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STRESS, SUSTAINABILITY, AND DEVELOPMENT OF LARGE MARINE ECOSYSTEMS DURING CLIMATE CHANGE: POLICY AND IMPLEMENTATION

Large Marine Ecosystems
Volume 18

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November 2013
Stress, Sustainability, and Development of Large Marine Ecosystems During Climate Change: Policy and Implementation

Editors: Kenneth Sherman, Sara Adams

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Stress, Sustainability, and Development of Large Marine Ecosystems during Climate Change: Policy and Implementation

Edited by Kenneth Sherman and Sara Adams

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FOREWORD

Large Marine Ecosystems (LMEs) annually produce 80 percent of the world's marine fish catch. These coastal ocean areas are overfished; polluted; and subject to nutrient over enrichment, acidification, accelerated warming from climate change, loss of biodiversity and key habitat areas under stress—including sea grasses, mangroves and coral reefs. These stressors are impacting the sustainable development of an estimated $12 trillion in goods and services contributed annually by LMEs to the global economy.

In June 2012, world political leaders at the United Nations Conference on the Environment and Development in Rio de Janeiro (Rio+20) committed to:

". . . *protect, and restore, the health, productivity and resilience of oceans and marine ecosystems, and to maintain their biodiversity, enabling their conservation and sustainable use for present and future generations . . ."*

Consistent with meeting the challenge of Rio, leaders directing the world's top financial, scientific, and technical institutions engaged since the mid-1990s in supporting sustainable development of the oceans, came together at an LME Conference convened at Boston's John F. Kennedy Library on 16 February 2013. They came from Copenhagen, New York, Paris and Washington D.C. to present their pathways towards the recovery and sustainability of LMEs during climate change. Other attendees included invited guests, scientists in Boston for the annual meeting of the American Association for the Advancement of Science, the public, and the press.

The institutional leaders from the National Oceanic and Atmospheric Administration, the Global Environment Facility, the International Council for the Exploration of the Sea, the Intergovernmental Oceanographic Commission of UNESCO and the Environment and Energy Group of the United Nations Development Programme spoke of their institutions' partnerships and their commitment to supporting the recovery and sustainable development of the world's LMEs.

The Global Environment Facility, World Bank, and United Nations are partnering with the international coastal ocean community in providing over $3 billion dollars in financial, scientific, and technical assistance to countries in Asia, Africa, Latin America, the Pacific, and eastern Europe in support of LME projects in over 100 developing countries that are moving toward restoring the health, food security, and economic vitality for billions of people around the globe dependent on LME goods and services.

In addition to the keynote talks of leaders from NOAA, the GEF, ICES, UNDP and IOC-UNESCO on the pathways forward to sustainable development of LMEs, the successful recovery and growth of LME goods and services will require more attention to multi-sectoral agreements for the use of LME space. Multiple uses include hydrokinetic energy, coastal transportation, fisheries, tourism, mining, and gas and oil production. Invited speakers and panelists shared experiences in coastal and marine spatial planning from generic and case study perspectives.

The Conference at the John F. Kennedy Library was followed by a linked LME science symposium on 17 February at the American Association for the Advancement of Science meeting at Boston's Hynes Convention Center with invited speakers providing results of LME case studies where actions have been initiated for moving toward sustainable development of the Benguela Current, Yellow Sea, and Humboldt Current LMEs.

Following reviews of LME presentations made by the world leaders of ocean finance and scientific institutions and experts on marine spatial planning at the JFK Library Conference, and the papers presented at the AAAS meeting, the results have been edited and arranged into eleven chapters presented in this volume. The chapters represent a substantial commitment of scientific partnerships and financial support by the GEF, ICES, UNDP, IOC-UNESCO, and NOAA, towards the recovery and sustainable development of the world's LMEs.

The Editors

Narragansett R.I.

November 2013

MESSAGE FROM THE CHAIRMAN OF THE CONFERENCE AND SYMPOSIUM ORGANIZING COMMITTEE

When deliberating on the venue for the Conference, the Organizing Committee considered it fitting to link the LME policy and management talks and the AAAS LME science presentations to the ideals and challenges of international cooperation pursued by President Kennedy and illustrated throughout the JFK Library and Museum. Whether the challenge was a dramatic stand-down to a global nuclear exchange, or a challenge to place a man on the moon, it was treated by President Kennedy with careful deliberation, resulting in successful outcomes of global significance.

The unprecedented stress and degraded condition of our oceans and especially the intensely used Large Marine Ecosystems around the coasts of the continents presents another challenge of global significance. We are faced with recovering and sustainably developing goods and services of large marine ecosystems contributing trillions of dollars annually to the global economy. It is in President Kennedy's spirit of responding to global challenges that the Conference was convened at the JFK Library and Museum.

The invited speakers share concerns and offer solutions for improving the condition of the world's LMEs. They are leaders in a collaborative international mobilization of scientific and financial support to over 100 developing nations engaged in the recovery and sustainable development of Large Marine Ecosystems in Africa, Asia, Latin America, the Pacific, and eastern Europe.

Kenneth Sherman, Chairman LME Conference
and AAAS LME Symposium Organizing Committee

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We are pleased to acknowledge the financial and logistical support of the Gordon and Betty Moore Foundation, the Global Environment Facility, the United Nations Development Program, NOAA, the International Union for the Conservation of Nature (IUCN), and the wonderful staff support provided by the Kennedy Library and Museum, especially Kate Hanagan, Special Events Coordinator; Nancy Tobin, our Event Coordinator, and Rhonda Elkins and Gail Delano. We are thankful to Nicole Maylett, Meetings Manager; Ginger Pinholster, Director of the Office of Public Programs; and Cassandra Jones, Program Associate for the Office of Public Programs of the American Association for the Advancement of Science (AAAS) for permission to link the LME JFK Library Conference to the annual meeting of the AAAS and the Symposium on Moving Toward Sustainable Development of Large Marine Ecosystems convened at Boston's John Hynes Convention Center.

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PART ONE:

INTERNATIONAL LEADERS WEIGH IN ON LMEs

1

LARGE MARINE ECOSYSTEMS: THE LEADING EDGE OF SCIENCE, MANAGEMENT AND POLICY

Jane Lubchenco, Ph.D.

Under Secretary of Commerce for Oceans and Atmosphere & Administrator, National Oceanic and Atmospheric Administration (NOAA), 2009-2013

On behalf of NOAA, I welcome you to this conference. NOAA is honored to be a part of the remarkable partnerships here today: GEF, ICES, UNDP, IOC-UNESCO. We are grateful to Ken Sherman for his visionary leadership.

It is appropriate that we are gathered here today in the John F. Kennedy Presidential Library. President Kennedy had a keen appreciation for the sea, holistic approaches, science and people.

Today, a number of global challenges threaten our oceans. For centuries, oceans have been our grocery stores, our pharmacies, our playgrounds, our churches and our sources of inspiration. We have long thought of oceans as infinitely vast and bountiful, with an unlimited capacity to absorb wastes and produce seafood. The reality is quite different. Oceans, as vast as they are, have been depleted and disrupted. And they are under increasing threats. Because healthy oceans are essential to human health and well-being, their disruption and depletion is a threat to global sustainability.

The Large Marine Ecosystem (LME) concept provides a compelling framework for understanding regional threats, status and trends in oceans. Monitoring and assessments of LMEs are vital to evaluating status and trends and targeting priorities. For example, emerging assessments of LMEs in U.S. waters are enabling us to understanding efficacy of existing management measures and emerging impacts of climate change and ocean acidification.

Both national and international actions to assess, protect and restore ocean health are in order. In 2012, UNDP-GEF released the “Catalysing Ocean Finance - Transforming Markets to Restore and Protect the Global Ocean” report. NOAA welcomes the findings of that report. In many cases, degradation of oceans can be reversed. Proven ocean-planning and policy tools, adequate financing, successes, removal of barriers, and local and regional ownership are key points of actions.

KEY CONCEPTS: LMEs AND ECOSYSTEM SERVICES

Coastal waters bear the brunt of human activities in oceans and receive much of the wastes and runoff from upstream watersheds. The 64 large ecosystems in coastal waters—defined by physical and biological criteria, (Figure 1)—produce over 80 percent of the world's marine fish catch annually and are focal sites for the bulk of marine aquaculture, recreation, shipping, energy extraction, etc.

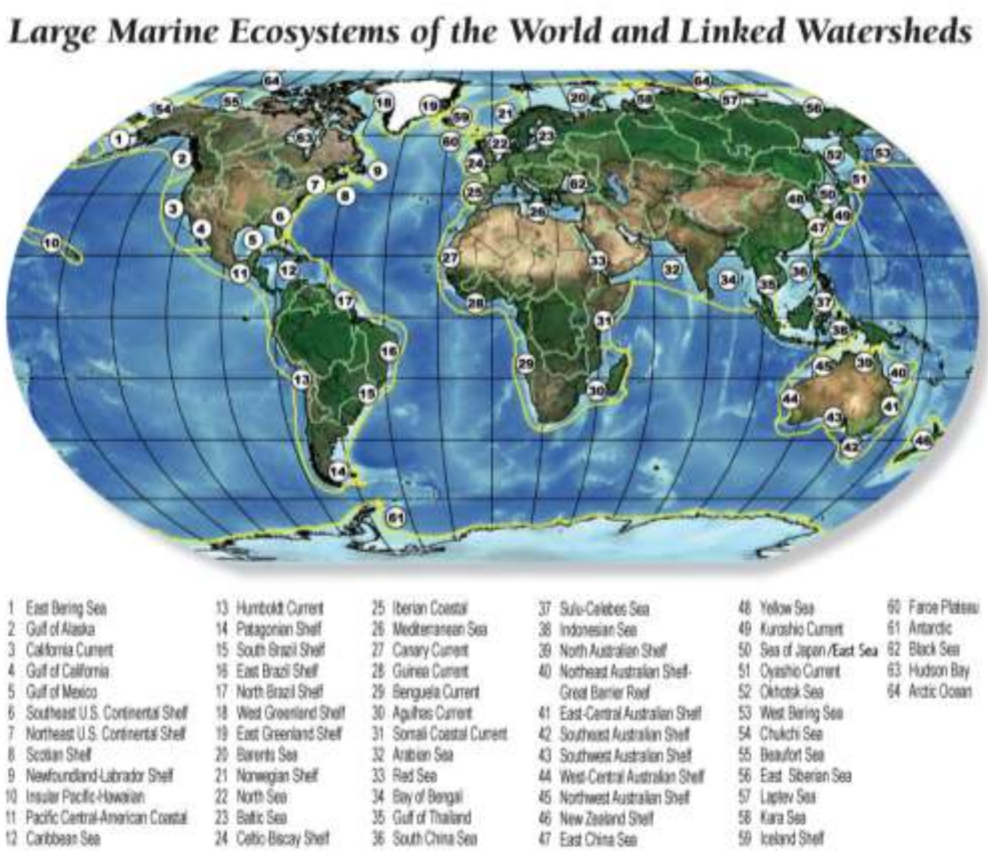

Figure 1. Large Marine Ecosystems of the World and Linked Watersheds (www.lme.noaa.gov)

When proposed, the LME concept was ahead of its time; today it guides research, monitoring, policy and management alike (Sherman, 1991). The LME concept recognizes the importance of biological and physical connectivity—as opposed to political boundaries—in the functioning of a large coastal marine ecosystem. It recognizes the two-way exchange of matter and energy between the upstream watershed and the adjacent LME. It focuses attention on the importance of the processes required to sustain healthy ecosystems and provides a platform for understanding impacts of environmental changes such as climate change and ocean acidification. The LME concept has catalyzed scientific studies and advanced international policies that were lacking at the time the concept emerged.

In parallel to progress in LME-scale science and policy, a better understanding of the wealth of benefits provided by ecosystems and how they are relevant to human well-being has emerged, e.g., from the 2005 Millennium Ecosystem Assessment (Figure 2). Healthy, resilient ecosystems provide a plethora of services such as provision of food, sequestration of carbon, control of pests and pathogens and provision of places for recreation and inspiration.

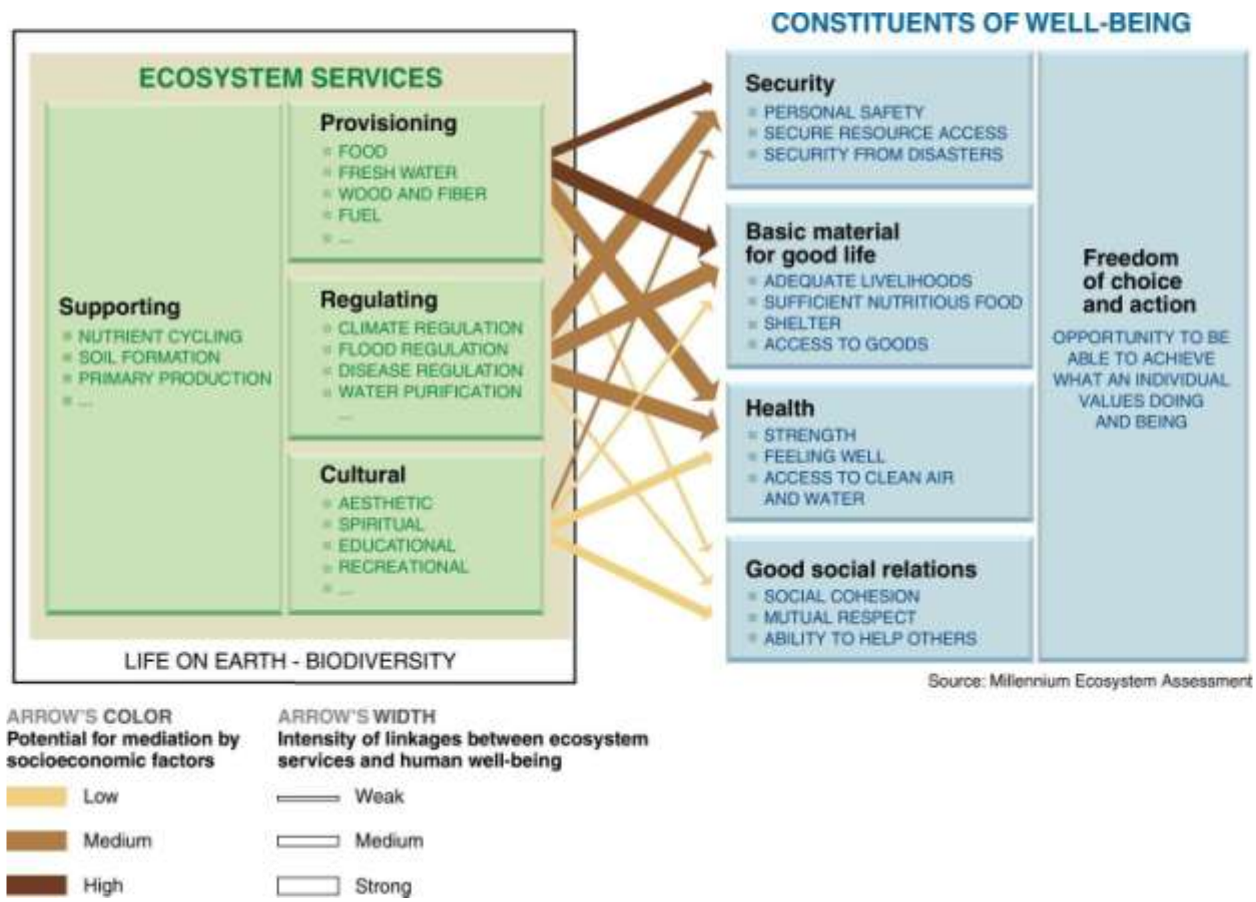

Figure 2. Ecosystem Services integrate ecosystems with human well-being. From the Millenium Ecosystem Assessment [http://www.unep.org/maweb/en/Global.aspx] (UNEP, 2006).

The ecosystem service concept connects the dots between ecosystem functioning and human well-being. These benefits are provided simply by the functioning of a healthy ecosystem—the interaction of plants, animals, microbes, people and the physical environment in a particular place. The delivery of these services can be altered when ecosystem functioning is changed, for example, by changes in species composition, addition of nitrogen through run-off of fertilizer, or climate change. As biodiversity is lost, as biogeochemical cycles are changed, as climate is altered, the functioning of the ecosystem is changed and the delivery of benefits from that system is altered.

One of the great strengths of the Millennium Ecosystem Assessment was the integration of approaches from both natural and social sciences. These concepts provide a powerful framework for understanding the trade-offs in services that may be associated with different land or ocean uses or the possible consequences of climate change, ocean acidification or other environmental changes underway. The new Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES; http://www.ipbes.net/) initiative provides an ongoing mechanism to strengthen the knowledge base at the science-policy interface for ecosystem services. These complementary advances—the LME concept and the ecosystem services concept—are now ripe for better integration.

ACHIEVING HEALTHY OCEANS

The U.S. has begun this integration as it focuses on stewardship of its oceans and coasts. In 2010, President Obama signed the nation's first ever policy on oceans: the U.S. National Policy on the Stewardship of the Oceans, Coasts and Great Lakes (Council on Environmental Quality, 2010; Executive Order, 2010). The policy focuses on the LMEs within U.S. waters (Figure 3) as planning units and considers the range of benefits from healthy oceans and coasts. It acknowledges that oceans are increasingly crowded places with many competing uses, and that smart planning is needed to accommodate multiple uses, defuse conflicts, and minimize adverse environmental impact. The policy promotes marine planning within the 11 U.S. LMEs where ecosystem-based assessment and management practices will be directed by regional planning bodies in partnerships with the federal government and various sectoral stakeholders.

This first-ever U.S. National Ocean policy is firmly grounded in the principle that "healthy oceans matter." This policy is the framework that guides our management decisions and actions toward achieving the vision of healthy, resilient oceans. Also significant in this policy is that it goes beyond a conflicted array of sector-by-sector and issue-by-issue approaches. The need for good sector management is still acknowledged, but such management is coupled with holistic approaches. The National Ocean Policy is grounded in a science-informed, ecosystem-based approach, and where precaution is applied when scientific information is uncertain. The policy strongly supports innovation of strategies that align short-term economic needs with the long-term conservation goals. Understanding humans to be integral to ecosystems, this policy acknowledges their role in the ecosystem, and it does so by embracing a bottom-up approach to governance, whereby local and regional engagement of stakeholders is critical to decision making.

This progress is encouraging, especially since oceans are changing rapidly and radically. Both progressive national and international efforts will be required to meet the challenge of achieving healthy oceans that can provide the full suite of benefits humans want and need, especially in light of climate change and ocean acidification. In the following paragraphs, I will focus on the overall health of the oceans, what we must do to achieve healthy oceans, what tools are available to help us make smarter choices in how we use the oceans.

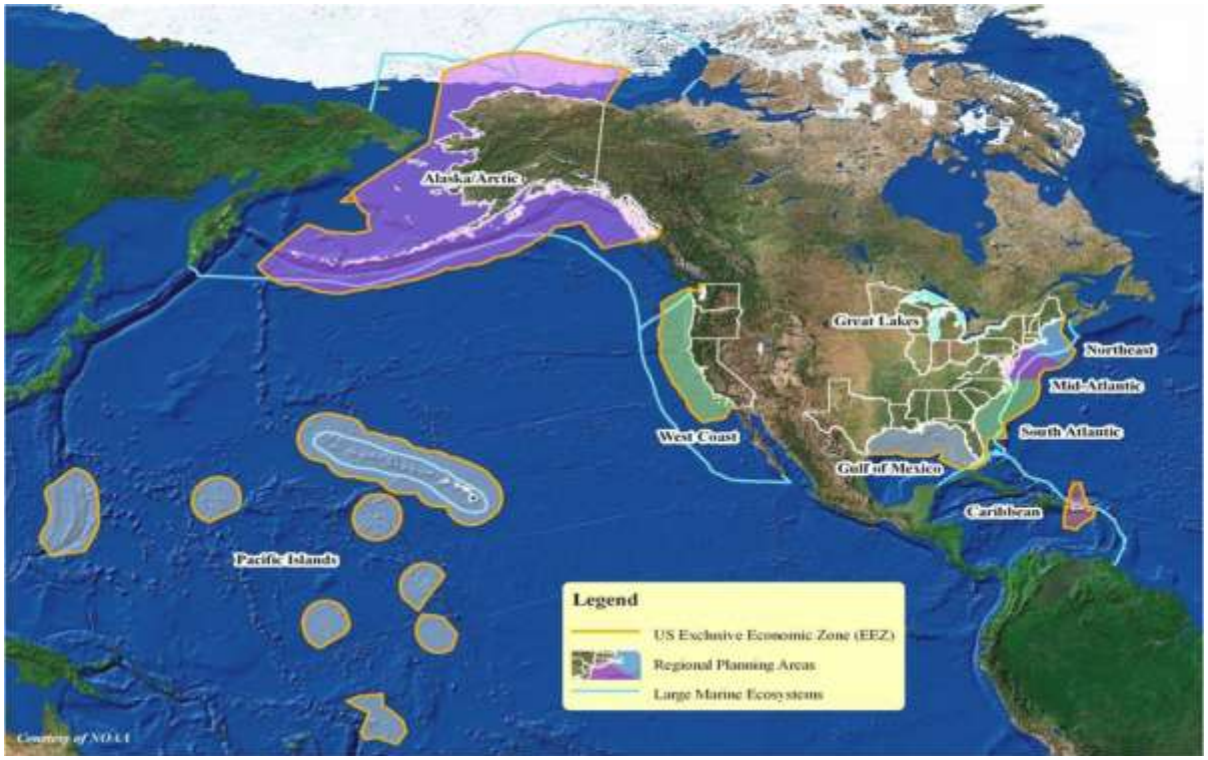

Figure 3. **U.S. LMEs and Marine Planning. Among the 11 U.S. LMEs enclosed by the blue boundary lines are the U.S. Northeast Shelf, U.S. Southeast Shelf, Gulf of Mexico, California Current, Gulf of Alaska, East Bering Sea, West Bering Sea, Chukchi Sea, Beaufort Sea, Insular Pacific Hawaiian Islands, and the Caribbean Sea LMEs (Council on Environmental Quality, 2010).**

STATE OF THE OCEANS

A deadly combination of local and global threats is putting ocean ecosystems, their services and people at risk. Overfishing, nutrient and chemical pollution, habitat alteration and invasive species continue to plague the oceans. More recently, climate change and ocean acidification have begun to interact with and exacerbate these more traditional stressors. While reducing carbon emissions is clearly an essential step to achieve healthy oceans, it is clear that adaptation measures are also in order. An efficient way to think about adaptation is two-fold: reduce traditional stressors (overfishing, invasive species, pollution) and protect biodiversity as a strategy to enhance resilience.

PROMISING APPROACHES

Achieving healthy oceans means maintaining or restoring basic processes within the ecosystem and creating or strengthening social institutions with the knowledge and power to effect lasting change. Together, these approaches must address a suite of threats and develop or employ effective tools to measure status, trends and progress. Today, I wish to focus on a subset of complementary actions required to achieve those goals, specifically (1) reduce greenhouse gases; (2) improve sectoral management; (3) incorporate the expectation of additional climate change and ocean acidification into management decisions; (4) conduct integrated ecosystem assessments; (5) develop and use holistic indicators of ocean health; and (6) develop and use tools that analyze trade-offs.

Amid the significant challenges in achieving those goals, there has been real progress on some of them in recent years. Let's take a closer look at each.

1. Reduce greenhouse gases. The need to reduce greenhouse gases significantly looms large, and the challenges are considerable. Increasing amounts of carbon dioxide in the atmosphere are not only changing the climate, but they are causing oceans to become more acidic. In addition to reducing CO_2 and other greenhouse gases, communities and nations need to become better prepared for impacts of climate change (Dunne et al., 2012).

2. Improve sectoral management. Most uses of oceans tend to be managed on a sectoral basis – fisheries by one agency or ministry, shipping by another, mining or gas and oil extraction by a third, etc. Few of those sectoral approaches have resulted in a use that has not damaged the surrounding ecosystem or had significant impacts on other uses. In parallel to efforts to improve integration across sectors, better ecosystem-based management within sectors is needed.

UN FAO data provide a startling look at how dramatically the picture for fisheries has changed in the last half century. Fishery management at the global scale has not been achieving sustainable use of oceans (Figure 4). There is significant room for improved fishery management within national waters as well as on the high seas.

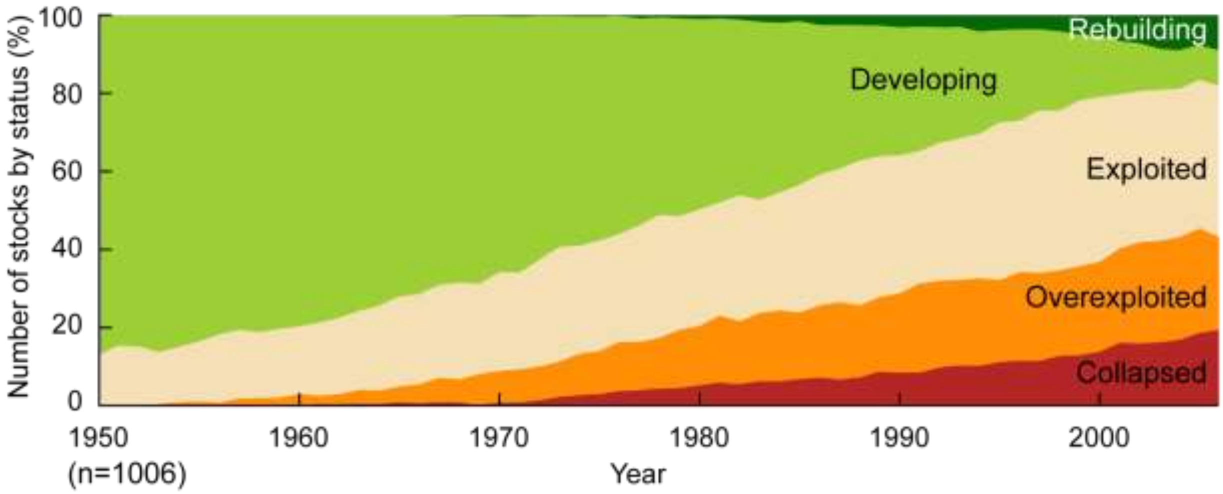

Figure 4. Global fisheries stock status plot courtesy of D. Pauly, University of British Columbia (Kleisner, Zeller, Froese, & Pauly, 2012).

Fishery management in the U.S. has changed dramatically in recent years. Legislation with 'teeth' and timetables, good science, committed management that includes fishermen, effective enforcement, and restructuring of incentives have transformed fishery management into an evolving success story as opposed to a continued downward spiral of fewer and fewer fish and thus fewer and fewer fishing jobs. Our goals are to end overfishing, prevent future overfishing, rebuild depleted stocks, protect and restore habitats important to the fisheries, and sustain vibrant coastal communities.

After decades of overfishing our wild fisheries, the U.S. is turning the corner on ending overfishing in U.S. waters and we are beginning to see stocks rebuild. Our latest accounting shows that nearly 80 percent of U.S. fish stocks that were scientifically examined are at or above the level able to provide maximum sustainable fishing. Moreover, 32 stocks have been rebuilt since 2001, with the vast majority of those within the last few years. The short-term sacrifices of fishermen are working, resulting in more fish and more fishing opportunities, more lucrative fisheries, but also healthier ecosystems (Costello, Gaines, & Lynham, 2008).

This progress was made possible because of tough legislation known as the Magnuson-Stevens Act and its 2006 reauthorizations. This legislation has teeth. It has transformed fisheries management in the U.S. into precautionary, science-based management that is working. The law requires NOAA to set annual catch limits based solely on scientific information, implement accountability measures, and meet deadlines for these requirements. Regional fishery management councils propose those catch limits as part of management plans, based on scientific information.

This legislation also allows the use of what we call 'Catch Shares' and what the EU calls 'Transferable Fishing Concessions.' In a Catch Shares programme, a specific portion of the total allowable catch is allocated to individuals, communities or other entities on an ongoing basis. This rights-based fishery management realigns the normal counterproductive incentives of traditional fishery management that often lead to a race for fish and serious overfishing. Catch Shares align fishermen's short-term and long-term economic interests; they align conservation and economic incentives. Catch Shares have the added benefits of enabling fishermen to have more control over their businesses and achieve greater profitability, fish more safely, and reduce unwanted by-catch. Around one third of U.S. fish stocks are now managed under a Catch Share program. In U.S. fisheries where they have been implemented, catch shares have ended the race to fish.

On the U.S. West Coast, for example, one can see the success of a recently established Catch Share program for the groundfish trawl fishery. During the first year of the program (2011), gross revenues increased for the groundfish fleet, compared to the five-year average for the fleet. Non-whiting fleet revenue was up 34 percent per vessel, from an average of $216,000 to slightly more than $289,000 in 2011. The whiting fleet saw revenues climb even more: a 180 percent increase, from about $273,000 on average during the last few years to $775,000 in 2011. In addition, the non-whiting fleet by-catch was significantly down. In 2011, discards comprised only about 5 percent while the 2010 discard rate was 17 percent.

Ending overfishing on high seas fisheries is much more challenging, in part because of the diversity of fishing countries who must agree on changes. The more progressive Regional Fishery Management Organizations (RFMOs) are trying to move to science-based and precautionary approaches but substantial challenges remain. Progress is painfully slow.

Apart from legal fishing that is governed by RFMOs, illegal, unreported and unregulated (IUU) fishing is a global problem that erodes the hard-won gains we are making to manage fisheries sustainably. It threatens restoration of oceans to a healthy condition, one that can provide a plethora of benefits including, but hardly limited to seafood. With more than three billion people depending on seafood for their primary source of protein, IUU fishing threatens global food security and thus global health. IUU fishing is a threat to the economy, robbing honest fishers, local communities, and the fishing industry that abide by the rules and costing the global economy between $10-23 billion per year.

Our goal is to close the world's ports to IUU vessels and to prevent their illegal catch from entering the market. To accomplish this, we initiated four actions: (1) The US signed the international **Port State Measures Agreement** to Prevent, Deter, and Eliminate Illegal, Unreported, and Unregulated (IUU) Fishing and (2) transmitted the **Pirate Fishing Elimination Act** to Congress. If passed, this act will keep U.S. ports clear of IUU fisheries products. (3) In September 2011, we signed a **joint agreement with the EU** to cooperate on this issue. Since then, collaboration and cooperation with the EU has grown. (4) We and other FAO members reached consensus on February 7, 2013 on a set of **flag state performance assessment criteria** embedded in an assessment process ftp://ftp.fao.org/FI/DOCUMENT/tc-fsp/2013/AdminRep_adopted.pdf (FAO, 2009, 2013). Thus after more than a decade of building counter-IUU fishing tools, we have finally addressed the core problem of flag state obligations and duties. Keys to future success lie in sustained and effective engagement and commitment by multiple players—nations, regional fisheries management organizations, civil society, enforcement entities and the multiple industries involved.

3. Incorporate the expectation of additional climate change and ocean acidification into management decisions.

Achieving better sectoral management is necessary, but not sufficient. Fishery and other sectoral managers must look to the conditions that are likely in the years ahead. Specially, the expectation of changing ocean conditions due to climate change and ocean acidification must be built into management and policy plans (Doney, 2006; Steinacher et al., 2010). Managers must plan for tomorrow. Doing so means entering new territory – anticipating and preparing for surprises. New methodologies, new awareness and political will are all required.

4. Conduct integrated ecosystem assessments. Integrated ecosystem-based management is needed to improved sectoral management and integration across sectors. One way to ascertain how we are doing in managing LMEs is through the five-point modular assessments for sustainable development (Figure 5).

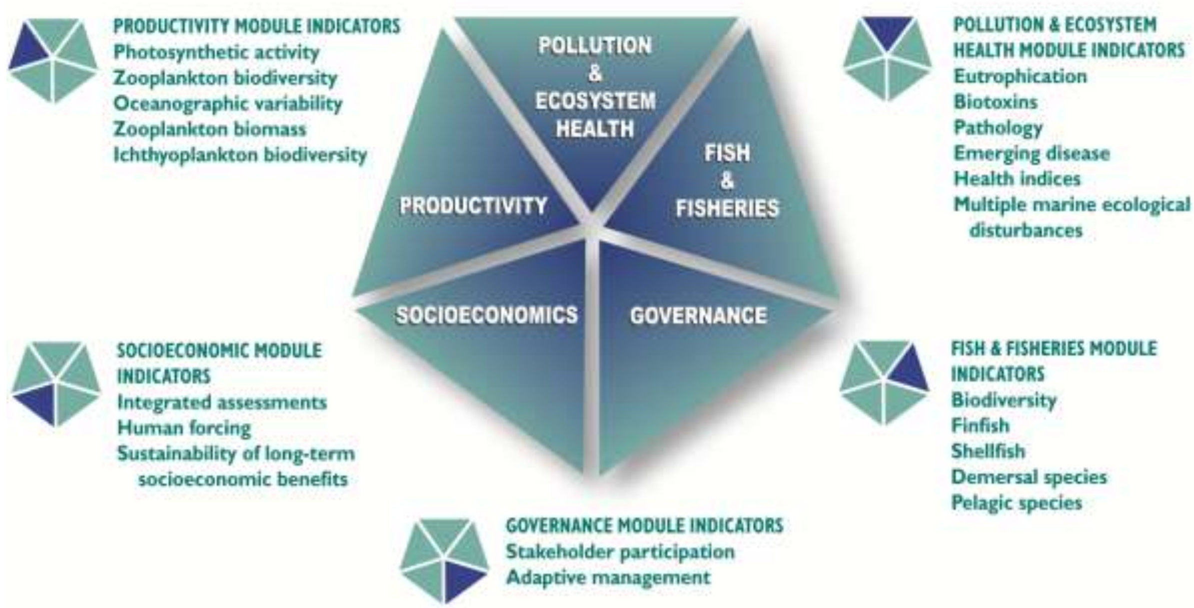

Figure 5. 5 Modules with Indicators (www.lme.noaa.gov)

The assessment modules are designed to be flexible in accommodating priorities of country-driven, GEF-supported LME projects. Five sets of indicators are used to monitor changing LME conditions: productivity, fish & fisheries, pollution and ecosystem health, socioeconomics, and governance.

To carry out these assessments, sustained monitoring and research efforts are needed to understand the interactions among various stressors that could be driving change. That understanding will help us make projects globally and at temporal and spatial scales needed by managers.

Parallel efforts are underway to do integrated assessments that function on delivery of ecosystem services. Many of these approaches are promising.

5. Develop and use holistic indicators of ocean health.

Indicators of status and trends are helpful in setting priorities and evaluating progress. Until recently most attempts at identifying indicators of ocean health were unsatisfactory because they were restricted to a specific place (making comparisons of different places difficult), inordinately expensive, or involved very long lists of diverse biogeophysical measures. More recently, a focus on holistic approaches and the benefits humans derive from ecosystems has resulted in simpler approaches. One such index is the new Ocean Health Index (OHI) (Halpern et al. 2012; www.oceanhealthindex.org) (Figure 6).

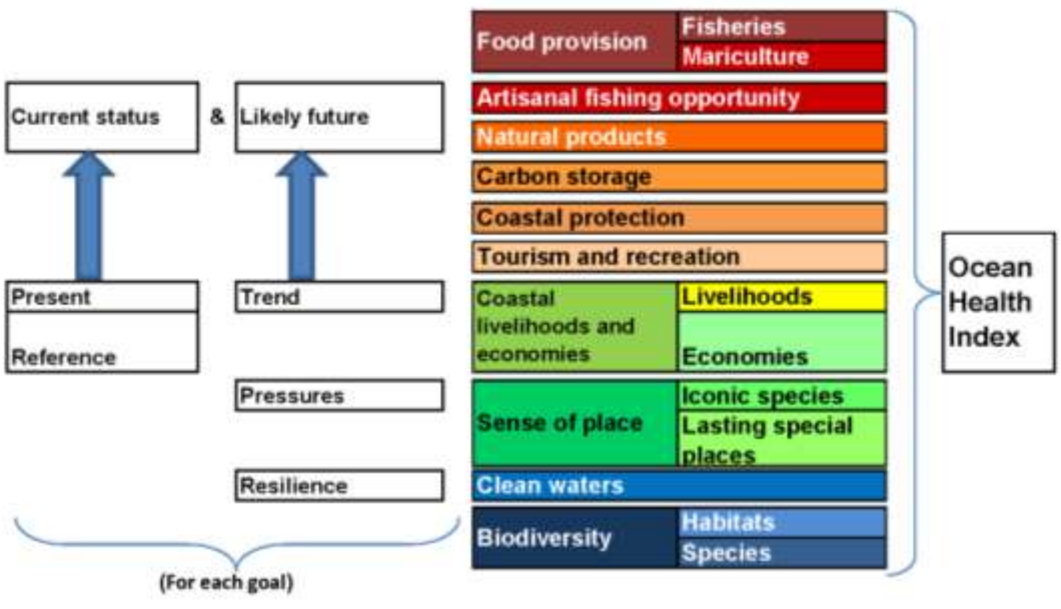

Figure 6. Ten public goals and sub-goals, a conceptual framework for calculating the Ocean Health Index. [Halpern, Longo et al. 2012. Nature 488:615]

Fashioned after the familiar Gross Domestic Product, or GDP, used globally to assign market values to all goods and services for a given country, the Ocean Health Index is a measure of the ocean's overall condition or ocean health. The index, which ranges from zero to 100, can be global or be for a single country, allowing country-by-country comparisons. (Figures 7 and 8)

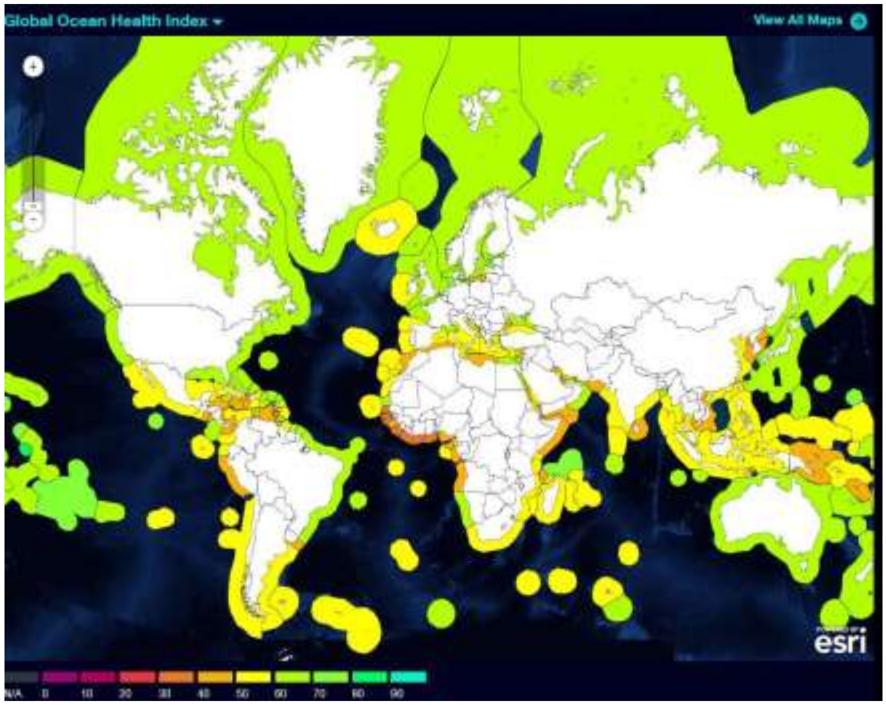

Figure 7. Global Ocean Health Index

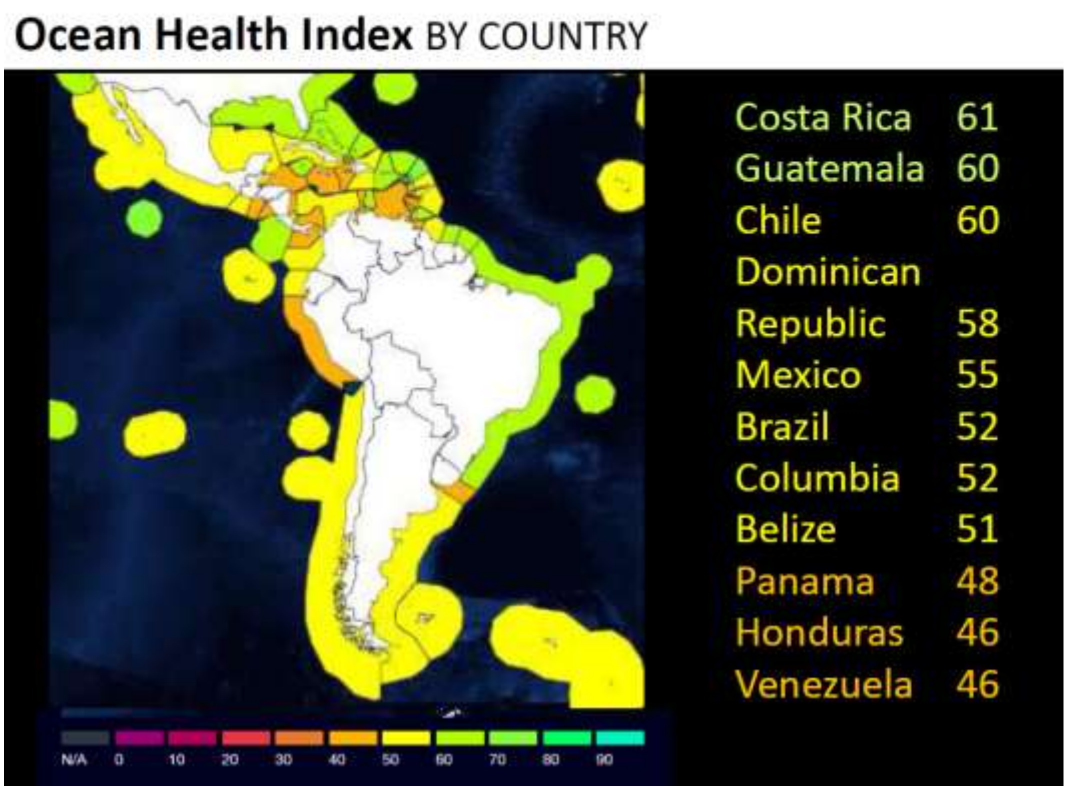

Figure 8. Ocean Health Index by a subset of countries

The Ocean Health Index measures sustainability through the lens of ecosystem services. These services are reflected in ten public goals: food provision, coastal livelihoods & economies, artisanal fishing opportunities, tourism & recreation, natural products, sense of place, carbon storage, clean water, coastal protection, and biodiversity. The global OHI is an area-weighted average of all country scores. Any single country's overall score is an average of the ten goals within its Exclusive Economic Zone (EEZ). There are no calculations made for the high seas. For each public goal, the current status and a five-year trajectory are taken into account. While the OHI provides a holistic and integrated view of ocean health globally and regionally, achieving healthy oceans will take attention to the global marine fisheries. Moreover, the OHI is newly proposed, and will undoubtedly benefit from additional scrutiny and use. The goal of having a simple, transparent and easily understood measure is laudable and should be supported.

6. Develop and use tools that analyze trade-offs. Another recently developed tool that is transforming ocean planning is Marine InVEST. Developed by the Natural Capital Project (www.naturalcapitalproject.org) (Figure 9), InVEST enables local decision-makers to understand the tradeoffs associated with different possible future scenarios for coastal and ocean uses. This tool integrates natural science, economics, behavioral science, social and cultural values and local knowledge.

Figure 9. Natural Capital Project: InVEST (www.naturalcapitalproject.org)

Development is often concentrated in coastal areas. In the U.S., the coastal population nearly doubled between 1960 and 2010 and is expected to grow another ten percent in this decade. According to the 2010 U.S. Census, of the 25 highest density counties in the country, 23 are coastal. There are, on average, three times as many people per square mile on the coast than inland in the U.S. More people means greater activity, demand for coastal resources and risk from sea level rise and coastal storms.

Many coastal communities around the world are at increasing risk from storm surge. Coastal habitats can help provide protection from flooding. These natural defenses include coral reefs, mangroves, coastal forests and marshes, oyster reefs, seagrass beds, and sand dunes (Figure 10, Arkema et al., 2013).

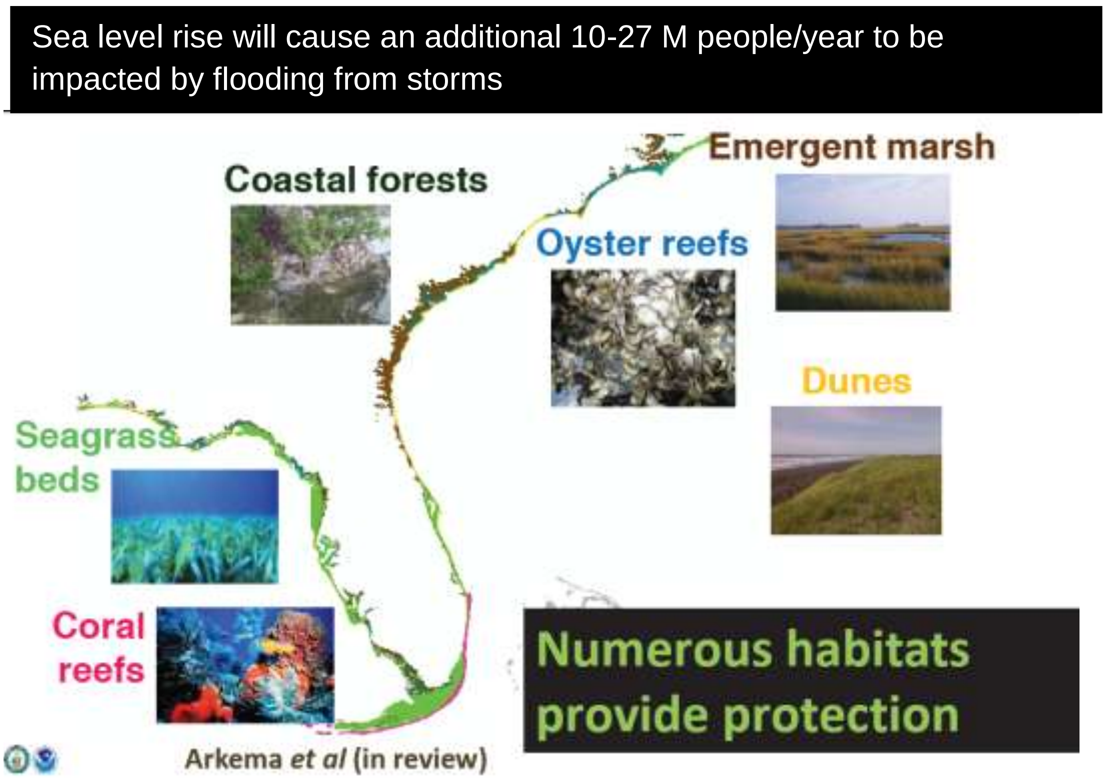

Figure 10. Habitats that ease coastal vulnerability to flooding (Arkema et al., 2013)

Previous studies have concluded there is significant economic benefit from activities that depend on these habitats. According to the World Resources Institute, in Belize, the economic benefit from the lobster, conch and finfish aquaculture industry is $14-16 million (US) per year. Tourism brings in $150-196 million each year. Belize enjoys a $231-347 million benefit per year from the mangroves and coral reefs that provide shoreline protection (Cooper, Burke, & Bood, 2009). Studies such as this one provide the current contributions of these sectors to Belize's economy. However, these figures do not project future contributions. Until recently, it was not easy to understand trade-offs in protection or restoration of coastal habitats vs other possible uses of those areas. Belize is a good example of how Marine InVEST is being used by planners to make decisions that consider tourism, coastal development, fishing, aquaculture, and other uses, as well as protection of coastal ecosystems.

