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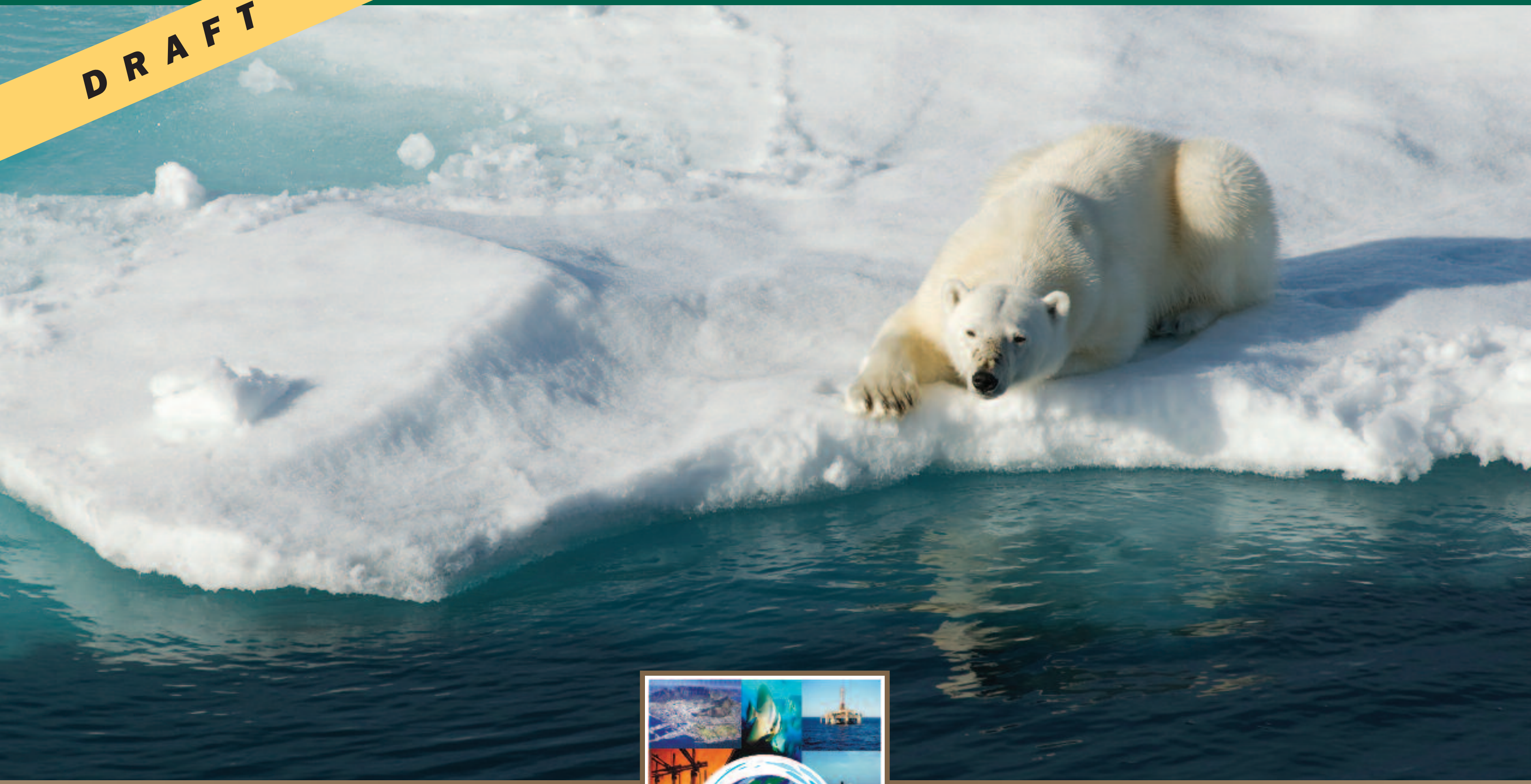

The Global Forum on Oceans, Coasts, and Islands

Oceans and Climate Change: Issues and Recommendations for Policymakers and for the Climate Negotiations

Policy Briefs prepared for the World Ocean Conference

May 11-15, 2009, Manado, Indonesia

Biliana Cicin-Sain
Volume Organizer and Editor

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Editor's Note: Global Forum policy publications are aimed at promoting discussion and action to advance the global oceans agenda. The perspectives expressed in this volume, including any errors or omissions, are the responsibility of the individual authors. These perspectives are not necessarily shared by all members of the Global Forum on Oceans, Coasts, and Islands, partner organizations, nor by the Global Forum's sponsoring organizations.

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Preface

The global oceans community is very thankful to the Government of Indonesia for hosting the World Ocean Conference 2009 to put the limelight on the relationship between climate change and oceans, coasts, and small island developing States (SIDS). The political consensus that will be reached by governmental representatives in issuing the Manado Oceans Declaration is very much appreciated and applauded by the global oceans community.

High-level ocean leaders from all sectors (governments, non-government organizations (NGOs), international organizations, science, and industry) participating in the 4th Global Conference on Oceans, Coasts, and Islands *Advancing Ecosystem Management and Integrated Coastal and Ocean Management in the Context of Climate Change*, April 7-11, 2008, Hanoi, Vietnam, urged the international community to focus on the relationship between oceans and climate change and the predicted profound effects on ecosystems and coastal populations around the world, especially among the poorest people on Earth and in SIDS.

In particular, conference participants identified the "special niche" that ocean and coastal leaders occupy (or hold), and adopted the following agenda for action for the Global Forum on Oceans, Coasts, and Islands to pursue in its Program of Work, 2008-2012:

- Put ocean issues in the climate negotiations and vice versa

- Understand and develop policy responses to global ocean changes (such as ocean warming, ocean acidification, changes in currents, changes in polar regions)

- Address the "climate divide" and promote international commitments and funding mechanisms to respond to the differential effects of climate change on different regions and peoples, especially in relation to developing countries and SIDS

- Encourage a wide range of adaptation efforts and appropriate financing mechanisms

- Properly manage mitigation efforts related to the oceans
    - Carbon capture and storage
    - Ocean fertilization
    - Curbing air pollution from ships

- Encourage alternative forms of energy using the oceans (such as wind power, tides, currents)

- Encourage capacity development, public education, and innovative private sector action to address the impacts of climate change on oceans, coasts, and SIDS

This volume of Policy Briefs has been prepared to provide all participants present at the World Ocean Conference in Manado and participants involved in the climate negotiations related to the UN Convention on Climate Change (UNFCCC) and the Kyoto Protocol with information and perspectives on the range of issues involved in oceans and climate change.

This volume, currently presented in Draft form, will be enhanced through the discussions that will take place during the World Ocean Conference, especially during the Global Ocean Policy Day and associated process, which represent the major opportunity during the World Ocean Conference for multi-stakeholder dialogue among high-level government officials, international organizations, NGOs, industry representatives, and scientists on the importance of the oceans in climate change, mitigation strategies, adaptation strategies, and financing issues. The funding support of the Global Environment

Facility, the United Nations Environment Programme, and the Indonesian Ministry of Marine Affairs and Fisheries in the preparation of the Global Ocean Policy Day is acknowledged with sincere thanks.

This volume has been produced by the Secretariat of the Global Forum on Oceans, Coasts, and Islands, in cooperation with faculty and students at the University of Delaware's Gerard J. Mangone Center for Marine Policy, and in close collaboration with colleagues from The Nature Conservancy; the World Wildlife Fund; the Institute for Sustainable Development and International Relations, France; the Sea Level Rise Foundation, Seychelles; NAUSICAA; and the World Ocean Network.

Please note that Global Forum policy publications are aimed at promoting discussion and action to advance the global oceans agenda. The perspectives expressed in this volume, including any errors or omissions, are the responsibility of the individual authors. These perspectives are not necessarily shared by all members of the Global Forum on Oceans, Coasts, and Islands, partner organizations, nor by the Global Forum's sponsoring organizations. The authors welcome comments and corrections to the various chapters in this volume.

On behalf of the Global Forum on Oceans, Coasts, and Islands, I would like to convey sincere thanks to the Government of Indonesia for its hosting of the World Ocean Conference, with special appreciation to the Minister of Marine Affairs and Fisheries Freddy Numberi and to the Governor of North Sulawesi S. H. Sarundajang. We all look forward to being in Manado, a world center of marine biodiversity and the Land of Smiling People.

Dr. Biliana Cicin-Sain
Co-Chair and Head of Secretariat
Global Forum on Oceans, Coasts, and Islands
May 2009

Chapter 1

At the Frontlines of Climate Change--Oceans, Coasts, and Small Island Developing States: The Need for Action Now

1. At the Frontlines of Climate Change—Oceans, Coasts, and Small Island Developing States: The Need for Action Now

By Biliana Cicin-Sain, University of Delaware and Global Forum on Oceans, Coasts, and Islands

Oceans and the Climate Negotiations

Nations around the world are in the process of negotiating a new climate regime to address the issues of climate change and forge new international agreements entailing deep cuts in greenhouse emissions and a complex of associated measures on mitigation, adaptation, financing, and technology. The intent is to produce a new climate regime that will launch the world toward a low-carbon future, thus avoiding the potentially devastating effects of climate change. The negotiations, expected to produce significant changes to the UN Convention on Climate Change (UNFCCC) and the associated Kyoto Protocol, will culminate in December 2009 in Copenhagen.

At its inception in 1992 at the Earth Summit in Rio de Janeiro, Brazil, the UN Framework Convention on Climate Change (UNFCCC) recognized the importance of coasts and of coastal management. In Article 4 of the Convention, under Commitments, the text notes that:

> "1. All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives, and circumstances, shall……..:
>
> (d) Cooperate in preparing for adaptation to the impacts of climate change; develop and elaborate appropriate and integrated plans for coastal zone management, water resources, and agriculture, and for the protection and rehabilitation of areas, particularly in Africa, affected by drought and desertification, as well as floods;"

The Convention thus reinforces the more general prescriptions concerning integrated coastal and ocean management contained in chapter 17 of Agenda 21 and shows how this management concept can relate to adaptation to the impacts of climate change.

However, in the current climate negotiations, discussions of the central role of oceans in climate regulation and the key role of coasts as areas at the frontlines of climate change, have been largely absent from the discussions.

It is important that considerations related to oceans, coasts, and small island developing States be given due consideration at the climate negotiations for a variety of reasons, noted below.

The Central Role of Oceans: Why it is Essential to Include Oceans in the Climate Negotiations? (contributed by Haymet 2009)

Two-thirds of the Earth's surface is covered by oceans, which regulate climate, modulate human-induced global change and provide food and energy resources. Human society relies on the oceans as a source for water, for fisheries, as a climate buffer, for international trade, and indeed for inspiration and solace.

Because of their immense capacity for storing heat and absorbing carbon dioxide, the oceans play a critical role in climate and climate change. Oceans regulate global temperatures and clouds—and therefore global climate—over timescales spanning months, years and centuries. Ocean warming and ocean acidification can severely impact marine ecosystems resulting in unprecedented, lasting changes that may be difficult, and in some cases impossible, to adapt to. Precise impacts cannot yet be predicted with certainty due to insufficient time-series data, modeling and analysis.

Oceans impact natural disasters
Many disasters, including devastating storms, hurricanes and tsunamis, originate in the oceans. Only with a deeper understanding of the behavior of the oceans and their relations to the atmosphere and the solid earth can such natural phenomena be predicted and devastation mitigated.

Oceans impact human health and well-being
Marine ecosystems provide much-needed food for the world's population. Preservation, protection and restoration of marine ecosystems are needed to develop ecosystem-based management for long-term sustainability of these critical resources.

Oceans impact energy resources
The oceans have the capacity to produce renewable energy from algae-based biofuels, offshore winds, waves, ocean currents and offshore solar sources.

Oceans impact dwindling water resources
Fresh water is in short supply in many parts of the world. The oceans play a key role in the global water cycle as the primary source of rainfall. Better understanding of variations in weather and precipitation patterns will enable more efficient use of scarce water resources.

Oceans impact marine ecosystems and biodiversity
Climate change results in alterations in the oceans that impact marine ecosystems and marine biodiversity. Changing temperatures of seawater are modifying the distribution, abundance and biodiversity of marine organisms around the globe and pollution and over- exploitation threatens the integrity of many coastal ecosystems. Marine ecosystems are also central to the planetary cycle of carbon and other greenhouse gases. The 2007 IPCC report warns of the immense threat to coral reefs. Increasing acidification of ocean waters due to the dissolution of excess carbon dioxide could endanger many marine life forms.

Major Climate Change Challenges for Oceans, Coasts, and SIDS

Ocean Changes Associated with Climate Change
The IPCC and other scientific sources have highlighted important findings regarding far-reaching ocean changes associated with climate change--ocean warming, sea level rise, changes

in ocean circulation, changes in polar regions, and ocean acidification (discussed in Balgos and McCole, section 3a, this volume).

Ocean Warming

Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations and it is *likely* that increases in greenhouse gas concentrations alone would have caused more warming than observed because volcanic and anthropogenic aerosols have offset some warming that would otherwise have taken place. Warming of the climate system has been detected in changes of surface and atmospheric temperatures in the upper several hundred meters of the ocean, and in changes to sea level rise (Balgos and McCole, section 3a. this volume).

Sea Level Rise

Sea level rise, together with extreme events such as hurricanes, will threaten coastal areas, increase erosion rates and exacerbate the impacts of tidal waves. Sea level rise will threaten the economies and well-being of many coastal communities, especially those that are low-lying. Hundreds of millions of peoples may be displaced. International law on climate-induced population movements is ill developed—there is no obligation to receive displaced populations from coastal areas nor to pay for the displacement costs.

Changes in Ocean Circulation

The circulation of seawater in the form of ocean currents is very important, as it regulates much of the earth's climate. An increase in the output of anthropogenic CO2 can result in a disruption of this process by causing an increase in ocean temperature, which results in a decrease of the density of seawater through the thermal expansion of water molecules (caused by an increase in ocean temperature), as well as desalinization of the water (caused by melting sea ice and increased precipitation), thereby causing the circulation of seawater in the North to slow down (Balgos and McCole, section 3a, this volume)

Changes in Polar Areas

It appears that ice cover in polar areas has decreased at a rate much faster than forecasted. The melting of ice could potentially have serious consequences for ocean conditions, such as effects on the circulation, overturning, ventilation, and changing circulation in the Arctic basin. Melting sea ice will increase sea level rise significantly. In addition, possible increased exploration pressure and competition could result, such as mining for minerals and extraction of hydrocarbons, fisheries, and shipping. An increase in the release of methane could occur from the melting of permafrost. Aboriginal tribes in the Arctic will also feel the impact of these changes, for instance, members of Arctic tribes report having an increase in respiratory distress in conjunction with extreme warm summer days (Balgos and McCole, section 3a, this volume).

Ocean Acidification

Scientists have established that ocean acidification is underway and that severe damages are anticipated as a result. The effects on marine ecosystems cannot yet be predicted precisely but there is a risk of profound changes to the food web, as calcification of marine organisms may be impeded or in some cases even prevented. Ocean acidification could affect marine food webs and lead to substantial changes in commercial fish stocks, which will adversely affect protein supply and food security for millions of people and the fishing industry. Ocean acidification could also affect other marine goods and services, e.g., management of waste, provision of chemicals to make new medicines, and regulation of climate) (Balgos and McCole, section 3a, this volume).

Challenges that Coastal Communities Will Face

Coastal communities (where 50% of the world's population lives), are at the frontlines of climate change—these areas will suffer the brunt of climate changes in the face of sea level rise, increased frequency and intensity of storms, and possibly endure major hardships such as possible displacement and resettlement of their populations. Coastal communities will need a range of adaptation measures, financing, and technology transfer to address these challenges. The climate issues that ocean and coastal leaders around the world will need to face will ineradicably change the nature of ocean and coastal management, introducing increased uncertainty, the need to incorporate climate change planning into all existing management processes, the need to develop and apply new tools related to vulnerability assessment, and the need to make difficult choices in what in many cases will be "no win" situations, involving adverse impacts to vulnerable ecosystems and communities (Global Forum on Oceans, Coasts, and Islands, 2008).

Among the coastal areas of the world that will be especially impacted, it is the "poorest of the poor" on earth, in particular, that will be most affected, and it is an international responsibility to address this "climate divide." Coastal nations in Africa, Latin America, East and South Asia, the 43 small island developing states, and polar regions will be affected the most. We will see profound impacts on vulnerable communities and ecosystems, including increases in weak and fragmented states, economic development impeded, and hundreds of millions of environmental refugees.

Climate change is adversely impacting marine and coastal ecosystems and biodiversity, affecting their ability to provide critical services (such as food, energy, medicines, natural shoreline protection against storms and floods, water quality maintenance, and other cultural and spiritual services, therefore directly threatening vulnerable communities. Climate change impacts on oceans and coasts are numerous and complex, and expected across polar, temperate, and tropical environments, from the surface to the ocean depths, profoundly altering ecosystem functions. For example, a recent study (Danovaro et al. 2008) pointed out that a 20-25% loss in species diversity may be associated with a reduction of 50-80% in ecosystem functions in deep sea areas (Smith et al, section 7a in this volume).

Climate change is already impacting the ability of marine and coastal ecosystems to provide food, income, protection, cultural identity, and recreation to coastal residents, especially vulnerable communities in tropical areas. In particular, coastal communities will face a variety of threats from climate change, including the following: (Hale et al, section 5a of this volume).

- Sea level rise--impacts the condition and distribution of coastal habitats and human infrastructure.
- Ocean physical changes (e.g. changes in water temperature, stratification, and currents)--affects species survival and distributions, ocean productivity, and the timing of biological events.

- Loss of sea ice--leads to reduced habitat for ice-dependent species in the Arctic and Antarctic and changes the habitat and productivity for other species. It also decreases the storm resiliency of coastal Arctic communities.
- Ocean acidification--impacts the growth and viability of sensitive marine organisms such as corals, bivalves, crustaceans, and plankton.
- Altered freshwater supply and quality--impacts coastal habitats, spawning migrations, and survival of anadromous species. (Hale et al, section 5a of this volume)

These impacts will continue and increase over the short to medium term, even as the community of nations works to reduce its greenhouse gas emissions. There is an urgent need to develop, implement, and fund ecosystem-based adaptation strategies in coasts and oceans as a central part of the global response to climate change. Coastal and marine ecosystem protection and restoration is the foundation for ecosystem-based adaptation, and strong and specific provisions for the development, implementation and funding of coastal and marine ecosystem-based adaptation need be a central part of a Post-2012 Climate Agreement (Hale et al, section 5a of this volume).

The importance of risk-based planning for adaptation using an integrated coastal and ocean management approach should be emphasized. A recent analysis from the Heinz Center carried out with the insurance industry, shows that proper planning for "resilient coasts" can yield significant positive results, e.g., five hundred commercial clients of the insurer, FM Global, experienced approximately 85 percent less damage from Hurricane Katrina as similarly situated properties. This significant reduction in the amount of damage was directly attributable to hurricane loss prevention and preparedness measures taken by these policyholders. The return on investment was striking—a $2.5 million investment in loss prevention resulted in $500 million in avoided losses (Tulou, section 5c, this volume).

Challenges to the Survival and Well-Being of Small Island Developing States
Sea level rise is already exacerbating inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. In addition, the following conditions are expected in SIDS nations: Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching; reduction of water resources in certain SIDS regions to the point of insufficiency to meet demand during low-rainfall periods; and increased invasion by non-native species.

Climate change-induced human displacement is also expected in SIDS: Some communities in SIDS countries are already being evacuated due to increased storm frequency and intensity and sea level rise. For example, several thousand people from the Careret Islands, Papua New Guinea had to evacuate their homes and move to an adjacent island following the destruction of their homes due to severe storms and high tides. Other island states, including Tuvalu and Kiribati, are currently preparing plans for eventual evacuation (Payet and Mendler de Suarez, section 4a, this volume).

Mitigation Options Using the Oceans
There are a variety of climate change mitigation efforts that involve the oceans; prominent options include carbon capture and storage, ocean fertilization, and curbing air pollution from

ships. Ocean-based alternative energy development can also be considered as an ocean-based mitigation option.

Carbon Capture and Storage

Carbon dioxide capture and storage (CCS), "a process consisting of the separation of CO_2 from industrial and energy-related sources, transport to a storage location and long-term isolation from the atmosphere" (IPCC 2005), is a mitigation technique with the potential to prevent large amounts of carbon dioxide (CO_2) from being released into the atmosphere, as it has the potential to reduce emissions by 80-90%. If CCS technology develops quickly, the method may be able to mitigate 20-40% of CO_2 emissions within fifty years. CCS can potentially be stored in several locations: in terrestrial geological formations, such as depleted oil and gas fields and deep saline formations; fixation with inorganic carbonates; under the sea floor; or in the ocean water column (Snyder et al, Chapter 8, this volume).

Ocean Fertilization

Natural iron fertilization that induces algal blooms is being studied as a successful biological carbon pump, removing carbon from the atmosphere and storing it deep in the ocean. Laboratory experiments have confirmed the possibilities of using iron to induce algal blooms. Since 1993, twelve experiments have taken place in the ocean without encouraging results. Injected iron particles did not stay at the surface long enough to be effective. Turbid water sank the particles and lack of sunlight limited the generation of phytoplankton. Ocean currents limited the effectiveness of measuring direct carbon capture in deeper waters. Naturally occurring iron fertilization was considerably more efficient and effective (Snyder et al, Chapter 8, this volume).

Curbing Air Pollution from Ships

Shipping transports 90% of the world's goods, with over 50,000 merchant ships in service. The 2007 IPCC report noted that global transport (including aviation and maritime) accounts for 13% of GHG emissions, with carbon dioxide (CO_2) being the primary GHG emitted by the maritime transport sector. There are efforts underway within the International Maritime Organization to pursue reduction of emissions of greenhouse gases from marine bunker fuels.

Encouraging Ocean-Based Alternative Energy

The ocean can provide for significant contributions to mitigation strategies, including alternative renewable energy sources such as wind, waves, tidal, ocean currents, and thermal energy conversion. Some of these sources require increased research and technology demonstration, others, stable financing and appropriate management frameworks. At present, offshore wind energy production appears to have the greatest immediate potential for energy production, grid integration, and, ultimately, climate change mitigation, in comparison to other marine renewable sources

Summary Observations and Recommendations for the UNFCCC Process

1. **Mitigation**

A Precautionary Approach to Setting Cuts in Greenhouse Emissions

The negative consequences of climate change on oceans, coasts, and SIDS may be dire and could be irreversible. Utmost precaution needs to be exercised to ensure the continuing functioning of the oceans to regulate climate, the ability of coastal communities to adapt to climate change effects, and the ability of SIDS nations to survive and enhance their wellbeing.

This calls for setting targets and processes that will ensure deep reductions in greenhouse gas emissions within a relatively short time frame. The positions of countries that are especially affected, such as the SIDS countries and other coastal nations especially vulnerable to climate change, should be given special consideration.

As noted by the German Advisory Council on Global Change, anthropogenic greenhouse gas emissions must be significantly reduced in a timely manner in order to halt further ocean warming, sea level rise, changes in circulation, changes in polar areas, and ocean acidification. Adaptation measures can only succeed if the present acceleration of sea-level rise and the increasing acidification of the oceans are halted (WGBU 2006).

Ensuring Resilience of Coastal and Marine Ecosystems

One major way to help maintain (and in some cases restore) ecosystem health, productivity and services in the face of climate change, while reducing poverty and safeguarding social and economic development, is the creation and effective management of networks of marine protected areas. Marine protected areas (MPAs) cover a diverse set of forms and management frameworks, ranging from village-level community-managed areas to multi-million hectare national parks, to protected areas in marine areas beyond national jurisdiction. Resilient marine protected areas networks that provide ecosystem goods and services represent an important avenue for addressing the impacts of climate change (Smith et al, section 7a, this volume).

Properly Regulating Mitigation Efforts Using the Oceans

Mitigation measures related to the oceans should be carefully scrutinized and, if promising, should be encouraged using appropriate regulatory frameworks.

Carbon Capture and Storage. Carbon capture and storage has high potential as a mitigation measure, but needs to be carefully studied and regulated to ensure that the practice is safe and effective.

Direct injection of CO_2 into the ocean is not recommended, due to the potential for irreversible harm to sensitive marine organisms.

CCS via injection into the seabed is a potential mitigation measure to address climate change, however, possible impacts to marine life, potential security risks, and the long-term ability of sites to successfully store CO_2 without leakage or diffusion to the ocean (and eventually the atmosphere) should be carefully studied and appropriate detailed regulatory frameworks should be developed.

Ocean Fertilization. It appears that this approach is not effective, is not well regulated, and that it could pose serious and unforeseen consequences for the ocean environment. This approach should hence be discouraged.

There are no specific regulations regarding ocean fertilization, and permitting requirements are unclear. The issue of ocean fertilization falls primarily between the 1982 United Nations Convention on Law of the Sea (UNCLOS) and the 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter and associated London Protocol (1996). However, there are no enforceable regulatory measures in either agreement. Parties to the London Convention and the London Protocol and the Convention on Biological Diversity have taken strong stances to limit these fertilization experiments (Snyder et al, Chapter 8, this volume).

The UNFCCC should specifically remove the incentive to continue these experiments by excluding them from the carbon offset program and participation in the carbon market.

Curbing Air Pollution from Ships. National authorities should encourage an accelerated conclusion of IMO deliberations regarding the curbing of air pollution form ships.

While waiting for an international framework on mandatory GHG emissions measures to be approved and enter into force, Port States can implement measures to encourage ships to reduce their speed (a 10% reduction of speed of the world's fleet can result in a 23.3% reduction in ship emissions), as well as offer cold-ironing facilities in-port (this allows ships to shut down their engines and connect to shore-based power to meet their energy needs while in port using cleaner sources of fuel).

Encouraging Ocean-Based Alternative Energy
Development of ocean-based alternative energy, such as windpower, currents, tides, ocean thermal energy conversion, should be encouraged as an alternative to conventional energy sources, provided that appropriate regulatory frameworks are put into place to safeguard the marine environment and its resources.

National governments can facilitate the development of ocean-based alternative energy industry through the following measures:

--the development of appropriate policy and regulatory frameworks
--the utilization of marine spatial planning giving priority, as appropriate, to marine renewable energy development
--consistent and dependable funding for marine renewable energy projects to facilitate large-scale development and implementation
--development of a national renewable energy policy framework, with targeted budgets on technology, research and development programs

2. Adaptation
Coastal communities everywhere, and especially in the developing countries and in SIDS nations, will be severely impacted by climate change.

Adaptation in coastal areas should be guided by the following considerations:

--Adaptation needs to happen immediately, including in relation to development that is already underway

--Adaptation needs to take many forms, using a variety of measures: hard structures (dykes, protective walls), soft measures (beach nourishment, protecting natural barriers such as wetlands), and floating measures (such as floating housing structures)

--Adaptation needs to be carried out through ecosystem-based approaches using existing integrated coastal and ocean management institutions and processes at local, national, or regional (e.g., Large Marine Ecosystems, Regional Seas) scales (Wowk, section 6a, this volume; Sherman, section 6b, this volume)

--Integrated, ecosystem-based adaptation aims to:

- Preserve and restore natural ecosystems that can provide cost-effective protection against some of the threats that result from climate change. For example, coastal ecosystems like wetlands, mangroves, coral reefs, oyster reefs, and barrier beaches all provide natural shoreline protection from storms and flooding in addition to their many other services (Hale et al, section 5a, this volume).

- Conserve biodiversity and make ecosystems more resistant and resilient in the face of climate change so that they can continue to provide the full suite of natural services. This is particularly important for sustaining natural resources (e.g., fish stocks, fuel, clean water) on which vulnerable communities depend for their subsistence and livelihoods (Hale et al, section 5a, this volume).

- Protect coastal populations and infrastructure in the coastal zone from the threats of climate change using a risk-based approach through existing integrated coastal and ocean management institutions. This entails, *inter alia*, (adapted from Tulou, section 5c. this volume):

    --Identifying and filling critical gaps in scientific understanding and developing the tools and methodologies necessary for incorporating climate change into risk assessments and risk mitigation decisions
    --Requiring risk-based land use and marine spatial planning
    --Designing adaptable infrastructure and building codes standards to meet future risks
    --Strengthening ecosystems as part of a risk mitigation strategy
    --Developing flexible adaptation plans
    --Maintaining a viable private property and casualty insurance market

--The UNFCCC should recognize the importance of marine and coastal areas and their vulnerability to climate change and fully incorporate integrated ecosystem-based adaptation strategies for marine and coastal areas into the following aspects of the UNFCCC negotiations:

--National Adaptation Programs of Action

--The shared vision for long-term cooperative action being discussed by the Ad Hoc Working Group on Long-term Cooperative Action under the United Nations Framework Convention on Climate Change (AWG-LCA)
--The program for Enhanced Action on Adaptation in the post-2012 climate agreement
--New measures related to Technology Development and Transfer

3. Financing

A sufficient level of financing needs to be mobilized to meet the adaptation and mitigation needs of coastal communities around the world to address climate change.

Financing the adaptation to climate change of the most vulnerable coastal populations in developing countries and SIDS should receive the highest priority. This includes financing of measures related to the management of displaced populations due to climate change.

Climate negotiations must take into consideration the need for increased investments and expanded international cooperation in research, development, and demonstration to improve understanding of the dynamics and impacts of global ocean changes that pose adverse impacts to coastal and ocean ecosystems and the communities that depend on them for goods and services, and to develop appropriate monitoring and early warning networks (Kullenberg et al. 2008; Vousden and Ngoile, section 6c in this volume).

Developed countries should provide assistance to developing countries in research, development, and deployment of solutions/adaptations to ocean changes.

Establishment of networks of marine protected areas to build resilience to climate change and protect biodiversity should be adequately financed, both in national areas and in areas beyond national jurisdiction.

4. Capacity Development/Technology Exchange

Capacity development and technology exchange will be essential to equip coastal communities with the capacity for adaptation to climate change and for deploying and monitoring appropriate mitigation measures using the oceans. The UNFCCC should give top priority to capacity development in adaptation and mitigation in developing nations and in SIDS.

5. Public Involvement

Public understanding and support of climate mitigation and adaptation measures is essential for governments to take and abide by actions to curb greenhouse emissions. The UNFCCC should encourage financing of measures to inform, educate, and empower the public to take personal and community decisions that move toward a low-carbon future.

In Conclusion

Decisive action that will preserve the central role of oceans in insuring the survival of the planet and address the threats faced by coastal communities all over the world and especially in the developing nations and in SIDS, is needed now. As noted by Payet and Mendler de Suarez in this volume (section 4a), “Time is not a luxury many of the world’s islands and coastal communities have. At stake are millions of island and coastal peoples from the Arctic to the tropics."

At present, people are worrying, with good reason, that the current global economic crisis will take attention away from dealing with climate change and from maintaining the unique role of the oceans as sustaining life on Earth by generating oxygen, absorbing carbon dioxide from the atmosphere, regulating climate and temperature, and providing a substantial portion of the global population with food, livelihoods, energy, and transportation.

This could be a major problem, but, at the same time, it may present opportunities. To every person on the street—whether in Manado, Buenos Aires, Shanghai, or Cairo—the economic crisis has demonstrated that we are so intertwined to one another in the global economy, that we will fall or rise together. For the global oceans community this is an opportunity to articulate that our economic survival must be tied to our environmental survival, and that the oceans play a key role in both our environmental and economic survival.

No one can do this alone—Not the governments, the UN, the NGOs, the private sector, the science sector. All are needed and cross-sector coalitions to articulate the centrality of oceans, coasts, and SIDS in the climate negotiations are imperative.

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Chapter 2

Oceans and the Climate Negotiations

2. Oceans and the Climate Negotiations

By Kateryna Wowk, NOAA National Ocean Service and Global Forum on Oceans, Coasts, and Islands, and Anama Solofa, UNDOALOS/ Nippon Foundation Visiting Fellow, University of Delaware

Context and Importance of the Problem

Coastal and ocean managers have decades of experience managing coastal and marine habitats and their threats, and can enhance the quality and effectiveness of climate change mitigation and adaptation efforts. Their expertise needs to be relied upon, particularly considering the fast pace at which changes are occurring. The global community must remain cognizant that we have the tools to solve the problems and that integrated, ecosystem-based management is one possible way. Coastal and ocean managers have specialized skills that can offer solutions toward building coastal resiliency. Advances in ocean observations should also be encouraged, as they have the potential to make relatively long-term forecasting of climatological parameters and conditions, including extreme events (e.g., El Niño). It is anticipated that by linking the oceans and climate communities, we will be enabled to effectively meet the climate challenge.

Background on Summary of the Climate Negotiations

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 (in-force 1994) to address global warming by stabilizing atmospheric concentrations of greenhouse gases. Signatories to the UNFCCC are split into three groups: Annex I countries (industrialized countries); Annex II countries (developed countries which pay for costs of developing countries); and developing countries.

The Kyoto Protocol, agreed to in 1997 (in-force 2005), exerts legally binding measures on Annex I parties to reduce overall emissions. The Kyoto Protocol further provides for three mechanisms (emissions trading, the Clean Development Mechanism, and joint implementation) to assist countries in meeting their target levels, and creates an Adaptation Fund to finance adaptation projects in developing countries that are Parties to the Protocol.

Currently, 192 nations have ratified the UNFCCC, 184 of which have ratified the Kyoto Protocol. At present, negotiations are guided by the Bali Action Plan, which has established a process under the Convention and Protocol, with the goal of reaching a comprehensive outcome agreement to resolve post-2012 issues at the Fifteenth Conference of the Parties (COP 15), to be held in Copenhagen, Denmark in December 2009. Many question the effectiveness of the Kyoto Protocol in its implementation, particularly regarding the efficiency and credibility of the flexible mechanisms by which industrialized nations can achieve part of their climate targets. This and other issues will need to be addressed in Copenhagen.

The 2007 Bali Roadmap and Bali Action Plan lays out a two-year negotiating process, culminating in Copenhagen, to finalize a legally-binding successor agreement to the Kyoto Protocol (set to expire in 2012). Key issues that need to be addressed include:

- Shared vision (which greenhouse gas reduction target for 2020?)
- Developed countries: Which commitments? (Annex I)
- Developing countries: Which actions? Will remain in one group?
- Finance: Which financial flows, what mechanisms, what governance?
- Technology transfer

The climate negotiations are highly complex, sensitive and largely transparent. There is a high-level of political attention and a heightened level of global public awareness. Deep divisions exist within the negotiations, not the least of which concerns the respective roles of Annex I and non-Annex I Parties, and in particular industrialized and large developing countries, in a multilateral post-Kyoto regime. Negotiations focused on the nature of the process, and those on mitigation to be undertaken by developed and developing countries, have been particularly resistant to the achievement of consensus (ENB 2007). Negotiations will need to continue focusing on the four "building blocks" seen as essential in the Bali Roadmap, including: adaptation, mitigation, technology transfer and financing.

The large number of players and ambitious agendas involved in UNFCCC processes may hinder additional cooperation among the climate and ocean sectors. The modest outcomes and large number of issues left unaddressed at the recent meeting of the Fourteenth Conference of the Parties to the UNFCCC, held in Poznan, Poland, December 2008, will lead to difficult negotiations in Copenhagen, further inhibiting the ability of participants to address new concerns and involve new partners.

Additionally, the recent global economic crisis has forced organizations to prioritize their needs and focus their efforts even more, lessening the flexibility to broaden an issue and address linkages. Unless the links between oceans and climate are made abundantly clear, as well as the urgent need to consider both systems in negotiations, it may prove difficult to engage the climate community in this new focus.

Mechanisms for Addressing Targets and Goals

There are a number of mechanisms set out under the Kyoto Protocol intended to allow countries to meet their emission-reduction targets and goals. There are further mechanisms proposed under the Bali Roadmap, as explained below. These and additional mechanisms will potentially be discussed and addressed in Copenhagen.

Mechanisms Under the Kyoto Protocol

1. Emissions Trading

   Article 17 of the Kyoto Protocol provides for the trade of unused emission units among nations. Excess capacity can be sold to countries that are over their emission targets (with a focus on carbon).

2. The Clean Development Mechanism (CDM)

   Article 12 of the Kyoto Protocol defines the CDM, which allows Annex B countries under the Protocol (including 38 Parties) to implement an emission-reduction project in developing countries, in order to earn saleable certified emission reduction credits.

3. Joint Implementation (JI)

   Article 6 of the Kyoto Protocol defines the JI mechanism, which allows countries with emission reduction/limitation commitments under the Protocol (an Annex B Party) to earn emission reduction units by partnering/investing in a project in another Annex B Party, which could be counted toward meeting its targets.

Mechanisms Proposed Under the Bali Roadmap

Reducing Emissions from Deforestation in Developing Countries (REDD)

In an effort to reduce forest degradation, estimated by the Intergovernmental Panel on Climate Change (IPCC) to contribute 20 per cent of the overall greenhouse gases entering the atmosphere, the Bali Action Plan and the COP13 Decision 2/CP.13 calls for a functioning international REDD finance mechanism in an agreed post-2012 framework, to be able to provide the appropriate revenue streams to fund activities toward the program. In response to the COP13 decision, requests from countries, and encouragement from donors, FAO, UNDP and UNEP have developed a collaborative REDD program, aimed at generating the required flow of resources to significantly reduce global emissions from deforestation and forest degradation.

Measurable, Reportable and Verifiable (MRV) Requirement

Paragraph 1.b of the Bali Action Plan provides for the parameters under which mitigation actions should proceed. Specifically, it calls for "[m]easurable, reportable and verifiable nationally appropriate mitigation commitments or actions including quantified emission limitation and reduction objectives by all developed country Parties (…)" (BAP 1.b.i 2007). In accordance with the principle of common but differentiated responsibilities, the MRV refers to:

(i) nationally-appropriate mitigation commitments or actions by all developed country Parties; and
(ii) the provision of technology, financing and capacity-building which enable and support nationally appropriate mitigation actions of developing country Parties in the context of sustainable development.

Paragraph 1.b.iii further calls for "[p]olicy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries."

However, this does not take into account the large carbon stocks of non-forested areas, which still need to be addressed. For example, Wetlands International, among others, is calling upon the Parties of UNFCCC to also address forested and non-forested peatlands, bogs and fens to reduce carbon emissions and to conserve and enhance their carbon stocks (Wetlands International 2008).

Mechanisms for Potential Discussion at Copenhagen

Other subjects for future discussion include the use of sectoral approaches, and approaches to enhance the cost-effectiveness of mitigation actions, including market mechanisms.

Risk Reduction and Management, and Insurance-Related Mechanisms

The need to manage and reduce risk, as well as the need to build resilience, will be major points of focus in Copenhagen. There is consensus among UNFCCC Parties that both concepts need to be integrated into broader national adaptation strategies. Discussions here will most likely focus on mechanisms to manage, reduce and share risk, with a focus on the most vulnerable countries (i.e., LDCs, SIDS, and countries in Africa affected by drought, floods and desertification).

Disaster reduction strategies and actions may draw on the 2005 Hyogo Framework for Action (HFA). For example, this could include the need to support the creation and strengthening of both regional and national integrated disaster risk reduction mechanisms, such as multi-sectoral national platforms, with designated responsibilities at the regional through local levels to facilitate coordination across sectors (HFA 2005, III.B.1.i.a). Also promoted in the HFA are mechanisms that encourage compliance and that promote incentives for undertaking risk reduction and mitigation activities (HFA 2005, III.B.1.i.c), and social safety-net mechanisms to assist the poor, elderly, disabled and other populations affected by disasters (HFA 2005, III.B.4.i.g).

Consideration is needed on whether a new risk mechanism under the Convention is needed, which might incorporate such areas as insurance, rehabilitation and/or compensation, and risk management (AWG-LCA 2009).

Potential UNFCCC Mechanisms to Address Climate, Oceans, and Security

Climate, oceans and security concerns can be addressed through a variety of UNFCCC mechanisms, including in adaptation, mitigation, and financing and technology. Innovative approaches might include a variety of market and non-market based policies, giving greater attention to national capacity and the co-benefits of adaptation measures, while still focusing on the need to reduce emissions. For example, enhanced wetland management could help to sequester carbon, provide greater protection to low-lying land areas vulnerable to sea level rise and conserve biodiversity (CCELP 2007).

Clean Development Mechanism (CDM)

Initiatives involving the CDM do not currently include coastal and oceans projects that focus on reducing emissions. Particularly regarding small-scale CDM projects, efforts should be incorporated and accounted for, with a focus on priority work with developing countries.

Proposed Risk Reduction and Management, and Insurance-Related Mechanisms

A mechanism created to manage and reduce risk could account for adaptation strategies focused on oceans and coasts, with a special emphasis on the most vulnerable countries. Such a strategy should focus on capacity-building, and should support and strengthen existing regional and national integrated disaster risk reduction mechanisms and adaptation planning and implementation strategies, taking into account all sectors (AWGLCA 2009).

Building Resilience, Creating Enabling Environments and Sharing Knowledge

Ocean and coastal issues could be addressed through a mechanism centered on building ecosystem and community resilience. Efforts here should focus on the need for ecosystem-based management, climate-resilient development, national capacity-building, knowledge sharing, and the need to enhance institutional arrangements and regional cooperation (AWGLCA 2009). Notably, there is a current lack of emphasis among Parties on the need to enhance ecosystem resilience. Instead, Parties converge on the need to build resilience through economic diversification. The need to also incorporate the concept of ecosystem resilience must be addressed in order to maintain ecosystems' natural states and enhance their abilities to absorb shocks, particularly in the face of large-scale and long-term changes.

Matching Enhanced Action on Adaptation with Financial and Technological Support

Sustainable and predictable financing to support adaptation planning and implementation also needs to be addressed. Such a strategy will need to support the preparation and implementation of national adaptation plans, particularly in developing countries. The decades of expertise of coastal and ocean managers should be relied on to enhance the integration of adaptation efforts into sectoral, national and regional planning. Further, their expertise can lend insight to, and provide support for, technologies for monitoring, forecasting, modeling, enhancing resilience and coastal zone management.

Nationally Appropriate Mitigation Actions (NAMAs)
There is convergence among Parties on the view that NAMAs should contribute to the sustainable development and economic growth of developing countries, and that, where appropriate, such actions should build on existing plans, programs and strategies. Adaptation strategies currently underway that focus on the special issue of oceans and coasts should be incorporated into NAMAs.

Technology Cooperation and Cooperative Research and Development
There is agreement on the need for institutional arrangements that incorporate a broad range of technology research and development planning, and implementation activities at the regional and international levels. Such arrangements should account for mitigation strategies that use or rely on the ocean, including renewable energy (e.g. off-shore wind power) and carbon dioxide capture and storage (ocean carbon sequestration).

Various Meetings of the Bali Action Plan and Country Perspectives

The Bali Action Plan sets the course for a series of negotiations that will culminate in Copenhagen, December 2009. Four major meetings were conducted in 2008, including:

- United Nations Climate Change Conference at its fourteenth session / Twenty-ninth sessions of the Subsidiary Bodies, Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP 4), *Ad Hoc* Working Group on Longterm Cooperative Action under the United Nations Framework Convention on Climate Change (AWG-LCA 3) and the *Ad Hoc* Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP 6), 2 - 13 December 2008, Poznań, Poland
- Accra Climate Change Talks - AWG-LCA 3 and AWG-KP 6, 21 - 27 August 2008, Accra, Ghana
- Bonn Climate Change Talks -Twenty-Eight Sessions of the Subsidiary Bodies, AWG-LCA 2 and AWG-KP 5, 2 - 13 June 2008, Bonn, Germany
- Bangkok Climate Change Talks - AWG-LCA 1 and AWG-KP 5, 31 March to 4 April 2008, Bangkok, Thailand

Additional meetings for 2009 include:

- Seventh session of the AWG-KP and fifth session of the AWG-LCA , 29 March to 8 April 2009, Bonn, Germany
- Thirtieth sessions of the UNFCCC Convention subsidiary bodies - SBSTA and SBI, eighth session of the AWG-KP and sixth session of the AWG-LCA, 1 June to 12 June 2009, Bonn, Germany
- Intersessional informal consultations, 10-14 August 2009, Bonn, Germany
- Ninth session of the AWG-KP and seventh session of the AWG-LCA, 28 September to 9 October 2009, Bangkok, Thailand
- Resumed Ninth session of the AWG-KP and resumed Seventh session of the AWG-LCA, 2-6 November 2009, Venue to be determined
- COP 15 and CMP 5, 7 December to 18 December 2009, Copenhagen, Denmark

The following tables summarize the various perspectives held in closing plenary by countries involved in the negotiating process for the AWG-LCA 5 and the AWG-KP 7 (ENB 2009):

Fifth Session of Ad Hoc Working Group on Long-term Cooperative Action under the United Nations Framework Convention on Climate Change (AWG-LCA 5) – Summary of Closing Plenary Statements

Party/Group	*Statement*
G-77/China	• expressed concern with very little engagement from developed countries and a serious Convention implementation deficit.
Enivronmental Integrity Group	• stressed that the work of AWG-LCA has important intergenerational implications in the context of sustainable development.
AOSIS	• expressed extreme disappointment with the lack of progress. • noted some disturbing trends in doubting scientific findings and called for clear milestones for each of the future meetings.
Least Developed Countries	• highlighted that the key guiding principle should be avoiding adverse impacts on the most vulnerable countries • called on developed countries to provide adequate financial support for adaptation actions.
EU	• noted progress in gaining a better understanding of some ideas such as REDD, a NAMA registry and technology transfer.
Gender Constituency	• noted that the transition to a low-carbon society should be socially just • the needs of the most vulnerable should be recognized.
Indigenous Peoples	• stressed that REDD must ensure prior informed consent of local indigenous communities and include their participation in all steps of governance.
14 Latin American and Caribbean countries	• called for very ambitious emission reductions • highlighted that adaptation is a necessity in developing countries.
Canada	• underlined progress made at this session pathways
Mauritania	• stressed the right to aspire to equitable development • called on developed countries to live up to their current commitments.
India	• negotiating text should be based on the Bali Action Plan • new issues outside its mandate, including concepts such as "advanced developing countries" and "low carbon development strategies," should not be introduced in that text.
Bolivia	• stressed that developed countries should pay their climatic debt.
USA	• called for a pragmatic approach and noted convergence on many issues such as adaptation and financial architecture.
Japan	• highlighted the need for coherence with the work under the AWG-KP.
Marshall Islands	• called for immediate and credible mitigation targets and for an action-oriented legally binding agreement.
Algeria	• stressed that attempts to link the two tracks and to differentiate among developing countries could slow down progress in AWG-LCA and make it difficult to reach agreement in Copenhagen.

