanography (IPCC, 2007) threaten coastal people (UN Habitat, 2008) and many human activities, including fishing, tourism, trade, and recreation (IPCC, 2007).

Marine species are directly threatened by rising temperature and the resulting changes in ocean conditions, and ecosystems may be substantially modified by shifts in the abundance and distribution of marine species (Brierley and Kingsford, 2009). For example, tropical species often live near the upper physiological limit of their temperature range (Tewksbury et al., 2008), so as waters warm, migration may be the only feasible survival strategy for these species. Such shifts in marine communities are already being observed (e.g. Perry et al., 2005). These shifts will probably have significant implications for both small fishing communities and industrial fishing nations, who may not be able to effectively follow target species, risking important sources of protein, income, and tradition. Changes in species abundance and distribution within or across borders could lead to serious conflict and will undoubtedly involve difficult and expensive legal negotiations.

Marine species and people are further threatened by the chemical changes that are taking place in the ocean as a result of CO_2 absorption. These changes are already being measured (Caldeira and Wickett, 2003; Feely et al., 2004); ocean chemistry is changing rapidly. Ocean acidification alters the sensory abilities of some species (e.g. Hester et al., 2008; Munday et al., 2009) and threatens the ability of others to build their skeletons or shells (Fabry et al., 2008). These chemical changes threaten all parts of marine food webs, including the human fishers and hunters who rely on marine resources, potentially threatening food security (Turley and Boot, 2010).

The combined effects of the physical, chemical, and biological changes within the ocean are likely to result in severe repercussions for hundreds of millions of people who rely on the ocean for food and income, perhaps leading to mass migration, an issue that current immigration conventions do not address (Hodgkinson et al., 2009). However, the integration of sound marine resource management into climate policies can aid in the mitigation of and adaptation to oceanic changes resulting from emissions of CO_2 and other GHGs.

3. Is the ocean considered sufficiently in the climate change forum?

Despite its significant role in climate regulation and vulnerability to climate change, the ocean is often relegated to footnotes and afterthoughts in the development of climate policy. This is evident in the proceedings of the recent Conferences of Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC), the premier international forum for negotiating international strategies for mitigation of and adaptation to the interference with the climate system resulting from emissions of CO_2 and other GHGs.

For example, the Parties to the UNFCCC have recognized that forests are an important part of the climate system and that their effective management will offer the co-benefits of climate change mitigation and ecosystem service provision to nearby people. Consequently, substantial amounts of time and resources are spent on forest management at UNFCCC COPs, and official decisions regarding forestry practices have recently been supported by COPs 13 (Bali), 15 (Copenhagen),16 (Cancún), and 17 (Durban), among others. These decisions involve negotiating parties directly discussing forests and reaching conclusions based on their discussions. However, a similar recognition of the importance of the ocean in climate regulation, the ocean's role as the largest active carbon sink, and the provision of services by healthy ocean ecosystems is noticeably lacking. Since the ratification of the UNFCCC, which includes a subparagraph (Article 4, paragraph 1(d)) promoting management of the ocean and coastal and marine ecosystems, ocean issues have rarely been mentioned during the negotiations and are certainly not featured heavily in conference decisions.

This imbalance is further apparent in the allocation of officially sanctioned side events during recent COPs. At COP 15, 31 side events were devoted to discussing issues related to forestry and deforestation, but only four dealt with any ocean-related topic. The situation did not improve at COP 16 (31/3) or COP 17 (28/4). This exercise is not intended to claim that forests are too heavily featured during the UNFCCC process, but rather to demonstrate the comparative undervaluation of the ocean at those same conferences.

4. How can the ocean be considered more significantly?

There are good reasons why the ocean's role in climate regulation, value as a carbon sink, and importance as a source of food and income for hundreds of millions of people around the world should receive more attention during the negotiation and implementation of climate policy. Achieving this result is a two-step process:

- Researching and designing policies that deal with ocean–climate issues.
- Injecting appropriate language into the laws and agreements at the highest levels of national and international climate change negotiation.

One could argue that the first step is well under way, if not complete. Ocean researchers and advocates already have a good idea of what policies could successfully manage oceanic carbon stores, preserve marine and coastal ecosystems, and support the continued provision of ecosystem services. For example, in 'Blue Carbon Policy Framework' (Herr et al., 2011), several policy opportunities to include oceanic carbon storage more significantly in international, regional, and national climate change mitigation strategies are discussed. Potential threats to the marine environment (e.g. shifting ecosystem ranges and changes to ocean chemistry) in the absence of mitigation policies are also well known (see above).