In 1998, the Belize government passed landmark legislation requiring coastal planning to address the rapid coastal development, overfishing, and population growth that threaten marine ecosystems and the livelihoods that depend on them. Its stated goal: the balanced and sustainable use of coastal and marine environment for the benefit of Belizians and the global community. Ten years later, little progress had been made in meeting these goals. A lack of scientific capacity existed for assessing tradeoffs among the multiple uses and potential impacts, and for providing that usable information to diverse stakeholders.

While prior plans for development and conservation of atolls and cays relied on expert advice and no spatially-explicit plans, the current planning efforts focus on ecosystem-based management of oceans and coasts, use of a science-based tool in conjunction with expert advice. For planning purposes, the coastal areas were divided into a series of regions (Figure 11).

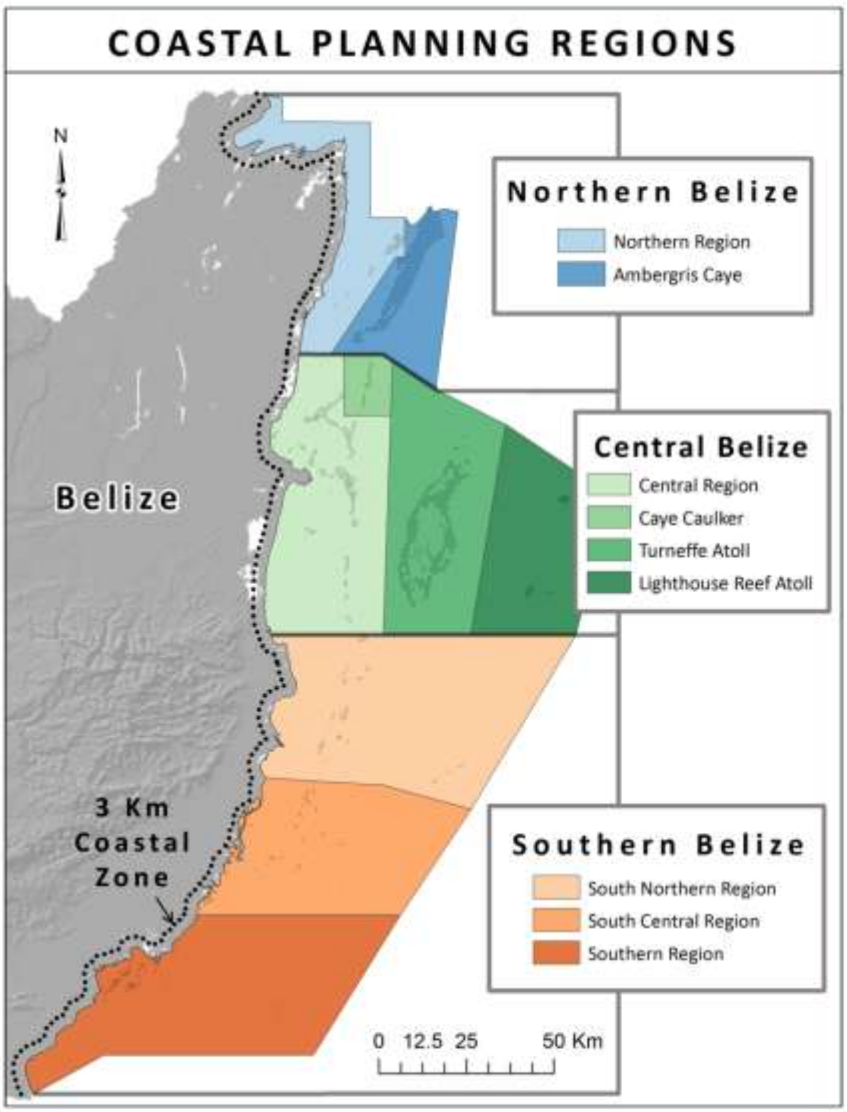

Figure 11. Coastal planning regions for Belize, (Clarke, Canto, & Rosado, 2013).

The new approach will result in a spatially-explicit plan for each. The current and three future scenarios shown (Figure 12) illustrate how three ecosystem services vary spatially, change under the different future scenarios, and the trade-offs involved.

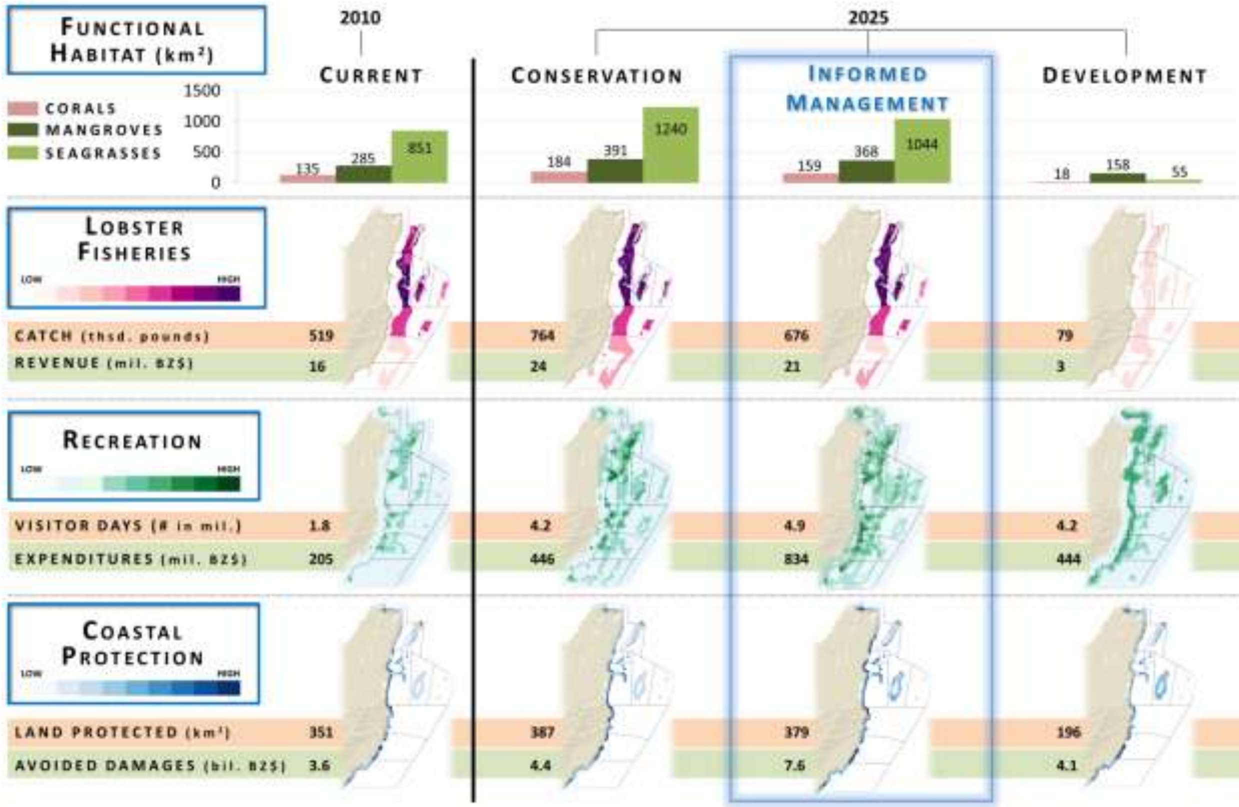

Figure 12. Changes in Ecosystem Services under different scenarios and trade-offs (Ruckelshaus et al., in press, Clarke et al., 2013 Draft for public review).

Maps like these are the result of iterations of stakeholders' feedback, scenario modification, improvement in inputs, and rerunning of models (Figure 12). The maps shown here are currently undergoing review in public consultations. They will likely be revised once again before the final plan is passed to the cabinet in the fall of 2013.

As can clearly be seen, areas that are developed, conserved, designated for lagoons or dredging differ under the three scenarios. Data generated by Marine InVEST models and tools allow comparisons to be made between conservation, development, and informed management scenarios (Figure 13).

In Belize, trade-offs emerged between services. The preferred option balanced revenue generating potential from sustainable tourism development with retention of local lobster fishery jobs and shoreline protection from storms.

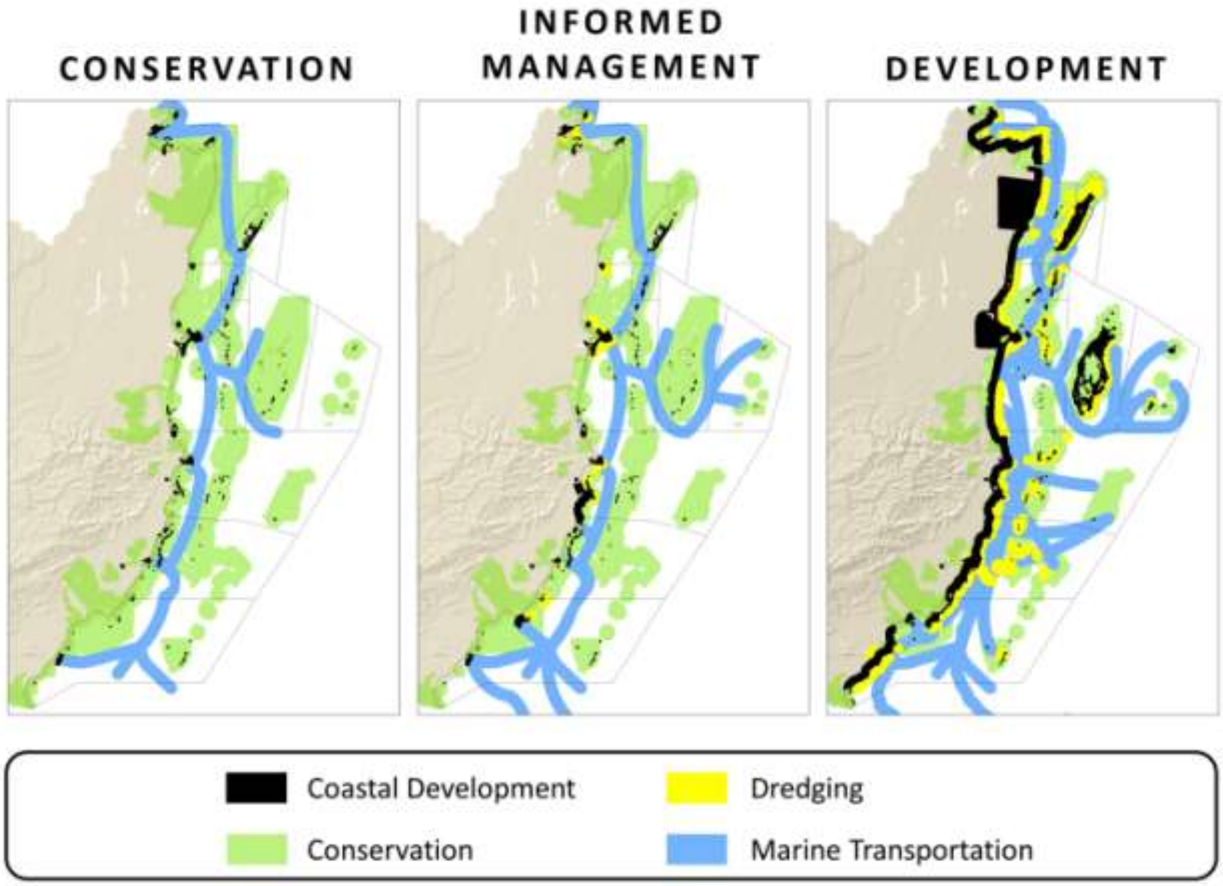

Figure 13. Three alternative future scenarios for the zoning scheme in the Belize Integrated Coastal Zone Management Plan. These maps are based on stakeholder feedback, scenario modification, improvement in model inputs, and re-running of models (Clarke, et al., 2013) [Draft for public review]. Note that only four zones of human uses (including conservation) are shown for simplicity.

The Natural Capital Project and their partners in Belize learned that coastal habitats are valuable to residents of Belize (Figure 12). That value includes protection from storms, lively fishery and tourism industries that provide food, jobs, and economic sustenance. Economic, nutritional and cultural and protection benefits were all important. The team also learned that simple accounting tools could be used to inform spatial planning to secure these multiple benefits by illuminating trade-offs through scenarios, models and the science underpinning them. The team emphasized that tools alone will not do the job, that clear objectives, partnerships, good science, and an iterative science-policy process were all essential.

Sustaining progress will take sustaining the process. This means growing ownership and capacity and it requires technical assistance in the form of training users to use the software and approaches from the beginning.

Figure 14. InVEST take-home messages and lessons (Ruckelshaus et al., 2013 -accepted).

The example I have shown illustrates how one tool and one project - Marine InVEST and the Natural Capitol Project - along with many NGOs active in the region are working collaboratively to infuse science and local knowledge and ownership into decision making. Exciting parallel efforts are under way, such as the World Bank's Wealth Accounting and Valuation of Ecosystems Services (WAVES) project, as well as other national and ecosystem service accounting efforts. We should be encouraged by this trend toward the science-informed, ecosystem approaches to management. Just as progress is being made with these approaches in managing U.S. fisheries, efforts like those being carried out by the Natural Capital Project and the World Bank are new beacons of hope for global sustainability nurtured through local and regional scales.

CONCLUSIONS

Achieving healthy oceans will require actions on multiple fronts: improved public awareness and political will, better incorporation of existing scientific knowledge into management and policy, conduct of new science and creation of LME-scale monitoring and research, realigning incentives to reward a focus on long-term sustainability, development and use of innovative tools, and precautionary, ecosystem approaches. NOAA looks forward to continuing our unique partnerships with the GEF, ICES, IOC-UNESCO and UNDP in advancing recovery and sustainable development of LMEs around the globe. We also look forward to continuing scientific and technical support to GEF-LME project augmentation, and to participation in the ICES LME Best Practices Working Group.

There is much to learn from our partnerships. As we go forward with implementing the National Ocean Policy, your experiences in financial leveraging, initiation of ecosystem-based assessment and management, and extraordinary examples of multinational shared LME governance Commissions are best practices that are mutually beneficial**.**

July 2013 will mark the 15th annual meeting of the IOC-UNESCO and IUCN LME Consultative Committee. NOAA's partnership with UNDP is likely to welcome new GEF-supported projects in the emerging economies of the Asian-Pacific regions the Sulu-Celebes Sea, the Indonesian Sea, and the Pacific Central American Coastal LMEs and also in the West Bering Sea.

The strong partnerships among the institutions represented here represent an unprecedented opportunity to usher in a decade of jointly focused actions toward recovering the health and sustainability of the ocean's bounty. For the seven billion of us on this planet, it is still possible for us to make individual and collective choices that will result in restoring and sustainably developing our planet's full potential for present and future generations.

ACKNOWLEDGEMENTS

I am grateful to Dr. Sandra Honda, Lt. Adrienne Hooper, Dr. Mary Ruckelshaus, Dr. Anne Guerry, and Dr. Katie Arkema for their assistance in providing material for this contribution.

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2

GEF SUPPORT TOWARD SUSTAINABLE DEVELOPMENT OF LARGE MARINE ECOSYSTEMS

Naoko Ishii, PhD, Chief Executive Officer, the Global Environment Facility (GEF)

Good afternoon everyone and thank you for coming. It is fitting that we are here at the JFK Library, with its view of Boston Harbor, once one of the most polluted waterways in America and now in the final stages of a major clean-up effort. Protecting marine environments is what has brought us together, and my organization—the Global Environment Facility—is a proud partner with others represented here today.

Boston Harbor is cleaner today thanks to a long-term, determined policy and political effort and the support of the public. But I am concerned, and I am sure you are too, that despite efforts such as this, our entire earth's ecosystems are under severe threat. We all know we have already gone beyond some of the safe planetary boundaries. We are collectively failing to reverse the damage we are doing to our global commons—the air, land, and water on which our lives depend. And our oceans are perhaps the most dramatic example of the tragedy of the global commons, because oceans suffer from a market failure and fragmented governance structure.

I became the CEO of the GEF last August, determined to address the tragedy of the global commons by building on our past contributions. I believe that what we need is transformational change to address this collective failure. For this purpose, I have initiated the long-term visioning exercise, GEF2020. We will address the tragedy of ocean and large marine ecosystems as part of it.

Today I would like to emphasize four key points:
First, our oceans are badly managed, and large marine ecosystems or LMEs represent the right approach to address multiple stresses in a comprehensive way.
Second, I want to outline what the GEF has done for LMEs.
Third, I would like to present two examples of GEF-funded projects that have shown the way to achieving results on a global scale.
And **fourth,** I want to make very clear that oceans are a fundamental part of the GEF's essential role as a champion of the global commons. Large Marine Ecosystems will be an important part of our long-term strategy.

Let me start with the first point. We humans live on the land, and that naturally takes our focus away from the sea. We forget that most of our planet is made up of coastal and marine ecosystems and that our economies depend on them. More than half the carbon sequestered by nature can be attributed to marine ecosystems. They play a major role in regulating the earth's temperature.

Coastal economies generate roughly $70 billion dollars per year in international trade in marine fisheries products. However, more than 40 percent of the world oceans is threatened by overfishing, pollution, physical alteration and destruction of habitats, and climate change; 60 percent of the world's major marine ecosystems is estimated to have been degraded or is being used unsustainably. Why does this degradation continue? Because, in my view, we are failing to properly value our ocean ecosystems, and there is no effective governance mechanism to bring collective action. The Stockholm Environment Institute calls our oceans the victim of a massive market failure. It stated the true worth of its ecosystems, services and functions is persistently ignored by policy makers.

Coastal ecosystems such as deltas, reefs and mangroves are increasingly threatened by agricultural runoff and wastewater. Yet how many people are aware that these 'blue forests' are believed to store carbon at rates several times higher than terrestrial carbon sinks, such as tropical forests? We need to vigorously promote the LME approach to address the causes of the problem in a comprehensive manner.

Now my second point: The GEF has been fighting these worrisome trends. Today, the GEF remains the world's largest financier of transboundary water collaboration. The GEF has been helping 172 countries work together on shared water systems with $1.1 billion in grants which leveraged an additional $6.6 billion of co-financing. Of this $1.1 billion, about one-third—$380 million in grants—has gone toward LMEs, accompanied by an additional $2.35 billion in co-financing.

Currently, 122 countries work with GEF finance on 20 Large Marine Ecosystems (LMEs) globally, representing one-half of all LMEs shared by developing countries. Many countries have agreed to joint commitments for significant action, such as the Benguela Current and Guinea Current LMEs in Africa, and the South China Sea and Yellow Sea LMEs in Asia. GEF-supported interventions occur at different scales, ranging from reduction of land-based pollution to municipal or provincial projects for integrated coastal management, to LMEs, to global-scale efforts. This approach recognizes that problems in the ocean ecosystem far offshore often originate far inland.

Let me move on to my third point about sharing critical lessons. The GEF has supported an ecosystem-based approach in the Benguela Current, one of 64 LMEs. The project is building political and stakeholder commitment to action, setting the stage for the world community to invest in capacity-building and technology. GEF support resulted in the establishment of the world's first LME Commission—the Benguela Current Commission (BCC)—representing multiple sectors in Angola, Namibia and South Africa, the three countries directly engaging in the sustainable management and utilization of the transboundary resources associated with the LME. The GEF has funded a second project for a legal agreement, the Benguela Current Convention. We are expecting to have a high-level signature ceremony for the Convention next month [Editors' note: The signing took place on 18 March 2013].

Another example: We at the GEF are particularly proud of one of our earliest projects—in the Danube River Basin—that has led to the recovery of the northwestern shelf of the Black Sea. Once a dead zone, this body of water has been significantly improved with a dramatic return of fish stocks. We learned critical lessons from this project:

- Pollution from land-based sources flowing into LMEs can only be addressed in a coordinated fashion by all involved states;
- A Strategic Partnership with the World Bank, UNDP and UNEP was key to mobilizing the necessary co-financing, institutional reforms and investments;
- Through the GEF, political commitments were garnered from the 17 States, and nutrient reduction projects were initiated by Austria and Germany. The Partnership is now bringing coordinated support and benefits to the transboundary basin and the marine environment under the Bucharest Convention and the Istanbul Convention.

This Strategic Partnership serves as an example of how the GEF can be a catalyst for the needed policy, legal, and institutional reforms, and for the technical investments in sectors required to address a serious transboundary water problem.

Places like Boston Harbor and the Black Sea demonstrate what concerted, coordinated effort—with strong political support—can achieve. However, in far too many places, our coasts and oceans are seriously degraded. The good news is that there is increasing recognition on the magnitude of the problem and a shared sense of urgency.

At the World Economic Forum in Davos last month, I was pleased to see environmental issues recognized very high on the global risk agenda. World Bank President Jim Yong Kim said in Davos: "In the worst climate scenario, my kids will live in a world without coral reefs, with acid oceans and with wars fought over water." We cannot allow that to happen.

With these concerns in mind, we at the GEF are developing its long term strategy, GEF2020, as well as the GEF-6 funding strategy.

This is my last point. Throughout this long-term vision exercise, we will explore how we can play a role as a champion of the global commons. We want to catalyse transformational change to reverse the worrisome trend in the global commons together with partners in the international community. We want to continue to pilot innovative models to bring about the systemic change. We would like to strengthen our collaboration with the private sector.

This exercise has just been initiated and your inputs are most welcome. Together with this long-term exercise, preparations for our four-year fund-raising exercise, GEF-6, are also under way. Here we will formulate concrete programmes for the next four years and propose them to donors. In the area of oceans and international waters, what we may want to propose is to focus on comprehensive approaches for reducing ocean hypoxia; expanding sustainable coastal management, particularly on protection of coastal ecosystems; and scaling up integrated approaches to abate unsustainable fisheries practices. In particular:

- GEF will aim to catalyse a transformation in the nutrient economy that will reduce nutrient pollution and coastal hypoxia in a sizeable number of Large Marine Ecosystems.

- The GEF will invest in the conservation of 'blue forests' to prevent further loss and degradation of coastal habitats.

- GEF will invest in policy, legal, institutional reforms and strategic partnerships that contribute to recovering and sustaining fish stocks, including regional and national legal and governance reforms.

Success of these ideas depends on a network of institutional partners and LME practitioners committed to urgently harmonizing approaches to address transboundary concerns about LMEs. The LME approach offers many innovative ideas for effective and holistic marine ecosystem management.

However, these programmes need the political driving force of official, high-level partnerships among regional groups of countries, GEF agencies, and other development partners. Policy and governance structures must not only embrace the approach, but ensure it receives long-term support, financial, infrastructural and political support. We need to communicate better to our politicians and finance ministers the economic impact of declining oceans, particularly on the world's most vulnerable and poor. Those efforts will enable the GEF to improve the quality of its program and obtain support from donors.

The GEF is a unique, networked institution with many partners poised to make smart investment choices that can help countries secure benefits from their shared coastal and marine resources. Healthy oceans are our goal and GEF stands ready to support countries, as they work with their neighbours to sustain shared coastal and marine resources.
Thank you.

3

ACCELERATED WARMING AND SUSTAINABILITY OF THE BALTIC SEA LARGE MARINE ECOSYSTEM

Anne Christine Brusendorff, PhD, General Secretary of the International Council for the Exploration of the Sea

Good afternoon to you all. I am very pleased to be here to tell you about my experience with the Baltic Sea LME Project. Two intergovernmental organizations were involved: HELCOM, with a specific focus on the Baltic, and ICES, with a broader geographic and scientific focus. The Baltic is a unique and vulnerable ecosystem, with conditions making it more sensitive to climate change. I would like to present to you some of the model projections, and to present to you the governance system that is in place in the Baltic. In so doing, I will try to single out what I think makes the Baltic LME Project so successful and, therefore, a good working model for other projects in future, where ICES could be assisting.

VALUING THE BALTIC SEA GOODS AND SERVICES

To begin, I would like to show some monetary figures highlighting the economic importance of the Baltic Sea to the region, supported by European and global valuations. A study which was carried out in the Baltic region showed that the value of the Baltic amounts to more than 5 billion euros annually**.** It certainly would be economically profitable, even if we are speaking only about eutrophication, to prevent the negative environmental effects associated with eutrophication. There are models that suggest that the overall profit, on average, for each of the Baltic countries would be around 2 million euros a year if we could stop eutrophication.

Looking from this monetary perspective, I quote from the very well known Swedish taxonomist, Linnaeus, "If we cared more about natural science, we would notice more and greater wonders in nature and at the same time contribute greatly to 'the improvement of our economy'." [from the *Oeconomica naturae* (*Economy of Nature*), Linnaeus 1749]**.** It seems that we are putting old wine into new bottles. The need to balance economic and environmental concerns is an old idea that needs further development today.

The valuations listed in Figure 1 compare well with figures from Europe. If we're just looking at European seafood, the value of this seafood is equal to that of Coca Cola and we see that the value is greater than that of Google.

I think these are very interesting figures and of course, as you are all aware, the numbers are comparable to the valuations of goods and services of LMEs we've heard from previous speakers. Each year in LMEs 80 percent of the world's marine fisheries catches are harvested and LME goods and services contribute an estimated 12 trillion dollars annually to the global economy.

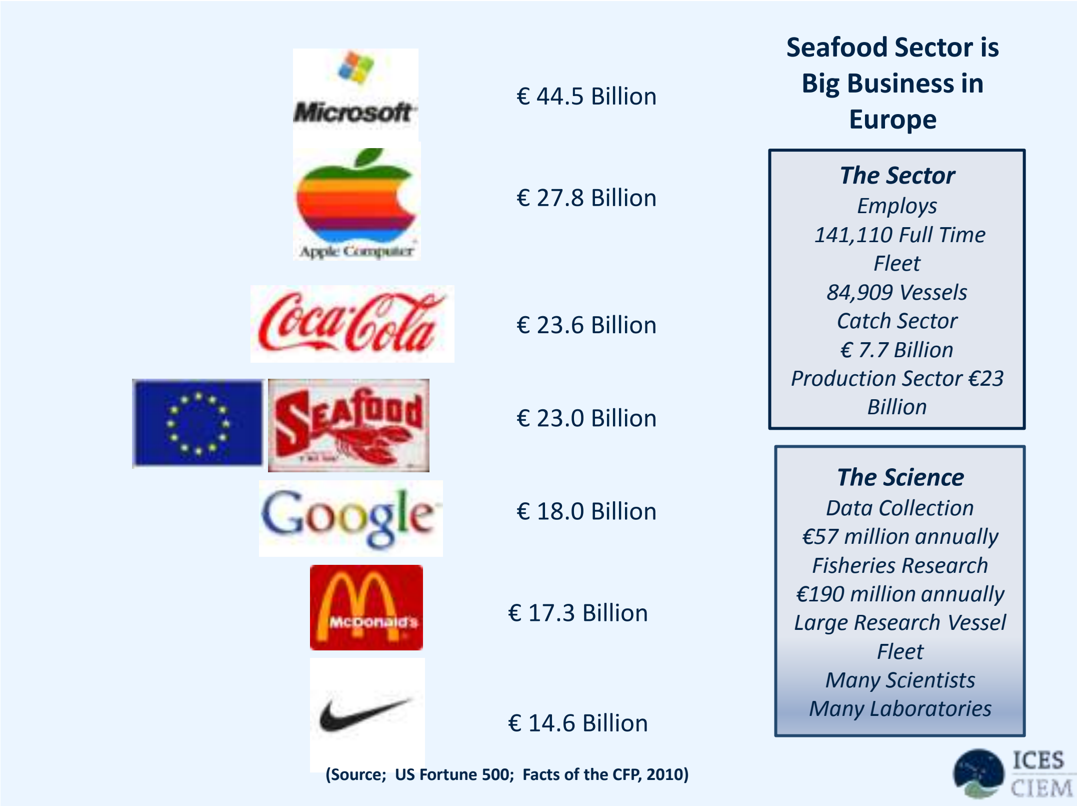

Figure 1. Comparative business valuations: US Fortune 500 and Facts of the CFP (Common Fisheries Policy), 2010

PHYSICAL CHARACTERISTICS OF THE BALTIC SEA LME

Here I would like to give a quick snapshot of the Baltic Sea LME and its exceptional and characteristic vulnerability (Figure 2).

Figure 2. The Baltic Sea LME and surrounding countries (HELCOM 2013).

What we are dealing with in the Baltic is a contained sea in which we have a water exchange that takes place only every 30 years. The Baltic Sea gets runoff water from many densely populated areas, with an estimated population of 90 million currently in the coastal areas of the surrounding countries. The resulting poor water quality is driving many marine species to the edge of their living conditions--first due to the brackish water, of course, but also due to the impacts of the human activities. The pollutants have a long residence time in the Baltic Sea and have a cumulative impact on marine species.

MAJOR THREATS TO THE BALTIC SEA LME

Of all the stressors on the Baltic Sea LME, four—eutrophication, hazardous substances, increasing maritime transport, and changes in biodiversity—are major threats to the health of the Baltic Sea LME. The vulnerabilities, together with human activities on land and at sea, lead to these four main areas where there is a need for further missions. The first is **eutrophication** with the Baltic affected by excessive inputs of nutrients stemming from either inadequately treated sewage, or from runoffs from agriculture. And in addition to that we have 25 percent of the total nitrogen load coming from nitrogen emissions from shipping in the Baltic Sea and from adjacent areas, and coming from land-based emissions outside the catchment area. It is, of course, extremely important to know these sources when you are attempting to come up with proposals for regulations.

ECOSYSTEM IMPLICATIONS OF CLIMATE CHANGE

We are still faced with the issue of **hazardous substances**, an issue that continues to be a risk despite substance prohibitions and substitutions of non-hazardous substances for several of the hazardous ones. Unfortunately, our knowledge of these hazardous inputs to the sea, of main input factors, still remains rather sparse.

Then we have the issue of **maritime transportation**. If you remember the map we showed just a while ago, it’s hard to believe, but this small area is actually shouldering up to 10 percent of the world’s goods transportation. This is underlined, for instance, by the marked increase that we have seen in the transportation of oil in the Baltic, which was around 80 million tons a year in the late 1990s. Presently we have around 170 million tons of oil being transported in the Baltic annually, and we have a prognosis stating that by 2020 we will have 250 million tons a year being transported within the Baltic.

All of this naturally affects the status of **marine biodiversity** as eutrophication, hazardous waste, and shipping threaten the future of species and biotopes. The cascading effects will affect many inhabitants of Europe.

Climate change complicates the story. Scientists conclude that air temperatures in the Baltic Sea Basin have already risen over the past century, increasing by approximately 1 degree Celsius in the northern areas and 0.7 degrees in the southern areas. This means that the warming in the Baltic Sea region is greater than the global mean temperature increase of 0.75 degrees Celsius reported by the IPCC. When we look at the seaward temperature, there is also an increasing trend.

The fourth major threat to the Baltic Sea LME, change in biodiversity, is driven in part by both temperature increase and salinity decrease. According to model projections, we can see that increased precipitation will take place that will lead to an increased runoff, and, consequently, we will have a decrease in salinity in the Baltic. For the ecosystem this will imply a decrease in the number of species and in some regions could lead to an increase in freshwater species (Figure 3).

Surface temperature changes may influence deep water oxygenation and this highlights the risk of continued spreading of anoxic areas during scenarios of continued climate warming. And it is important to know that the Baltic is already faced with a large number of dead bottom-sea areas that cover an area the size of Denmark. The increase in temperature and decrease in oxygenation, increase in precipitation, and decrease in salinity, will also mean that in the long run we could see a drastic decline in recruitment of cod.

In conclusion, there is evidence that climate change will prompt **both** eutrophication and the decline in biodiversity. We have to be aware that uncertainty exists especially regarding food web functions. However, existing knowledge calls for a precautionary approach and thus much more stringent measures when attempting to mitigate eutrophication and reduce biodiversity loss.

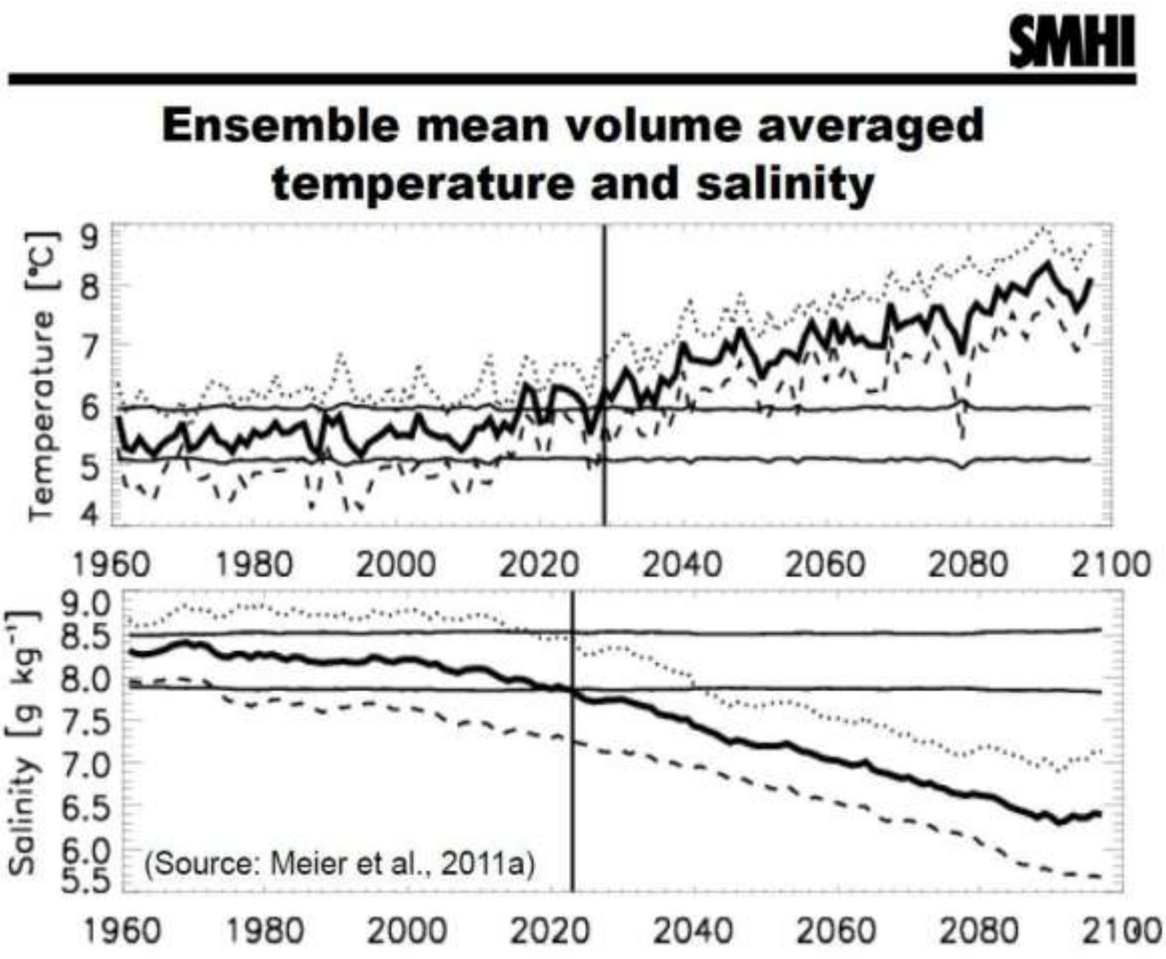

Figure 3. Temperature and salinity in the Baltic Sea Basin, 1960 to 2100. "This material is reproduced with permission of John Wiley & Sons, Inc., from Meier et al. Hypoxia in future climates: A model ensemble study for the Baltic Sea. GEOPHYSICAL RESEARCH LETTERS, VOL. 38, L24608, doi:10.1029/2011GL049929, 2011."

BALTIC SEA LME GOVERNANCE AND EXPERT SCIENCE

ICES and HELCOM

This leads me to the governance structure in place for the Baltic Sea LME. This is a central factor in the successful outcome of the Baltic Sea LME Project. The two main actors here were ICES and HELCOM, and in a nice way they supplemented each other. Both had legally based Commissions; both had a main focus on protecting the marine environment by ensuring a sustainable level of human activities; and both proposed and took measures, based on scenarios for tradeoffs to be taken in order to obtain this protection for the marine environment. While HELCOM, based on legal and scientific information also makes policy decisions, ICES is focused on a broad acceptance of scientific information. The ICES scientific work thus encompasses both a purely scientific component, which in part is driven by a bottom-up approach and, in part, by a wish to interact with society and deliver operational science-based inputs to societal actions. On top of this, ICES delivers advice, based on specific requests by competent authorities. It is most important to note that all the science and scientific advice coming from ICES is unbiased and apolitical. In addition, ICES delivers on two other components: a data centre that provides a range of data handling, data control, and data parts for direct use, and a training programme that has an increasing number of activities both as regards scope and number of courses. Besides its wider membership from outside the Baltic and including North Atlantic countries, ICES has also gained strength from alliances with scientific institutes in South America and from various strategic partnerships, such as in the Pacific with its sister organization PICES, and in the Arctic with the International Arctic Science Committee (IASC), and the Arctic Monitoring and Assessment Programme (AMAP) under the Arctic Council.

Influence of the BSLME Project Grows in Terms of Membership, EU Maritime Policy, and Global Maritime Policy

The work and achievements of the international institutions for the Baltic region are strongly influenced by geopolitical circumstances, which at the time of the Baltic LME Project preparations, starting in the early 2000s, initially included four European Union member states. During the project implementation phase this increased to eight European Union member states out of the nine HELCOM Baltic Sea countries. During project implementation, the EU launched several activities within the marine and maritime fields. Thus we have a ‘Communication on the thematic strategy on the protection of the marine environment’ that was followed up by the adoption of a directive in 2008, known as the Marine Strategy Framework Directive. The main aim of this directive is to obtain good environmental status in all European seas by 2020 through an application of the Ecosystem-Based Approach.

Furthermore, the EU also issued a Maritime Green paper, called, “The Future of Maritime Policy, A European Vision for the Oceans and the Seas,” that led to the adoption of the EU Integrated Maritime Policy. The Marine Strategy Framework Directive is considered to be the environmental pillar of the EU Integrated Maritime Policy. As part of the Integrated Maritime Policy, in 2009 the EU strategy for the Baltic Sea region was adopted and it is still being affirmed in support of implementation of the HELCOM Baltic Sea Action Plan. As we sit here now, there are preparations within the EU also for the development of a Maritime Spatial Planning Directive. Importantly, all these EU initiatives build on global developments such as the 1992 Convention on Biological Diversity, and its decision from 2000 to apply an ecosystem approach, as well as the commitments from 2002 at the World Summit on Sustainable Development (WSSD) on the application of the ecosystem approach.

The HELCOM Baltic Sea Action Plan

Building on all these international initiatives, HELCOM in 2003, following a HELCOM Ministerial Conference, and a Joint HELCOM–OSPAR Ministerial Conference, decided to start the implementation of the ecosystem based approach. This coincided with the start of the Baltic LME Project. Work that culminated in 2007 with the adoption of the Baltic Sea Action Plan during a HELCOM Ministerial meeting in Krakow in Poland.

You may now be asking yourselves "how does the Baltic Sea LME Project fit into the picture?" As I see it, the Baltic Sea LME Project paved the way in the Baltic for the application of the ecosystem based approach to management by joining the forces of ICES and HELCOM in the region, ensuring that science, promoted and developed, fit into the governance system and decision-making process. Implementing the ecosystem based approach to management is about effective governance, and about having the best scientific information available for management advice.

The BALTIC LME Project 2003–2007

To give a little bit of background about the Project, it was funded by a $5.5 million grant from the Global Environment Facility (GEF) with the World Bank as the implementing agency, with substantial additional support, direct as well as in-kind, coming from other sources. The Project activities were structured around two components: the Large Marine Ecosystem component that was led by ICES, and the land and coastal component which was managed by the Swedish Agricultural University, and the World Wildlife Fund (WWF). Overall the project was managed by HELCOM. The beneficiary countries were Estonia, Latvia, Lithuania, Poland, and the Russian Federation (Table 1).

Table 1. An Outline of the Baltic Sea LME Project 2003 - 2007

BALTIC SEA LME PROJECT 2003-2007

- GEF / USD $5.5 million Grant
- World Bank; implementing agency
- Managers: HELCOM, ICES, Swedish Agricultural University (SLU) and WWF
- Component (1) Large Marine Ecosystems
- Component 1 Major Outcomes:
  Monitoring and assessment
  Ecological objectives and indicators
  Multiple Marine Ecological Disturbances (MMED)
  GIS and databases
- Component (2) Land and Coastal
- Component 2 Major Outcomes:
  Agricultural interventions
  Coastal Zone Management
  Monitoring and Assessment
- Project Beneficiaries: Estonia, Latvia, Lithuania, Poland, and Russia
- MAJOR LEGACY OF THE BALTIC SEA LME PROJECT SCIENTIFIC NETWORK
  - Application of an ecosystem approach
  - ICES and HELCOM constituencies
  - Basis for the HELCOM Baltic Sea Action Plan
  - Increased assessment capacity
  - Coordinated Baltic Science Programme

The overall goals of the Project were to introduce the ecosystem based approach to the management of Baltic Sea LME coastal and marine environments; to reduce pollution from non-point sources, especially with a focus on agricultural activities; and to increase sustainable agriculture and fisheries, and in particular through **Component 2** to improve the living conditions for the local populations through sustainable use of natural resources in agricultural and coastal areas.

The more specific outcomes of the LME Project were, and still are, if we are specifically looking into **Component 1**, an expansion of the geographic coverage and improvement of the integration of the open sea and the near-shore activities in the eastern Baltic Sea, to fill gaps in the ICES monitoring networks for fisheries and environmental monitoring. As a matter of fact, ICES is now working with HELCOM and other European regional seas on a proposal to ensure that we can further this integration of fisheries and environmental monitoring, for implementation of the Marine Strategy Framework Directive, where EU countries have a deadline of 2014 to put forward such monitoring strategies. So here again, we can see a very nice connection with the work that started at the Baltic LME Project. Specific examples of what was obtained include the expansion of the use of Ships of Opportunity for a more cost effective monitoring of changes in the plankton communities and in the environmental parameters. The Baltic LME Project included the development of eutrophication related indicators; it included a set of indicators for assessing ecosystem recoveries related to improved agricultural practices and then, importantly when we are talking about looking at tech devices and at a more holistic approach, an enhancement of the knowledge of multiple marine ecological disturbances (MMEDS) regarding their ability to signal decline in ecosystem health, for example; and eventually and consequently looking at the introduction and operationalization of the application of methodologies for assessment.

All of this has meant that we needed to have the data in place, so there was a lot of work that was conducted in gathering and vetting data, insuring quality control, and also building up databases put together with GIS related instruments.

If we look into **Component 2** and the overall outcome of that component, it is focused on field activities to curb environmental impacts of nutrient flow from farmland, as well as monitoring and assessment of nutrient scenarios. Here again, we see the important linkage between land and sea components. If we want to achieve a healthy marine environment, we have to look at the sources of pollution coming from land. More specifically, we also saw increased environmental awareness including development of business plans that led to farm investments. And here we have some very strategic partnerships—one in that specific area administered by NEFCO, the Nordic Environment Finance Corporation—partnerships that were at the same time offering and administering the GEF grant and then also directly offering loans under some very good conditions.

As regards Coastal Zone Management, we had local demonstration projects in which local stakeholders were involved in solving transboundary management issues. For monitoring and assessment, we worked for an increased understanding of the level of pollution from agriculture on environmental impacts and on improved data on nutrient losses and different counter measures.

Rather than continuing to emphasize single achievements, I would like to highlight one overall and sustained achievement even after the close of the Baltic Sea LME Project, namely the scientific network that was established by the Project and that still exists to this very day, maybe in a different form, but the foundation for the network was made during the Project. This scientific network led to an increased assessment capacity, especially in the eastern Baltic countries—a capacity that provided the basis for the HELCOM Baltic Sea Action Plan to be built on the application of the ecosystem approach.

This action plan was based on cooperation and coordination between two intergovernmental organizations, ICES and HELCOM, and on the subsequent bringing together of these two constituencies. Very importantly, this evolved into a Baltic Sea scientific programme identifying the science that needs to be carried out in order to support management bodies. This is called the BONUS Programme and it consists of a pot of common money, 100 million Euros, half funded by the countries around the Baltic and the other half funded by the EU.

CONCLUSIONS

I should like to summarize by pointing to the strengths of the Baltic Sea LME Project and to the factors that I find to be of importance in succeeding with establishing and executing such a large-scale Project (Table 2).

Table 2: What is important for a successful project?

REQUIREMENTS FOR A SUCCESSFUL PROJECT

- **Strong commitment to implementation**
- **Well established international structures and working programmes**
- **Personal commitment**
- **Local knowledge and a scientific network of excellence**
- **Close links to EU and Global Policy initiatives**
- **Financial priority setting**

The first is a strong commitment to the implementation of the agreed actions through well-established international bodies with structures and working programmes in place, and also, importantly, through devoted and committed persons who can carry the project through and steer the process.

Another thing that has been very important to the Baltic Sea LME project has been a blend of Baltic region-specific knowledge and priorities, with a network of scientific excellence that extends beyond the region. Here it has been important to have a close link to the EU and to global policies and their implementation, allowing priority-setting for the use of financial resources.