Seventh session of the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP 7)– Summary of Closing Plenary Statements

Party/Group	*Statement*
[1]**Japan**	• expressed concern over the scope of the AWG-KP's work and urged close cooperation between the two AWGs *(supported by Turkey, the Russian Federation, Ukraine, Croatia, Belarus, Australia and others)* • highlighted that cooperation between the AWGs is necessary for a fair, comprehensive and effective post-2012 framework and requested that these concerns be reflected in the meeting's report.
Canada	• stressed that an environmentally-effective agreement in Copenhagen requires

[1] Please note: A list of acronyms is found at the end of the paper.

	very close coordination by the AWGs.
Croatia	• highlighted that the world is very different from 20 years ago when the distinction between Annex I and non-Annex I countries was established.
New Zealand	• the AWGKP's work is challenged in the absence of a shared vision and global long-term goal.
Russian Federation	• progress achieved so far does not point towards a global and comprehensive agreement in Copenhagen.
Australia	• urged every effort be made to ensure coherence and consistency between the AWGs
South Africa	• noted that the two groups meet at the same time and place at every session, meaning that parties have an understanding of what is going on in each group and a formal link is therefore unnecessary.
Environmental Integrity Group	• noted some positive steps forward
EU	• stressed that the incoming Chair had been given a clear mandate to prepare text on amendments and decisions to be adopted in Copenhagen. • emphasized the AWG-KP's mandate covers the broad range of issues in the work plan
New Zealand	• the above issues are really "aspects of the same issue," namely Annex I further emission reductions, and emphasized the need for finalizing LULUCF rules before the targets.
G-77/China	• highlighted the AWG-KP's "very clear and definite" mandate to reach conclusions on Annex I parties' emission reductions. • expressed "extreme disappointment" over the lack of substantive discussion on Annex I parties' emission reductions • noted that other issues are important, they must not distract from the AWG-KP's focus. • emphasized the necessity of reaching agreement in Copenhagen "to save the planet."
A number of developing countries	• expressed disappointment at the conclusions on Annex I emission reductions.
Botswana	• historical responsibility seemed to be turning into historical and current irresponsibility.
China	• the atmosphere was "excessively occupied" by Annex I emissions, denying developing countries space for sustainable development. • urged Annex I parties to show responsibility and move forward with concrete steps.
Lesotho	• expressed disappointment that even the science had been doubted in the negotiations.
USA	• emphasized that "the times have changed" • anticipates being more active, expressing interest in various issues under the AWG-KP, including the flexibility mechanisms and LULUCF (Land Use, Land-Use Change and Forestry).

Policy Recommendations

Working with key spokespersons (e.g., AOSIS), the marine community should pay special attention to SIDS and the Arctic cases as major bellwethers of forthcoming changes, and highlight special cases to personalize the issues (e.g., displacement of the citizens of Kiribati). Further emphasis should be placed on changes in the Arctic that will drive changes elsewhere, which specific examples, where possible.

Focus should also be given to the broad dissemination of information on the need to embrace a wide range of efforts including hard structures (dykes, protective walls) and soft measures (beach renourishment, protecting natural barriers (wetlands)), providing successful examples and best practices, including cost-effective approaches and methodologies, where possible.

List of Acronyms

AOSIS – Alliance of Small Island States
AWG-LCA – *Ad Hoc* Working Group on Longterm Cooperative Action under the United Nations Framework Convention on Climate Change
AWG-KP – *Ad Hoc* Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol
CDM – Clean Development Mechanism
CMP – Conference of the Parties serving as the Meeting of the Parties to the Kyoto Protocol
COP – Conference of the Parties
EIG – Environmental Integrity Group, Mexico, the Republic of Korea and Switzerland
HFA – Hyogo Framework for Action
IPCC – Intergovernmental Panel on Climate Change
JI – Joint Implementation
LDC – Least Developed Countries
LULUCF – Land Use, Land-Use Change and Forestry
MRV – Measurable, Reportable and Verifiable
NAMA – Nationally Appropriate Mitigation Actions
REDD – Reducing Emissions from Deforestation in Developing Countries
SIDS – Small Island Developing States
UNFCCC - United Nations Framework Convention on Climate Change

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Chapter 3

Understand and Develop Policy Responses to Global Ocean Changes: Ocean Warming, Sea Level Rise, Changes in Currents, Changes in Polar Regions, and Ocean Acidification

3a. Addressing Global Ocean Changes

By Miriam Balgos and Kathleen McCole, University of Delaware and Global Forum on Oceans, Coasts and Islands

Context and Importance of the Problem

Scientific investigations have established the causal relationships between increased atmospheric greenhouse gas concentrations, global warming, and major global ocean changes, including: 1) ocean warming; 2) sea level rise; 3) changes in circulation; 4) changes in polar regions; and 4) ocean acidification. The IPCC, in its 4th Assessment Report, states that "Warming of the climate is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level…" (IPCC 2007b). "At continental, regional and ocean basin scales, numerous long-term changes in climate have been observed. These include changes in arctic temperatures and ice, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of extreme weather including droughts, heavy precipitation, heat waves and the intensity of tropical cyclones…" (IPCC 2007b).

This brief provides an overview of these changes, the current policy responses including gaps, and recommendations for consideration by the UNFCCC and other stakeholders.

Ocean Warming

Global warming refers to the gradual increase in global surface temperature, observed or projected, as one of the consequences of changes in net radiation energy caused by anthropogenic emissions (IPCC 2007b). According to the IPCC report, "most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations and that it is *likely* that increases in greenhouse gas concentrations alone would have caused more warming than observed because volcanic and anthropogenic aerosols have offset some warming that would otherwise have taken place." Warming of the climate system has been detected in changes of surface and atmospheric temperatures in the upper several hundred meters of the ocean, and in changes to sea level rise. The IPCC report states that "Observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000 m and that the ocean has been absorbing more than 80% of the heat added to the climate system. Such warming causes seawater to expand, contributing to sea level rise" (IPCC2007c). Attribution studies have established anthropogenic contributions to all of these changes. The observed pattern of tropospheric warming and stratospheric cooling is *very likely* due to the combined influences of greenhouse gas increases and stratospheric ozone depletion (IPCC 2007c).

For the next two decades, a warming of about 0.2^{o}C per decade is projected for a range of emission scenarios. Even if the concentrations of all greenhouse gases and aerosols had been kept constant at year 2000 levels, a further warming of about 0.1^{o}C per decade would be expected (IPCC 2007b). Emission scenarios provide best estimates of global average surface air warming within the range of 1.8-4°C at the end of the 21st century.

A study of the physical extent and rates of sea surface temperature trends in relation to fisheries biomass yields and SeaWiFS derived primary productivity[1] of the world's 64 large marine ecosystems (LMEs) showed the consistent warming of LMEs except for the California Current and the Humboldt Current LMEs (Sherman et al. 2008). The study reported that "the warming trend observed in 61 LMEs ranged from a low of 0.08 degrees C for the Patagonian Shelf LME to a high of 1.35 degrees C in the Baltic Sea LME" and that "the relatively rapid warming exceeding 0.6 degrees C over 25 years is observed almost exclusively in moderate and high latitude LMEs" with the warming in low latitude LMEs reported to be several times slower than the warming in high latitude LMEs. The study also reported that "in addition to the Baltic Sea, the most rapid warming exceeding 0.96 degrees C over 25 years is observed in the North Sea, East China Sea, Sea of Japan/East Sea, and Newfoundland-Labrador Shelf and Black Sea LMEs" (Sherman et al. 2008).

Continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely* be larger than those observed during the 20th century (IPCC 2007b). It is important to note that ocean warming, as a result of the release of anthropogenic CO_2, will be a partial cause of the various issues outlined in the categories below, such as sea-level rise, change in ocean circulation (including the slowing of the Meridional Overturning Circulation which further warms the ocean), and change in the polar regions, with the exception of ocean acidification, which could have manifold ramifications at the global, regional and local levels.

Sea-Level Rise

Sea-level rise is a change in global average sea level brought about by an increase in the volume of the world ocean due to increase in global temperature (IPCC 2007b). The melting of inland glaciers and continental ice sheets, such as the Antarctic and Greenland ice sheet, contributes to sea-level rise, which can also be caused by land level subsidence. The IPCC reports that sea level rise from 1993-2003, can 'very likely' be attributed to the shrinking of ice sheets (IPCC2007c). Throughout the 20th century, global sea-level rise averaged 1.5–2.0 cm per decade with a rate of change of 1.7+-.5 mm/yr. Presently, the rate of change of sea level rise is 3.1+-.7 mm/yr. Satellite measurements show that the decadal rate already reached 3cm in the past decade (IPCC 2007b).

If warming continues, there is a risk of further increase of rate in sea-level rise. There are indications that the continental ice sheets on Greenland and in the Antarctic are beginning to disintegrate. This has the potential to cause several meters of sea-level rise in the next centuries. The IPCC (2007) states that "The last time the polar regions were significantly warmer than present for an extended period (about 125,000 years ago), reductions in polar ice volume led to 4 to 6 m of sea level rise." In addition, the rate of change of sea level rise is expected to increase, with a predicted rate of change of 4 mm/yr in 2090 (IPCC2007b). Therefore, the threat of sea level rise is likely imminent and of major concern.

Sea level rise, in conjunction with developmental pressures, could potentially have devastating effects that will impact various stakeholders, especially those in the small island developing States (SIDS) and other developing countries. It is predicted that sea level rise

[1] The Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Project provides quantitative data on global ocean bio-optical properties to the Earth science community. Please see: http://oceancolor.gsfc.nasa.gov/SeaWiFS/BACKGROUND/SEAWIFS_BACKGROUND.html

together with extreme events such as hurricanes will further threaten the coasts (WBGU 2006). Sea level rise will increase erosion rates and exacerbate the impact of tidal waves, which will create issues for infrastructure and coastal stability. In addition, increased coastal flooding can cause contamination of freshwater, creating public health concerns. Sea level rise is most detrimental to low lying areas, especially low lying developing countries, as well as the SIDS. The sea could encroach upon SIDS communities, causing climate change-induced population movements. Based on projections using GIS, the World Bank has predicted that "hundreds of millions of people in the developing world are likely to be displaced by sea level rise within this century" (Dasgupta et al. 2007). Under international law as it stands at present, there is no obligation to receive displaced populations from coastal areas, nor is the question about costs resolved. In the long term, however, the international community will not be able to ignore the problem of displaced populations from coastal areas and will therefore need to develop appropriate instruments to ensure that affected people are received in suitable areas, ideally areas corresponding to their preferences. In addition to displaced populations, the IPCC predicts that "the cost of adaptation could amount to at least 5-10% of Gross Domestic Product (GDP)" (IPCC2007b).

Sea level rise will also have significant impacts on various ecosystems. For example, the IPCC reports that, "salt marshes and mangroves are projected to be negatively affected by sea-level rise especially where they are constrained on their landward side, or starved of sediment" (IPCC2007b). It will also alter the salinity of coastal areas which will create problems for estuarine ecosystems. These changes will have effects on ecosystem services which would greatly impact fisheries and tourism (Kullenberg et al. 2008). In order to mitigate these impacts, it is important to hold sea level rise to a long term maximum of 1m, with a rate of rise of no more than 5cm per decade. "Otherwise there is a high probability that human society and natural ecosystems will suffer unacceptable damage and loss" (WBGU 2006).

Changes in Ocean Circulation

Another impact of global climate change is the possible change in ocean currents due to a disruption in water flow. The circulation of seawater in the form of ocean currents is very important, as it regulates much of the earth's climate. One of the most important factors of ocean circulation is the Atlantic Meridional Overturning Circulation (MOC), which transports warm surface water to the deep sea where it flows from the North up to more Northern latitudes. In addition, the MOC brings warm surface water from the North and transports it to more northern latitudes. This process results in a turn-over of warm water in the North Atlantic. An increase in the output of anthropogenic CO_2 can result in a disruption of this process by causing an increase in ocean temperature, which results in a decrease of the density of seawater through the thermal expansion of water molecules (caused by an increase in ocean temperature), as well as desalinization of the water (caused by melting sea ice and increased precipitation). This decrease in density will likely cause the circulation of seawater in the North to slow down (WBGU 2006). Studies have already observed a reduction in salinity in the Nordic Sea, such as that conducted by Curry and Mauritzen (2005) which suggests that critical thresholds for desalinization will be reached within the next century, resulting in severe changes for the MOC. In addition, Bryden et al. (2004) have found evidence that suggests that the MOC has already slowed down by 30% between 1957 and 2004, although analyses of these data are under dispute.

In conjunction with previous studies, the IPCC report states that "despite prediction models, the observed changes in the Northern Hemisphere circulation are larger than simulated in response to 20th-century forcing change." In addition, the IPCC states that "it is *very likely* that the Meridional Overturning Circulation (MOC) of the Atlantic Ocean will slow down during the 21st century (IPCC 2007b)." Models predict an average reduction by 25% by 2100, although this average ranges from zero to 50%. However, these changes will most likely not be abrupt in nature, and long-term predictions based on these figures cannot be made with great accuracy (IPCC 2007b).

Changes in circulation could have disastrous results. The North Atlantic Current, as well as the exchange of heat in this region could virtually be shut down, decreasing heat transfer to north. These changes could result in the reduction of regional temperatures in the North, and the increase of regional temperatures in the South. Sea level rise in various regions could increase significantly (WBGU 2006). In addition, an increase in the export of nutrients and carbon to the deep sea could occur, as well as an increased flow of seawater to shallow seas (Kullenberg et al. 2008). There could also be detrimental effects on the biological community and its structures, such as a predicted 50% reduction of plankton biomass in the Atlantic, as well as other impacts on fish and pelagic systems (WBGU 2006). Impacts could include ecosystem changes, such as "changes in productivity, fisheries, ocean carbon dioxide uptake, ocean oxygen concentrations and terrestrial vegetation" (IPCC 2007c), including changes to those with high levels of biodiversity, such as such as coral reefs, seamounts, and vents. The impacts of other factors such as acidification, warming, species changes, and inflows of new species, could exacerbate the impacts of the change in circulation (Kullenberg et al. 2008).

Changes in Polar Regions

Research conducted in recent years has shown that changes in the polar regions are occurring rapidly. The IPCC confirms that "for observed decreases in snow and ice extent are also consistent with warming. Satellite data since 1978 show that annual average Arctic sea ice extent has shrunk by 2.7 [2.1 to 3.3]% per decade, with larger decreases in summer of 7.4 [5.0 to 9.8]% per decade. Mountain glaciers and snow cover on average have declined in both hemispheres" (IPCC 2007b). In addition, reduction of permafrost and the melting of the Greenland ice sheet have been observed. Shrinking of ice sheets has also resulted in a decrease of habitat available for organisms, such as the polar bear.

There are various predictions that can be made based on results from current models. Models predict that the mean surface temperature will increase by another 3 degrees C by 2050 (Kullenberg et al. 2008). Models predict that by the end of the 21st century, summer arctic sea ice may disappear completely. However, it appears that ice cover has decreased at a rate much faster than forecasted. In addition, the melting rates of ice from the ice sheet in Greenland "could result in virtually complete elimination of the Greenland ice sheet and a resulting contribution to sea level rise of about 7m if global average warming were sustained for millennia in excess of 1.9 to 4.6°C relative to pre-industrial values" (IPCC 2007b). Despite these predictions, melting rates of ice sheets in Greenland and Antarctica could increase or decrease in the future (see chapter 3b in this volume). The melting of ice could potentially have serious consequences for ocean conditions, such as effects on the circulation, overturning, ventilation, and changing circulation in the Arctic basin.

The expected impacts from changes in the polar regions are extensive. Melting sea ice will increase sea level rise significantly, and "contraction of the Greenland ice sheet is projected to continue to contribute to sea level rise after 2100" (IPCC 2007b). In addition, possible increased exploration pressure and competition could result, such as mining for minerals and extraction of hydrocarbons, fisheries, and shipping. An increase in the release of methane could occur from the melting of permafrost. Aboriginal tribes in the Arctic will feel also the impact of these changes, for instance, members of Arctic tribes report having an increase in respiratory distress in conjunction with extreme warm summer days (Kullenberg et al. 2008). Other than the direct effects of warming on the polar regions, the melting of ice could potentially have serious consequences for ocean conditions, such as effects on the circulation, overturning, ventilation, and changing circulation in the Arctic basin.

Ocean Acidification

Increasing atmospheric carbon dioxide concentrations lead to increasing acidification of the ocean. Ocean acidification is the increased concentrations of CO_2 in sea water causing a measurable increase in acidity (i.e., reduction in ocean pH). Ocean acidification may lead to reduced calcification rates of calcifying organisms such as corals, mollusks, algae and crustacean (UNFCCC 2007b).

Scientists have established that ocean acidification is underway. Projections based on SRES scenarios give reductions in average global surface ocean pH16 of between 0.14 and 0.35 units over the 21st century, adding to the present decrease of 0.1 units since pre-industrial times (IPCC 2007b). Impacts of acidification on some major calcifiers are already detectable; naturally high-CO_2 marine environments exhibit major shifts in marine ecosystems, e.g., some coastal waters have become corrosive to the shells of some bottom-dwelling organisms (Monaco Declaration 2008). Furthermore, ocean acidification is accelerating and severe damages are expected. The average atmospheric CO_2 concentration could reach double the pre-industrial level of 280 ppm by 2050, at which level, coral calcification rates would decline by about one-third; reef erosion will dominate; and large areas of the polar oceans will become corrosive to shells of key marine calcifiers (Monaco Declaration 2008).

Unabated continuation of this trend will lead to unprecedented levels of ocean acidification over the past several million years and will be irreversible for millennia. The effects on marine ecosystems cannot yet be predicted precisely but there is a risk of profound changes to the food web, as calcification of marine organisms may be impeded or in some cases even prevented (WBGU 2006). Ocean acidification could affect marine food webs and lead to substantial changes in commercial fish stocks, which will adversely affect protein supply and food security for millions of people and the fishing industry. Ocean acidification could also affect other marine goods and services, e.g., management of waste, provision of chemicals to make new medicines, and regulation of climate (Monaco Declaration 2008).

Current Policy Options

The changes in the climate system can only be mitigated by means of drastic reductions in anthropogenic greenhouse gas emissions. Ocean acidification can be controlled only by limiting future atmospheric CO_2 levels (Monaco Declaration 2008).

Among the greenhouse gases, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are estimated to account for 50, 18, and 6 per cent, respectively, of the overall global warming effect arising from human activities. CO_2 is produced in large quantities from the consumption of energy from burning fossil fuels and deforestation while methane and nitrous oxide are produced mainly from agricultural activities. The United Nations Convention on Climate Change (UNFCCC) addresses all greenhouse gases not covered by the 1987 Montreal Protocol to the United Nations Convention on Protection of the Ozone Layer. The Kyoto Protocol to the UNFCCC, adopted in 1997 and entered into force in 2005, provides legally binding commitments to emissions reductions of six greenhouse gases: carbon dioxide, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF6). The Kyoto Protocol uses three innovative mechanisms (joint implementation, the clean development mechanism and emissions trading) to strengthen the cost-effectiveness of climate change mitigation by creating opportunities for Parties to cut emissions, or enhance carbon 'sinks', more cheaply abroad than at home with the assumption that despite regional differences in the cost of limiting emissions or expanding removals, the effect for the atmosphere is the same regardless where the action is taken (UNFCCC 2007).

Critics of the Kyoto Protocol infer that the application of its mechanisms (joint implementation, the clean development mechanism, and emissions trading) will not lead to significant reductions in emissions. For instance, Kulkarni (2003) states that levels of greenhouse gases will most likely not be reduced below 1990 levels through implementing the Kyoto Protocol alone. He states that reductions made during a commitment period between 2008 to 2012 will be "too small to make an impact" and he suggests that "the Kyoto Protocol should mandate investments in renewable energy technologies in developed and developing countries that could meet energy needs without a sustained growth of the fossil fuel energy system (Kulkarni 2003). However, Lohmann states that various decisionmakers have unanimously promoted the Protocol as a "necessary first step toward more serious efforts to address climate change" and the voices of many critics have been ignored (Lohmann 2003). The current negotiations leading up to a successor agreement provide an opportunity to review the efficacy of current and proposed solutions and to coalesce in the implementation of better climate change mitigation and adaptation mechanisms and strategies.

Recommendations

Recommendations for the climate negotiation:

Global anthropogenic greenhouse gas emissions must be significantly reduced in a timely manner in order to halt further ocean warming, sea level rise, changes in circulation, changes in polar areas, and ocean acidification. Adaptation measures can only succeed if the present acceleration of sea-level rise and the increasing acidification of the oceans are halted (WBGU 2006).

Discussions on the ideas and options that can be considered to achieve the above objective were held during the first round of negotiations that took place in Bonn, Germany, on 29 March to 8 April 2009. The fifth session of the *Ad Hoc* Working Group on Long-term Cooperative Action under the United Nations Framework Convention on Climate Change (AWG-LCA 5) focused on the key elements of the Bali Action Plan (decision 1/CP.13), namely mitigation, adaptation, finance and technology, and a shared vision for long-term cooperative action under the Convention, while the seventh session of the *Ad Hoc* Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP 7) focused on emission reductions by Annex I parties under the Kyoto Protocol beyond 2012, and on legal issues, including possible amendments to the Protocol, all of which will be further discussed in the forthcoming climate talks in June and in August in Bonn, and in September-October in Bangkok, and eventually in Copenhagen during the UNFCCC COP 15. Various opinions were expressed at the Bonn meetings, on the long-term cooperative action and a shared vision on the implementation of the UNFCCC, on emission reductions, nationally appropriate and other mitigation actions, and on various issues of adaptation, finance and technology put forward by various groups including, but not limited to, the

Alliance of Small Island States (AOSIS), the G77 and China, the Umbrella Group[2], developing countries, least developed countries (LDCs), the European Commission and other regional groups, the Environmental Integrity Group (EIG)[3] as well as individual governments (ENB 2009).

Specific recommendations:
Specific recommendations relevant to the role of oceans in the climate system and uses of the oceans in mitigation and adaptation, which are given in the other chapters of this volume, are envisioned to find their way in the text to be negotiated at the forthcoming climate talks. These are broadly characterized as follows:

Mitigation

- Global anthropogenic greenhouse gas emissions must be approximately halved by 2050 from 1990 levels. Adaptation measures can only succeed if the present acceleration of sea-level rise and the increasing acidification of the oceans are halted (WBGU 2006)
- In order to prevent dangerous climatic changes but also to maintain the state of the oceans, the rise in near-surface air temperature should be limited to a maximum of 2°C relative to the pre-industrial value while also limiting the rate of temperature change to a maximum of 0.2°C per decade (WBGU 2006)
- Since ocean acidification can be controlled only by limiting future atmospheric CO_2 levels, it is therefore important to ensure that anthropogenic CO_2 emissions are limited, regardless of reductions of other greenhouse gas emissions. It is recommended that the special role of CO_2 compared to other greenhouse gases be taken into account in the negotiations on future commitments under the United Nations Framework Convention on Climate Change (Monaco Declaration 2008).

Adaptation

- Optimal combinations of measures of protection, managed retreat and accommodation are needed and the people affected by adaptation or resettlement measures need to be involved in decision-making on such measures;
- Because of anticipated sea-level rise, national and international strategies need to be developed for protection and accommodation, as well as for a managed retreat from endangered areas;
- There is a need to improve the linking of nature conservation with coastal protection. The process of drawing up coastal protection plans and strategies for the sustainable use and development of coastal zones must integrate all key policy spheres (integrated coastal zone management) (WBGU 2006).

Financing and Other Mechanisms

- Climate negotiations must take into consideration the need for increased investments and expanded international cooperation in research, development, and demonstration to improve understanding of the dynamics and impacts of global ocean changes that pose adverse impacts to coastal and ocean ecosystems and the communities that depend on them for goods and services (Kullenberg et al. 2008).

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[2] *The umbrella group is a loose coalition of non-EU developed countries which formed following the adoption of the Kyoto Protocol* (UNFCCC 2007)
[3] *EIG is a recently formed coalition comprising Mexico, the Republic of Korea and Switzerland* (UNFCCC 2007)

- Developed countries should provide assistance to developing countries in research, development, and deployment of solutions/adaptations to these ocean changes
- Increased political tension in the polar regions requires more intergovernmental dialogue and development of regional, possibly global regime formation to address climate change issues and associated security needs since change threatens all aspects of northern life, and opens it up to broader and more frequent accessibility (Kullenberg et al. 2008).
- Support for further research is needed on ocean warming (quantifications; economic coupling; human security complexes with changes in food, health, hazards due to weather, flooding, climate variability); sea level rise (determining local rates of sea level rise; understanding interacting impacts; determining costs and benefits of alternatives: adapt, move, mitigate; human displacements); changes in circulation (quantifying and looking at synergistic effects and feedbacks potentially amplifying other effects); changes in polar regions (increased political tension requiring more intergovernmental dialogue; regional, possibly global regime formation, with comprehensive security needs); and ocean acidification (consequences of acidification for marine ecosystems and for biogeochemical cycles) (Kullenberg et al. 2008).

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3b. Climate Change and the Arctic Marine Environment

By William M. Eichbaum, Vice President for Arctic and Marine Policy, World Wildlife Fund, US

Introduction

This paper is a summary of the latest information regarding the impacts that global climate change is now having and can be expected to have on the Arctic marine environment. To the extent currently possible there is consideration of how some of these changes may be expected to affect the global environment, including key feedback phenomenon related to global warming. In concluding the paper, several important policy considerations are set forth.

Magnification of Climate Change Impacts in the Arctic

It is ironic that the two most dramatically different realms of the marine environment appear to be experiencing the most intense, rapid, and negative impacts of global warming. These are the coral reef systems of the tropics and the ice-dominated regions of the poles.

In the case of the Arctic, an initial critical fact is that the region experiences warming temperatures at about twice the rate of the global average. This means that the approximate global average in increase in temperature of 1.0 degrees C during the industrial era has resulted in an Arctic average rise of 2˚C. Also, as climate change science, models and observations improve, it is clear that all observed or predicted trends have continued and that virtually every physical and biological system of the Arctic is affected. Most significantly, some observed change has occurred at rates significantly faster than predicted and in some cases may have reached a tipping point -- that is the changes may not be readily reversed.

Sea Ice

Among the most dramatic changes in the Arctic has been the loss of sea ice. Especially, the extent of loss of summer sea ice has massively accelerated in recent decades. The two years of greatest loss, 2007 and 2008, had an areal extent of ice that was about 40% less than the 1979-2000 mean. This loss is significantly greater than had been predicted by any models and some experts are now predicting that there could be no summer sea ice in the Arctic by 2013. Of subtler, but equally profound concern, is that multi-year ice has decreased by as much as 80 %.

The loss of ice in the Arctic Ocean has serious consequences. First, as the white surface of ice is replaced by the dark surface of the ocean for much of the year, the loss of associated reflective quality (the Albedo Effect) allows more of the sun's energy to be absorbed by the oceans, further contributing to their warming.

In association with this loss of ice there has been an observed increase in atmospheric temperatures the causes of which are not completely understood. This increase, however, may be considered a contribution to the overall rise in global temperatures.

In addition, as sea ice is lost, the impact on key species of the Arctic region, such as polar bears and ringed seals, is dramatic. These and many other species are completely dependent on the ice environment for their food as well as vital habitat. There is a growing body of evidence that these species are suffering negative impacts through such indices as overall population numbers, average body weight, and reproductive success.

Finally, the loss of sea ice contributes to what may be profound changes in the lives of the people of the region. As sea ice is lost, its role in buffering the land from the ravages of storm events decreases, and that, in combination with melting of the permafrost, contributes to significant erosion of coastal environments, resulting in the potential destruction of many communities -- there has already been some displacement of villages in the Arctic from their traditional locations. The loss of ice also opens the Arctic up to a new level of economic exploitation through oil and gas development, increased shipping through previously closed routes such as the Northwest Passage, and greatly expanded fishing areas. Unless properly carried out, these activities could have profoundly negative impacts on the Arctic marine environment.

The Greenland Ice Sheet

If the Greenland Ice Sheet were to melt into the sea, it would contribute about 7 meters to global sea level rise. While there is no basis to predict that this will happen in this century, current observations suggest that the existing rate of melt is a significant contributor to existing sea level rise, on the order of 10 to 15 %. Of greater concern is the fact that there is a growing body of evidence that the rate of melt of the Greenland Ice Sheet is increasing. While the dynamics that may be causing this acceleration are not well understood, they are possibly a combination of the impacts of a rising and warming ocean on the outfalls of glaciers as well as the impact of increasing freshwater water availability filtering through glaciers and providing a lubricant between the ice mass and the underlying rock and, thereby, accelerating movement to the sea.

In the short term, the melt of the Greenland ice sheet and other Arctic glaciers clearly contributes to the phenomenon of global sea level rise. There is also growing evidence that the extent of sea level rise in this century will be more significant than previously thought -- perhaps as much as one meter. Of much greater significance is the possibility of some irreversible point being reached in which the basic stability of the ice sheet is compromised, thereby assuring a level of sea level rise that would be catastrophic for many of the coastal regions of the world.

Fundamental Change to Ocean Circulation

The Atlantic Meridional Overturning Circulation (MOC) consists of a northward inflow of warm, saline upper-ocean waters from the low latitudes and a southward low of cold, dense, deep layers from the high altitudes. Global climate change could significantly alter the MOC through both the introduction of greater amounts of freshwater into the Arctic from especially the northward flowing rivers of Asia, and the increased heating of Arctic waters through the elimination of sea ice and other causes. The MOC is a major driver of ocean circulation, especially in the Atlantic. Changes could have profound impacts on overall ocean circulation with significant impacts on fisheries distribution and abundance as well as impacts on global weather. These are not well understood at this time.

Changes in Primary Productivity

The Arctic marine environment is extremely productive from a biologic perspective. As a result, several of the world's most productive fisheries, those of the Bering and Barents Seas are Arctic fisheries. This productivity is based on the unique combination of nutrients and sunlight at the edge of the ice which then provides the energy for a rather simple but very rich biologic system both in the marine as well as the terrestrial environments of the Arctic.

There is growing evidence that with the increase in temperature and loss of sea ice in the Arctic that this system is changing. While overall productivity may remain the same or even increase, there may be a shift away from the ice-dependant species such as spectacled eiders and polar bears and the fish they eat toward a more pelagic fauna. What the consequences of this might be for the rich fisheries of the Arctic are now uncertain; although, it is clear there will be unpredictable change. (Arrigo et al., 2008)

Ocean Acidification

Observations around the globe find an important increase in the acidification of the ocean due to the uptake of anthropogenic carbon. This increased acidification can threaten all marine calcifying species, such as certain plankton groups, clams, snails and corals. Recent modeling demonstrates that the largest pH changes happen in Arctic waters, in part, due to greater warming of sea water and the retreat of sea ice. Among the plankton groups affected, pteropods are vital building blocks of the marine food web in the Arctic, and reduction in their abundance would have grave impacts on other species throughout the food-web of the Arctic, including terrestrial species that are dependent on marine life for their food. (Steinacher et al., 2009)

Conclusions

It is clear that the Arctic marine environment is undergoing rapid and significant change as a result of global climate change. Many of these changes will be particularly profound for the Arctic and will alter that Sea so that within this century it will be a New Sea, with characteristics that are neither entirely predictable nor likely to be conducive to the survival of much of the biodiversity that is so characteristic of the region today and on which many of its people are dependent for their survival.

Of equal importance, several of these changes in the Arctic marine environment are very likely to have consequences that reach out to the rest of the globe, both within the marine realm and perhaps at an even more far-reaching level. In this regard, the potential for ice melt in the Arctic to exacerbate the problem of sea level rise is profound. Similarly, feedback loops from Arctic change that impede global efforts to mitigate the impacts of green house gas emissions are likely to be significant. Additionally, the stability of ocean circulation systems and the fisheries productivity so dependent on those patterns are at risk.

A global greenhouse gas mitigation strategy should work to avoid these destructive changes. The only way of avoiding them is to assure that greenhouse gas emissions are kept at a level low enough to assure the long-term viability of the Arctic and its bio-physical processes.

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Other material in this paper is based on a report entitled "Arctic Climate Impact Science---an update since ACIA", issued in April, 2008 by WWF International Arctic Programme, Oslo, Norway.

3c. The Pacific Ocean: Scientific Consensus on Issues and Problems

Presented by Margaret Caldwell, Center for Ocean Solutions and Steve Palumbi, Hopkins Marine Station, Stanford University

Background

The Center for Ocean Solutions – in partnership with the World Conservation Union (IUCN) and Ocean Conservancy – led the development of the Pacific Ocean Science Consensus Statement. Developed and signed by leading scientists from more than 20 Pacific nations, the Statement identifies four major threats across Pacific ecosystems, economies and geographies: pollution, overfishing, climate change and habitat destruction. The Statement explains the seriousness of the problems, the urgent need for action, and the existence of viable solutions. Development of the Statement is one of the first steps in the Pacific Ocean 2020 Challenge, an ambitious initiative to identify the threats and impacts to the Pacific Ocean and develop and implement solutions. For more information on these initiatives and the Center for Ocean Solutions, please visit: www.centerforoceansolutions.org

Presently, the Pacific Ocean Scientific Consensus Statement has been signed by over 400 scientists. To sign the Consensus Statement, send an e-mail with your name and institution to POIstatement@stanford.edu.

Ecosystems and People of the Pacific Ocean - Threats and Opportunities for Action: A Scientific Consensus Statement

Executive Summary:

The people from around the Pacific Ocean, from the Arctic to Antarctic, from countries populous and sparse, are witnessing a decline of the Pacific Ocean's vast resources and in the ability of people to use those resources. Pollutants, nutrient and sediment run-off from land, overfishing, habitat destruction, and climate change emerge repeatedly as the major causes. Though this wide-spread similarity of threats across the Pacific Ocean is alarming, it also provides the opportunity to craft solutions that target pan-Pacific problems and therefore provide hope to hundreds of millions of people who rely on the Pacific Ocean and its ecosystems.

The Pacific, Covering Half the Global Ocean

The Pacific Ocean is the largest single geographic feature on our planet. It represents half the world's ocean area, occupies one-third of the earth's surface, and helps support hundreds of millions of people. The Pacific Ocean contains complex ecosystems and supports ocean-based economies that produce a wealth of resources for local and global benefit. The Pacific is also the engine room of Earth's climate and the storeroom of its ocean biodiversity. However, Pacific Ocean is not being managed sustainably. A host of interacting impacts threaten the future of the human communities around it, the future of life within the Pacific, and the future of our global climate.

A Complex Ocean, a Common Crisis

The Pacific Ocean supports much of the world's marine and terrestrial biodiversity. Threats to the Pacific's ecosystems and to communities that depend on its bounty continue to intensify as its resources are over- harvested, and sediments, nutrients and chemical pollution pour off the land. Marine habitats ranging from shallow corals, mangroves and sea grasses to previously inaccessible deep sea beds show decaying health. Some species of large tuna, sharks and turtles have experienced significant declines, marking the progressive depletion of top predators and other large species in the Pacific Ocean. These reductions jeopardize economies, local livelihoods, and food security across the globe. Climate change exacerbates these threats and increases the vulnerability of coastal and ocean ecosystems and resources.

Scientists who study Pacific Ocean ecosystems have worked together to summarize the most important environmental threats to the Pacific Ocean and its people, and to identify opportunities for addressing many of these threats. This consensus statement:

1. Identifies and prioritizes key threats to the health and productivity of the Pacific Ocean - many accelerated by climate change – for which there is broad consensus in the scientific community.
2. Highlights the environmental and socioeconomic impacts of these threats.
3. Outlines a 'road map' that identifies available solutions for these broad categories of threats.

Although the threats are serious, it is not too late to take decisive action to prevent almost certain future catastrophes, and that will bolster a critical part of the life of our planet.

Threats Facing the Pacific Ocean

A review of environmental threats across the Pacific Ocean shows remarkable similarity between the major problems experienced in poor and rich countries alike, in densely settled areas and rural zones, in populous nations and on small islands. Across these diverse areas, three rank as the most pervasive and serious local threats: habitat destruction, pollution from sewage and land run-off, and over-fishing. In addition, climate change imperils all Pacific ecosystems, already creating pulses of warm water, hypoxic dead zones, and acidic conditions. These threats interact with one another to damage natural ecosystems, reduce biological and human economic diversity, destroy productivity, and make human use of the sea more difficult. Each is described briefly below. Though this summary suggests that the Pacific Ocean faces ecological peril, it also reveals that countries very different in wealth, population, size, and culture face similar problems. The presence of these same dominant threats across the Pacific suggests that effective solutions to these problems will have major beneficial impacts for societies across the Pacific Ocean. These societies form a network of nations and communities connected by the vast Pacific Ocean, joined by their mutual reliance on the ocean, and united in their need and will to repair its damage.

Pollution: Organic pollutants from sewage, nutrient pollution from fertilizer run-off, plastic marine debris, toxic dumping and oil spills, urban run-off and dispersed pollutants combine to create one of the most critical classes of ocean threats. Sewage and farm run-off can create dead zones, algal blooms, and acidic areas.
Across the Pacific organic pollution can fundamentally alter the basic ecosystem structure, create human health risks, and stresses economies. Plastics and other long-lived industrial products accumulate in vast areas in the North Pacific Gyre and on beaches and shorelines around the Pacific. They clog habitats and strangle seabirds, turtles, sea mammals, and fish, and, in certain areas, outnumber plankton. The rate of breakdown of some chemicals is so slow that they persist for decades. In the case of old fishing gear, nets and long lines continue

to fish long after they are lost at sea. Toxic chemicals, oil and run-off debilitate coastal marine life, reduce birth rates, and create hormonal disruption.

Habitat destruction: Productive marine habitats are lost to destructive fishing practices, poor agricultural land use, inappropriate coastal development, and industrial wastewater. Destructive fishing, including coastal trawling, the use of dynamite or poisons, and indiscriminate netting, can destroy habitats and reduce fishery productivity. Land use practices that create erosion, or eat up mangroves and smother sea grass beds reduce coastal ecosystem health and impair local productivity. Poorly designed development projects for tourism, roads, housing, urban centres, and aquaculture needlessly destroy coastal habitats across the Pacific and limit livelihoods that depend on ecosystem productivity.

Overfishing and exploitation: Unsustainable resource use reduces fish stocks throughout the Pacific, limiting fish catches and often causing ecological shifts that further reduce biodiversity and productivity. Over-hunting of herbivores results in uncontrolled growth of algae and seaweeds, which can smother corals and other bottom-dwelling organisms. Fishing on the high seas for top predators such as sharks has made these creatures rare across the Pacific. International tuna fleets often fish unsustainably in waters controlled by small countries, strip stocks to low levels and move on. Bycatch further reduces fish stocks because large numbers of non-target species with low economic return are discarded as waste back into the ocean. Artisanal and recreational fishing suffer when local needs outstrip local supply, causing displacement of fishing activity, reduced income and insecure food supply. Habitat destruction exacerbates overfishing by reducing fishable area and productivity.

Climate change: Pacific countries have already seen strong effects of ocean warming, changes in ocean circulation and abrupt shifts in precipitation patterns. The bleaching and subsequent death of reef-building corals caused by warm water pulses have destroyed reef ecosystems, or required decades to recover. Shifts in ocean and atmospheric currents have created massive dead zones or changed migration patterns of whales and seabirds. Some ocean areas have already acidified to levels known in laboratory studies to cause harm to ocean life. In addition, decreasing pH levels due to CO_2 acidosis are shifting the ecological balance of marine plankton and bottom dwelling species that form calcium skeletons. The rates of current environmental change far outpace anything seen in human history, and are likely to accelerate in the near future. These new conditions present serious challenges to the Pacific Ocean Community for the next decades or centuries.
Many areas of the Pacific Ocean may become uninhabitable due to sea level rise, coastal inundation, shifting rainfall, collapse of fresh water supplies, or changes in the migration patterns of food species. These changes will increase the number of impoverished people and reduce the stability of many nation states.

Multiple stressors multiply harm: When marine life is subjected to multiple stressors, such as pollution, habitat destruction, over-fishing, and changing climate, populations of ecologically and economically important species can collapse. From coral reefs to kelp forests to cold water deep seas, an increase in harm and a decrease in growth and reproduction can wipe out once productive communities. In this sense, global climate change is coming at the worst possible time, when many communities around the Pacific – both human and ecological – are threatened by other powerful problems.

Solutions and options for a better future

Maintaining ecosystem health and sustainability should be as fundamental a goal as economic development. While there are currently no solutions in place to solve all these problems across the Pacific Ocean, a set of sensible approaches to pervasive environmental problems can be deployed in a concerted way to limit and even reverse environmental harm, returning Pacific ecosystems and communities to greater health. Overall, solutions must significantly reduce pollution from human sewage, sediment and run-off from poor land use practices, flows of debris and toxic material into the sea from point and nonpoint sources, and unsustainable extraction of marine organisms. Major reductions (some up to 95% of current rates) are probably required in discharges of nutrients and sediments from land to sea.

New technologies, innovative market mechanisms, and financial tools that promote adoption of sustainable practices can empower local communities, help maintain the cultural richness of the Pacific Ocean nations, and reduce the human footprint on the Pacific. In many cases, the straightforward response to an environmental problem (such as pollution or habitat destruction) might be simply to prohibit the human activities that cause the pollution or habitat loss. But for large and complex problems such as those that span the whole Pacific, learning how to stop or alter the activities that give rise to these problems is the key to a set of enduring environmental solutions. Strategic changes that can lead to effective solutions include incorporation of ecological principles in economic decisions, use of financial and market instruments such as environmental bonds, legacy trusts, catch share programs, and tax systems to create incentives for activities that promote rather than degrade ecosystem health, and environmental education across the age spectrum to build capacity for local populations in ecosystem and economic management.

Climate change mitigation is a global task, and yet a united Pacific can be instrumental in promoting frank global dialogue about establishing and achieving mitigation targets. The long term health of Pacific ecosystems and human communities across the ocean requires aggressive mitigation of global greenhouse gas emissions. Key to the solution is the observation that the Pacific contains some of the highest and lowest emitting countries.

In addition to mitigation, each region within the Pacific must adopt sustainable adaptation strategies for ecosystems and human communities in the face of climate change. Though these strategies will need to be locally tailored, they can draw on similar principles to solve common problems. For example sea level rise will impose different challenges for highly urbanized coastal communities than for rural areas, but both geographies can consider a common range of adaptation options to achieve some protection for vulnerable human settlements and ecosystems.

Effective and enduring solutions require capacity-building within the Pacific Ocean Community and integrated problem solving. The solution to the spatial and economic challenges in sustainable management of the Pacific Ocean lies in collaboration at many levels, including social, scientific, regulatory, institutional, and information technologies. To help promote sustainable change in how communities across the Pacific interact with their common ocean, we propose a new executive institution – one that joins banking, industrial, ecological, and educational expertise into a single collective enterprise that can help build capacity within and advise Pacific nations and evaluate overall progress. Combining financial, livelihood, conservation, and educational goals and functions into a collaborative institution would encourage managers and decision makers to examine and address issues across the larger whole, and cultivate the integrated ecological, economic and education understanding and problem solving that progress requires. Pacific Ocean countries need to coordinate their expertise, creating open access online information systems, for example, for education, research, and resource management. A Pan-Pacific Century Trust could provide economic resources and management knowledge for the entire Pacific community, and could deliver education and expertise in how to apply sustainability principles to economic development.