As already mentioned, however, there has been little progress on the second, and practically more difficult, step of convincing those at the negotiation table to consider language involving the ocean. COP decisions, as well as national legislation, are often necessarily general in order to ensure that they are applicable to a wide range of stakeholders and to avoid limiting the effectiveness of implementing agencies. Therefore, it can be difficult to obtain support for specific issues. Even the general acknowledgement of an issue as important, however, can inspire a reaction, and the assignment of an issue to a working group, subsidiary body, or committee leads to significant and timely analysis and action (again, forest management is an example).

Tables 1 and 2 provide a menu of marine policy actions that should be considered when negotiating the best ways to address global climate change. These actions are broadly divided into two categories: those that deal with mitigating future climate change (Table 1) and those that deal with adapting to ongoing change (Table 2). Marine mitigation strategies include the protection of important coastal and marine carbon stores, which are rarely considered in the global carbon budget (Herr et al., 2011), support of renewable energy practices that harness some of the vast amounts of available ocean energy (wind, tidal, solar, etc.), and consideration of marine commerce activities such as shipping, in order to mandate higher energy efficiency (e.g. by slowing ship speed; Faber et al., 2010), among others.

Some adaptation strategies include:

- The analysis of coastal development and marine resource use to reduce practices that permanently alter natural systems and increase risk.
- The support of practices that facilitate disaster risk reduction for coastal communities.

TABLE 1 Recommendations to enhance consideration of the ocean in climate change mitigation policies

Policy action	Level of implementation	Possible costs of implementation	Possible benefits of implementation
Utilize oceanic threshold data (akin to atmospheric CO_2 levels) to design and support emission reduction targets. These targets should consider ocean warming (°C) and acidification (pH), as well as non-linear changes to oceanic water masses. Continue to support oceanic temperature and pH monitoring efforts, and implement new programmes in order to document the approach and potential exceeding of these thresholds	International	Opportunity costs associated with choosing one threshold over another; direct costs associated with support of oceanic monitoring networks	Tangible mitigation targets
Ensure that CO_2 emissions reduction targets consider the impacts of ocean acidification, not just climate change, as reductions in CO_2 equivalents may reduce the impacts of climate change without mitigating acidification	International	Loss of benefits of CO_2 equivalent reductions; costs associated with CO_2 reduction	Prevention of harmful impacts of ocean acidification; synergistic benefits to the climate systems of reduced CO_2 emissions
Protect coastal and marine ecosystems, especially mangrove forests and tidal marshes that sequester significant amounts of carbon and provide other ecosystem services to local communities	National; local	Opportunity costs associated with preventing land-use change	Food and income generation for local communities; other ecosystem services such as coastal protection
Fund and deploy research into effective and efficient means of marine renewable energy generation	International; national; local	Direct costs associated with research grants	Job creation in renewable energy sector; new technological innovations
Support marine renewable energy by offering economic incentives for large, early investments (e.g. feed-in tariffs or other forms of price guarantees that have proven successful in other sectors of the energy industry)	National; local	Direct costs associated with incentives; ecological impacts when projects are poorly sited	Job creation in renewable energy sector; stable, government-backed investment opportunities
Include the global shipping fleet in emission reduction schemes; implement technological and operational measures that reduce ship emissions	International; national	Costs associated with retrofitting existing ships; potential increase in ship building costs	Job creation in ship technology sector; fuel cost savings; direct emission reduction

- The protection of both vulnerable and somewhat resilient ecosystems in order to maximize adaptation capacity (Marshall et al., 2009).
- The preparation for unpredictable costs associated with a changing ocean, such as the migration of people, living marine resources, or shipping lanes.

Both active adaptation strategies (including ecosystem-based adaptation (see Hale et al., 2009) and technological fixes) and reactive strategies (such as ecosystem restoration) have marine components that should be explored in more depth and incorporated more significantly into climate change policies.