It is the mission of ICES to collate, synthesize, and coordinate marine science, and to enable provision of best available evidence for use by decision-makers. From its inception in 1902 to the present institution of 20 member countries bordering the North Atlantic, the geographic reach of ICES has expanded. The current geographic scope embraces the North Atlantic Ocean and adjacent European seas including the Baltic and Arctic, and includes a strategic partnership stretching into the Pacific (PICES). Future ICES activities will make use of the work of the ICES LME Working Group on Best Practices, as well as the existing synergies with the IOC–IUCN–

NOAA Consultative Committee Meeting of LMEs. These activities are part of the ICES movement towards integrated marine ecosystem assessments and the expanding role of ICES in delivering advice at the regional seas level.

Based on earlier experience with the Baltic Sea LME Project, the current ICES LME Group on Best Practices, and the already existing synergies with the IOC, IUCN, and NOAA Consultative Committee Meetings on LMEs, backed up by the recent move of ICES in line with current policy developments towards integrated marine ecosystem assessments and advice to be delivered at the regional seas level, ICES is ready, well prepared, and capable to enter into similar projects in future. Thank you very much.

4

CATALYSING OCEAN FINANCE: TRANSFORMING MARKETS TO RESTORE AND PROTECT THE GLOBAL OCEAN

Andrew Hudson, PhD, Head, UNDP Water & Ocean Governance Programme and Veerle Vandeweerd, PhD, Director, UNDP Environment and Energy Group

Veerle Vandeweerd, the Director of the Environment and Energy Group at UNDP in New York, regrets being delayed in India and not being able to personally deliver her talk here today. In baseball parlance, I will be pinch hitting for Veerle today. She sends her best regards and remains a strong advocate and supporter of all our work with Large Marine Ecosystems (LMEs). I am Head of the Water and Ocean Governance Programme at the UNDP. Like many others here, it's a real pleasure for me to be back in Boston. I'm definitely a true Bostonian: born here, grew up here, went to University here, and worked here for a while.

Today I'd like to share with you some work supporting the LME approach to coastal ocean assessment and management that we've been doing in the Global Environment Facility unit of UNDP. The results were released in December by UNDP jointly with the GEF in Washington D.C. in a two-volume document entitled, *Catalysing Ocean Finance* (Hudson & Glemarec, 2012). I will say that the remarks of Jane Lubchenco, the NOAA Administrator, GEF CEO

Naoko Ishii, and ICES General Secretary, Anne Christine Brusendorff, were all music to my ears because what I'm going to share with you is very much aligned with the visions in the presentations so far. Other speakers have commented on the utility of the LME approach to the assessment and management of coastal ocean goods and services. Marine and coastal resources within the boundaries of LMEs provide at least $3 trillion annually in economic goods and services plus an estimated $20.9 trillion per year to the global economy in non-market services (Costanza et al., 1997). Due to their proximity to the countries and the sizeable fraction of the human population that lives near the coasts, LMEs are centres of coastal pollution and nutrient over-enrichment, habitat degradation (e.g. sea grasses, coral reefs, mangroves), overfishing, invasive species, biodiversity loss, and climate change effects. Since much of human economic activity occurs in or adjacent to LMEs, most of the economic losses highlighted for the oceans as a whole are taking place in LMEs.

It is not a big surprise to anyone here that oceans and the 64 LMEs that border the world's continents represent a huge source of socioeconomic benefit, both in a market and non-market context. They serve as a source of goods and services to the global economy. They provide a sizeable proportion of our food for human consumption, ocean related tourism, and most goods on earth—some 90 percent of internationally traded goods and commodities—are transported by ships.

Oceans and LMEs are a huge source of energy—historically of fossil fuels but increasingly a potential source of large stores of renewable energy. In terms of non-market services, the ocean stores and recycles enormous reservoirs of carbon, nutrients, and heat. So it's a huge engine for maintaining the stability of ecosystem services critical to life on earth. Lastly, it is recognized that LMEs are huge contributors to poverty reduction. For many coastal-ocean nations, typically 5 to 8 percent of GDP depends on ocean sectors; but for some countries, particularly in Southeast Asia, as much as 20 percent of GDP depends on LMEs and on healthy oceans, underscoring the importance of healthy marine ecosystems to support sustainable human development.

MARKET VALUE OF OCEAN GOODS AND SERVICES

As part of the *Catalysing Ocean Finance* analysis, we did some rough estimates on the market value of some of the key ocean services. Fisheries and aquaculture account for about a hundred billion dollars a year; transport and shipping about half a billion dollars a year; around 30 percent of all global oil and gas is collected and retrieved offshore by industries bringing in about 90 billion dollars a year. Tourism represents about 5 percent of global GDP, about 6 percent of global jobs, and a simple back-of-the-envelope calculation, using some US data as proxy, suggests that ocean-related tourism adds on the order of $270 billion a year to the global economy. In sum, the global contribution of the oceans, just on a purely market basis, is on the order of a trillion dollars a year and about half a billion jobs.

But, as you have already heard from Dr. Lubchenco and others, we are still facing quite serious challenges and risks to our oceans and to LMEs in particular. The key five stressors that most people agree on are (1) overfishing, (2) coastal hypoxia (which we'll look at in more detail later), (3) invasive species, (4) habitat loss (e.g. coral reefs, sea grass, mangroves and others), and (5) the emerging but clearly important issue of ocean acidification. Not only are most of these issues still bad, but in the majority of cases they're accelerating geometrically and that is, in many ways, the most disturbing trend.

COSTS OF POOR OCEAN MANAGEMENT

We considered estimated costs of these key ocean threats. NOAA Fisheries and FAO and World Bank did an excellent study a couple of years ago of overfishing (Arnason, Kelleher, & Willman, 2008). They estimated a 50 billion dollar a year net economic loss from overfishing (Table 1).

Table 1. Estimated costs of poor ocean management on socioeconomic development

ESTIMATED COSTS OF POOR OCEAN MANAGEMENT ON SOCIOECONOMIC DEVELOPMENT	
Overfishing	$50 billion/ year
Coastal Hypoxia/ Eutrophication	$200 - $790 billion/ year
Invasive Aquatic Species	$100 billion/ year
Coastal Habitat Loss	Unknown but large
Ocean Acidification	$1.2 trillion/ year (2100) in “BAU” scenario
TOTAL COSTS today at least	$350 - $940 billion/ year

Some important work was done by the European nitrogen assessment group on the impact of hypoxia in Europe. We scaled that up and the total is between 200 and 800 billion dollars a year in global economic impacts from hypoxia (STAP, 2011). Our GloBallast Programme (www.globallast.imo.org), a joint initiative by IMO, UNDP and GEF under GEF International Waters, did a rough estimate that invasive species cost the world about a hundred billion dollars a year in economic damages. I don’t know of anyone who has figured out what the coastal habitat loss figure is, but it’s clearly a very large number. Ocean acidification is increasing, of course, and if we don’t get things right with the low-carbon economy we need to move to, the estimate is that by the year 2100 in the business-as-usual carbon emission scenario, we could have global damages of $1.2 trillion per year, and that was in a scaled-down viewpoint of the kind of damages that ocean acidification can cause. Even ignoring the future impacts of climate change on oceans, today we are already looking at a third of a billion to a billion dollars a year in various socioeconomic losses due to poor ocean management.

POLICY FAILURES DRIVE OCEAN DEGRADATION

One of the key points we make in *Catalysing Ocean Finance* is that all of these ocean degradation issues ultimately stem from certain key policy failures, often associated with market failures (Hudson, 2012; Hudson & Glemarec, 2012). For example, coastal hypoxia, whether in the Baltic Sea or in other LMEs, tells us that we as a society have not internalized the economic damage these nutrients are causing to our LMEs and to the larger oceans. The real costs are showing up in the environment, but have yet to show up in the price of fertilizer or in penalties for excessive use of fertilizer, for example, and we have not adequately funded the technologies and management practice needed to clean up wastewater and deal with other nutrient runoff management.

We need to significantly curtail the introduction of marine invasive species and it is widely known that shipping is one of the principal vectors. We need to understand the cost to the environment of untreated ballast water and we need broad adoption and enforcement of new international regulations to ensure that shippers accept and internalize the costs of treating ballast water to make it safe and clean to release, as ships go from port to port.

We need to do a much better job at estimating the value of both the market and non-market LME services that coastal habitats provide and build those into our policies and economic frameworks.

We need to make significant progress in internalizing the socioeconomic and environmental costs of unsustainable fisheries management; this externality is compounded by very large negative subsidies to the sectors that promote overfishing, on the order of $16 billion a year globally, based on some very good work by Rashid Sumaila and others at the University of British Columbia. (Sumaila & Pauly, 2006).

Lastly, if we are to effectively address the issue of ocean acidification, we need to understand that the root cause of this ‘existential’ threat to ocean ecosystems is the same as that for impacts of climate change on the atmosphere: we need to internalize the environmental cost of carbon into our energy economy by putting a proper price on carbon.

PLANNING APPROACHES TO CATALYSING OCEAN FINANCE

We have observed that the principal negative ocean stressors are overfishing, hypoxia (due to nutrient over-enrichment), invasive species, coastal habitat loss, and ocean acidification. We know that these issues have not yet been fully addressed. However, if you look at certain sub-samples of the media, you might see and hear a doomsday story. You could get the feeling that it’s hopeless; it’s gone too far, and we can’t turn the corner on these trends. But that doomsday story is not necessarily the case.

In *Catalysing Ocean Finance* we focused on reviewing three methodological approaches that we’ve been applying within the International Waters portfolios of UNDP-GEF and other GEF agencies for the last 20 years. Even though each is unique in its own right, there’s a generic similarity, summarized in Table 2. First and foremost, you need to prioritize key ocean and LME issues based on good science and, to the degree possible, good socioeconomic data analysis as well. Second step is identifying where the key barriers lie. That is, we need to identify what is driving poor LME management and LME degradation, whether they are informational, institutional, regulatory, and other barriers. Then we need to identify the key suites of policy and economic instruments that will change these trends, remove these barriers to move toward more sustainable LME and ocean management. Then lastly, once you agree on the appropriate mix of policy instruments to use, is to begin implementation. That is key to the story of what *Catalysing Ocean Finance* is all about. It is the implementation of these agreed policies and other instruments that has driven sizeable flows of financial capital and investment for ocean restoration and protection. In catalysing ocean finance, policy reform serves to create the proper ‘enabling conditions’ that can be a key driver for increased investment.

Table 2. Four-step approach to catalysing ocean finance (UNDP, *Catalysing Ocean Finance* Vol 1, p.17)

STEPS TO CATALYSE OCEAN FINANCE
Step 1: Prioritize ocean issues based on sound scientific and economic analysis
Step 2: Identify barriers creating market failures that drive ocean degradation
Information Barriers
Regulatory Barriers
Technology Barriers
Institutional Barriers
Financial Sector Barriers
Step 3: Determine appropriate mix of policy instruments to remove barriers
Identify finance type for underlying investment needs
Select cornerstone public instrument
Select complementary public instruments
Step 4: Implement policy instruments, catalyse public and private financial flows, national and international

Volume II of *Catalysing Ocean Finance* focuses on the methodologies and the case studies stemming from those methodologies. Basically there are three methodologies. The first is the GEF-developed concept of a **Transboundary Diagnostic Analysis** linked to a **Strategic Action Programme**, a strategic planning process known as TDA/SAP. We are fortunate that Al Duda, formerly a senior advisor at the GEF and one of the founders of this methodology, is in the audience today. Through three of its case studies, *Catalysing Ocean Finance* demonstrates that the TDA/SAP methodology has been highly effective in moving nations toward LME sustainability including through sizeable leveraging of investments. The second methodology is **Integrated Coastal Management (ICM)**. We are certainly not saying the GEF invented ICM, but that the GEF embraced, adopted and applied it in a number of contexts to very good effect, and you will see that shortly. The last approach I would point to is where in several key cases we **built on existing or emerging LME, regional, or global ocean and legal frameworks** as tools to foment transformational change in some key ocean sectors, especially shipping and fishing.

KEY RESULTS FROM THE CASE STUDIES

The second volume of *Catalysing Ocean Finance* contains key results from six case studies featured in our analysis: the Danube River with the Black Sea LME, Western Central Pacific Fisheries, Yellow Sea LME, FrePlata, PEMSEA, and GloBallast.

GloBallast Programme

The GEF-supported, UNDP implemented, IMO-executed GloBallast Programme is focused specifically on the issue of ships carrying invasive species in ballast water. Ships carry 5-7 billion tons of water around the planet every year. Ballast water is loaded in one port, unloaded in another, leading to what we've seen as explosions of aquatic invasive species around the world. There are many global examples of this. So in parallel to the GEF GloBallast Programme over the last thirteen or fourteen years, the international community was negotiating a new international legal instrument on ballast water that was adopted in 2004 by the international community and is now going through the ratification process and is getting increasingly close to coming into force. In supporting that process, we've been helping upwards of seventy countries to put together new national policy and legislation on ballast water, implementing certain institutional reforms, and assistance to integrate ballast water management into national environmental plans and regulatory frameworks. In parallel with the signal that the coming into force of the ballast water Convention is sending to the private sector, we've already seen well over a hundred million dollars invested in research and development on ship ballast water treatment technologies. I've had the pleasure of attending a few ballast water technology development conferences where this has been promoted and must say that the pace and degree of innovation has been astonishing in response to the anticipated demand for treatment systems. When the Convention is in force, ships and ship owners will need to be in compliance with the provisions of the Convention. The overall financial commitment is estimated to be on the order of 35 billion dollars for ships to be compliant with this treaty. So, it's quite catalytic, to say the least.

Black Sea LME

A series of GEF Black Sea LME projects, linked to 'sister' projects in the Danube River basin, extended over nearly 20 years of GEF support working in both the Danube and the Black Sea LME helped lead to a transformation in the management and ecological status of these closely linked transboundary ecosystems (Figure 2).

Figure 2. The Black Sea LME Drainage Basin

In the late 1980s the Black Sea was facing severe eutrophication and hypoxia due to the excess nutrient burdens primarily from the Danube. UNDP, the GEF and World Bank supported all the

Black Sea LME countries in policy and regulatory reform, and helped create and strengthen the Danube Commission and the Black Sea Commission and other associated institutional bodies. Equally importantly, these programs helped the countries of the basin prepare investment portfolios that ultimately translated into about three billion dollars in nutrient reduction investments in the Black Sea Basin, reducing nitrogen burdens by 25,000 metric tons per year, phosphorous by 4,000 metric tons per year, and, in the most recent data, demonstrating the first large scale reversal of a hypoxic area on earth, in the Black Sea Northwest Shelf. Some of the data show the trend from the early highly hypoxic period (shown as more blue and green in Figure 3) to a contemporary, more oxygen-enriched (yellow and orange) state reflecting the virtual elimination of the Black Sea NW Shelf hypoxic zone (Figure 3). During the worst stages of hypoxia in the late eighties, the Black Sea Northwest Shelf had local extinctions of a number of taxa and species, and we are now seeing a return of these taxa to the ecosystem as it recovers (Figure 4). We're not finished yet, of course, but clearly the Black Sea has shown significant recovery and is in a much better situation. In the Danube, for nitrogen, phosphorus and chlorophyll-a, 68, 88, and 100 percent of Danube waters, respectively, were recently rated as Class I or II in the Danube Water quality index that is considered to be compliant with good water quality.

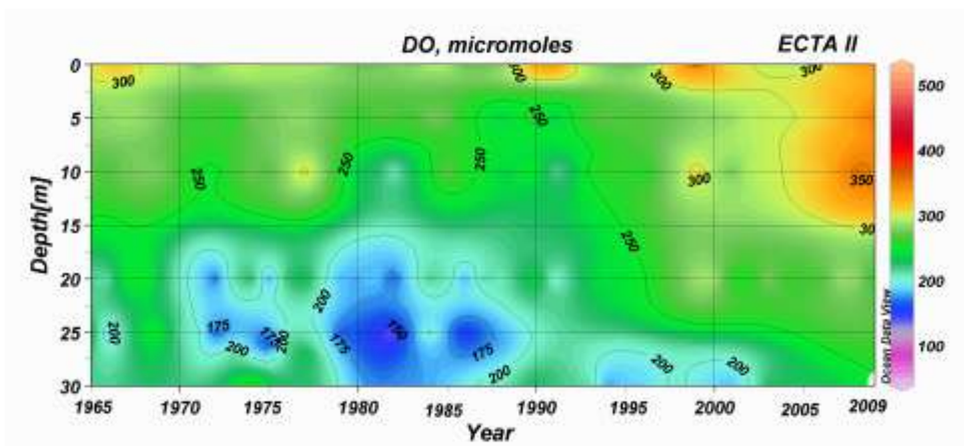

Figure 3. Reversal of eutrophication and hypoxia in the NW shelf of the Black Sea as reflected in oxygen concentrations (umol/l) off Constanta, Romania (blue and green correspond to low oxygen areas during periods of greatest hypoxia; orange illustrates return of more oxygenated waters).

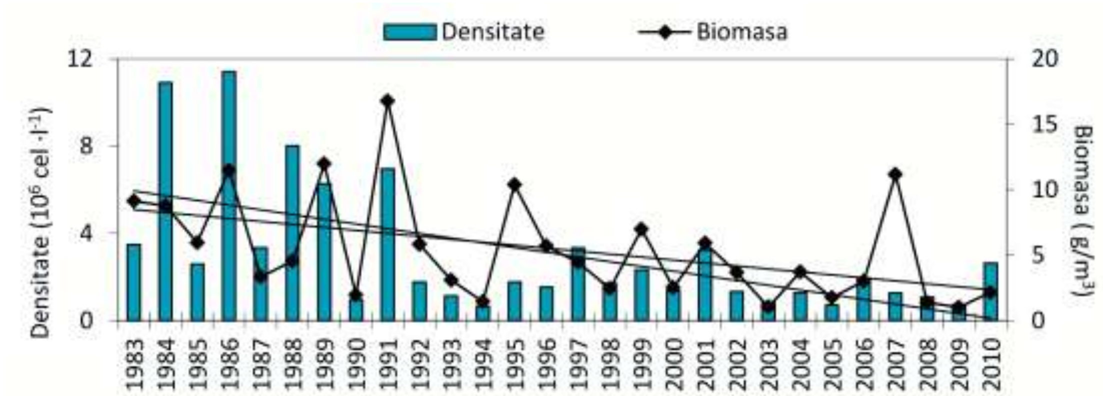

Figure 4. Number of macrozoobenthos taxa near Constanta, Romania, 199-2009 (Source: NIMRD-Constanta, Black Sea Commission archive)

In sum, the GEF grant financing in the case of the Danube Basin and the Black Sea LME catalysed additional financial support at a ratio of 57:1 (Table 3). Through this strategic, long-term intervention combining governance reform and catalytic environmental finance, the Danube/Black Sea ecosystem is on the road to recovery in terms of its functioning and effective delivery of both environmental and socioeconomic benefits to the nearly 160 million residents in the 17 countries of the basin.

Table 3. Catalytic Ocean Finance Summary for the Danube Basin and Black Sea LME project

Catalytic Ocean Finance Summary for the Danube Basin and Black Sea LME project—Amount (US $)	
Total GEF Grant Financing	$51.89 million
Total Programme Co-financing	$91.988 million
Catalysed Public and Private Sector Financing	$2.983 billion
Catalytic Finance Ratio (Total Catalysed Finance: UNDP-GEF Finance	57:1

Other UNDP-GEF case studies featured in *Catalysing Ocean Finance* include the Yellow Sea LME, the Rio de La Plata (shared between Uruguay and Argentina), the East Asian Seas LMEs through the PEMSEA Programme, and work with sustaining Pacific fisheries in the West and Central Pacific.

Yellow Sea LME

To promote the recovery and sustainability of the Yellow Sea LME, the two countries participating in the GEF-supported, UNDP-implemented YSLME project (Peoples Republic of China and Republic of Korea) completed a joint TDA/SAP process leading to commitments to reduce nutrient burdens by ten percent over each of a series of 5-year time frames. Equally impressive, the countries committed to a fishing pressure reduction of 25 to 30 percent based on scientific and social analyses of the carrying capacity of the Yellow Sea LME for sustainable fisheries. Based on a GEF grant of $14.7 million, programme co-financing of $10.3 million, and catalysed public and private sector financing from the YSLME countries of $10.86 billion, the catalytic finance ratio for the YSLME project is 737 to 1 (Table 4)

Table 4. Catalytic Ocean Finance Summary for YSLME

Catalytic Ocean Finance Summary for Yellow Sea LME —Amount (US $)	
Total GEF Grant Financing	$14,744 million
Total Programme Co-financing	$10.302 million
Catalysed Public and Private Sector Financing	$10.863 billion
Catalytic Finance Ratio (Total Catalysed Finance: UNDP-GEF Finance)	737:1

Rio de la Plata and Maritime Front (RPMF)

In the Rio de la Plata, following completion of the bi-national TDA and SAP and associated National Action Plans endorsed across multiple jurisdictions in both countries, UNDP-GEF assisted Uruguay and Argentina and their two bi-national commissions in putting together investment portfolios totaling just over two and a half billion dollars for their pollution reduction and habitat protection needs. Those pollution reduction investments are now underway, focused on reducing releases of untreated sewage waters and industrial pollutants into the basin, and on reducing nutrient discharges to key wetland protected areas.

In both Argentina and Uruguay, facilitated by the FrePlata Strategic Action Programme process, existing legal frameworks have been built upon to prepare new legislation for pollution control and integrated water resources management. Both governments have strengthened their institutional and cooperation frameworks for the shared integrated management of the RPMF. Through the strengthening of bi-national Commissions, national agencies and local governments dealing with RPMF issues, the project has helped to catalyse actual investments that were almost twice the original goals ($2.62 billion vs. $1.45 billion; Table 5).

Table 5. Catalytic Ocean Finance Summary for the FrePlata Programme

Catalytic Ocean Finance Summary for the FrePlata Programme—Amount (US $)	
Total GEF Grant Financing	$9.31 million
Total Programme Co-financing	$19.83 million
Catalysed Public and Private Sector Financing	$2.62 billion
Catalytic Finance Ratio (Total Catalysed Finance: UNDP-GEF Finance)	281:1

LMEs of the East Asian Seas

Covering about ten countries in East Asia, UNDP-GEF's work supporting the PEMSEA programme, or Partnerships in Environmental Management for the Seas of East Asia, has led to 11 percent of all the East Asian coastline under Integrated Coastal Management (ICM) programmes from a baseline near zero, and the region is largely on schedule to reach a target of 20 percent of coastline under ICM by 2015. With support from PEMSEA over nearly twenty years, over $10 billion has been leveraged to support investments in pollution reduction and other environmental mitigation actions in the East Asian Seas.

With support from UNDP-GEF, a series of four GEF International Waters projects was initiated, starting in 1993, with a cumulative GEF investment of $36.1 million (Table 6). In total, environmental investments leveraged through PEMSEA-facilitated ICM and sub-regional programme implementation have amounted to $369 million of which $78.65 million came from the private sector and the balance from the public sector (Table 6). This translates to an environmental investment leverage ratio of 12.8 to 1 for GEF funds over the 4 projects. If the pollution reduction projects that have been catalysed by PEMSEA in the Bohai Sea and Manila Bay are considered, the ratio increases to more than 275 to 1. Notably, 1.46 billion or 47 percent of the world's 3.1 billion people who live in the coastal zone (<100 km from the ocean) live in the East Asian Seas region. This underscores that the impacts of PEMSEA on coastal sustainability through upscaling of ICM are not just regional, but global in their scale.

Table 6. Catalytic Ocean Finance Summary for the PEMSEA facilitated projects for the East Asian Seas

Catalytic Ocean Finance Summary for the PEMSEA facilitated projects for the East Asian Seas LMEs — Amount (US $)	
Total GEF Grant Financing	$36.1 million
Total Programme Co-financing	$94.12 million
Catalysed Public and Private Sector Financing (through 2007)	$369.21 million
Catalysed Public and Private Sector Financing (incl. Manila Bay and Bohai Sea)	$9-11 billion
Catalytic Finance Ratio (Total Catalysed Finance: UNDP-GEF Finance)	13:1
Catalytic Finance Ratio (including Manila Bay & Bohai Sea)	277:1

West and Central Pacific Fisheries and SIDS

In the West and Central Pacific, UNDP-GEF has been supporting a series of projects in 14 Pacific Small Island Developing States (SIDS) since 1997 in processes related to the negotiation, adoption and coming into force and implementation and compliance with the West Central Pacific Fisheries Convention. This also led to the establishment and full sustainability of the West and Central Pacific Fisheries Commission; major fishing states along with all Pacific SIDS now have membership in the Commission. These projects have helped the Pacific Island countries in their efforts to meet and enforce the provisions of that Convention, including vessel monitoring systems, onboard observers, ecosystem-based management, quota systems, and many other aspects. A key benefit from this effort over the 1997-2010 period has been a tripling of both the gross revenue and the fish yield realised by the Pacific island countries themselves. Over the 1997-2010 period, the cumulative net economic benefits to the Pacific Island Countries totaled $3,214 million (Table 7).

Table 7. Catalytic Ocean Finance Summary for West/ Central Pacific Ocean Fisheries

Catalytic Ocean Finance Summary for West/ Central Pacific Ocean Fisheries	
Total GEF Grant Financing	$15.1 million
Total Programme Co-financing	$150 million
Catalysed Public and Private Sector Financing	$3,214 million
Catalytic Finance Ratio (Total Catalysed Finance: UNDP-GEF Finance)	213:1

In the Pacific, the tuna and associated fisheries sector can represent 20 to 30 percent or more of GDP of these island nations. This underscores the tremendous contribution of these UNDP-GEF programmes in supporting economic development in these mostly poorer small island states.

SUMMARY OF RATIOS FOR CATALYTIC FINANCIAL IMPACT OF GEF INVESTMENTS FOR 6 CASE STUDIES

A summary of ratios of catalytic impact of GEF investments for six case studies is shown in Figure 5. For each case study, the graph summarises the ratios of total catalysed public and private finance to GEF grant (public) finance. What's important here is that these numbers are big. They're not 5 to 1, or 10 to 1, but in many cases 100s to 1, showing the potentially transformational power of the GEF as a source of public finance to transform markets for ocean restoration and protection.

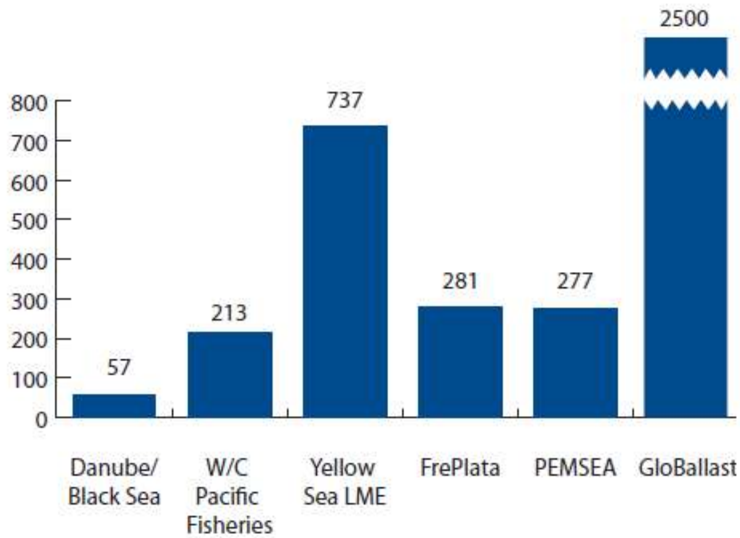

Figure 5. Catalytic ocean finance ratio (Catalysed public & private finance: UNDP-GEF finance) for the six case studies. UNDP, *Catalysing Ocean Finance* (2012) Vol 1, p.27.

A key message of this analysis is that the scale of new public financing required to create the necessary enabling policy environment that can catalyse sizeable sums of financial flows and lead to transformational change at regional and global scales in ocean sectors such as shipping, fisheries and wastewater, is not as insurmountable as one might think.

This leads to the final component of *Catalysing Ocean Finance*, where we use both the financial and ecosystem stress reduction results from the six case studies as 'proxies' to scale up the derived results to a global level aimed at addressing key threats to LME and broader ocean sustainability.

FISHERIES EXPLOITATION TRENDS

I won't go over the slides in relation to LMEs that Jane Lubchenco has already shown you, but clearly there has been a long trend of growth in the proportion of overexploited fisheries, now at almost 40 percent. In short, world wild fish catch leveled off around 1985 or so and it has been effectively flat since then (Kleisner, Zeller, Froese, & Pauly, 2012).

Over this nearly 30 year period, the only reason we've still had sufficient supplies of seafood to meet global demand is that aquaculture has been growing at a rate on the order of 9 to 11 percent per year, and now makes up around 46 percent of globally consumed seafood products; otherwise in that same period, we would have had a sizeable deficit. Unfortunately, we also know that much of that aquaculture is unsustainable.

Catalysing Ocean Finance examines how several of the key strategic planning methodologies described in the case studies volume can be used to promote adoption and implementation of the proper blend of policy instruments that are needed to transition to sustainable fisheries at a global level. Key among these is building on and strengthening some of the global and regional legal and institutional frameworks such as regional fisheries management organizations; redirecting destructive fisheries subsidies to enhance management and enforcement; scaling up rights-based approaches such as ITQs; and achieving, or exceeding, Aichi target of 10 percent of the global oceans under MPAs. Bringing forward sound science and the precautionary approach will further enhance these objectives. The WTO has been involved over the years in a series of negotiations regarding fisheries subsidies. While these negotiations are not yet completed, there has been progress and there seems to be potential commitment to move toward phasing out negative fisheries subsidies. Through International Waters projects such as those in the West and Central Pacific and the Yellow Sea, UNDP-GEF has demonstrated that the TDA–SAP approach can be a very effective planning methodology to move fisheries closer to sustainable practice by creating the necessary enabling environment for fisheries governance reform.

Catalysing Ocean Finance also explores the sizeable financial resources that could be leveraged for sustainable fisheries through a broad scaling-up of Individual Transferrable Quotas (ITQs). One estimate has the potential additional revenue from ITQ sales at a global scale to be on the order of 40 billion dollars a year. That would be new revenue that could be put into conservation programmes, management programmes, scaling up marine protected areas, and all the other things we know we need to do to move toward sustainable fisheries. The Convention on Biological Diversity (CBD) has the Aichi biodiversity target of bringing the world's Marine Protected Areas (MPA) up to 10 percent of ocean area. Analyses in *Catalysing Ocean Finance* and other sources suggest the costs of achieving these targets are substantial, in the tens of billions of dollars, underscoring the need to redirect and leverage sizeable new financial resources as described above.

HYPOXIC AND EUTROPHIC AREAS

Some excellent work has been done over the years by a number of investigators looking at the long-term trends in hypoxic and eutrophic areas, basically observing a near doubling every ten years for the last few decades (Diaz & Rosenberg, 2008; Sutton et al., 2010). This is true geometric growth. Similarly, work done by Seitzinger and others on continental nitrogen burdens to the ocean basically indicates a tripling of the nitrogen fluxes to the global oceans since pre-industrial times. The business-as-usual (BAU) scenario predicts another doubling or tripling by the year 2050 (Seitzinger, Sherman, & Lee, 2008). These results suggest that at this stage it is fair to say that the perturbation of the global nitrogen cycle is becoming just as severe as the perturbation of the carbon cycle (via the burning of fossil fuels), and equally drastic actions are going to be called for in the use of fertilizers and agricultural practices, and wastewater management, to promote the recovery, processing and re-use of valuable nutrient commodities.

The good news is that we already have on hand a range of policy instruments that could be used to start to tackle the nitrogen issue. As we heard for the Baltic Sea LME from Anne Christine Brusendorff, these are in particular linked to improvements in the management and regulation of agricultural-related nutrient emissions from fertilizer and manure run-off from poorly managed manure piles. There are some excellent pilot study results that can be scaled up, such as putting in place nutrient emissions cap and trade mechanisms in river basins on a national or even international basis. Fertilizers often get subsidized which promotes their overuse; reform could bring subsidies instead to good nutrient management practices that promote efficient use of fertilizers, that promote recovery, and even that promote the recovery and re-use of vital nitrogen resources from waste water, among other possible mechanisms.

An estimate for the public costs of addressing LME hypoxia at a global level was derived based on scaling up Danube/Black Sea TDA/SAP experience to all LMEs (and linked river basins) impacted by hypoxia, and by scaling up PEMSEA's success at reducing hypoxia hot spots through ICM approach. This analysis led to an estimated one-time public cost of about $2.5 billion, leading to catalysed finance of about $76 billion, and avoided costs of $200 to $790 billion per year.

INVASIVE SPECIES—SHIP HULL FOULING

In addition to ship ballast water, it is well known that the other key vector for transport and introduction of aquatic invasive species is the exterior of the ship, via ship hull fouling (Figure 6). To address ship hull fouling comprehensively at a global scale, *Catalysing Ocean Finance* suggests taking a very similar approach to that applied to ship ballast water under the GEF-UNDP-IMO GloBallast programme for the last 15 years.

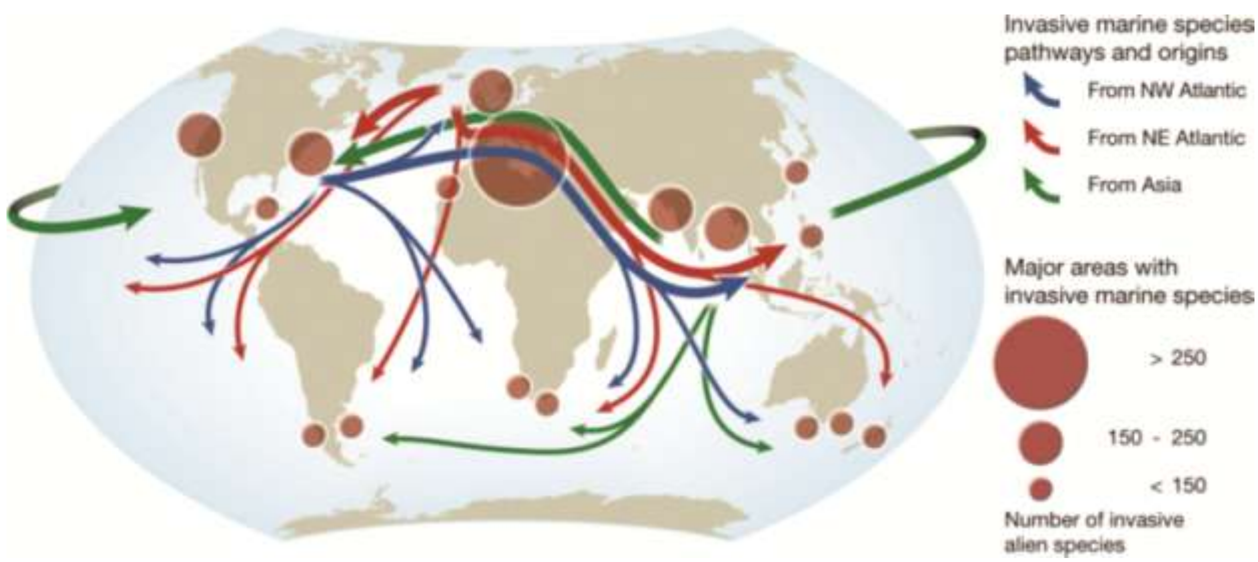

Figure 6. Invasive Marine Species Pathways and Origins from UNEP/GRID-Arendal Maps

Already, the IMO has issued voluntary guidelines for managing hull fouling as they did in the beginning for ballast water which then moved into a full scale international process to negotiate the convention on ship's ballast water and sediments, adopted in 2004 and presently in the process of receiving ratifications towards its coming into force. We would like to see a similar process ensue for hull fouling that would ultimately lead to a new international instrument on minimizing invasive species risk from hull fouling. In parallel, a global GEF program similar in design to the GloBallast programme, is needed. Support for countries' governance and legislative reforms, support for R&D and other private-sector consultation, and coordination mechanisms are needed to catalyse, in the same way as in the ballast water example, a real upsurge in investment in the kinds of technologies and innovative approaches required to minimize invasive species risk from ship hull fouling.

CO_2 CONTINUES TO RISE AND OCEAN pH DROPS

Last but by no means least, as Dr. Lubchenco the NOAA Administrator has described, is the issue of ocean acidification. We have ample evidence that about 30 percent of the CO_2 that we are emitting via the burning of fossil fuels, is dissolving into the ocean. This CO_2 dissolves into the ocean and forms carbonic acid, a weak acid, but nevertheless an acid. As a result, the ocean is slowly but inexorably getting more acidic. So far, average ocean pH has decreased about 0.1 pH unit that represents about a 30 percent increase in acidity and this change has occurred in an extremely short period of time compared to natural rates.

Figure 7 from Carol Turley's group at Plymouth Marine Lab shows that, in the business-as-usual fossil fuel use scenario, ocean pH would drop an additional 0.3 to 0.4 units by 2100. The effects of ocean acidification would be most immediate and severe in the polar regions where some of the world's most important and productive fisheries are located, and can thus have potentially devastating effects on higher latitude LMEs and open ocean areas on a global scale.

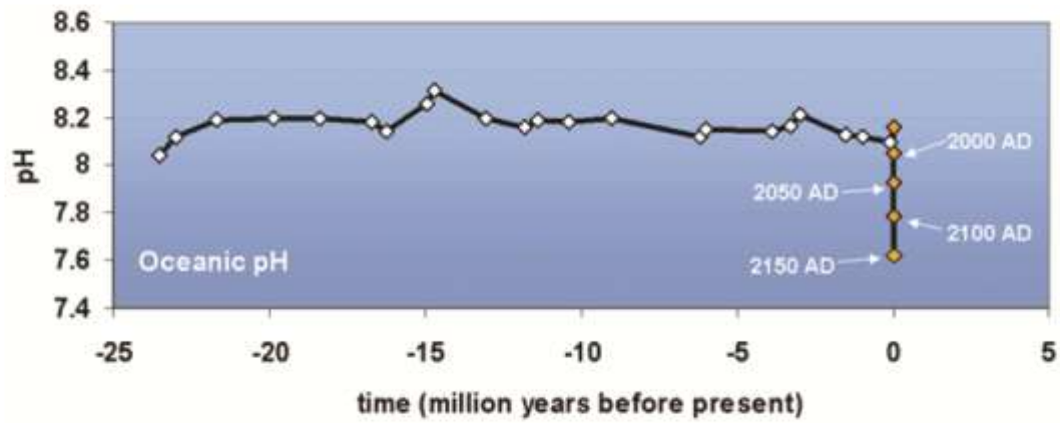

Figure 7. Changes in Ocean pH over the last 25 million years and projections in 'business-as-usual" fossil fuel use scenario (Turley et al., 2006)

In *Catalysing Ocean Finance* we focus on two key areas or sectors where changes in how ocean practices go forward could have not a solution, perhaps, but have a meaningful impact on climate change and associated with that ocean acidification. The first is shipping. At present international shipping contributes about 2.7 percent of global greenhouse gas emissions—an important piece but perhaps not in comparison to other sectors and sources. But, shipping is growing very rapidly, 4 percent per year or so, as the world economy grows and gets richer and middle-income countries want more and more stuff. Ships carry that stuff, 90 percent of all internationally traded goods move via ship. Depending on the overall trajectory of CO_2 emissions on earth, in the worst-case 'business-as-usual' scenario, according to IMO estimates shipping's contribution could increase to 12 to 18 percent of global CO_2 emissions and this would clearly not be a good situation. So the IMO and its member states as of January of this year have already adopted new international standards covering two areas: EEDI, for ship energy efficiency design index, and SEEMP, shipping energy efficiency management plans. IMO estimates show that under the scenario of implementing these standards for the next 20 or 30 years, would deliver a reduction in CO_2 emissions of about a gigaton per year, a billion metric tons of $CO_{2,}$ which is on the order of 3 or 4 percent of present-day global emissions so a big deal if these standards are successfully implemented. Furthermore, implementation of the shipping energy efficiency standards would deliver net fuel savings to the industry estimated at $90 - $310 trillion per year by 2030. Thus the shipping industry is positioned to both make a meaningful contribution to mitigating global climate change while saving very sizeable sums towards the bottom line.

BLUE CARBON – POTENTIAL CONTRIBUTION TO CLIMATE CHANGE MITIGATION

Seagrasses and mangroves, even though they occupy a relatively small area of earth, on a per hectare per year carbon sequestration basis, they are large potential "blue carbon" sinks. Under a best case scenario, a global upscaling of blue carbon could offset global CO_2 emissions by 0.4 to 3 percent—a pretty big contribution to the mitigation of global carbon loading (Pendleton et al., 2012). Beyond the CO_2 mitigation benefits, even larger economic benefits could be realized from blue carbon via restored and new habitat that protects coasts from storm surges, and from maintenance of other ecosystem services that coastal habitats provide such as fish spawning areas and nurseries. In the best case scenario we're looking at about a gigaton per year of net new carbon sequestration that could be achieved by scaling up blue carbon globally. Notably, the projected global emissions from shipping which would be realized under the scenario of successful implementation of EEDI/SEEMP are about 1.5 gigatons per year (vs. 2.6 gigatons per year in 'business as usual' scenario). This suggests an outcome whereby, in the best possible scenario, combining successful scaling up of blue carbon with a highly efficient, much lower carbon shipping sector, ocean related sectors could approach the equivalent of a climate neutrality. This quite feasible scenario sends a powerful message that addressing global climate change lies well within our reach if the necessary political will can be found to put in place the appropriate policy mix that will transform us towards a truly low emission, climate resilient development pathway.

Regarding new policy instruments, on ocean acidification *Catalysing Ocean Finance* suggests building on the United Nations Framework Convention on Climate Change (UNFCCC) as an existing legal mechanism, or some have come up with the idea of a completely new multilateral environmental agreement on ocean pH and ocean acidification. The international community must decide. We also need to make sure we get the blue carbon right; the inventory methodologies are complicated, and we will have to see how far the marine community can come to get a robust, verifiable and replicable blue carbon methodology that can then be scaled up for key ecosystem types such as mangroves and seagrasses. Lastly, we need to promote the development of GEF or other programmes that can support countries (flag and port states) and companies (ship owners, ship builders) in their efforts to adhere to these new ship energy mandates towards an industry with a much lower global carbon footprint.

CONCLUSIONS

In conclusion, the key message of *Catalysing Ocean Finance* is that reversing ocean degradation is not necessarily a hopeless or intractable problem. A summary of scaling up actions to address the four main ocean ecosystem threats is provided in Table 8.

Table 8. Scaling up Actions to Restore Ocean Ecosystems. From Catalysing Ocean Finance, Vol. 1 p.51

	Ocean Hypoxia	Ocean Acidification	Overfishing	Marine Invasive Species
	Reduce nutrient over-enrichment of coastal areas	Energy efficient shipping Protect & restore coastal carbon sinks	Reduce unsustainable fishing practices	Reduce aquatic species transfer via ship hull fouling
Strategic Planning Methodologies	• Scale up TDA/SAP in 20 remaining LMEs (& linked river basins) facing hypoxia • Scale up ICM in same LMEs as tool to leverage nutrient pollution reduction investments and protect nutrient sinks	• Build on UNFCC – Ocean pH target (minimum) – Adoption of Blue Carbon • Build on new IMO ship energy efficiency guidelines • ICM, TDA/SAP to help promote scaling up local and national Blue Carbon initiatives	• Build on Global & Regional Legal & Institutional Frameworks – Complete WTO negotiations to phase out negative fisheries subsidies – Strengthen RFMOs & LME institutions • TDA/SAP: Scale up in ~50 LMEs/fisheries areas facing depletion/overexploitation • ICM as cross sectoral tool to promote sustainable fishing & aquaculture	• Build on anticipated international instrument on Ship Hull Fouling • Incorporate hull fouling issue into LME TDA/SAPs where invasives are priority issue
Policy Instruments	• Nutrient management regulations • Nutrient emissions cap and trade in river basins (national, regional) • Fertiliser subsidy reform • Subsidies to agricultural nutrient reduction practices & technology • Subsidies to wastewater and industrial nutrient recovery & re-use • Global nutrient reduction fund capitalised by innovative financial mechanism(s)	• Amend UNFCCC to incorporate safe ocean acidity limit & catalyse action on low carbon economy • Blue carbon inventory methodologies • Tools, methodologies, standards & guidelines to promote uptake of IMO energy efficiency guidelines – Ship management plans (SEEMP) – Ship design standards (EEDI) – Facilitate private sector R&D	• Shift negative fisheries subsidies $16 billion/yr to sustainable aquaculture & MPAs • Scale up Individual Transferable Quotas (ITQ), $ to MPA, aquaculture, management • CBD Aichi Biodiversity Target 11-10% oceans under MPAs • Ensure sound science, EBA, data sharing, precautionary principle in RFMO & LME commission mandates • UN Fish Stocks Agreement, FAO Code of Conduct, Port State Measures, etc.	• Tools, methodologies, standards & guidelines on hull fouling management • Support to negotiations and enhanced capacity for implementation of possible new international agreement • Facilitate private sector technology R&D
Costs, Benefits & Catalysis	• Public costs: – TDA/SAP LMEs: $1.0 billion (1 time) – ICM global: <$1.5 billion (1 time) • Benefits (avoided costs): $200-790 billion/year • Catalysed Finance: – TDA/SAP LMEs: $60 billion – ICM global: <$16 billion	• Public costs: $420-820 million (1 time) • Benefits (avoided costs) – Shipping on CC: $88 billion/yr (2050) – Blue Carbon on CC: $16-94 billion/yr (2050) – Shipping $90-310 billion/yr (fuel savings) by 2030 • Catalysed Finance: – Blue Carbon $0.3 - 5.1 billion/yr – Shipping ~$20 billion (1 time)	• Public costs: – RFMOs/LMEs: $496-600 million (1 time) – MPAs @ 10% ocean: – Establish $28 billion (1 time) – Operation $21 billion/yr • Benefits (avoided costs): $50 billion/yr • Catalysed Finance: – Shifted subsidies: $16 billion/yr – ITQ sales: $40 billion/yr – RFMOs/LMEs: $232 billion (1 time)	• Public costs: $20 million (1 time) • Benefits (avoided costs): $10-90 billion/yr • Catalysed Finance: $10-30 billion

If the leaders of today, the decision makers, the governments, the policy makers, at this pivotal point can decide to be the key catalyst of transformation in global LMEs and ocean management, an additional public investment of about five billion dollars over 15 years, could be enough to transform ocean management going forward and to preserve trillions in ocean ecosystem services. But we don't have much time for indecision. The issues are largely getting worse geometrically, and we've learned in the GEF that the timeframe to facilitate the institutional, policy and regulatory changes, and required investments, is not 5-10 years but 15-20 or more years. So the time to begin is now.