We must act now. The best science indicates that over the next century we can expect to see dramatic declines in the health of the Pacific Ocean, its ecosystems, and the people that rely on this shared resource, unless concerted and prompt action to address known threats is taken. Identifying common problems, uncovering their underlying causes, and addressing them now may allow the Pacific nations to enter the next century as world leaders in the creation of vibrant, intact and highly functioning economically and ecologically sustainable communities.

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The Consensus Statement is available on-line at:
www.centerforoceansolutions.org/data/consensus_statement.pdf

Chapter 4

Addressing the "Climate Divide" and Promoting International Commitments and Funding Mechanisms to Respond to the Differential Effects of Climate Change on Different Regions and Peoples

4a. Addressing the "Climate Divide": An International Imperative

By Rolph Payet, Special Advisor to the President of Seychelles and CEO, Sea Level Rise Foundation; Janot Mendler de Suarez, GEF IW:LEARN; and Caitlin Snyder, University of Delaware an Global Forum on Oceans, Coasts and Islands.

Introduction

> *Yes, we have averted many wars. We have resolved many conflicts. But in this age of relative peace and security, new enemies are staring us in the face. Hunger, pandemics, under-development, poverty, economic turmoil, environmental degradation, the iniquity of the global trading system… These are the enemies which, if not overcome, will shatter the foundation of civilisation.*
> *President James Michel addressing the UN General Assembly, September 2008.*

It took more than 40 years for the international community to start paying serious attention to the issue of climate change. While there is now widespread political attention being given to climate change, the planet faces a number of challenges--that of bringing down global emissions to safe levels (stabilization as defined by the IPCC as "a level that would prevent dangerous anthropogenic interference with the climate system") and the survival of many of the world's nations and civilizations. The planet is now on the brink of a global shift in climate and although the science is compelling and the economic findings are credible, the international community is caught in an impasse over the commitment of larger economies to address the issues of mitigating causal emissions and adapting to impacts and threats proactively.

Time is not a luxury many of the world's island and coastal communities have. At stake are millions of island and coastal peoples from the Arctic to the tropics. The world's biodiversity distribution is changing rapidly and the oceans are no exception. Recent mass coral bleaching events have shown how a warming climate may render such important coastal ecosystems extinct within our lifetime. Climate change-induced migration of important marine species, combined with over-exploitation, threatens the world fish stocks and ocean acidification will have global implications for the marine food web.

> *"It's the poorest of the poor in the world, and this includes poor people even in prosperous societies, who are going to be the worst hit … [as] people who are poor are least equipped to be able to adapt to the impacts of climate change and therefore, in some sense, this does become a global responsibility" (IPCC 2007).*

A growing body of scientific reports document evidence of villages that have had to be abandoned, of freshwater aquifers and coastal agricultural areas affected by the ingress of seawater. Rising sea levels and extreme weather events have exacerbated coastal erosion and displacement of people as far north as Alaska. While there is uncertainty as to thresholds or tipping points and parameters of impacts in some specific areas, today's climate science is sufficient for the international community to take action on climate change based upon the principle of 'common but differentiated' responsibility. The argument that effective climate change mitigation to below harmful levels will dilute economic growth does not hold water. In fact, the recent global economic crisis as a result of uncontrolled economic expansion has effectively led to a slow-down in the world economy. The International Monetary Fund declared in April 2009 that this global economic crisis is 'by far the deepest global recession since the Great Depression'.

On the other hand, the call for stimulus spending without transforming consumption and reversing unsustainable use of natural resources will only aggravate the climate change dilemma and entrench the world economy further. Such a unipolar approach will also render the possibility of a feasible solution to the climate crisis even more challenging. The effects of extreme weather events are now considered to be significantly more likely to increase in frequency and intensity than considered in the initial IPCC assessment report. As suggested by the Stern Review (2007), investment in resilience and vulnerability risk reduction can avoid future humanitarian disasters and associated costs of far greater magnitude. Investing in resilience is investing in the capacity for change and involves technical as well as financial transfers that reduce vulnerability. Solutions to climate change and the economic crisis are inextricably linked, and significant opportunities for a concerted approach are at hand. The need to stimulate spending and create jobs can and should be aligned to simultaneously solving the climate change issue. The international community should ensure that the twin issues of climate change and economic recovery are set together on the highest global agenda.

> *What we are really talking about is as much an ethical issue as an issue that sort of concerns the stability of global society. In the framework of the Convention on Climate Change, it's clearly specified that resources will be provided by the developed countries to the developing world and that transfer of technology, in particular, will be facilitated by the developed countries. So I think it's there in the agreement, but it's a question of implementing it both in letter and spirit, and there, may I say, enough is not happening.*
> *Rajendra Pachauri, chairperson of the Intergovernmental Panel on Climate Change*

Transforming the economy to bridge the climate change divide is the way forward. Mechanisms such as carbon emissions trading and other incentive schemes have been instrumental in advancing the development of renewable energy and contribute to emissions reductions, but evidence shows that this can only be part of the solution. A global emissions trading mechanism, however efficient, will not resolve the current climate crisis. More decisive, new and diverse approaches will be required. Clearly, governments will need to take the lead in decisive policy and investments decisions.

The issue of mitigating risks and financing adaptation, especially to reprieve the plight of the many millions that are already experiencing impacts on the frontlines of climate change must be resolved without further delay. Risks which are differentially experienced by populations least responsible for greenhouse gas emissions should be preferentially reduced or transferred and ensuring adequate revenue streams to finance adaptation will require a variety of known as well as the testing of innovative new mechanisms. These may include carbon trading, caps and credits, insurance schemes, payments for ecosystem services, endowment of adaptation funds developed and managed by institutions in the affected countries such as the Sea Level Rise Foundation, etc. In order to balance trade-offs and respond to priorities stemming from hierarchical, individualistic as well as egalitarian interests, policies are needed to capitalize on no-regrets opportunities in the short term and to mobilize natural and social capital to leverage direct investment in adaptive capacity and vulnerability reduction. Effective enforcement mechanisms are also part of the necessary toolkit that governments must deploy to ensure compliance to reduce emissions beyond harmful levels.

Parties concur that adaptation to the additional burden of climate change is important to all countries, especially developing countries, particularly LDCs, SIDS and countries in Africa affected by drought, floods and desertification.
UNFCCC, Fulfillment of the Bali Action Plan and components of the agreed outcome, Note by the Chair, 18 March 2009

As the world comes together in Copenhagen to discuss the future of the Kyoto Protocol and post-2012 commitments, it is imperative that governments do not lose sight of the fact that they collectively need to make the right policy decisions. If all countries agree to emissions reductions, in accordance with the principle of common but differentiated responsibilities, then we would have taken a great stride for humanity in resolving the climate crisis. The Global Forum on Oceans, Coasts and Islands has expressed concern over the magnitude of expected impacts of climate change on the world's most important ecosystem service--the ocean. This policy brief is a contribution to this important strategic process, and will serve to guide the Manado World Ocean Conference.

Outcome of the IPCC Process

Establishment of the Scientific Basis

There is strong scientific consensus on the causes, the expected impacts and the strategies for adaptive response to build resilience in the coastal ecosystems and societies affected by climate change. The Climate Change 2007 Synthesis Report Summary for Policymakers (SPM), which was approved in detail at IPCC Plenary XXVII (Valencia, Spain, 12-17 November 2007), represents the formally agreed statement of the IPCC concerning key findings and uncertainties detailed in Working Group contributions to the Fourth Assessment Report. There is high agreement and much evidence that with current climate change mitigation policies and related sustainable development practices, global GHG emissions--and therefore the associated impacts of a changing climate--will continue to grow over the next few decades. Continued GHG emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century. Because understanding of some important effects driving sea level rise is too limited, this report does not assess the likelihood, nor provide a best estimate or an upper bound for sea level rise, which remains one of the most significant threats while also acting as a multiplier for other climate-related impacts on coastal and island peoples and the ecosystems upon which they rely.

Specific systems, sectors and regions are likely to be especially affected by climate change. Impacts on terrestrial ecosystems cover a full spectrum ranging from tundra, boreal forest and mountain regions as well as the polar sea ice biome's sensitivity to warming; Mediterranean-type ecosystems' reduction in rainfall and tropical rainforests where precipitation declines; coastal mangroves, salt marshes seagrass beds and coral reef systems subject to multiple stresses. Water resource systems are arguably the most vitally impacted aspect of the global ecosystem. Some dry regions at mid-latitudes and in the dry tropics are already being impacted by changes in rainfall and evapotranspiration. Areas dependent on snow and ice melt and agriculture in low latitudes are also affected due to reduced water availability. Low-lying coastal systems are under increasing stress due to sea level rise and at heightened risk due to more frequent, intense, and less predictable extreme weather events.

Differentially Severe Impacts on Specific Populations, Regions, and Oceans

Human health is significantly and differentially impacted in populations with already low adaptive capacity. Africa, because of low adaptive capacity and projected climate change impacts, Asian and African megadeltas, due to large populations and high exposure to sea level rise, storm surges and river flooding, and small islands, where there is high exposure of population and infrastructure, are particularly vulnerable to projected climate change impacts, as is the Arctic, because of the impacts of the highest relative rates of projected warming on natural systems and human communities. Within other areas, even those with high incomes, some people (such as the poor, young children and the elderly) can be particularly at risk, and the greater impact on the poor and marginalized is already evident in many regions of the world. The uptake of carbon due to human activity since 1750 has led to the ocean becoming more acidic, with increasing atmospheric CO_2 concentrations leading to further acidification projected over the 21st century. While the effects of observed ocean acidification on the marine biosphere are as yet undocumented, the progressive acidification of oceans is expected to have particularly negative impacts on coral reef ecosystems and fisheries – threatening the sustainability of significant economic and social benefits contributing to the food and economic security of coastal and island peoples.

Developing Countries and SIDS

There is scarcely disagreement about the existence of the 'climate divide"--that the poorest people on earth are the most affected by climate change. In light of the fact that those most affected by climate change are also those with the least agency, access and capability for advocacy, a collective policy response is needed to address the "climate divide". The Global Forum on Oceans, Coasts and Islands encourages timely and decisive international commitments and the establishment of robust funding mechanisms to respond to the differential effects of climate change on different regions and peoples. In its 2007 report, the IPCC, amid growing global concern, called urgent attention to the growing "climate divide" that exists between the developed and the developing world-- that is to say, the brunt of the damage acting as the catalyst for global climate change has been created by the developed world but its impacts will be felt most readily by the developing world.

The IPCC has documented with very high confidence or high confidence statements of the expected impacts of climate change on key sectors such as agriculture, ecosystems, water, coasts, health, industry and settlements (Working Group II SPM refers to the source of the statements, timelines and temperature projections). The magnitude and timing of impacts that will ultimately be realised will vary with the amount and rate of climate change, emissions scenarios, development pathways and adaptation, but these are some examples of projected regional impacts:

<u>Africa</u>

By 2020, due to climate change:

- From 75 to 250 million people are projected to be exposed to increased water stress.
- Yields from rain-fed agriculture could be reduced by up to 50% in some countries.
- Agricultural production and access to food is projected to be severely compromised in many African countries, further adversely affecting food security and exacerbating malnutrition.
- Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations.
- The cost of adaptation could amount to at least 5 to 10% of Gross Domestic Product (GDP).

- By 2080, an increase of 5 to 8% of arid and semi-arid land is projected in Africa.

<u>Asia</u>

By the 2050s:

- Freshwater availability is projected to decrease in Central, South, East and South-East Asia, particularly in large river basins.
- Coastal areas, especially heavily populated megadelta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and in some areas also from the rivers.
- Major population centers at low elevations, including Mumbai, India; Shanghai, China; Jakarta, Indonesia; Tokyo, Japan; and Dhaka, Bangladesh, will be particularly vulnerable to the effects of climate change.
- Climate change is projected to compound existing pressures on natural resources and the environment associated with rapid urbanisation, industrialisation and economic development.
- Due to projected changes in the hydrological cycle, endemic morbidity and mortality due to diarrhoeal disease associated with floods and droughts are expected to rise in East, South and South-East Asia.
- More than 90 million people may potentially be affected by sea level rise in South Asia (Figure 1).

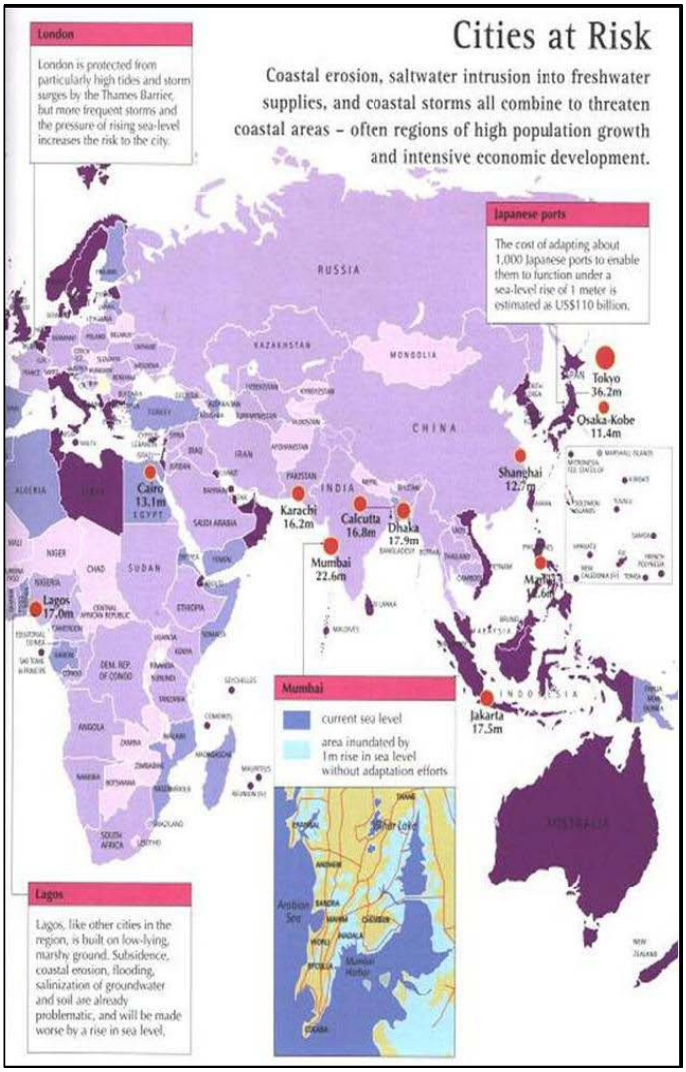

Figure1: Cities at risk (Dow *et al., 2006*)

<u>Small Islands</u>

Sea level rise is already exacerbating inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities.

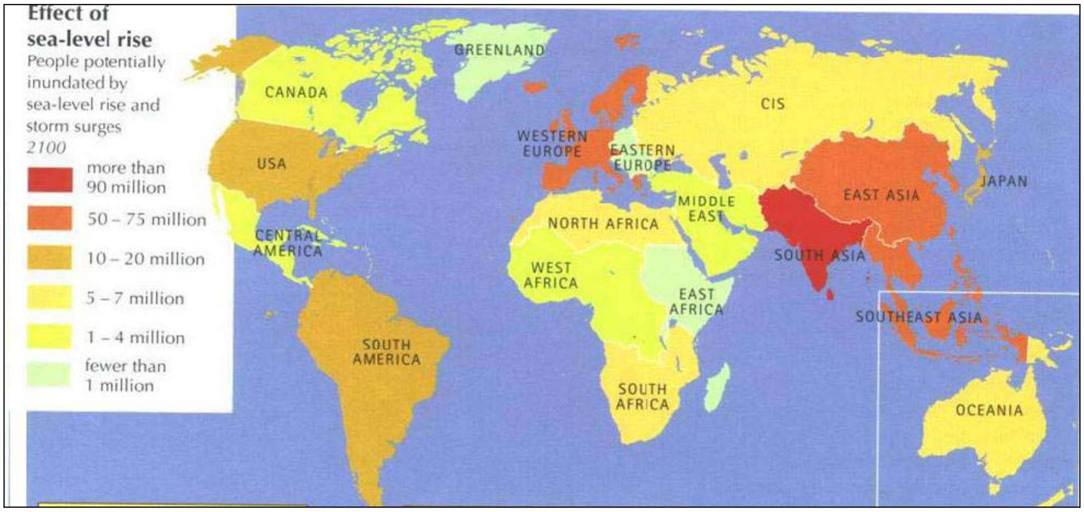

Figure2: Projected effects of Sea Level Rise on coastal populations by 2100 (Dow *et al.*, 2006)

- Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources.
- By mid-century, climate change is expected to reduce water resources in many small islands, e.g. in the Caribbean and Pacific, to the point of insufficiency to meet demand during low-rainfall periods.
- With higher temperatures, increased invasion by non-native species is expected.
- Communities in some island States are already being evacuated due to increased storm frequency and intensity and sea level rise. For example, several thousand people from the Careret Islands, Papua New Guinea had to evacuate their homes and move to an adjacent island following the destruction of their homes due to severe storms and high tides. Other island states, including Tuvalu and Kiribati, are currently preparing plans for an eventual evacuation (Kullenberg et al 2008).

<u>Polar Regions</u>

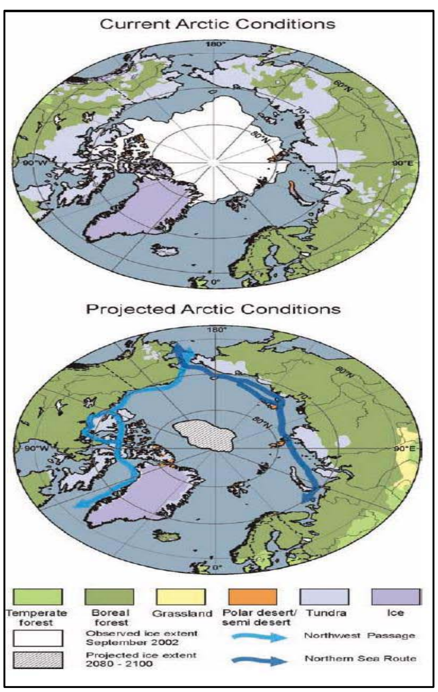

Figure 3: Projected arctic conditions for 2050 (IPCC, 2007)

The main projected biophysical effects are reductions in glaciers, ice sheets and sea ice, and changes in natural ecosystems with detrimental effects on many organisms.

- In both polar regions, specific ecosystems and habitats are projected to be vulnerable, as climatic barriers to species invasions are lowered.
- The Arctic region and its indigenous peoples are particularly vulnerable to the effects of climate change, especially those resulting from changing snow and ice conditions.
- Mean surface temperatures are projected to increase by another 3°C by 2050, leading to vast reductions in summer sea ice (Figure 3) and an extensive loss of ice-based ecosystems and related species.
- A global temperature increase of 3–4°C could further result in 330 million people being

permanently or temporarily displaced through flooding impacts, particularly those in the Arctic region.

- Detrimental impacts would include those on infrastructure and traditional indigenous ways of life, with much of the negative effects driven from the ocean.

Climate change effects on developing nations and SIDS are significant, as they will have environmental, economic, and human health impacts on coastal communities. The need to address these issues in the oceans community is a vital first step in combating the potentially devastating effects of climate change with specific attention to the developing world and SIDS.

> *One of the major lessons from the 4th Assessment report is that "Responding to climate change involves an iterative risk management process that includes both adaptation and mitigation and takes into account climate change damages, co-benefits, sustainability, equity and attitudes to risk across sectors, regions and populations and very likely under- estimate damage costs because they cannot include many non-quantifiable impacts"* {SPM 5.7}

Mitigation and Adaptation Responses – Outcomes of the Negotiation Process

Brief Background

In 1992 the global community established the United Nations Framework Convention on Climate Change (UNFCCC) with the express purpose of stabilizing atmospheric concentrations of greenhouse gases to avoid "dangerous anthropogenic interference" with the climate system. To implement this common purpose, delegates to the Third Conference of the Parties (COP) of the UNFCCC in 1997 agreed on the Kyoto Protocol, which commits industrialized countries and those in transition (known as Annex I parties) to reduce overall emissions of six greenhouse gases by an average of 5.2% below 1990 levels between 2008-2012 (called the first commitment period). Large emitters initially refused to sign the protocol claiming a number of reasons. Increased evidence of climate change and increased political consciousness caused the Kyoto Protocol to enter into force on the 16 February 2005, more than eight years later. To date many of these commitments remain largely unfulfilled, hence the need for a paradigm shift in Copenhagen 2009. To advance its work, the Kyoto Protocol established an Ad-hoc Working Group (*Ad Hoc* Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol, AGW-KP), the last session of which met in Bonn in March 2009.

In December 2007, in Bali (Indonesia) parties agreed on the Bali Action Plan. The Bali Action Plan constitutes a two-year road map to conclude negotiations by Copenhagen 2009.

AOSIS and Its Role in the Climate Change Negotiations

The Alliance of Small Island States (AOSIS) is a vocal coalition of Small Island and low-lying coastal countries, established in November 1990 during the World Climate Conference, to have one voice on climate change. Collectively SIDS represent 20% of the United Nations but only 5% of the world's population, so as a group AOSIS can be very influential.

AOSIS forms part of the Group of 77 and has made significant contributions to the evolution of the UNFCCC and Kyoto Protocol process, noting that the first two countries to sign the UNFCCC were the small island states, Seychelles and Mauritius. AOSIS led the way as the first group of countries to propose a draft text during the Kyoto Protocol negotiations, for reductions in the carbon dioxide greenhouse gas emissions of up to 20% from 1990 levels by 2005.

The positions of AOSIS are routinely challenged by other negotiating groups, even within the G-77 and China group of countries. The G-77 and China founded in 1964 consists of 132 members with extremely diverse positions, since they include oil-producing countries, small island states, Least-Developed Countries (LDCs), industrializing countries and middle-income countries. Often there is no consensus on issues, which results in groups within the G-77 and China, such as AOSIS, to speak on their own behalf.

The AOSIS Position, as proposed by Grenada, following the 6th Session of the AWG-KP and 4th Session of the AWG-LCA:

Mitigation - Global Emission Reduction Goals and Their Implications for Annex I Efforts
AOSIS has expressed its views on global emission reduction goals within the context of the AWG-LCA.[1] These views are equally pertinent to any examination of the sufficiency of Annex I Party efforts under the Kyoto Protocol for the second commitment period, as under the Convention Annex I Parties are to take the lead in reducing greenhouse gas emissions. AOSIS is of the view that:

1. Stabilization of atmospheric greenhouse gas concentrations should be ***at well below 350 ppm CO2***.
2. Global average surface temperature increase should be limited to ***well below 1.5º C*** above pre-industrial levels
3. Global greenhouse gas emissions must ***peak by 2015***.
4. Global CO_2 reductions of ***greater than 85%*** are required by 2050.

To achieve this goal:

1. Annex I Parties collectively, whether or not Parties to the Kyoto Protocol, must reduce their emissions by ***more than 40%*** of their 1990 levels by 2020.
2. Annex I Parties collectively, whether or not Parties to the Kyoto Protocol, must reduce their emissions by ***more than 95%*** of their 1990 levels by 2050.

Adaptation – A Multi-Window Mechanism to Address Imminent Risks and Exposure of SIDS to Climate Change Impacts
Even with basic financial risk management mechanisms in place and efforts implemented to reduce physical risks and exposure, some measure of loss and damage due to climate change impacts will be unavoidable and must be addressed. In the view of AOSIS, an essential part of the post-2012 agreement must be a Multi-Window Mechanism to Address Loss and Damage from Climate Change Impacts in SIDS and other developing countries particularly vulnerable to the impacts of climate change. This new Multi-Window Mechanism would consist of three inter-dependent components to address loss from extreme weather events, the unavoidable or uninsurable loss from the adverse effects of climate change, and areas where risk can be reduced and managed.

- Insurance Component, e.g. Caribbean Catastrophe Risk Insurance Facility
- Rehabilitation/Compensatory Component - risks that are uninsurable, e.g. salinisation of soils; sea level rise
- Risk Management Component, e.g. preventative actions; building resilience (through risk transfer as well as technology transfer)

[1] FCCC/AWGLCA/2008/Misc.5/Add.2 (Part I) (AOSIS input on shared vision).

These three components play different and complementary roles and comprise necessary components of an integrated approach to risk reduction, risk transfer and risk management efforts. Taken together, the three components aim to enhance adaptive capacity and build resilience of SIDS and other countries particularly vulnerable to the impacts of climate change.

Perspectives on the State of the Negotiations

The 5th Session of the AWG-KP/ Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA) focused on a draft negotiating text prepared by the Chair for mitigation, adaptation, finance and technology, and long-term cooperative action.

Under mitigation the aim, among other issues, is to negotiate for further commitments for annex I Parties. Further commitments imply agreeing on levels required to stabilize emissions by a certain time, role of emissions trading and land use change, improved emissions/sinks, calculating potential economic impacts of such measures and including certain sectoral emissions such as aviation and marine transport. This complex set of issues is likely to complicate negotiations and allow for collective bargaining on various fronts. However, agreement was reached on preparation of texts for the next round of negotiations in June 2009.

The AOSIS position is presented on the basis of the urgency of the climate change issue and the need to take proactive action to stabilise greenhouse gas emissions. Further work will be needed to develop this position within the context of the new text being developed and the issues raised under cooperative international action and as highlighted by various groups as being impediments to proactive emissions reductions. The likelihood that further issues may be raised seems possible, especially since some Annex 1 parties have proposed alternative commitments which fall short of the recommendations of the IPCC. On the other hand, developing countries will only commit to significant reductions if financial and technical support is forthcoming from the developed countries. The discussion on nationally appropriate action (or NAMAs) focused largely on mitigation that can simultaneously address issues of poverty and levers for development in developing countries which can be achieved through technology transfer and financial support.

The key question is what commitments would nations be prepared to take home, and whether these emission reductions would cause any noticeable change in greenhouse emissions? AOSIS remains disappointed at the token gesture given by Annex I parties on the issue of emission reductions and seeks to continue to push for further and more substantive targets.

Despite these concerns progress on adaptation measures was significant, with clarification on technical perspectives of adaptation. However many States were in favour of a more down-to-earth and pragmatic approach to adaptation and the adoption of an adaptation framework that addresses the particular needs of those countries that would be most affected by climate change. The issue of availability of new and additional resources for adaptation remains an important factor in the negotiations. Issues such as capacity building, appropriate adaptation technologies, and risk reduction mechanisms as priorities for financing and technical support are of particular importance for AOSIS and other developing country groupings. Of relevance to the Global Oceans Forum is the increase in awareness of the ecosystem approach to adaptation and recognition of needs for mainstreaming adaptation within national processes and institutions.

The proposal by AOSIS for the Multi-Window Mechanism focusing largely on risk reduction, compensation and insurance measures led to concerns being raised as to the adequacy of these mechanisms to address adaptation. Further work would need to be undertaken by AOSIS to make this multi-window mechanism more acceptable. The scope should perhaps be widened to include the issues raised concerning adaptation and more innovative financial mechanisms explored. Since the June 2009 negotiations will focus on the financial support needed to bring developing countries on board and to tackle adaptation, it is imperative that we consider this issue further during the Global Oceans Forum sessions in Manado.

The next section of this policy brief makes some recommendations and provides a contribution to further development of the adaptation proposal advanced by parties to the UNFCCC and Kyoto Protocol.

Recommendations Leading up to Copenhagen (from the Bali Action Plan)

Responding to climate change involves an iterative risk management process that includes both adaptation and mitigation and takes into account climate change damages, co-benefits, sustainability, equity and attitudes to risk across sectors, regions and populations and very likely under-estimate damage costs because they cannot include many non- quantifiable impacts. (SPM, 5.1)

There is high agreement and much evidence that all stabilization levels assessed can be achieved by deployment of a portfolio of technologies that are either currently available or expected to be commercialized in coming decades, assuming appropriate and effective incentives are in place for their development, acquisition, deployment and diffusion and addressing related barriers. (SPM 5.5)

"…an ideal and efficient climate change policy would be relatively inexpensive and would have a substantial impact on long-run climate change." – William Nordhaus, Yale University

There is high confidence that neither adaptation nor mitigation alone can avoid all climate change impacts; however, they can complement each other and together can significantly reduce the risks of climate change. (SPM 5.3)

The policies that will support efficient and effective adaptation need to incentivise and facilitate systems thinking and the activation of partnerships among sectoral and organizational stakeholders and institutions to leverage social capital, protect natural capital and stimulate return on investments that can be measured in mitigation of the greenhouse gasses which force climate change while contributing to environmentally and economically sustainable mechanisms to protect the cultural heritage of coastal and island communities on the frontlines of climate change, and establish the underpinnings for progressive global economic reforms required to achieve Millennium Development Goals – and bridge the climate divide.

A. Enhanced action on mitigation of climate change
    1. Match action by developing countries with financial and technological support

B. Enhanced action on adaptation to climate change

1. Match action by developing countries with financial and technological support
2. Consider potential frameworks for insuring against climate-related risks, other arrangements for risk-sharing

C. Enhanced action on the development and transfer of technology to support mitigation and adaptation
1. Focus on how technology for developing countries should be generated, governed and delivered, and on technological cooperation.
2. Focus on cooperative research and development of new technology
3. Focus on development/issue of intellectual property rights for existing technology

D. Enhanced action on the provision of financial resources and investment to support mitigation and adaptation
1. Focus on how technological and financial support for developing countries should be generated, governed and delivered, and on technological cooperation.
2. New methods of funding may include assessed contributions of public finance, funds generated from market mechanisms, and levies on international transactions

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4b. Climate-Induced Population Movements

By François Gemenne, Institute for Sustainable Development and International Relations (IDDRI), France

Introduction

Climate change is widely expected to induce large-scale population movements. These movements will be associated with different impacts of climate change, including (but not limited to) sea-level rise, soil degradation, and extreme weather events. Amongst the regions that will be mostly affected are the coastal and deltaic regions, as well as the small island developing states. The relationship between climate change impacts and population movements has been documented in some recent publications, including a large-scale empirical research project, 'Environmental Change and Forced Migration Scenarios' (EACH-FOR, **www.each-for.eu**). This policy brief presents some of the key findings gathered from empirical research, as well as policy recommendations for UNFCCC decision-makers.

Key Findings from Empirical Research (EACH-FOR Project)

Climate Change is an Increasingly Important Migration Driver, Which is Often Intertwined with Other Migration Triggers

The impacts of climate change often come in addition to other environmental problems faced by migrants, including extreme aridity and irregular rainfall, deforestation, water, soil and air pollution, landslides, etc. It is often a cumulative process that leads to eventual migration. Furthermore, environmental issues are deeply embedded in a socio-economic context that cannot be ignored to understand migration processes.

Migration is a Traditional Coping Mechanism

Migration has been used often as a means to cope with the effects of some periodic, environmental events, such as droughts or floods. A preferred option is temporary or seasonal migration. During periods of environmental stress, for example, people move to other areas, in particular to urban centres, to earn money.

In some areas these traditional patterns have changed in recent decades, partly because of climate change but also because of other human-induced factors such as sedentarization of nomadic people and the disruption and opening up of the traditional rural society by colonization, urbanization, migration, schooling, media, tourism and state interventions.

Migration is a Strategy to Improve Food and Livelihood Security of Both the Migrants and Their Relatives that Stay Behind

Many of the people who migrate due to environmental problems are willing to return back if the environmental problems are mitigated, since seasonal migration (mostly within the country) has always taken place. In general, these people are very attached to their land and they would migrate only as a last resort.

The Ownership of the Land is a Very Important Factor that Influences the Migration Decision

As long as the farmers are hired on the land, they are very mobile and flexible in response to environmental changes. Owners of the land would not leave unless there is no other way or they are officially displaced by the government.

Migration Occurs When Livelihoods Cannot Be Maintained

The environment is the basis for agriculture, which is still the major income source for the majority of the population in the developing countries. When this economic basis is threatened by the environmental degradation, people migrate elsewhere in search of an alternative livelihood. However, in many cases all sectors of society were impacted, and not only the agricultural sector.

Migration Decisions are Complex

Research results repeatedly point to the interconnectedness of environmental factors with economic, social and political factors affecting the migration flows of people. The natural and human-made disasters are a complex mix of both natural and socio-political and economic processes. While the environment can be an important "push factor" for migration (and in some cases it is the sole driving factor), it is often closely interwoven with other social, economic and political triggers for migration decisions. Other "push factors" include missing infrastructure (social services, education, etc.) and the withdrawal of the state from rural areas. At the same time there are often significant "pull factors", especially more promising economic opportunities elsewhere and the supposed attractions of urban areas.

Who Migrates?

Most often, people who want to leave their villages/regions/country can only do so if they have the necessary financial means and access to networks that support migration. In fact, the financial means are often not available, since the environmental degradation had a negative impact on their income. In many cases, the most vulnerable are unable to migrate when faced with environmental degradations.

Policy recommendations to UNFCCC decision-makers

Develop Further Research, Especially on the Empirical Side

The relationship between climate change and migration remain poorly understood, and empirical studies are scarce and scattered. The topic should be given higher importance in the research agenda, as well as in the IPCC reports. No sensible policy response can be developed as long as research has allowed for a better understanding of the environment-migration nexus.

Improve the Capacity to Adapt

Adaptation strategies could reduce the environmental vulnerability and increase the resilience of local populations. Investment in reducing vulnerability and improving the capacity of local communities to adapt must be taken into account in every policy implemented. Policies should also take advantage of the wealth of traditional indigenous knowledge accumulated by the local population in dealing with environmental challenges.

Mitigation is Also Necessary

Care should be taken that efforts to reduce emissions of greenhouse gases in one region (e.g. through the use of biofuels) do not lead to environmental degradation in other regions (e.g. biodiversity loss and soil degradation through monocultures for biofuels).

Training, Education, and Networking

Education campaigns could increase understanding of the causes and consequences of environmental degradation and available options to reduce it. Training of farmers (and herders and fishers) in sustainable practices would lower environmental degradation. There is a strong need interdisciplinary and transdisciplinary networks to foster dialogue between experts and a wide range of other stakeholders on questions such as adaptation strategies, the linkages between environmental change and forced migration, and processes of resettlement. International dialogues could promote exchange of experiences and learning among regions.

Migration Is Not Always a "Bad Thing"

Emigration – both internal and international – is an essential element of processes of economic development and modernization. In many cases, migration can be developed as an adaptation strategy. Policies to curb migration could impact negatively on the livelihood security and economic development of a developing region, and may even accelerate the overexploitation of natural resources.

Costs Cannot Be Borne By the Most Affected Countries

Migration has a cost, for the migrants themselves, but also for origin and destination countries, though migration also yields many benefits. These costs can be considered as externalities of climate change, and cannot be borne by the most affected countries, which are generally developing countries. Hence mechanisms of cooperation need to be developed within UNFCCC to share the burden of these costs.

Policy recommendations to other decision-makers

Implement Sustainable Development

Development policies should support protection of natural resources and control the non-sustainable overexploitation of water and land resources. A further major focus for sustainable development should be on disaster risk reduction. Investment and public/private partnerships must be guided to strengthen sustainable productive, income-generating activities and improve quality of life. This means investing in activities that generate jobs without destroying ecosystems and reviving some traditional regional industries. Rural communities should also be strengthened by providing them assistance for family agriculture, recognition of ancestral knowledge and practices, support for self-organisation and self-management, and ensuring them a continued access to land. Fair agricultural and trade policies would reduce poverty and enhance quality of life in developing countries.

Improve the Livelihoods of Seasonal Migrants

Recognising that seasonal migration is a viable coping strategy for many households, efforts should be made to establish facilitated seasonal work programmes to help migrants find viable work opportunities.

Resettlement Must be Carefully Planned

Better planning is needed before migrants are resettled. Programmes aimed at a better integration of migrants in the places of destination need to be fostered. The social and cultural cohesion and the human rights of those being resettled must always be considered. New homes should be ready before people are moved.

Chapter 5

Encourage a Wide Range of Adaptation Efforts (Soft, Hard, Floating) in the Context of Ecosystem-Based and Integrated Coastal and Ocean Management

5a. Ecosystem-Based Adaptation in Marine and Coastal Ecosystems

By Lynne Zeitlin Hale, Imen Meliane, Sarah Davidson, Trevor Sandwith, Jonathan Hoekstra; The Nature Conservancy; Steven Murawski, Ned Cyr, Kenric Osgood, National Marine Fisheries Service, NOAA; Marea Hatziolos, The World Bank; Pieter Van Eijk, Wetlands International; Nicholas Davidson, Ramsar Secretariat; William Eichbaum, World Wildlife Fund-US

Climate change is already impacting the ability of marine and coastal ecosystems to provide food, income, protection, cultural identity, and recreation to coastal residents, especially vulnerable communities in tropical areas. These impacts will continue and increase over the short to medium term, even as the community of nations works to reduce its greenhouse gas emissions. There is an urgent need to develop, implement, and fund ecosystem-based adaptation strategies in coasts and oceans as a central part of the global response to climate change. Coastal and marine ecosystem protection and restoration is the foundation for ecosystem-based adaptation, and strong and specific provisions for the development, implementation and funding coastal and marine ecosystem-based adaptation need be a central part of a Post-2012 Climate Agreement.

Human Societies Depend on Marine and Coastal Ecosystems

The ocean is a unique, extraordinary and vital element of our planet, covering more than 70 per cent of its surface. It sustains life by generating oxygen, absorbing carbon dioxide from the atmosphere, and regulating climate and temperature. Marine fisheries and aquaculture provide more than 15% of global protein in people's diets and directly support more than 43 million jobs. Fish provide more than 50% of dietary protein for people in many small island developing states and coastal countries like Bangladesh, Cambodia, Ghana, and Sierra Leone (FAO, 2008). In addition, marine and coastal ecosystems provide a wide range of other important services to human society, including medicines, natural shoreline protection against storms and floods, water quality maintenance, and other cultural and spiritual benefits (UNEP, 2006). Marine and coastal ecosystems have long been under severe stress from habitat degradation, overexploitation and pollution (Millennium Ecosystem Assessment, 2005).

Climate change is already impacting the 50% of humanity that lives along coasts

Population densities in coastal regions are about three times higher than the global average, with **23 per cent of the world's population living both within 100 kilometer distance of the coast and less than 100 meters above sea level**. Sixty percent of the world's cities with a population of over 5 million are located within 100 kilometers of the coast. Many of the world's poorest communities also live along the coast and rely on mangrove and reef-based fisheries for food security and on tourism for foreign exchange, particularly in small islands and tropical developing countries. This, coupled with poor adaptive capacity of the local populations and the governments, makes these areas highly vulnerable.

Climate change is affecting marine and coastal ecosystems through various ways (IPCC, 2007; Griffis *et al*., 2008):

- Sea level rise - impacts the condition and distribution of coastal habitats and human infrastructure.

- Ocean physical changes (e.g. changes in water temperature, stratification, and currents) - affects species survival and distributions, ocean productivity, and the timing of biological events.
- Loss of sea ice - leads to reduced habitat for ice-dependent species in the Arctic and Antarctic and changes the habitat and productivity for other species. It also decreases the storm resiliency of coastal Arctic communities.
- Ocean acidification - impacts the growth and viability of sensitive marine organisms such as corals, bivalves, crustaceans, and plankton.
- Altered freshwater supply and quality - impacts coastal habitats, spawning migrations, and survival of anadromous species.

These impacts on marine and coastal ecosystems and biodiversity are affecting their ability to provide critical ecosystem services, directly impacting on livelihoods of ocean dependant communities and threatening those most vulnerable.

The Global Response to Climate Change – Mitigation and Adaptation

There is an immediate need for a significant reduction in greenhouse gas emissions to reduce the impacts of climate change and avoid catastrophic consequences in the long term. In the absence of such strong mitigation action, it is possible that the most vulnerable ecosystems, such as coral reefs, will cease to function in their current forms within a few decades (Hoegh-Guldberg *et al*., 2007).

Even if mitigation measures aimed at reducing greenhouse gases and slowing climate change are implemented now, the earth's climate will continue changing over the short to medium term, due to lag effects of temperature in response to the build-up of CO^2 already in the atmosphere. This will result in significant impacts, particularly in the marine and coastal environments. Measures to increase resilience in the face of these changes are a necessary complement to mitigation actions.

There is a need for comprehensive adaptation strategies to consider not only "hard solutions," but also ecosystem-based adaptation.

So far, existing and proposed adaptive responses to climate change in coastal areas have focused on using "hard" engineering solutions to try to build our way out of the problem. These approaches include reinforcing seawalls, building dams, levees and channels to control flooding, and repairing or relocating infrastructure and even whole settlements. Such expensive infrastructure responses, though in some cases necessary, will not be sufficient to address the full scope of climate change impacts, and can exacerbate the destruction of fragile ecosystems, further reducing their ability to adapt. For example, seawalls and jetties that are built to protect stretches of shoreline often result in increased erosion and further loss of habitat on directly adjacent or downstream shorelines.

Integrating "soft" and "hard" engineering approaches to adaptation would also allow for the development of structural measures targeted at protecting the natural ecosystems themselves, in cases where climate impacts extend beyond their natural resilience. In the Mississippi Delta for example, plans are being developed for the construction of small dikes that protect salt marshes and coastal peatlands against erosion and allow them to naturally regenerate. Subsequently, the regenerated coastal ecosystems contribute to the resilience of the Delta as a whole and are able to provide their full range of services.

Ecosystem-Based Adaptation

Ecosystem-based adaptation aims to:

- Preserve and restore natural ecosystems that can provide cost-effective protection against some of the threats that result from climate change. For example, coastal ecosystems like wetlands, mangroves, coral reefs, oyster reefs, and barrier beaches all provide natural shoreline protection from storms and flooding in addition to their many other services (CBD, 2009).
- Conserve biodiversity and make ecosystems more resistant and resilient in the face of climate change so that they can continue to provide the full suite of natural services. This is particularly important for sustaining natural resources (e.g., fish stocks, fuel, clean water) on which vulnerable communities depend for their subsistence and livelihoods.

Ecosystem-based adaptation requires collective action among governments, communities, conservation and development organizations, and other stakeholders to plan and empower action that will enhance environmental and community resilience to climate change impacts. In addition, it can be a major opportunity for community-based adaptation. Vulnerable coastal communities can be engaged, employ local knowledge and participate directly in developing and applying ecosystem-based solutions.

Benefits of Ecosystem-based Adaptation

Ecosystem-based adaptation strategies provide a cost-effective way to reduce vulnerability to climate change and have multiple benefits to people and local communities. Some of these benefits in the marine and coastal environment are:

Shoreline protection. Across the globe, there are numerous examples of the important role that coastal ecosystems such as mangroves, wetlands, and coral reefs play in coastal protection as they dissipate wave energy. Mangrove restoration in Vietnam has been shown to attenuate wave height and thus reduce wave damage and erosion (Mazda *et al.,* 1997). Sri Lanka's Muthurajawela marsh, a coastal peat bog covering some 3,100 hectares, is an important part of local flood control. In Malaysia, the value of intact mangrove swamps for storm protection and flood control has been estimated at US$ 300,000 per km, which is the cost of replacing them with rock walls (Ramsar Convention on Wetlands, 2005). Analysis of recent disasters — such as the December 2004 Indian Ocean tsunami and the hurricanes that struck North and Central America in September and October 2005 — demonstrates the importance of habitat protection and natural resource management in decreasing vulnerability to extreme events (Sudmeier-Rieux *et al*., 2006) . It is important to note that progressive members of the insurance industry, a primary driver in where and how coastal development occurs, are now recommending that a strong risk mitigation strategy should recognize the enormous protective value of ecosystems and other natural infrastructure, such as coastal wetlands, barrier islands, trees, mangroves and other vegetation. This reflects the industry's understanding that natural infrastructure is essential to society's efforts to address climate change, and that these systems must be included as part of any adaptation strategy (Heinz Center and Ceres, 2009).

Sustenance of local livelihoods. The World Bank's Climate Change Framework Strategy (2008) warns that the disproportionate impacts of climate change on the poorest and most vulnerable communities could set back much of the development progress of the past decades and plunge communities back into poverty. Ecosystem-based adaptation helps maintain ecosystem productivity and supports sustainable income-generating activities in the face of climate change. For example, in Kimbe Bay, Papua New Guinea, coral reef resilience principles were applied to design a network of marine protected areas to help the Bay's ecosystems withstand the impacts of a warming ocean and continue to provide food and other resources to local communities (Green et al., 2009). In Samoa, mangroves are being planted as part of a larger restoration project to enhance food security and protect local communities from storm surges which are expected to increase as a result of climate change (UNDP, 2008), and in Myanmar, communities are replanting mangroves in the Ayerwaddy Delta following the destructive impact of Cyclone Nargis, which devastated life and property in the absence of mangrove forests, cleared over time for paddy cultivation. (Tripartite Core Group, 2008)

Re-enforce mitigation efforts. Coastal wetlands, including marshes and mangroves, sequester substantial amounts of carbon (Pritchard, 2009), so also play a crucial and incremental role in reducing the pace and scale of climate change itself. For example, a conservative estimate is that mangroves sequester an estimated 112 ± 85 Tg C per acre, which is mostly an underestimation due to the lack of information about fine root activities. This amount of carbon sequestration is comparable with that for tropical terrestrial forests (Alongi, 2008; Bouillon *et al*., 2007).