TABLE 2 Recommendations to enhance consideration of the ocean in climate change adaptation policies

Policy action	Level of implementation	Possible costs of implementation	Possible benefits of implementation
Eliminate unsustainable subsidies and other incentives that promote coastal and marine development projects that alter local systems, increase risk, and threaten the continued provision of ecosystem services. Replace these incentives with rewards that support projects that undertake a more holistic approach to natural resource use and support long-term food and income generation without sacrificing global change adaptation benefits	National	Direct costs could be zero sum if goals behind subsidies are changed but values are neither increased nor decreased; indirect (including job loss) and opportunity costs are associated with changes to development practices	Increased coastal resiliency (potentially very valuable); consistent ecosystem services; job creation in sustainable development sector
Noting a preference for cost-effective, proactive management of marine living resources and ecosystems, restore key systems (already altered through human activities) in regions especially vulnerable to ocean change	National; local	Restoration efforts can be very directly expensive	Increased coastal resiliency; consistent ecosystem services; increased carbon sequestration in complete systems
Develop consistent, stable funding strategies that promote creative adaptation solutions and reward individuals and organizations who utilize a holistic approach to marine resource management and use	International; national	Potential loss associated with failed investments; opportunity costs of choosing one investment strategy over another	Savings gained from long-term strategies rather than short-term projects; potential new solutions to existing problems
Prepare for unpredictable costs and difficulties of a changing ocean. Examples include the negotiation costs associated with the movement of ocean change displaced persons, the migration of fisheries resources across international borders, and the increases in fuel costs associated with potential changes to shipping lanes/prevailing currents	International; national	Initial investments in new legal structures	Potential savings in negotiations costs; savings in conflict resolution costs; protection of human life and livelihoods

Continued

TABLE 2 Continued

Policy action	Level of implementation	Possible costs of implementation	Possible benefits of implementation
Monitor marine ecosystem change in order to identify priority areas for adaptation actions. Ensure that the newest environmental and socio-economic research findings are consistently used to improve these actions. Be prepared to monitor and evaluate adaptation efforts and change course when better methods arise or when evidence demonstrates a lack of success of ongoing approaches	International; national; local	Costs associated with data collection and dissemination; loss of initial investments and sunk costs during strategy change	Efficient use of limited funds by preventing waste associated with continuation of failing programmes
Incorporate monitoring and evaluation of global change adaptation efforts into existing environmental (e.g. ecosystem indices, diversity surveys) and socio-economic (e.g. standard of living surveys) monitoring programmes, with the purpose of maximizing available resources	National; local	Costs of preparing new educational materials and starting new programmes; potential changes in priority of existing programmes	Savings associated with synergies that utilize a common management structure to achieve multiple goals
Manage ocean change together with traditional development and conservation goals to ensure that all three can be successful without (i) competing for limited human and financial resources or (ii) working in isolation of each other (sometimes to a harmful degree)	International; national; local	Potential harmful changes in priority or weakening of existing programmes	Savings associated with synergies that utilize a common management structure to achieve multiple goals
Incorporate local, traditional, and indigenous knowledge into all of the above adaptation strategies, many of which should be geared towards the local level	International; national; local		Utilization of a large, potentially solution-based population

Tables 1 and 2 also offer a suggested level of implementation and possible costs and benefits of implementing each action. Some recommendations require action at multiple levels of governance and are recognized accordingly. For example, designing economic incentives for investing in marine renewable energy installations may be best accomplished at the national level, while local involvement is necessary when determining the best places to site those installations. Similarly, funding for research on problems associated with climate change may be provided by both international and national sources. Information on potential costs and benefits is provided in order to help answer questions associated with the implementation of these policy actions. Specific dollar amounts are not estimated, as this is outside the scope of this article, but general costs/benefits are mentioned to demonstrate the tradeoffs that may be necessary in order to achieve the goal of designing ocean-inclusive climate change policies. There are, of course, costs associated with any one of these policy actions, but implementation of such actions could begin to address the undervaluation of the ocean in the climate change forum.

5. Conclusions

The ocean is a major, often undervalued contributor to the global climate system and is particularly vulnerable to climate change and acidification. As the world moves forward in negotiating the best ways to address carbon emissions, it is important to consider the linkages between the ocean and our ability to mitigate and adapt to global change. Healthy, robust marine and coastal ecosystems not only contribute to climate change mitigation, but also help society become more resilient to change. Climate policy development should acknowledge these connections and work to ensure the protection of the ocean and its role in climate regulation and provision of ecosystem services.

Overlooking the importance of the ocean to the climate system when devising climate policies risks their success. Effective policies – at all levels of governance – must acknowledge the role of the ocean and attempt to prevent intolerable changes to the ocean–climate system. Just as forest management has been integrated into climate policy discussions as an acknowledgement of the importance of forests to the regulation of climate and mitigation of climate change, ocean management should be incorporated into future climate policy formulation.

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