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5

LME ASSESSMENT AND MANAGEMENT STRATEGIES FOR THE OCEAN AND COASTS

Wendy Watson-Wright, PhD, Executive Secretary, Intergovernmental Oceanographic Commission and Assistant Director-General, UNESCO

It is indeed a great pleasure to be invited to speak to you at this high-level Conference on the Sustainability of Large Marine Ecosystems. Thank you for having given me this opportunity.

Let me acknowledge our partner organizations that are supporting the LME efforts globally: NOAA, UNDP, UNEP, ICES and of course the GEF that has been such a great catalyst for implementing the LME approach in so many coastal regions of the world. The Intergovernmental Oceanographic Commission of UNESCO, the IOC, has for more than 20 years promoted the concept of ecosystem based management for our oceans through the LME approach. With our unique mandate as the only UN body responsible for Ocean Sciences, observation and capacity building, the IOC has contributed to the LME's movement, not only from a scientific and conceptual point of view but also through concrete implementation of GEF funded LME projects on the ground.

I'd like to structure my presentation today around a number of questions that are in my view critical for the sustainability and further development of LMEs around the world: I would like to focus on five questions:

- What are the present and future climate-related threats?
- Where does the science need to go?
- How can we integrate LME needs within global and regional ocean observations frameworks, and keep systematic track of the health of LMEs globally?
- How can we trigger policy response through cross-sectoral Management and transboundary Governance in LMEs?
- What human and institutional capacities are needed for supporting such paradigm shifts?

1. CLIMATE RELATED STRESSORS AND THEIR IMPACTS

1.1 Sea Surface Temperature and Ocean Heat Content

We now have robust scientific evidence that climate change on time scales from decades to centuries has profound consequences for the marine and coastal environment with potentially devastating socioeconomic effects. Ocean warming has occurred from the surface to a depth of about 700 metres, the zone in which most marine life thrives. Ocean heat content changes were important in scientific arguments attributing climate change to anthropogenic causes.

There has been a clear trend in the past twenty years of increase in the upper ocean heat content as can be seen in **Figure 1**. The variation in that quantity has decreased over time as the global network of upper ocean temperature profiles has dramatically increased with the Argo profiling float network.

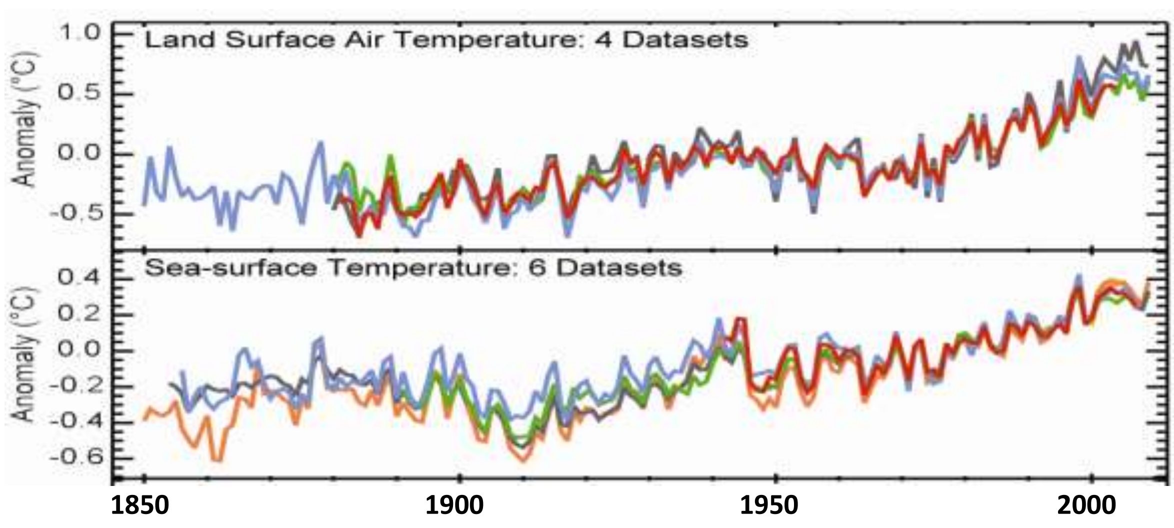

Figure 1. Land and sea surface temperatures over 125 years. Source: http://www.metoffice.gov.uk/hadobs/indicators/11keyindicators.html

This process has, of course, not spared the World's LMEs; quite the contrary. For the period of 1982 through 2006, sea surface temperatures in 61 of the 64 LMEs followed an increasing warming trend, while 18 of the 64 warmed two to four times faster than the global average reported by the IPCC **(Figure 2).** Ocean heat content has also risen (**Figure 3**).

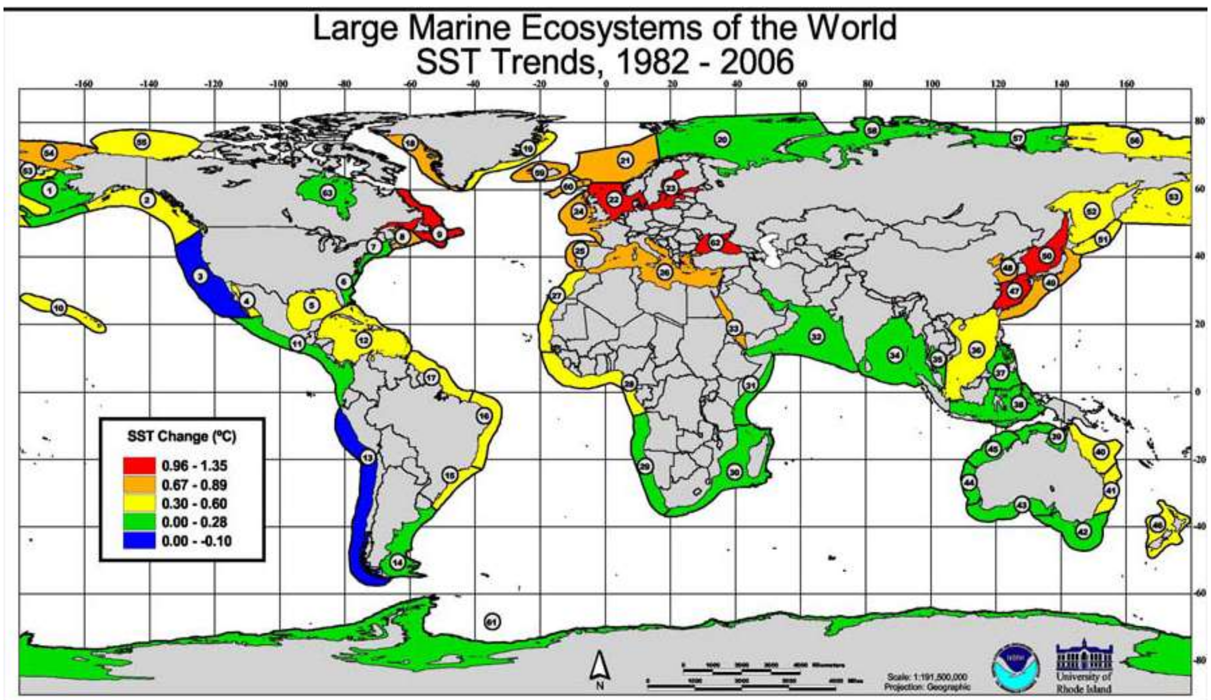

Figure 2. Net SST change (°C) in Large Marine Ecosystems, 1982-2006. Three clusters of fast (pink) and super-fast (red) warming are evident around the Subarctic Gyre in the North Atlantic, in the European Seas, and in the East Asian Seas. The Indian Ocean LMEs warmed at slow rates. The California Current and Humboldt Current LMEs experienced a slight cooling (Belkin, 2009).

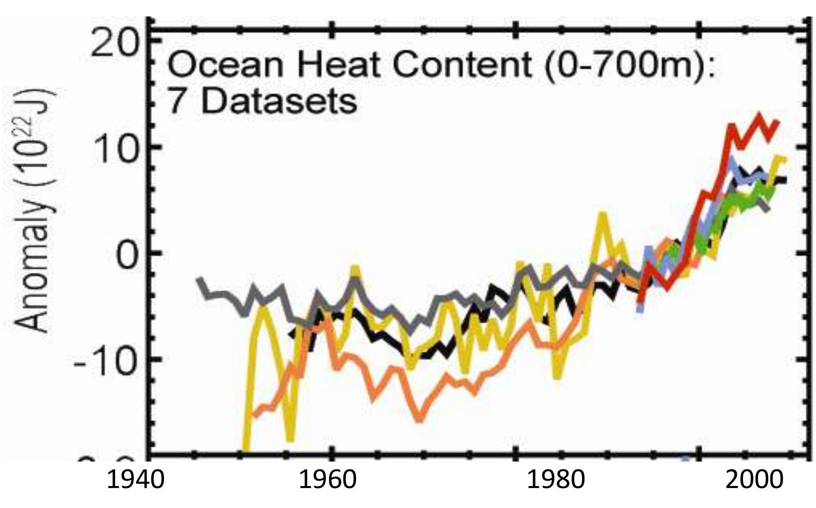

Figure 3. Ocean heat content to 700m based on 7 datasets. Based on Levitus et al., (2009).

1.2 Rising Sea Level

Temperature rise is having another impact—on sea level--and may also start to affect ocean circulation (Figure 4).

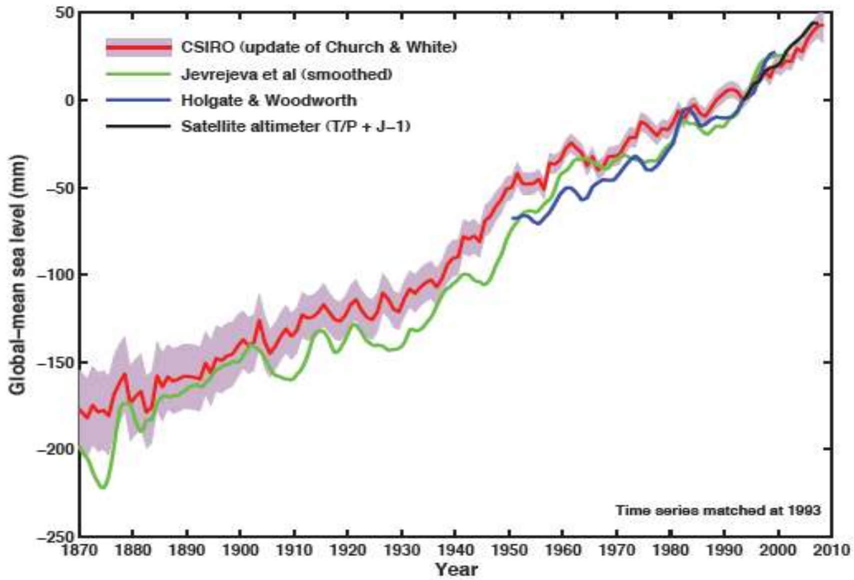

Figure 4. Global mean sea level from 1870 to 2008 with 1 standard deviation error estimates updated from Church and White (2006; red) from Jevrejeva et al. (2006; green) and from 1950 to 2000 from Holgate and Woodworth (2004; blue). The TOPEX/Poseidon/Jason-1 and 2 global mean sea level (based on standard processing as in Church and White 2006) from 1993 to 2008 is in black. All series have been set to a common value at the start of the altimeter record in 1993. From Church, J.A., Aarup, T., Woodworth, P.L., Wilson, W.S., Nicholls, R.J., Rayner, R., Lambeck, K., Mitchum, G.T., Steffen, K., Cazenave, A., Blewitt, G., Mitrovica, J.X. and Lowe, J.A. (2010). Sea-Level Rise and Variability: Synthesis and Outlook for the Future, in Understanding Sea-Level Rise and Variability (eds. J.A. Church, P.L., Woodworth, T. Aarup and WS. Wilson, Wiley-Blackwell, Oxford, UK.) doio: 10.1002/9781444323276.ch13

Ice loss from Antarctica and Greenland has accelerated over the last 20 years, and will soon become the biggest driver of sea level rise. Water from the two polar ice sheets may add 15cm to the average global sea level by 2050 (Figure 5).

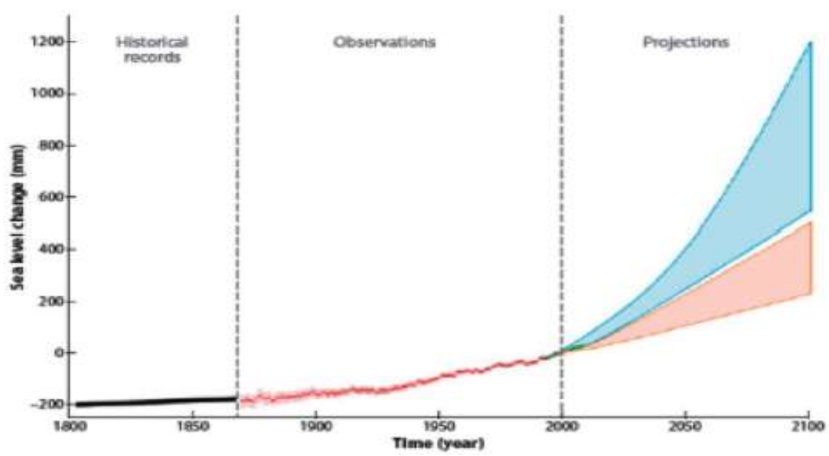

Figure 5. Projected sea level increase by 2100 . Source: Holiday, P., S.L. Hughes, M. Quante and B. Rudels. 2011. Sea level rise and changes in Arctic sea ice. In: ICES Status report on climate change in the North Atlantic; P.C. Reid and L. Valdes (eds). ICES Cooperative Research Report, No 310: 262pp.

More than half the human population lives in the coastal zone, and projections show a rapid increase in the coastal population to 75 percent by the year 2025. This, of course, exposes more and more people to ocean-related hazards, often exacerbated by sea level changes.

1.3 Changes in Ocean Circulation

Melt water from shrinking ice sheets could affect ocean circulation (most notably in the North Atlantic, where the Meridional Overturning Circulation is largely driven by the creation of dense, cold, saline water) and could therefore disrupt the entire global thermohaline circulation (Fig.6).

Figure 6. Earth's ocean circulation pattern changes with increased temperature and decreased salinity from ice melt. Illustration credit: www.clamer.eu/ component/content/ article/66, Image ©Glynn Gorick

1.4 Ocean Acidification, the Hidden Partner of Climate Change

Whilst not a direct result of climate change, but rather what has been termed "the other CO_2 problem," or "the hidden partner of climate change," ocean acidification is emerging as a critical challenge affecting the ocean and LMEs alike. On a yearly basis about one quarter of excess human CO_2 emissions is absorbed by the ocean, and ocean uptake of CO_2 and other greenhouse gases is the largest natural mechanism available to remove anthropogenic emissions from the atmosphere.

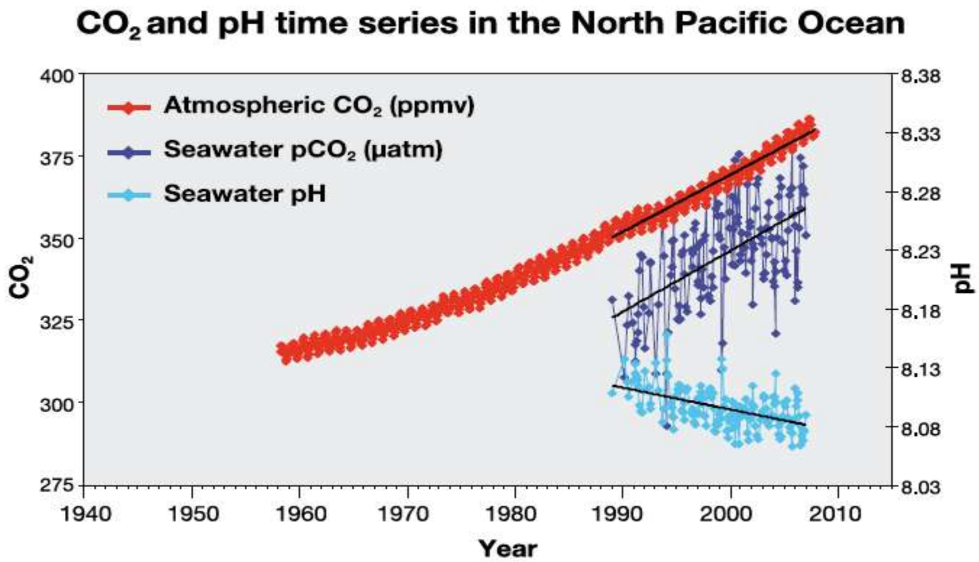

Figure 7. Time series of atmospheric CO_2 at Mauna Loa and surface ocean pH and pCO_2 at Ocean Station Aloha in the subtropical North Pacific Ocean. Mauna Loa data: Dr. Pieter Tans, NOAA/ESRL; HOTS/Aloha data: Dr. David Karl, University of Hawaii [modified after Feely (2008)]. Atmospheric CO_2 at Mauna Loa is in parts per million volume, ppmv; red; surface ocean pCO_2 (µatm; blue) and surface ocean pH (light blue) at Ocean Station ALOHA in the subtropical North Pacific Ocean. Image is also available from CLEAN:Community:Workshops:Climate Complexity Workshop 2012:Workspace.

That absorption has prevented even faster warming of the atmosphere, but has the side effect of changing the carbon chemistry of the ocean and slowly making it more acidic, as you can see from the slowly decreasing pH in turquoise as measured at Ocean Station Aloha just north of Hawaii (Fig.8). Ocean acidity increases the amount of energy needed by many small ocean organisms in constructing their carbonate shells and structures, and in some places will make it impossible for these organisms to live (Fig.8).

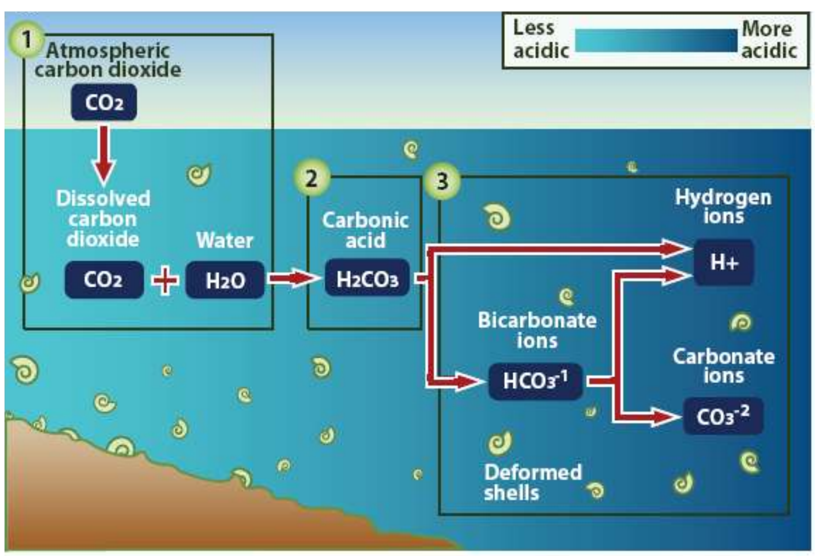

Figure 8. Diagram showing the chemical processes involved in ocean acidification. Image from the University of Maryland.

This will have impacts on ocean ecosystems that science is still examining. But business as usual scenarios for CO_2 emissions could make the ocean up to 150 percent more acidic by 2100.

Ocean acidification is the hidden partner of climate change. Nowadays the ocean is more acidic than it has been for the last 800,000 years. The increasing acidity levels reduce the ocean's future capacity to absorb carbon dioxide, leaving more emissions in the atmosphere. This will have adverse impacts in marine biodiversity, particularly species that rely on calcareous structures like coral reefs, shellfish, and echinoderms and other invertebrates.

By 2100, 70 percent of corals will be exposed to corrosive waters. Model calculations indicate a fall of 0.1 pH since pre-industrial times at the current 380 ppm CO_2 level. Increasing levels are expected to result in further decreases of 0.3 to 0.5 pH by 2100. Changes in acid-base status will almost certainly exacerbate the effects of climate change on marine species, particularly on "lower" invertebrates, further reducing their geographical distribution (Pörtner, 2008). This effect is not limited solely to calcifiers as physiological effects of a higher pCO_2/low pH ocean are systemic throughout life history stages—and even more poorly understood in non-calcifiers than calcifiers, e.g., the responses of fish to higher pCO_2 are poorly understood.

1.5 Changes in Distribution and Abundance of Marine Life

These physical and chemical changes of the ocean are impacting ecosystems as thermal tolerance ranges in a warming ocean change the distributions of species. There will be more shifts in species composition in phyto/zooplankton communities (mainly large to small individuals) and changes in diversity and species richness of fish (Figure 9).

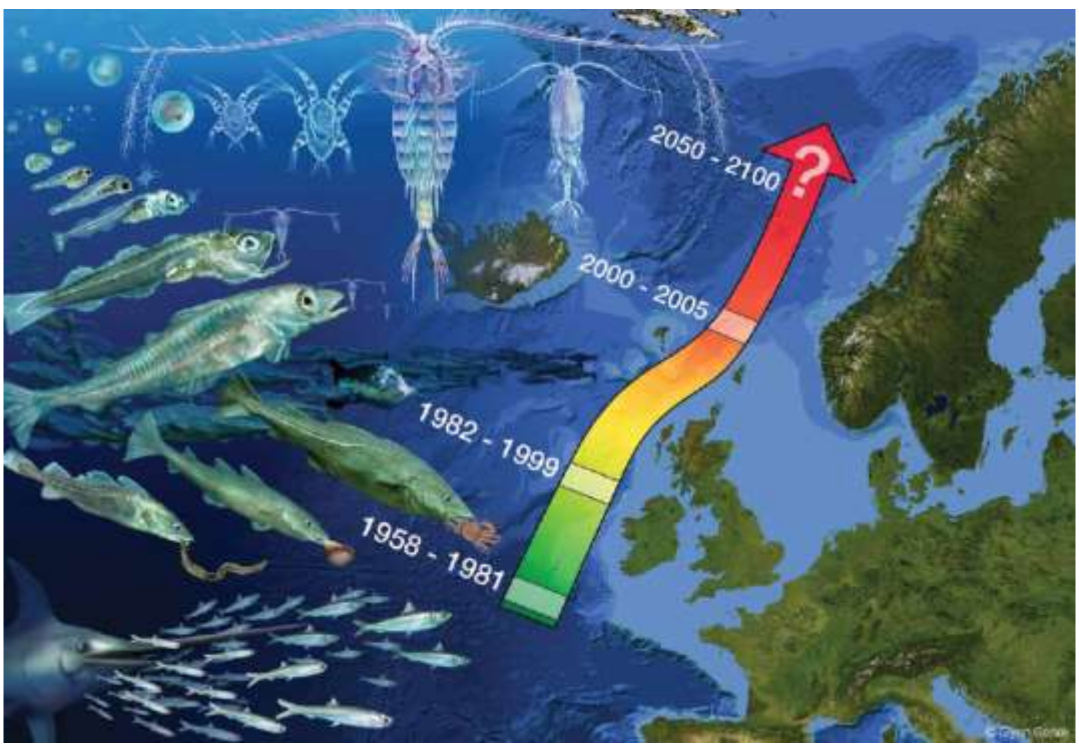

Figure 9. Changes in distribution and abundance of marine life with increasing temperatures. Illustration "© Glynn Gorick. On Web at www.clamer.eu/component/content/article/66 .

This has already been observed in a number of areas with range expansions of tropical species; range contractions of temperate and cold water species. These changes in fisheries distribution have direct consequences on the associated fleet structure and operations. These, in turn, have management implications for the harvesting of ‘shifting biomass,’ especially across jurisdictional boundaries.

Together, ocean acidification and ocean warming are having impacts on the ocean carbon cycle and productivity and, combined with other human stressors such as eutrophication, coastal urbanization, over-fishing and alien species, put the world’s LMEs and the populations that depend on their services, under tremendous pressures. One issue cannot be isolated from another and only through an ecosystem approach will we be able to clearly understand how individual LMEs will shift with changing conditions (Figure 10).

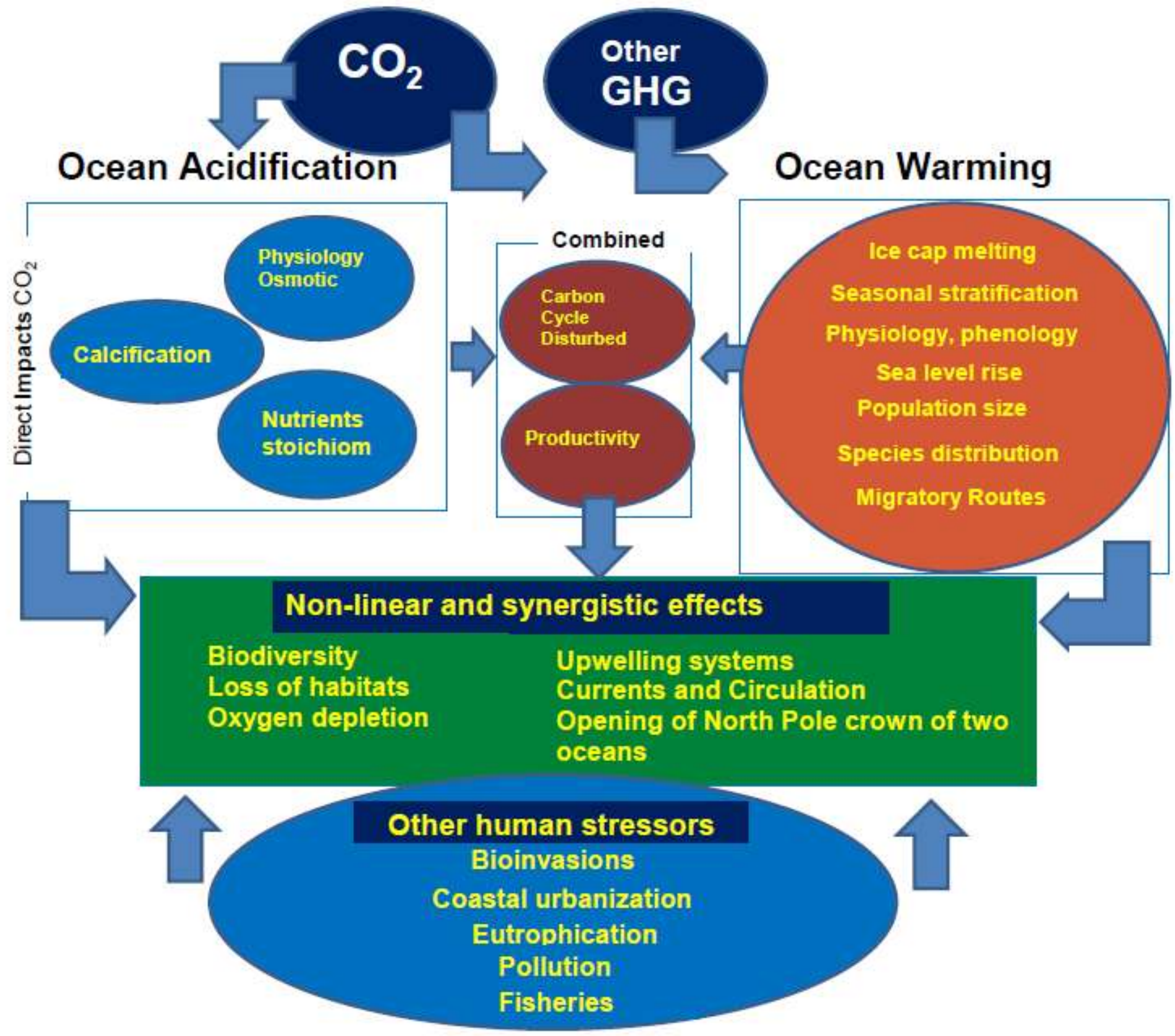

Figure 10. Climate Change and the World’s LMEs Source: Valdés L, PC Reid and J. Alheit (2011). Introduction to Climate change. In: ICES Status reort on climate change in the North Atlantic. PC Reid and L Valdes (eds). ICES Cooperative Research Report, No. 310: 262pp.

At the same time we need to recognize that we can't manage what we don't measure: the major goods and services provided by the ocean and LMEs remain at a low level of knowledge. In order to live with the ocean and from the ocean in a sustainable way, scientific research and observation/monitoring of the ocean and the mobilizing of indigenous knowledge have to be encouraged. (Figure 11)

HABITATS ECOSYSTEMS	GOODS and SERVICES: Organic matter input/chemo-synthetic primary production	Nutrient cycling	Resil-ience	Habitat	Food, minerals, oil, gas	Micro organ-isms	Climate regulation	Bio-remediation	Educational, scientific, spiritual
Continental shelves	some	little	little	some	some	no	no	little	little
Continental slopes	some	little	no	little	some	no	no	little	little
Abyssal plains	some	little	no	little	little	no	no	little	little
Submarine canyons	little	little	no	little	little	no	no	little	little
Deep-sea trenches	little	no	no	little	little	no	no	little	no
Seamounts	some	little	no	some	some	no	no	no	little
Carbonate mounds	little	little	no	little	no	no	no	no	no
Hydrothermal vents	some	no	no	some	some	some	no	no	some
Cold seeps	little	little	little	little	some	some	little	little	little
Mud volcanoes	little	little	no	little	little	some	little	no	little
Cold-water corals	some	no	little	some	some	no	no	no	some
Deep-sea sponge fields	little	no	no	little	no	no	no	no	little
Whale falls	some	little	little	little	little	little	no	no	no

Key: State of knowledge ■ good knowledge ■ some knowledge ■ little knowledge ■ no knowledge

Figure 11. Ecosystem goods and services from UNEP (2007) Deep-Sea Biodiversity and Ecosystems: A scoping report on their socio-economy, management and governance. UNEP-WCMC Biodiversity No. 28.

2. FUTURE SCIENTIFIC DIRECTIONS

2.1 Understanding Climate Change within LMEs

Let me now say a few words on where the science is with regard to understanding climate change and variability within LMEs. We need to know where we are today and where we need to be in terms of building additional knowledge to achieve sustainable management of LMEs.

From a physical perspective: we have achieved consistency in observed anomalies of temperature and related variables, a coherent overall understanding of patterns of change, and a quantitative understanding and pattern attribution using models.

Where do we need to go? We need cutting-edge research directions in physical oceanography, including using multi-variable detection and attribution in development of decadal predictions. We need more accurate forecast of non-linearity and tipping points in ice melt and ocean currents.

2.1.1 Chemical understanding of climate change within LMEs: Ocean acidification and carbon

Looking at the chemistry of our ocean, we have observed that trends in carbon, pH and ocean acidification exist, appear persistent, and show coherent, although still incomplete, understanding. In this context, I would cite two reports that illustrate the complexity of the ocean acidification problem—Grid Arendal's Blue Carbon report (2009) and the IOC report on Ocean Fertilization (2009). Blue *Carbon - The Role of Healthy Oceans in Binding Carbon* is a Rapid Response Assessment report released 14 October 2009 at the Diversitas Conference, Cape Town, South Africa. Compiled by experts from GRID-Arendal and UNEP in collaboration with the UN Food and Agricultural Organization (FAO) and the UNESCO International Oceanographic Commission and other institutions. *Ocean Fertilization: A scientific summary for policy makers* is the IOC Report on Ocean Fertilization prepared with assistance of SOLAS and advice by the Secretariat of IMO and discussions by the 2009 International Technical Working Group on Ocean Fertilization of the London Convention/London Protocol. This report is dedicated to the 50th anniversary of IOC.

Where we need to go with Ocean Acidification and Carbon
We need to improve the detection of ocean pCO_2 trends and inventory departures from expected values. We need the attribution of the contribution of increasing atmospheric CO_2, climate variability and climate change on regional/ LME trends. We need to improve our understanding of the impact of changes in ecosystems on the ocean carbon cycle, as well as vulnerability of coastal carbon sinks and their valuation. We need to quantify the uncertainty in trends and identify the impacts of OA on marine biota.

2.1.2 Chemical understanding of climate change in LMEs: Oxygen
We have observed that trends in sub-surface oxygen exist, and appear persistent, but we have no coherent understanding of patterns of change. The implications of de-oxygenation are still poorly known particularly in terms of oxygen stress on fish and other marine organisms, reduction in available habitat and reduction in growth performance of fish.

Where do we need to go? Cutting-edge research directions on ocean oxygen must include the following: attribution of oxygen changes to climate change and/or variability, understanding of tropical de-oxygenation, impacts on marine life, and effective management practices to reduce coastal de-oxygenation.

2.2 Large Marine Ecosystem Functioning and Tipping Points

Impacts on large marine ecosystems and subsystems within them are reported; observed trends exist, and appear persistent and coherent although, again, we still have incomplete quantitative understanding.

We have several tasks in front of us. We need to integrate multiple data streams (including genetic) into information. We need to understand the impact of multiple stresses, including climate change, fisheries, ocean acidification and de-oxygenation on species, size distribution, life stages and trophic dynamics. We need to identify LME shifts in condition and tipping points, as well as the capacity of the LMEs to adapt. This is critical for defining management options in coastal areas as well as socio-economic impacts, including livelihoods and the ability to adapt to climate change.

2.3 Socioeconomic Studies in LMEs

Over the past several years, a rapidly growing literature on Large Marine Ecosystems has emerged, focused mostly on issues of biological and physical conditions. Increasingly, the results of scientific research have revealed the degradation of ocean regions, including coastal pollution, the over-exploitation of fisheries, invasions of exotic species, and blooms of harmful algae, among other effects. In sharp contrast to these scientific studies, analysis of the socioeconomic characteristics of LMEs has received relatively little attention to date. Although a general framework for monitoring and assessing the socioeconomic aspects of LMEs has been developed, few detailed studies grounded in empirical data have been undertaken in individual LMEs. Characterizing the socioeconomic features of LMEs is critical to developing an understanding of the extent to which nations have the financial resources to undertake programmes of sustainable development (Figure 12).

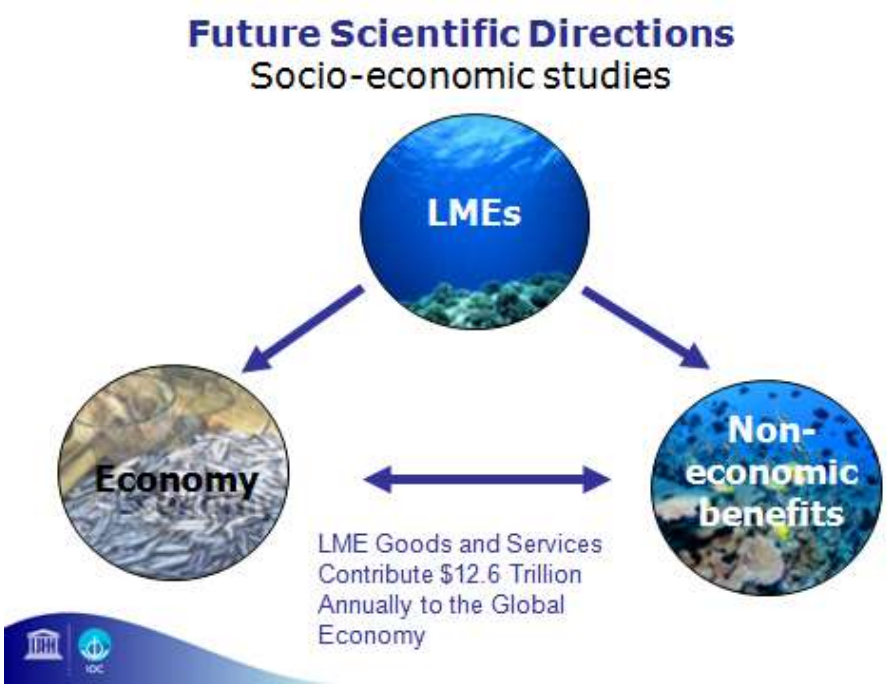

Figure 12. Valuing LME inter-related goods and services

2.4 . From Research to Ocean Observations

Since 1988 when the IOC voted to form the Global Ocean Observing System, the GOOS has led IOC's move into operational oceanography. Originally configured from dozens of existing observing systems and with the boost of the recently developed Argo profiling floats, the GOOS has grown into a system of systems spanning the globe. Figure 13 portrays the scope and the end-to-end requirements of an operational system. Starting with the scientific processes to be measured in the center of the image, in-situ and satellite observation platforms (on left) can now transmit data in real time to satellites (Figure 13).

Figure 13. End-to-end requirements of an operational Global Ocean Observing System

The data is communicated to data assembly centers and distributed to computing centers where models can assemble views of the whole earth, accessible to ocean managers in all nations. In turn useful marine products are delivered to aid coastal communities managing their developing coastal economies.

The mandate of the GOOS to serve the climate community has guided much of the development to date, but following the Ocean Observation '09 conference and responding to the call for environmental services for sustainable development at Rio+20, the GOOS is now preparing itself to broaden its coastal, biogeochemical and ecological observation capabilities. Key to this expansion is the Framework for Ocean Observation (Figure 14) which specifies a systems engineering approach for evaluation and implementation of future observation technologies and programmes.

In the design of this framework, we try to engage these different scientific questions, societal benefits and various communities that require sustained ocean observations. These include biodiversity, the Large Marine Ecosystems community, as well as regional seas and regional fisheries management organizations, global fisheries agreements, global marine assessments, and ecosystem-based approaches to management of the ocean environment.

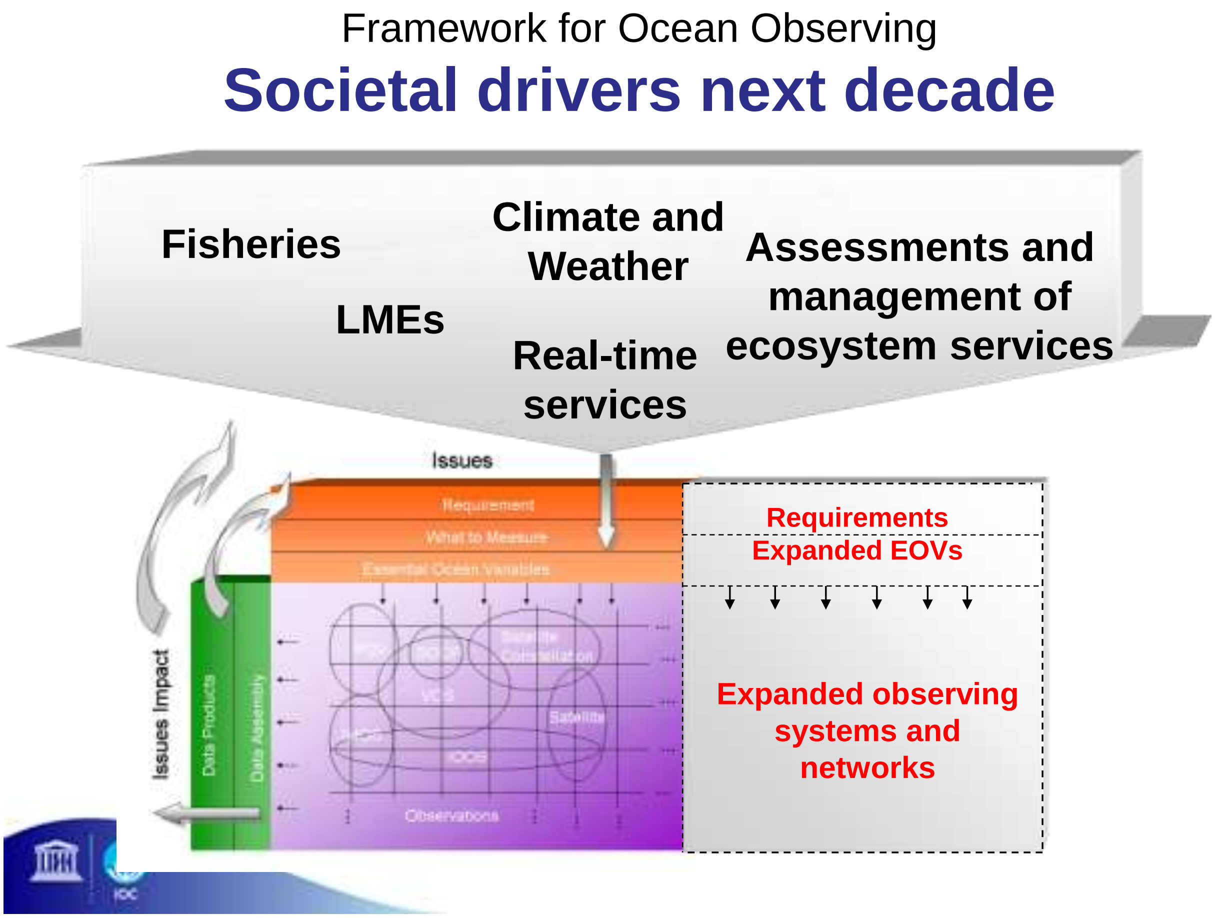

Figure 14. Framework for Ocean Observation

A central concept of the Framework is that the nations of the world cannot afford multiple ocean observing systems each responding to different expressed requirements—that one integrated system that responds to many different requirements will be far more fruitful. I strongly believe that this approach is very much applicable at the LME level.

2.5 LME Projects and GOOS Networks

The GOOS network is organized around a number of GOOS regional alliances which once overlaid on top of operational LME projects around the world, and so makes the rationale for LMEs collaboration with GOOS much clearer and more obvious (Figure15).

Beyond the geographical coverage, the key point is that both GOOS and LMEs share common observations. They both have limited resources and are regionally implemented. They have mutual emphasis on capacity building; in fact, LME projects and GOOS are both intended to be permanent structures with sustainable funding by national institutions. LME projects operate in many countries that are most in need of assistance/capacity building to initiate observing programs like GOOS.

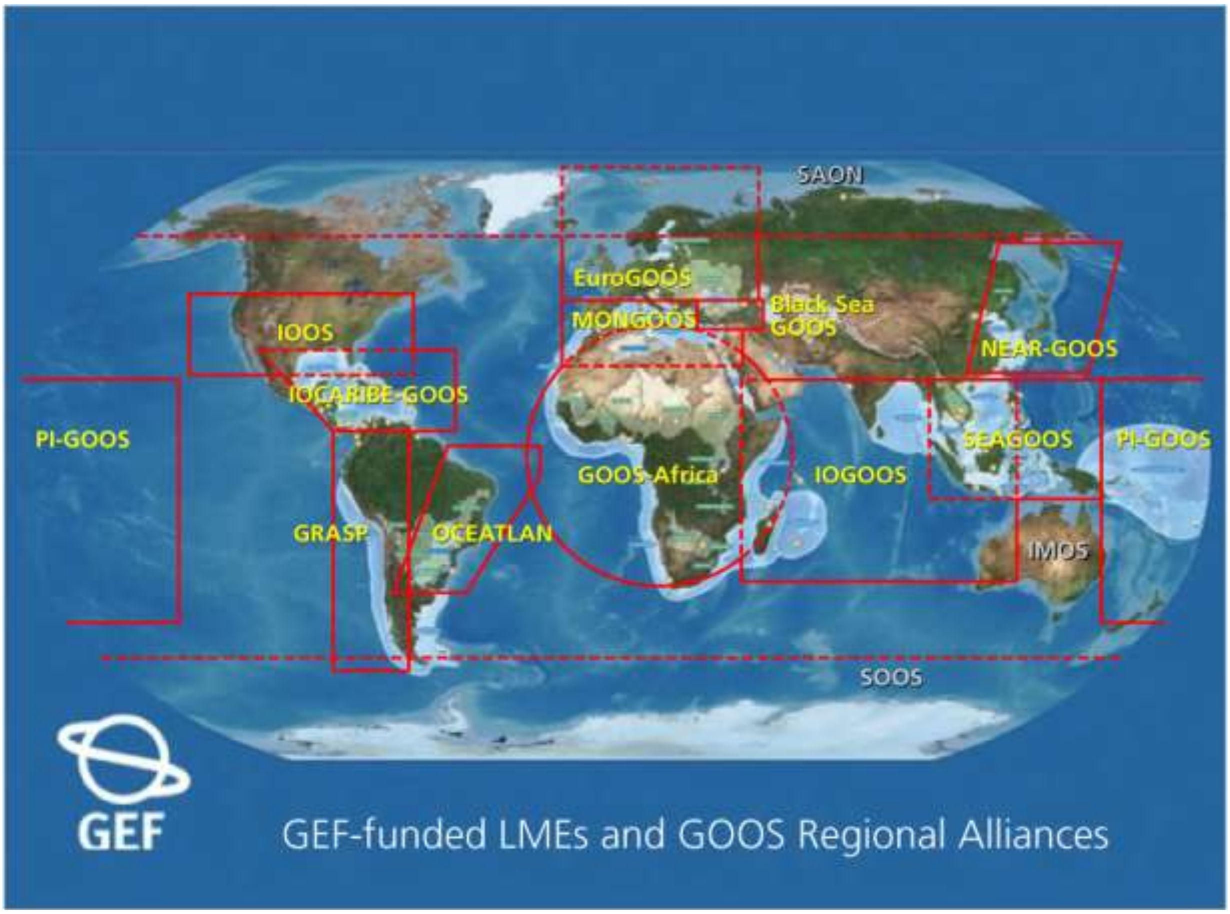

Figure 15. GEF-funded LMEs and GOOS Regional Alliances

2.6 From Observations to Assessments

Moving beyond the research and observations, we have heard several times that the GEF has invested billions of USD in operationalizing the LME concept within transboundary waters. But do we have a mechanism to systematically monitor the changing conditions of our ecosystems? We know where the stressors are and what the drivers are, but can we report information on natural and socioeconomic factors in relation to specified ecosystem management objectives? And ultimately can we confidently say that GEF interventions are improving the situation on the ground? (Figure 16)

To answer these questions, we need to have a dashboard to help measure the health and sustainability of LMEs, to know if we are in the red or the green phase of LME development (Figure 16). I believe this is why GEF decided earlier this year to fund the Transboundary Water Assessment Programme (TWAP). This project will provide an assessment of transboundary water systems (Open Ocean, Large Marine Ecosystems, Rivers, Lakes, Groundwater) to inform future GEF interventions for environmental protection and sustainable development.