Guiding Principles for Ecosystem-based Adaptation

Guiding principles for developing effective ecosystem-based adaptation strategies include:

- ***Use nature's infrastructure first.*** Natural ecosystems provide valuable protection and other services for free, and we should take advantage of them. Maintaining and restoring "nature's infrastructure" should be a priority for reducing vulnerability to climate change impacts. As the effects of climate change become more severe, there will be, however, situations where engineering and hard structures may be necessary, such structures need be built in sync with nature and its changing patterns.
- ***Healthy ecosystems will be more resilient to climate changes.*** Ecosystem-based adaptation strategies should include a focus on minimizing other anthropogenic stresses that have degraded the condition of critical ecosystems. It is also important to take into account the full range of impacts, as one environmental change may have cascading effects.
- ***Make use of existing management practices and governance infrastructure.*** The most effective ecosystem-based strategies currently available apply established best practices in land, water, and natural resource management to confront the new challenges posed by climate change. **Effective integrated coastal management programs** are central to adaptation planning; and **marine protected area networks** can make an enormous contribution to maintaining natural connections across seascapes so that ecosystems can continue to function and to provide services to dependent communities (Smith *et al*., 2009).
- ***Involve diverse stakeholders in strategy development.*** Ecosystem-based adaptation presents a tangible opportunity to solve climate change problems by aligning conservation, development, and poverty alleviation interests. Such synergies benefit from government collaboration with indigenous and local communities, conservationists, relevant private sector stakeholders, development specialists, and humanitarian aid specialists.
- ***Work with government and the private sector to provide incentives for "climate smart" development and discourage development in vulnerable and sensitive habitats.*** The financial and insurance sectors can and need to play a positive role in ecosystem-based adaptation by fully recognizing and accounting for risks associated

with development in vulnerable areas and providing incentives for maintaining "nature's infrastructure."

- ***Adaptive management is imperative***. While the general trends in climate change are well-documented, the timing and magnitude of local changes remain difficult to predict accurately. Ecosystem-based adaptation strategies should include monitoring so that management actions can be quickly adjusted in response to changing conditions. Management objectives may need to be revised and geographic priorities may need to be reconsidered to protect natural climate change "refugia", or to triage places suffering severe climate change impacts.
- ***Be prepared for the unimaginable***. In preparing for climate change, we need to keep in mind the possibility of non-linear, abrupt changes or step functions which can alter the state of an ecosystem or biome quickly once a threshold has been reached. These uncertain but high consequence events (such as de-glaciation or alteration of oceanic currents) need to be acknowledged and social resilience to cope with such changes developed.
- ***A regional approach is needed.*** Ecosystems stretch beyond political and geographical boundaries, and this is particularly true for the marine environment. Therefore, efforts need to be made to design adaptation measures that are not limited by these boundaries. Adaptation measures for a resource shared by multiple states can succeed only through integration of a regional or transboundary dimension.

Effective Ecosystem-based Adaptation Requires Enhanced Assessment Methods and Decision-Support Tools

Ecosystem-based adaptation is a new endeavor that needs to be quickly mainstreamed. It is therefore urgent that the emerging body of research and experience be made widely available and that new information be rapidly disseminated. There are a number of useful tools that are now available to help managers, communities and decision makers undertake ecosystem-based adaptation. These tools include guides for mainstreaming ecosystem-based adaptation in coastal development and management (CRC, URI, 2009); enhancing reef resilience to climate change (www.reefresilience.org) and implementing Integrated Ecosystem Assessments (IEAs) which allow managers to simultaneously track multiple ecosystem indicators relative to climate change and to develop more comprehensive management responses (Levin *et al*., 2009). There is a need for additional development of such tools and to transfer technology and build capacity for their use.

Examples of Coastal and Marine Ecosystem-based Adaptation Resources

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Reef Resilience Toolkit: www.reefresilience.org

Ecosystem-based Adaptation and a Post-2012 Climate Agreement

In the run-up to the UNFCCC COP15 in Copenhagen in December 2009, the Parties to the convention are considering how to implement each aspect of the Bali Action Plan, including a shared vision, enhanced action on adaptation, and a financial mechanism. Preparatory discussions prior to and during COP14 began to focus attention on adaptation, in particular addressing the needs of the most vulnerable countries, communities, ecosystems, and related livelihoods. There are calls for adaptation to be given at least the same level of priority as mitigation, to be contextual, and build on local knowledge. Many developing countries are also calling for adaptation to be community-driven and ecosystem-based, reflecting the dependence of communities on natural resources for their livelihoods.

Recommendations

1. Protect and restore coastal and marine ecosystems as a foundation for ecosystem-based adaptation in coastal areas. Wetlands, beaches, and reefs--both coral and shellfish--provide not only valuable biodiversity and habitat benefits; they are also nature's shoreline defense system. These habitats need increased protection. Action also needs to be taken to conserve areas behind today's estuaries, beaches, and wetlands so that as sea level rises, landward migration can occur.

2. Fully incorporate ecosystem-based adaptation strategies in National Adaptation Programs of Action: Currently, only 25 countries (eight of which are small island developing states) refer to ecosystem-based adaptation in their National Adaptation Programs of Action (NAPA). NAPAs of all coastal countries would benefit from vulnerability assessments of their marine and coastal ecosystems and tailored ecosystem-based adaptation responses such as restoration of coastal ecosystems and the establishment of marine protected areas

3. Include ecosystem-based adaptation in the decisions of the Parties to the UNFCCC at COP15 in accordance with the outline provided in the Bali Action Plan. In particular**:**

- **(i)** **Ecosystem-based adaptation should be part of the adaptation component of the shared vision for long-term cooperative action currently being discussed by the AWG-LCA.** The full scope of actions for implementation of adaptation measures, including ecosystem-based adaptation, should be included in a framework that is consistent with the principles of common but differentiated responsibilities and in accordance with national capacities, and the social and economic conditions in countries.
- **(ii)** **Ecosystem-based adaptation should be one of the concepts underpinning the program for Enhanced Action on Adaptation in the post-2012 climate agreement.** There is a need for integration of ecosystem-based adaptation into sectoral, national and regional planning. Emphasis should be placed on marine and coastal ecosystems, especially in the least developed countries and small island developing states, where economies are highly dependent on the resilience and productivity of natural ecosystems.
- **(iii)** **Coastal and marine ecosystem-based adaptation should be a focus of new technology development and transfer.** Effective methods for implementing coastal and marine ecosystem-based approaches to adaptation should be collated, compiled, and made available through professional development and other capacity-building programs such as those designed to share knowledge and develop expertise at community and seascape scales. The development of the Reef

Resilience Network, Ecosystems and Livelihoods Adaptation Network (ELAN) and other efforts to build capacity, share lessons learned, and link the science and practice of ecosystem-based adaptation should be encouraged.

(iv) **Increase financial resources and investment to support action on ecosystem-based adaptation in coastal and marine ecosystems.** There needs be improved access to adequate, predictable, and sustainable financial resources that can enable the successful design, implementation, monitoring, and adaptive management of coastal and marine ecosystem-based adaptation strategies. In addition, when hard infrastructure projects are built, mitigation funding to offset losses to natural systems should be included in their financing. Finally, development assistance for adaptation should be provided in a coherent and coordinated way to ensure that ecosystem-based adaptation is considered and funded as an integral part of any adaptation project.

4. Recognize the urgent need for specific attention and increased funding for marine and coastal ecosystems. Because of their critical importance in providing coastal protection, reducing the impacts of natural disasters, and sustaining the livelihoods of hundreds of millions of vulnerable people, marine and coastal ecosystems should be one of the highest priorities for ecosystem-based adaptation intervention and support, particularly in small island developing states and least developed coastal nations. There is an urgent need for an immediate halt of the continuing degradation of marine and coastal ecosystems to allow them to help support coastal communities in the face of climate change.

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5b. Section on "Encouraging A Wide Range of Adaptation Efforts," 2008 Global Forum Policy Brief on Climate, Oceans, and Security

By Gunnar Kullenberg, former Executive Secretary, Intergovernmental Oceanographic Commission (IOC-UNESCO); Janot-Reine Mendler de Suarez, former Deputy Director and Project Coordinator, The Global Environment Facility International Waters Learning Exchange and Resource Network (GEF IW:LEARN); Kateryna Wowk, NOAA National Ocean Service and Global Forum on Oceans, Coasts, and Islands; Kathleen McCole and Biliana Cicin-Sain, University of Delaware and Global Forum on Oceans, Coasts, and Islands

Editor's note: This section presents relevant excerpts from the Global Forum's 2008 Policy Brief on Climate, Oceans, and Security (Kullenberg et al, 2008). The Introduction section relies on information provided by Margaret Davidson, Director, Coastal Services Center, NOAA)

Introduction

Enhancing options for adapting to climate change is a multifaceted process. First, as has long been discussed, many of the physical and ecological mitigation strategies that we would wish to undertake in order to 'contain' the rapidly escalating costs of coastal disasters are also the same practices that we need to promote to ensure coastal community resilience in the face of climate change. For instance, siting, engineering and construction practices with regard to physical structures (elevation of buildings, enhanced construction standards) are designed societally and economically. There are infrastructure siting and design projects that are being conceptualized today that by the time that they are actually built, it will be apparent that they are unfortunately sited or inadequate in their design capacity. We need to begin now to rescope physical infrastructure requirements for coastal margins and take an approach that is economically strategic given limited funds worldwide for physical infrastructure.
Secondly, the need to recognize, enhance or preserve coastal ecosystem functions such as flood mitigation or water filtration is even greater in an era of rapid acceleration of sea levels and increasing extremes of drought and floods. Communities through proper change analysis can begin to understand a much more strategic approach toward 'green infrastructure', e.g. the acquisition, restoration and even creation of ecologically essential habitats so as to ensure the availability of services such as wildlife corridors and flood protection in a few decades from now.

A comprehensive approach towards 'coastal change detection' will allow us to more effectively identify climate threats to human and associated ecological communities. A climate vulnerability assessment will enable government at all levels to be more strategic about their physical and green infrastructure siting and investments. The following provides further description of some of these concepts. For information on specific ocean-related/ ocean-driven changes, as well as mitigation efforts, as related to climate change please see Sections II.4 and II.5, respectively, of Kullenberg et al, 2008.

a) Mainstreaming Climate Adaptation through Emphasis on Climate Variability and Extremes

<u>Climate adaptation</u>

Climate adaptation refers to the policies and actions designed and implemented to reduce the negative impacts of climate change. Key issues associated with adaptation include:

- Adaptation can have many different dimensions and is most effective when approached as an ongoing and flexible process.
- *Adaptation vs. Mitigation* - Climate adaptation is different from climate mitigation, which focuses on lessening human impacts through reduction of greenhouse gas emissions.
- *Mainstreaming* - Mainstreaming involves integrating climate adaptation strategies into existing decision processes such as planning, economic development, and environmental protection activities.
- *Climate Change vs. Climate Variability and Extremes* – For most stakeholders and decision-makers, impacts associated with gradual increases in average temperatures over the next 50 years are too distant to result in immediate adaptation actions. Decision-makers are, however, interested in the potential near-term impacts of climate variations and extremes. There is a need to more clearly demonstrate relevant connections between long-term climate change (e.g. long-term temperature increases) and shorter-term variability and extremes (e.g. flood frequency, drought magnitude and probability, rainfall intensity storm locations and frequency).

Climate Change and Variability Overview

The summary below highlights ongoing trends in global climate change and anticipated regional-scale impacts. Successfully engaging decisionmakers and mainstreaming adaptation will depend heavily on the ability to translate long-term global climate change trends into regional and local risks related to climate variability and extreme events. The information below comes from "Climate Change Impacts on the United States - The Potential Consequences of Climate Variability and Change" by the National Assessment Synthesis Team, US Global Change Research Program, published in 2000.

Current global climate change trends include:

- Global average surface temperature has increased by over 1ºF during the 20th century. About half this rise has occurred since the late 1970s.
- Seventeen of the eighteen warmest years in the 20th century occurred since 1980.
- Higher latitudes have warmed more than equatorial regions, and nighttime temperatures have risen more than daytime temperatures.
- As the Earth warms, more water evaporates from oceans and lakes, which will eventually fall as rain or snow.
- During the 20th century, annual precipitation has increased about 10 percent in the mid- and high-latitudes.
- Warming is also causing permafrost to thaw, and is melting sea ice, snow cover, and mountain glaciers. Global sea level rose 4 to 8 inches (10- 20 cm) during the 20th century because ocean water expands as it warms, and because melting glaciers are adding water to the oceans.
- The relevant question is not whether the increase in greenhouse gases is contributing to warming, but rather, what will be the amount and rate of future warming and associated climate changes, and what impacts will those changes have on human and natural systems.

Projected climate variability and extreme event impacts at the regional scale include:

- Increases in flooding associated with stronger rainfall events, increased saturation and overall increased precipitation amounts.
- Increases in flash flooding associated with more sudden snow melts and unseasonal rainfall.
- More catastrophic impacts from more frequent and intense hurricanes.
- More damaging storm surges associated with sea level rise.
- More damaging overall storm impacts associated with loss of natural buffers to sea level rise.
- Permanent loss of coastal infrastructure to inundation from sea level rise.
- Coastal erosion associated with sea level rise.
- Reduction in freshwater sources due to increased evaporation from warming temperatures or drought conditions in certain areas.
- Increasing fluctuations in weather and climate extremes such as increased flooding in one year and severe drought the next.
- Reduced availability of water resources in dryer areas, exacerbating current competition for water among various sectors.
- Increases in landslides from more intense and frequent rainfall.
- Permafrost thawing from warming temperatures causing increased erosion, landslides, and sinking of ground surfaces.
- Retreating and thinning of sea ice increasing inundation, storm surges and significant coastal erosion.

Risk-Based Climate Adaptation

Risk is the combination of likelihood and consequences. Risks are assessed for both current and future conditions, with the option of examining either specific events or an aggregation of events over time. Key characteristics of risk-based approaches to climate adaptation include:

- Assessment of likelihood of climate events based on historic trends and predictions of climate variability and extremes.
- Assessment of the potential consequences of climate events to physical, social and natural systems.
- Assessment of baseline conditions and methods to facilitate adaptive approaches to implementation.
- Evaluation of climate adaptation options in terms of their costs and benefits in reducing unacceptable risks.
- Development of policies and action plans to reduce risks to acceptable levels.
- Identification of effective mechanisms for mainstream adaptation programs into regional and local decision processes.
- Flexibility to accommodate changes to risks over time.
- Mainstreaming through connections to ongoing hazard risk assessment and management processes.

Resiliency-Based Approaches to Climate Adaptation

Vulnerability is defined as susceptibility to damages from climate extremes or variability. It is often referred to as the sensitivity of a system to anticipated impacts. Resilience goes a step further than vulnerability, identifying the extent to which communities have the adaptive capacity to absorb and rebound from anticipated impacts. Characteristics of resiliency-focused approaches to climate adaptation include:

- Identification of indicators of resilience capacities of physical, social, economic and environmental systems and their interdependencies with each other.
- Development of locally-specific thresholds associated with resilience indicators.
- Identification and implementation of processes to assess and track community capability to withstand the consequences of climate variability and extremes.
- Community-based resilience assessment processes to facilitate necessary coordination and cooperation among different sectors (public, private, non-profit) and across numerous disciplines such as land use planning, economic development, natural resource management, social agencies, education and emergency management.
- Mainstreaming climate adaptation strategies into resilience-focused policies, actions and initiatives.

<u>Future Directions</u>

There are a number of things that can be done or explored in the near future to strengthen the linkages between climate, hazards, community resilience and climate adaptation. Some of these include:

- *Improve Climate Change Impact Science* – through improved observations, modeling and forecasting, continue efforts to better understand and predict on a regional scale, the effects of climate change and variability. Increase the understanding of socioeconomic relevance of adaptation in addition to focusing on the natural science components.

- *Improve Local Relevancy of Climate Information* – provide credible climate information in contexts that are useful and usable to local decision-makers. It is critical to provide clear and understandable information upon which to base local adaptation decisions. Whenever possible, link climate change predictions to past and current experiences with extremes and variability to more effectively demonstrate meaningful context for nonscientists. Given the nature of uncertainty associated with current climate models, it is also imperative that we improve our ability to effectively communicate uncertainty to non-technical audiences.

- *Develop Improved Risk-Based Tools* – provide risk assessment tools (useful at regional and local scales) to identify current and projected exposure to existing and predicted climate extremes and variability. Linking climate change variables to more local and immediate risks associated with extreme events will generate higher interest and use than tools focused exclusively on long-term climate risks. Focusing on the development of risk-based tools to be used in screening for climate considerations as part of existing planning and implementation processes will likely be more effective in mainstreaming climate adaptation than the development of new stand alone plans.

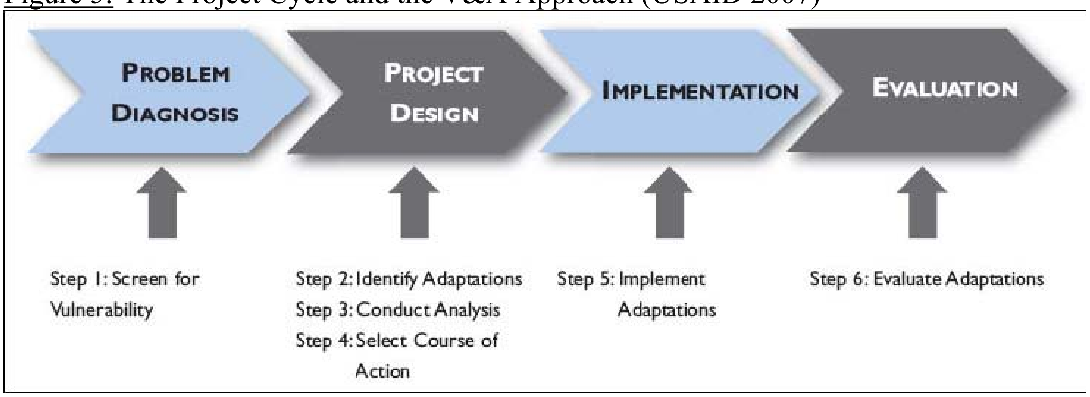
- *Develop Resilience Assessment Processes and Tools* – provide tools and information resources for use in assessing resilience at the community scale. Link specifically to risks associated with current and future climate extremes and variability. Identify the most appropriate indicators of resilience across physical, social, economic and environmental systems of communities. Develop community-based processes and methods for pursuing collaborative approaches to resilience assessment and implementation of adaptation strategies.

- *Provide for Outreach, Training and Technical Support* – Build off of existing networks dedicated to reducing hazard impacts such as coastal managers, floodplain managers, land use planners, conservation planners, natural resource managers, and emergency managers. Those currently involved in hazards management are most likely to be the "early adopters" in incorporating climate change considerations into decision processes. The experiences of early audiences will provide case studies and best practices upon which to expand and improve future activities.

b) USAID and the Adaptation Guidance Manual
In the summer of 2007 the U.S. Agency for International Development (USAID) published a manual intended to assist with the integration of climate information into development and adaptation efforts, *Adapting to Climate Variability and Change: a Guidance Manual for Development Planning to assist with the integration of climate information into development efforts*. This is the first of many tools USAID is developing to assist planners and stakeholders in adapting to a changing climate.

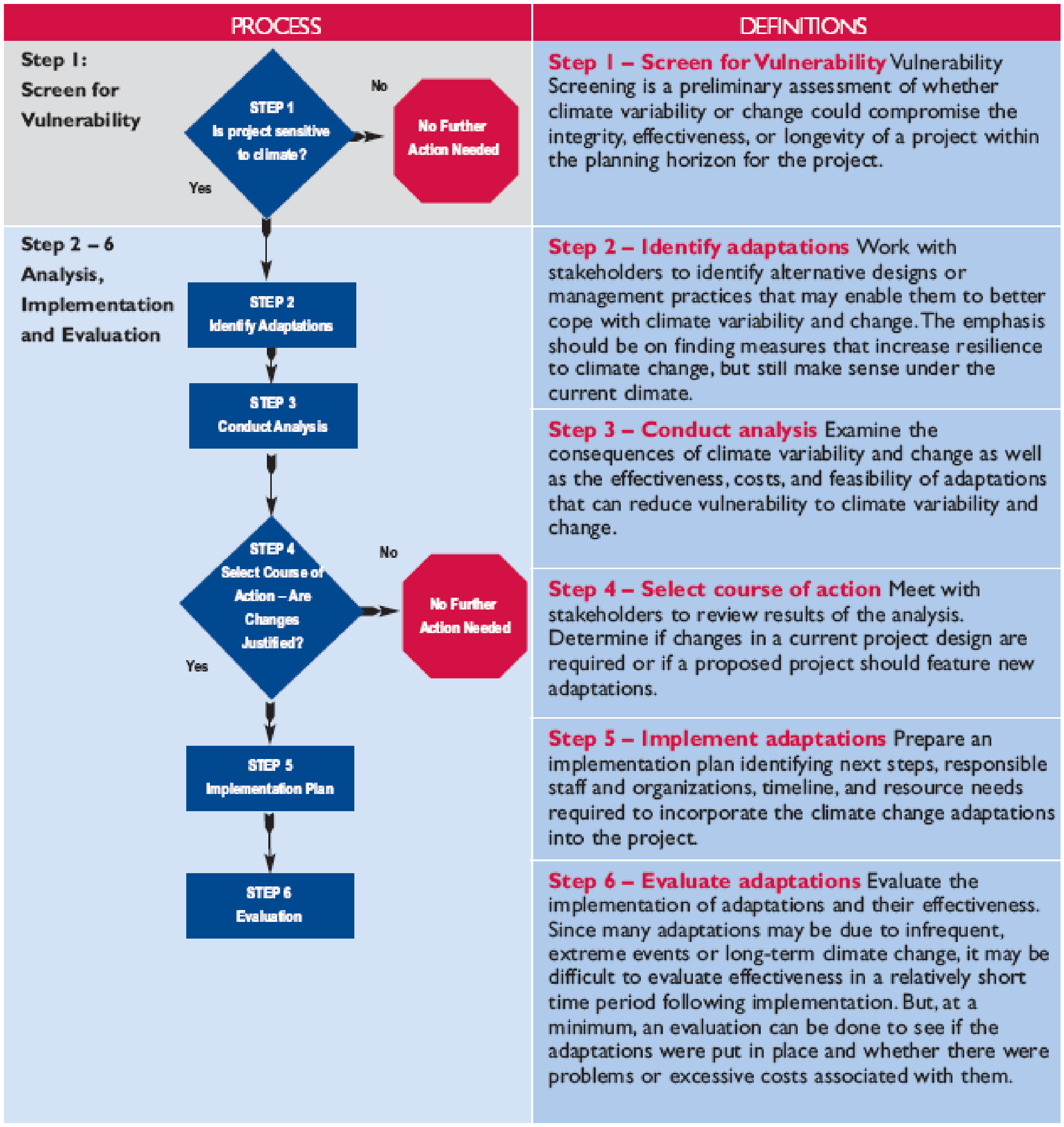
The Global Climate Change Team of USAID has been working to address the causes and effects of climate change since 1991. The organization has developed a design process referred to as a "project cycle" that includes four basic steps of problem diagnosis, project design, implementation and evaluation. This basic process is then further developed into a flexible six-step approach for assessing vulnerability and identifying and implementing climate change adaptations, termed the V&A approach (Figure 5).

Figure 5: The Project Cycle and the V&A Approach (USAID 2007)



As noted above, the V&A approach is flexible and intended to be tailored and applied to various projects at any stage. The approach observes the needs of a specific project and uses only those steps that a certain project requires. Following is a brief description of the six-step approach, which is also summarized in Figure 8.

Figure 8: Steps to Incorporate Climate Change into Project Planning (USAID 2007)



Step 1: Screen for Vulnerability – Screening for a prospective project's vulnerability involves a determination of whether the project might be affected by climate variability or climate change. This also involves determination of whether or not a project is within the organization's manageable interests, capacity, or resource constraints. Furthermore, analysts must be cognizant that not only are some projects particularly sensitive (e.g. water resources, coastal development, and natural resource management), but also that projects will likely need to rely on readily available information and expert opinions. According to USAID "[t]he most difficult part of adapting to climate change will be gathering data about climate change for a specific location and interpreting that data to understand possible impacts on your project".

Step 2: Identify Adaptation Options – Step 2 involves the compilation of an initial list of adaptation strategies and the application of a mutually agreed upon process by the organization, its implementing partners, and stakeholders. The initial list is then prioritized. A high degree of participation, including local and national decision-makers and stakeholders, should be pursued.

Step 3: Conduct Analysis – This step is conducted to evaluate each of the adaptation options for effectiveness at building resilience to the effects of climate change. Imperative in this step is consideration of the project's timeframe, budget, and analytical requirements for implementation. A variety of criteria can be used in this analysis, listed in the report.

Step 4: Select Course of Action – In selecting an adaptation option it is important to engender a sense of local ownership of both process and decision among the organization, its implementing partners, decision-makers, and stakeholders. Further, the decision must take into account a nation's economic, environmental and social goals, not in terms of the success of the project.

Step 5: Implement Adaptations – Implementation typically includes the following: better definition of the specific tasks, schedule, and roles of the implementing partners, decision-makers, and stakeholders; and resource requirements.

Step 6: Evaluate the Adaptations – This step is taken to determine whether the project delivers the intended benefits and/or causes unanticipated adverse outcomes.

Evaluation should also be conducted of the process itself to determine how well the steps worked, the role stakeholders played, the usefulness of the analysis, etc. For further information on this process please visit the USAID 2007 report at: http://www.usaid.gov/our_work/environment/climate/docs/reports/cc_vamanual.pdf

c) ICZM, IWRM and the LME approach

In addition to the above adaptation methods, we must remain cognizant of those tools which have been effectively utilized by the global oceans community to adapt to changing environmental conditions. Integrated coastal zone management (ICZM), integrated water resources management (IWRM) and the Large Marine Ecosystem (LME) approach are arguably the best management tools the global community has for adaptation to climate change and ensuring environmental security. Further, their successful application has been demonstrated and documented. These approaches are embraced at varying levels of policy by a growing number of countries as a means to balance multiple users, build the integration across sectors and increase benefits from coastal and marine resources while sustainably managing the ecosystem to ensure its continued production of goods and services.

These methods require adaptive, ecosystem-based management which allows mangers to: focus on the structures, processes, resilience, functions and interactions among ecosystems; respond to the complex, shifting interactions; and, alter management schemes in light of new information and enhanced understanding of ecosystem processes.

In applying ICZM, IWRM or the LME approach managers should be aware that the specific stages of the processes will vary according to the area being managed and the actors involved. Coastal and ocean managers should further keep in mind that the transition to these approaches to oceans must be incremental and collaborative.

Climate variability is introducing new threats to human and environmental security, creating a need for policymakers, governments and stakeholders alike to invest in building capacity in ecosystem-based adaptive management approaches at all levels, and deploy these methods to manage, reduce and adapt to vulnerability and risk. ICZM, IWRM and the LME approach facilitate this process by providing methods which bridge science and policy based on the precautionary principle, embrace the use of environmental valuation, flows, and payments for ecosystem services, and expand access to risk management, reduction, and transfer through insurance and innovative financial instruments and funding mechanisms.

d) UNDP adaptation learning mechanism (country-level data)

The Adaptation Learning Mechanism is a GEF project capturing and disseminating adaptation experiences and good practices via an open knowledge platform, with co-financing from the Swiss Agency for Development and Cooperation and the Institut de l'Énergie et de l'Environnement de la Francophonie. UNDP is implementing the project in partnership with World Bank and the United Nations Environment Programme (UNEP). Launched in December 2007, the ALM Web site provides access to adaptation resources, including project case studies, best practices and other tools, such as the UNDP-developed database of adaptation profiles of individual countries. Initially developed by UNDP, the country adaptation profiles contain climate-change adaptation information for over 140 developing countries. This regularly updated online database includes information ranging from key vulnerabilities to historical scientific data on climate risks, climate change and impacts projections, and links to related online resources and project Web sites. Country profiles also allow user submissions of related documents and links.
http://www.adaptationlearning.net/

e) Nairobi Work Programme on Impacts, Vulnerability & Adaptation to Climate Change

Unlike mitigation of greenhouse gases, adaptation to the impacts of climate change is a cross-cutting theme under the UNFCCC, which in 2006 mandated the five-year Nairobi Work Programme on Impacts, Vulnerability and Adaptation to Climate Change (NWP) to assist countries, in particular developing countries, least developed countries and SIDS, to improve their understanding and assessment of impacts, vulnerability and adaptation, and in making informed decisions on practical adaptation actions and measures to respond to climate change on a sound, scientific, technical and socioeconomic basis, taking into account current and future climate change and variability, through nine areas of work: methods and tools; data and observations; climate modeling, scenarios and downscaling; climate-related risks and extreme events; socioeconomic information; adaptation planning and practices; research; technologies for adaptation; and economic diversification.

The expected outcomes of the NWP are enhanced *capacity* at the international, regional, national, sectoral and local levels to further identify and understand impacts, vulnerability, and adaptation responses, and to select and implement practical, effective and high-priority adaptation actions; improved *information* and advice to the UNFCCC on the scientific, technical and socioeconomic aspects of impacts, vulnerability and adaptation; enhanced development, dissemination and *use of knowledge* from practical adaptation activities; enhanced *cooperation among all actors*, aimed at enhancing their ability to manage climate change risks; and enhanced *integration of adaptation to climate change with sustainable development* efforts. Climate, oceans and security policies can effectively be aligned with and build on Nairobi Work Program objectives.

f) Gender and Climate Change

From a gender perspective, a significant breakthrough was achieved at COP13 in Bali: For the first time in UNFCCC history, a worldwide network of women, organizations and institutions, gendercc –women for climate justice (http://www.gendercc.net/), were established. The group published several position papers articulating the women's and gender perspectives on the most pressing issues under negotiation, and for the first time a range of activities on women's and gender issues was organized in conjunction with the COP. Women for Climate Justice call upon governments, international agencies and all stakeholders to confront in particular the causes of vulnerability to climate change, and to ensure gender equity in all phases and aspects of funding: when designing, implementing, and evaluating proposals, and in reporting on programs.

Adaptation must be defined as an integrated concept, which is targeting the causes of vulnerability in social groups and in particular of women. Whereas new funding mechanisms are needed to cover the costs of adaptation for those countries contributing proportionally little to climate change and lack the resources to cope with its impacts, the same applies within nations, where women and the poor suffer the impacts of climate change disproportionately, *inter alia* due to lack of information, capacity, financial constraints.

Women and gender experts should be involved in the development of funding criteria and programs as well as in decisions about funding. Gender analysis should be mandatory and attention should be paid to meeting both quantitative and qualitative targets for the participation of women, with primary consideration to impacts of programs on the social situation of women and men in all aspects of their lives, communities and livelihoods. Women are rarely involved in technology needs assessment or transfer schemes; strategies need to be developed for technology exchange processes to help rural and indigenous women increase household productivity and alleviate work loads while adapting to climate change. Adaptation and mitigation technologies need to be embedded in broader capacity building and properly adapted to women's needs.

Gender responsible criteria for programs/projects should include social and economic justice, women's human rights, environmental sustainability, and contributing to the reduction of poverty and social inequalities, while encompassing a gender perspective. Gender sensitive indicators for measuring progress in the review of funds, programs and mechanisms should be based on these criteria.

Women and men do not have equal access to property, money, funds and markets, hence benefits from funding and financing mechanisms are also unequal. Gender analysis should include examination of the effects of market-based approaches on women, indigenous and poor communities, in order to ensure that factors critical to sustainable development, such as social justice, gender equality and poverty reduction, are not overlooked. Women for Climate and Justice have proposed that the UNFCCC allocate 20 percent of all donor funds to be earmarked for activities and projects explicitly addressing women and designed by women / gender experts.

Source

Kullenberg, Gunnar, Janot-Reine Mendler de Suarez, Kateryna Wowk, Kathleen McCole, and Biliana Cicin-Sain, *Policy Brief on Climate, Oceans, and Security* presented at the 4th Global Conference on Oceans, Coasts, and Islands, April 7-11, 2008, Hanoi, Vietnam. Available: http://www.globaloceans.org/globalconferences/2008/pdf/Climate-and-Oceans-PB-April2.pdf

5c. The Heinz Center/Ceres[*] Report:
Resilient Coasts: A Blueprint for Action

Presented by Christophe A. G. Tulou, Director, Coastal Initiative Program, Heinz Center

Preface

The Heinz Center and Ceres—along with those who have developed and endorsed this Blueprint—undertook the challenging task of forging consensus on principles and actions to increase coastal resilience for three fundamental reasons: our coasts are threatened, there are reasonable steps to counter those threats, and we as a nation are not yet taking them.

Powerful storms are wreaking increasing havoc along the world's coasts, as Hurricane Katrina and Cyclone Nagris indelibly demonstrated. A recent assessment by the Wharton School's Risk Center revealed a dramatic surge in global economic losses from natural disasters, increasing from just over $50 billion in the 1950s to almost $800 billion in the 1990s, with about $420.6 billion so far in the current decade (through 2007)[1]. Munich Re estimated worldwide economic losses from natural catastrophes at $200 billion for 2008, up from $82 billion in 2007[2]. Lloyd's of London and Risk Management Solutions (RMS) predict that flood losses along tropical Atlantic coastlines would increase 80 percent by 2030 with about one foot of sea level rise[3]—in line with the conservative estimates of the 2007 report of the Intergovernmental Panel on Climate Change.

Of particular interest are the commonsense and cost-effective steps our nation can take to drastically reduce such risks and their associated economic impacts. Five hundred commercial clients of the insurer, FM Global, experienced approximately 85 percent less damage from Hurricane Katrina as similarly situated properties[4]. This significant reduction in the amount of damage was directly attributable to hurricane loss prevention and preparedness measures taken by these policyholders. The return on investment is striking—a $2.5 million investment in loss prevention resulted in $500 million in avoided losses.[5]

An increasing number of studies underscore the value and wisdom of reducing our coastal vulnerabilities. Wharton has demonstrated that homeowners in Florida could reduce losses from a severe hurricane by 61 percent, resulting in $51 billion in savings, simply by building to strong construction codes[6]. Putting this in perspective, the same cost reductions applied to Katrina damages would have reduced the $41.1 billion worth of insured property losses to about $16.1 billion. Similarly, the National Institute of Building Sciences showed that every dollar spent on mitigation saves society about four dollars on recovery costs[7]. Despite this

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[*] The H. John Heinz III Center for Science, Economics and the Environment, a think tank dedicated to improving the scientific and economic foundation for environmental policy, Washington, DC; Ceres, a leading coalition of investors, environmental groups and other public interest organizations working with companies to address sustainability challenges such as global climate change, Boston, MA, US.

[1] Wharton Risk Management and Decision Processes Center, University of Pennsylvania. "Managing Large Scale Risks in a New Era of Catastrophe." 2007 http://opim.wharton.upenn.edu/risk/library/Wharton_LargeScaleRisks_FullReport_2008.pdf

[2] Munich Re. 2009. NatCatSERVICE http://www.munichre.com/geo

[3] Lloyd's and RMS. 2008. "Coastal Communities and Climate Change: Maintaining Insurability."

[4] Dankwa, D. 2006. "FM Global Touts Underwriting by Engineering as Superior." *Best's Review*, p. 93, June.

[5] Green, M. 2006. "Preparing For the Worst." *Best's Review*, pp. 40-44, April.

[6] Wharton, 2007.

[7] National Institute of Building Sciences/Multihazard Mitigation Council. 2005. Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities. Vol. 1. Washington,

evidence, nearly all U.S. coastal cities and towns lack adequate land use requirements and building code standards to realize these savings. Among the additional benefits of substantially reduced risks and costs are a stabilized coastal insurance market and less expensive premiums.

Even with stronger building codes, our coasts face escalating risks. Roads, transit lines and drinking water supplies—the lifelines of our coastal cities—are already facing pressures they were not designed to withstand. The National Research Council estimates that a sea level rise of 2-4 feet, expected to occur in the next century, would inundate 27 percent of the major roads in the Gulf Coast[8]. Yet today, in most places, even new development is not being designed to withstand the impacts of swelling seas. As the national science agencies renew their commitment to climate science, priority must be placed on providing local governments with the predictive capacities and other tools they need to adapt land use and infrastructure for an uncertain future.

The need to adapt is also an opportunity to restore our coastal ecosystems, which are a critical complement to defensive infrastructure. Wetlands provide an estimated $23.2 billion each year of storm surge and flood protection along our coastlines, according to a study by the University of Vermont[9]. Yet the combined pressures of climate change and development—over half our population lives along the coasts—have led to the systematic depletion of protective wetlands. Clearly, the resiliency of our coastal populations and our ecosystems go hand in hand.

Our goal in producing this Resilient Coasts Blueprint is to provide and inspire leadership and direction throughout our businesses, governments, and communities. The endeavor's broad-based collaboration, along with the group's intention to implement these principles where appropriate within their institutions and advocate for their broader adoption, underscores the importance of common cause and collective action. Evidence shows we can reduce our risks and our costs by 50 percent or more, creating a powerful foundation for this Blueprint—for while the threats may be inevitable, catastrophes are not.

Critical Need, Immediate Opportunity

Sea level rise, temperature increases, changes in precipitation patterns and other climate-related changes are expected to occur and to become increasingly more severe over the coming decades. The need to adapt to these climate-driven changes and to better manage existing coastal risks is obvious and immediate. Changing climatic conditions pose an unprecedented threat to U.S. coastlines, where the majority of our population resides and the majority of our economic activity occurs. Over half the U.S. population lives in coastal counties and almost half of the nation's gross domestic product – $4.5 trillion – is generated in those counties and in adjacent ocean waters.[10] Further, insured property values along the

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DC.

[8] Committee on Strategic Advice on the U.S. Climate Change Science Program; National Research Council. 2009. "Restructuring Federal Climate Research to Meet the Challenges of Climate Change."

[9] Costanza, R., Perez-Maqueo, O., Martinez, M., Sutton, P., Anderson S., and Mulder, K. 2008. "The Value of Coastal Wetlands for Hurricane Protection." AMBIO: A Journal of the Human Environment. June.
[10] United States Commission on Ocean Policy. "An Ocean Blueprint for the 21st Century." 2004 http://oceancommission.gov/documents/full_color_rpt/000_ocean_full_report.pdf.

Gulf and Atlantic coasts have been roughly doubling every decade.[11] By the end of 2007, the Gulf and Atlantic coasts had nearly $9 trillion of insured coastal property.

As coastal development is intensifying, so are coastal property losses. The higher wind speeds, storm surge, flooding, and erosion hazards intrinsic to coastal regions increase the likelihood of property damage, degradation of coastal ecosystems, and subsequent social costs. Changing climate trends may increase the potential for more frequent and severe damage. Routinely, policymakers, developers, and property owners are not aware of the present and future risks associated with coastal development. We must now give high priority to implementing adaptation strategies to protect the natural and built environments on which society depends.

> For the purposes of this Blueprint, *coastal resilience* is the capacity of humans, communities and ecosystems to withstand and bounce back from the inevitable impacts of coastal storms and climate change, including rising sea levels.

Reducing the physical and economic risks associated with coastal hazards is not only critical, but is also often cost-effective. An analysis by the National Institute for Building Safety concluded that investments made to minimize impacts from earthquakes, flood, and wind yielded more than four dollars of benefit for every dollar spent.[12] Another study estimated that coastal wetlands in the United States provide $23.2 billion worth of storm protection services each year.[13] The new threats posed by climate change will also require new solutions. We must develop knowledge, tools and approaches for quantifying risk from climate change in a way that allows planners, underwriters and others to formulate and implement adaptation strategies. Improved land use planning and building codes, as well as the maintenance of a strong private insurance marketplace, will be central to the success of any mitigation strategy. The Resilient Coasts Blueprint outlines these vital steps.

This Blueprint is offered as a tool to advise the new Administration, Congress, state and local leaders—as well as their counterparts in the private sector—as they confront the unprecedented challenges that climate change poses to the American economy and the environment. The Blueprint states basic principles fundamental to coastal resiliency in the face of intensifying hazards and suggests strategies for climate change adaptation. Resilient Coast signatories endorse these principles and, as feasible and appropriate, will implement them in their own practices and advocate for broader adoption. These principles recognize long-term responsibilities and opportunities for private sector engagement and government action at all levels. We envision the Resilient Coasts Blueprint as a first step toward reconciling the ecological, social and economic health of our coasts. This reconciliation is critical to ensure a prosperous and sustainable future for coastal communities.

Resilient Coasts Principles

Identify and fill critical gaps in scientific understanding and develop the tools and methodologies necessary for incorporating climate change into risk assessments and risk mitigation decisions

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[11] AIR Worldwide. "The Coastline at Risk: 2008 Update to the Estimated Insured Value of U.S. Coastal Properties." http://www.air-worldwide.com/publicationsitem_ektid14604.aspx

[12] Multihazard Mitigation Council. "Natural Hazard Mitigation Saves." 2005 http://www.nibs.org/MMC/MitigationSavingsReport/Part1_final.pdf.

[13] Costanza, R., Perez-Maqueo, O., Martinez, M., Sutton, P., Anderson S., and Mulder, K. "The Value of Coastal Wetlands for Hurricane Protection." AMBIO: A Journal of the Human Environment. June 2008.

Risk-reduction strategies must be based on assessments adequate to support critical and costly risk mitigation investments. While much of coastal climate change risk results from choices on where and how we build along the coast, calculating future risks based on forecasts of climate change are fraught with uncertainties that make effective adaptation planning difficult. A critical step toward better quantifying future change is to advance scientific understanding and develop the methodologies necessary to refine forecasts and make them useful for adaptation purposes.

For example, current estimates of sea level rise have uncertainties both in terms of timing and extent, creating some risk in making costly and time-sensitive investments on these forecasts. These uncertainties may delay implementation of adaptation plans or lead planners to address only the higher probability, lower impact scenarios. Consequently, improving technologies and methodologies to reduce uncertainty would prove invaluable. In the case of sea level rise, as one example, the relationship between rising temperatures and ice sheet breakdown must be better understood.

Tools that can help translate expected climate change into localized impacts on the built and natural environment are also necessary. Current flood, shoreline and inundation maps, used for land use and infrastructure planning and mortgage due diligence, do not accurately reflect current risks, let alone future risks, posing significant challenges for adaptation. In the case of sea level rise, the development and dissemination of high-definition, digital flood and coastal maps, based on assessment of data from LIDAR* surveys and other data-gathering techniques, is essential. These maps should be created to include a variety of scenarios for potential future sea level increases. There also is strong need for climate change models and other tools that enable improved predictions of future coastal storms and which clearly describe the uncertainties of those predictions.

Funding of this research is a top priority, as it is a critical step in implementing risk mitigation strategies. Additionally, attempts to address nearer term risks must be designed to be adapted as our understanding of climate change impacts improves.

Require risk-based land use planning.
Ultimately, federal, state, and local governments should integrate natural hazards into land use planning with a goal of protecting development from significant and frequent coastal hazards, including storm surges, storm-generated waves, and erosion. In addition, during the land use planning process, government entities should consider climate-related risks, including the likelihood and extent of climate change-related hazards, and identify actions to protect or adapt in specific geographic locations. In especially vulnerable coastal areas, government entities might designate no-build and no-rebuild zones, similar to floodway zones in riverine areas, and/or provide private property owners with incentives to relinquish property or development rights in these areas through land exchanges, land banks and the transfer or trading of development rights.

Design adaptable infrastructure and building code standards to meet future risk.
As part of any local adaptation plan, construction, retrofit and operational standards for new and existing public and private infrastructure should be routinely assessed and modified. Some plans may need to allow for evolving information and uncertainty about the pace of climate change. As always, local plans and investments should account for regional planning

* Light Detection and Ranging (LIDAR) is a remote sensing system used to collect topographic data. This technology is used to document topographic changes along shorelines.

efforts and for the density of populations being protected, and also should take into consideration localized forecasts of climate change impacts. In addition, new approaches to infrastructure might be considered, such as decentralized energy and water treatment systems that would be less susceptible to catastrophic loss or disruption than the traditional centralized systems.

Likewise, standards for new building construction and for building retrofits should be modified to take into account new levels of climate change protection and risk mitigation requirements. For low-income households, the federal government and states could provide subsidies for any retrofits required because of climate change risk.

Strengthen ecosystems as part of a risk mitigation strategy

A strong risk mitigation strategy should recognize the enormous protective value of ecosystems and other natural infrastructure, such as coastal wetlands, barrier islands, trees, mangroves and other vegetation. This natural infrastructure is essential to society's efforts to address climate change, and these systems must be included as part of any adaptation strategy. Federal, state, local and private entities should protect and restore these natural features to mitigate threats to built and natural systems. For example, government entities can establish incentives and/or regulations to make ecosystem preservation and enhancement part of adaptation funding, risk-based land use planning and post-disaster rebuilding.

Develop flexible adaptation plans

Given the uncertainty in many forecasts of climate change, it is essential that adaptation plans be flexible and amendable to incorporate higher levels of climate change protection as required. For example, a bridge built to function under five-foot storm surge conditions might be designed so it could be modified should higher levels actually occur.

Maintain a viable private property and casualty insurance market

It is critical to maintain a private property and casualty insurance market by allowing private insurance companies to set risk-based premiums that thereby communicate the cost of risk to consumers. While not every risk is insurable, regardless of the price, a resiliency strategy must recognize insurance as an indispensable tool and maximize its effectiveness. Insurance cannot play its role if land use, building codes and physical protection are not sufficiently robust. In turn, the insurance industry must give appropriate consideration and weight to the demonstrable reduction in risk provided by improved building standards and other risk mitigation efforts.

An empowered and stable private insurance market will help ensure that unaffected taxpayers will not bear the burden of catastrophic loss. It will also provide the right price signals and incentives for risk mitigation. As the risk to a property grows because of location or other climate-related factors, the associated insurance premiums will increase because of the greater likelihood of damage, providing an incentive to build in less risky areas and/or build or retrofit properties to higher standards. For owners of existing properties who are unable to afford steeply rising premiums, such as low-income homeowners, government should seek a transparent means of subsidizing insurance cost while also helping those receiving assistance to mitigate their risk.

Integrate climate change impacts into due diligence for investment and lending

Wise investing will involve asset managers understanding the impacts of climate change on their investments and managing that risk, especially in real estate, infrastructure and other financial instruments. Responsible banks will need to understand the levels of exposure within their investment and lending portfolios by incorporating climate risks into their due diligence.

Project Endorsers

Arup, Calvert Asset Management Company, Inc., Center for Clean Air Policy, City of Charleston (SC), Coastal States Organization, F&C Asset Management, Fireman's Fund Insurance Company (a company of Allianz), Harvard Medical School (Center for Health and the Global Environment), Hazards and Vulnerability Research Institute (University of South Carolina), Institute for Sustainable Communities, Lloyd's of London, Monmouth University (Urban Coasts Institute), National Wildlife Federation, The Nature Conservancy, National Oceanic and Atmospheric Administration (NOAA), Pax World Investments, Reinsurance Association of America, Risk Management Solutions (RMS), Jonathan Rose Companies, Southern Alliance for Clean Energy, Swiss Re, the Wharton School (Risk Management and Decision Processes Center), and Travelers.

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Integrated Coastal Zone Management in the Mediterranean

From Local to Regional, How to Stop the Loss of Biodiversity ?

December 18 – 19 2008
Nice, France

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Workshop 2

The ICZM coping with Climate Change

1. CLIMATE CHANGE IN THE MEDITERRANEAN

1.1. Nature of the phenomenon

It has now been proved that the climate is changing and IPCC's last report shows that the areas surrounding the Mediterranean are "hotspots". The models associated with IPCC's A1B scenario (see Box 1) suggest that there will be an average rise in annual temperatures of 2.2 to 5.1°C by the end of the century, i.e. much higher than the world's average rise, even if we will not be able to detect this rise with certainty for 15 to 25 years. The rise should be higher inland than on coasts, at sea or on islands, and it should be more notable in summer (2.7 to 6.5°C) than in winter (1.7 to 4.6°C). There will be more heat waves and they will be longer and more intense, with more dry days exceeding 40°C, which will increase the risk of deaths and forest fires.

Forecasts also suggest that annual rainfalls will drop by 4 to 27%, and once again this phenomenon will be more notable in summer than in winter. North Africa will be particularly affected, given that a reduction has already been observed over the last decades in Cyprus, Spain, Greece, Israel, Italy and Turkey. Therefore, droughts should also be more frequent and more intense. All combined these signs of climate change help to exacerbate already acute fresh water problems in the Mediterranean, i.e. increased evaporation, rarefaction of the resource, salinization of coastal aquifers. At the same time, episodes of strong rain my increase rather than decrease.

Finally, it is still difficult to forecast the rise in sea level at regional level, especially in the Mediterranean basin. It could reach 23 to 47 cm by the end of the 21st century according to IPCC, whose 2007 forecasts are considered as optimistic. If this happens, many Mediterranean regions would be susceptible to submergence or erosion, among which we can cite the extreme cases of the archipelago of Kerkennah in Tunisia, Alexandria and the Nile Delta in Egypt, Thessalonica in Greece and even Venice in Italy.

Box 1. Some details on figures relating to climate change

There are still many uncertainties with regard to climate change modelling and these uncertainties are not necessarily decreasing as progress is made in research dedicated to the climate and which IPCC summarizes in its reports. For a given scenario on greenhouse-gas emission, the ranges of uncertainty remain wide, and neither the most optimistic nor the most pessimistic scenarios can be excluded. For example, the IPCC's simulations do not take into account the behaviour of ice caps which could be responsible for about 30% of sea-level rise.

In this document, we have chosen to work with figures provided by IPCC based on scenario A1B which is usually used for popularization and often qualified as "intermediary" even if it corresponds to an economy which is still very energy-intensive – it includes sustained economic growth, a demography stabilized by 2050, energy sources evenly balanced between fossil energy and other energies (nuclear, renewable) and the rapid introduction of new technologies. However, it is not more probable or less probable than another scenario: everything still depends upon demographic, economic, and technological evolutions and the decisions[1] made within the framework of international negotiations on the climate.

1.2. Vulnerability and impacts on Mediterranean coasts

The IPCC defines climate vulnerability as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity".

Mediterranean societies and their environment are proving to be very vulnerable to current and future climate changes for natural reasons (historically limited water resources for example) and because of development modes – particularly coastal development and intensive development of coastal tourism. Therefore, climate change is an emerging threat which presents two major, constantly interacting challenges: (i) it magnifies the strain on ecosystems that have already been deteriorated by pollution, the destruction of habitats or the over-exploitation of natural resources; (ii) it calls into question development strategies of the past – or the present – in the light of new physical conditions it imposes or suggests.

Climate change impacts are extremely varied, linking the changes themselves (temperatures, rainfall, winds, increases in sea level, etc.) with all socio-economic sectors and natural systems. As for the latter, the potential effects are produced at different levels of biological organisation, from physiological dysfunctions of individuals to modifications of a community and its functioning, via local extirpations or/and the extension of certain species (notably invasive species). All the forecasts concerning the consequences of global warming on biodiversity as a whole are very worrying. Based on a moderate climate change scenario, it is now predicted that 15 to 37% of Mediterranean species will be extinct by 2050 (UNEP-MAP-CAR/ASP, 2008). The impact on fishing resources particularly could be devastating given that most stocks have already been very much reduced by over-fishing.

It would be fastidious to enter into a full review of the potential effects of climate change but the increase in sea level is of prime importance in discussions on integrated coastal zone management and it illustrates the challenges and their interrelations well. Such an increase, which is already perceptible and likely to accelerate, would affect:

- Ecosystems : beaches, dunes, lidos, lagoons and marshes are the unique or favoured habitats of many animal and plant species and would be affected by accelerated erosion. The ecological function of lagoons, for example, is very dependent on their depth and salinity and these are likely to change. Mediterranean wetlands as a whole, which have already been put to a severe test by human development, are very vulnerable to an increase in water levels as the spatial evolution of many of them has been limited by infrastructures, dikes and dwellings.
- Human installations: as development has taken place mainly in coastal zones, loss of constructions or agricultural land to flooding by the sea (temporary flooding) seems a real threat. The gradual receding of the shore line brings installations near the shore closer and closer to the waves.

In its introduction, the ICZM Protocol shows how worried Mediterranean countries are about the "risks threatening coastal zones due to climate change" and expresses "the need to adopt sustainable measures to reduce the negative impact of natural phenomena[1]". It then calls upon the Parties to take "prevention, mitigation and adaptation measures to address the effects (…) of climate change[2]" and "adopt the necessary measures to maintain or restore the natural capacity of the coast to adapt to changes, including those caused by the rise in sea levels[3]".

[1] Introduction, paragraph 5.

[2] Article 22.

[3] Article 23.

Therefore, to deal with climate threats, the Protocol underlines the need to both reduce greenhouse gases (prevention), and adapt to the effects that cannot be avoided. This framework document will focus on this second line of action.

2. ADAPTING TO CLIMATE CHANGE

2.1. Definition

The ICZM defines adaptation as an "adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities".

Generally, we can distinguish various types of adaptation, notably:

- anticipatory or reactive adaptation, i.e. before or after the

occurrence of the phenomenon that we need to adapt to;
- public or private;
- Autonomous or planned.

2.2. Coping with the rise in sea level

To cope with the rise in sea level, three main types of adaptation are usually presented, over and above non-action: protection, "accommodation" and strategic retreat. Table 1 summarises some of the advantages and drawbacks. On this basis, we can further explore[4] examples of strategies to promote the conservation of coastal ecosystems, then the protection of human installations.

[4] According to Carreno et al., 2008.

Strategies	Advantages	Drawbacks
Protection Freeze coast line (dikes, rock-armour) or deal with causes of erosion (breakwaters, jetties, re-depositing sand)	Efficiently solves local problems Very socially acceptable	High cost The phenomenon of erosion is simply moved to other sectors Disruption of sedimentological function
« Accommodation » (adjustment in natural or human systems to a new or changing environment) Adapt to the phenomenon by enacting construction regulations (zoning, raising foundations, etc.), and measures to compensate for property or systems destroyed	A gain of space and conservation of natural shore condition Local policy Low cost Compensation and extra cost of protecting shore are avoided	Local measures and not uniform Measures do not meet long-term imperative
Strategic retreat Move the objects threatened further inland	More efficient in the short and long-term No maintenance No impact on sedimentary function	A need for space inland and land where infrastructures and activities can be moved to Difficult to implement in zones where socio-economic interests are important or infrastructures and urbanisation are extensive Not very socially acceptable
Non-action Decide not to take any action	Preserve natural functions	Implementation limited to natural areas where very little is at stake

Table 1. Advantages and drawbacks of different adaptation options to cope with the rise in sea level (according to Carreno *et al.*, 2008)

Strategies for the conservation of coastal ecosystems:

- Allow environments to adapt on their own: do not let infrastructures prevent them from evolving, therefore move some of the existing ones and avoid building new ones by creating un-constructible zones (100-metre strip, 100 years, etc.). Climate change should also be integrated into environmental impact studies and into land-use and town-planning documents.
- Strengthen the ability of coastal habitats and species to adapt on their own: climate threats are exacerbating phenomenon that already exist (fragmentation of ecosystems, pollution, over-exploitation, etc.), it increases the need for more protected areas that are larger, better located, better managed, more interconnected (networks of protected areas, corridors, greenbelts, etc.), and the need to reduce or move sources of occasional pollution (urban and industrial pollution) and diffuse pollution (agricultural).

Strategies for the protection of human installations:

- Plan the strategic retreat: move coastal installations inland to protect them from coastal hazards, i.e. make the coastal zones less artificial. Of course, it may be difficult to get the different players involved to accept this but experience shows that when the stakes are quite low, the process can be understood; to such an extent that many cases have already been noted in the Mediterranean.
- Manage the risk by introducing risk prevention plans, town planning programmes, and by making it illegal to build on strips of 100 or more metres (100 years, 2 metres altitude, etc.).
- Use insurance and compensation mechanisms which are sometimes more effective and less costly than other types of measures. Use the price of insurance and even the impossibility to insuring property for eviction purposes.
- Use strong defences to protect the coast when there is no other alternative (an environment which is highly urbanised, a very active economy which cannot be moved, etc.).

2.3. Adopting new decision-making modes

Implementing adaptation strategies finally requires an in-depth revision of the way decisions are taken on investment and land-use. In short, the most robust solutions should be chosen (whatever the future evolution of the climate in a plausible range) instead of trying to find the best solution(s) for a given climate scenario. Hallegatte (2008) provides four sets of guidelines to taking more robust decisions:

− Institutionalize long-term planning and ensure a regular revision process to take account of the new information available. Adaptation is a continuous learning process.

− Promote “no-regret strategies” i.e. strategies that reduce vulnerability of a system at negative, null or negligible cost (by taking “pessimistic” margins in the design stage of an infrastructure rather than having to conduct further work later, for example).

- Favour strategies that are reversible over irreversible choices: for example, refusing to urbanise has a well known short-term cost, but if new information shows in the future that the area is safe, urbanisation can be allowed virtually overnight. Allowing urbanisation now, on the other hand, yields short-term benefits, but if the area is found dangerous in the future, the choice will be between retreat and protection, two options which are often extremely costly and not always feasible.
- Avoid focussing on technical adaptation solutions: sometimes institutional or financial tools can be more appropriate (for example insurance schemes for agriculture or the implementation of early warning systems rather than costly coastal protection). The key advantage of these “soft” adaptation options is that they imply much less inertia and irreversibility.

In the end, we see that adapting to climate change has a great deal in common with integrated coastal zone management. We shall now describe the link between these two notions, how they interact and under what conditions they can work in synergy.

3. ICZM AND ADAPTING TO CLIMATE CHANGE

3.1. Shared principles

First of all, we should point out that ICZM and adaptation share the same general sustainable development objective – the sustainability of human activities and their underlying ecosystems. Adaptation aims to “reduce the negative impact[6]” of climate change which could ensure sustainability, while article 5-a of the Protocol indicates that ICZM aims to “facilitate (…) the sustainable development of coastal zones”. More precisely, the Protocol explicitly states that one of ICZM’s aims is to prevent natural risks. We see this in article 5-e which specifies that ICZM should strive to “prevent and/or reduce the effects of natural hazards and in particular of climate change, which can be induced by natural or human activities”. It should also be stressed that “the preservation of the integrity of coastal ecosystems” and thus biodiversity, which is one of the main objectives of ICZM[7], has a major role to play in the field of adaptation. Indeed, efficient coastal ecosystems provide many services which help combat the impacts of climate change (wetlands and availability of water resources, dunes and erosion, etc.).

There are also some obvious overlapping principles: coordination, participation of stakeholders in decision-making processes, discussions between scientists and managers, etc. As stated by the ICZM Protocol and the IPCC respectively, ICZM and adaptation are intended to be continuous, dynamic processes[8] of decision-making and “adjustment[9]”, which do not imply reaching a stable, utopian condition: managing a coastal zone is never totally “integrated” and a coastal system can never be totally “adapted”.

[7] Article 5-d.

[6] IPCC definition

[8] Article 2-f.

[9] IPCC definition.

Therefore, the long-term is a crucial aspect of these two approaches which necessarily integrate future demographic, economic, ecological and social changes that coastal regions experience.

3.2. ICZM as a tool for adaptation: the example of the Protocol

These shared objectives – sustainable development in general and prevention of natural risks in particular – and the shared principles have corresponding implementation tools that are partially similar. Thus, several of the Protocol's measures should contribute to adaptation to climate change.

As far as sectoral measures are concerned, there are tools to assess projects that could impact the coastal environment which the Protocol states should be used for two purposes, i.e. "environmental assessment[10]" and "risk assessment[11]". By contributing to the prevention of coastal erosion and the protection of biodiversity, regulations on the extraction of sand and river sediment[12] could also contribute to adaptation to climate change and ICZM implementation. In addition, institutional coordination, which is greatly encouraged by the Protocol[13], would lead to the "reconciliation» of marine and land administrations, based on a scheme of integration. It could bring together the themes of "Biodiversity" and "Climate" and also the competent departments which are often prevented from working together because of the compartmentalisation of Conventions and the resulting administrative divisions. Finally, the Protocol encourages Parties to "develop scientific and technical research[14]" and in general "promote scientific and technical research on integrated coastal zone management[15]". In this way, scientists could help assess coastal regions' vulnerability to climate changes and guide decision-makers towards suitable solutions to land-use issues.

From a more cross-sectoral point of view, policies and schemes on land-use and urban development, i.e. the "rational planning of activities[16]", constitute basic tools in ICZM and in adaptation. The actual idea of integration requires States and local authorities to avoid any "spreading out" of sectoral adaptation measures which are not strategically linked to each other. It is essential that the integrated tools for ICZM implementation ("coastal strategies, plans and programmes"), which are required by article 18 of the Protocol, integrate climate change issues and particularly adaptation solutions. In this context, the level at which such documents are drawn up will be just as important as the competent authority: as the Protocol states, "coastal plans and programmes" should be drawn up at "an appropriate territorial level[17]". Henceforth, it is essential these documents be applied to homogenous parts of the coast but failing this, the specific characteristics of each part should at least be taken into consideration, especially their vulnerability to climate change. Therefore, it would be inappropriate to apply the same adaptation policies to coastal zones with radically different geomorphic characteristics (coastal topography, susceptibility to erosion, etc.)

[10] Article 19.
[11] Article 6-i.
[12] Article 9-d(ii).
[13] Article 7.
[14] Article 25-1-b.
[15] Article 25-2.
[16] Article 5-a.
[17] Article 18-3

and economic or social characteristics (a community's dependence on coastal activities, etc.). For example, although it has been proven that a non-constructible strip along coastlines can preserve coastal ecosystems and protect communities from flooding and erosion, its ideal width very much depends on local circumstances. In some cases, the one hundred metres specified in article 8-2 of the Protocol are sufficient. In other cases, using the "one hundred years strip" will be more pertinent, necessitating a study on the probability of coastal erosion and rise in sea level. Moreover, much depends on the types of land-use envisaged (see Figure 1). Therefore, the difficulty lies in coinciding the administrative territory, planning document implementation zone and physical territory with the same characteristics.

Heavy facilities buildings and roads POSITION OF SHORE IN 60 YEARS
Light facilities POSITION OF SHORE IN 30 YEARS
Light mobile facilities POSITION OF SHORE IN 10 YEARS
No facilities
Present beach
Sea

Figure 1. Propositions for rational management of coastal areas in a situation where the shore line retreats (according to Cazes-Duvat and Paskoff, 2004[18])

4. FOOD FOR THOUGHT

4.1. Adaptation: can we succeed where we failed in the past?

When exploring the link between integrated coastal zone management and climate change, we should not lose sight of the fact that climate change mainly comes into play by accentuating threats and problems – sometimes opportunities – that already exist. Problems in Mediterranean coastal zones do not stem from the impact of climate change but from the impact of unsustainable development models so far adopted by the societies concerned. The problem of erosion is a good example of this. It is a major challenge for many Mediterranean coastal zones but it is mainly related to:

- coastal installations: sea defence facilities which prevent shore drift and accelerate erosion down shore, walls and rock armour at the top of the beach, destruction of dunes by treading or construction, etc.
- river installations: it is estimated that sediment input from rivers

[18] V. Cazes-Duvat, R. Paskoff, 2004. Les littoraux des Mascareignes entre nature et aménagement, L'Harmattan, Paris.

decreased by 90% in the second half of the 20th century because of the construction of dams and the massive extraction of granular material.

However, climate change amplifies existing threats, sometimes in a decisive way by bringing out threshold effects, with ecosystem functions for example. It encourages the "over-sizing" of certain policies so as to have the latitude to cope with a very uncertain future, and above all it raises old questions by calling upon Mediterranean societies to succeed where they have failed in the past decades, i.e. to reconcile economic development with the sustainable management of coastal zones.

4.2. A need for expertise which is contextualised and anchored in the territories

The historical weakness of research on adaptation has meant that experts have tended to communicate mainly about risks and can offer few solutions. Although this approach is important, it is often badly received by the players directly concerned. Moreover, even when describing risks, there is a need for more local modelling and information but these are often given on a global scale or at best a regional scale. For example, figures on impacts or adaptation strategies in terms of GDP points do not indicate "who will lose out and where", which is essential if appropriate public policies which are favourable to "losers" are to be developed. Yet the objectives, interests and reasoning of the different players with regard to climate impacts and adaptation strategies are often divergent. Adaptation should not pretend to ignore these divergences but should recognise them and deal with them using the array of tools available: participation, negotiation, mediation, communication, reaching a consensus but also arbitrating in favour of some interests to the detriment of others. Adaptation and integrated coastal zone management should remain horizons which we strive to reach via continuous, contextualised processes and not via stereotype procedures.

4.3. Is there a synergy between protection of coastal zones, the fight against climate change and adaptation to its impacts?

This document has focussed on the many synergies that exist between ICZM and adaptation to climate change because it is only logical to concentrate first on courses and measures that could produce positive impacts at all levels. However, it is important to note that these synergies have their limits and in some cases it will be necessary to arbitrate and choose priorities:

- Adaptation may involve the implementation of greater coastal defence mechanisms which usually interfere with the natural processes underlying ecosystem services.
- The possible effects of climate change on coasts (rise in sea level, coastal erosion, changes in the way ecosystems function) could exacerbate disputes on the use of areas and resources – these types of disputes are already common in Mediterranean coastal zones. Moreover, unless there is a sound strategic framework based on

ICZM, the probable increase in extreme weather conditions (storms, increased rainfall, droughts, etc.) could lead to the adoption of limited, crisis measures which in the end correspond to a "bad adaptation".

- Reducing emissions could also have negative consequences on coastal zones: we are referring to the renewed construction of dams on rivers to produce energy which negatively effect integrated coastal zone management and adaptation. On the other hand, even if this is not the purpose of this document, ICZM can help reduce emissions (transport planning, etc.).
- Finally, we should remember that there are many examples of adaptation measures which have a negative impact in terms of reducing greenhouse gas emissions: desalting plants, air-conditioning, etc.

These points illustrate the need to implement integrated adaptation approaches which include impact studies on the environment and climate. At the same time, climate concerns should be integrated into development processes in general[19], and into coastal strategies, plans and programmes in particular.

[19] This corresponds to the English notion of "mainstreaming".

4.4. Can we depend on climatologists? (Un)certainties and integrated coastal zone management

Hallegatte (2008) considers that climate change represents much more than a change in climatic conditions: for decision-makers it represents increased uncertainties. Climate models are badly adapted to existing decision-making frameworks and the uncertainties they raise are not residual: they are not even starting to lessen and, whatever the case, the future climate greatly depends on future greenhouse gas emissions which depend on decisions that have not yet been taken (see Box 1). The basic uncertainty on climate change will not be dispelled in the coming years: decision-makers should not count on climatologists, economists and other modellers to help them avoid making difficult decisions in uncertain contexts.

Therefore, managers should definitely not suspend all decisions until a perfect – and illusory – knowledge of ideal adaptation measures is found for a given coastal zone. To the contrary, they should learn how to govern in a state of uncertainty and to base their actions on scientific data that is often incomplete. Adaptation strategies should basically be robust to cope with a wide array of possible futures. Thus, climate change resembles a range of futures that are not improbable and for which the current climate scenarios provide an initial estimation, without indicating that such and such a scenario is more or less probable than another.

Finally, it is clear that public and private players involved in coastal issues should improve the way they use information on the climate, i.e. should integrate it more into their policies, development plans, business plans, etc. Nevertheless, the main change that global warming will bring may not be actual weather changes but (i) uncertainties about future climatic conditions – which were marginal in previous centuries and which could be

[20] Hallegatte, 2008.

ignored in the decision-making process[20]; (ii) uncertainties about future policies on the reduction of greenhouse gas emissions and their structuring effect on all economic sectors.

The prospect of climate change is an opportunity (which also brings its constraints) for Mediterranean States to reappraise their medium and long-term strategies for the development and management of coastal zones. This study should be conducted and implemented very soon without losing sight of the fact that:

- For many players, climate change is synonymous with hypothetical problems that could materialise in the next 20 to 30 years while their action is guided by definite problems that they have to deal with now.
- According to most of the models currently available, if average temperatures stabilise at +2°C (the objective expressed by the European Union), major changes in our modes of development should ensue. Therefore, all the forecasts we can make for the medium and long-term should be envisaged in a society that has been profoundly transformed by the pursuit of this objective, or with climate changes that are much more radical than we usually imagine.

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Chapter 6

Encourage Adaptive Management Institutions at Scales from Regional (e.g., LMEs, Regional Seas, to National, to Local)

6a. Encourage Adaptive Management at Regional, National, and Local Scales

By Kateryna Wowk, NOAA National Ocean Service and the Global Forum on Oceans, Coasts, and Islands

Adaptive Ecosystem-Based Management

The 2002 World Summit on Sustainable Development (WSSD) produced a set of goals seeking to promote the ecosystem approach and integrated coastal and ocean management (ICM) at the national level, and to encourage and assist countries in developing ocean policies and mechanisms on integrated coastal management. The goals further call for assistance to developing countries in coordinating policies and programs at the regional and sub-regional levels aimed at conservation and sustainable management of fishery resources, and implementing integrated coastal area management plans, including through the development of infrastructure.

Countries and regions have taken the ecosystem-based management (EBM) approach and its principles into consideration in the planning and implementation of development and environmental management initiatives. At the 7th meeting of the United Nations Open-ended Informal Consultative Process on Oceans and the Law of the Sea (ICP) in 2006, national delegates agreed that "there is no universally agreed definition of an ecosystem approach, which is interpreted differently in different contexts" although there are key agreed elements of the approach, including: 1) ecosystems are inclusive of humans; and 2) management is inclusive of both conservation and sustainable use of coastal and ocean resources. ICP7 delegates stressed the need for capacity building for developing States, particularly in marine scientific research and transfer of technologies.

The EBM approach, the definition of which is continuously evolving, is widely embraced but not yet widely implemented on the ground. The concept has been incorporated in global, regional, national and subnational ocean research, management and conservation initiatives, but in general implementation is lacking among sectors for a number of reasons, including a lack of consensus on what operationalization of EBM entails and a lack of capacity for implementation. However, a number of important efforts at various scales are currently underway.

Adaptive Management Institutions at Various Scales

National Ocean Policies and Exclusive Economic Zone (EEZ) Management

In the last 10 years, an increasing number of countries have undertaken combined efforts to formulate and implement an integrated policy for the governance of their EEZs in order to harmonize existing uses and laws, to foster sustainable development, to protect biodiversity and vulnerable resources and ecosystems, and to coordinate the actions of the relevant government agencies that are typically involved in ocean governance. It is estimated by the Nippon Foundation Research Task Force on National Ocean Policies that about 20-30 countries have taken concrete steps toward cross-cutting and integrated national ocean policy (Cicin-Sain, VanderZwaag and Balgos 2009). These national ocean policies are notably congruent in terms of overall principles and approaches, including EBM and ICM in particular, and most recognize the need for transparency, public and stakeholder involvement, incentives for cooperative action, and a national ocean office with clear responsibilities.

Ecosystem-based Management in Regional Ocean Areas
Managing regional ocean areas necessitates consideration of the ecological, economic, and social aspects of marine areas and ecosystems, and requires the integration of marine sectors, levels of government and space. At the regional level, EBM is being applied through 16 Large Marine Ecosystem (LME) projects and through 18 UNEP Regional Seas Programmes (RSPs).

The Global Environment Facility (GEF)-supported LME projects constitute a network of 110 countries in Africa, Asia, Latin America and eastern Europe that are working together to understand and manage transboundary marine issues of pollution, eutrophication and overfishing, recognizing the complexities of the interactions among the composites of such ecosystems, including plants, animals, microbes, physical environmental features and socio-economic activities within an ecosystem. Other key collaborators in this global program include NOAA, IUCN, IOC and several other UN agencies.

Regional Seas Programmes attempt to mitigate the accelerating degradation of the global oceans and coastal areas through the sustainable management and use of the marine and coastal environment, by engaging neighboring nations in specific actions and plans to protect shared marine environments. Twelve of the programs have adopted legally binding conventions, most with associated protocols on specific issues, and 15 RSPs have adopted Action Plans. The majority of RSPs have incorporated principles of ICM, and have agreed upon ICM indicators to measure success. As the coordinating body, UNEP/RSP is charged with enhancing linkages, coordination, and synergies among regional and partner programs, organizations and actors.

Adaptive Management in Areas Beyond National Jurisdiction
There exists a sense of urgency that we must also move toward integrated, EBM of areas beyond national jurisdiction (ABNJ). The current situation, however, is characterized by the sectoral management of different uses by different global and regional institutions, with little opportunity for area-wide environmental management and assessment. Emerging uses in ABNJ (e.g., bioprospecting, carbon capture and storage, ocean fertilization, mariculture facilities and floating energy facilities) are not yet adequately managed and a number of legal/policy gaps exist (Cicin-Sain et al, 2008).

Expansion/Scaling up and Regional Approaches
It is important to note cases where the scaling up of EBM has been successful, so that lessons may be drawn and applied, where appropriate. One prominent example is the Partnerships for Environmental Management in the Seas of East Asia (PEMSEA), which has successfully modeled the pilot and demonstration approach to ICM in 14 East Asian countries. In this regional effort, one or more sites in each country now aims to consolidate and transfer lessons learned to 20 percent of the coastline by 2017. Furthermore, national efforts are being reinforced by region-wide partnerships created to support the implementation of the Sustainable Development Strategy for the Seas of East Asia, the regional framework adopted by 11 East Asian countries to institutionalize regional coordinating mechanisms. Another successful example can be found in the Mediterranean, where an Integrated Coastal Zone Management (ICZM) Protocol mandated the establishment of a common framework for the integrated management of the Mediterranean coastal zone. This Protocol provides for the implementation of necessary measures to strengthen regional cooperation in addressing continuing severe pressures and problems on coastal resources.

The Challenges

Ecosystem management initiatives implemented to adapt to a changing climate will require continual reassessment of the effectiveness and appropriateness of such initiatives, as new information is brought to light and as conditions change. The uncertainties inherent in the future of ocean and coastal management necessitate collaboration across levels of government, across sectors and through time. The LME approach, among others, has been shown to be an appropriate management tool in many cases, and can facilitate understanding of how the global community can effectively adapt to a changing environment to sustainably manage and develop our oceans and coasts at local, national and regional levels.

There is a need to move toward cross-sectoral joint enforcement at the regional level. To this end, an option could be to develop a new Global Environment Facility (GEF) program in regional ocean governance, including marine areas beyond national jurisdiction. Regional experimentation would allow for practical demonstrations of what approaches may work, and show how existing sectoral processes could be coordinated and enhanced to achieve cross-sectoral management. Possible regional cases identified are the Algulhas and Somali Current Large Marine Ecosystems (East Africa/Western Indian Ocean), the OSPAR Region (Northeast Atlantic), the Coral Triangle/French Polynesia, and the Arctic.

While it is important to emphasize the need for adaptive management at the regional scale, institutional aspects at smaller scales also require consideration. For example, due to ocean warming some living marine resources are changing their migration patterns at a much smaller scale than the LME. Institutional adjustments are needed to incorporate adaptive management at the transboundary, sub-regional and local scales, to enhance cooperation at all levels.

Policy Recommendations

Effectively demonstrating the value of enhancing adaptive management measures with a specific focus on oceans and coasts remains a challenge. The lack of parsimonious indicators to showcase the value of adaptive, EBM at various levels needs to be addressed. Unless EBM initiatives can be shown to be able to meet the challenges of adaptive management in a changing climate, support for these initiatives from government and intergovernmental organizations will be difficult to enhance. Successful case studies need to be detailed and the information disseminated to the climate and ocean communities, to promote EBM/ICM initiatives at various institutional and spatial scales, thereby demonstrating their value, and to provide guidance on operationalizing the concepts.

Finally, a key challenge that must be addressed is the professional training of the next generation of ecosystem practitioners, including scientists, technicians, policy specialists, and resource and environmental managers in various regions. Focus should also be given to building stronger capacity at local levels, and providing better information to the public about their abilities to contribute to problem-solving.

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6b. Adaptive Management Institutions at the Regional Level: The Case of Large Marine Ecosystems

By Ken Sherman, NOAA National Marine Fisheries Service

Executive Summary

A global effort is underway by scientists, stakeholders, resource managers, and multisectoral ministerial representatives (e.g. fisheries, transportation, mining, energy, tourism, environment) from 110 countries representing over half of the countries around the globe (56.4%). The effort is focused on reversing the downward spiral of coastal ocean resource degradation through the implementation of an ecosystem-based approach to assess and manage goods and services of Large Marine Ecosystems (LMEs). Through a systematic spatial and temporal scaling across multiple jurisdictions (e.g. community, national, transboundary, and international) a generic suite of indicators is applied to monitor the annual changes in LME productivity, fish and fisheries, pollution and ecosystem health, socioeconomics, and governance. A growing number of established multinational LME-focused commissions are serving as the institutional framework for restoring and sustaining LME goods and services. The indicator metrics are applied to newly-established adaptive management regimes to reduce coastal pollution, restore damaged habitats, and recover depleted fisheries with due consideration given to the effects of climate warming.

Context and Importance of the Problem

The world's coastal ocean waters continue to be degraded by unsustainable fishing practices, habitat degradation, eutrophication, toxic pollution, aerosol contamination, and emerging diseases. The scale and severity of risks to humanity associated with depletion and degradation of near coastal oceans is well documented. Lack of attention to policy, legal and institutional reforms has resulted in coastal water pollution from sewage and industrial wastes, human health risks, overexploitation of fisheries, the destruction of economically important coastal habitats (coral reefs, mangroves and seagrasses), and alien species propagated by maritime transport. All these trends lead to socioeconomic losses (Duda 2009).

The world's Large Marine Ecosystems (LMEs) annually produce 80% of the marine fisheries biomass, and are global centers of coastal pollution and biodiversity loss. Most LMEs are overfished and have degraded habitats and polluted coastal waters. They are increasingly over-enriched, with hotspots of nitrogen loading in both developed and developing countries (Seitzinger 2008). They are also impacted by the effects of climate change. Warming trends since 1984 have been observed in 61 of the 64 LMEs, ranging from a low of 0.08 degrees C in the Patagonian Shelf LME to a high of 1.35 degrees C in the Baltic Sea LME. In addition to the Baltic Sea, the most rapid warming exceeding 0.96 degrees C over the past 25 years is observed in the North Sea, East China Sea, Sea of Japan/East Sea, and Newfoundland-Labrador Shelf and Black Sea LMEs (UNEP 2008). These trends indicate warming rates that are two to four times faster than reported globally by the IPCC (2007).

The accelerated warming is having a positive effect on the fishing biomass yields of LMEs in the northern northeast Atlantic (Iceland Shelf, Faroe Plateau and Norwegian Sea LMEs) and a negative effect in the more southern LMEs of the northeast Atlantic (North Sea, Celtic Biscay Shelf, and Iberian Coastal LMEs). Patterns of positive influence of warming were observed in the increased biomass levels of zooplankton and biomass yields of zooplanktivorous fish species (blue whiting, herring, capelin) within the Iceland Shelf, Faroe Plateau and Norwegian Sea. In contrast, significant declines were reported for both zooplankton biomass levels and fisheries yields in the North Sea, Celtic-Biscay Shelf and Iberian Coastal LMEs. These fast warming clusters of LMEs are experiencing declines in biomass trends representing 4.1 mmt (6.4%) of the mean annual global fisheries biomass yield. Zooplankton abundance levels in these three LMEs are in decline, reducing the prey field for zooplanktivores. This is one example of how ecosystem indicators can be combined for a greater understanding of the relationship between human activities and warming patterns in LMEs.

Adaptive Ecosystem-Based Management: Current Status of the Concept

Large Marine Ecosystems (LMEs) are regions of ocean space of 200,000 km² or greater, encompassing coastal areas from river basins and estuaries out seaward to the break or slope of the continental shelf or out to the seaward extent of a well-defined current system along coasts lacking continental shelves. LMEs are defined by ecological criteria including (1) bathymetry, (2) hydrography, (3) productivity, and (4) trophically linked populations. An ecosystem-based approach to the management of coastal and marine resources is needed that can operate at multiple scales and harness stakeholder support for integrated adaptive management in both Northern and Southern countries (Duda 2009). A five-module indicator approach to the assessment and management of LMEs has proven useful in ecosystem-based projects for measuring changing states in LME (i) productivity, (ii) fish and fisheries, (iii) pollution and ecosystem health, (iv) socioeconomics, and (v) governance. Ecosystem measurements for the first three modules provide a sound scientific foundation for management policies that include both socioeconomic benefits for people and a mutually agreeable governance regime.

With the support of the Global Environment Facility (GEF), the World Bank, five UN agencies and two NGOs, a major effort is underway to recover and sustain depleted fish stocks, restore damaged habitats, reduce and control pollution and over-enrichment, and adapt to climate change. The effort introduces an ecosystem-based adaptive management approach to recover stressed LMEs in 110 countries of Africa, Asia, Latin America and eastern Europe participating in 16 GEF-supported LME Projects.

Adaptive Management Institutions at Various Scales

An adaptive management strategy has been adopted by the 110 countries presently engaged in GEF-supported LME assessment and management projects. Within the LMEs, activities focused on Integrated Coastal Management (ICM) and Ecosystem-Based Management (EBM) are taken into consideration in the process of the Transboundary Diagnostic Analysis (TDA) and the formulation of the Strategic Action Programme (SAP) for the LME with due consideration of local, national, and international scaling. The incremental spatial and temporal scaling in the utilization of marine resources requires adequate spatial and temporal monitoring and assessment actions framed around the 5-module suites of indicators to provide the information base for taking adaptive management decisions from the community level, to the national, transboundary and international level.

An overarching governance approach in the form of a Commission and/or serial management actions at different scales within the LME can address multiple user issues, habitat restoration issues, fisheries recovery issues, and goods and services issues at multiple scales (Duda and Sherman 2002). Experiences and lessons learned have proven effective at the level of the multiple ministries responsible for the various sectors (e.g. fisheries, transportation, environment, energy, and tourism). The ministerial approvals are obtained at the national levels with full knowledge that the ministries are entering into a five year agreement to address transnational and transboundary issues that have been prioritized through the GEF supported TDA and SAP process, thereby integrating local and national interests of ICM within the context of EBM at the multiple scales of the LME.

Ecosystem-based Management in Large Marine Ecosystems (LMEs)
In GEF-supported LME projects, the countries bordering an LME jointly prepare a TDA based on consensus that ranks coastal resource issues, identifies and prioritizes transboundary problems, analyzes socioeconomic impacts, outlines root causes and advances possible remedies and actions for sustaining LME goods and services. The process of planning and implementing a program to recover depleted fisheries, reduce coastal pollution, restore damaged habitats, and adapt to climate change in an LME is financially supported by the GEF and donor countries for two 5-year phases. On the basis of the TDA, the countries prepare a SAP in which they propose to remedy the transboundary issues identified in the TDA and outline community, national and regional commitments to policy, legal and institutional reform. Countries follow Project goals and milestones leading towards an adaptive, ultimately self financing management regime for LMEs. The objectives of the TDA and SAP process for LMEs are consistent with the 2002 Johannesburg targets and Plan of Implementation of the World Summit on Sustainable Development to: achieve substantial reductions in land-based sources of pollution; introduce an ecosystems approach to marine resource assessment and management by 2010; designate a network of marine protected areas by 2012; and maintain and restore fish stocks to maximum sustainable yield levels by 2015.

In the mid-1990s the scientific basis for moving toward ecosystem-based assessment and management of marine goods and services was put forward by Lubchenco (1994) and the Ecological Society of America (Christensen et al. 1996). This movement represents a paradigm shift moving from single species assessments to multiple species assessments and the LME scale for measuring changing ecosystem states on an annual basis with a focus not only on ecosystem goods but also on ecosystem services (Table 1). More recent attention has been focused on the diminished services of marine ecosystems to humans and the concern that small changes in ecosystem resilience and robustness can lead to non-linear interactions, regime shifts, and collapses (Levin and Lubchenco 2008). Risks of ecosystem collapse are significantly diminished in robust and resilient LMEs. It is important to maintain close linkages among management activities framed to sustain socioeconomic ecosystem benefits.

FROM	TO
Individual species	**Ecosystems**
Small spatial scale	**Multiple scales**
Short-term perspective	**Long-term perspective**
Humans: independent of ecosystems	**Humans: integral part of ecosystems**
Management divorced from research	**Adaptive management**
Managing commodities	**Sustaining production potential for goods and services**

Table 1. A paradigm shift to ecosystem-based management. (from Lubchenco J. 1994). The scientific basis of ecosystem management. 103rd Congress, 2d session, Committee Print. U.S. Government Printing Office.

Expansion/Scaling up and LME Approaches

The GEF-supported LME projects are implementing the integrated and adaptive management of oceans, coasts, and estuaries through an ecosystem-based approach that considers different time and space scales relevant to the ecosystem. GEF funding catalyzes integrated management at the scale of communities, municipalities, coastal provinces, and contributing river basins, scaling up to the LME scale through additive and integrative synthesis of information from the annual monitoring of changes in productivity, fish and fisheries, pollution and ecosystem health, socioeconomics, and governance at the appropriate spatial and temporal frequency of measurement metrics. LME programs can have a cascading effect in transforming governance, improving people's awareness of important ecosystem goods and services at risk and social values. The bottom up TDA and SAP process allows for national inputs to the LME project from coastal communities. The activities span the extent of country interest (established in the National Strategic Plans), transboundary resources and the entire LME. The GEF LME project footprint on the global scale encompasses actions underway to recover and sustain the goods and services identified in the TDA and SAP plans of actions, effecting the livelihoods of hundreds of millions of people engaged in marine fisheries, aquaculture, tourism, shipping, energy and marine industry activities in Africa, Asia, Latin America and eastern Europe (Hoagland and Jin 2006).

LME Best Practices Examples

(1) Benguela Current LME Commission

The multisectoral approach to assessment and management has been adopted in the establishment of the three-country Benguela Current Commission. South Africa, Namibia, and Angola signed an agreement in August 2006 to formally establish the Benguela Current Commission (BCC) that provides for joint management of the goods and services of the Benguela Current LME. Establishment of the BCC is a culmination of effort by scientists, stakeholders, resource managers, and multisectoral ministerial representatives (e.g. fisheries, mining, transportation, energy, tourism, environment) from the three countries. Within the framework of the Benguela Current LME Commission, the three countries will collectively manage transboundary environmental and resource issues including recovering and sustaining fish stocks, mitigating the effects of offshore mining, oil and gas production, mariculture, shipping, transport and tourism, and improving the condition of degraded habitats. The BCC in partnership with the GEF, UNDP, other agencies including US-NOAA, and Norwegian, German, and Icelandic marine specialists is advancing the understanding of the physical and biological drivers of change through assessments that will support management actions for protecting and sustaining the highly valued goods and services of the BCLME. Now in its fifth year, the BCLME Program has allocated US$10 million in support of systematic assessments of the BCLME. Considerable effort is presently underway by the Project in bringing the information from each of the five modules together into an integrated ecosystem-based assessment that describes the overall ecological condition and supports management actions for the recovery and sustainability of the goods and services of the ecosystem.

Effort is presently underway to extend the LME Commission approach to the 16 countries presently participating in a GEF-supported Guinea Current LME Project. The participating countries have agreed to establish an Interim Guinea Current Commission. In addition, initial steps for establishing a joint LME Commission for the Yellow Sea is under consideration to assess and manage the shared resources of the Yellow Sea LME (www.yslme.org/doc/rstp4/reg%20gov.pdf). Both China and Korea are moving forward within the framework of a GEF-supported joint SAP to recover and sustain the critically important shared goods and services of the YSLME.

Adaptation Actions in the Yellow Sea LME Project

The long-term objective of the YSLME project is to ensure environmentally sustainable management and use of the Yellow Sea LME and its watershed by reducing stress and promoting the sustainable development of a marine ecosystem that is bordered by a densely populated, heavily urbanized, and industrialized coastal area. An important action resulting from the project is the successful implementation of management actions in China to reduce fishing effort by 30% during the strategically important summer months for spawning in the Yellow Sea LME. This fishing ban has effectively protected juvenile fish, leading to an increase in the quantity and quality of fish catches (Tang 2009).

Enhancing Regional Adaptive Management Institutions – Policy Options

How Can Institutional Adaptive Management at Regional Scales Best Be Enhanced?

The process in use by 110 developing countries that operationalizes the TDA/SAP process provides the way forward to the practice of ecosystem-based management at multiples scales within the LME. National interests are taken into consideration at the governance level of an agreed upon LME Commission. The practice at present is most advanced in West Africa and in Northeast Asia where the beneficiaries are the tens millions of people in communities along the coast of the Yellow Sea and in communities extending from Guinea-Bissau to Cape Town, South Africa. The LME outreach footprint has grown from the initial demonstration project in the Gulf of Guinea in the mid 1990s to the significant level of US$1.8 billion in financial assistance provided by the GEF and the World Bank to initiate ecosystem based assessment and management practices to reduce coastal pollution, restore damaged habitats, and recover depleted fisheries in 16 LMEs.

Critique of Policy Options

What are Some of the Anticipated Benefits of Enhancing Adaptive Management at Various Institutional Scales, and, In Particular, In Promoting the LME Approach?

Adaptive management has successfully been operationalized across multiple scales and sectors. The five modules have provided a framework for engaging academic, governmental and private interests to focus on concerted efforts for the recovery and sustainability of LME goods and services. The paradigm shift has been successfully practiced from individual species to ecosystems, from the small spatial scale to multiple scales, from a short term perspective to a long term perspective, and from management divorced from research to adaptive management. The LME approach offers a strategy for reducing coastal pollution, restoring damaged habitats and recovering depleted fisheries, based on an integration of science and management at the LME scale.