A central approach to this LME component is the vulnerability of ecosystems and human communities to natural and anthropogenic stressors, and impairment of ecosystem services.

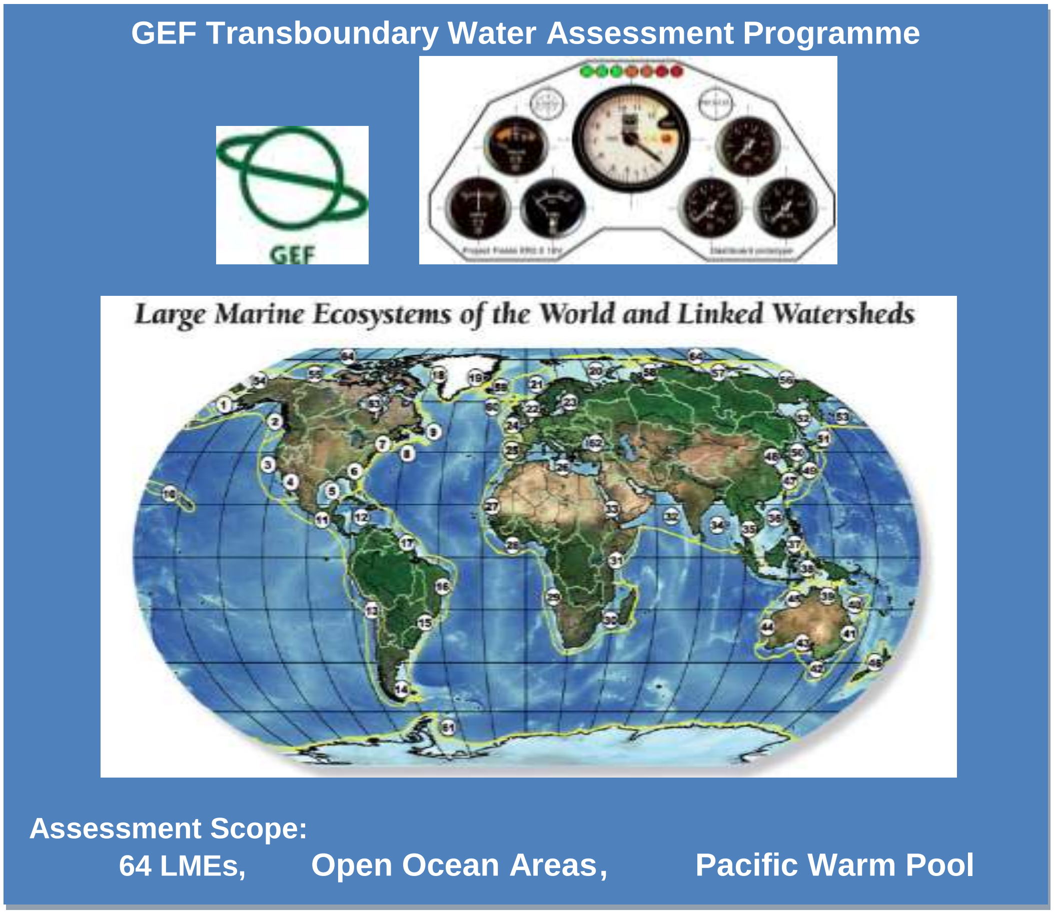

Figure 16. From Observation to Marine Assessments: *GEF Transboundary Water Assessment Programme (TWAP) and LME scale*

The TWAP will therefore be implemented on the basis of a conceptual framework that explicitly shows the links between human vulnerability and natural and anthropogenic stressors, ecosystem services and consequences for humans (with governance as an overarching concept), so that cause and effect can be better identified. This framework also accommodates other ecosystem services in addition to fish and fisheries. Further, it incorporates the five LME modules–(i) productivity, (ii) fish and fisheries, (iii) pollution and ecosystem health, (iv) socioeconomics, and (v) governance–and integrates ecological, socio-economic, and governance indicators into a unified LME assessment framework.

The approach will consist in populating a core set of status indicators across all 64 LMEs and build around the five existing LME modules, allowing for global comparison and prioritization for intervention and ultimately financial allocation from GEF and other donors. In this respect, the methodology is forward looking, and will provide a forecast of what might be the status of LMEs in 20 or 40 years from now.

I want to acknowledge the gentleman in the middle of the row in Figure 17, Dr. Al Duda, formerly with GEF, who was instrumental in developing this unique partnership of institutions to carry forward the Transboundary Water Assessment Program.

Figure 17. Pictured at UNEP headquarters in Nairobi, at a meeting of the TWAP Steering Committee are L to R: Fatoumata Keita-Ouane, Maryam Niamir-Fuller, Al Duda, Ibrahim Thiaw, and Peter Gilruth

2.7 Future Scientific Directions: Open Ocean and LME Partnerships

The project is also building a partnership of institutions that will participate and contribute in the conduct of this global transboundary water assessment.

The idea is that the partnership which is led by IOC will be sustained over time and will conduct such global assessment on a regular basis. Whilst the main client of TWAP is clearly the GEF, such a mechanism will also help individual LMEs and national decision makers in assessing the overall health of their resources whilst also anticipating future stressors that may affect their marine ecosystems (Figure 18).

Beyond the TWAP, we at IOC also consider LMEs as an effective building block for contributing scientific data and indicators to a number of global assessment processes such as the UN World Ocean Assessment (WOA) launched in 2010. As such, I do believe the participation of the LME projects will be critical to reflect the existing wealth of information and data that are being collected and utilized by countries that have adopted transboundary water management approaches. The ultimate goal of the WOA is to provide a sound, scientific basis for decisions at the global level on the world's ocean and seas, as well as a framework for national and regional assessments and management decisions.

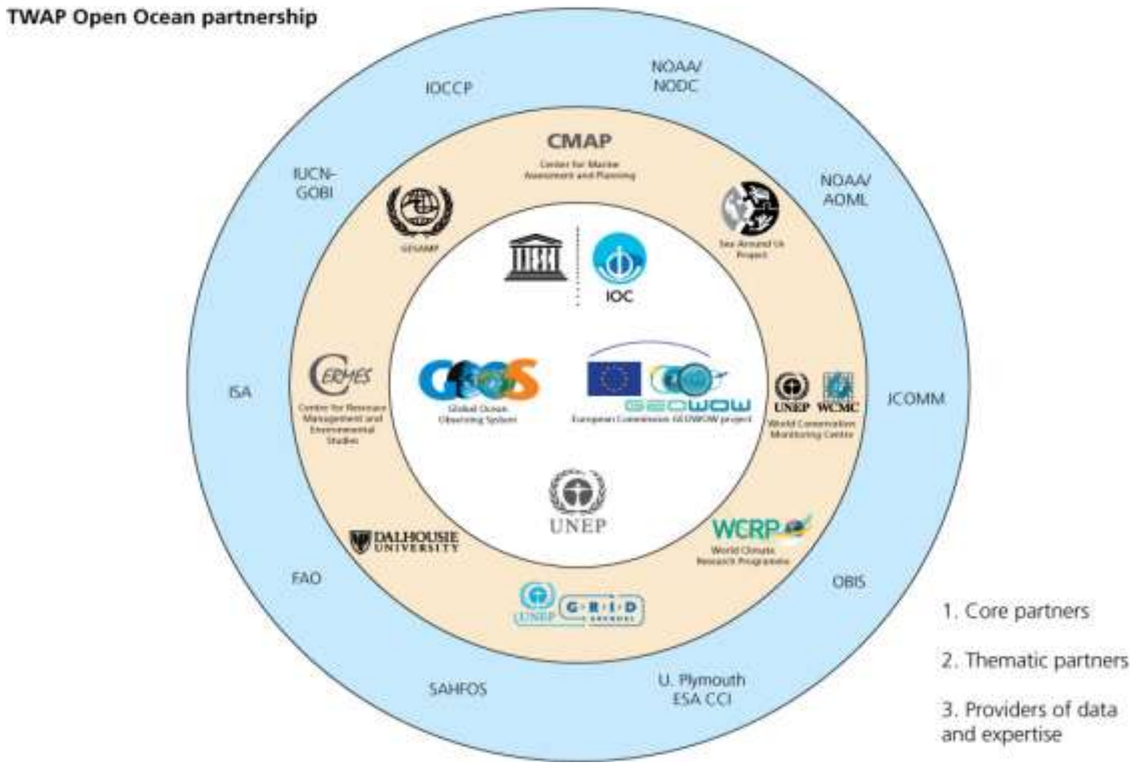

Figure 18. Core partners, thematic partners and providers of data and expertise to the Open Ocean and LME Partnership

2.8 Triggering Cross-sectoral Management and Transboundary Governance in LMEs

A global science/policy interface for the world's ocean is critical and much needed, but this is not sufficient -- we also know that actions are needed at the LME level, and that in order to move beyond LME assessment, cross-sectoral, multi-scale management, and transboundary governance processes need to be put in place to meet the ecosystem and sustainable development objectives of LMEs (Figures 19 & 20).

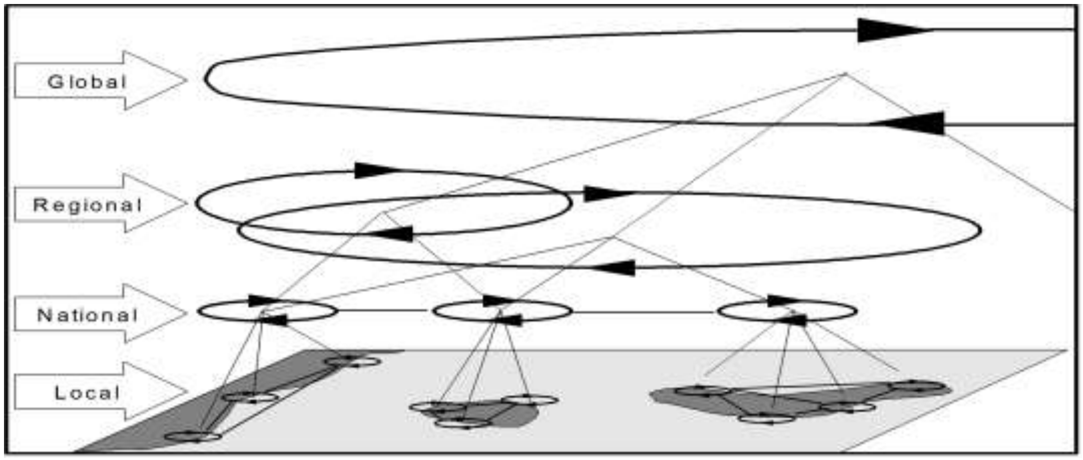

Figure 19. Triggering cross-sectoral management and transboundary governance in LMEs at local to global scales

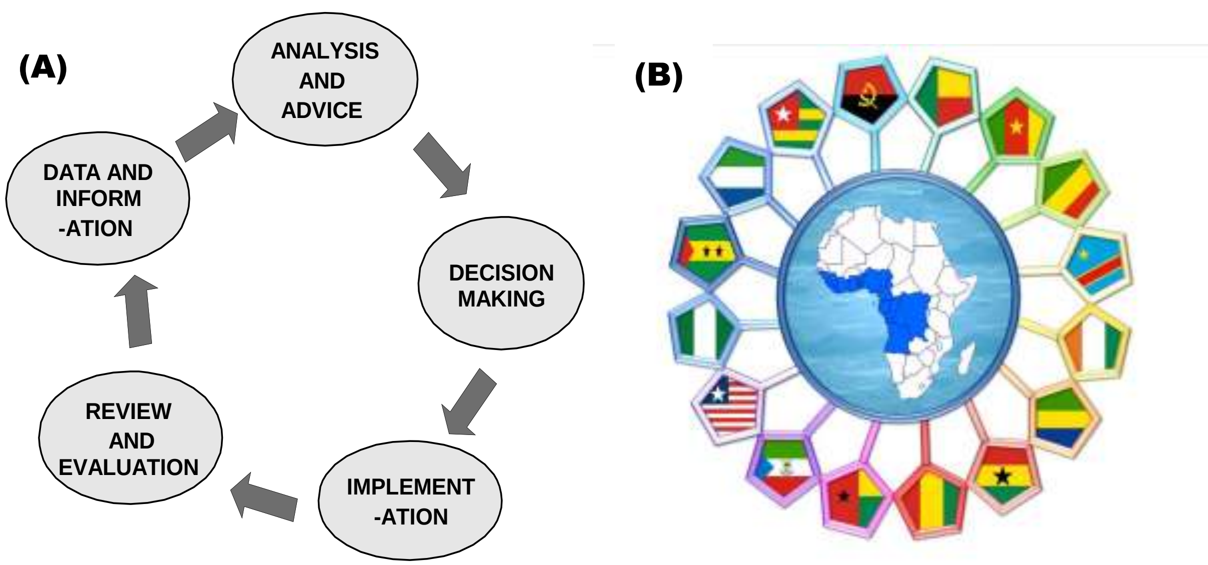

Figure 20. Triggering cross-sectoral management and transboundary governance in LMEs at (A) data based assessments and analyses on changing LME conditions inform advice and decision making and implementation of actions for sustainable development of LME goods and services, and (B) Transboundary management actions supported by the 16 nation Guinea Current LME project in West Africa.

3. WHAT IS MARINE SPATIAL PLANNING?

At IOC we define Marine Spatial Planning as a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process. (IOC, 2006)

3.1 From LME Assessment to Marine Spatial Planning

I believe that Marine Spatial Planning has a key role to play in operationalizing the LME approach, particularly in transforming assessment into transboundary management plans. The definition is from the first international conference on marine spatial planning organized by IOC in 2006. We know that MSP is a complicated and difficult process, but it boils down to four fundamental questions. To answer the first question, "Where are we now?" requires data provided by assessments. To answer the second question, "Where do we want to go? needs accurate data to build likely scenarios. Third, when we ask "How do we get there?," we need appropriate and agreed-upon management plans. Fourth, to ascertain what we have accomplished we need to continually monitor and evaluate what we've done. Each one of these four questions involves scientific activities that include both natural and social sciences.

The LME approach has traditionally focused on the first question: Where are we now? And we have continuing applied research, data collection and analysis, state-of-system indicators and monitoring, and problem assessment.

However, to produce real results in the management of multiple use marine areas we need to address the other three questions through the application of good social science methods, coupled with the best available natural science information. This would include stakeholder participation, identification of goals and measurable objectives, development of alternative future scenarios, and the selection of desired vision.

How do we get there?
MSP applied in the context of LMEs would provide processes for the identification of alternative management measures as well as performance indicators of management measures. Incentives must be put in place to implement the new measures and change behavior. Frequent evaluation of effectiveness, efficiency and equity of management strategies is required. There needs to be a spatial management plan together with the means to implement and enforce that plan.

What have we accomplished?
We cannot know what we have accomplished unless we can monitor and evaluate the performance of the management plan and continuously adapt the spatial management plan until it works.

3.2 IOC Building Capacity for MSP

- We have convened the first International Conference on MSP, 2006
- We published the first Operational Guide to Marine Spatial Planning, 2009
- We have established an MSP Website with updates of the Guide, Examples of Good MSP Practice, Downloadable Reference Material, and 35 Case Studies, 2007
- At the same time we actively promote MSP internationally as an Operational Process toward Ecosystem-based Management
- As part of our mandate in capacity development, we train new MSP professionals
- In 2013, we will also launch a new Guide on MSP Performance Monitoring and Evaluation

On this note, I would like to publicly acknowledge the support of the Gordon and Betty Moore Foundation and its Marine Program Leader, Dr. Barry Gold. Since 2006 the Moore Foundation has funded the IOC work on Marine Spatial Planning and contributed to the international dissemination of this approach.

And whilst we are talking about building capacity, beyond the political willingness, the expansion of the LME projects around the globe will also boil down to human and institutional capacity to implement ecosystem-based management. There are a number of gaps that need to be addressed by the international community and countries:

1. We need to identify, review and synthesize the best assessment and management practices among LME practitioners
2. We need mechanisms to facilitate and exchange lessons learned with regional and global partners, and
3. We need a mechanism to inform LME scientists and managers on broad ocean issues, new methodologies and science-policy breakthroughs in shaping ecosystem-based management (Figure 20)

4. BUILDING A GLOBAL COMMUNITY OF LME PRACTITIONERS: INTEGRATION OF EXPERTISE AND BEST PRACTICES

We need a coordinated approach to training, capacity development and outreach in LMEs in order to integrate expertise and best practices successfully.

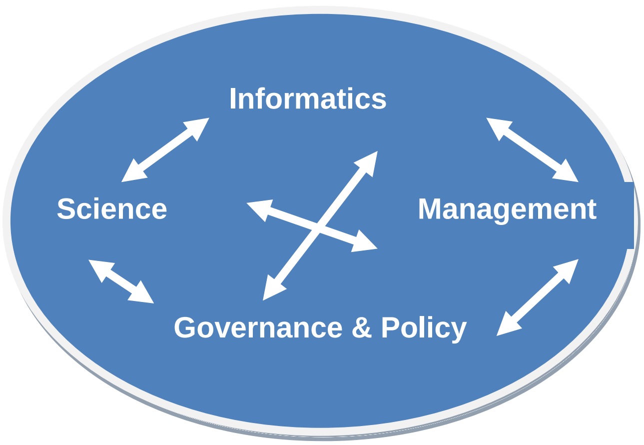

Figure 20. Schematic for integration of natural and social sciences expertise and management for LMEs

In this respect the GEF financial support of the LME Community of Practice project, will advance the LME project implementation significantly. The project will support actions necessary to generate knowledge, harness public and private partnerships, support South to South learning and improve performance of LME projects.

I am sure you will all recognize this eminent scientist with whom I could not agree more (Figure 21).

"Integrated research, monitoring, training, and outreach programs at the large-marine-ecosystem scale are urgently needed in every large marine ecosystem."

Quotation from Foreword, "Lessons from the Ice Bear" p.xiii *in* Ecosystem-based Management for the Oceans, K. McLeod and H. Leslie, eds. 2009, Island Press.

Figure 21. Jane Lubchenco, Under Secretary of Commerce for Oceans and Atmosphere.

So in closing, in order to reach sustainable development of our LMEs and to protect our ocean, we need a fundamental change in the way we think and act.

We should note that there are positive signals with respect to ecosystem-based management for ocean and coasts. Of course, the elimination of subsidies that contribute to overfishing and fleet overcapacity, the need to combat illegal fishing and to guarantee access to fishing resources to small-scale artisanal fishers are important issues, particularly in the context of LMEs.

But we should remind our constituencies that the international community has taken a commitment to 'protect, and restore, the health, productivity and resilience of oceans and marine ecosystems,' as well as to 'effectively apply an ecosystem approach and the precautionary approach in the management.' We need to translate these commitments within each LME, from the coasts of Peru bordering the Humbold Current LME to those of Mozambique along the Aghulas Current LME. We need to use existing opportunities such as the World Bank *Global Partnership on Oceans* to catalyse change.

I thank you very much for your attention and I look forward to our discussion.

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PART TWO:

MARINE SPATIAL PLANNING AND LME CASE STUDIES

6

MARINE SPATIAL PLANNING AS A FRAMEWORK FOR SUSTAINABLY MANAGING LMEs

Barry D. Gold, DSc, Program Director, Marine Conservation, Gordon and Betty Moore Foundation

I want to begin by acknowledging Ken Sherman's leadership in the development of the Large Marine Ecosystem (LME) concept. In February 1988, 25 years ago to the month, I helped Ken organize the third in a series of symposia he had begun arranging at AAAS meetings, and like this one, that 1988 meeting on the LME concept was held in Boston.

Today, I want to talk about a vision for the oceans that is hopeful and achievable. I want to talk about creating value and wealth from oceans that are sustainably managed.

THE MYTH OF THE OPEN OCEAN

Recent opinion research has shown that most Americans think of the ocean as a vast expanse that is sometimes awe inspiring … often rejuvenating … and maybe even a bit frightening. I suspect this is a view shared by people around the world. A piecemeal approach to ocean management hasn't worked and without change the situation will get worse. It should come as no surprise then that the continued expansion of activities in the ocean is leading to conflicts between different users and clashes between our use of ocean resources and the health of marine ecosystems.

Shipping routes cross the migration paths of endangered whales … coastal homeowners worry about what wind farms will look like on the horizon … and some fishing practices are decimating the very species they target.

CUMULATIVE EFFECTS OF HUMAN USES ON MARINE ECOSYSTEMS

As **Figure 2** shows, over 40 percent of the world's oceans are heavily affected by human activities and few if any areas remain untouched by humans. The map also helps us understand that the oceans are really a larger integrated whole, and that we need to take an integrated approach to their management.

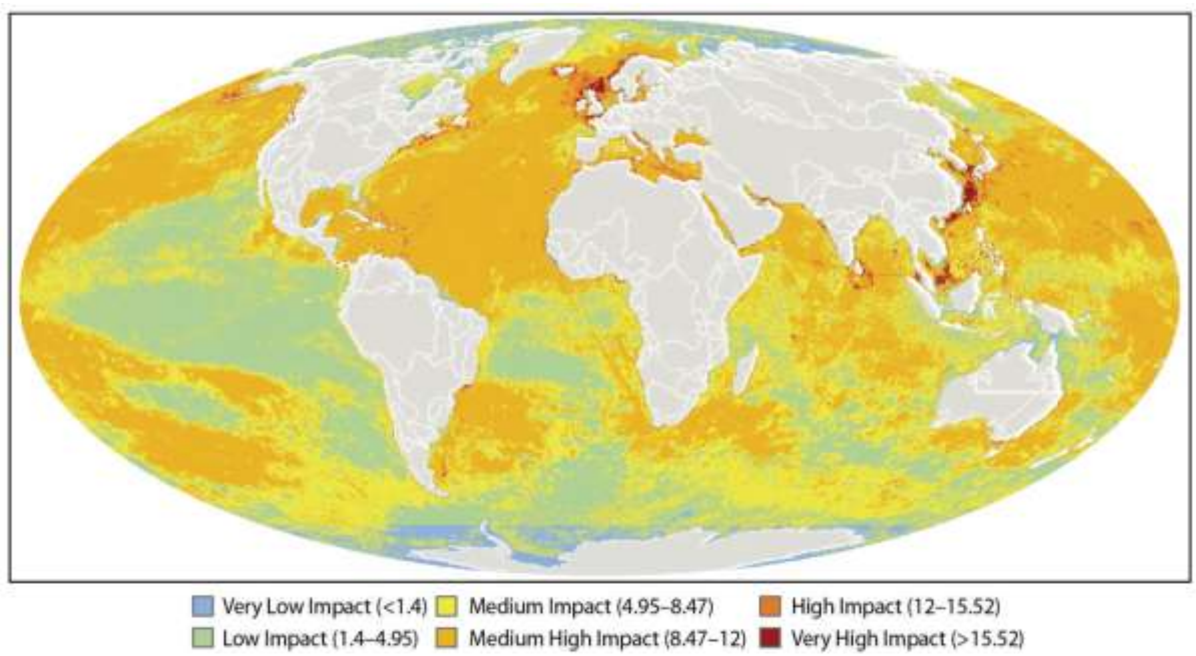

Figure 2. Cumulative effects of human uses on marine ecosystems (globalmarine.nceas.ucsb.edu)

SO, WHAT IF?

What if we expand marine spatial planning (MSP) so that 30 percent of the world's exclusive economic zones (EEZs) have approved MSP plans? What would that look like? We'd have resilient and productive marine ecosystems, based on marine spatial plans that meet the needs of future generations. And in the end, we'd have extraordinary and healthy global oceans that support the demands of the 9 to 10 billion people projected to live on the planet by 2050 – 750 million of whom are projected to live in poverty and 3 billion of whom are projected to enter the middle class.

To achieve this vision, a new narrative about the ocean is required—one that intentionally puts people in the center, an approach that sees humans as an integral component of the earth's ecosystems—one of collective engagement, perhaps among previously unlikely allies.

USES OF MARINE ECOSYSTEMS AND RELATED THREATS

For too long, we've all been trotting out the same five threats to the ocean: overfishing, habitat degradation, pollution, invasive species, and climate change.

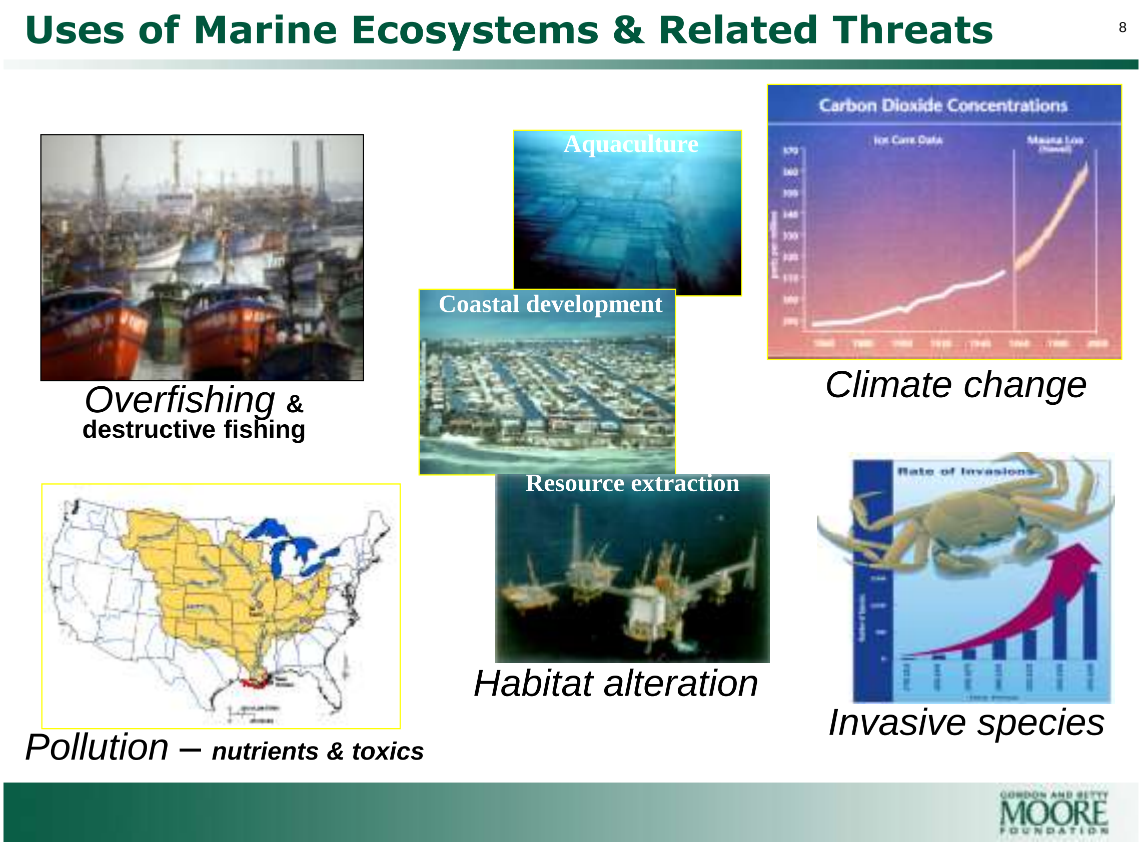

Figure 3. Uses of Marine Ecosystems and Related Threats

While we can all agree these threats are grave, there's a sixth threat that must be addressed. That sixth threat is our failure to balance the economic and social needs of our planet's people when it comes to the ocean. And I don't mean the stale debate about "jobs versus the environment." I mean a pragmatic approach that is based on principles of sustainability—driven by economic, environmental and social objectives—where we make explicit tradeoffs in order to maximize the use of ocean resources in a sustainable way. An approach that balances continued *economic development* of ocean areas with *preservation of the natural marine ecosystems* we depend on. The approach we need to take will require collective action—where industry, local communities, NGOs, governments, and academics, roll up their sleeves and together address the challenges of an increasingly crowded ocean. It is an approach where there is recognition and wide agreement that a healthy ocean is in the benefit of everyone's interests—whether it's economic, recreational or ecological.

Figure 4. Collective impact: balance of socioeconomic development (left) with preservation of natural marine ecosystems (right).

OCEAN PLANNING REPRESENTS A PARADIGM SHIFT

Marine Spatial Planning has such potential. It's the answer to a previous approach that isn't working for us anymore. For years, ocean management has focused on individual sectors. And history has shown us that no one wins when we all fight over use on a block by block scale. In the United States, at least 20 federal agencies implement over 140 federal ocean-related statutes. We have separate regulatory approaches for fisheries, aquaculture, shipping, oil and gas, etc. But that doesn't allow us to resolve conflicts across sectors. And it leads to ad-hoc decision making with no clear authority. MSP is a powerful tool—an integrated and holistic process—that can transform the way we manage and preserve our oceans.

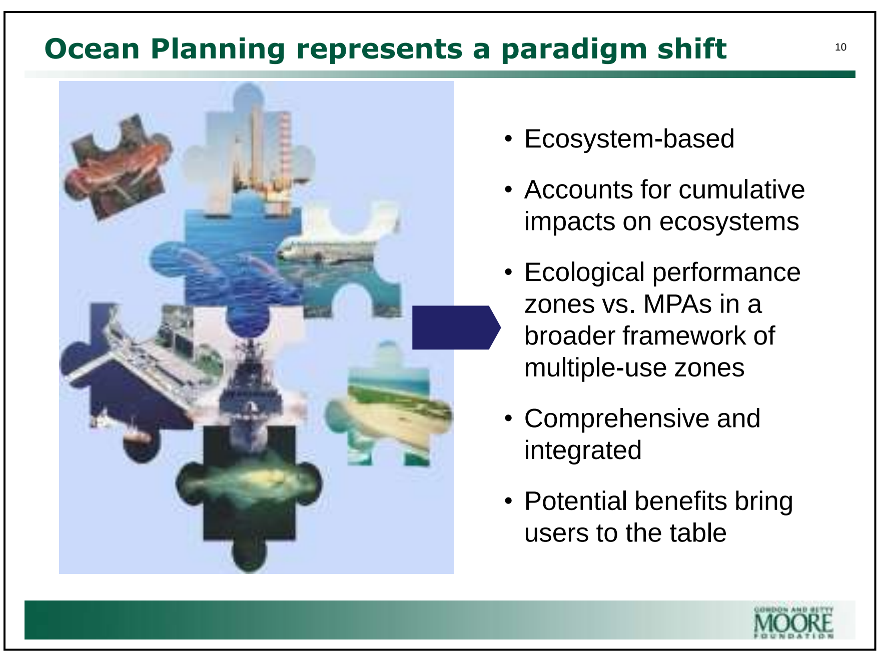

Figure 5. Ocean Planning

A MASSACHUSETTS EXAMPLE

As many of you know, the Massachusetts Ocean Act, which grew out of a recommendation of the 2004 Massachusetts Ocean Management Task Force, a 23-member panel appointed by then-Governor Mitt Romney, passed the Massachusetts Senate and House and was signed into law by Governor Deval Patrick.

The Ocean Act was amended to address concerns of fishing interests and others and did not strip any state agency of its authority, but required that their activities be consistent with the ocean management plan. It led to Massachusetts developing and implementing a marine spatial plan, and efforts are now underway to improve the plan and the process. In an op-ed commenting on the Massachusetts Oceans Act, Leon Panetta said:

> *The oceans have been like the Wild West, with the uses in any given area dependent on who gets there first.*
>
> *(Leon E. Panetta, former co-chairman of the U.S. Joint Oceans Commission Initiative and currently Secretary of Defense)*
> *Boston Globe Newspaper Company, November 18, 2007*

Importantly, the plan did not lead to economic catastrophe and in fact it did some good, though Massachusetts continues to face real challenges with respect to the health of some of its fisheries and the economic livelihoods of the communities that depend on fishing.

MASSACHUSETTS PUBLIC OPINION

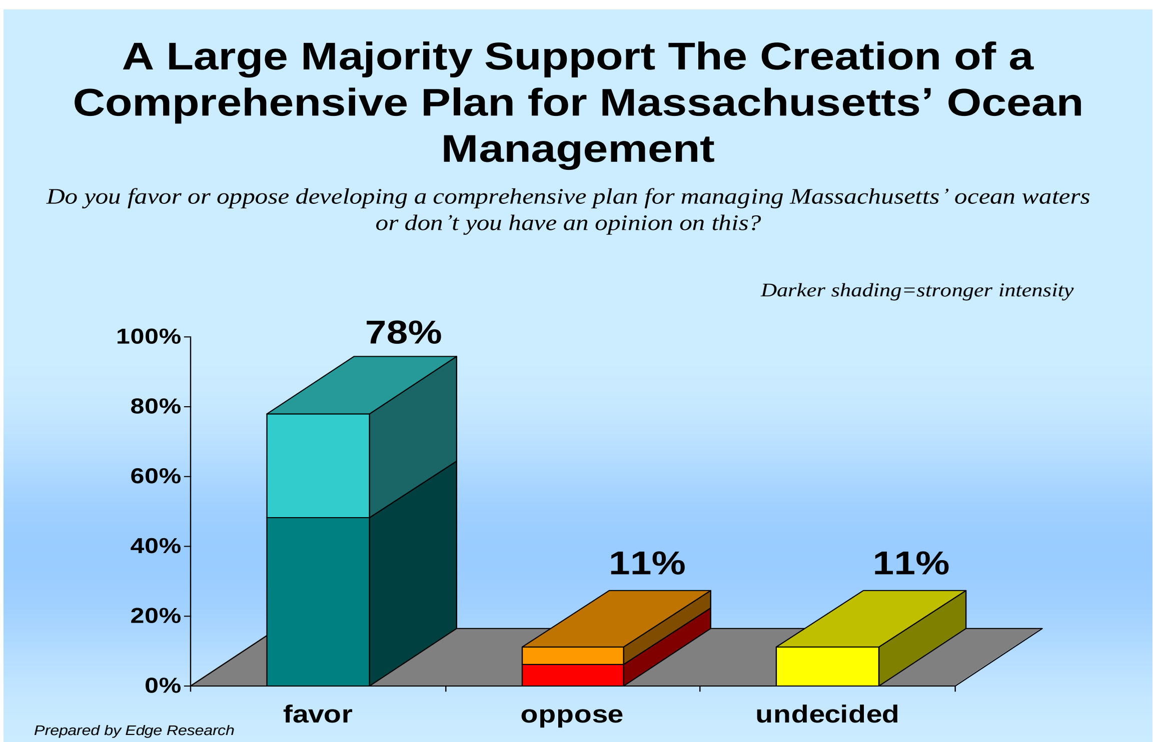

Figure 6. Public support for the creation of a comprehensive plan for Massachusetts' Ocean Management

GUIDANCE FROM U.S. NATIONAL OCEAN POLICY

Today, US National Policy adopted in 2010 recognizes 11 Large Marine Ecosystems (LMEs) designated for coastal and marine spatial planning

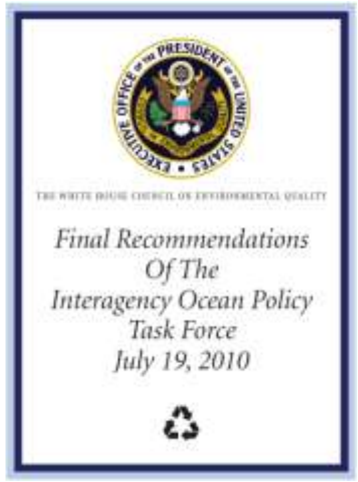

Figure 7. Cover*, Final Recommendations of the Interagency Ocean Policy Task Force*, 19 July 2010

LARGE MARINE ECOSYSTEMS AND REGIONAL PLANNING AREAS

LMEs are emerging as the next frontier for renewable energy, home to potential wave, wind and tidal power (Council on Environmental Quality, 2010; Executive Order, 2010)

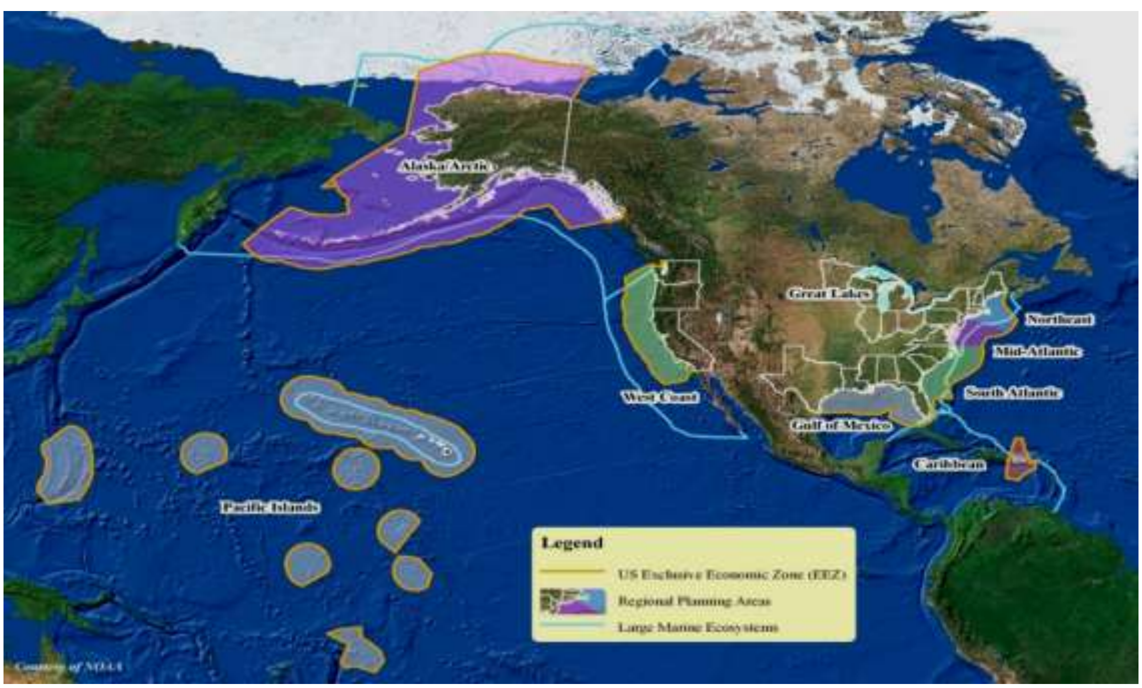

Figure 8. White House Council on Environmental Quality (CEQ); p.52 in Final Recommendations of the Interagency Ocean Policy Task Force, 19 July 2010

LMEs, FIVE MODULES WITH INDICATORS

Ken Sherman described the five-module strategy in 1995, and presented this diagram in 2002.

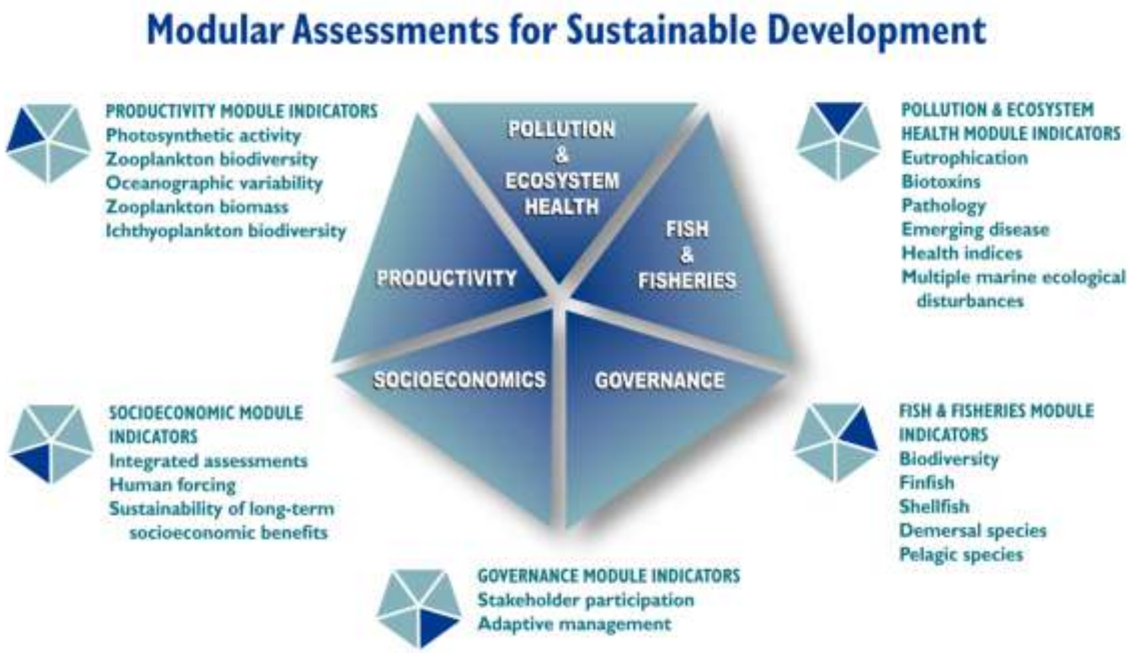

Figure 9. Five modules with indicators to support the LME assessment and management strategy (www.lme.noaa.gov). (Duda & Sherman, 2002; Sherman, 1995)

There are currently 17 GEF-supported projects involving 110 developing countries. All are involved in doing large marine ecosystem assessment and management, and at some level considering LME productivity, fish and fisheries, pollution and ecosystem health, socioeconomic, and governance in activities for sustaining ecosystem goods and services.

GUIDANCE FROM THE UNESCO REPORT ON MSP (http://www.unesco-ioc-marinesp.be/)

In practice, MSP:

- Enables managers to tackle large, system-level problems
- Promotes appropriate, compatible, sustainable uses
- Increases management efficiency through improved information exchange and interagency coordination
- Ensures opportunities for appropriate development space
- Advances stakeholder involvement via a transparent and structured process
- Creates ability to maximize benefits to humanity from an appropriate portfolio of uses

In a number of countries, particularly in Europe where coastal and ocean areas are smaller and already pretty crowded, this kind of ocean planning is happening now. In Belgium, Germany, England, and Canada planners are making inventories of all the existing and planned activities in their country's waters, identifying sensitive ecological areas that need protection, and then combining all this information to develop long-term plans for ocean use.

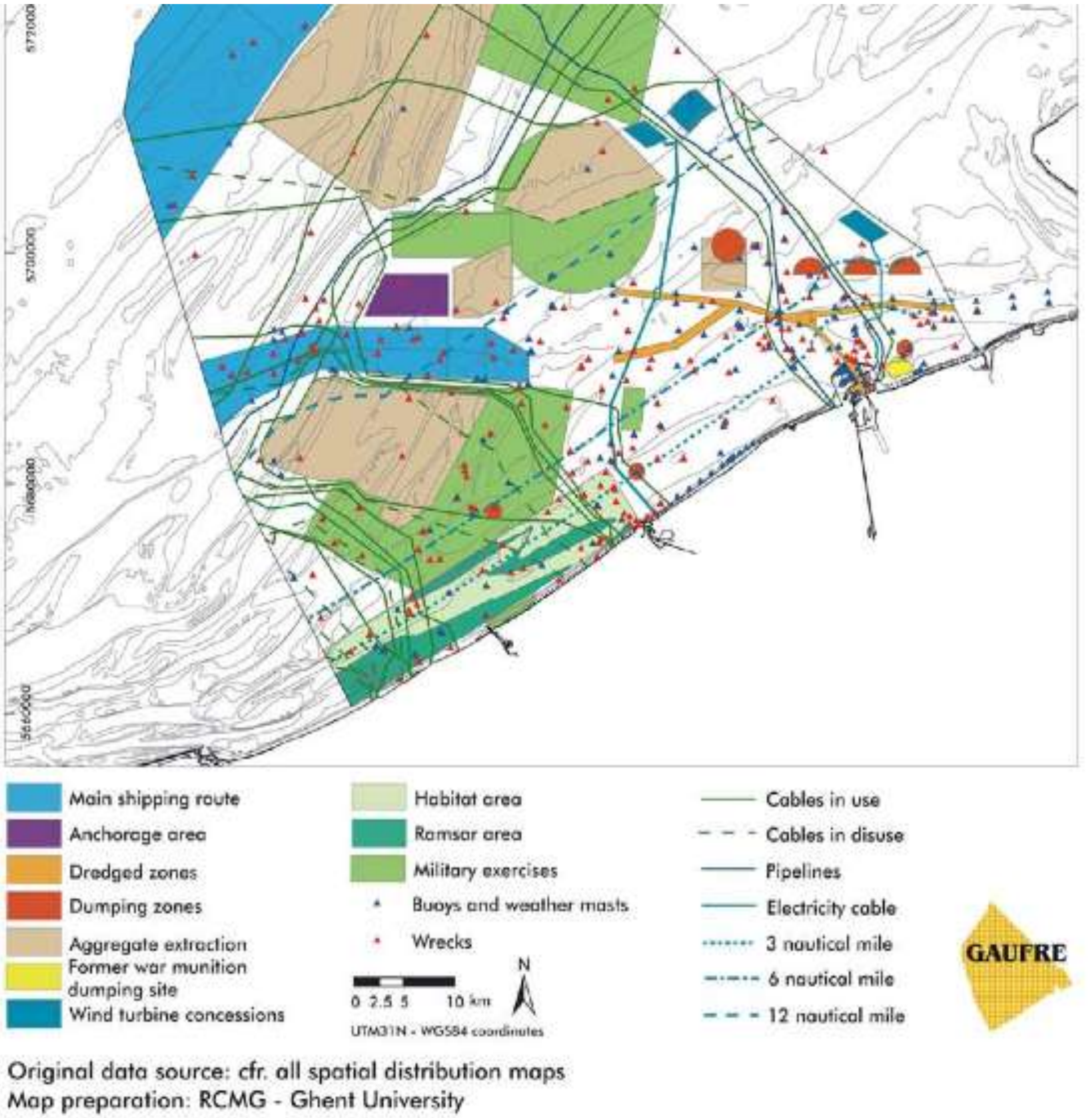

Figure 10. Existing multiple uses of ocean and coastal ocean waters to consider in planning.

STATUS OF MSP

Coastal and marine spatial management is gaining considerable interest and momentum around the world as numerous countries have started to use MSP to achieve sustainable use and biodiversity conservation in large marine ecosystems.