Advanced sampling methodologies including the use of satellite remote sensing and in situ automated buoys are providing the means to monitor and assess environmental variability caused by climate change and measure its effects on the annual productivity cycle within the LME. Initial analyses of the effects of global warming and nutrient over enrichment have been reported for all 64 LMEs and are included in a UNEP Large Marine Ecosystem Report, posted on the web at: www.lme.noaa.gov/

The LME approach has been shown to be useful and adaptable in facilitating actions by the global community of nations to advance the upward spiral toward the recovery and sustainability of the contribution of marine goods and services to the world economy valued at US$ 12.6 trillion annually.

Challenges

What are some of the challenges in advancing adaptive management at various institutional scales?

In several LMEs, pollution and eutrophication are important driving forces of change in biomass yields. Unless substantial technological innovations and management changes are implemented, increasing food production and industrialization will undoubtedly lead to increased export of Nitrogen to coastal ecosystems with resultant water quality degradation. Based on a business-as-usual (BAU) scenario, inorganic Nitrogen export to coastal systems is predicted to increase 3-fold by the year 2050 (relative to 1990) in Africa and South America. Substantial increases are predicted for eastern Europe and in North America. Alarmingly large absolute increases are predicted for eastern and southern Asia (Seitzinger 2008).

In global terms, what is presently lacking is a process to identify, review, and synthesize the best assessment and management practices among the community of marine ecosystem practitioners for the exchange of lessons learned. However, what is newly available is a set of indicators to serve as a baseline to showcase the value of adaptive ecosystem-based management at different scales and institutional levels. The UNEP LME report and five module summaries provide a framework for suites of indicators that measure changes in LME (i) productivity, (ii) fish and fisheries, (iii) pollution and ecosystem health, (iv) socioeconomics, and (v) governance. Each of the LMEs is significantly influenced by human activities and natural and environmental perturbations including climate change. All of the variables (human and natural) are included in the 5 modular assessments that are conducted over the annual biological production cycle within each of the LMEs. Modular metrics support the science-based assessments of changing conditions that are critically important inputs to policy and management decisions and actions. The adaptive management spatial scale at its greatest dimension is the entire LME with due consideration given to smaller scales, in an additive and integrative process to determine whether conditions within the LME in any given annual cycle are deteriorating or improving in an upward spiral consistent with the objectives of the TDA/SAP process mirroring the WSSD marine targets.

The need to support the professional training of the next generation of ecosystem practitioners, including scientists, technicians, policy specialists and resource and environmental managers at the various institutional levels is a major challenge. The training of marine ecosystem experts and capacity building in developing countries needs to be addressed. A global GEF Community of Practice for learning and experience sharing among LME projects can serve as the means for ecosystem practitioners to advance the science of ecosystem-based management and the practical application of science to management issues. A target is to move from the present number of 2,500 LME practitioners to 10,000 by 2012.

Policy Recommendations

Enhance Support and Capacity

It is necessary to significantly augment support to developing countries for planning and implementation of two 5-year phased LME projects so they can become financially self sustaining. The principal financial mechanism is the GEF. It is the only international institution with the financial resources to initiate support to over 100 developing nations in bridging the scientific and jurisdictional gaps and to assist them in reversing the downward spiral driving the health of the world's oceans. The GEF has shown that it can successfully energize countries in the implementation of projects to protect, grow and sustain marine ecosystem goods and services.

Adapt to Climate Change at Various Scales

The forward movement toward LME restoration and sustainability requires monitoring and assessment activities with sufficient spatial and temporal frequency to measure the effects of climate warming. A strategy for incorporating adaptation to climate change impacts has been crafted. It includes the metrics of the productivity module using satellite remote sensing and instrumented in situ buoy technology to monitor the effects of climate warming on the physical and biological processes effecting the annual biological productivity cycle. Information is also obtained on sea level changes, thermocline formation, and vertical and horizontal circulation. Given the present levels of CO^2 increases, it is necessary to close the gap between assessments and forecasts of ocean impacts of climate warming at multiple scales within LMEs, and implement adaptive policies for the use of LMEs and open ocean goods and services. Of immediate concern are adaptations in the use of marine resources that will respond to expected changes in ocean acidification, sea level rise, circulation patterns, coral reefs and coastal erosion. Within Arctic LMEs, ice melt while providing new shipping opportunities is requiring cultural and socioeconomic adjustments in Arctic communities. Present methodologies are available for monitoring changing states of LMEs with regard to climate change. Summaries of trends in primary productivity, chlorophyll, SST, fisheries biomass yields, and nutrient loading are available for all 64 LMEs as an initial baseline in the UNEP LME Report (UNEP 2008; www.lme.noaa.gov/).

Indicators for Progress

Indicators for progress are readily available from the outputs of the GEF LME projects. An outcome of the Yellow Sea LME Project is the reduction of fisheries effort by 30% in China during the summer spawning season for demersal species (Tang 2009). Angola in the Benguela Current LME claims major ownership and licensing of fisheries enterprises that engage in sustainable fishery practices in the LME. Improved agricultural practices and waste water treatment plants for removing toxins and excessive nutrient loading have already proven to be pragmatic and effective actions to reduce levels of nutrient over-enrichment in the Black Sea LME.

The UNEP LME Report provides an essential baseline on ecological condtions within the world's 64 LMEs. Significant investment by the GEF and national governments has allowed for the examination of systematic measurements of primary productivity, chlorophyll, ocean fronts, sea surface temperature and anomalies in SST, multidecadal time series of annual fisheries biomass yields, value, mean trophic levels, fisheries conditions relative to stock conditions and amount of primary productivity required to support the mean annual catch levels and information on nutrient over-enrichment and coastal eutrophication. The Report can serve as a baseline for regular 3-year interval reporting of global marine assessments, of interest to the community of nations and under consideration by the UN system.

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6c. Adaptive Management in East Africa and the Indian Ocean: Long-Term Monitoring and Early Warning Mechanisms for Predicting and Managing Climate Change

By David Vousden, UNDP GEF Agulhas and Somali Currents Large Marine Ecosystem Project, and Magnus Ngoile, UNDP GEF Agulhas and Somali Currents Large Marine Ecosystem Project

Executive Summary

Marine ecosystem interactions are critical to climatic variability (both in terms of their climatic driving functions, as well as their being impacted by variability in climate). Yet research is lacking in many areas linking marine ecosystems and climate change. Monitoring is fragmented and unsustainable thereby preventing scientists and policy-makers from making informed decisions on ecosystem-based management and on adaptive reaction to climate change. Various discussion documents related to the IPPC reports focus heavily on the need for adaptation to climate change, on developing a framework for action, particularly at the national level, and on matching financial and technical support (primarily focusing on technologies for adaptation). Little attention, however, has been given to the need for monitoring and measurement mechanisms at the regional and local level that can A. provide accurate indications of specific changes related to climate change at the ecosystem level whilst B. identifying the scale and distribution of expected impacts, and C. translating these into reliable predictions and policy guidelines which countries can act upon so as to adapt and mitigate/avert the negative impacts.

The world urgently needs geographically-focused long-term ‘ocean-atmosphere’ monitoring systems in place and needs to link these into regional early warning systems. These should both identify and predict changes with sufficient lead-time such that countries can react, adapt and manage themselves in terms of food security, protection of water supplies, coastal defenses and general survival. Any investment in mitigation and adaptation (globally, regionally or locally) can only realistically be prioritised and targeted in a cost-effective manner based on the feedback from such monitoring systems and from the early warning ‘front-line’.

Background and Predictions

The IPCC 2007 Summary for Policymakers[4] identifies that, in relation to predicted ecosystem impacts, just a 2^{o} C rise in global average annual temperature would significantly increase the risk of extinction of up to 30% of species, while most corals would be bleached (possibly beyond recovery) and significant shifts in species range would be inevitable. However, under the new predictions, a 4^{o} C rise would result in significant (greater than 40%) species extinctions around the globe, while approximately 30% of global coastal wetlands would be lost and millions of people could expect to experience annual coastal flooding. Smith *et al*.[5] identify that climate change over the next century is likely to adversely affect hundreds of millions of people through increased coastal flooding after a further 2 °C warming from 1990 levels. Less than a 1 °C warming from 1990 levels will result in significant reductions in water supplies (0.4 to 1.7 billion people affected).

In Africa, regional environmental experts participating in the Global Ocean Observing System (GOOS) have warned that climate change will lead to oceanic acidification and increase surface water temperatures. Oceans naturally absorb CO_2 from the atmosphere.

Levels of CO_2 in the air have increased due to climate change and thus oceans have been absorbing more CO_2 than previously, which has contributed to oceanic acidification. This will affect fish stocks and, as a result, threaten the livelihoods of small-scale fishing communities. Acidity levels affect fish and shellfish larvae which need calcium carbonate to build their shells and skeletons. This must inevitably pose a threat to communities that depend on fishing for their survival. Such fishing communities in southern and eastern Africa are already among the most vulnerable population groups in the world. According to the United Nations Food and Agricultural Organisation (FAO), their living conditions are characterised by overcrowding, low levels of education as well as lack of access to schools, health care facilities and infrastructure. In Africa alone, the IPCC Summary defines projected regional impacts as follows:

By 2020

- Between 75 and 250 million of people are projected to be exposed to increased water stress due to climate change.
- In some countries, yields from rain-fed agriculture could be reduced by up to 50%. Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition.

By 2080 Onward

- Projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5% to 10% of Gross Domestic Product (GDP).
- An increase of 5% to 8% of arid and semi-arid land in Africa is projected under a range of climate scenarios.

In Small Islands, the Summary defines the following expected impacts:

- Sea level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities.
- Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources.
- By mid-century, climate change is expected to reduce water resources in many small islands to the point where they become insufficient to meet demand during low-rainfall periods.
- With higher temperatures, increased invasion by non-native species is expected to occur, particularly on mid- and high-latitude islands.

The Need for Sustainable Monitoring and Early Warning Mechanisms

A critical area that is still not receiving enough urgent attention is that of ocean-atmosphere linkages and the relationship between marine ecosystem drivers (currents, sea surface temperatures, upwellings, etc) and climate stability. The oceans are a major driving force behind climatic stability and variability (as is clearly demonstrated through ENSO and El Nino related impacts and the effects of the Indian Ocean dipole on monsoons). Equally importantly, the ‘knock-on’ effect from climate change will be felt through the ocean-atmosphere linkages within the large marine ecosystems of the world as current regimes alter, productivity levels change, sea surface temperatures and salinities vary. Entire ecosystems could ‘shift’ in terms of their physicochemical and biological characteristics as well as in terms of their boundaries and extent. Understanding trends and predictability of extreme weather events is directly linked to an understanding of these ocean-atmosphere relationships and how currents and temperature affect and drive regional weather and climate.

Although the linkages between the oceans and the atmosphere have significant implications to global climate as a whole, certain areas of the world are more highly affected by ocean-atmosphere interactions than others. The east African coast and the Western Indian Ocean is a point in case. There are others around the world. Undoubtedly there is an urgent need to establish the baseline in such places in terms of water parameters (temperatures, salinities, pH, current regimes, productivity, etc). But this baseline is already changing with alterations in climate, and resultant changes in ocean-atmosphere linkages. Then there is an equal urgency to establish sustainable long-term monitoring processes that can compare present status with the baseline along with vulnerability assessments, and show how far, how fast and what the impacts are most likely to be from any changes that are occurring. Armed with this information it should then be possible to develop more accurate models and thus create an 'early warning' system upon which to base and then fine-tune adaptation measures and related governance and policy strategies.

There has been a lack of emphasis in terms of the focus on community-based research and this has resulted in outcomes of climate models and scenarios that are too broad for any useful planning and adaptation at local scales[1]. Consequently, the global scientific community has proved ineffective in the assessment of technical, institutional, economic and cultural elements in different regions and has inappropriately attempted to apply standard market-evaluation frameworks to subsistence economies and traditional land use systems. Although climate change simulations and predictions are necessary to forecast likely changes and impacts, so far they have been limited in their capacity to predict local and regional effects because of their coarse geographic and time scales. Such large scale predictions of change are of little value to decision-makers at the regional, national or community level. The conclusion is that most vulnerability assessments using the common methodology fail to consider scales that are fine enough to provide adequate community level guidance for adaptive management[6].

The 4th Global Conference on Ocean, Coasts and Islands (Vietnam, April 2008) noted a number of urgent future directions necessary to strengthen the linkages between climate, hazards, community resilience and climate adaptation. These included (*inter alia*):

- Improving the science for the assessment of climate change impacts through improved observations, modeling and forecasting and continue efforts to understand and predict on a regional scale, the effects of climate change and variability.
- Increase the understanding on the relevance of conducting socioeconomic assessments of adaptation in addition to focusing on natural science components.
- Provide credible climate information in contexts that are useful and usable to local decision-makers upon which to base local adaptation decisions.

Meeting the Challenges

In terms of understanding the effects of climate change at the national and regional level and responding with management needs to deliver appropriate adaptation to predicted impacts, it would now seem imperative that long-term mechanisms are set in place that can provide accurate and up-to-date data to feed into predictive models that are more spatially focused and targeted than is currently the case.

The LME modular approach (focusing on understanding ecosystem variability and its adaptive management) recognises the need to collect baseline information and monitor changes and trends in three specific areas of scientific concern that are considered to be essential to the overall structure of the ecosystem. These are (i) Fish and Fisheries, (ii) Productivity and (iii) Ecosystem Health and Pollution. These then link into information collected through the fourth module (Socio-economics) to arrive at guidelines for the fifth module (Governance). If the LME approach is seen in terms of the long-term regional/national monitoring needs for climate change there are very close linkages. Many of the indicators used to assess ecosystem variability are inevitably similar or the same as those that are necessary to capture related trends resulting from climate change.

One example of this can be shown within the Agulhas and Somali Current Large Marine Ecosystems Project (ASCLME) currently being implemented by UNDP (through GEF funding) throughout the western Indian Ocean region. This Project has a system boundary that runs from Somali in the north to the tip of South Africa and out beyond Seychelles and Mauritius to the edge of the Mascarene Plateau (see Figure 1 below). The objective of this project is to clearly define the ecosystem boundaries, understand the major transboundary impacts within these ecosystems (through Transboundary Diagnostic Analyses) and develop Strategic Action Programmes for effective management and governance of these ecosystems.

A major focus of the ASCLME Project is the collection of baseline data within the western Indian Ocean marine environment that will identify the transboundary impacts on human societies as well as on vulnerable species and habitats. A critical component will be the translation of the scientific information and data into management and policy briefings to guide the countries and the region in the overall sustainable governance of these critical important marine resources. Community involvement and community livelihoods are important components of this science-to-governance process. In order for this to be effective, baseline studies must act as a foundation for long-term monitoring and this long-term monitoring is essential for any LME governance process to be sustainable.

In this context, the ASCLME Project is putting significant resources into both offshore and inshore data collection and monitoring within a region of the oceans that A. has a major impact on the western Indian Ocean islands and the eastern half of the continent of Africa (in terms of marine resources, community welfare and climate/weather) and B. is a region about which very little is known in terms of the marine environment and the ocean-atmosphere linkages. In adopting this data collection programme, the ASCLME Project is now focusing on the development of long-term monitoring mechanisms that include:

1. Developing a firm baseline of information on currents, water quality, productivity, fisheries, species distributions, etc.
2. Identifying trends through regular coastal and ship-based field sampling.
3. Adopting continuous monitoring mechanisms by way of deployment of *in situ* equipment arrays positioned so as to capture pertinent information on ecosystem variability and ocean-atmosphere parameters related to ecosystem impacts (specifically climate change-related).
4. Feeding this information into regional and sub-regional models for predictive purposes.
5. Link this information to coastal livelihoods and capacity within the region.
6. Ensuring that the results of this process are translated into Policy Briefs and Management Guidelines to feed back into ecosystem management as well as to guide socioeconomic level decision-making.

Figure 1 (below) shows the up-to-date understanding of oceanic current movements across the western Indian Ocean LMEs (much of this information has come to light very recently within the last 18 months). It also shows the distribution of various fixed monitoring systems that are the foundation of a network that will not only monitor ecosystem variability in real-time, but will provide the foundation for a western Indian Ocean ‘early warning’ system for climate change impact. This early warning and long-term monitoring system consists of UTRs (underwater temperature recorders), ATLAS (Autonomous Temperature Line Acquisition System) moorings and ADCPs (Acoustic Doppler Current Profilers). This will provide permanent recordings of atmospheric parameters (wind speed, air temperature, humidity, precipitation, etc) as well as sea surface and seabed temperatures, salinities, carbon flux, seawater acidity, and current direction/velocities. Many of these instruments are already in place, with further deployment and maintenance planned for 2009/2010 and beyond (see Figure 3 below).

This permanent network of instrumentation is being supplemented by field data collections from research vessels, particularly the *R.V. Dr. Fridtjof Nansen*, a Norwegian vessel currently on loan to the UN through FAO. Figure 2 (below) shows the various research cruise areas and lines for 2008 and 2009, with the predicted areas for 2010. The data collection covers an enormous area, much of it previously un-surveyed. Sampling parameters include:

- Environmental stations
  - Physical oceanography (Conductivity, temperature, oxygen)
  - Chemical oceanography (salinity, nutrients)
  - Biological oceanography (plankton, chlorophyll)
- Acoustic surveys to identify fish stocks and distributions
- Pelagic and demersal trawls: Biodiversity assessment of fish, crustaceans and other invertebrates
- Bathymetric survey: Multibeam echo sounder survey to develop detailed bathymetric map of the seafloor
- Bird and mammal survey:
- Genetic and isotope samples of fish, invertebrates & plankton

Coastal studies will also supplement this information database in terms of inshore fisheries trends as well as coastal livelihoods and the study of potential impacts to coastal communities. Part of the monitoring process will focus on measuring changes within coastal communities as a result of ecosystem variability and climate change so as to better predict long-term impacts and management needs. It is further intended to expand this monitoring process using remote sensing and satellite imagery, specifically in terms of collecting data on ocean colour (for productivity and photosynthesis) and sea level altimetry, etc. This will be an integral part of the eventual climate and ecosystem variability modelling process at the regional and sub-regional level which will then lead to the guidelines and policy briefs at a national level.

The development of this highly effective and comprehensive monitoring network has been made possible through a number of partnerships. In particular, NOAA (the USA’s National Atmospheric and Oceanic Administration) have provided all of the ATLAS systems as part of their contribution to the RAMA (Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction) network, as well as a number of floating data collection systems. The EAF (Ecosystem Approach to Fisheries)-Nansen Project has worked closely with ASCLME along with FAO (the UN Food and Agricultural Organisation) to ensure access and efficient use of the *R.V. Nansen.* ASLCME has also been working closely with the World Bank/GEF supported South Western Indian Ocean Fisheries Project and the French IRD (Institute for Research and Development) in relation to the collection of fisheries data.

The offshore regional oceanographic monitoring and assessment networks are linked to the nearshore national based oceanographic monitoring networks supported by ASCLME and partners. Through its capacity building activities, ASCLME has provided to the countries of the region some basic oceanographic equipment to monitor and assess the changes in the nearshore oceanographic conditions. The countries are each engaged in developing a Marine Ecosystem Diagnostic analysis in the efforts to baseline the ecosystem conditions, including the socioeconomic status of the communities, so as to record any changes induced by climate change, this being seen as a priority source of impact on the ecosystems. This will then feed into the overall regional Transboundary Diagnostic Analyses as part of the delivery from the ASCLME Project.

The ASCLME monitoring network potentially represents one of the most sophisticated long-term LME monitoring and early warning systems outside of the developed world. As such it can act as a pilot system for regional and sub-regional modeling, prediction and effective, adaptable governance. However, the reality of this situation is that an enormous effort has gone into developing this monitoring network and into the deployment of a very comprehensive string of autonomous recording equipment backed up by ship- and shore-based ground-truthing, as well as the socioeconomic assessments. Now, sustainability represents a very real threat to this early-warning system and therefore to the ability to predict change and impact, and to drive adaptive management processes based on long-term time series data and information. The ASCLME Project has limited funding and a limited lifetime. GEF funding requirements define the need for sustainability and ownership beyond these limits. In order to address this need, additional sources of funding will need to be identified regionally and globally. After all, LMEs do not just drive local and regional climates or support local and regional economies but are also responsible for global interest.

In recognizing the potential for effective long-term monitoring, early warning and predictive management the ASCLME initiative demonstrates cutting-edge work in the region that links the local-national as well as the regional-global needs.

Policy Requirements

- There is growing evidence that early IPCC predictions for global warming and climate change have been too conservative.
- Whether the expected impacts are natural or anthropogenic in origin, it is now critically important to be able to recognise and measure the potential impacts in order to guide adaptive management.
- Limited monitoring of indicators of change along with a lack of quantifiable measurements at regional and sub-regional levels hinder any attempts at adaptive management. Probable impacts are recognised but extent, distribution and socioeconomic implications are not currently predictable.
- Long-term monitoring mechanisms are essential in order to provide clear, reliable indicators of variability within marine ecosystems, and to provide early warnings of climate-change related impacts

Policy Recommendations

- To focus on the development of regional partnerships, particularly within the LMEs, that can catalyse the necessary actions to set up effective monitoring and early warning networks in priority areas.
- To recognise the priority within the primary global funding agencies to ensure a level of sustainability for these monitoring and early warning networks sufficient to

proving their value and credibility in providing policy-level guidance and driving adaptive management processes.

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Figure 1: The ASCLME Project Area Showing Current Flows and Fixed Monitoring Instrumentation

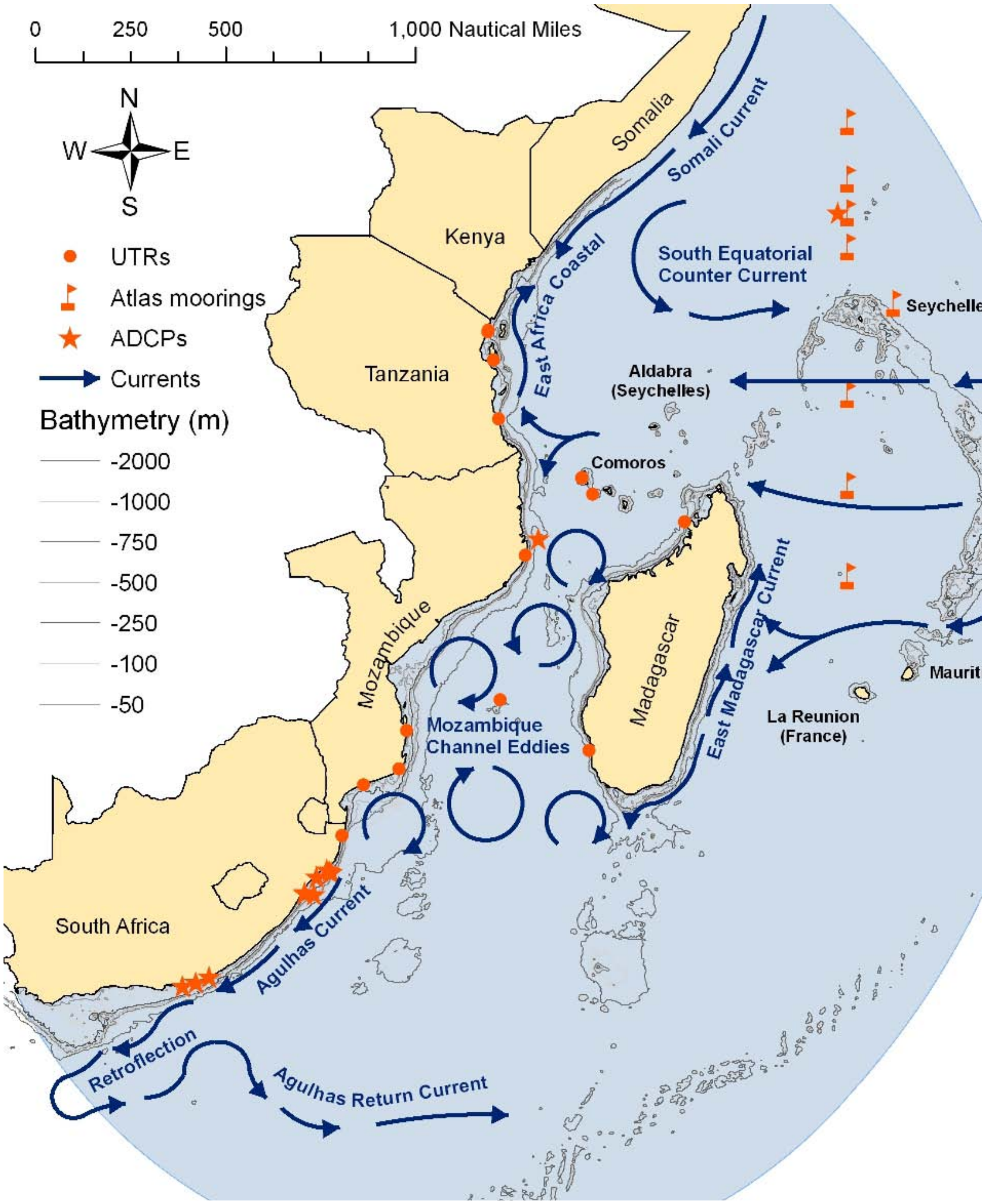


Figure 2: Completed and Proposed Field Data Collection Cruises within the ASCLME Region 2008-2010

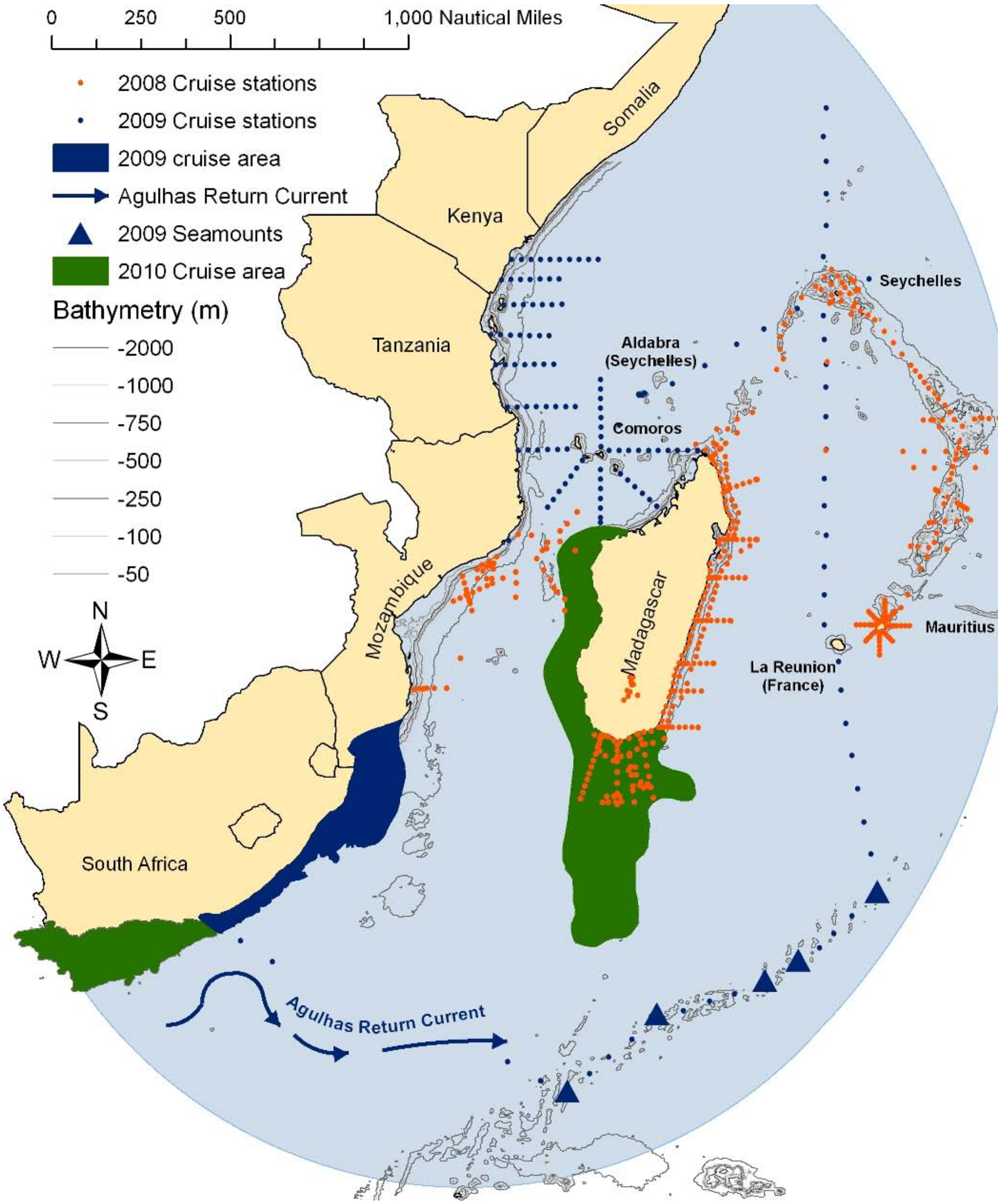
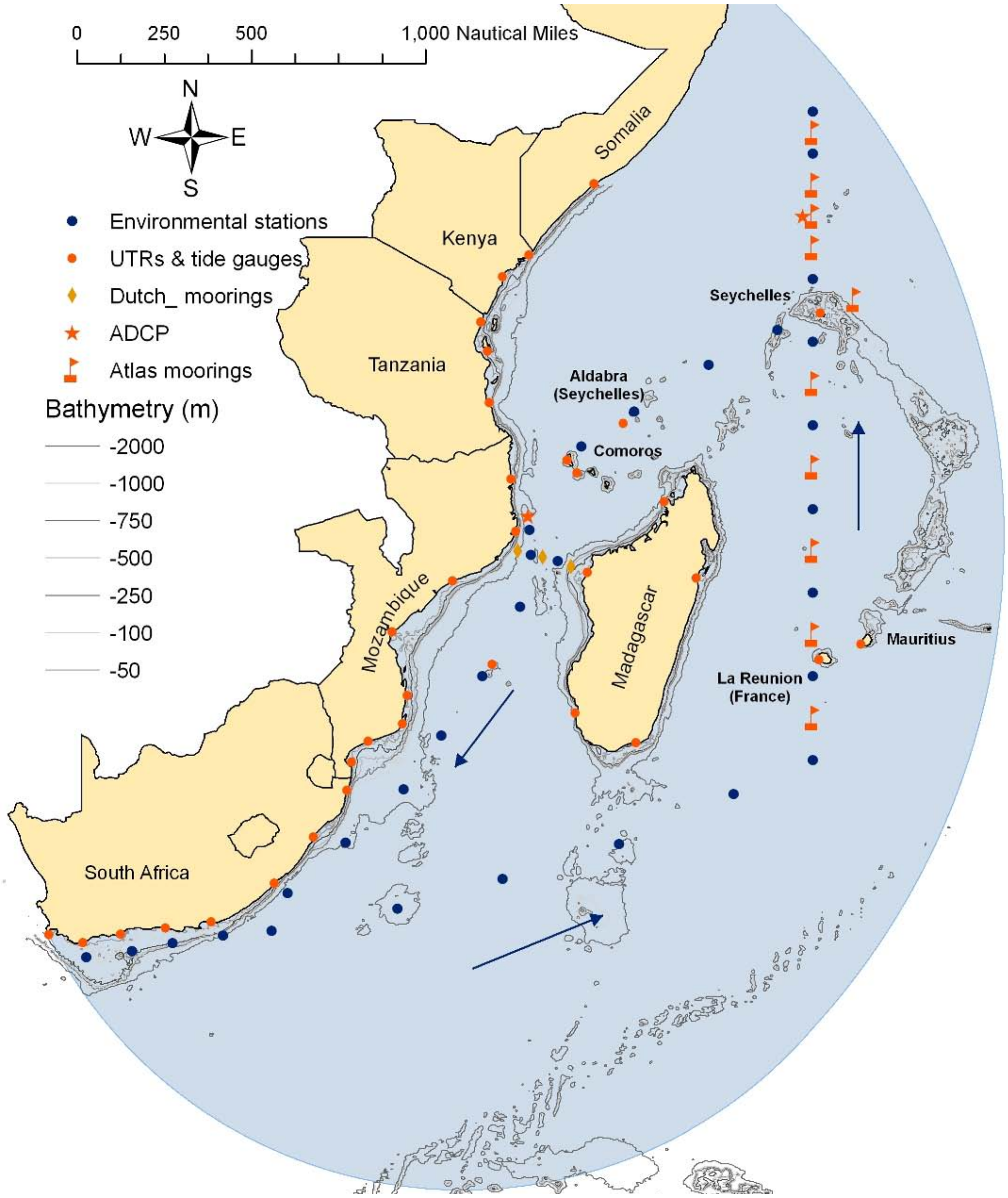


Figure 3: Future Long-Term Data Collection Planning for ASCLME region (Maintenance of fixed instrumentation plus seasonal repetitive field sampling lines)



Chapter 7

Climate Change and Marine Biodiversity

7a. Impacts of Climate Change on Marine Biodiversity and the Role of Networks of Marine Protected Areas

By Scott E. Smith, Imèn Meliane, and Alan White, The Nature Conservancy; Biliana Cicin-Sain and Caitlin Snyder, University of Delaware and Global Forum on Oceans, Coasts, and Islands; and Roberto Danovaro, Census of Marine Life

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Marine and coastal ecosystems provide food, income, protection, cultural identity, and recreation for billions of people, especially vulnerable communities in tropical areas. Climate change is impacting the ability of these ecosystems to provide these services. Marine protected areas cannot halt climate change, but they can play an important role in reducing its impacts on coastal and marine biodiversity and ecosystem services.

Introduction

Billions of people around the world, especially poor communities in tropical areas, depend on ocean and coastal ecosystems for their survival and well-being. More than a billion people worldwide rely on fish as their main source of protein. Fisheries and associated industries employ 38 million people directly, and another 162 million indirectly. Nature-based tourism on coral reefs is estimated to contribute $30 billion to the global economy each year. Coastal ecosystems such as mangroves, reefs, and wetlands provide protection against floods, disease and wastes, and improve water quality. Moreover, the cultures and traditions of many coastal peoples are intimately tied to marine ecosystems (UNEP, 2006).

The contribution of marine and coastal ecosystem services to local, regional, and national economies is substantial. For example, a recent study (Emerton, 2009) of the value of Indonesia's coastal ecosystems identified a potential value of sustainable fisheries from coral reef areas alone of more than US$1.2 billion—almost half of the value of national fisheries production. The coastal protection afforded by coral reefs has an economic value of US$50,000/km in areas of high population densities and up to US$1 million/km in areas where tourism is the main use. In total, Indonesia's coral reefs are estimated to have a value of US$314 million for coastal erosion prevention. The same study found that marine and coastal ecosystems are responsible for about 49% of the Keladupa sub-district economy, and coral reef fisheries provide the main source of income for almost 80% of the residents in the Raja Ampat Regency. Marketed mangrove products generate 22% of the local economy of Ranong province in Thailand (IUCN, 2008). Estimates of direct tourism revenue generated from the presence and use of medium to good quality coral reefs in the Philippines range from US$ 38,000 to 63,000 per km^2 (White and Trinidad 1998).

More generally, the pioneer investigation by Costanza and others (1997) pointed out that the economic value of aquatic ecosystems would represent about 63% of services annually provided by the entire planet. A substantial amount of these would be provided by deep sea ecosystems. For example, a recent study (Danovaro et al. 2008) pointed out that a 20-25% loss in species diversity may be associated with a reduction of 50-80% in ecosystem functions in deep sea areas. The deep oceans (>1000 m depth) represent the largest biome of the biosphere; although ecosystem processes at those depths are relatively slow, the covered surface is so large that ecological functions of the deep seas overwhelm the terrestrial ecosystem's role. The deep sea hosts a huge - still hidden – biodiversity, so that climate-driven threats to deep-sea biodiversity might have severe consequences at a global scale.

The Impacts of Climate Change on Coastal and Ocean Ecosystems and Biodiversity
Climate change is adversely impacting marine and coastal ecosystems and biodiversity, affecting their ability to provide critical services, therefore directly threatening vulnerable communities. Climate change impacts on oceans and coasts are numerous and complex, and expected across polar, temperate, and tropical environments, from the surface to the ocean depths, profoundly altering ecosystem function:

- Rising seas can erode and inundate coastlines and valuable wetlands and can increase salinity in coastal water sources and lands used to produce food.
- Increased water temperatures make corals more vulnerable to bleaching and change the geographic ranges of some marine species; already 20% of the coral reefs are estimated to be damaged beyond repair.
- Increasing acidification of the oceans as a result of CO^2 absorption reduces the ability of key marine organisms like corals, plankton, and shellfish to build shells and skeletons, ultimately affecting many commercial fisheries and even the largest animals in the oceans because of their dependence on plankton and other food generated lower in the food chain.
- In combination, these changes make coastal areas more vulnerable to the increased frequency and intensity of storms also expected with climate change.
- Changing wind patterns and sea temperatures impact on various oceanographic processes, including upwellings and surface currents, changing population abundance and distribution for many marine species, affecting ocean productivity.
- Alteration of water circulation due to climate change can modify patterns and intensity of deep waters formation, thus impacting deep-sea communities (Canals et al. 2006)
- The predicted decline in O_2 concentrations in the deep sea resulting from lower sea-surface O_2 concentrations, reduced ventilation of the mid-water from ocean warming, and local eutrophication events will lead to an expansion of oceanic dead zones.

Climate change is also exacerbating other threats to the oceans and coasts from over fishing and land-based nutrients and sediments, and invasive species find it easier to establish, proliferate and expand their range. The cumulative consequences of these threats should be considered together with the continuing growth of the world population, the predicted increase of coastal development and pollution, and the increased pressure on the marine resources (including those still preserved in the deep seas) as they become scarce.

Urgent action is needed to preserve and restore ocean and coastal ecosystems and reduce climate change impacts on billions of people.

Marine Protected Area Networks: Bolstering Resilience, Buffering Impacts
One major way to help maintain (and in some cases restore) ecosystem health, productivity and services in the face of climate change, while reducing poverty and safeguarding social and economic development, is the creation and effective management of networks of marine protected areas (IUCN-WCPA, 2008). Marine protected areas[1] (MPAs) cover a diverse set of forms and management frameworks, ranging from village-level community-managed areas

[1] Various names, including marine reserve, fishery reserve, closed area, no-take area or zone, sanctuary, park, wilderness area, and locally managed area, among others, are used to describe an MPA

to multi-million hectare national parks. They have a wide array of objectives that can include fisheries management, biodiversity conservation, and social and cultural uses. They can range from areas that allow multiple uses to areas that restrict all access.

MPAs can contribute to the conservation of ocean species and habitat, and aid in the development of sustainable fisheries. MPAs protect exploited species during critical stages of their life, and act as insurance against poor and inadequate fishery management (Mulongoy and Gidda, 2008). The Locally Managed Marine Areas (LMMA) Network in the Pacific has enabled some coastal communities to revive methods that have been used traditionally as part of their culture for many generations, while at the same time creating economic benefits. For example, LMMA results in Fiji since 1997 include a 20-fold increase in clam density in the *tabu* areas, an average 200-300% increase in harvest in adjacent areas, tripling of fish catches; and 35-45% increase in household income (Scherl and Emerton, 2008).

MPAs cannot halt threats associated with climate change, including ocean acidification. However, well designed MPAs and MPA networks have proven to be an important tool in increasing the resilience and adaptive capacity of coral reefs to bleaching, by protecting them from other disturbances such as increased nutrient loads, pollution, diver and boat damage, sedimentation, and destructive and over fishing. They also act as refugia, protecting areas and functions critical in the life cycles of important marine species. Refugia are important to protect larval sources which aid in the recovery of damaged areas. MPA networks that include mangroves and other coastal wetlands, beaches, and important estuarine areas have reduced the vulnerability of coastal habitats and communities to storms and coastal erosion impacts.

The benefits of MPAs, and especially their ability to reduce the adverse impacts of climate change, are greatly enhanced through the design and management of connected networks rather than individual protected areas. Networks are more effective at protecting and sustaining the full range of habitats and species on which ecosystem services depend, particularly when complemented with better management outside the MPAs. Existing research and management practices have demonstrated that connectivity among sites within a network helps insure against the risk of losing an important habitat or community type following a disturbance such as a bleaching episode or intense storm. The widespread replication of these experiences for increasing the resilience of MPA networks in the face of climate change impacts provides a solid foundation for rapid expansion of these important management approaches as a key strategy for protecting ocean and coastal ecosystem services and the wide range of benefits they provide us.

Components of a Resilient MPA Network

Effective management, including integrated management of coastal ecosystems, is essential to keep ecosystems healthy. Reducing threats is the foundation for successful conservation and the core of resilience-based strategies.

Full protection of critical areas that can serve as reliable sources of seed for replenishment and presentation of ecological functions is essential. These areas include spawning grounds, nursery habitats, areas of high species diversity, areas that contain a variety of habitat types in close proximity, and potential climate refugia.

Connectivity (both biological and ecological) should be maintained among and between habitats to ensure larval exchange and replenishment of affected populations and fish stocks and can enhance recovery following disturbance events.

Risk-spreading through inclusion of replicates of representative species and habitats ensures that some habitat areas and species will be protected and remain viable given the uncertainty of exactly where and how strong impacts of climate change will be.

Resilient marine protected areas networks that provide ecosystem goods and services are the first line of defense of communities vulnerable to the impacts of climate change. Much work remains to realize this potential, however. Today, MPAs cover approximately 0.8% of the oceans, and most are small, individual protected areas (two-thirds of the global marine area protected is contained within only 10 MPAs), and practically absent in the deep sea. While the percentage of coastal areas within MPAs is somewhat larger, covering over 4% of continental shelf areas worldwide, this is still insufficient. A variety of off shore critical habitats and processes, including biogeochemical cycles at the global scale that are mostly driven in the deep ocean (Dell'Anno and Danovaro, 2005), pelagic ecosystems (Game et al., *in press*), and areas that lie beyond national jurisdiction remain unprotected. Many MPAs are not effectively managed and few have reliable financial resources to sustain their operations. Furthermore, while various goals of establishing MPA networks have been agreed upon by the Parties to the Convention on Biological Diversity and through other global agreements during the past decade, progress in most countries is well below that needed to meet them (Spalding et al., 2008; Wood et al 2008).

The successful use of MPA networks as a tool to help reduce the impacts of climate change will require multiple actions. Among the most critical are to engage with and address the needs and concerns of key stakeholders, including the communities who depend most on coastal and ocean ecosystem services. The traditional knowledge of indigenous and local communities and other stakeholders of their environment should be incorporated into governance systems that involve them in the planning, managing, decision-making, and monitoring. Efforts should be made to build the capacity of local communities to understand climate change impacts and how they affect their use of resources and ecosystem services. It is particularly important to engage community members in monitoring and management activities, as this raises their awareness of the impacts of climate change on their surrounding ecosystems, and helps them understand and support the need to manage resource use in appropriate ways.

There is a growing body of research and experience on managing for resilience. This experience has been summarized in a number of useful tools that are now available to help managers and decision makers them address climate impacts.

Existing Guidelines to Manage in the Face of Change Include:

<u>Establishing Resilient Marine Protected Area Networks - Making it Happen</u>
IUCN World Commission on Protected Areas (IUCN-WCPA) (2008). Washington, D.C.: IUCN-WCPA, National Oceanic and Atmospheric Administration and The Nature Conservancy. 118 p.
<u>Managing Mangroves for Resilience to Climate Change</u>
McLeod, Elizabeth and Salm, Rodney V. (2006). Managing Mangroves for Resilience to Climate Change. IUCN, Gland, Switzerland. 64pp.
<u>Managing Seagrasses for Resilience to Climate Change</u>
Björk M., Short F., Mcleod, E. and Beer, S. (2008). Managing Seagrasses for Resilience to Climate Change. IUCN, Gland, Switzerland. 56pp.
<u>Honolulu Declaration on Ocean Acidification and Reef Management</u>
McLeod, E., R.V. Salm, , K. Anthony, B. Causey, E. Conklin, A. Cros, R. Feely, J. Guinotte, G. Hofmann, J. Hoffman, P. Jokiel, J. Kleypas, P. Marshall, and C. Veron. 2008. The Nature Conservancy, U.S.A., and IUCN, Gland, Switzerland.
<u>A Reef Manager's Guide to Coral Bleaching</u>
Marshall P.A. and Schuttenberg, H.Z. (2006). A Reef Manager's Guide to Coral Bleaching. Great Barrier Reef Marine Park Authority, Australia
<u>Reef Resilience Toolkit:</u> http://www.reefresilience.org

Recommendations

1. Resilient MPA networks are an important tool for adapting to the adverse impacts of climate change. **Significant financial support for national and regional efforts to create and sustain MPA networks should be included in adaptation funding mechanisms under the UNFCCC post-2012 climate agreement.** This should include support for mechanisms and incentives to build locally sustainable financing that engage local stakeholders and governments.