Nineteen countries have already completed or are in the process of completing marine spatial plans…four countries have completed countrywide plans…three countries have achieved some level of sub-national implementation, often very small as in the US, . . . three countries are working on marine spatial plans, . . . at least one country is stalled, and . . . another eight countries have completed some form of MSP pilot. That's a big deal and we've made huge gains in just ten years.

Table 1 Status of MSP: Countries completed or in the process of completing Marine Spatial Planning (MSP)

19 countries completed or in the process of completing MSP:

- **Completed MSP countrywide**: Belgium, Netherlands, Norway, Germany
- **Implemented MSP at sub-national level:** United States, Germany, China
- **Working on it:** Spain, Portugal, Australia
- **Trying but lacks federal support:** Canada
- **Completed MSP pilot projects:** Philippines, China, Poland, Latvia, UK, Sweden, Finland, St. Kitts-Nevis

Source: Bud Ehler

At the end of 2012, about ten percent of the world's EEZs have approved marine spatial plans, mostly due to two countries: Norway and Australia (combined they represent about eight percent of the area of the world's EEZs). So, if we step outside and look at the oceans, how do things look today? On the surface, things look pretty good.

What's Our Vision for the Future? Use oceans, but don't use them up:

> ***"We can have a much more effective, efficient, durable set of policies and practices that make it clear it's fine to use oceans, you just can't use them up."***
>
> ***Jane Lubchenco, NOAA Administrator***

Ultimately, ocean planning recognizes that maintaining healthy ecosystems will lead to vibrant coastal communities with sustainable economies. Like any kind of successful public policy, Ocean Planning will require tradeoffs and compromises, and funding for good implementation on the water.

We'll need to bring everyone together who has an interest in the ocean and focus on the future, allowing Marine Spatial Planning to help defuse some of the traditional "us vs. them" battles over ocean space.

CAN WE AGREE ON A SUSTAINABLE EFFICIENCY FRONTIER?

Similarly, we're starting to see that MSP can lead to important economic, ecological and social benefits, as well. A recent study by Crow White (White, Halpern, & Kappel, 2012) has calculated benefits in the millions of dollars to multiple sectors from marine spatial planning, including conservation. In the North Sea, we've seen benefits to fisheries from wind farms.

We also have anecdotal evidence of reduced conflicts and streamlined permitting processes that reduce transaction costs and may lead to increased buy-in and compliance. As well as the protection of local communities and their cultural heritage by ensuring that they're involved in the process.

Together, let's send a clear and consistent message that MSP is about taking a common sense approach to our oceans and our future. And let's be proud of what has been accomplished so far.

In the US—as recently as 2006—the term MSP was barely recognized. Today, we have a Presidential directive to provide a national framework for ocean planning. Internationally, 20 countries have embraced MSP and that list is growing. While opponents of MSP in the US paint it as a top-down government imposition, momentum is building at the state and regional levels to get plans on the water. Working together we have the opportunity to create resilient, productive marine ecosystems that will continue to support life on our ocean planet.

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Duda, A. M., & Sherman, K. (2002). A new imperative for improving management of large marine ecosystems. *Ocean and Coastal Management, 45*(2002), 797-833.

Executive Order. (2010). *President Obama, Executive Order 13547: Stewardship of the Ocean, Our Coasts, and the Great Lakes*.

Sherman, K. (1995). Achieving regional cooperation in the management of marine ecosystems: The use of the large marine ecosystem approach. *Ocean and Coastal Management, 29*(1-3), 165-185.

White, C., Halpern, B. S., & Kappel, C. V. (2012). Ecosystem service tradeoff analysis reveals the value of marine spatial planning for multiple ocean uses. *Proc Natl Acad Sci USA, 109*(12), 4696-4701.

7

MARINE SPATIAL PLANNING APPLICATIONS FOR LME MANAGEMENT IN NORTH AMERICA

Sandra T. Whitehouse, PhD, Senior Policy Advisor, Ocean Conservancy

The goals defined by the U.S. National Ocean Policy as put forth in Executive Order (EO) 13457 issued in 2010 are in essence: protect ocean health, support sustainable use, and preserve maritime heritage. In order to achieve these goals, managers must employ an ecosystem-based approach to assessment and management that considers societal, economic and ecological factors together. Coordination among tribal, state and federal resource management entities is critical to moving beyond a single sector approach to manage holistically for multiple uses and ecological parameters. Coastal and marine spatial planning (CMSP) is merely a mechanism that can be used in order to manage on an ecosystem basis to achieve these goals (Figure 1).

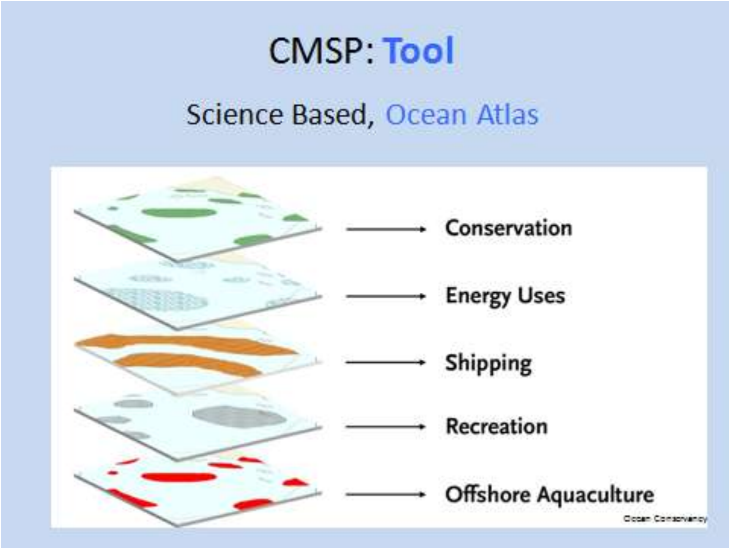

Figure 1. Coastal and Marine Spatial Planning (CMSP): Science-based ocean atlas tool. Image Source: Ocean Conservancy, 2010.

There are numbers of places around the world that have employed CMSP to manage large marine ecosystems. Of the large marine ecosystems (LMEs) in the United States, I am going to focus on the Northeast Continental Shelf (Figure 2).

Figure 2: Map of the US Northeast Continental Shelf LME with Regional Planning Areas (RPAs) designated for the Northeast (purple) and Mid-Atlantic (tan) areas.

The Northeast Shelf LME encompasses two planning regions as defined by the National Ocean Policy: the Northeast and the Mid-Atlantic (Figure 2). With respect to governance, the Northeast region has a regional ocean partnership known as NROC (Northeast Regional Ocean Council) that was formed in 2005 to provide a voluntary forum for New England states and federal partners to coordinate and collaborate on regional approaches to ocean and coastal issues. There is also the Northeast regional planning body that was formed in 2012 in response to the EO for the more specific purpose of doing CMSP. These two entities are working closely together to manage the Northeast region on an ecosystem basis using CMSP. The Mid-Atlantic planning effort is also underway.

In the Northeast region there are multitudes of existing uses including shipping, recreational and commercial fishing, whale watching and recreational uses. Members of the coastal communities and Native American tribes have long-standing and strong economic, cultural and spiritual ties to the coast and ocean (Figure 3).

Figure 3. Existing Ocean Uses: American Lobster fishing, NOAA 2013 (top left); **Black Falcon ShippingTerminal** by Dave Ryan, The Boston Globe 2005 (top right); **Wampanoag Tribal Officer** on tribal land**,** by Debbie Thumacki (2009) *Boston Globe* article on wind turbines (middle left); **two windsurfers** by Manuel Gonzalez Olaechea y Franco 2005 (middle center); **beach** by Cape Cod Chamber of Commerce 2012 (middle right); **Whale watching** , NOAA 2012 (bottom left)**; Rockport Harbor** by Terry Ballard (bottom right)

There are also emerging uses such as the development of offshore wind and hydrokinetic renewable energy projects and offshore aquaculture (Figure 4).

Figure 4. Emerging Ocean uses: Sheringham Shoal Wind Farm 2012 (top left) Pettersen, Harald/Statoil; National Renewable Energy Laboratory, DOE Cobscook Bay Tidal Energy Pilot Project 2012 (top right);. Atlantic Salmon Aquaculture 2008 (bottom left) U.S. Department of Agriculture; Liquified Gas tanker arriving in Boston 2005 (bottom right) by Liquigraphs/Flickr.

PLANNING TO EVALUATE CUMULATIVE IMPACTS

CMSP is a way to reduce conflict among LME uses (such as sailing and building offshore wind farms) and between uses and the environment (such as bottom trawling and deep-sea corals). Comprehensive planning in the form of CMSP can also aid in the evaluation of cumulative impacts from activities including fishing, nutrient runoff and dredged material disposal, all of which take place in this region. The two main drivers for doing this type of planning for the Northeast Shelf LME have been wind development and conservation.

CMSP for the Northeast Shelf LME has an advantage in that two of the five states in the Northeast region, Rhode Island and Massachusetts, have recently done this type of planning for state waters and have collected a wide range of data (plans completed in 2010 and 2009 respectively) (Figure 5).

Figure 5. NROC map shows the overlap of planning for state waters of Rhode Island and Massachusetts.

The Rhode Island Coastal Resources Management Council, using its authority under the Coastal Zone Management Act, developed the Rhode Island coastal and marine spatial plan as a Special Area Management Plan (known as the Ocean SAMP). The plan was developed to promote a balanced and comprehensive ecosystem-based management approach to the development and protection of Rhode Island's ocean-based resources. Specifically, the state wanted to define an offshore renewable energy area as well as areas for conservation (Figure 6).

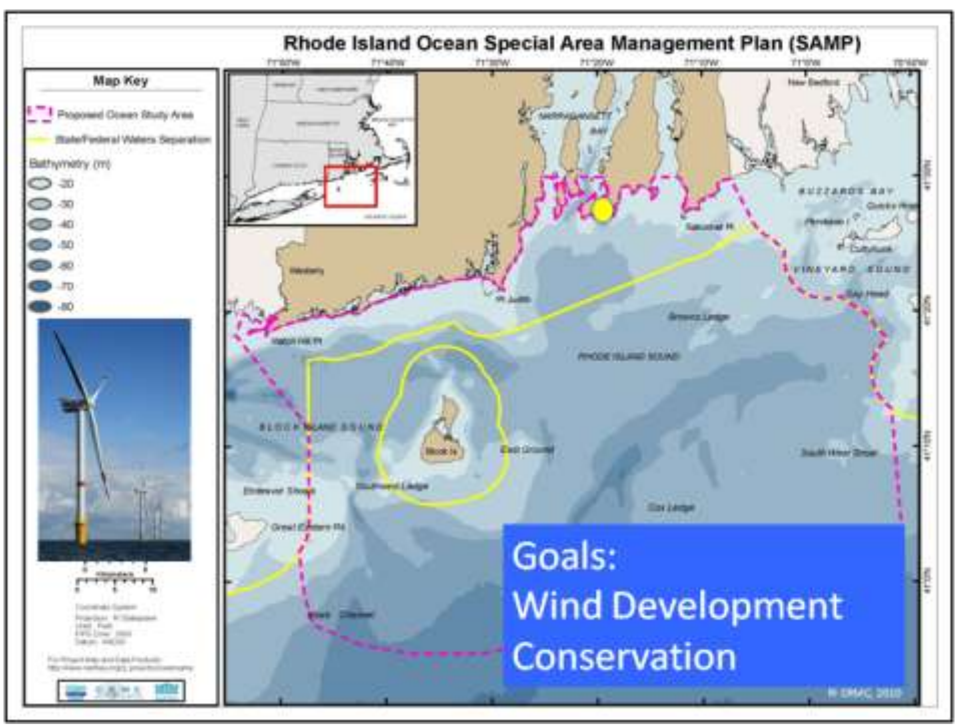

Figure 6. Special Area Management Plan for wind development and conservation.

Image Source: Rhode Island Coastal Resources Management Council. *Rhode Island Ocean Special Area Management Plan (Ocean SAMP).* 2010:10.

The best available science was collected and compiled and many maps were produced to help make the decisions necessary to site a wind farm, including wind speed, bathymetry and bottom type. The SAMP area includes a number of large rocks and boulder fields that were created during the Pleistocene glaciations [B.D. Stone and H.W. Borns (1986), Pleistocene glacial and interglacial stratigraphy of New England, Long Island and adjacent Georges Bank and the Gulf of Maine, *in* Sibrava, V. et al. eds, Quaternary glaciations in the Northern Hemisphere: *Quaternary Science Reviews*, v.5, p.39-52]. It was important to collect this information both because of the difficulty of driving a piling for a wind turbine into a boulder field as well as the habitat value of these areas for many species, including the commercially valuable American Lobster (*homarus americanus*) (Figure 7).

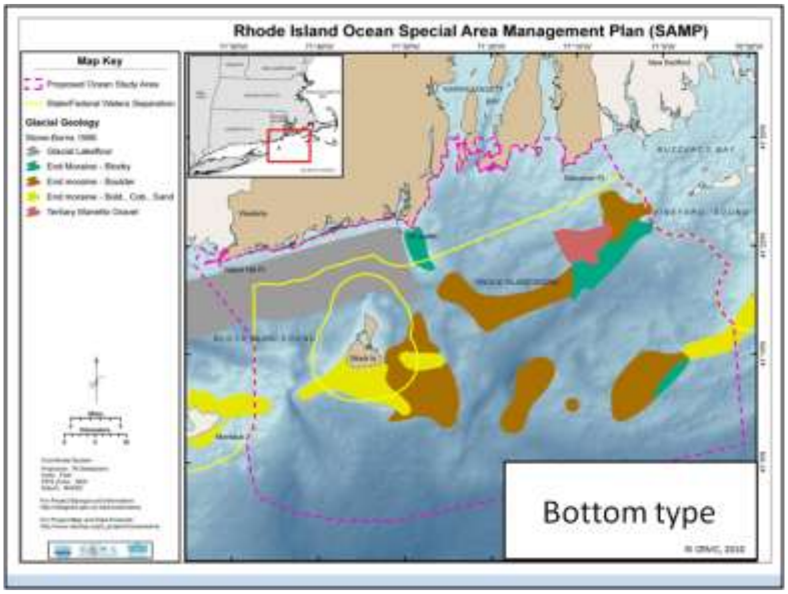

Figure 7. Bottom substrate types depicted in State of Rhode Island Special Area Management Plan (SAMP)—

Rhode Island Coastal Resources Management Council. Rhode Island Ocean Special Area Management Plan (Ocean SAMP). 2010:189.

Recreational and commercial fishing (using both fixed and mobile gear) takes place throughout the area (Figure 8).

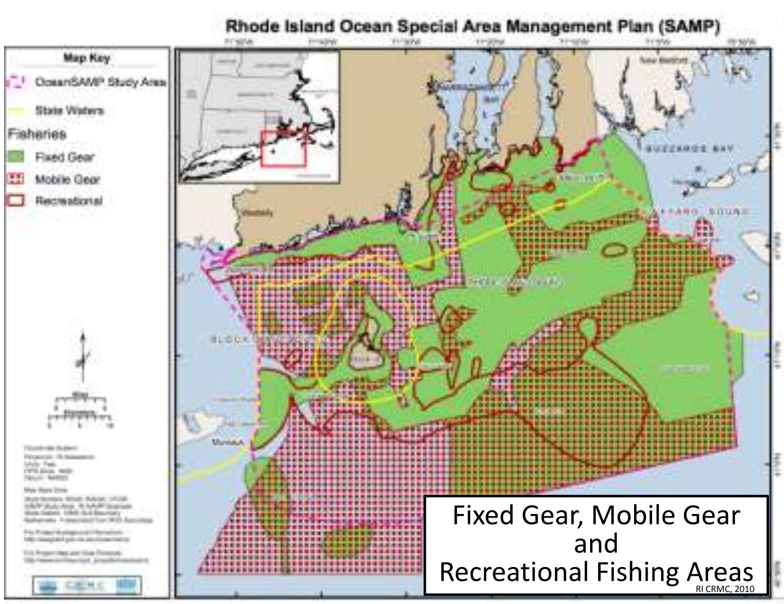

Figure 8. Fixed and mobile sites for fisheries gear and recreational fishing areas

Source: Rhode Island Coastal Resources Management Council. Rhode Island Ocean Special Area Management Plan (Ocean SAMP). 2010:100.

There is significant shipping activity including tankers, container ships and barges especially east-west along the coast and north-south to and from the Rhode Island ports (Figure 9).

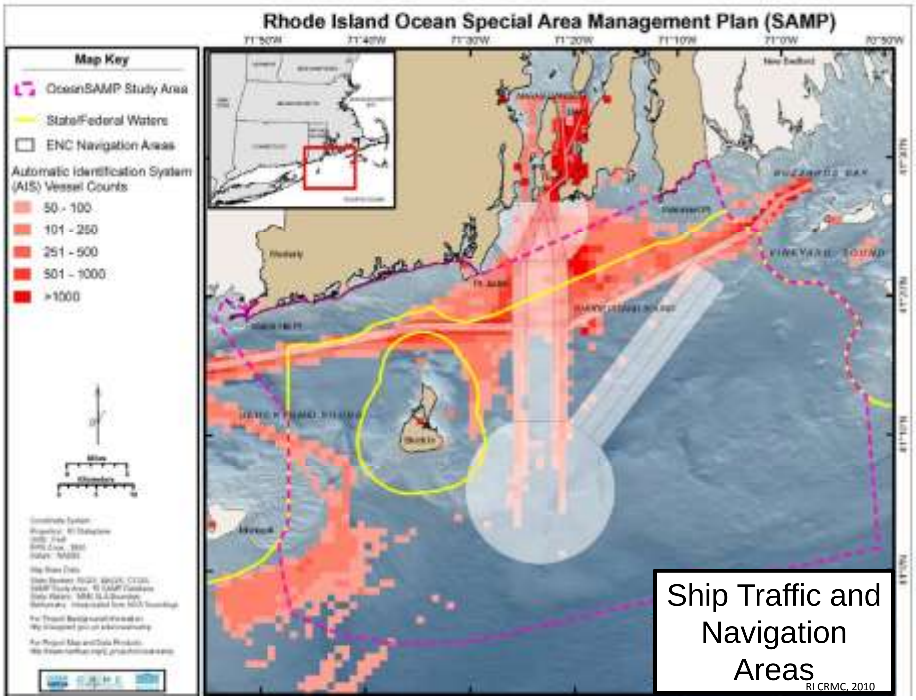

Figure 9. Shipping lanes and navigation areas in coastal waters off the R.I. coast—

Rhode Island Coastal Resources Management Council. Rhode Island Ocean Special Area Management Plan (Ocean SAMP). 2010:28.

There are several trans-Atlantic cables that transect the planning area and places that need to be avoided by developers based on previous activities such as dredged material disposal and naval weapons testing during the past century that resulted in at least the possibility of unexploded ordinance, bombs and depth charges (Figure 10).

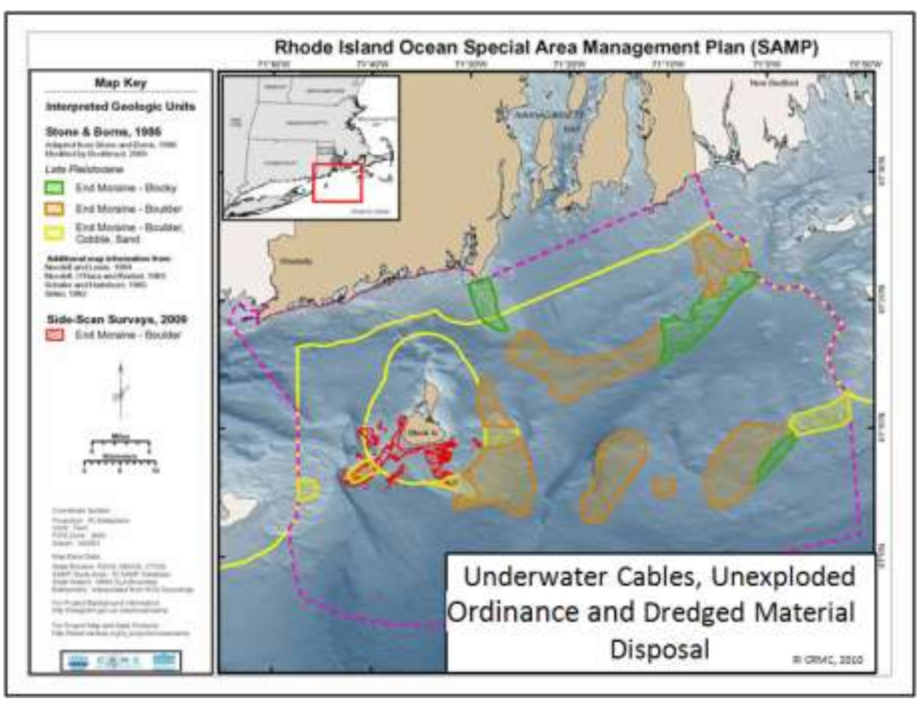

Figure 10. Locations of underwater cables, unexploded ordinance and dredge disposal sites off the R.I. coast—

Rhode Island Coastal Resources Management Council. Rhode Island Ocean Special Area Management Plan (Ocean SAMP). 2010:48

With respect to important ecological areas, diving duck habitat is just one of many conservation criteria. Of the many outputs or results of the plan, two were to define an area in state waters appropriate for renewable energy off of Block Island. Deepwater Wind is now in the permitting process for a wind project in an area south of Block Island (RICRMC, RI Ocean Special Area Management Plan—*Ocean SAMP 2010: 77).*

In approximately half of the SAMP area, no industrial development is allowed. While this is only the minimum level of conservation, further levels of protection may be added in the future for some areas.

On the regional scale of the Northeast Shelf LME, the planning process was launched in 2012. The work of NROC for the past year has primarily focused on data collection and stakeholder engagement.

Some of the maps created to illustrate features and information about the area include data about bottom trawling, locations of deep-sea coral and sites identified by the Bureau of Ocean Energy Management (BOEM) as lease areas for offshore wind. Clearly some of these habitats and ocean uses pose the potential for conflicts (Figure 11).

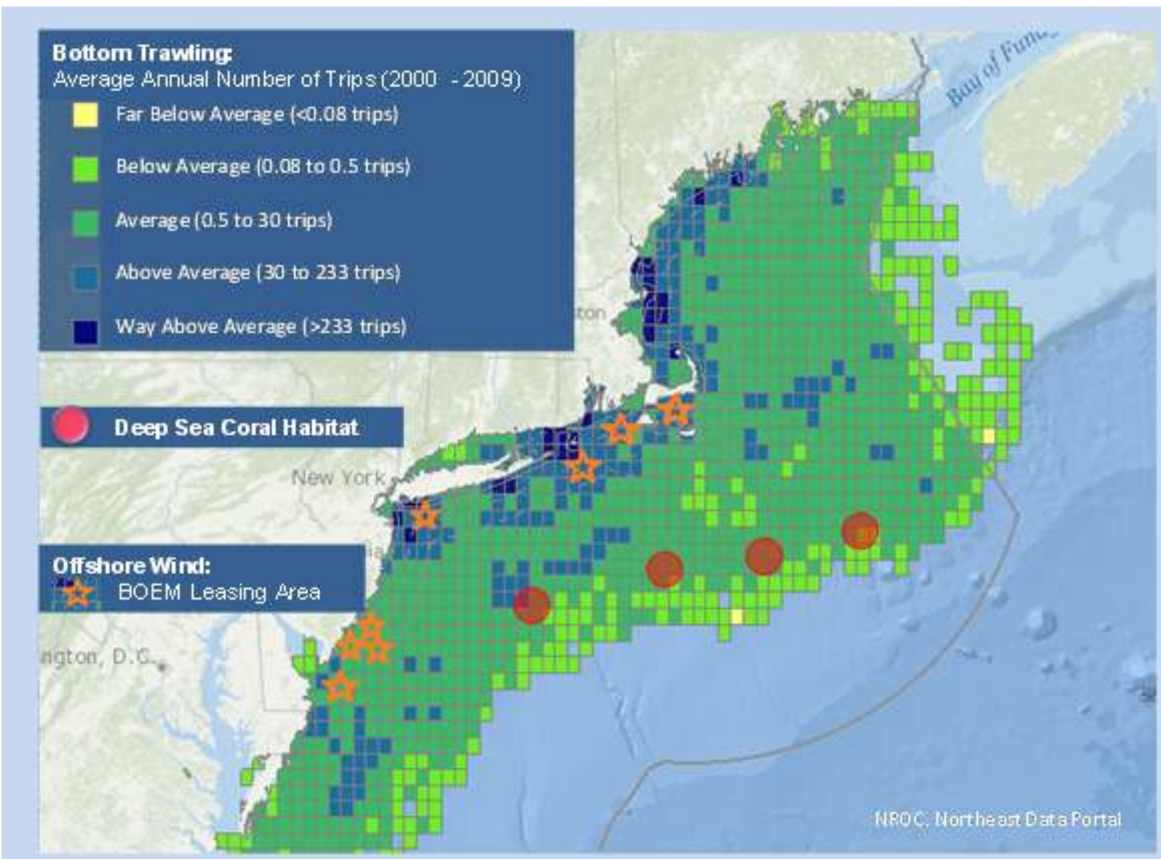

Figure 11. Bottom trawling areas in relation to coral habitat and offshore wind leasing areas—Northeast Regional Ocean Council, Northeast Data Portal. 2012. Web. http://www.northeastoceandata.org/ .

Other data layers that illustrate the need for coordinated management, in this case to minimize the probability of whale strikes, are right whale sightings and shipping lanes (Figure 12).

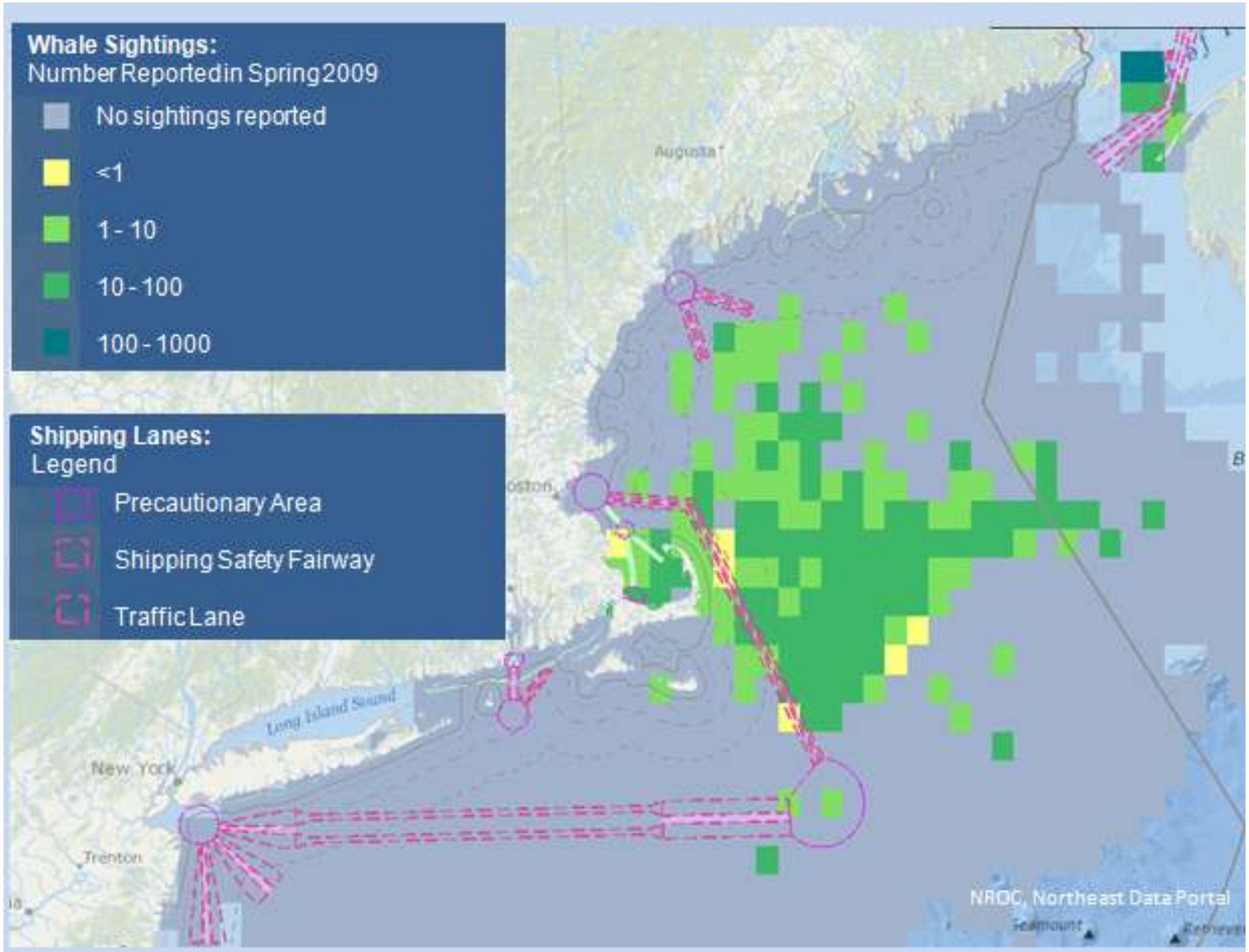

Figure 12. Shipping Lanes and Whale Sightings. Northeast Regional Ocean Council, Northeast Data Portal. 2012. Web. http://www.northeastoceandata.org

As the Coastal and Marine Spatial plan for the Northeast Shelf LME is being developed, the need to prepare for climate change will be integrated into many aspects of the plan.

The National Ocean Policy and Executive Order of 19 July 2010 guides regions around the coastal U.S. to protect, maintain, and restore the nation's ocean, coastal, and Great Lakes resources and ensure resilient ecosystems and their ability to provide sustained delivery of ecosystem services and specifies that plans should consider resilience with respect to the effects of human uses, natural hazards and global climate change.

In the Northeast Shelf LME, impacts from climate change are already evident. Rhode Island water temperatures have increased by 0.5°C since 1958 (Figure 13).

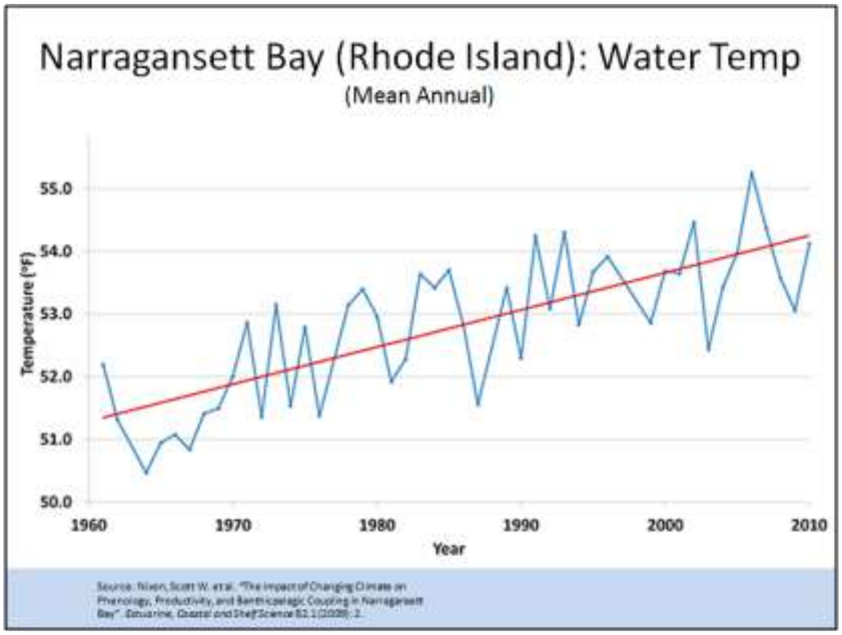

Figure 13. Increasing trend in water temperature of Narragansett Bay. Image Source: Nixon et al. "The Impact of Changing Climate on Phenology, Productivity, and Benthicpelagic Coupling in Narragansett Bay". *Estuarine, Coastal and Shelf Science* 82.1 (2009): 2.

Associated with the warmer waters, there has been a species shift from abundances of commercially valuable demersal fish species such as winter flounder (*Pseudopleuronectes americanus*) to less valuable pelagic species such as scup (*Stenotomus chrysops)*. Warm-water invasive species such as the red lionfish (*Pterois volitans*) have now entered the waters of the Northeast Shelf LME.

Another impact of climate change is sea level rise with an observed change from the Newport, RI, tide gauge of 2.58 millimeters each year (Figure 14).

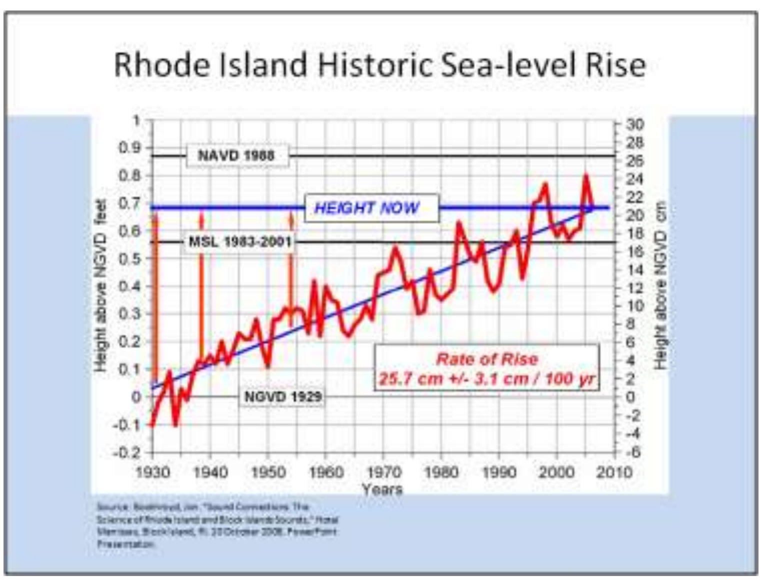

Figure 14. **Historic RI Sea-level Rise.**

Jon Boothroyd,. "Sound Connections: The Science of Rhode Island and Block Island Sounds," Hotel Manisses, Block Island, RI. 20 October 2008. PowerPoint Presentation.

One example of an ecologically and economically valuable habitat that will need to be managed considering climate change is a salt marsh. Overlays that model future impacts of climate change with existing uses and future spatial demands will be powerful and important tools. One more example of the impacts of climate change in the Northeast is the increase in annual precipitation of 5-17 percent in the past 100 years (Figure 15).

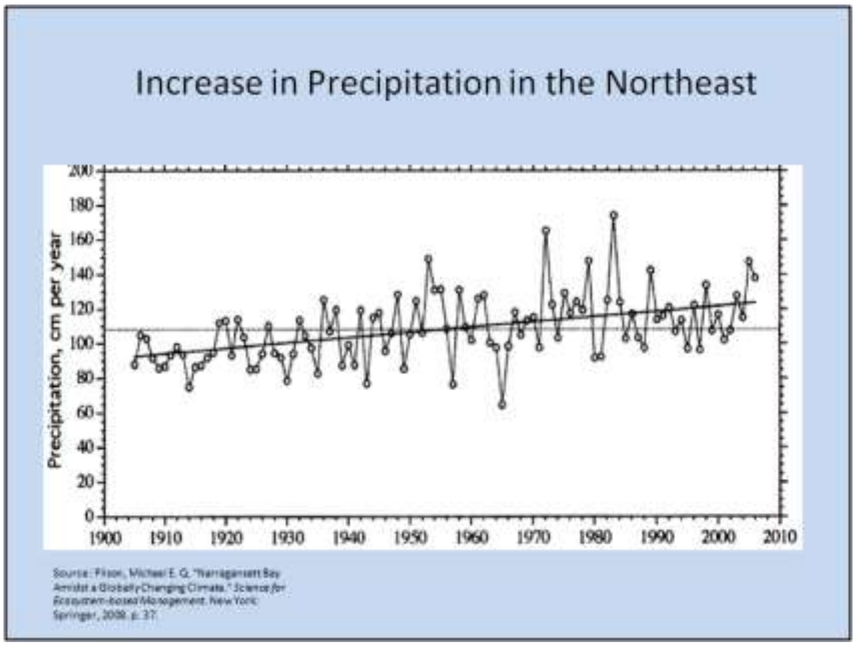

Figure 15. Decadal trend of increasing precipitation in the Northeast region of the U.S.

Pilson, Michael E. Q. "Narragansett Bay Amidst a Globally Changing Climate." *Science for Ecosystem-based Management*. New York: Springer, 2008. p.37.

Furthermore, more of the annual rainfall is coming in heavy rainfall events [P.C. Frumhoff, J.J. McCarthy et al. (2007) Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis report of the Northeast Climate Impacts Assessment. Cambridge, MA: Union of Concerned Scientists] (Figure 16).

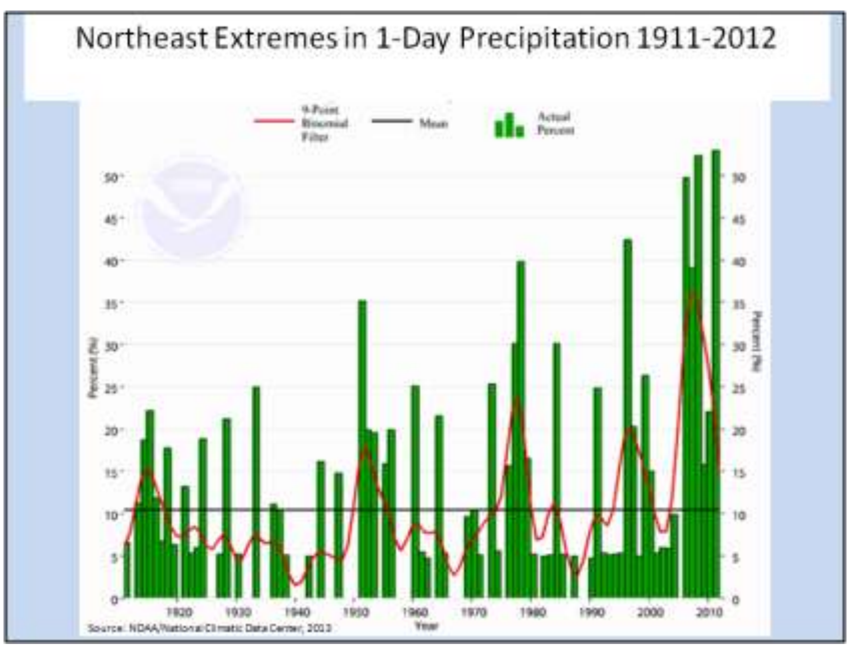

Figure 16. **Northeast Precipitation Extremes, 1911-2012.**

National Oceanic and Atmospheric Administration, National Climate Data Center."Northeast Extremes in 1-Day Precipitation." U.S. Climate Extremes Index (CEI). 2013. Web. http://www.ncdc.noaa.gov/extremes/cei/graph/ne/4/10-03

An example of the detrimental result of this trend was seen in 2005 when heavy spring rains caused a widespread harmful algal bloom along the Northeast coast of the LME. It came immediately before the height of tourist season and was devastating for many of the region's shell fishermen (Figure 17).

Figure 17. Coastal extent of a harmful algal bloom event along the northeast coast of the U.S.

Anderson et al. "The Global, Complex Phenomena of Harmful Algal Blooms." *Oceanography Society* 18.2 (2005): 136-147.

In conclusion, we need to use a process like CMSP to understand how climate change will impact the Northeast Shelf LME as well as how to develop projects like offshore wind that can contribute to reductions in carbon emissions.

8

MARINE SPATIAL PLANNING AND LARGE MARINE ECOSYSTEMS IN MEXICO

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Mexico is surrounded by five Large Marine Ecosystems (LMEs), all of them with different bathymetric, hydrographic, biological, trophodynamic, socioeconomic and governance features (Sherman and Hempel, 2008).

Amongst the several policy and planning instruments for the management of coastal and ocean zones, the ecological spatial planning (ESP) approach seems to be the most comprehensive, effective and appropriate for application to LMEs complementing the 5 modular approach to LME assessment and management (Sherman and Hempel, 2008. op.cit). Indeed, ESP is aimed at regulating and encouraging sustainable development with any given land or sea use and its associated productive activities, while protecting the environment through the sustainable use of its natural resources. The strength of the spatial planning approach is supported by a thorough analysis of trends in environmental degradation and the study of scenarios for decreasing harvesting potential of actual resources.

A spatial planning program aims to establish guidelines and provisions for preserving, restoring, protecting and sustainable harvesting the natural resources that occur at any given area on land, coast or sea, including those of federal jurisdiction, and all of them are subjected to law enforcement as published by a federal, state or municipal decree.

In Mexico, oceans are a federal governance matter. The federal agency in charge of formulating, issuing and executing marine spatial planning processes is the Ministry of Environment and Natural Resources (SEMARNAT), along with other federal agencies, and those corresponding at the state and municipal levels.

THE MARINE SPATIAL PLANNING PROCESS

Spatial planning is a rigorous, transparent, participative and adaptive process of several steps (Figure 1), of which the core formulation of the planning study also involves several stages (Figure 2).

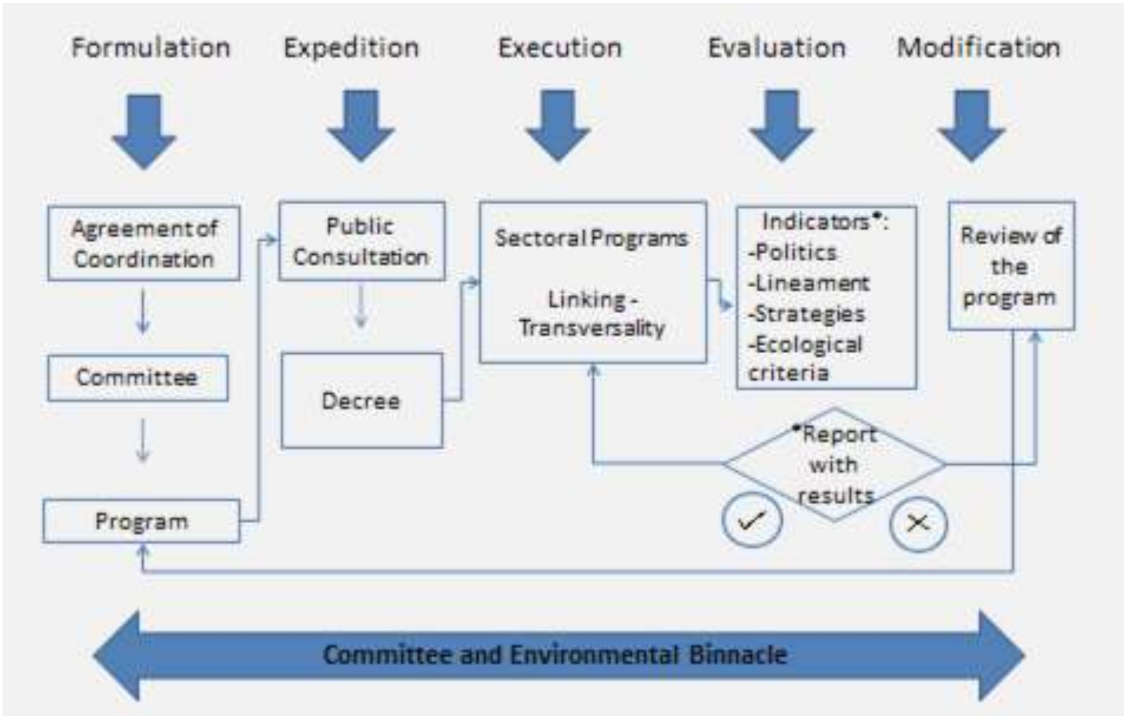

Figure 1. Phases of the policy process of marine spatial planning.

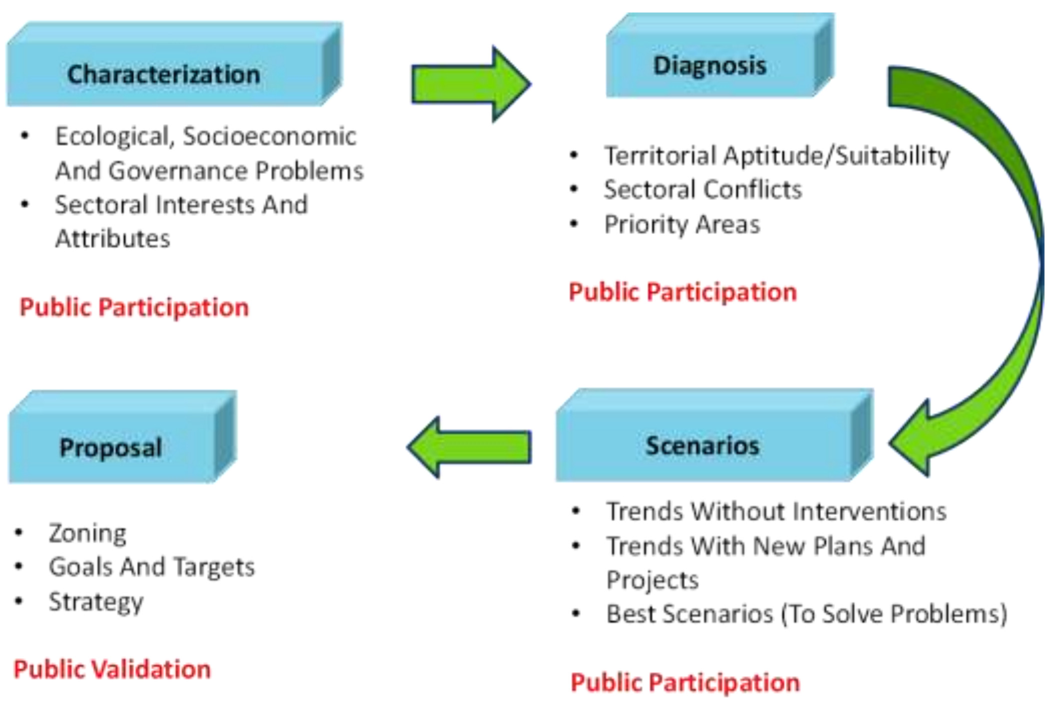

Figure 2. Stages of the technical studies of marine spatial planning

MARINE SPATIAL PLANNING PRACTICE

The Exclusive Economic Zone (EEZ) comprises four regions, each eligible for a particular planning process (Figure 3), in accordance to certain ecologic, social, economic, and governance features, and their issues are differentially approached (Table 1) in relation to their degree of progress (Table 2).

Figure 3. Areas of Marine Spatial Planning in México.