2. **Efforts to meet established global goals to create and effectively manage resilient MPAs and MPA networks need to be substantially increased and extended to cover the deep seas**. Progress in most countries is well below the goal of establishing MPA networks by 2012 agreed upon by the Parties to the Convention on Biological Diversity and by the Heads of State at the 2002 World Summit on Sustainable Development.
   - Priority attention should be placed on increasing the resilience of marine and coastal ecosystems by establishing and improving the design of MPA networks that take into account predicted climate impacts.
   - Regional challenges such as the Micronesia Challenge, Caribbean Challenge, and Coral Triangle Initiative play an important role in strengthening political will and catalyzing national and regional action to achieve the 2012 global goal. Expanded support is needed for such initiatives in these and other regions.
   - Progress should be made to scale up MPA networks to encompass the open ocean and deep sea, as many essential ecological processes and services are linked to these offshore areas, including areas that lie beyond national jurisdiction.

3. Vulnerability assessments should be conducted at regional and local scales to identify coastal and deep-sea habitats and communities highly vulnerable to climate change impacts, and the possible actions required to mitigate these impacts at appropriate scales.

4. Increased investments are needed by governments, scientists, donor agencies, civil society organizations, and others to improve our understanding of the ways that climate change affects the provision of coastal and ocean ecosystem services, and how to increase resilience of natural ecosystems in the face of these impacts. Particular attention is needed with respect to ocean acidification and improving connectivity within MPA networks and between MPAs and the wider ecosystems of which they are a part.

5. Improved and targeted educational and informational materials are needed to communicate the impacts of climate change on marine ecosystems and encourage the development of appropriate ecosystem-based adaptation strategies that are sensitive to and appropriate at local scales of intervention.

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7b. Saving the Forests to Save the Reefs– The Links Between REDD and Coral Reefs

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Abstract
Climate change threatens to render the world's coral reefs functionally extinct. Either a failure to stabilize atmospheric CO_2 below 450 ppm, or a failure to constrain global mean temperature rise to 2°C, will ultimately eliminate many carbonate coral reef ecosystems. The level of global greenhouse gas emission reductions required to constrain CO_2 concentrations to 450 ppm, or to constrain global mean temperature rise to 2°C, requires that emissions from tropical deforestation be greatly reduced during the 21st century, even with substantial mitigation in all other sectors (e.g., fossil fuels). Thus, retaining most of the world's remaining tropical forests (e.g., a REDD mechanism or equivalent) is essential to protect the world's coral reef ecosystems and the goods and services they provide to more than 500 million people.

Coral Reefs and Climate Change
Increases in atmospheric CO_2 concentrations since the industrial revolution have driven increases in average tropical ocean temperatures of nearly 0.5°C, and an increase in surface ocean acidity by 0.1 pH unit with a concomitant drop in surface seawater carbonate ion concentration of ~30 mmol kg^{-1}. These changes have moved coral reefs into thermal and chemical conditions that they have not experienced for at least the past 720,000 years. In a single year in 1998, an estimated 16% of the world's coral reefs were destroyed by severe coral bleaching events.

As a general rule, an important thermal threshold for corals occurs at approximately 1°C above the long-term summer maximum for a region. If this threshold is exceeded for extended periods corals undergo mass bleaching (a breakdown of their symbiosis with dinoflagellates). If temperatures exceed 2°C above the long-term summer maximum, mass coral mortality is likely. Such local rises in summer sea surface temperature are likely to be associated with global mean temperature increases (ΔT) of 2.5-3°C. Stabilizing GHG concentrations between 445-490 ppm CO_2equivalents (350-400 ppm CO_2) would potentially limit equilibrium ΔT to 2-2.4°C, using a best estimate of global climate sensitivity, but would require global reductions in GHG emissions of 50-85% by 2050, relative to 2000 levels.

The second threshold for corals is the concentration of carbonate ions in seawater below which coral reefs can no longer maintain the carbonate frameworks that characterize coral reefs. Increasing atmospheric CO_2 decreases the carbonate ion concentration through its impact on ocean acidity. The balance between the production (calcification) and loss (biological, physical, and chemical erosion) of calcium carbonate on a coral reef determines whether or not reef structures can be maintained. Decreases in carbonate ion concentration will cause both a decrease in carbonate production and an increase in its loss. As concentrations of atmospheric CO_2 increase, fewer coral reefs will be able to calcify at rates that can keep up with biological, physical and chemical erosion. These reef frameworks are critically important in providing the three-dimensional habitats that are homes to over a million species and for playing critical roles in the protection of inshore coastal ecosystems and human infrastructure from the force of ocean waves. Most coral reef scientists believe that it is necessary to maintain atmospheric CO_2 well below 450 ppm to preserve coral reefs. Therefore, both critical thresholds for coral reefs might be met if global mean temperature increases are constrained to 2°C.

Tropical Forests and Climate Change

Land use change currently contributes ~17% of global anthropogenic greenhouse gas emissions. Most future climate projections are based on the IPCC SRES scenarios that assume that land use change emissions will dramatically decrease over the twenty-first century. These scenarios appear to be mostly optimistic about deforestation futures. Present trends of tropical deforestation show little signs of abating as avoided deforestation policies in many tropical countries are either not in place or are often violated. In temperate countries, plans to re-forest large areas are in their infancy and are likely to be offset by the release of carbon due to the increase in forest fire frequency expected under climate change. Continuing deforestation could ultimately lead to estimated releases of 450 - 800 Gigatons of Carbon (GtC) in the 21st century, of which 395 GtC could originate from tropical forests.

A probabilistic modeling approach was used to examine the role of remaining tropical forests in enhancing or inhibiting society's ability to meet various GHG concentration and temperature targets over the 21st century. This advanced upon previous works by investigating the influence of tropical deforestation on global mean temperature rise in conjunction with stringent mitigation in all other (non-tropical forest, including fossil fuel) sectors. This analysis examined a 3% annual global emission reduction from non-tropical forest sectors, corresponding to an 80% emissions reduction between 2000 and 2050 (some of the highest published possible rates of emission reduction). An 80% global emissions reduction *and* a retention of all remaining tropical forests intact gives a 65% probability of constraining global mean temperature rise to 2°C. If these emission reduction rates are achieved but tropical deforestation continues at the rates estimated by the FAO (2.2GtC annually), the probability of staying below 2°C is more than halved with temperatures still rising in 2100. Only zero or low tropical deforestation rates (0.8 GtC/yr) have a greater than evens chance of constraining temperature change to 2°C. However, should current tropical deforestation rates continue, then mitigation rates substantially exceeding those generally accepted as possible would be required.

Saving the Forests Saves the Reefs

Retention of nearly all remaining tropical forests (i.e., an effective REDD policy), coupled with an 80% reduction in emissions from all other sectors, is essential to constraining global mean temperature rise to 2°C and hence to the preservation of coral reef ecosystems from the damaging effects of climate change. Thus, a major global effort to reduce fossil fuel emissions *and* retain tropical forests is necessary in order to have the greatest chance of saving most of the world's coral reef ecosystems. Regionally, saving tropical forests provides many co-benefits that also help save coral reef ecosystems. Principle among them is a reduction of sedimentation into streams and finally on to near shore reefs. This, in turn, removes this stress and helps build resiliency for these coral reef ecosystems.

Chapter 8

Mitigation and Oceans: Properly Manage Mitigation Efforts that Use the Oceans—Carbon Capture and Storage, Ocean Fertilization; Curb Air Pollution from Ships; Other Mitigation Options

8. Mitigation and Oceans: Property Manage Mitigation Efforts Using the Oceans--Carbon Capture and Storage, Ocean Fertilization; Curb Air Pollution from Ships; Other Mitigation Options

by Caitlin Snyder, Miriam Balgos and Madeleine Russell,
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Introduction

There are a variety of climate change mitigation efforts that involve the oceans. This brief addresses three prominent options: Carbon capture and storage, ocean fertilization, and curbing air pollution from ships.

Carbon Capture and Storage

Introduction

The IPCC defines carbon dioxide capture and storage (CCS) as "a process consisting of the separation of CO_2 from industrial and energy-related sources, transport to a storage location and long-term isolation from the atmosphere" (IPCC 2005). The IPCC has identified CCS as a mitigation technique with the potential to prevent large amounts of carbon dioxide (CO_2) from being released into the atmosphere, as it has the potential to reduce emissions by 80-90% (IPCC 2005). If CCS technology develops quickly, the method may be able to mitigate 20-40% of CO_2 emissions within fifty years (IPCC 2005). As the technique holds great promise to eliminate large quantities of CO_2, a number of organizations and national governments are conducting ongoing studies of CCS suitability.

A number of industries may benefit from CCS technology, including power plants, cement plants, steel production, and biomass facilities. As the largest source of industrial emissions, power plants may receive the greatest possible CO_2 emission reductions from CCS (WRI 2008). Estimates of costs of capturing CO_2 from power plants range from US$11 to US$57 per ton of CO_2, depending on the conditions of the plant and the type of capture technology (IPCC 2005). Based on ongoing demonstration projects, a question remains about the level of capture technology can achieve (WRI 2008). The capture of carbon, which includes the separation from other elements and the compression of the CO_2, will require increased energy from the source plant. This can result in an increase in fuel consumption of between 16 and 31% (based on the type of fuel and plant) (German Advisory Council 2006).

CCS can potentially be stored in several locations: in terrestrial geological formations, such as depleted oil and gas fields and deep saline formations; fixation with inorganic carbonates; under the sea floor; or in the ocean water column. This brief will focus on the latter two storage options.

Storage Options

Under the Seabed

Injecting CO_2 under the seabed follows a similar process to terrestrial storage. Selecting storage sites will require a thorough risk assessment to identify potential hazards associated with the site. The primary concern with storage in geological formations is the risk of CO_2 leakage. Leakage of CO_2 could have devastating immediate consequences for the surrounding marine life, as well as long-term effects on the ocean as a whole. There are also concerns related to the transport of the CO_2 to the injection site. The laying of pipelines will disturb marine habitat on the seabed surface and in the sediment, as they may need to be buried to protect against damage from fishing gear. Security and maintenance of the pipelines are also a concern.

Several projects involving seabed injection are ongoing. The Sleipner Project, located in the North Sea of the coast of Norway, captures CO_2 from natural gas processing and began operation in 1996. The project removes approximately one million tons of CO_2 each year from the natural gas processing and injects it into a saline reservoir approximately 800 meters below the seabed. The project has a twenty-five year lifespan and its operators predict the reservoir can store twenty million tons of CO_2.

In the Water Column

Injecting CO_2 directly into the water column from a ship or fixed pipeline has been proposed. If CO_2 is injected at depths over three kilometers, its density is greater than seawater and it will sink and form lakes or plumes along the ocean bottom (Kullenberg et al 2008). Direct injection poses risks, as it will alter the physical and chemical characteristics of seawater. Around the injection site, pH values can change by several units (German Advisory Council 2006). The impacts to the surrounding ocean area depend on the dissolution rate of the injected CO_2, which varies based on the form of CO_2 injected (solid, liquid, gas, or hydrate), the depth and temperature of the site, and water currents (IPCC 2005). The amount of CO_2 injected will have varying impacts, as large amounts (hundreds of Gt CO_2) will result in eventual changes throughout the entire ocean and small amounts (several Gt CO_2) will produce immediate changes in the region of the injection (IPCC 2005). Such an influx of CO_2 and the resulting increase in acidity could have devastating consequences on the surrounding marine life, as these organisms are sensitive to minute changes. Although models suggest that injected CO_2 would remain in the ocean for several hundred years, eventually ocean mixing will lead to CO_2 being exchanged with the atmosphere (IPCC 2005). To date, injections of CO_2 have taken place in the laboratory, but not *in situ* in the deep ocean.

Based on the technology and energy required to capture and inject the carbon into the sea floor or in the ocean, total costs range between US$20 to US$100 per ton of CO_2 (German Advisory Council 2006).

Legal Frameworks

Amendments to both the 1996 London Protocol to the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1996 London Protocol) and the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) have removed legal barriers to the storage of CO_2 in the seabed. In 2006, the 1996 London Protocol was amended to permit storage of CO_2 in seabed geological formations starting in February 2007. The OSPAR Convention adopted amendments in 2007 to permit Parties to store CO_2 in geological formations under the seabed, as well. The 1996 London Protocol Amendments do not address the storage of CO_2 in the water column, but the OSPAR Convention prohibits the release of CO_2 into the water column and on the seabed.

Several States have taken measures to regulate CCS. The European Council adopted a Directive on the geological storage of carbon dioxide in April 2009. The Directive notes the amendments to the London and OSPAR Conventions. The Directive applies to CO_2 storage within the territory of European Union (EU) Member States, their exclusive economic zones

(EEZs), and on their continental shelves. Initial research indicates that “seven million tones of CO_2 could be stored by 2020, and up to 160 million tonnes by 2030, assuming a 20 % reduction in greenhouse gas emissions by 2020 and provided that CCS obtains private, national and Community support and proves to be an environmentally safe technology” (European Union 2009). The Directive provides guidance for EU Member States when identifying and developing CCS sites. The Directive prohibits the injection of CO_2 into the water column (European Union 2009). It calls for ongoing monitoring of any identified CCS site to prevent and address leakage issues.

In July 2008, the United States’ Environmental Protection Agency (EPA) issued a proposed rule Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells, which seeks to establish technical guidelines for the permitting and injection of CO_2 into wells in the United States. The proposal applies to terrestrial wells, as well as those located in territorial waters of U.S. states (U.S. EPA 2008). Injection sites further offshore may be governed by other federal laws, such as the Marine Protection, Research, and Sanctuaries Act (MPRSA). The EPA gathered comments on the proposed regulations until December 2008, and the agency is now working on reviewing the rule based upon the comments.

Bottom line and Recommendations

A number of uncertainties associated with CCS in the ocean and seabed exist, including the impacts to marine life, the potential security risks, and the long-term ability of sites to successfully store CO_2 without leakage or diffusion to the ocean (and eventually the atmosphere).

Direct injection of CO_2 into the ocean is not recommended, due to the potential for irreversible harm to sensitive marine organisms.

CCS via injection into the seabed is a potential mitigation measure to address climate change; however, it should be used as part of a package of options. Relying too heavily on CCS may result in a ‘business as usual’ situation – serving as an incentive to increase the emissions’ share of fossil fuel plants and other heavy polluting industries, as well as reducing States’ focus on the development of cleaner renewable energy technologies.

Prior to implementing CCS on a large scale, policy makers should be confident that the methods and technologies are effective in reducing CO_2 emissions over the long-term, as well as offer safe and sustainable options for mitigating climate change, while at the same time protecting the oceans and their resources.

Ocean Fertilization

Background and Status on the Technology

Natural iron fertilization that induces algal blooms is being studied as a successful biological carbon pump, removing carbon from the atmosphere and storing it deep in the ocean. Laboratory experiments have confirmed the possibilities of using iron to induce algal blooms (Powell 2009). However, concerns for the inherent risks and costs to the environment suggest the precautionary approach is appropriate.

The biogeochemist, John Martin, considered the lack of iron to be the limiting factor to the size of huge algal blooms in the ocean and developed the Iron Hypothesis, publishing *Glacial-Interglacial CO2 Change: The Iron Hypothesis* in 1990. Studying glacial ice, he found iron-rich blooms responsible for drawing down enormous amounts of carbon from the atmosphere (Martin 1990). This study raised the question, would enriching the present day ocean with iron enhance the ability of algal blooms to absorb significant amounts of carbon out of the atmosphere (Powell 2009)? Laboratory results in controlled environments showed favorable results with astounding numbers. The capacity of iron-enhanced algal blooms to draw down carbon was encouraging. Iron fertilization was considered a viable solution (IUCN 2008).

Since 1993, twelve experiments have taken place in the ocean without encouraging results. Injected iron particles did not stay at the surface long enough to be effective. Turbid water sank the particles and lack of sunlight limited the generation of phytoplankton. Ocean currents limited the effectiveness of measuring direct carbon capture in deeper waters (Powell 2009). Naturally occurring iron fertilization was considerably more efficient and effective. The most recent attempt, a controversial cruise called LOHAFEX, noted that the phytoplankton bloom attracted amphipods (which came and fed on the bloom), rather than carbon, reducing the experiment's intended effectiveness. The LOHAFEX researchers were also able to attribute the ineffectiveness of the carbon capture to a lack of silica in the area, a necessary component for forming nodules that have the weight to carry the carbon deep enough to be an effective storage mechanism (Dipl.-Ing 2009).

The results of recent iron fertilization experiments specifically focused on the drawdown of carbon have determined that current methods are ineffective. Significant ecological implications that ocean fertilization creates more risk than gain are making these experiments less profitable. Naturally occurring algal blooms are the result of far more factors than available iron (Pollard 2009).

A broader understanding of this multifaceted issue is necessary. Environmental concerns include the propagation of less desirable species, such as jellyfish, due to increased nutrients in the water (IUCN 2008). Decomposition of the algal bloom creates a low oxygen area known as a dead zone, and it is feared that dead zones may become more numerous with large-scale ocean fertilization. Inability to measure the success of carbon sinking to the ocean seafloor for permanent storage has created concerns that the carbon is re-released into the atmosphere in a short time period. Similarly, there are concerns about the effects of added carbon to each layer of ocean environment, and the addition of iron that is not taken up by the blooms sinking into seafloor ecosystems (Powell 2009).

Current Regulatory Framework

There are no specific regulations regarding ocean fertilization, and permitting requirements are unclear. The issue of ocean fertilization falls primarily between the 1982 United National Convention on the Law of the Sea (UNCLOS) and the 1972 London Convention on the Prevention of Marine Pollution by dumping of Wastes and Other Matter and associated London Protocol (1996). However, there are no enforceable regulatory measures in either agreement (Gjerde 2008).

Parties to the London Convention and the London Protocol took a strong stand in June 2007, calling for utmost caution with regards to ocean fertilization, regarding any large-scale operations as "unjustified." The Convention for Biological Diversity (CBD) called for a moratorium on fertilization experiments during its Ninth Meeting of the Conference of the Parties, held from 19-30 May 2008 in Bonn. The CBD urges limiting ocean fertilization to careful scientific research, with emphasis on prior review, and thorough consideration of the impacts on the marine environment. These experiments are not to be driven by the carbon market, or considered an appropriate offset investment. Restricting experiments to coastal waters, thoroughly considering potential impacts on the marine environment, and calling for effective transparent global regulation are part of CBD requirements (CBD COP 2008).

Policy Recommendations

Climate change is accelerating the global search for effective ways to reduce greenhouse gas emissions and buildup of carbon in the atmosphere. Carbon markets and offset incentives create economic opportunities to develop successful strategies. The limited contribution of ocean fertilization experiments suggests it is not a viable solution. Regulations are being considered to strictly limit the scope and nature of scientific research in this area, and to limit the profitability of continued experiments.

Considering the lack of success of twelve ocean fertilization experiments, and considering the mounting evidence of negative consequences and potential irreversible harm to the ecosystem, it follows that scientific support has not developed sufficiently to continue ocean fertilization projects. The UNFCCC would be wise to specifically remove the incentive to continue these experiments by excluding them from the carbon offset program and participation in the carbon market. Far more efficient and effective mechanisms are necessary to reduce greenhouse gases, with long-term potential and proven successful strategies.

Climate Change and Ship Emissions

Shipping transports 90% of the world's goods, with over 50,000 merchant ships in service (ICS 2009). In its Fourth Assessment Report, the IPCC noted that global transport (including aviation and maritime) accounts for 13% of GHG emissions (IPCC 2007). Carbon dioxide (CO_2) is the primary GHG emitted by the maritime transport sector. In 2007, the International Maritime Organization (IMO) estimated shipping accounts for 1.12 billion metric tons of CO_2, contributing over 3% of global CO_2 emissions (SCBLG 2007). This is an increase from a 2000 IMO study that estimated the shipping industry emitted 419.3 million tons of CO_2 each year (Marintek 2000). As additional ships are introduced into service, the GHG emissions from ships are projected to grow. The shipping industry has demonstrated an average 5% annual growth in activity over the past thirty years (ICCT 2007). Between 1990 and 2005, the UNFCCC indicates that GHG emissions from international maritime transport increased by 7% (UNFCCC 2007).

The Kyoto Protocol identifies the IMO as the appropriate international body to work with the Parties to address ship emissions. Article 2, paragraph 2 of the Kyoto Protocol states:

> *The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively. (UN 1998)*

As the Kyoto Protocol only references Annex I countries in relation to the IMO and its role in GHG emission reductions, the IMO may be limited in its ability to compel any non-Annex I countries to adopt any measures mitigating GHGs. The IMO faces disagreement among its members over the application of the principle of 'common but differentiated responsibilities' to the shipping industry. Certain IMO members support the application of the principle, arguing that any mandatory GHG reductions must only apply to Annex I countries.

However, this may be difficult to apply, as 75% of the world's merchant ships are flagged in developing countries, but owned by companies based in developed countries.

The Subsidiary Body for Scientific and Technological Advice (SBSTA), which provides information and advice on technological and scientific matters related to the Convention, considers issues related to ship emissions. Under IPCC guidelines for the preparation of greenhouse gas (GHG) inventories and UNFCC annual reporting guidelines, emissions from maritime transport "should be calculated as part of the national GHG inventories of Parties, but should be excluded from national totals and reported separately." Ship emissions do not fall under Annex I Party reduction commitments of the Convention and Kyoto Protocol. SBSTA receives information from the International Maritime Organization (IMO) regarding the steps the IMO is taking to reduce ship GHG emissions. At its 28th Session (June 2008), the SBSTA agreed to consider issues related to ship emissions at its 32nd session in May/June 2010.

During its 58th session in October 2008, the IMO's Marine Environment Protection Committee (MEPC) moved forward in the development of technical and operational measures to reduce GHG emissions, including the development of an Energy Efficient Design Index (EEDI) for new vessels, an efficiency management plan for ships, and a voluntary code on best practices for energy efficient ship operation. (IMO 2008). MEPC approved draft guidelines for the EEDI for new ships, to be used and evaluated during a trial period. The MEPC also considered market-based measures, and will continue this discussion during its 59th session in July 2009. The outcomes from MEPC 59 will be presented at COP-15 in Copenhagen.

The IMO has also established a Working Group on Greenhouse Gas Emissions from Ships, which held its second intersessional meeting in March 2009. The Working Group considered a number of technical and operational measures to increase fuel efficiency and reduce GHG emissions from ships. The Working Group reviewed and refined the EEDI based on feedback received since the draft Interim Guidelines were approved in October 2008. It is likely the EEDI will become mandatory for all new ships under any GHG reduction framework developed by the IMO.

In addition to the IMO, outside entities have proposed several ways in which ship emissions can be reduced. The International Marine Emission Reduction Scheme (IMERS) seeks to "(1) raise financing to tackle climate change and (2) reduce shipping emissions, whilst recognizing the UNFCCC principle of common but differentiated responsibilities" (IMERS 2009). IMERS advocates putting a levy on vessel fuel based upon any GHG emissions occurring above a pre-determined emissions cap. Additional groups have advocated for an industry-wide switch to cleaner fuels, a reduction of ship speed, and continued research on ship design to improve fuel efficiency. States can petition the IMO to establish Emission Control Areas (ECA), as the United States and Canada did in March 2009. Under the US-Canada proposal, ships would be required to use fuel containing no more than 1,000 parts per million of sulfur by 2015; the ECA would extend out to 200 nautical miles along the Atlantic and Pacific coasts of both countries.

Ship emissions can be reduced in three ways: technical measures, operational measures, and market-based measures.

Technical

Technical measures include a substitution of alternate fuel and energy sources for the bunker fuel and the introduction of fuel efficiency measures. Alternative fuel sources may include low sulfur marine diesel oil and marine gas oil, and natural gas. A switch to these fuels will reduce particulate matter, nitrogen oxides, nitrous oxides, and CO2. Although there have been arguments against switching from residual fuels due to a presumed increase in GHG emissions from the increased refining needed for marine diesel and marine gas oil, recent research suggests that an increase in CO2 emissions would be less than one percent and GHG emissions over the total fuel cycle may actually be reduced due to increased efficiency (Corbett and Winebrake 2008). A switch to natural gas may reduce CO2 by up to 20%, although the costs associated with supplying the gas and the required technology are quite high (Kahn et al 2007). Further technical measures may include specialized hull coatings and changes to ship design, for example a bulbous bow and a stern flap. Experiments with kites or sails are ongoing, as these offer a way for vessels to harness wind power and significantly reduce emissions.

Operational

Operational changes may be taken by shipping companies or ports to improve efficiency and save on fuel costs. Reducing the speed of the world's fleet by just ten percent by 2010 would result in a 23.3% reduction in ship emissions (Marintek 2000). A number of ports have instituted voluntary speed reduction programs to reduce emissions, including the Ports of Los Angeles and Long Beach and the Port of San Diego. Ships that reduce their speed are rewarded with financial incentives and public recognition of their contribution to emissions reductions. Certain shipping lines, including Moller-Maersk, and Hapag-Lloyd, require their ships to reduce their speed in an effort to save fuel costs and reduce emissions.

Cold ironing is an option for ports to provide to ships while in port, as it allows ships to shut down their engines and connect to shore-based power to meet its energy needs. Shore-based power, especially if provided by renewable resources, is cleaner than continued burning of residual fuel. A number of ports in California offer cold ironing to visiting vessels.

Market-based

Economic instruments to encourage behavioral change are a third option for reducing ship emissions. Cap-and-trade systems and a carbon tax are both options that have been discussed for the shipping industry. Market-based measures can drive technical and operational changes, although they remain controversial.

Bottom Line and Recommendations

While waiting for an international framework on mandatory GHG emissions measures to be approved and enter into force, Port States can implement measures to encourage ships to reduce their speed, as well as offer cold-ironing facilities in-port.

Other Mitigation Options

Additional mitigation options involving the oceans include renewable energy resources and the enhancement of biological sinks. For example, the Asian Network of Using Algae as a CO_2 Sink is pursuing the enhancement of natural CO_2 uptake of coastal areas by cultivating algae and seaweed. In addition, restoration of mangroves, seagrass beds, and coral reefs may improve the CO_2 uptake of these areas. The net contributions of these activities to CO_2 reduction are unclear, and further research is needed as to their large-scale effectiveness.

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Chapter 9

Encouraging Alternative Forms of Energy Using the Oceans

9. Encouraging Alternative Forms of Energy Using the Oceans

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Context and Importance of the Problem

The oceans occupy a central role in the climate change issue. They serve as a sink for a large portion of the earth's carbon dioxide and are demonstrating some of the tangible effects of global warming through sea level rise. Increasingly, attention is also being paid to the vast mitigation potential of the oceans, namely as a major source of alternative energy. As with other major types of renewable energy such as solar and terrestrial wind power, ocean-based alternative energy relies on the inherent characteristics of the oceans and can, in most cases, be found and harnessed throughout the world. Also, renewable energy ventures, as the IPCC states "…are often economically beneficial, improve energy security and reduce local pollutant emissions" (IPCC 2007, pg 61).

While the source of this immense energy resource is globally pervasive, actually harnessing this power requires safe and reliable technology, effective policy and regulatory frameworks, and stable sources of funding. The first of these two primary requirements are only gradually being met for many types of marine renewable energy resources and the third continues to elude projects attempting to harness this resource. Alternative sources of energy from the oceans, being in competition with other existing sources of renewable and non-renewable energy must also demonstrate their relative cost effectiveness to "…achieve large penetrations of the world's electricity system over the time frame required, but all of these hurdles are surmountable" (WWI 2009, pg136). This report will outline these obstacles and means of overcoming them as well as the global status of marine renewable energy.

Renewable Energy and the Ocean

Production Potentials and Status at the Global Level

The ocean can provide for significant contributions to mitigation strategies, including alternative renewable energy sources such as wind, waves, tidal, ocean current and thermal energy conversion. The close proximity of marine renewable energy resources to coastal load centers with large populations presents an inherent advantage over many land-based sources. However, aside from offshore wind, these types of renewable energy resources are only very gradually becoming commercially attractive. In many cases, the technology to develop this mitigation potential may be lacking, can have high implementation or operational costs, or have unknown consequences. Research and development must be encouraged to advance this technology and utilize the vast energy potential of the ocean, thereby decreasing dependence on fossil fuel energy sources. This section will briefly address emerging initiatives in this field and potential problems that may arise as we look to the oceans to mitigate the effects of a changing climate.

Offshore Wind Power

Offshore wind energy is increasingly becoming a viable source of renewable energy and is attracting global attention because of its inherent advantages and successful demonstration. Comparatively, offshore wind energy is the most developed form of energy production from the oceans in terms of technology and present and prospective policy frameworks. Wind turbine technology for offshore wind has been accelerated by research and experience in terrestrial wind energy projects. Viable policy options and frameworks also facilitate the development of offshore wind. In light of these factors, offshore wind energy production appears to have, compared to other marine renewable resources, the greatest immediate potential for energy production, grid integration, and, ultimately, climate change mitigation.

While land-based wind energy will likely remain the dominant form of wind energy in the immediate future, offshore installations will become increasingly important. Offshore wind energy projects are more complex and expensive to install and maintain compared to land-based wind, but they also possess a number of key advantages. Winds are typically stronger and more stable at sea than on land, resulting in higher production per unit installed. Afternoon winds in the sea tend to match well with load demands in the summer, which is not true for onshore wind. At sea, wind turbines can be bigger than land-based turbines because of the logistical difficulties of transporting very large turbine components from the place of manufacturing by road to installation sites on land. Wind farms at sea also have less potential to cause concern among neighboring citizens and other stakeholders unless they interfere with competing maritime activities or impact negatively on important marine environmental interests. In fact, wind farms at sea may be beneficial to protecting marine ecosystems and may generate synergies with other emerging uses of the sea such as offshore aquaculture, which can benefit from the substructures of wind farms (Offshore Wind Energy 2008).

Large-scale offshore windfarms have already been implemented and are in operation in a number of countries. As of 2007, offshore wind projects were operational in Europe, including in the UK, Denmark, Norway, The Netherlands, Germany, and Sweden. Projects have also been proposed in eight states in the US (Mandelstam 2009), and in the UK, The Netherlands, France, Sweden, Italy, and Spain (Offshore Wind Industry Group 2007).

Technological developments are also advancing this option at a remarkable pace and increasing the attractiveness and viability of offshore wind energy for potential investors. Present proven technology allows the placement of turbines at depths of 0-45 meters, with a potential of up to 430GW generated power; however, deepwater floating technologies at depths of 60-900 meters, with a potential of up to 1533GW generated power, are in the demonstration and development phase. Recent advances are providing larger turbines, improved blade design, and decreased manufacturing costs (Mandelstam 2009). These developments, coupled with its inherent advantages, make offshore wind energy a practical solution to the high energy demands of many coastal areas.

Policy developments in this field are also making significant progress, notably in Europe, the US and Canada, and facilitating the large-scale integration of offshore wind energy. Given that the offshore wind industry is presently operating in a number of European countries, the Offshore Wind Industry Group, a working group of the European Wind Energy Association, recommends the establishment of a European policy framework as well as the creation of stable markets for offshore wind. Marine spatial planning with a priority in wind power projects in certain areas also facilitates efficient and environmentally friendly planning procedures. These improvements, in addition to stable cost benchmarks and targets and increased cooperation in research and development, will accelerate the development of offshore wind in Europe (Offshore Wind Industry Group 2007). A fully developed offshore wind market in Europe can then potentially be used as a model for the implementation of offshore wind policy frameworks elsewhere, particularly in nations with large continental shelves conducive for offshore wind operations, such as China.

In December of 2008, the European Commission released a communication regarding the further development and integration of offshore wind in European nations, recognizing the vast potential of offshore wind to contribute to all three objectives of the new Energy Policy: reducing greenhouse gas emissions, ensuring security of supply and improving EU competitiveness. While recognizing the significant potential of offshore wind and its advantages, the communication also recognizes the need to facilitate the development of offshore wind through marine spatial planning, regional cooperation on-site and grid planning between nations, energy regulators, transmission system operators, and other relevant stakeholders, more favorable regulatory conditions for investment in transnational grids, and large-scale integration of offshore wind into European electricity grids (Offshore Wind Energy 2008). When these goals are met and an efficient framework for offshore wind energy is implemented, the European example could be utilized for large-scale development and integration of this and other types of marine renewable energy elsewhere.

Wave Energy

The dynamic nature of the oceans presents a major driving force behind another type of renewable energy, ocean hydrokinetic energy. Of this category, wave energy has been attracting significant attention and is presently being developed in a number of regions. The force of the ocean surface wind-generated waves can be observed at the coast, where this energy can cause considerable disruptions. The power potential of an average wave per kilometer of beach is estimated at about 40 MW. In regions where they regularly occur, such waves could constitute a very substantial energy source carrying with it few environmental impacts such as those related to the construction of facilities. The wave energy can be transformed by means of floating or fixed constructions. The latter uses the oscillating water column generated by the wave to push air through a turbine. This concept has been proven by a pilot plant in the UK and is commercially utilized. The floating devices convert the wave energy by being lifted up and down through coupling to a hydraulic system. Other types of wave energy technology, such as overtopping devices and attenuators are also being tested and implemented in different regions (Kullenberg et al. 2008).

A number of nations are currently developing wave energy technology, estimating production potentials, and establishing demonstration projects. In 2004, the Electric Power Research Institute estimated US wave energy production potential at 252 TWh per year. Denmark has been researching and testing wave energy as early as 1987 and has established research programs in support of demonstration projects and technology development. Various technologies are also being tested in the US, the UK, and Portugal, although these have yet to converge on a single best technical approach (Hagerman 2008). Deepwater wave energy projects are also being developed and sited off the coasts of Ireland and Norway (Sweeny 2009).

A few companies in particular have been ambitiously pursuing wave energy in Portugal. A Scotland-based company, Pelamis Wave Power Ltd, presently has three wave energy projects in various stages of development. The first of these to become operational, known as the Aguçadoura project, was purchased from the Portuguese company Enersis and is the world's first, multi-unit wave farm and the first commercial unit for wave energy converters with a 2.25MW capacity (Pelamiswave.com). However, there have been reports that this project has recently been stalled due to technical issues and financial setbacks (Copps 2009). This example demonstrates the need for sustained funding, especially in the early stages of renewable energy projects.

Tidal Energy

Another form of ocean-based hydrokinetic energy that utilizes the enormous power of tidal movements is also being examined and developed. Large barrages in areas of high tidal ranges can make use of this substantial source of power. An example is the Rance barrage in Brittany, France, built in 1966 (Summerhayes 1996). This generates half a million kilowatts of power per tidal cycle. While requiring an initial investment of 100 million USD, the operating costs are lower than any other power station in France, the fuel is free, and there are no waste products. Areas with a tidal range exceeding 10 meters, which appears to be the requirement, exist in many countries, such as the UK, Russia, Canada, and China, and tidal barrages have also been constructed in these countries. The technology required to utilize the power of tidal energy is readily available and potential sites are plentiful.

A project aimed at harnessing the power of the high tidal range of the Severn Estuary in the UK is presently being examined by the British government and has been added to a shortlist under consideration for funding (Jha 2009). If implemented, the 16-kilometer long barrage would include 216 turbo-generators of 9 meters in diameter, with a total capacity of 8640 MW. The annual output would amount to 17 TW hours of electricity, equivalent to burning 8 million tons of oil, and corresponding to 7 percent of the electrical use of England and Wales. Companies in the UK and Ireland have begun establishing test sites using underwater turbines in various configurations to harness tidal energy. The US has also been active in this industry, exploring potential sites since 2005 (Hagerman 2008). The environmental impacts of implementing such technology must, of course, be assessed in detail (Kullenberg et al. 2008). Tidal energy projects can have significant effects on estuarine and freshwater aquatic habitats. The construction of a barrage to harness tidal energy can cause changes in water turbidity and nutrient dynamics, resulting in significant changes to habitats. Fish movements will be physically restricted by the presence of a barrier (Tidal and Current Power Generation 2008). These costs, however, should also be evaluated in the context of the impacts of burning oil, which are likely to be significantly higher (Kullenberg et al. 2008).

Ocean Current Energy

The other major form of ocean-based hydrokinetic energy utilizes the prodigious energy potential of ocean currents. Many ocean currents, such as the Gulf Stream off the east coast of Florida, US, and the Kuroshio off the east coast of Japan, flow as enormous rivers carrying many millions of cubed meters of water per second. This energy source is largely untapped and could potentially be utilized through turbine technology. However, the transformation is only gradually becoming commercially viable (Kullenberg et al. 2008).

There exist a number of technical challenges to ocean currents as a viable source of renewable energy. The present major challenges are large water depths and long submarine cable transmission distances. These hurdles will need to be overcome before ocean current energy generation can be developed and tested on a large scale. Despite these obstacles, there also exist inherent advantages to this option. Since there is no flow reversal, a substantial baseload potential exists, and considering the large role that ocean currents play in solar energy distribution, ocean current energy could have significant implications for climate change mitigation as well. This, however, is still being researched (Hagerman 2008).

Ocean Thermal Energy Conversion (OTEC)

Technology used to convert thermal energy stored in parts of the ocean into electricity also presents a feasible option for renewable energy production. The principle of ocean thermal-energy conversion, commonly referred to as OTEC, uses the difference in temperature between the surface waters and the subsurface waters, about 20-25 °C, over a depth range of 500-1000 meters in the tropical zones of the ocean. Dependent upon a large thermocline, tropical areas, roughly between the Tropics of Capricorn and Cancer, have proven the most viable areas for the largest production potential. Various technological options, such as open-cycle, closed-cycle, and hybrid approaches are being tested, each having their respective pros and cons. A first modern-type but very small closed-cycle OTEC plant was constructed in Hawaii in 1979. There is much potential for OTEC projects for oceanic islands in the tropics lacking other energy sources, and considerable research is still being pursued in this area (Kullenberg et al. 2008). OTEC projects, thus far, have been limited to small-scale energy production and, as a result, have yet to encourage significant investment and policy development.

The environmental impacts of OTEC are mainly related to lowering of the surface water temperature and increasing the nutrients in the euphoric zone, thus possibly enhancing the biological productivity. Increasing nutrients in surface waters can also stimulate algae growth, which could potentially become a sink for excess carbon dioxide, lending more weight to the climate change mitigation potential of this option, although the implications of this would need to be examined. One possibility for making OTEC commercially attractive is to utilize the cold subsurface waters, which are rich in nutrients, to support mariculture installations in association with an OTEC plant. The cold water could also be utilized for air-conditioning, to cool the soil, or to obtain clean freshwater through desalination. It is this combination of OTEC, mariculture, and the achievement of a number of other by-products, which is currently being researched in order to make the integrated system commercially attractive. An integrated approach, in this respect, is being adopted, involving science, technology, and users in partnerships (Kulleberg et al. 2008). The importance of this becomes evident when considering the substantial capital investment required upfront and the limited number of viable sites for OTEC projects.

Osmotic Power

Salinity gradient energy is an often-overlooked source of renewable energy. Various concepts on how to make use of salinity gradient power have been around for more than twenty years. One such concept is the Pressure-Retarded Osmosis (PRO), in which seawater is pumped into a pressure chamber where the pressure is less than the osmotic pressure difference between fresh water (or low salinity water) and seawater (or higher salinity water). Freshwater then flows through a semi-permeable membrane and increases the volume (or pressure) within the chamber; a turbine is spun as the pressure is compensated. Early technologies were not considered promising, primarily because they relied on expensive membranes. Membrane technologies have advanced somewhat, but they remain the technical barrier to economical energy production and efforts are currently underway to address those issues. Once membranes with a particular efficiency have been developed, osmotic power may become a competitive source of renewable energy. In Norway, a company called Statkraft is in the process of building the world's first complete facility for osmotic power generation to develop this technology and make osmotic power a viable source of renewable energy. They claim that a full-scale commercial osmotic power plant could be in place as early as 2015 (statkraft.com).

Bio-diesel from Algae

Some innovative researchers are now looking toward the use of microalgae and macroalgae (or seaweed) as a viable source of biodiesel. Research into algae production has largely been guided down three tracks: open and covered ponds, photobioreactors, and fermenters, with the first two being the most widely pursued. There has also been investigation into siting algae farms in ocean areas, although these came under scrutiny due to potential effects on beaches and ocean wildlife (Kram 2009). However, as the technology is developed and nations with favorable growing conditions and plentiful coastlines begin to look toward marine renewable energy, this option may become technically viable in the future.

An advantage of biodiesel is that it can be used in existing diesel engines without requiring any modification. Biodiesel is non-toxic and biodegradable, and growing algae can provide a sink for carbon dioxide, thereby contributing to its climate change mitigation potential. Algae are an economical choice for biodiesel production, because of their availability and low cost. Despite these advantages, however, biodiesel production from algae is still developing and most of the production is taking place in terrestrial areas.

Environmental impacts associated with alternative energy from the oceans
As with any new technology that utilizes natural resources or resides in the biosphere, there will likely be corresponding ecological impacts that must be assessed. They key here is to determine the degree of these impacts and compare the costs of the impacts with that of other options (e.g. fossil fuels, land-based renewables). The uncertainty surrounding the environmental impacts of marine renewable energy technology hinders its development by encouraging resistance from environmental interests unwilling to accept this risk and discouraging potential investors wary of project failure due to exorbitant ecological impacts. To accommodate these concerns developers must work in cooperation with environmental interest groups, involving them at the outset and informing them of known and potentially unanticipated impacts. Scaled-down pilot projects will also help to hone in on reliable technology and demonstrate environmental impacts on a small scale, thereby bolstering investor confidence and stimulating capital investment.

Stakeholders must also be aware of and acknowledge potential positive ecological effects associated with marine renewable technology. Immobile underwater structures, in the case of offshore wind platforms for example, can serve as artificial habitats, which can potentially support local juvenile fish communities, thereby strengthening local fisheries. In some cases, smaller fishing vessels can also operate in an around offshore wind farms. These potentially beneficial by-products should be emphasized as another advantage to marine renewable energy not often present in land-based renewable and fossil fuel energy development.

How can the ocean community most effectively encourage the development and implementation of these types of alternative energy?
The ocean community should investigate and promote the use of best-practices and good management of renewable resources, such as offshore wind, ocean-based hydrokinetic energy, and ocean thermal energy, and promote where appropriate by looking to country examples (e.g., Denmark, Germany and Norway).

Guidelines also need to be identified and established, in concert with appropriate regulatory frameworks and best practices for implementing alternative energy technologies in the ocean and coastal environment.

Recognizing the present lack of information with regards to the potential environmental impacts of marine renewable energy projects, certain acceptable levels of environmental effects, as well as the potential positive ecological effects of these projects, need to be investigated

Policy Analysis

Policy and Financing Options to Support Alternative Energy From the Oceans
In addition to reliable and efficient technology, there must exist appropriate policy and regulatory frameworks as well as consistent and dependable funding for marine renewable

energy projects to facilitate large-scale development and implementation. The non-existence of regulatory frameworks or uncertainty of applications of existing regulatory mechanisms to the marine renewable energy industry presents a major obstacle to its development (Hawsey 2009). Only when these obstacles are overcome will ocean-based alternative energy realize its full potential. While frameworks and funding sources for marine renewables are largely lacking, aside from offshore wind, there presently exist a number of viable options to meet these requirements.

Often, a primary driver behind renewable energy development is the existence of a national renewable energy policy framework, with targeted budgets toward new technology development, as well as research and development programs within or directly involving government departments and agencies. To support market deployment, there should be guaranteed prices, investment incentives, a regulatory and administrative infrastructure, and a competitive market framework that adequately internalizes any externalities. This type of framework serves to provide government support in various forms and can legitimize developing renewable energy technologies. As of 2008, national government policies for renewable energy from the oceans exist in the UK, Ireland, Portugal, France, Germany, Japan, and New Zealand. These involve aspects such as targeted deployment, and guaranteed price obligations, among others. Other nations with public demonstration infrastructures for renewable energy pilot projects are Denmark, Norway, and Spain (Bhuyan 2008).

A central obstacle to the development of alternative energy from the oceans is the availability of financing. Generally, these projects require significant sources of early-stage capital, which could originate from a variety of both public and private sources. The need for early-stage financing is emphasized by factors such as incumbent competition for funding with other renewable and non-renewable resources, the risk associated with these types of projects, their capital intensive nature, and the existing regulatory uncertainty associated with marine renewable energy. To stimulate a framework that would lend greater support to early-stage financing there must be a disruptive public policy, with determined leadership and mechanisms to level the playing field with the oil and gas industry, as well as a significant attitude shift with regards to renewable energy potential (Staby 2009). Initial funding could potentially come from federal grants, loans and loan guarantees, research and development limited partnerships, and royalty trusts. Another structure to monetize tax subsidies for these projects is what is known as a "partnership flip." This involves the ownership of a project by an institutional investor, in partnership with the developer, who is allocated the majority of the economic returns until the return reaches a certain level, at which point the interest on the investment is lowered and the developer has an option to repurchase their interest. Yet another option for monetizing tax benefits is a prepaid service contract, involving the buyer of the electricity making an advance payment for electricity that can cover as much as half of the capital cost of the project (Martin 2008). Options such as these serve to increase initial investment in energy projects and can provide a viable source of capital funding for ocean-based alternative energy programs.