For two LMEs planning processes have been decreed and are currently being implemented (Gulf of California, 2006 and Gulf of Mexico, 2012); the other two LME planning processes are in the formulation stage (Northern Pacific and Central Southern Pacific Ocean). The Gulf of Mexico LME planning process is particularly oriented to regulate activities of the energy, maritime and fisheries sectors, while planning processes in the Pacific consider the interactions among the tourist, conservation and fishery sectors.

The planning process for the Gulf of California was the very first experience of its kind in the country, and was approached more from a scientific basis than from the required managerial foundation, which was actually launched in order to address the continuing spatial conflicts among the tourism, conservation and fishery sectors (Gutiérrez-Mariscal *et al*, 2007). The specific by-law provision on matters of spatial planning (SEMARNAT, 2003), encouraged a more participative process under an integrated framework of principles and procedures, by which conflict resolution became a core theme. From this new managerial vision—which included the signing of a coordination agreement, the establishment of decision committees, and the installation of a dynamic environmental log for the planning process—the core proposal was finally agreed among the several stakeholders, and decreed two years after its launching as the first federal marine spatial planning process.

Table 1. Topics addressed by Marine Spatial Planning for Mexican Large Marine Ecosystems (LMEs) and Regions.

ECOLOGICAL OCEAN USE PLANNING	MARINE AREAS OF THE GULF OF CALIFORNIA LME	MARINE AND REGIONAL AREAS OF THE GULF OF MEXICO AND CARIBBEAN LMEs	MARINE AND REGIONAL AREAS OF THE NORTHERN PACIFIC	MARINE AND REGIONAL AREAS OF THE SOUTHERN CENTRAL PACIFIC
POLLUTION	X	X	X	X
ECOSYSTEM HEALTH	X	X	X	X
FISH AND FISHERIES	X	X	X	X
GOVERNANCE		X		X
SOCIOECONOMIC		X		X
PRODUCTIVITY	X	X	X	
CLIMATIC CHANGE		X		

Table 2. Current State of Processes in Marine Spatial Planning in Mexican Large Marine Ecosystems (LMEs) and Regions.

PROCESS/ REGION	THE GULF OF CALIFORNIA LME	MARINE AND REGIONAL AREAS OF THE GULF OF MEXICO AND CARIBBEAN LMEs	MARINE AND REGIONAL AREAS OF THE PACIFIC NORTH	MARINE AND REGIONAL AREAS OF THE PACIFIC SOUTH CENTER
COORDINATION AGREEMENT	09 OF JULY 2004	28 OF SEPTEMBER 2006	22 SEPTEMBER 2009	10 OF OCTOBER 2011
MEMBERS OF THE COMMITTEE (FEDERAL, STATE AND COUNTY AGENCIES AND STAKEHOLDERS IN THE REGION)	SEMARNAT, SAGARPA-CONAPESCA,SECTUR, SEGOB, SCT, SEMAR, SEDESOL GOVERNMENTS OF THE STATES OF: BAJA CALIFORNIA, BAJA CALIFORNIA SUR, NAYARIT, SONORA, AND NORTHWEST CONSULTATIVE ADVICE FOR THE SUSTAINABLE DEVELOPMENT.	SEMARNAT, SEMAR, SCT, PEMEX , SRA, SEGOB, PEMEX GOVERNMENTS OF THE STATES OF: TAMAULIPAS, VERACRUZ, TABASCO, CAMPECHE, YUCATÁN AND QUINTANA ROO	SEGOB, SEMAR, SEDESOL, SEMARNAT, SENER, SE, SAGARPA, SCT, SECTUR, PEMEX, CFE GOVERNMENTS OF THE STATES OF: BAJA CALIFORNIA, AND BAJA CALIFORNIA SUR.	SEGOB, SEMAR, SEDESOL, SEMARNAT, SENER, SE, SAGARPA, SCT, SECTUR, PEMEX, CFE GOVERNMENTS OF THE STATES OF: JALISCO, COLIMA, MICHOACÁN, GUERRERO, OAXACA AND CHIAPAS.
STAKEHOLDERS	NGO´S, ECONOMIC SECTORS, GROUPS OF INTEREST	NGO´S, ECONOMIC SECTORS, GROUPS OF INTEREST	NGO´S, ECONOMIC SECTORS, GROUPS OF INTEREST	NGO´S, ECONOMIC SECTORS, GROUPS OF INTEREST
CURRENT SITUATION	DECREED THE 29 OF NOVEMBER 2006	DECREED THE 24 OF NOVEMBER 2012	PROPOSAL	DIAGNOSIS

The second experience was the one for the Gulf of Mexico LME. An exceptional exercise indeed, since it considered the explicit interaction between terrestrial and marine ecologic and economic processes as a whole coupled system, and where a high resolution window at the Solidaridad municipality, within the state of Quintana Roo, was also included in order to closely address these sectoral interactions. An additional unique feature of this experience deals with its explicit linkage to the GEF-project of the Gulf of Mexico Large Marine Ecosystem (GoM-LME) project as implemented by Mexico and the United States since 2009. This coupled spatial planning event is also a first as both countries share goals, objectives, and development strategies, which eventually may set the course for similar institutional arrangements for the Gulf of California LME, based on the experience of its execution.

The two remaining exercises, one in the North Pacific (NP) and the other in the Central South Pacific (CSP), are following successful deployment models of the decreed planning processes, such as a highly motivated public participation (Figure 4) by explicitly including also the afore-mentioned law-enforced regulating principles on the matter.

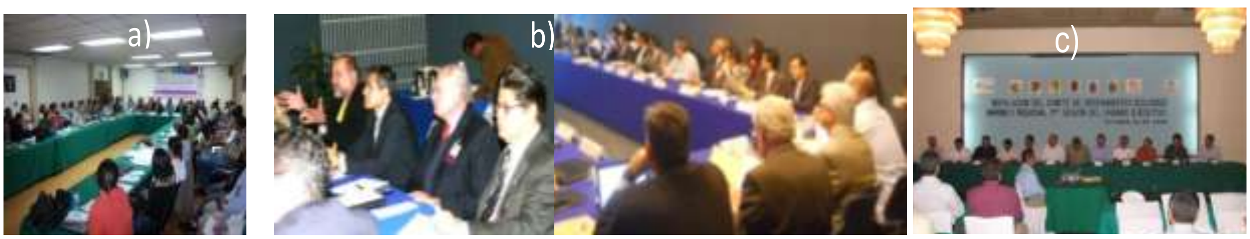

Figure 4. Public, transparent and accountable Marine Spatial Process.

The CSP experience is including the Ocean Health Index approach (Halpern *et al*, 2008; 2012), in the LMEs project framework (Sherman *et al*, 1996; Hennessey & Sutinen, 2005; Olsen *et al*, 2006), and the International Oceanographic Commission's set of environmental indicators (UNESCO, 2006). The latter, were explicitly considered in designing the core spatial planning studies of the region for its ecological, social-economic and governance dimensions.

THE MARINE SPATIAL PLANNING STRATEGY 2013-2018

In Mexico, several marine spatial planning exercises started as such 25 years ago, but it was not until 2006 that the Gulf of California LME was actually formulated and decreed formally. The experience gathered from this process supported the devising of a National Strategy for the Spatial Planning of Oceans and Coasts a year later (Semarnat, 2007), which as well encouraged further efforts to spatially plan all marine areas of the country. The decree of the Gulf of Mexico LME process in 2012 and the significant progress on the Pacific coast, are examples of these efforts.

In the near future, once these latter processes are decreed, those from the Gulf of California, the Gulf of Mexico and the Caribbean Sea LMEs should be fully implemented for execution, and should be continuously assessed though monitoring system of performance, effectiveness and accomplishment indicators.

Another strategic planning protocol deals with devising guidelines and provisions for the attention of critical coastal ecosystems such as mangroves, coastal lagoons, dunes, and marine grasses and reefs, in order to control both natural and anthropogenic stressors to their resilience. In addition, this approach also considers the explicit implementation and linking with the National Policy of Coasts and Oceans, as approved by the Inter-ministerial Commission for the Sustainable Management of Oceans and Coasts (CIMARES, 2008-12; Figure 5).

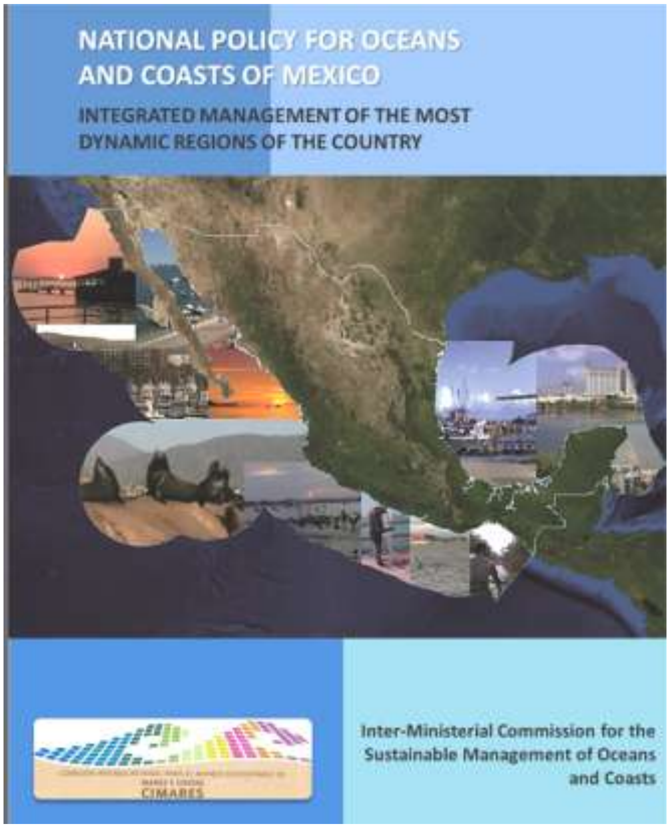

Figure 5. National Policy for Oceans and Coasts of Mexico (Approved by the Inter-Ministerial Commission for the Sustainable Management of Oceans and Coasts in 2012).

A major encouragement to formulate and implement LME projects comes from those projects of which Mexico is a part, such as the Pacific Central American Coastal LME, and the California Current LME, along with the Gulf of Mexico LME and the Gulf of California LME. In order to strengthen these planning and management processes, approaches such as application of the Ocean Health Index and Integrated Coastal Zone Management assessment and management practices will be encouraged, in addition to the continued inclusion of ecological, social, economic and governance indicators for monitoring and assessment. With an integrated perspective, so as to complement other policy instruments, work to decree more natural protected areas and partnerships with near-by countries are also considered, along with the strengthening of LME practices in transboundary areas in order to reduce pollution and other terrestrial impacts. Further efforts include the creation of shelter-from-fishing zones, and the formulation and implementation of Memos of Understanding (MoUs) as for example with U.S. EPA and NOAA (Figure 6).

As enforced by law, government verdicts of environmental impact assessments for federal public works and facilities now consider spatial planning processes' provisions, such as those for fishery and tourism-related sectors of the Gulf of California LME and the Gulf of Mexico LME, notwithstanding the differences of scale in most projects. Indeed, for such local-scale projects, regional planning provisions are mostly applied as guidelines instead of regulations, and the precautionary principle is always considered when relevant information is lacking or insufficient, to prevent further ecosystem degradation.

a) EPA Gulf Guardian Award to the GoM-LME project in 2012. Left: Lisa Jackson, former administrator of USA-EPA; Right: Juan Elvira, former Minister of Environment and Natural Resources (Mexico-Semarnat).
b) Binational Meeting to formalize MoU between Mexico and USA-NOAA for marine and coastal issues. From left to right: Antonio J. Díaz de León, Director-General Environment, Regional and Sectoral Policy Division SEMARNAT; Jane Lubchenco, Under Secretary of Commerce for Oceans and Atmosphere & Administrator, National Oceanic and Atmospheric Administration 2009-2013; Bonnie J. Ponwith, Director Southeast Fisheries Science Center, NOAA.
c) Signature of the Memorandum Of Understanding between USA-EPA and Mexico-SEMARNAT concerning Environmental Cooperation in COASTAL AND AQUATIC ECOSYSTEMS. Left: Juan Elvira, former Minister of Environment and Natural Resources; Right Lisa Jackson, former Administrator of USA-EPA.

Figure 6. Examples of international efforts for LMEs, marine planning and ocean policy.

These issues of scale certainly demand that future spatial planning processes are deployed at higher resolutions to include as many pertinent spatial areas as required.

LESSONS LEARNED AND GOOD PRACTICES

Governmental involvement, coordination and public participation, are major features of current planning processes and are considered “good practices”, as derived from seminal experiences. Indeed, the Gulf of California LME planning process had a strong scientific prominence over management, which resulted in a generalized rejection from the several stakeholders who were not involved in the process from the outset. The new legal mandates published in 2003, offered a new vision which vastly improved the different scenario models along with the management of the involved sectoral interactions, allowing the formal participation of governmental constituencies and the effective involvement of stakeholders as early as during the characterization phase of the process. The opening of discussion opportunities, such as the Committee and the public consultations, paved the way for addressing conflict-resolution through discussion of long-term visions at the stakeholders’ meetings. New challenges also appeared, such as devising effective mechanisms for discussion, which eased differences among participating actors through open and candid debate that in the end resulted in a marine spatial planning instrument that was decreed by the government for the first time ever in Mexico.

The MSP instrument has actually allowed for increases in the comprehensiveness of environmental public policies given its explicit linkages with environmental impact assessments, land, ocean and coastal use-change authorizations, and the design of natural protected areas. In addition, it has found a place in the decision making process of major stakeholders such as PEMEX–the Mexican oil company—not only from its regulatory character, but for its planning competence in designing energy-related projects in a more sustainable way. Moreover, the spatial planning approach has been adopted by several other agencies and constituencies to develop their own scenario models, such as those of the mining industry.

Within this transversal/intersectoral approach, the work of the Inter-Ministerial Commission for the Sustainable Management of Oceans and Coasts (CIMARES) is probably the best example of how effective these discussion opportunities have proven to be. The President established this Commission in 2008 with the purpose of coordinating several multisectoral efforts of the public administration aimed at putting together and implementing national policies related to the oceans and coasts through the spatial planning and sustainable development processes. The structure and accomplishments of the Commission after 5 years of uninterrupted work, are summarized in Table 3.

Table 3. Activities of the Mexican Inter-Ministerial Commission for the Sustainable Management of Oceans and Coast

CREATION	INTER-MINISTERIAL SESSIONS	AGREEMENTS	WORKING GROUPS/WG MEETINGS	CROSSCUTTING PRIORITY SUBJECTS
13 June 2008	8 Meetings (in 4 years)	More than 50	7/60	20

Integrated methodologies – Diagnostics and scenarios

As a technique, the spatial planning process has been vastly improved by the conceptual developments of the *alternative scenario models*, which now include the notion of *sectoral conflicts*, where sectoral interests are identified from the *environmental attributes* of the resources and spaces they use. Multi-criteria and multi-purpose models have been also included in the analyses of these conflicts using *utility functions* with biogeophysical, social and economic variables, and their results are assessed using optimization algorithms for the selection of the best land, coastal and sea-use options.

The spatial planning process has become more comprehensive by including diagnostics and scenarios on several seemingly unrelated environmental issues such as conservation, degradation, desertification, or ecosystem pollution and biodiversity. The maintenance of ecological processes providing environmental services, and the operational linkages with other planning instruments for natural protected areas and critical habitats aimed at protecting terrestrial wildlife, and refuge zones for aquatic species, have also contributed to the afore-mentioned all-inclusive nature of the spatial planning approach.

Other issues adding to this far-reaching scope include: the importance of natural resources for the development of sectoral activities, the susceptibility of certain spaces and activities to natural risks or the negative effects of climate change, the integrated management of coastal zones and watersheds, increasing population trends and their concomitant demand for urban infrastructure, equipage and services, and the consideration of causes and effects of cumulative environmental impacts –in space and time.

Transparency, public information, accountability, adaptation and monitoring

Process transparency, openness to the public, and accountability, has been crucial to marine spatial planning development, and the *binnacle log* its major tool. Active participation of stakeholders and the society by and large, is logged and can be accessed by just about anyone interested in how the meetings developed, how sectoral representatives performed, what the Committee decisions were, which events were broadcasted or which public consultations called, among many other issues including actual geographical information resulting from the technical studies.

The adaptive character of the MSP instrument has also been important and has been developed from close monitoring of the process and, in some cases, the actual modification of planning proposals to meet new present conditions. Indeed, in contrast to the terrestrial domain, where 15 percent of the spatial planning experiences has been modified in some way, none of the afore-mentioned marine exercises has been modified.

The legal certainty of the instrument has been granted by its explicit reference in the comprehensive environmental law –the General Law of Ecological Equilibrium and Protection to the Environment (LGEEPA by its acronym in Spanish), and its specific provisions on the matter—where the clarity of the technical and managerial procedures is strongly enforced. From its programmatic nature, the MSP instrument by itself encouraged the Presidential Act, during the last administration (2006-2012), by its application in creating and implementing a National Strategy for the Ecological Planning of the Territory in Oceans and Coasts.

The Work Ahead and Room for Improvement

Outstanding progress has been made on public participation, transparency, accountability, adaptation and technical thoroughness, but there is still room for:

- ✓ Process development and marine models at higher resolution on a wide scale,
- ✓ Improving analytic approaches on sea-level rise scenarios and changes in ocean dynamics deriving from current global warming projections, including but not limited to issues on vulnerability and risk, adaptation, and the integrated management of coastal zones and watersheds,
- ✓ Developing cost/benefit assessments of proposed strategies and programs in order to ensure their effectiveness and accomplishments,
- ✓ Developing the monitoring component of the actual binnacle log for homogeneity and consistency, and as a definite tool for the assessment of objectives accomplished, goals reached and strategy effectiveness, aside of its current service for transparency and event registry,
- ✓ Improving the comprehensiveness of the several planning and policy instruments –*e.g.*, for wildlife management, sustainable forestry, natural protected areas design and other sectors—by considering the spatial planning approach its core foundation. From this perspective, most government subsidies that are currently applied in response to certain stakeholders' benefit, instead of making actual investments based on planned priorities, would be avoided.
- ✓ Improving the inter-sectoral/transversal advantage of planning instruments in order to avoid the insidious effects of current restraining sectoral policies. In fact, by

unambiguously linking spatial planning processes to other planning instruments –for instance those developed in the tourism industry, urban infrastructure, or fishery management plans— the whole territorial planning practice would actually provide for the expected societal benefits of every public expenditure deemed sustainable,

- ✓ Creating automated systems for analyzing and visualizing scenarios, in near-real time, for the several projected impacts of economic activities on a certain zone or region, and for the assessment of concurrent strategic options intended to ease the use of areas and resources by competing stakeholders over coasts and seas,
- ✓ Devising executive schemes for marine spatial planning processes, by using economic, fiscal or technologic instruments which would allow for the accomplishment of any given program objectives, and
- ✓ Ensuring the execution of devised strategies resulting from any given planning process by issuing agreements among stakeholders and by their consideration within pertaining sectoral programs of the several participant institutions.
- ✓ Looking after and incorporating the Mexican experience in current and future LME projects overlapping Mexico's EEZ, particularly on its social, economic and governance dimensions.

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9

THE RESILIENCE AND ROBUSTNESS OF THE HUMBOLDT CURRENT LARGE MARINE ECOSYSTEM

Michael J. Akester, Regional Project Coordinator Chile-Peru, Humboldt Current Large Marine Ecosystem Project (HCLME)

OVERVIEW

The Humboldt Current Large Marine Ecosystem (HCLME) covers an area of approximately 4 million km^2 – about half the size of Brazil, the world's 5th largest country, or 40 percent the size of the USA, with 60 percent of the area beyond national jurisdiction (ABNJ). Not only is it a large expanse but its nearshore nutrient rich upwelling areas support approximately 20 percent of the world's fish landings, with Peru being the largest global fishmeal and fish-oil product exporter—important inputs to the expanding worldwide aquaculture industry. The area is also highly biodiverse with over 10,000 species registered of which Polychaeta, Aves, and Mammalia have endemic species represented. Introduced species come from 31 taxa with Rhodophyta, Salmoniforme, and Polychaeta contributing the greatest number of exotics, thereby increasing the risk of biodiversity loss and reduced ecosystem resilience through competition. The rich biodiversity supports a thriving tourism industry from Southern Chile to the Galapagos Islands in Ecuador. However increasing coastal population size with associated needs for employment, freshwater, energy and food, with concomitant waste disposal problems, are placing the highest stress levels on the system since the start of the industrial age. When this is coupled with climate change scenarios and high natural environmental variability caused by the ENSO (El

Niño Southern Oscillation) and LNSO (La Niña Southern Oscillation), producing dramatic changes in species composition and abundance, it is evident that what has been to date a resilient and robust system could be facing a period of long-term negative change. Whilst there is evidence of system cooling due to increased upwelling in the Peruvian upwelling front, there is also evidence of warming due to the ingression of equatorial surface water at the northern extreme. Predictions suggest there could be up to three decades of increasing or equal high anchovy productivity followed by a series of decadal declines with productivity levels in 2100 at around 15 percent of those experienced today. Increases in acidification and the expansion of the oxygen minimum zone (OMZ) further complicate the system's resilience to change. Attempts to mitigate this problem involve the setting up of Marine Protected Areas (MPA) and a series of National Parks with associated buffer zones and habitat restoration.

INTRODUCTION

The oceanographic mechanisms leading to the high productivity in the Humboldt Current Large Marine Ecosystem (HCLME) are well documented: Ekman transport resulting in a movement of surface water at right angles to the direction of the predominant wind. In the case of the HCLME the Ekman transport moves water away from the Chilean and Peruvian coastal areas, surface waters moving offshore are replaced by nutrient-rich cold water from the Pacific depths close to the coast. The rate of this upwelling depends on the wind speed. For example the velocity of the upwelling water along the Peruvian coast (5°S to 18°S), is governed by the speed of the permanent southerly wind, the rapidity of which changes with the season - highest in austral winter (June to September) and weakest in summer—December to March (Croquette et al., 2004).

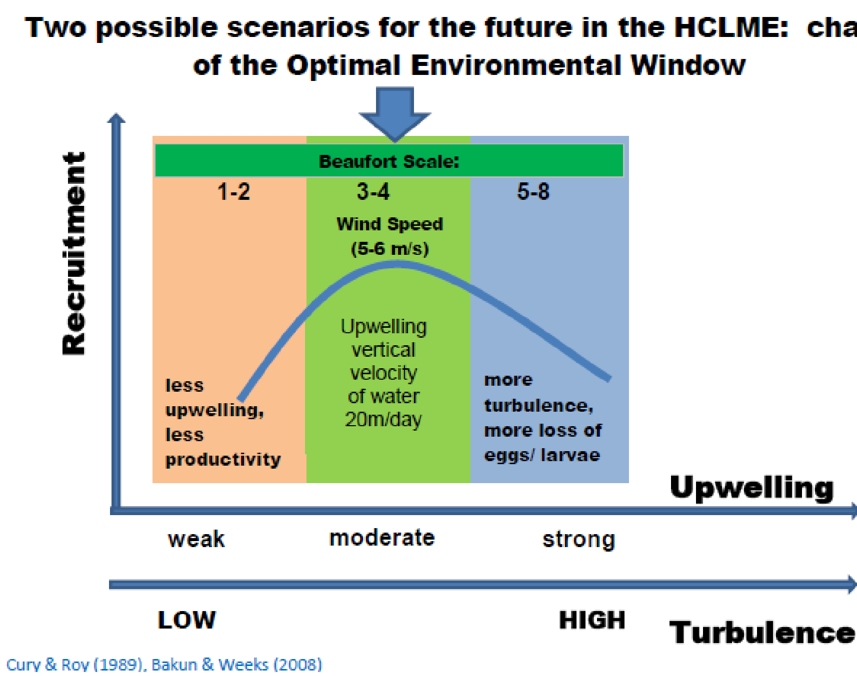


Figure 1. The relationship between fish recruitment and water upwelling vertical velocities as generated by southerly wind speeds in the Humboldt Current LME. The diagram indicates an optimal water upwelling speed 'window' of around 20m/day as generated by wind speeds of 5-6 meters per second (10-12 knots, 11-13 mph or 3 to 4 on the Beaufort scale. Source: Cury & Roy 1989, Bakun & Weeks 2008 – modified.

The vertical upwelling rate also determines how productive the system is, as slow upwelling, less than 10m/day vertical velocity, creates a reduced daily nutrient exchange whereas a more rapid vertical flow, >30m/day, provides many nutrients (Figure 1). However these can be lost to the coastal primary production system as they may not be fully assimilated into the food chain and the larvae of marine species are dispersed away from the nearshore high productivity areas. Other factors governing primary productivity (PP) like the strength of sunlight determine the peak productivity times, which in the Peruvian case are out of phase as ideal upwelling conditions occur in the austral winter while peak PP occurs in the summer. In Chile the situation is different with PP coinciding with upwelling intensity (Pennington et al., 2006).

The cold deep water close to the Chilean-Peruvian coastline contains the carbon fallout from the very high primary productivity in the photic zone. As the phytoplankton die off and sink they decompose releasing nutrients. The decomposition process consumes oxygen and generates supersaturated levels of carbon dioxide thereby contributing to the lower pH of 7.7 and Minimum Oxygen Zone <20mol/L (<0.64mg/L).(Figure 2 A and B).

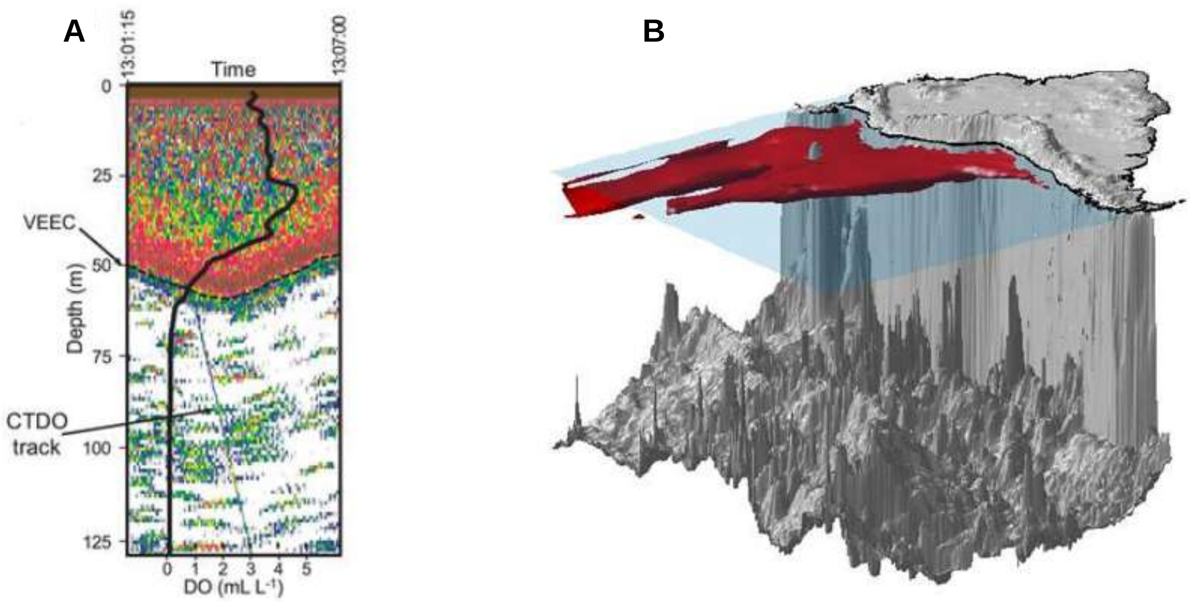


Figure 2A. – Acoustic Reading showing the depth of the Minimum Oxygen Zone in the HCLME Source: Bertrand A, Ballón M, Chaigneau A 2010

Figure 2B. – 3-D image of the Minimum Oxygen Zone in the HCLME off the coast of Chile and Peru. Source: DePol – Holz *et al*, 2007

The MOZ depth and thickness varies with oceanographic conditions. When it comes closer to the surface (<50m depth) there is a reduction in the area in which animals requiring well oxygenated water can live and feed (Figure 2A&B)(Bertrand A, Ballón M, Chaigneau A, 2010; De Pol-Holz *et al* 2007). During climate change scenarios the size of the MOZ increases and the depth below the surface is reduced. Therefore animals requiring oxygen levels >2mg/L will be forced closer to the surface where they will be exposed to greater predation risks. Benthic animals in continental shelf areas are exposed to hypoxia conditions leading to massive die-offs like the 80 percent scallop mortalities in Sechura, Peru during February 2012.

BIODIVERSITY

The HCLME area is characterized by high biodiversity, over 10,000 species, many of which are endemic, demonstrating interesting patterns of endemism probably caused by ENSO events and OMZ expansion during the Neogene period, 23 to 3 million years ago, (Moreno *et al* 2006). During this period mammals and birds continued to evolve into roughly modern forms, while other groups of life remained relatively unchanged. The most significant event being the connection of North and South America at the Isthmus of Panama, cutting off ocean currents between the Atlantic and Pacific oceans promoting climate changes and the creation of the Gulf Stream (Lourens, L., *et al.,* 2004).

Work carried out on patterns of endemism in Chile by Moreno *et al.* notes that OMZs associated with coastal upwelling areas would have been generated at the Mio-Pliocene onset of the Humboldt upwelling system. Fossil records show the existence of massive mollusc extinctions (up to 70 percent of species) during the late Pliocene in the 'Peruvian province'. These mass extinction events are probably associated with the onset of OMZ. Although these changes are over geological time, the present-day closer-to-surface trend for the HCLME OMZ and possible alteration of ENSO patterns by climate change in an area characterized by low pH, could well lead to an accelerated negative change in terms of biodiversity reduction. There are also increasing threats from the introduction of exotic species, 77 registered at present, either accidentally via ship ballast water or adherence to ship hulls or due to aquaculture activities (Miloslavich P, et al., 2011).

PREDICTED ALTERATION IN ANCHOVY PRODUCTION DUE TO CLIMATE CHANGE

The main fishery in Peru is that of the low trophic level (LTL) anchovy (*Engraulis ringens*) that contributes >90 percent of the recorded landings. Most of the fish (99 percent) are processed for fishmeal and oil as important inputs to the global aquaculture industry. Even with fishmeal substitution in aquaculture feeds there is a continued need for essential fish oils and an increasing global demand for anchovy oil. The Direct Human Consumption (DHC) of anchovy is being actively promoted in Peru but only represents about one percent of the landings. Low Trophic Level (LTL) species like the anchovy also play a vital part in marine food chains. Reduced anchovy abundance, as experienced during ENSO events (Figure 3), causes large scale seabird and sea-mammal deaths.

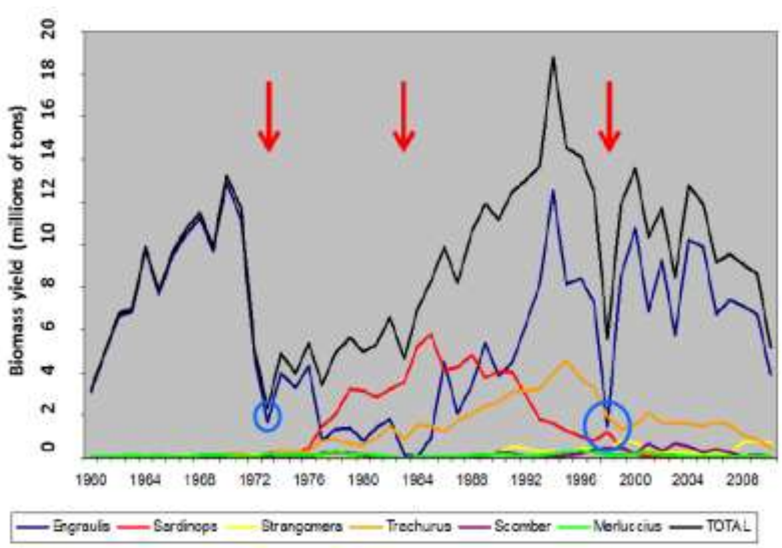
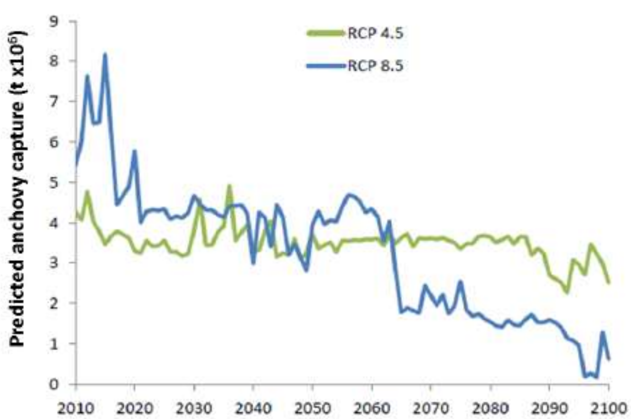


Figure 3. Biomass yield in the HCLME area over time showing ENSO events (red arrows) and corresponding fish capture reductions. The most dramatic falls for anchovy production were the collapses of 1972 and 1998 (blue circles). Seabird populations in Peru have yet to fully recover from the 1998 ENSO event. 6.12 million tons of anchovy were landed in 2011. In 2012 fisheries management quota reductions led to reduced landings of approximately 3.5 million tons in the Peruvian sector of the HCLME. Source: Serra et al., 2012 modified.

Climate change induced sea surface temperature (SST) increases, coupled with increased wind speed and associated upwelling vertical velocities have an impact on anchovy population distribution and abundance. In 2012 Peruvian anchovy landings were down 44 percent from 2011 (6.2 million tons) at 3.5 million tons. Reduced quotas were imposed for the second half of 2012 as many anchovy juveniles were detected and the overall biomass had dropped below the 6 million tons considered to be necessary for sustainable fisheries management.

The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.



Predicted anchovy landings in Peru over the period 2010 to 2100 under two climate change scenarios: Representative Concentration Pathways (RCP) 4.5 'stabilization' and RPC 8.5 'pessimistic'.

Figure 4 The Intergovernmental Panel on Climate Change (IPPC) Representative Concentration Pathway models for stabilized and worst case climate change scenarios applied to the HCLME and the anchovy catch in Peru as predicted in the study by Dr. Jaime Mendo (UNALM Fisheries Faculty) and Dr. William Cheung of the University of British Columbia (UBC) Canada.

One recent study on the anchovy populations in Peru (Mendo and Cheung, 2013 unpublished) has made predictions using historical SST and wind energy data coupled with Intergovernmental Panel on Climate Change (IPPC) Representative Concentration Pathway (RPC) models. The study suggests that under stabilized climate change scenarios (RCP4.5 in Figure 4); the existing trend for steady nutrient rich upwelling will increase with a gradual reduction of productivity and resulting lower anchovy landings until 2100. Under the more pessimistic climate change scenarios (RCP8.5) the production levels are predicted to rise until around 2015 followed by a 40 percent decline and then a period of lower and variable anchovy capture for four decades prior to a gradual collapse over the final three decades to 2100 (Figure 4). Hence there is a long term prediction for anchovy abundance to decline under worse case scenarios to around 15 percent of levels experienced today.

These predictions are based on historical anchovy abundance data from the Peruvian Marine Institute (IMARPE) over the period 1983 to 2006. Although it is reported that the HCLME area is recently cooling, the long-term trend has shown SST warming and concomitant wind force increases (Figure 5). In addition primary productivity and oxygen concentration trends were studied.

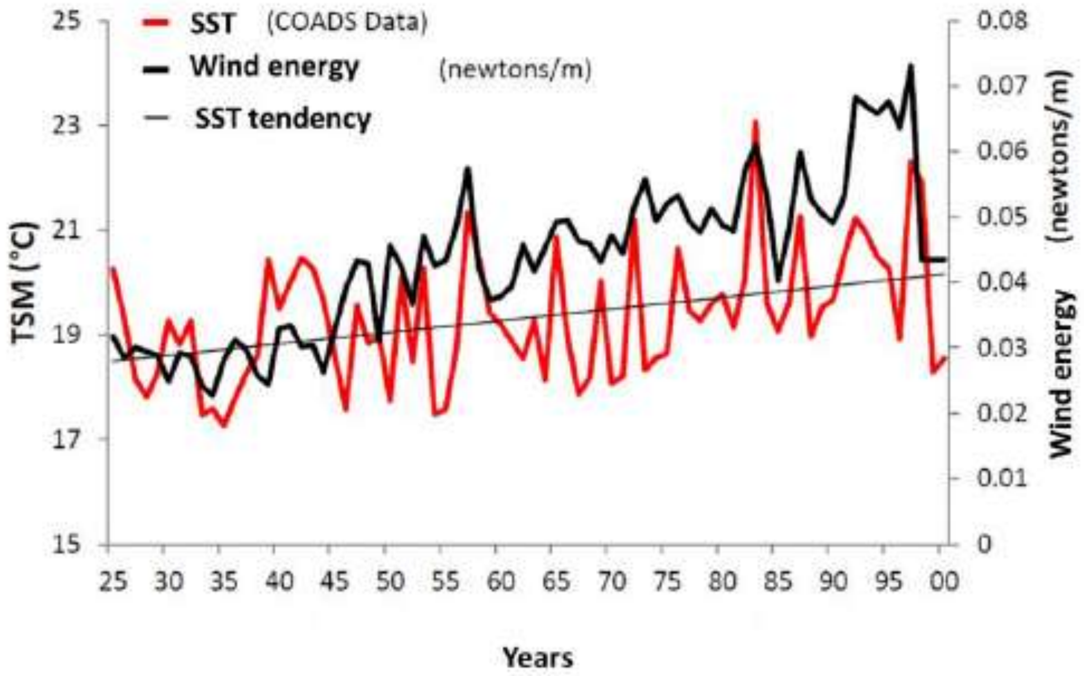


Figure 5. Comprehensive Ocean-Atmosphere Data Set (COADS) Sea Surface Temperature (SST) and wind force data and trend as recorded by shipping off the Peruvian coast from the 1920s to the year 2000. Source: Mendo and Chueng, 2013.

Figure 6 'Sugar Loaf' Jellyfish *Chrysaora plocamia* are increasing in abundance causing economic losses for the anchovy fleet in Peru as processing plants refuse to accept the catch if jellyfish are found in high quantities >40 percent. During the Peruvian austral summer 2008-9, 5 percent of anchovy hauls contained >30 percent *Chrysaora plocamia* leading to economic losses of >$200,000 during 35 days of fishing. Source: Quiñones, J., *et al.,* (2012)

Bakun and Weeks (2004) suggest that climate change will increase SST and wind speed, following the trend as shown in work by Mendo & Chueng (2013). This in turn will increase upwelling speeds and phytoplankton biomass increases due to increased nutrient availability and reduced zooplankton 'grazing' as the latter will be moved offshore by Ekman transport. Phytoplankton bloom die-offs will increase oxygen consumption and CO_2 production, thereby limiting food availability and water quality conditions for the anchovy. Warmer conditions, overfishing and eutrophication are contributory factors regarding the increase in jellyfish like *Chrysaora plocamia* as an anchovy bycatch.

HCLME GOODS AND SERVICES

Goods and services provided by the HCLME are many and varied: (1) one of the most productive fisheries in the world, (2) climate regulation locally and worldwide due to the cold upwelling currents and periodic El Niño (ENSO) and La Niña Southern Oscillation (LNSO) events, (3) biological control, (4) greenhouse gas absorption, (5) oil & gas from the narrow continental shelf, (6) guano abstraction, (7) genetic resource and biodiversity protection, (8) nutrient cycling, (9) marine transport, (10) waste treatment, (11) multi-faceted employment, and (12) tourism/recreation.

It is also important to note that greenhouse gasses are produced in the HCLME upwelling zones.

Tourism in the HCS area is increasing as tourists are encouraged to become more aware of the marine and coastal environments. Activities include whale watching, visits to the increasing numbers of National Parks, Eco-Tourism, home-stay with fisherfolk and a number of watersports. However the increasing use of outboard motors increases pollution and accidental turtle deaths.

Population increase and the tendency for people to move from rural to urban environments, especially in the coastal belt where more than 50 percent of the population in Chile and Peru now live, brings increased pressures on the HCLME in terms of reduced freshwater discharge to the system and increased pollution from urban and industrial waste. The area is one of the world’s biggest copper and iron ore producing regions hence there is a tendency for point source pollution. In areas where iron from iron ore concentrating plants enters the system, either by effluent water or airborne particles, could stimulate primary productivity, as often iron is a limiting nutrient in the sea. However associated heavy metal inputs could be detrimental to human health when marine produce is consumed.

When the natural, yet extreme conditions in the HCLME (lower pH, shallow Oxygen Minimum Zone (OMZ), supersaturation of CO_2, ENSO-LNSO variability), are combined with climate change scenarios, its ability to resist and adapt to unfavorable conditions could be stretched to the limit—an uncertain limit as estimates of the HCLME carrying capacity have not been calculated.

If this occurs, the food chain will be severely impacted leading to biodiversity changes and modified population dynamics: reduced seabird populations (reduction in guano production – valuable as an organic fertilizer), reduced higher trophic level fish species abundance and migration to other areas and reduced marine mammal abundance. Some of the marine mammals are ‘keystone’ species like the South Pacific sea otter *Lontra feline*, hence a reduction in their abundance will have a negative impact on the sensitive coastal macro algal beds and the rich biodiversity that they harbour.

THE VALUE OF HCLME SERVICES

In order to better protect the goods and services derived from the HCLME, and to ensure that the system’s resilience is not weakened, there is a need to place a value on these. This is a difficult process but even approximate values will be of use when political decisions have to be made about future investments regarding waste treatment, fisheries management, tourism, oil and gas exploration, marine transport and the derivation of taxes destined for ecosystem protection. Work carried out nearly two decades ago by Costanza et al., (1997) estimated that an average value of the entire biosphere was US $33 trillion per annum. In the mid '90s the global gross national product total was around US $18 trillion per annum. During 2013 socio-economic studies in Chile and Peru carried out by the GEF-UNDP Humboldt Current LME project will gather information on the value of the HCLME goods and services.

ECOSYSTEM-BASED MANAGEMENT

In an attempt to mitigate some of these negative trends impacting the HCLME, work is ongoing to promote Ecosystem Based Management (EBM). This holistic approach accepts that the human population has exploited, and will continue to exploit, the HCLME's goods and services and recognizes that conservation measures need to be promoted in relation to these needs and that Marine Protected Areas should be carefully zoned to incorporate a range of activities together with strict 'no take' zones. As an example, the recently established Peruvian Guano Islands, Isles and Capes National Reserve contains 22 protected islands and 11 capes with a total land surface area of 140,833 ha. The 22 islands are in the process of being zoned so as to ensure a viable mix of biodiversity protection, repopulation of depleted areas and sustainable resource management including guano extraction, tourism and fishing.

In Chile a Marine Protected Area (MPA) is in the process of being established in the Robinson Crusoe (Juan Fernandez) Islands (Figure 7). One of the main local fisheries in the Crusoe islands is for the Fernandez Rock Lobster (*Jasus frontalis*) – a species under consideration for Marine Stewardship Council (MSC) certification. This is a good example of how HCLME goods and services can be safeguarded and vulnerable benthic biodiverse communities be better protected, following EBM principles.

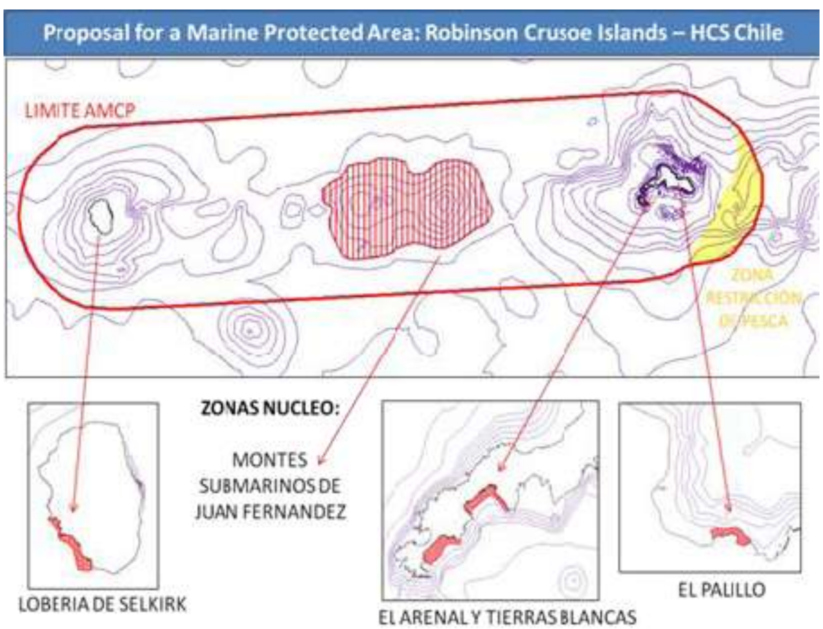


Figure 7. Proposed Marine Protected Area (MPA) in the Juan Fernandez Islands, Chile (red area). The area covers a number of important seamounts with several endemic species including the Fernandez Rock Lobster, only found in the Chilean Desventurados and Juan Fernández Islands. This species is on the IUCN Red List as being 'data deficient'. The possibility of MSC certification of the fishery is being considered as a means of ensuring sound fishery management practices.
Map source: Miriam Fernandez et al., (2010).

SUSTAINABLE PRODUCTION

In Peru the GEF-UNDP Humboldt Current LME project is working closely with an association of fisherfolk, middlemen, and processing plants (La Asociación Pesquera para el Consumo Humano Directo de Pisco - assisted by the Consorcio Group from Spain) to promote the direct human consumption (DHC) of anchovy as a more environmentally friendly resource use than the current fishmeal and oil production practices (Figure 8). Artisanal fishing boats land quality large-size anchovy to be salted prior to two very different marketing strategies. The first involves the production of a cheap ($2/kg) easily transportable product for consumption in isolated areas in Peru where there is no cold-chain. The second includes an additional value addition process by the hand filleting of the salted anchovies for canning in olive oil and export ($20/kg). MSC certification is being sought so as to demonstrate the sustainability of the associations' fishing practices. An MSC pre-assessment study was undertaken in 2012 and recommended actions are being followed up on actively.