Although recent economic conditions have sunk many projects in the past year, a market upturn is expected to positively affect the marine renewable energy sector by the end of the summer (Martin 2009). In light of decreasing funds from the private sector, developers are beginning to look more toward government funding in support of early stage financing and pilot project development. While beneficial for initial funding, government support is not an optimal source of consistent funding (Kleeschulte 2009). This further necessitates the creation of a market for renewable energy to support this burgeoning industry.

Some nations, such as the US, are looking to the use of a Renewable Portfolio Standard (RPS), a policy mechanism requiring electrical supply companies to produce a specified fraction of their electricity from renewable sources, and Power Purchase Agreements (PPA), contracts between electricity generators and host site owners or lessors to purchase energy from providers, to facilitate the creation of a market for offshore wind power. The use of feed-in tariffs, or renewable energy payments, is also becoming a popular way of supporting renewable energy initiatives, especially in the UK and Germany. In addition to fair leasing procedures and operating fees, policy drivers required for this type of mechanism include stable production incentives in the short-term, national RPS and transmission legislation in the mid-term, and effective carbon regulation in the long-term. (Mandelstam 2009)

Clarifying jurisdiction with regards to permitting processes and environmental standards is also a necessary means to financing and regulatory obstacles. The sheer number of different types of energy conversion technologies and options signifies that the industry is moving at a pace that regulatory frameworks are unable to keep up with. When technologies begin to converge on a single best approach and technical standards are clarified, regulatory frameworks will likely begin to catch up. Determining an evaluation protocol will also help to achieve this by allowing technical due diligence, reducing the inherent risks associated with all new technology, and allowing investors to appropriately and systematically assess progress (Lewis 2009). This can be accomplished by the use of technical standards and "roadmaps" that define the long-term strategy of a project and emphasize the use of scaled down test projects. Strategies outlined in these "roadmaps" should involve deployment, technical, and commercial strategies. Proper planning and scaled testing will also ensure the reliability and survivability of equipment (Meggitt 2009). By reducing much of the inherent risk, scaled tests serve to increase the willingness to contribute to early-stage as well as sustained funding for marine renewable energy projects (Jeffrey 2009). Currently, the International Electrotechnical Commission (IEC) has created a new technical committee (TC) to address the ever increasing demand for alternative renewable resources. IEC TC 114, Marine Energy – Wave and Tidal Energy Converters, is determining international standards for marine renewable technologies that will reduce technological risks and stimulate investor confidence.

Supporting alternative energy from the oceans in developing nations and small island developing states (SIDS)

Developing nations and SIDS occupy a central role in climate change mitigation and adaptation. While bearing a minimal amount of responsibility in the causes of global warming, these nations will likely face the earliest and most extreme impacts, largely due to the fact that a significant portion of their populations are situated at or near the coastline. These issues become exacerbated when considering the limited capacity of these nations to defend against sea level rise and their severe vulnerability to storms powered by warming ocean waters, which are likely to increase in incidence and intensity. In light of this, the need of developing coastal nations to advance renewable energy in pursuit of both climate change mitigation and economic expansion becomes evident.

Presently, there exist a variety of opportunities for funding alternative energy from the oceans in developing nations. Several developing nations have already implemented large-scale renewable energy programs. These programs serve to facilitate outside funding and program expansion to include ocean energy sources. Development banks and financing organizations, such as the World Bank, the Asian Development Bank, and the Global Environment Facility, can also serve a central role in funding these types of projects, although in the past they have focused somewhat less on alternative energy from the oceans. Other financing institutions, including international (Fortisbank, Rabobank, Triodos, etc.), domestic, and bilateral (USAID, KfW, etc.) organizations, as well as foundations (Blue Moon Foundation, UN Foundation, Shell Foundation, etc.) possess potential funding for projects in developing nations. Notwithstanding such funding opportunities, there remain issues that stand in opposition to the development of this industry. Financing issues such as the lack of bankable projects and high transaction costs, a policy bias toward fossil fuels, an inappropriate regulatory framework, and institutional obstacles including the lack of capacity to develop, implement, and operate projects remain significant barriers (Siegel 2006).

SIDS face issues confronting developing nations with regard to climate change, yet must also cope with an increased vulnerability to the impacts of sea level rise and ocean-powered storms. It has been estimated that for an additional 20 centimeter rise in sea level, 65 percent of the Marshall Islands and Kiribati will be inundated and that a 100 centimeter rise in sea level rise could inundate 70 percent of the land mass of Seychelles (UN/DPI 1999). In light of this and other factors, the Barbados Plan of Action and the Mauritius Strategy address the importance of climate change in the future of SIDS and call for greater promotion of renewable energy, more support for SIDS to develop significant renewable energy sources, and the development and transfer of technologies to assist in addressing climate change, among others.

There are, however, a number of factors that interfere with the sustainable development of SIDS and, consequently, their ability to develop renewable energy programs. These include SIDS' poor access to modern energy services, their reliance on fossil fuels, and their limited purchasing power. SIDS' small size, in particular, severely limits their ability to take advantage of economies of scale available to larger states. A number of programs and initiatives, such as the Caribbean Renewable Energy Development Program, the South Pacific Regional Environment Program, and the Pacific Islands Energy Policy and Plan, have sought to address renewable energy development in SIDS and to facilitate the establishment of support mechanisms for this purpose. Often, the effectiveness of these types of initiatives and strategies depend upon the availability of regional implementation mechanisms. In light of this factor, options such as regional renewable portfolio standards (RPS) and regional clean development mechanism (CDM) strategies have been put forth (Byrne et al. 2005).

While the small size of SIDS presents obstacles to marine renewable energy development, they also present opportunities not present in larger nations. Technology experimentation and grid integration becomes much more feasible in the smaller context of SIDS than in larger nations with greater energy demands. These types of experimentation can be tested in SIDS then, once proven successful, and used as a model for large-scale integration in larger areas. This factor presents a remarkable opportunity for SIDS to push the marine renewable energy agenda forward.

Policy Recommendations

To promote the need for a new ocean-based renewable energy sector, consider vulnerabilities that may arise under the current energy sectors, including: storms and oilrigs; pipelines and refineries; heat waves and A/C demands; tundra and pipelines; mountain glaciers and hydropower; sea level rise and nuclear plants; and, biofuels and storms and drought.

Promote the notion that mitigation needs to begin immediately, including regarding development already in the pipeline, and encourage the development of regulatory structures and policy frameworks for ocean-based hydrokinetic energy sources. Examine existing and proposed models for offshore wind power grid integration and how they could be applied elsewhere.

Promote a preference in marine spatial planning programs for more developed renewable energy sources in certain areas, such as offshore wind, based on determined production potentials.

Promote the development of financing mechanisms for pilot projects in ocean-based hydrokinetic energy sources, such as wave, tidal, and current energy, and ocean thermal energy conversion to further develop energy production capacity.

Focus on identifying and implementing practical and cost-effective approaches, as well as the creation of incentives for funding and policy adaptation to facilitate the development of the industry, and clarify and implement actions that can be taken in the near-term.

Train personnel and seek advice on the most appropriate approaches, particularly in developing nations and Small Island Developing States, and support regional initiatives and frameworks for renewable energy production in Small Island Developing States.

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Chapter 10
Oceans and Climate Change: Mobilizing the Public and the Private Sector for Action

10. Oceans, Climate Change and the Public: Mobilizing the Public and the Private Sector for Action

By Miriam Balgos, Biliana Cicin-Sain, and Joseph Appiott, University of Delaware and Global Forum on Oceans, Coasts, and Islands; Manuel Cira and Philippe Vallette, World Ocean Network and NAUSICAA Centre National de la Mer, France; Christophe Lefebvre, French Marine Protected Areas Agency and IUCN; and Peter Neill, World Ocean Observatory

Context and importance of the problem

The UNFCCC recognizes the importance of public education in achieving the goals of the Convention and the Kyoto Protocol. Article 6 (Education, Training and Public Awareness) of the Convention "calls on governments to promote the development and implementation of educational and public awareness programs, promote public access to information and public participation, and promote training of scientific, technical and managerial personnel" (UNFCCC n.d.). The Kyoto Protocol calls on Parties to cooperate in and promote, at the national and international levels, the development and implementation of educational and training programs, including the strengthening of national capacity building; and to facilitate, at the national level, public awareness and public access to information (UNFCCC n.d.).

The Earth Summit in Rio de Janeiro in 1992 led to the designation of 1998 as the first International Year of the Ocean and a year later the General Assembly of the Intergovernmental Oceanographic Commission of UNESCO "emphasized that the IOC should promote initiatives in the field of education by establishing partnerships with […] other organizations with expertise in this area [considering] the importance of both environmental education and public awareness of marine affairs." The 2002 World Summit on Sustainable Development in Johannesburg broadened the concept of sustainable development and confirmed the education objectives of the Millennium Development Goals and the Dakar Framework of Action toward education for all. As a result, the Decade of Education for Sustainable Development (DESD) was officially adopted by the 57th UN General Assembly in December 2002 for the period 2005-2014 to:

1. Learn about and deepen awareness of environment issues and problems
2. Reflect on our modes of living, shifting these toward sustainability
3. Empower people to take concrete actions to resolve the environmental challenges they face

National strategies for addressing climate change can only succeed with the full engagement of the general public and major stakeholders, who need to be persuaded to adjust their activities in a way that reduces their direct emissions. There are several tools for gaining public support, including: 1) Policies to raise the cost of activities that emit GHGs and reduce the costs of similar activities that do not; 2) Regulations and standards that mandate changes in products and practices; and 3) Taxes and subsidies that are modified to influence behavior. Public information and education is essential for generating public support for such policies and encourage voluntary changes in habits that will lead to lower emissions (UNFCCC 1994). This is also mentioned in national strategies in the framework of the DESD.

Many governments, intergovernmental and non-governmental organizations (IGOs and NGOs) are already working actively to raise awareness. The scale of the changes required to significantly reduce CO2 in the atmosphere, and the vast number of people and interests that must be influenced, call for outreach activities of a much greater magnitude than is currently being done (UNFCCC n.d.). Public education is also needed on the implications of climate change for the world's oceans and coastal communities, the role of the oceans in climate change phenomena, the prospects for mitigation and adaptation measures that use the oceans, and the need for stakeholders to commit to measures that address the role of the oceans in regulating climate change.

To date, public understanding of the "implications" of climate change has been confused by counter-arguments questioning the science by special interests, focused on certain outcomes such as melting of polar caps, sea level rise, and storm frequency and intensity Acidification, for example has received far less attention, only now coming to the fore in the context of the deterioration of coral reefs. Additional climate effect on the marine food chain is another example, infrequently mentioned in the consideration of the fisheries crisis. The point here is that the public has become aware of limited climate issues incrementally and in a limited manner. There has been no coherent attempt to explain the integrated systems, inter-related impacts, and cross-cutting social consequences of the process going forward. Just as narrow causes and effects are addressed, equally narrowly defined mitigation options must also be addressed. Until this larger perspective is established as the core message and motivating strategy, increasing public awareness, continuing misunderstanding, lack of political will, and indifference will result.

It has also been shown that people do not just passively receive new information; they actually fit new information to their existing cultural models and concepts. People apparently understand global warming, for example, by reference to their earlier experience of natural fluctuations in temperature and to their understanding of pollution, ozone depletion, and photosynthesis and respiration. Therefore, it has been recommended that communication initiatives with the public regarding global environmental change should take into consideration their pre-existing models and concepts (Kempton et al. 1995).

UNFCCC Actions Aimed at Encouraging Public Involvement

At COP 8 (New Delhi, October/November 2002), Parties adopted the "New Delhi Work Programme" on Article 6 of the Convention, a five-year country-driven work programme engaging all stakeholders, and recommending a list of activities that could be undertaken at the national level to facilitate the implementation of Article 6 activities.

To further develop and implement the New Delhi Work Programme, Parties requested the UNFCCC Secretariat to:

- *Facilitate regional workshops that could advance the work on assessing needs, identifying priorities, sharing experience and exchanging information on related activities; and*
- *Work on an information clearing house that would include information on existing resources* (UNFCCC n.d.).

To date, four regional workshops of this type have been organized in Europe, Africa, Latin America and the Caribbean, and Asia and the Pacific region, as well as an additional workshop dedicated to the small island developing States (SIDS). A UNFCCC report provides a synthesis of lessons learned and opportunities that have been discussed in these forums, and sets down possible elements of a new strategic approach that emerged from the workshops and that would reinforce the current framework offered by New Delhi Work Programme (UNFCCC 2006). A prototype information network clearinghouse (CC:iNet) was launched at COP 11, November 2005, in Montreal, which serves as a clearinghouse for information sources on public information, education and training in the field of climate change designed to help governments, organizations and individuals gain access to ideas, strategies, contacts, experts and materials that can be used to motivate and empower people to take effective action on climate change (UNFCCC n.d.).

Based on the recommendations of the UNFCCC Subsidiary Body for Implementation at its twenty-seventh session in Bali in December 2007, the COP, at its thirteenth session in Bali in December 2007, adopted the amended New Delhi Work Programme for a further five years. A review of the work programme will be undertaken in 2012, with an intermediate review of progress in 2010, to evaluate its effectiveness and identify emerging gaps. The UNFCCC Secretariat was also mandated to organize thematic regional and subregional workshops to share lessons learned and best practices, prior to the intermediate review of the work programme in 2010. The SBI also determined that the prototype clearinghouse (CC:iNet) is an important tool for promoting the implementation of Article 6 and invited the UNFCCC secretariat to further enhance CC:iNet in line with the evaluation report (FCCC/SBI/2007/26).

It seems that there is limited advancement of the New Delhi program because there has been no specific arrangement for funding of these activities under the program (ILO no date). The successor agreement to the Kyoto Protocol should include explicit language about the need to include public education and outreach activities in the funding mechanisms. Furthermore, there is a need to specify the need to fund public outreach activities that 1) promote appropriate individual and social behavior to ensure that the ecological role and functions of the oceans in climate regulation are maintained; 2) encourage public support for appropriate mitigation and adaptation efforts that use the oceans.

It is important here to differentiate between public education and public outreach. The former typically refers to formal programs in schools, a necessary component, but not the same in terms of who does it and how it is done. Climate change, at least in much of the developed world, is finding its way into curriculum in science, environmental studies, and sometimes economics. There are efforts in the US, Europe, India, and Japan, among others, where that change is underway. The problem is with the larger public and the strategy is different.

World Ocean Network Initiatives
The World Ocean Network (WON), initiated in 2002, is an international awareness-raising alliance of aquariums, science and education centres, and NGOs that cooperate to foster sustainable use of the ocean through the promotion of stewardship of the "World Ocean." Today, WON convenes more than 250 organisations all over the world, which welcome 150 - 200 million visitors per year. Each of these institutions works locally, but the development of partnerships and the common work realised by the network allows a worldwide impact.

Public outreach requires broad-based, continuous messaging using media that penetrates both formal education and informal awareness. There are a number of effective international networks contributing to public discussion of oceans and climate issues. The founding principle for the World Ocean Observatory (recommended by the 1998 Independent World Commission on the Future of the Ocean) was just that: to build an openly accessible, science-based place of exchange about the ocean defined as "an integrated, global, social system. The W2O Climate Change event (see www.thew2o.net/events/climatechange/index.html) attempts to create such a place of climate and ocean which, with modest additional resources can not only be expanded in content but also "distributed" proactively through a communications network built from existing networks of government agencies, education organizations, cultural institutions, environmental centers, and individuals worldwide.

"Caring for the Blue Planet, you can make a difference. Think of the significant difference 6 billion of us can make" is the slogan that has been adopted as a common message to inspire behaviour change. Aquariums and natural science museums play a key role in informing citizens about the need for sustainable consumer behavior. A public survey, Oceanics, conducted by European aquariums and science centres in 2003 confirmed a general public's need for better information about human impact on the ocean and about what concrete action could be taken to protect it. The survey further showed that the general public considers aquariums and scientific museums as the most trustworthy sources of information about sea. They are believed to be more reliable than TV and newspapers.

Active in involving younger generations in public discussions, the World Ocean Network promotes various youth groups in addressing ocean issues. The first Ocean Parliament, jointly convened by the International Ocean Institute and the World Ocean Network, devised a set of recommendations that could facilitate the international community in meeting its climate change mitigation commitments. These recommendations focus primarily on the enforcement of decisions and accountability in that respect, increasing security for coastal populations, enhancing cooperation between developed and developing countries, and providing a strong educational framework to prevent further degradation of the environment by future generations.

The European Youth Ocean Forum, also hosted by the World Ocean Network and convened in 2007, voiced its desire to encourage educational programs, increased accessibility to information, and increased transparency in support of greater cooperation among scientists, citizens, and policymakers.

Growing Public Concern Regarding Climate Change and Global Forum Recommendations for Action to Inform the Public

According to the 2008 research by IMPACTS[1] on public awareness, attitudes and behaviours concerning global climate change, energy independence, lower energy costs and slowing global warming rank 3rd, 4th and 6th among the US priority issues while global warming, sustainable energy and air pollution come 1st, 2nd and 3rd of current environmental issues. According to the OCEANICS survey, 74% of people asked in 2003 about environmental issues ranked air and land pollution 1st, 2nd or 3rd and 58% ranked climate change 1st, 2nd or 3rd.

Responses must be developed to address this growing concern and to educate the public as to how to act responsibly and make wise choices at the individual and community levels. The Global Forum on Oceans, Coasts and Islands Working Groups all acknowledge that:

- More accurate media information on ocean matters is needed;
- "The public is part of the solution" – in their everyday life and in decision-making processes; and
- Traditional knowledge and cultural heritage are important.

It has been emphasized that climate variability and its impact on the ocean and the ocean's impact on climate have to be explained to the public and media. The Global Forum Working Group on Climate, Oceans and Security more specifically recommends:

- To explain mechanisms and prepare public opinion for the impacts of climate change
- To mainstream adaptation to climate change within all stakeholders
- To make sure that climate variability, its impact on the ocean, and the ocean's impact on climate are understood and taken into account
- To promote sustainable consumption and production pattern and promote renewable energy to reduce GHG emissions

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[1] 2008 research by IMPACTS for a collaborative project between the Ocean Project, Monterey Bay Aquarium and National Aquarium in Baltimore.

To meet these recommendations, World Ocean Network participants and partners are planning to implement a series of activities in 2009-2010, in the spirit of the UN Decade of Education for Sustainable Development 2005-2014. Following the lines of its initial promoters, the Decade of Education for Sustainable Development is designed to educate and deepen awareness of environmental issues and problems, reflect on our models of living, renewing these towards sustainability, and empower people to take concrete actions to involve the challenges they face.

Learn and Deepen Awareness of Environmental Issues and Problems

The promotion of the concept of the "World Ocean" demonstrates that one ocean exists as the life support system on Earth and that everyone needs to care for it.
By mobilising thousands of professionals, the objective is to reach millions of people throughout the world with this message.

1. Organisation of workshops to mobilise stakeholders and information and education for professionals:

- In the framework of the World Ocean Conference Global Policy Day, 11-13 May 2009 World Ocean Conference, Climate Change Impacts on Oceans and the Role of Oceans in Climate Change, Manado, Indonesia
- In association with the European ACCENT (Action on Climate Change though Engagement, Networks and Tools) Initiative, September 2009, Rovaniemi, Finland
- In association with COLACMAR (13th Latin American Congress on Marine Sciences), 26-30 October 2009, Havana, Cuba
- In association with the East Asian Seas Congress, Partnerships at Work: Local Implementation and Good Practices, 23-27 November 2009, Manila, Philippines,
- In parallel with COP15, The 15th Annual Conference of the Parties under the United Nations Framework Convention on Climate Change, 7-18 December 2009, Copenhagen, Denmark
- World Ocean International Academy for educators as well as media in 2010, following the 5th Global Conference on Oceans, Coasts and Islands, May, Boulogne sur Mer, France.

2. Promotion of online resources to provide professionals with facts and figures and activities to reach their audiences:

- IGLO (International Action on Global Warming) / ASTC (Association of Science-Technology Centers) toolkit
- World Ocean Observatory events' section and a regular update of the Ocean Info Pack developed in English, French, Spanish by WON in the frame of the Global Forum action towards the implementation of the WSSD Action Plan of Implementation

An information display will also be exhibited at the UNFCCC preparatory conference, 1-12 June 2009, Bonn, Germany**.** The exhibition will be dedicated to the activities in relation to climate change organised on World Ocean Day. It will be the first opportunity to highlight WON contributions to Ocean Day and to show decisionmakers how important public information is for climate-related matters and to call for their support for a stronger outreach effort toward citizens in order to empower them in their everyday life.

Network jointly with other partners such as the Ocean Project

World Ocean Day will be celebrated on June 8 with the common international theme: "***One Ocean, One Climate, One Future"***. The celebration of the World Ocean Day has been strongly promoted by the World Ocean World Ocean Day, which has just been designated by the UN General Assembly as an official international day. It is recognized that it is high time to mobilise new participants, especially stakeholders, so that state agencies, research institutes, corporate businesses, etc. also celebrate and support World Ocean Day and help to raise the awareness of millions of citizens to climate change related issues.

Reflect on Our Modes of Living, Renewing These Toward Sustainability

If we change our behaviour we can reduce GHG emissions by 50 %. According to the IMPACTS survey, when it comes to climate change over 61 % of all ages, over 80 % of 12-18 years old think that the actions of individual people can make a positive difference. In order to help achieve this objective, the World Ocean Network is promoting the Citizenship of the "World Ocean," as symbolised by the Passport of the Citizen of the Ocean, the emblem of a community of citizens who care for the ocean.

- In becoming a Citizen of the Ocean, the individuals agree to reflect on their way of life, to adopt a new behaviour toward the ocean, and to carry out a number of actions e.g.: "I use the most energy efficient form of transportation (…); I try to convince friends and professional colleagues to do the same."
  To help the Citizens of the Ocean share their experiences and take further actions a newsletter is circulated and specific web pages for the Citizens of the Ocean are created on the WON portal.

- Over 500, 000 copies of the Passport of the Citizen of the Ocean have been printed in two versions adapted to adults (in 8 languages) and children (in 4 languages) – including English, French, Japanese, Portuguese, and Spanish.
  The first Indonesian version will be printed on the occasion of the WOC'09.
  The first Chinese version will be printed on the occasion of World Ocean Day, June 8, 2009.

- The most active Citizens of the Ocean will be acknowledged as Ambassadors of the Ocean on World Ocean Day, thus becoming spokespersons for ocean and climate related positive actions.

Empower People to Take Concrete Actions to Resolve the Challenges They Face

Public debates equip individual citizens with the understanding, skills, and knowledge that enable them to perform their role effectively. They facilitate discussion about both existing problems and ways of life and they are an opportunity to involve the general public in decision-making processes.

This year and next, debates will be organised with stakeholders and the public to discuss ocean and climate change issues in line with UNFCCC negotiations and to help to implement decisions made at COP 15:

- Global Forum on Oceans, Coasts and Islands - Channel and North Sea approach, 9-11 June 2009, Boulogne sur Mer, France
- 30 ACCENT Local Citizens Debates in 15 aquariums and science centres throughout Europe along 2010.

Youth Parliaments for the Ocean are aimed at enhancing the involvement of young people in ocean stewardship and governance. As future consumers, decision makers, managers, and users of marine resources, young people can play a significant role in securing their future and that of generations to come.

In 2009, two Youth Parliaments are already planned:

- World Ocean Network Youth Forum, Ocean, Climate and Our Future, 12-16 May and 8 June 2009, Reunion Island
- 2nd EAS Youth Forum**,** Youth of the East Asian Seas Region and Climate Change, 23-27 November 2009, Manila, Philippines.

Mobilizing the Private Sector

In addition to public awareness of and involvement in ocean and environmental issues, mobilizing the private sector to address the oceans and climate issues is a top priority. Private industries should be encouraged to engage in addressing oceans and climate issues through market-based and other non-regulatory mechanisms in partnership with environmental organizations.

A good example of private involvement in promoting ocean and coastal health is an alliance formed in 1998 in which a private group, Groupe Danone, along with EVIAN, one of its businesses, committed support to the RAMSAR Convention on Wetlands of International Importance. Following ten years of fruitful collaboration, the two partnered with the World Conservation Union (IUCN) in 2008 to work collaboratively to restore natural environments. The Groupe Danone's recent creation of a "Danone Fund for Nature", a financing mechanism for mangrove restoration, also provides a good example for how private companies, once initially involved in the environmental action sphere, provide potential for continued cooperation and support. This project, which will be implemented by Oceanium, a Senegalese non-governmental organization, is poised to plant 500 hectares of mangroves into 400 villages, which will subsequently be designated as a marine protected area. This project will provide multiple benefits in the form of poverty reduction by employment and sustainable use of mangrove products, recovery of biodiversity, and carbon sequestration for climate change mitigation.

Recommendations

For the UNFCCC:

There is a need to develop and implement effective strategies for communication and for mobilizing public involvement at all levels and in all sectors of society to facilitate stakeholder discussion and to devise and implement solutions.

Funding to support public education and outreach strategies should be included under the Adaptation Fund.

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10. Oceans, Climate Change and the Public: Mobilizing the Public and the Private Sector for Action

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Context and importance of the problem

The UNFCCC recognizes the importance of public education in achieving the goals of the Convention and the Kyoto Protocol. Article 6 (Education, Training and Public Awareness) of the Convention "calls on governments to promote the development and implementation of educational and public awareness programs, promote public access to information and public participation, and promote training of scientific, technical and managerial personnel" (UNFCCC n.d.). The Kyoto Protocol calls on Parties to cooperate in and promote, at the national and international levels, the development and implementation of educational and training programs, including the strengthening of national capacity building; and to facilitate, at the national level, public awareness and public access to information (UNFCCC n.d.).

The Earth Summit in Rio de Janeiro in 1992 led to the designation of 1998 as the first International Year of the Ocean and a year later the General Assembly of the Intergovernmental Oceanographic Commission of UNESCO "emphasized that the IOC should promote initiatives in the field of education by establishing partnerships with […] other organizations with expertise in this area [considering] the importance of both environmental education and public awareness of marine affairs." The 2002 World Summit on Sustainable Development in Johannesburg broadened the concept of sustainable development and confirmed the education objectives of the Millennium Development Goals and the Dakar Framework of Action toward education for all. As a result, the Decade of Education for Sustainable Development (DESD) was officially adopted by the 57th UN General Assembly in December 2002 for the period 2005-2014 to:

1. Learn about and deepen awareness of environment issues and problems
2. Reflect on our modes of living, shifting these toward sustainability
3. Empower people to take concrete actions to resolve the environmental challenges they face

National strategies for addressing climate change can only succeed with the full engagement of the general public and major stakeholders, who need to be persuaded to adjust their activities in a way that reduces their direct emissions. There are several tools for gaining public support, including: 1) Policies to raise the cost of activities that emit GHGs and reduce the costs of similar activities that do not; 2) Regulations and standards that mandate changes in products and practices; and 3) Taxes and subsidies that are modified to influence behavior. Public information and education is essential for generating public support for such policies and encourage voluntary changes in habits that will lead to lower emissions (UNFCCC 1994). This is also mentioned in national strategies in the framework of the DESD.

Many governments, intergovernmental and non-governmental organizations (IGOs and NGOs) are already working actively to raise awareness. The scale of the changes required to significantly reduce CO2 in the atmosphere, and the vast number of people and interests that must be influenced, call for outreach activities of a much greater magnitude than is currently being done (UNFCCC n.d.). Public education is also needed on the implications of climate change for the world's oceans and coastal communities, the role of the oceans in climate change phenomena, the prospects for mitigation and adaptation measures that use the oceans, and the need for stakeholders to commit to measures that address the role of the oceans in regulating climate change.

To date, public understanding of the "implications" of climate change has been confused by counter-arguments questioning the science by special interests, focused on certain outcomes such as melting of polar caps, sea level rise, and storm frequency and intensity Acidification, for example has received far less attention, only now coming to the fore in the context of the deterioration of coral reefs. Additional climate effect on the marine food chain is another example, infrequently mentioned in the consideration of the fisheries crisis. The point here is that the public has become aware of limited climate issues incrementally and in a limited manner. There has been no coherent attempt to explain the integrated systems, inter-related impacts, and cross-cutting social consequences of the process going forward. Just as narrow causes and effects are addressed, equally narrowly defined mitigation options must also be addressed. Until this larger perspective is established as the core message and motivating strategy, increasing public awareness, continuing misunderstanding, lack of political will, and indifference will result.

It has also been shown that people do not just passively receive new information; they actually fit new information to their existing cultural models and concepts. People apparently understand global warming, for example, by reference to their earlier experience of natural fluctuations in temperature and to their understanding of pollution, ozone depletion, and photosynthesis and respiration. Therefore, it has been recommended that communication initiatives with the public regarding global environmental change should take into consideration their pre-existing models and concepts (Kempton et al. 1995).

UNFCCC Actions Aimed at Encouraging Public Involvement

At COP 8 (New Delhi, October/November 2002), Parties adopted the "New Delhi Work Programme" on Article 6 of the Convention, a five-year country-driven work programme engaging all stakeholders, and recommending a list of activities that could be undertaken at the national level to facilitate the implementation of Article 6 activities.

To further develop and implement the New Delhi Work Programme, Parties requested the UNFCCC Secretariat to:

- *Facilitate regional workshops that could advance the work on assessing needs, identifying priorities, sharing experience and exchanging information on related activities; and*
- *Work on an information clearing house that would include information on existing resources* (UNFCCC n.d.).

To date, four regional workshops of this type have been organized in Europe, Africa, Latin America and the Caribbean, and Asia and the Pacific region, as well as an additional workshop dedicated to the small island developing States (SIDS). A UNFCCC report provides a synthesis of lessons learned and opportunities that have been discussed in these forums, and sets down possible elements of a new strategic approach that emerged from the workshops and that would reinforce the current framework offered by New Delhi Work Programme (UNFCCC 2006). A prototype information network clearinghouse (CC:iNet) was launched at COP 11, November 2005, in Montreal, which serves as a clearinghouse for information sources on public information, education and training in the field of climate change designed to help governments, organizations and individuals gain access to ideas, strategies, contacts, experts and materials that can be used to motivate and empower people to take effective action on climate change (UNFCCC n.d.).

Based on the recommendations of the UNFCCC Subsidiary Body for Implementation at its twenty-seventh session in Bali in December 2007, the COP, at its thirteenth session in Bali in December 2007, adopted the amended New Delhi Work Programme for a further five years. A review of the work programme will be undertaken in 2012, with an intermediate review of progress in 2010, to evaluate its effectiveness and identify emerging gaps. The UNFCCC Secretariat was also mandated to organize thematic regional and subregional workshops to share lessons learned and best practices, prior to the intermediate review of the work programme in 2010. The SBI also determined that the prototype clearinghouse (CC:iNet) is an important tool for promoting the implementation of Article 6 and invited the UNFCCC secretariat to further enhance CC:iNet in line with the evaluation report (FCCC/SBI/2007/26).

It seems that there is limited advancement of the New Delhi program because there has been no specific arrangement for funding of these activities under the program (ILO no date). The successor agreement to the Kyoto Protocol should include explicit language about the need to include public education and outreach activities in the funding mechanisms. Furthermore, there is a need to specify the need to fund public outreach activities that 1) promote appropriate individual and social behavior to ensure that the ecological role and functions of the oceans in climate regulation are maintained; 2) encourage public support for appropriate mitigation and adaptation efforts that use the oceans.

It is important here to differentiate between public education and public outreach. The former typically refers to formal programs in schools, a necessary component, but not the same in terms of who does it and how it is done. Climate change, at least in much of the developed world, is finding its way into curriculum in science, environmental studies, and sometimes economics. There are efforts in the US, Europe, India, and Japan, among others, where that change is underway. The problem is with the larger public and the strategy is different.

World Ocean Network Initiatives

The World Ocean Network (WON), initiated in 2002, is an international awareness-raising alliance of aquariums, science and education centres, and NGOs that cooperate to foster sustainable use of the ocean through the promotion of stewardship of the "World Ocean." Today, WON convenes more than 250 organisations all over the world, which welcome 150 - 200 million visitors per year. Each of these institutions works locally, but the development of partnerships and the common work realised by the network allows a worldwide impact.

Public outreach requires broad-based, continuous messaging using media that penetrates both formal education and informal awareness. There are a number of effective international networks contributing to public discussion of oceans and climate issues. The founding principle for the World Ocean Observatory (recommended by the 1998 Independent World Commission on the Future of the Ocean) was just that: to build an openly accessible, science-based place of exchange about the ocean defined as "an integrated, global, social system. The W2O Climate Change event (see www.thew2o.net/events/climatechange/index.html) attempts to create such a place of climate and ocean which, with modest additional resources can not only be expanded in content but also "distributed" proactively through a communications network built from existing networks of government agencies, education organizations, cultural institutions, environmental centers, and individuals worldwide.

"Caring for the Blue Planet, you can make a difference. Think of the significant difference 6 billion of us can make" is the slogan that has been adopted as a common message to inspire behaviour change. Aquariums and natural science museums play a key role in informing citizens about the need for sustainable consumer behavior. A public survey, Oceanics, conducted by European aquariums and science centres in 2003 confirmed a general public's need for better information about human impact on the ocean and about what concrete action could be taken to protect it. The survey further showed that the general public considers aquariums and scientific museums as the most trustworthy sources of information about sea. They are believed to be more reliable than TV and newspapers.

Active in involving younger generations in public discussions, the World Ocean Network promotes various youth groups in addressing ocean issues. The first Ocean Parliament, jointly convened by the International Ocean Institute and the World Ocean Network, devised a set of recommendations that could facilitate the international community in meeting its climate change mitigation commitments. These recommendations focus primarily on the enforcement of decisions and accountability in that respect, increasing security for coastal populations, enhancing cooperation between developed and developing countries, and providing a strong educational framework to prevent further degradation of the environment by future generations.

The European Youth Ocean Forum, also hosted by the World Ocean Network and convened in 2007, voiced its desire to encourage educational programs, increased accessibility to information, and increased transparency in support of greater cooperation among scientists, citizens, and policymakers.

Growing Public Concern Regarding Climate Change and Global Forum Recommendations for Action to Inform the Public

According to the 2008 research by IMPACTS[1] on public awareness, attitudes and behaviours concerning global climate change, energy independence, lower energy costs and slowing global warming rank 3rd, 4th and 6th among the US priority issues while global warming, sustainable energy and air pollution come 1st, 2nd and 3rd of current environmental issues. According to the OCEANICS survey, 74% of people asked in 2003 about environmental issues ranked air and land pollution 1st, 2nd or 3rd and 58% ranked climate change 1st, 2nd or 3rd.

Responses must be developed to address this growing concern and to educate the public as to how to act responsibly and make wise choices at the individual and community levels. The Global Forum on Oceans, Coasts and Islands Working Groups all acknowledge that:

- More accurate media information on ocean matters is needed;
- "The public is part of the solution" – in their everyday life and in decision-making processes; and
- Traditional knowledge and cultural heritage are important.

It has been emphasized that climate variability and its impact on the ocean and the ocean's impact on climate have to be explained to the public and media. The Global Forum Working Group on Climate, Oceans and Security more specifically recommends:

- To explain mechanisms and prepare public opinion for the impacts of climate change
- To mainstream adaptation to climate change within all stakeholders
- To make sure that climate variability, its impact on the ocean, and the ocean's impact on climate are understood and taken into account
- To promote sustainable consumption and production pattern and promote renewable energy to reduce GHG emissions

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[1] 2008 research by IMPACTS for a collaborative project between the Ocean Project, Monterey Bay Aquarium and National Aquarium in Baltimore.

To meet these recommendations, World Ocean Network participants and partners are planning to implement a series of activities in 2009-2010, in the spirit of the UN Decade of Education for Sustainable Development 2005-2014. Following the lines of its initial promoters, the Decade of Education for Sustainable Development is designed to educate and deepen awareness of environmental issues and problems, reflect on our models of living, renewing these towards sustainability, and empower people to take concrete actions to involve the challenges they face.

Learn and Deepen Awareness of Environmental Issues and Problems

The promotion of the concept of the "World Ocean" demonstrates that one ocean exists as the life support system on Earth and that everyone needs to care for it.
By mobilising thousands of professionals, the objective is to reach millions of people throughout the world with this message.

1. Organisation of workshops to mobilise stakeholders and information and education for professionals:
- In the framework of the World Ocean Conference Global Policy Day, 11-13 May 2009 World Ocean Conference, Climate Change Impacts on Oceans and the Role of Oceans in Climate Change, Manado, Indonesia
- In association with the European ACCENT (Action on Climate Change though Engagement, Networks and Tools) Initiative, September 2009, Rovaniemi, Finland
- In association with COLACMAR (13th Latin American Congress on Marine Sciences), 26-30 October 2009, Havana, Cuba
- In association with the East Asian Seas Congress, Partnerships at Work: Local Implementation and Good Practices, 23-27 November 2009, Manila, Philippines,
- In parallel with COP15, The 15th Annual Conference of the Parties under the United Nations Framework Convention on Climate Change, 7-18 December 2009, Copenhagen, Denmark
- World Ocean International Academy for educators as well as media in 2010, following the 5th Global Conference on Oceans, Coasts and Islands, May, Boulogne sur Mer, France.

2. Promotion of online resources to provide professionals with facts and figures and activities to reach their audiences:
- IGLO (International Action on Global Warming) / ASTC (Association of Science-Technology Centers) toolkit
- World Ocean Observatory events' section and a regular update of the Ocean Info Pack developed in English, French, Spanish by WON in the frame of the Global Forum action towards the implementation of the WSSD Action Plan of Implementation

An information display will also be exhibited at the UNFCCC preparatory conference, 1-12 June 2009, Bonn, Germany**.** The exhibition will be dedicated to the activities in relation to climate change organised on World Ocean Day. It will be the first opportunity to highlight WON contributions to Ocean Day and to show decisionmakers how important public information is for climate-related matters and to call for their support for a stronger outreach effort toward citizens in order to empower them in their everyday life.

Network jointly with other partners such as the Ocean Project
World Ocean Day will be celebrated on June 8 with the common international theme: "***One Ocean, One Climate, One Future***". The celebration of the World Ocean Day has been strongly promoted by the World Ocean World Ocean Day, which has just been designated by the UN General Assembly as an official international day. It is recognized that it is high time to mobilise new participants, especially stakeholders, so that state agencies, research institutes, corporate businesses, etc. also celebrate and support World Ocean Day and help to raise the awareness of millions of citizens to climate change related issues.

Reflect on Our Modes of Living, Renewing These Toward Sustainability
If we change our behaviour we can reduce GHG emissions by 50 %. According to the IMPACTS survey, when it comes to climate change over 61 % of all ages, over 80 % of 12-18 years old think that the actions of individual people can make a positive difference. In order to help achieve this objective, the World Ocean Network is promoting the Citizenship of the "World Ocean," as symbolised by the Passport of the Citizen of the Ocean, the emblem of a community of citizens who care for the ocean.

- In becoming a Citizen of the Ocean, the individuals agree to reflect on their way of life, to adopt a new behaviour toward the ocean, and to carry out a number of actions e.g.: "I use the most energy efficient form of transportation (…); I try to convince friends and professional colleagues to do the same."
  To help the Citizens of the Ocean share their experiences and take further actions a newsletter is circulated and specific web pages for the Citizens of the Ocean are created on the WON portal.

- Over 500, 000 copies of the Passport of the Citizen of the Ocean have been printed in two versions adapted to adults (in 8 languages) and children (in 4 languages) – including English, French, Japanese, Portuguese, and Spanish.
  The first Indonesian version will be printed on the occasion of the WOC'09.
  The first Chinese version will be printed on the occasion of World Ocean Day, June 8, 2009.

- The most active Citizens of the Ocean will be acknowledged as Ambassadors of the Ocean on World Ocean Day, thus becoming spokespersons for ocean and climate related positive actions.

Empower People to Take Concrete Actions to Resolve the Challenges They Face
Public debates equip individual citizens with the understanding, skills, and knowledge that enable them to perform their role effectively. They facilitate discussion about both

existing problems and ways of life and they are an opportunity to involve the general public in decision-making processes.

This year and next, debates will be organised with stakeholders and the public to discuss ocean and climate change issues in line with UNFCCC negotiations and to help to implement decisions made at COP 15:

- Global Forum on Oceans, Coasts and Islands - Channel and North Sea approach, 9-11 June 2009, Boulogne sur Mer, France
- 30 ACCENT Local Citizens Debates in 15 aquariums and science centres throughout Europe along 2010.

Youth Parliaments for the Ocean are aimed at enhancing the involvement of young people in ocean stewardship and governance. As future consumers, decision makers, managers, and users of marine resources, young people can play a significant role in securing their future and that of generations to come.

In 2009, two Youth Parliaments are already planned:

- World Ocean Network Youth Forum, Ocean, Climate and Our Future, 12-16 May and 8 June 2009, Reunion Island
- 2nd EAS Youth Forum**,** Youth of the East Asian Seas Region and Climate Change, 23-27 November 2009, Manila, Philippines.

Mobilizing the Private Sector

In addition to public awareness of and involvement in ocean and environmental issues, mobilizing the private sector to address the oceans and climate issues is a top priority. Private industries should be encouraged to engage in addressing oceans and climate issues through market-based and other non-regulatory mechanisms in partnership with environmental organizations.

A good example of private involvement in promoting ocean and coastal health is an alliance formed in 1998 in which a private group, Groupe Danone, along with EVIAN, one of its businesses, committed support to the RAMSAR Convention on Wetlands of International Importance. Following ten years of fruitful collaboration, the two partnered with the World Conservation Union (IUCN) in 2008 to work collaboratively to restore natural environments. The Groupe Danone's recent creation of a "Danone Fund for Nature", a financing mechanism for mangrove restoration, also provides a good example for how private companies, once initially involved in the environmental action sphere, provide potential for continued cooperation and support. This project, which will be implemented by Oceanium, a Senegalese non-governmental organization, is poised to plant 500 hectares of mangroves into 400 villages, which will subsequently be designated as a marine protected area. This project will provide multiple benefits in the form of poverty reduction by employment and sustainable use of mangrove products, recovery of biodiversity, and carbon sequestration for climate change mitigation.

Recommendations

For the UNFCCC:

There is a need to develop and implement effective strategies for communication and for mobilizing public involvement at all levels and in all sectors of society to facilitate stakeholder discussion and to devise and implement solutions.

Funding to support public education and outreach strategies should be included under the Adaptation Fund.

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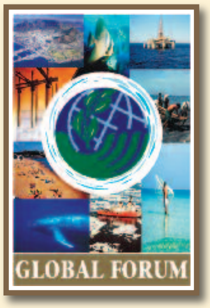

About the Global Forum on Oceans, Coasts, and Islands

The Global Forum on Oceans, Coasts, and Islands was first mobilized in 2001 to help the world's governments highlight issues related to oceans, coasts, and Small Island Developing States (SIDS) on the agenda of the 2002 World Summit on Sustainable Development (WSSD), and was later formalized at the WSSD in Johannesburg. The Global Forum is a response to perceived needs:

- for fostering cross-sectoral dialogue on ocean issues among governments, NGOs, international organizations, and the private and scientific sectors
- for constant advocacy for oceans at the highest political levels
- for taking an ecosystem-based and integrated approach to oceans governance at national, regional, and global levels

Since 2001, the Global Forum has involved ocean experts representing all sectors from 105 countries to advance the global oceans agenda by: 1) promoting the implementation of international agreements related to oceans, coasts, and SIDS, especially the goals emanating from the 2002 WSSD; 2) analyzing new emerging issues such as improving the governance regime for ocean areas beyond national jurisdiction and addressing the impacts of climate change; and 3) promoting international consensus-building on unresolved ocean issues.

The Global Forum has organized four Global Conferences (in 2001, 2003, and 2006 at UNESCO in Paris and in 2008 in Hanoi, Vietnam); organized the Ocean Policy Summit in Lisbon in 2005 documenting experiences with integrated oceans governance in countries and regions around the world; prepared a number of "report cards" on the implementation of the WSSD ocean targets and of the 1994 Barbados Programme of Action for SIDS; reports on ocean issues in island states; reports on capacity development needs on ocean and coastal management in different world regions; and provided a series of Internet information services, including periodic newsletters.

In late 2006, the Global Forum began a strategic planning effort in collaboration with governments, United Nations agencies, NGOs, industry, and scientific groups, to advance the global oceans agenda over the ten-year period to 2016. Twelve Multinational Expert Working Groups, involving 254 experts from 72 countries, are considering the major global oceans issues, identifying strategic opportunities for advancing the global goal/target in the next decade, and recommending priority action steps for implementation by national and international decisionmakers.

See http://www.globaloceans.org

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