The extraction of products from marine macroalgae is a second area where the GEF-UNDP HCLME project aims to promote sustainable resource use. Artisanal fisherfolk associations are being assisted with the process of improved management (Marcona in Ica Province) and the repopulation of algal beds (Paracas Bay, Ica Province) that have previously been over-exploited or damaged by pollution. The reestablishment of algal beds provides a natural refuge for benthic species that in turn are exploited under management plans. This has been successful in around 50 percent of the seabed resource management areas established in Chile and will soon be adopted in Peru. Value addition of algal products also generates local employment and ensures improved prices for the raw products and therefore greater incentives to protect the resource.

Figure 8. Anchovy for direct human consumption (DHC) Pisco, Peru:
A) Artisanal boat
B) Quality raw material
C) 1st step processing (salting)
C_1) Low cost protein to improve local diets (US$ 2/kg)
D) Packaging the anchovy product for human consumption
(D_1) Anchovy product boxed and ready for shipment

Photos: M.J. Akester

CONCLUSION

The HCLME is highly productive and its services are critical to the well-being of many millions of people both within the region and elsewhere in terms of food and fishmeal-oil production and climate regulation, among many other attributes. It is biodiverse with more than 10,000 species inhabiting its waters, many endemic to the region. Its unique characteristics have hitherto ensured a level of resilience despite the variations caused by natural ENSO and LNSO events. However climate change is compounding natural phenomena like the OMZ and acidity in the HCLME. When this is coupled with local pollution from urban and industrial waste or noise pollution and exotic species introductions from marine shipping, hydrocarbon exploration and exploitation, increasing population pressure, plus the tendency for fisheries to be over-exploited, it is clear that changes need to be made to better protect the HCLME. Predictions using climate change models indicate that the key low trophic level pelagic species, like the anchovy, may suffer a population collapse within this century due to temperature increases and OMZ depth changes. The calculation of the value of the system's goods and services and eventually an estimation of its carrying capacity will help governments decide where investments need to be made to ensure that these goods and services continue to be provided. The EBM approach coupled with the establishment of National Parks, Marine Protected Areas and improved management systems including MSC certification are some of the methods currently being applied by the GEF-UNDP HCLME project in Chile and Peru to help maintain the HCLME's resilience.

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10

CARRYING CAPACITY OF THE YELLOW SEA LME FOR ACHIEVING SUSTAINABILITY

Yihang Jiang Consultant for the Yellow Sea Large Marine Ecosystem Project (YSLME) and Andrew Hudson, PhD, Principal Technical Advisor, International Waters & Head, Water & Ocean Governance Programme, UNDP

BACKGROUND INFORMATION ABOUT THE YELLOW SEA LME

The geographic area of the Yellow Sea Large Marine Ecosystem (YSLME) was defined as the body of water bounded to the west by the Chinese coastline south of Penglai; to the north by a line from Penglai to Dalian; to the east by the Korean Peninsula and Jeju Island and a line drawn from Jindo Island off the south coast of the Korean mainland to the Chaguido, west coast of Jeju Island; and to the south by a line running from the north bank of the mouth of the Yangtze River (Chang Jiang) to the south-western coast of Jeju Island (Figure 1). It covers an area of 400,000 km^2 and measures approximately 1,000 km by 700 km.

Five large coastal cities with tens of millions of inhabitants border the sea: Qingdao, Dalian and Shanghai in the People’s Republic of China (PRC); Seoul/Incheon in the Republic of Korea (ROK); and Pyongyang/Nampo in the Democratic People’s Republic of Korea (DPRK). This population relies on the Yellow Sea LME for many services such as: provision of capture fisheries resources (in excess of two million tonnes per year) and mariculture (6.2 million tonnes per year); the support of wildlife; provision of bathing beaches and tourism; and its capacity to absorb nutrients and other pollutants. The ability of the Yellow Sea to provide multiple services is defined here as the “ecosystem carrying capacity,” and all the services are summarized as (i) provisioning services; (ii) regulating services; (iii) supporting services; and (iv) cultural services. Figure 2 shows the components considered within the term “ecosystem carrying capacity” in the Yellow Sea.

Figure 1. Location of the Yellow Sea LME

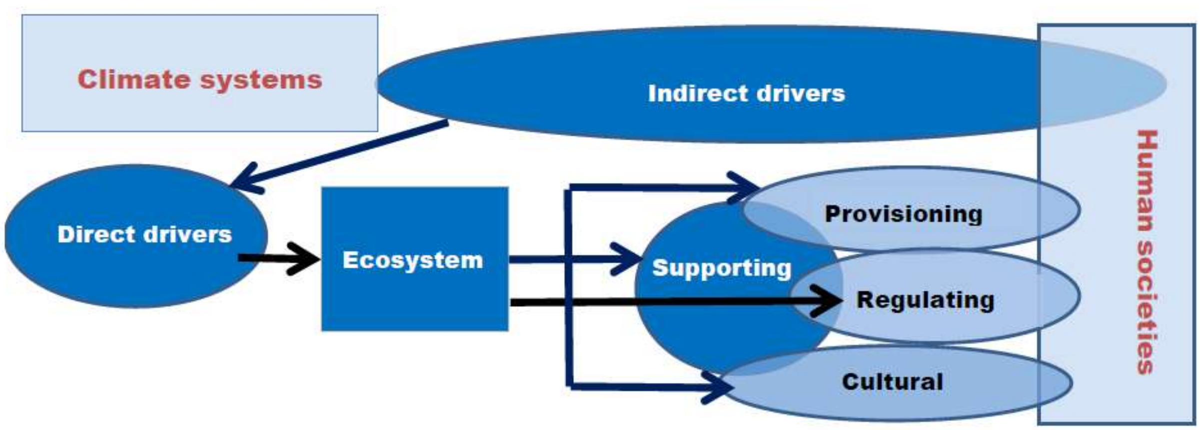

Figure 2. Considerations of the ECC in the Yellow Sea

Commercial use of the living marine resources of the Yellow Sea dates back several centuries but intensification of capture fisheries followed the introduction of the bottom trawl in the early twentieth century and resulted in rapid loss of economically important species such as the red seabream by the 1930s. Fishing effort steadily increased post-war and increased threefold between the early 1960s and early 1980s during which time the proportion of demersal species such as small and large yellow croakers, hairtail, flatfish and cod declined by more than 40 percent in terms of biomass.

The semi-enclosed nature of the Yellow Sea and the rapid economic development of the surrounding area have resulted in an increasingly polluted and over-exploited sea. This large marine ecosystem (LME) faces major transboundary problems, including a dramatic increase in fisheries landings that have grown from 400,000 tonnes to 2.3 million tonnes in the past 20 years, continued increases in the discharge of pollutants, changes to ecosystem structure and function leading to an increase in jellyfish and harmful algal blooms. Additionally, there has been a 40 percent loss of coastal wetlands from reclamation and conversion projects representing a major loss of habitat for many species, resulting in a significant degradation of biological diversity. On top of these immediate threats lie the potential impacts of climate change, and in particular, changes in basin circulation.

ENVIRONMENTAL PROBLEMS

Over-fishing

Fishing efforts in the Yellow Sea exceed ecosystem capacity to provide provisioning services. This is evidenced by the decrease in mean size at catch of most species since 1986. In addition, the composition of the catch has dramatically changed. In general large commercially valuable species have been replaced by smaller, lower trophic level, less valuable pelagic species. Furthermore, the mean trophic level of the main commercial species in the Yellow Sea has decreased due to dietary changes as a result of ontogenetic shifts in diet; potential temperature induced changes in availability of dietary items that may reflect climate change impacts; and over-fishing of the prey items of carnivorous fish including anchovy. Changes in species abundance as a consequence of over-fishing have consequences for the overall structure and productivity not only of the fish community but of the aquatic food chains in the wider Yellow Sea ecosystem. The decline of the Yellow Sea fisheries directly affects the livelihoods and food security of the local people, as well as having significant broader socioeconomic impacts due to the extremely high value placed on these biological resources.

Problems of Sustainability in Mariculture

The production from mariculture and freshwater aquaculture from China and ROK has grown significantly and in 2005 these countries accounted for 44 million metric tonnes or 70 percent of the world's total production, with China accounting for the bulk of the growth. Mariculture accounted for approximately 14 million tonnes in 2004 of which the greatest increases were from mollusc culture. There are signs however that these increases are not sustainable, and recently the productivity per unit area has begun to fall, as the area under cultivation grows. This fall in productivity may be due to the fact that only unsuitable cultivation areas now remain, or that increased proximity of farms has resulted in increased disease transmission between farms, raised concentrations of organic wastes and increased competition for food resources amongst cultivated organisms. These factors all increase stress and lower the growth and survival rates of the cultured organisms, thus reducing production.

Pollution

The major contaminants in the Yellow Sea have been identified as inorganic nitrogen and phosphate, faecal contaminants, heavy metals, persistent organic pollutants (POPs), polycyclic aromatic hydrocarbons (PAHs) and marine litter. Inorganic nitrogen and phosphate are important nutrients that sustain phytoplankton (single celled algae) communities that form the basis of the marine food chain. However, high concentrations stimulate rapid phytoplankton growth that cannot be consumed by zooplankton at the rate at which it is produced, leading to eutrophication and harmful algal blooms (HABs). Contamination of coastal marine waters by bacteria and viruses derived from direct discharge of untreated domestic waste can result in contamination of seafood, particularly mussels, oysters and scallops, under mariculture. The resulting illnesses vary from minor stomach ailments to dysentery and typhoid. Heavy metals, although possibly significant locally around industrial areas, are not considered a transboundary problem. PAHs are also likely to be a more localized issue associated with certain industrial processes although this class of compound can be mutagenic or carcinogenic. Incorporation of POPs into the food chain is, however, part of a global problem and can lead to increased health risks to humans.

The major pollutants from land-based sources in the YSLME are mainly nutrients (mainly N and P), in various forms, and heavy metals, as identified in the Transboundary Diagnostic Analysis (TDA) (UNDP-GEF 2007a). Considering the nutrients are highly transboundary in nature, the major efforts of the second project will focus on the reduction of nutrient discharge. During the first project, it was determined that the nutrients are mainly transferred from land to ocean through river inputs and atmospheric deposition. During summer, the hypoxia zones can be identified in the mouth of the Yangtze River, as shown in Figure 3.

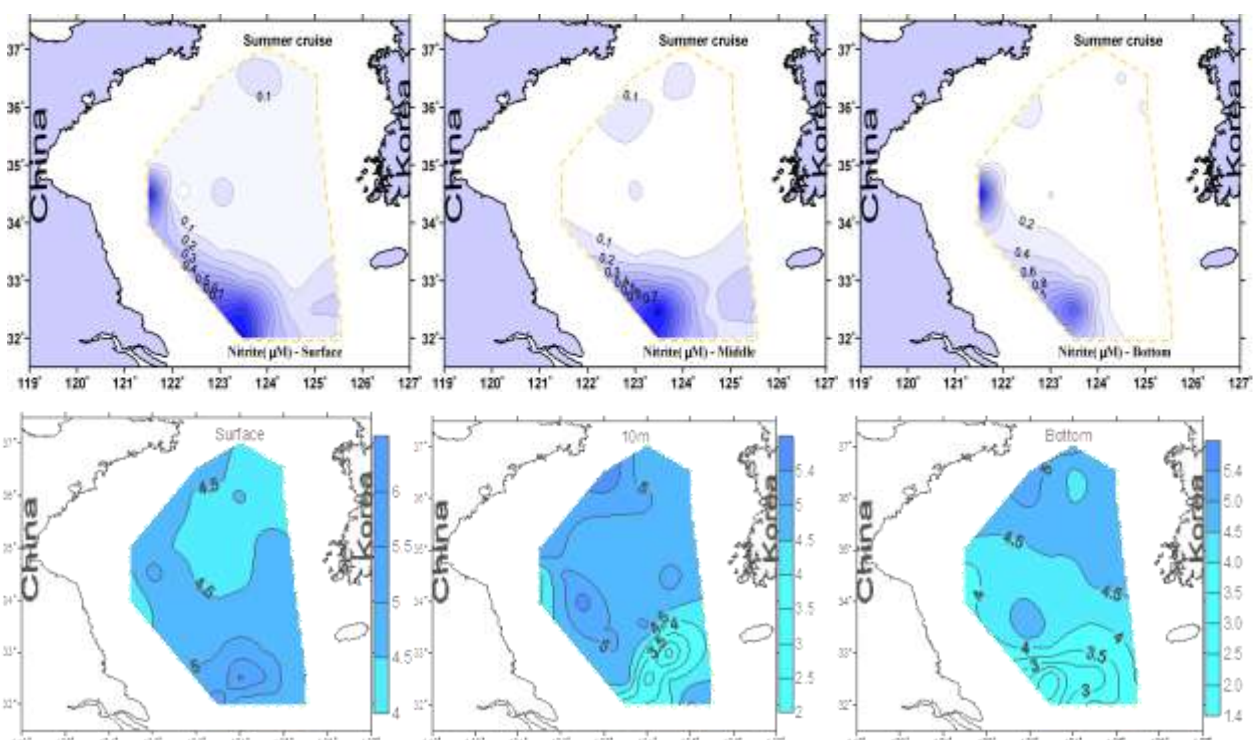

Figure 3. Nutrients and DO distributions in YS (Source: YSLME co-operative cruises)

The extensive and frequent over-use of chemical fertilizers and the increased discharges of untreated and/or partially treated industrial and domestic wastes have raised the concentration of dissolved inorganic nitrogen in coastal waters of the Yellow Sea LME. The Yellow Sea LME is vulnerable to eutrophication as it is isolated from the East China Sea by a strong thermohaline front, has weak circulation internally, and the flushing time is around seven years. Consequently nutrients such as nitrogen accumulate in the ecosystem. Algal production during a eutrophic episode frequently results in depletion of the nutrients and collapse of the bloom with mass mortality of the algae that sink to the bottom. The resulting bacterial decomposition causes oxygen depletion in the bottom water causing fish kills and mass mortality of other less mobile organisms, especially in mariculture establishments. Benthic biomass appears to have decreased and the proportion of polychaetes seems to have increased, these changes are frequently associated with increasing eutrophication of the sediments. As the benthic community is an important food source for many commercially important demersal fish species, its reduced diversity could have significant consequences.

Jellyfish Blooms

The joint cruises conducted under the UNDP-GEF YSLME first project and other studies reported that, the abundance of jellyfish has increased in recent years leading to clogging of fishing nets and increased likelihood of bathers being stung. The recent regional fishery stock assessment cruises provide similar evidence of an increase in jellyfish abundance (Figure 4). Recently it has been suggested that the increase in marine litter and construction of concrete structures such as jetties and wharfs has increased the habitat available to the asexual reproductive stage of these jellyfish. In addition, the reduction of plankton-eating fish stocks brought about by over-fishing, combined with the change from predominantly diatoms to dinoflagellates, has increased the food available to support the growth of jellyfish blooms. There appears to be a growing consensus that pollution, acidification of the sea and changing phytoplankton communities are leading to increased jellyfish densities in many regions. Not only do these higher jellyfish densities impact the tourists and fishermen in the Yellow Sea, they also directly impact fish stocks through feeding on the fish larvae and reducing the availability of zooplankton which is an important food source for larval fish. The increases in jellyfish have wider transboundary implications as a consequence of movements of jellyfish out of the Yellow Sea to neighbouring seas.

	China	**Korea**
Species	*Cyanea nozakii* & *Cyanea purpure*	*Nemopilema nomuri*
Spring (%)	14	0
Fall (%)	86	19

Figure 4. Survey results on jellyfish blooms in the Yellow Sea; photo of jellyfish on deck, YSLME fishery stock assessment cruise.

CONSIDERATIONS OF MANAGEMENT SOLUTIONS

During the implementation of the UNDP-GEF Project entitled Reducing Environmental Stress in the Yellow Sea Large Marine Ecosystem (YSLME)(UNDP-GEF 2007b), the coastal countries carried out the TDA and SAP processes, as shown in Figure 5. The Transboundary Diagnostic Analysis (TDA) re-examined the regional marine environmental data and information; identified the marine environmental problems in the Yellow Sea LME; identified the priorities of the problems; and determined the causes of the problems through causal chain analysis.

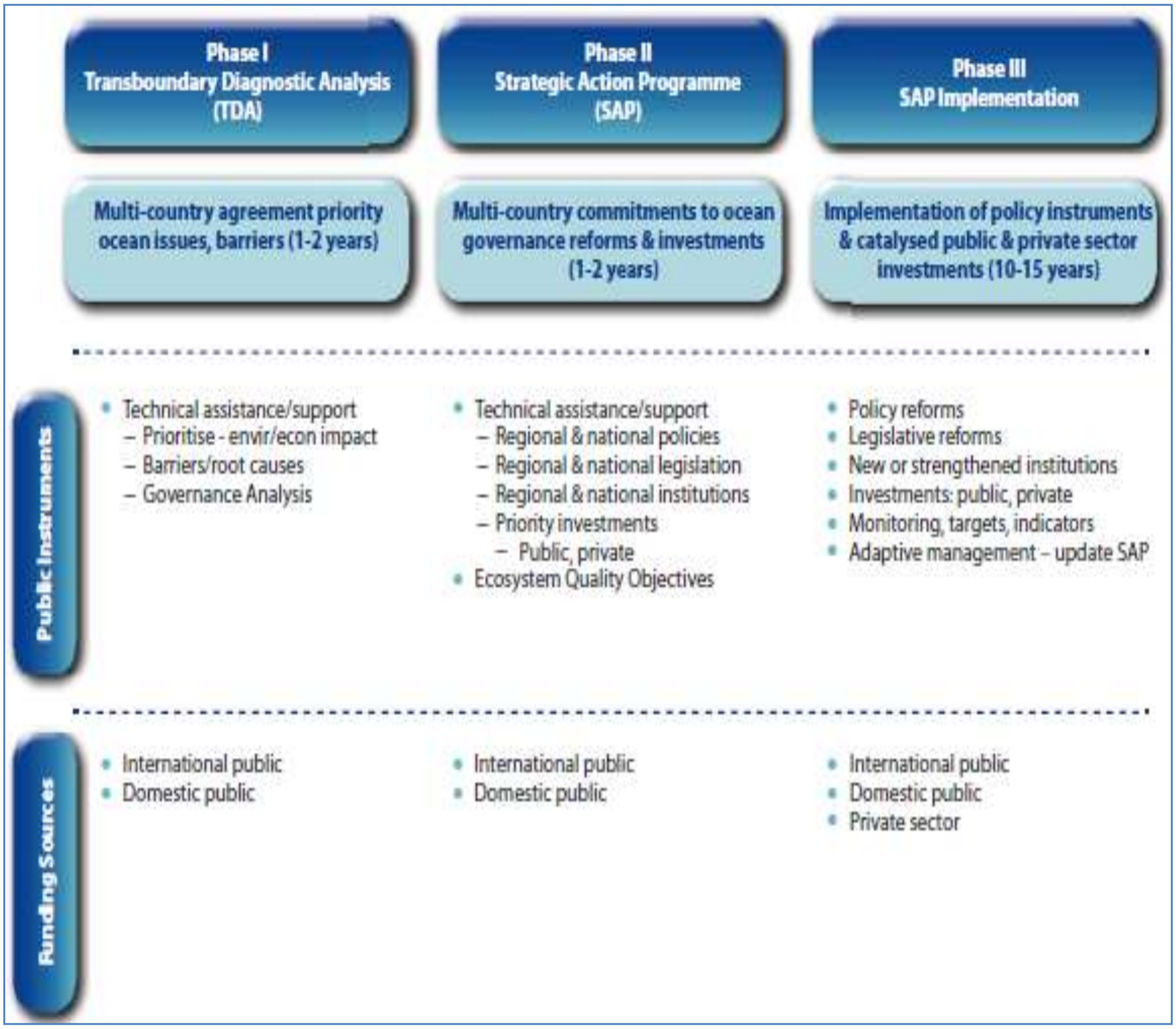

Figure 5. Summary of the YSLME TDA and SAP processes (Source: Catalysing Ocean Finance, Vol. 2; UNDP-GEF 2012.

Following the TDA findings, the regional Strategic Action Programme (SAP) (UNDP-GEF 2009) obtained the agreements with all the coastal countries of the Yellow Sea on the 11 management targets and associate management actions to address the environmental problems identified. Figure 6 shows the 11 management targets; and Figure 7 presents the signing ceremony of the YSLME SAP with participation of all the coastal countries of the Yellow Sea.

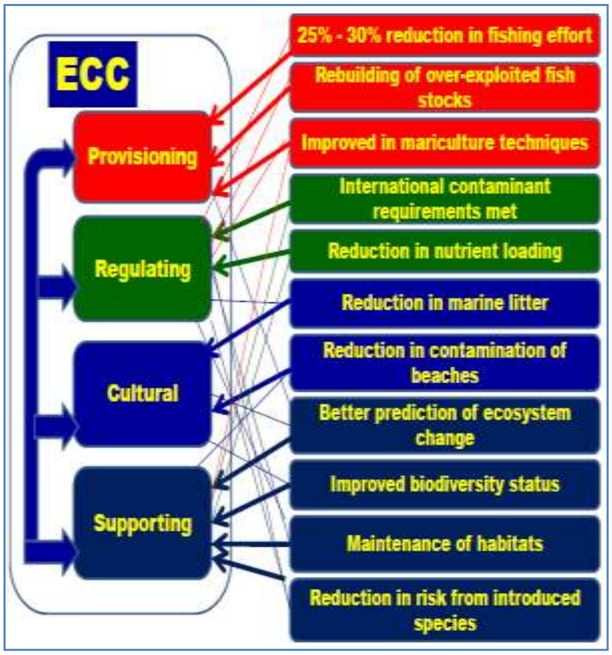

Figure 6. Management targets and their relationship with ECC

Figure 7. Representatives from China and RO Korea signed the SAP; the Project Manager, the representatives from UNDP-GEF and DPR Korea observed the signing ceremony

From Figure 6, it is clear that each management target has direct and/or indirect links with the ecosystem services, and they contribute collectively to strengthen the ecosystem carrying capacity (ECC). In the GEF International Waters Portfolio, the YSLME project is the first to apply the ecosystem carrying capacity approach to address marine environment problems in shared international waters.

Considerations of ECC in Management Plan

Originally, "carrying capacity" was a concept in ecology that was applied to the population density achieved at the asymptote in the logistic population growth equation (Odum, 1983; Dame and Prins 1998). More recently, the term has broadly come to mean the maximum biomass that can be sustained by the available resources. This ecosystem-based concept forms the basis of Carver and Mallet's (1990) definition of carrying capacity as the maximum standing stock of a particular cultured species at which production is maximized without negatively affecting growth rates. That definition may not always apply to commercial aquaculture, because production may be maximal even though individual growth rates are low. Because of such inconsistencies, Smaal et al.,(1998) proposed a definition for aquaculture production where "exploitation carrying capacity is the stock size at which a maximum yield of the marketable cohort is achieved." Recently, Newell (2007*)* proposed that "ecological carrying capacity" for bivalve aquaculture be defined as "the standing stock of suspension-feeding bivalves where the consumption of phytoplankton, enhancement of nutrient removal, and other ecosystem services are maximized without negatively affecting water quality, sediment biogeochemistry, and overall ecosystem function."

Reducing Fishing Efforts

The fishery industry has had rapid development and played an important role in developing the rural economy and increasing farmers' income in the countries around the Yellow Sea. However, in the absence of adequate knowledge of the characteristics of the existing marine fishery resources and fishery economics, marine fishery resources have become overexploited. The production of approximately 2 million tonnes before the 1960s increased to 3 million tonnes by the mid-1970s. With the increase of fishing vessels and the increased horsepower of their engines, combined with the modernization of fishing gear and methods, fishery resources in coastal and inshore waters have largely declined. By the mid-1980s, the production from capture fisheries increased by an average of 20 percent, with small pelagic species comprising more than 60 percent of the total catch (Figure 8).

To ensure appropriate ECC is applied in the YSLME, the YSLME SAP proposed a target of a 25-30 percent reduction of fishing effort to be achieved through the control of boat numbers with 25-30 percent of the fishing fleet being decommissioned by 2020; the stopping of fishing in certain areas and seasons to protect vulnerable stocks or life stages of certain species; and improved monitoring and assessment of fish stocks. The SAP also proposed that fish stocks should be rebuilt through: an increase in mesh sizes and the use of more selective fishing gear; stock enhancement by restocking of overexploited stocks and through habitat improvement; and improved fisheries management and the use of Total Allowable Catch (TAC) and Individual Transferable Quotas (ITQ).

The boat buy-back actions have been planned and implemented in China and ROK with substantial financial support from China and ROK governments. The objective is to reduce the number of fishing vessels by 30 percent of the current fleet by 2020. Total resources committed by the two countries to support fishing effort reduction amount to $3 billion.

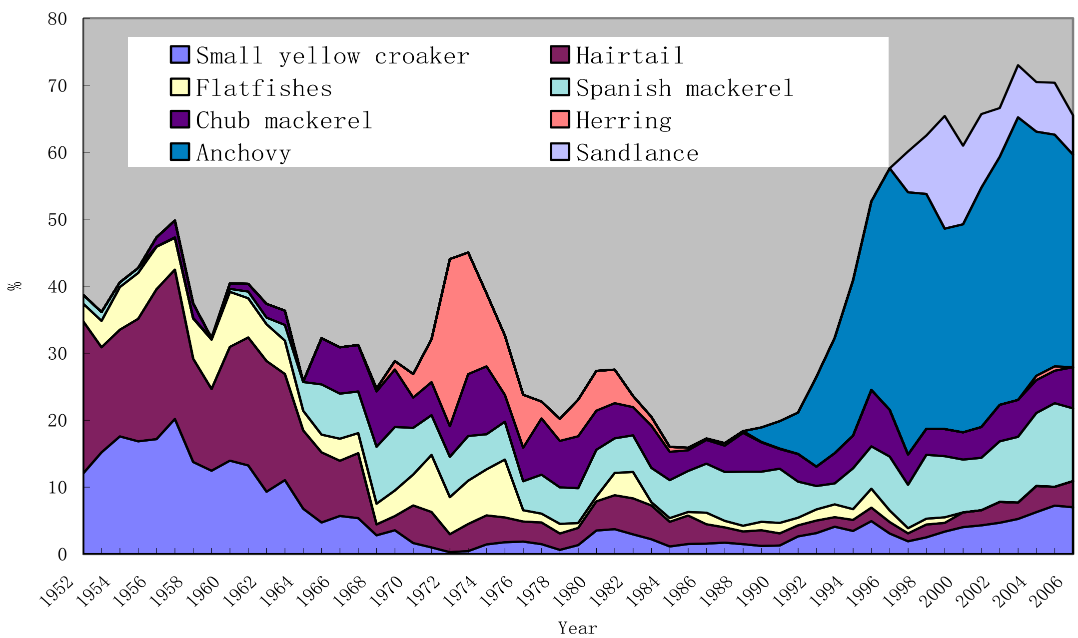

Figure 8. Species composition in the Yellow and Bohai Seas (source: Jin. X)

The project will support complementary activities to ensure that the target reduction in the number of fishing vessels is met. The project will mainly cover the costs of coordination of actions, to facilitate the necessary actions jointly implemented in both countries. The project will carry out following activities:

- Reviewing current national criteria and developing guidelines for vessel selection;
- Identifying appropriate fishing boats—buying back and decommissioning the fishing boats;
- Carrying out necessary institutional study on the effects of buy-back on the reduction of fishing effort and recovery of fish stocks;
- Assisting in improving the licensing system;
- Implementing a regional cost-benefit analysis of boat buy-back; and
- Assisting in providing alternative livelihoods and carrying out necessary training.

To monitor usefulness and effectiveness of the management actions mentioned above, there were three activities to evaluate these fisheries SAP management actions:

a) Determine the effectiveness of closed areas and seasons in fisheries management.

   Outputs: Assessment of the reduction in fishing effort due to closed areas and seasons, and their impact on fish stocks and fish catches through monitoring the catches of selected fishing boats before and after the area closures, carrying out a cost benefit analysis of the area closures, and collecting historical records to compare the species composition changes recorded after the area closure.

b) Demonstrate the effectiveness of stock enhancement

   Outputs: Assessment of the effectiveness of the release of hatchery-raised juvenile olive flounder (*Paralichthys olivaceus*) in rebuilding fish stocks using mark-recapture techniques in Shandong province. Assessment of restocking of Chinese fleshy shrimp (*Fenneropenaeus chinensis*) was carried out in Liaoning province.

c) Demonstrate the effectiveness of boat buy-back

   Outputs: Description of the success of the ROK government's fishing boat buy-back and its impact on reducing fishing effort through interviewing fisher folk to assess the perception of the impact on fish stocks and assessing the government's policy on reducing fishing effort.

The project was also involved in the organization of the first joint regional fisheries stock assessment exercise between China and ROK. The results were analysed. The results of harmonization exercises in ageing of fish and stomach contents analysis suggest that diets of fish species on each side of the Yellow Sea are very different and that earlier differences in growth rates in such fish as small yellow croaker and chub mackerel may be real and not the result of differences in measuring techniques as previously suggested. These surveys have now sparked interest in further collaboration.

Integrated Multi-Trophic Aquaculture (IMTA)

How would the ecosystem-based approach work, in a practical sense, to solve the marine environmental problem in the Yellow Sea LME? Let's have a look at the fisheries issues as an example.

As Figure 9 shows, in order to solve the identified problem of over-fishing, there is a need to reduce fishing effort. However, cutting fish catches by one third will leave the coastal countries, in particular China, with a substantial deficit in producing and providing seafood protein. There is a need to make up this shortfall with protein provided by marine aquaculture or mariculture. To further develop mariculture using traditional approaches will have serious environment impacts, in particular nutrient discharges and use of anti-biotics. To ensure the negative impacts from mariculture are minimized, while productivity is enhanced, the issue of sustainability needs to be addressed. One of the solutions from the management actions of YSLME is to introduce integrated multi-trophic aquaculture (IMTA). In order to show how IMTA works in a practical way, and to show the relative benefits for mono-culture, polyculture and IMTA, the YSLME Project carried out several demonstration projects.

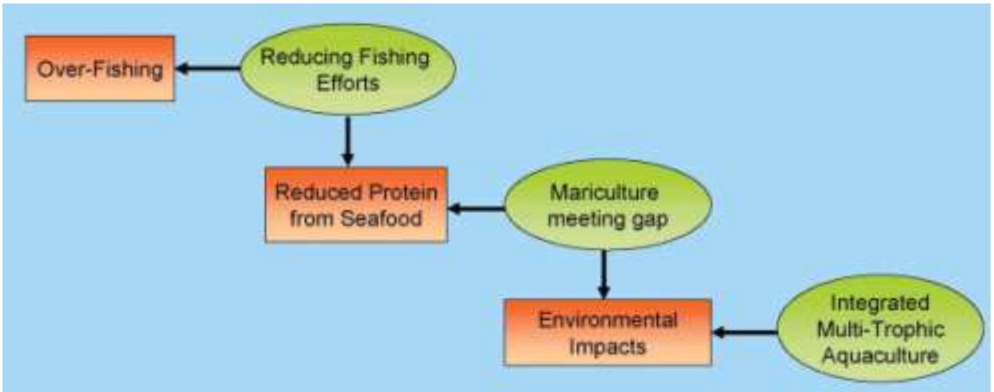

Figure 9. Logical consideration of management action on fisheries

Mono-culture for many mariculture farmers in the region was traditionally focused on only one species, either algae or fish. Polyculture is where two or more species are cultured together, usually with some added benefit in terms of productivity. IMTA is a type of polyculture where species from different trophic levels (e.g., algae, fish and oysters) are cultured together so that the waste products of one species are utilized by another.

In the Sanggou Bay on the eastern tip of Shandong province in China, several trials of different IMTA systems are underway. In China, more than 11 million tonnes of shellfish were cultured in 2006 *(*Zhang et al, 2007). Shellfish (mollusc) culture is often associated with environmental impacts due to organic enrichment of the sediments associated with the increased sedimentation rates from the production of pseudo faeces and faeces produced by the molluscs (oysters, clams, scallops, etc). This enrichment can result in anoxic conditions causing changes to the benthic community that become dominated by opportunistic polychaetes. However, a recent study suggests that, despite 20 years of mariculture, the Sanggou Bay has avoided environmental impacts associated with shellfish culture in other parts of the world, as a result of the low culture density in Sanngou Bay, the current regimen, and the co-culture of oxygen-producing seaweed. Together, these factors work to prevent anoxia in the sediments (Zhang et al, 2009). As farmers switch to the more profitable shellfish and fish culture, the demands on the environment will increase. To counteract this, the YSLME project is promoting the use of IMTA and the concept of carrying capacity. Carrying capacity models with adaptive management can be used to optimize the culture density of various species so that nutrient flows are balanced and the environmental condition is maintained.

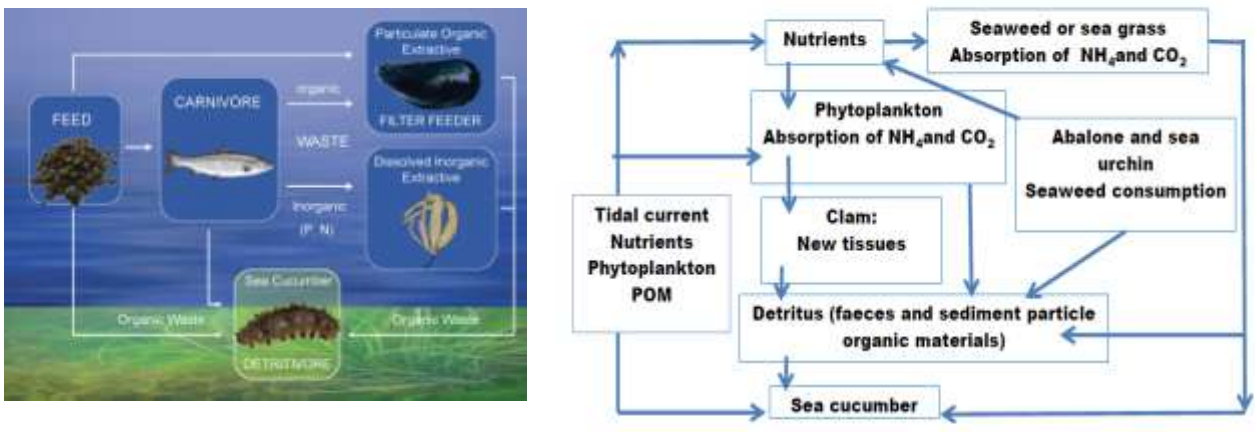

Figure 10. Two schematics of the IMTA model in Sanggou Bay (Fang et al. 2009)

While the water quality is kept in good condition in the Sanggou Bay by applying IMTA, the economic yield of the mariculture farmers has been increased from that of traditional mono-culture in the change to IMTA. Figure 11 shows the result of the YSLME demonstration project on economic valuation in the Sanggou Bay that applied the methods introduced in the YSLME's Regional Guidelines for Economic Valuation, and compared the economic benefits between monoculture and IMTA. The net benefit of IMTA is about three times higher than that of the monoculture of kelp and scallops.

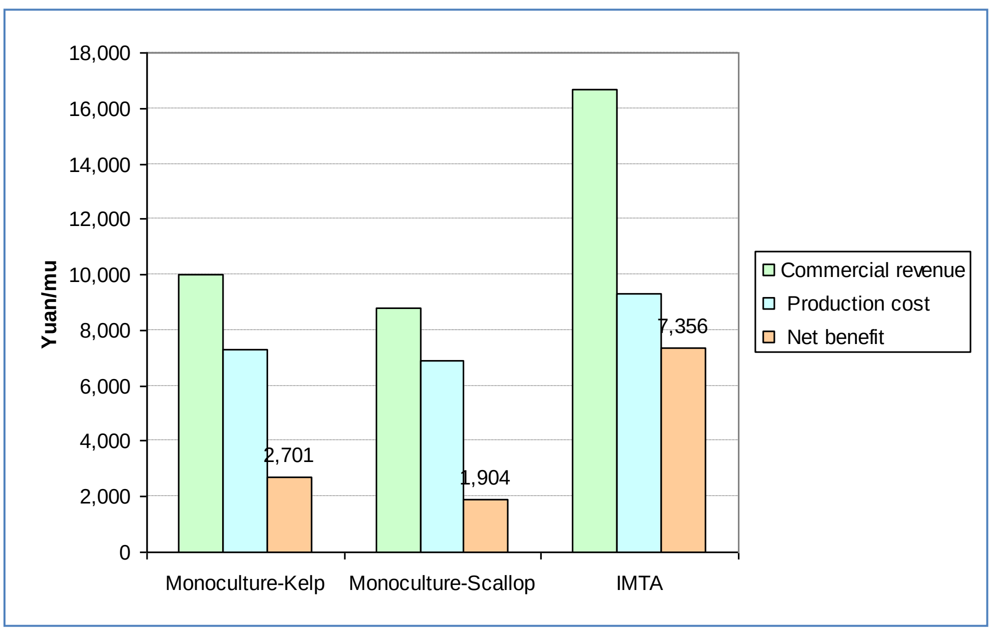

Figure 11. Economic valuation results of IMTA in the Sanggou Bay

SUMMARY

The UNDP-GEF Project on Reducing Environment Stress in the Yellow Sea Large Marine Ecosystem (YSLME) produced a regional management plan, the YSLME Strategic Action Programme, based on the concept of ecosystem carrying capacity. From a number of demonstration activities, YSLME provides excellent examples on how to apply the ecosystem-based approach in LME management actions. The successful conclusion of the project's current phase provides good experiences for future considerations on applying ecosystem carrying capacity to achieving the sustainable development of marine and coastal areas. In the meantime, it also provides challenges to expanding the experiences from small scale geographic coverage to much larger areas.

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11

SCIENCE TO GOVERNANCE IN THE BENGUELA CURRENT LARGE MARINE ECOSYSTEM

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Dr. Hashali Hamukuaya at the podium at the LME Conference, JFK Library, 16 February 2013, speaking on Marine Spatial Planning and Governance in the Benguela.

1. INTRODUCTION

The Benguela Current Large Marine Ecosystem (BCLME) Programme from the mid-1990s to 2008 was a joint initiative implemented by UNDP and funded by the Global Environment Facility (GEF) and the Governments of Angola, Namibia and South Africa to promote the integrated management and sustainable use of resources of the BCLME. It was designed to identify, through a Transboundary Diagnostic Analysis (TDA), the transboundary threats and root causes such as the decline of valuable transboundary commercial fish stocks, harmful algal blooms, alien invasive species and sources of pollutants. The results and outcomes of the TDA process were used to formulate planning, management and policy actions to address the threats and root causes as identified. These actions are captured in a Strategic Action Programme (SAP) that was endorsed by the governments in 2002. A major milestone of the BCLME Programme was the establishment of an Interim Benguela Current Commission, through an Interim Agreement (IA), as a long-term mechanism to implement a science-based integrated approach to ocean governance.

In August 2008 the Benguela Current Commission (BCC) came into being in Windhoek, Namibia with the appointment of an Executive Secretary. The Commission, the first LME Commission of its kind in the world, is serving to formalize almost two decades of collaboration, trust building and cooperation between Angola, Namibia and South Africa. This has been complemented by initiatives in capacity building and empowerment in marine scientific research, planning and management.

In June 2009, the GEF started supporting the governments for the implementation of the SAP by the fully institutionalized BCC (SAP IMP Project). To date the Benguela Current Commission is fully institutionalized with all requisite structures and functions in place and, with implementation of a diverse development programme.

A major milestone to date is the Benguela Current Convention that was signed on 18 March 2013, the world's first intergovernmental multi-sectorial Large Marine Ecosystem (LME) convention. The Convention makes permanent the Benguela Current Commission. Once ratified the Convention becomes the formal overarching legal framework for use of, and access to, the BCLME.

This paper shares an evolution in the Benguela Current Large Marine Ecosystem Region from science to governance by demonstrating the use of scientific information and data in shaping the Benguela Current Commission and the Benguela Current Convention, and their work programmes and framework for national and bilateral policy and management harmonization.

2. THE BENGUELA CURRENT LARGE MARINE ECOSYSTEM (BCLME)

The Benguela Current Large Marine Ecosystem (BCLME) (Figure 1) is one of the world's four eastern boundary upwelling systems. Based on its primary production estimates of >300 $gC\ m^{-2}yr^{-1}$ from satellite imagery, it is rated as a Class I ecosystem (i.e. with high biological productivity). It is defined as that part of the Southeast Atlantic that lies between 14 and 37°S, east of the 0° meridian, encompassing the coastal upwelling regime, frontal jets and the eastern part of the South Atlantic gyre. The wind-driven coastal upwelling system, the most powerful in the world, is characterized by strong annual upwelling along the coast of southern Namibia and seasonal upwelling to the north and south. The northern boundary of the upwelling region coincides with the Angola Benguela Frontal Zone (ABFZ) where the warm Angola Current meets the cool Benguela upwelling regime. The southern boundary is considered to be the Agulhas current retroflection area, that typically lies between 36 and 37°S. The upwelling system is thus bounded at both extremities by warm water regimes, making it unique in that respect. The Benguela Current itself flows northwards along the coasts of the three nations bordering the BCLME, viz. Angola, Namibia and South Africa.

For many decades, the system has supported valuable commercial fisheries for small pelagic species, demersal fish (mainly hakes), horse mackerel, rock lobster and a variety of other species. In Namibian waters, over-fishing by local and distant-water fleets (DWFs) prior to Independence in 1990 (Willemse, 2002) has severely reduced the stocks of sardines, from which the system has not recovered, possibly indicating a major regime shift there.

Pollution is mainly localized in small harbor environments, but all major forms of pollution are likely and ecosystem degradation does exist in coastal waters of the BCLME from hazardous wastes from mine tailings, dredge spoils, deforestation of coastal mangroves, soil erosion, oil spills, marine debris, and invasive species (BCLME TDA 1999 [document available at http://iwlearn.net/iw-projects/789/reports/bclme_tda_1999.pdf/view].

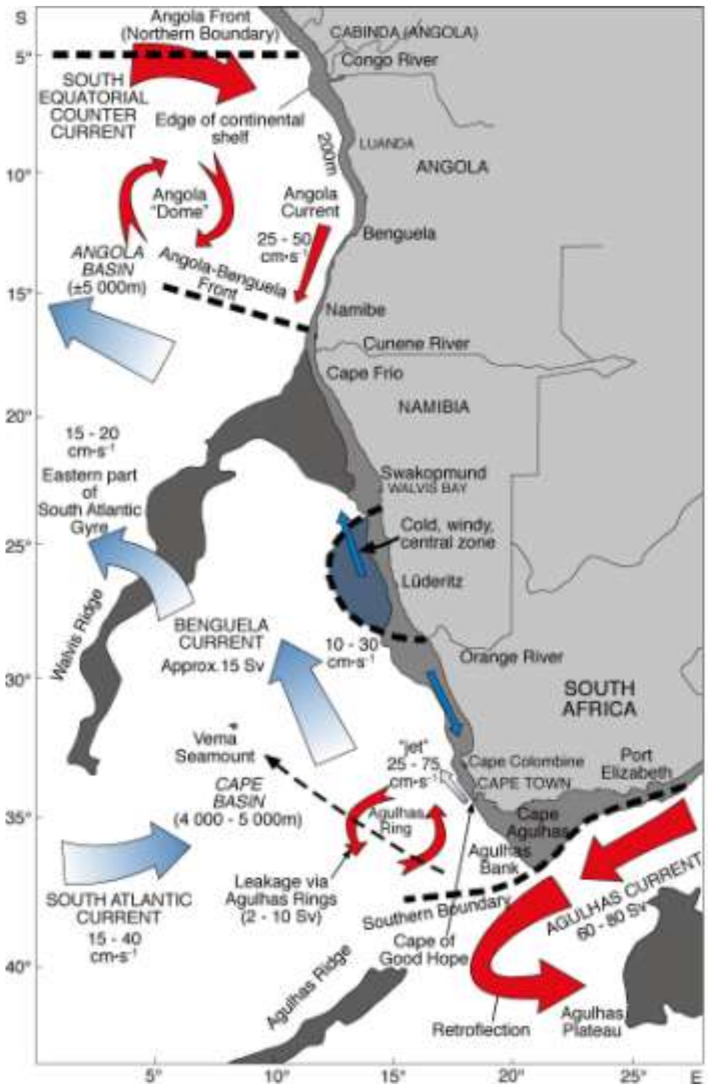

Figure 1: Salient physical features of Southeast Atlantic and Benguela upwelling system (adapted from the BCLME Programme).

The BCLME is primarily driven by climate, making the system susceptible to change and increased variability as a consequence of change and greater variability in global climate (UNEP 2006; Hampton & Willemse 2012). Of particular concern are possible teleconnections between the Benguela Current and large-scale ocean-climate processes in the North Atlantic and the Pacific (including *El Niño* events) that mounting evidence suggests are altering and becoming more variable due to global climate change.

INVOLVEMENT OF THE GEF IN THE BCLME REGION

Dialogue and collaboration for sustainable development of the Benguela Current Large Marine Ecosystem (BCLME) increased during the early to mid-1990s, marking in 2012 some 20 years of collaboration and cooperation among the governments of Angola, Namibia and South Africa for the protection, conservation and sustainable use of the BCLME.

Two Global Environment Facility (GEF) financed and UNDP supported interventions played catalytic and critical roles in initiating this partnership, facilitating trust and confidence building over the years and, finally seeing it maturing with the establishment of the world's first intergovernmental, multi-sectorial LME Commission.

The GEF support entailed applying the International Waters (IW) TDA/SAP guidance from the GEF based on the "Large Marine Ecosystem Approach" that includes five modules—i) productivity, ii) pollution and ecosystem health, iii) fish and fisheries, iv) governance and v) socio-economics (Sherman *et al.* 2009).

TDA/SAP Development and Implementation:

The Benguela Current Large Marine Ecosystem (BCLME) Programme was designed to address transboundary environmental problems and provide a means for Angola, Namibia and South Africa to resolve these problems through a long-term partnership. The BCLME Programme had four main expected outcomes: 1) an established Benguela Current Commission to enable the three countries to engage constructively and peacefully in resolving transboundary issues that threaten the integrity of the BCLME; 2) a framework to implement an ecosystem-based management approach; 3) increased benefits derived from the management and harvesting of shared fish stocks; and 4) improved capacity and overall management of human impacts on the BCLME.

Implemented in three phases between 2002 and 2008, the BCLME Programme supported over 100 projects worth $7 million, working closely with its sister programme, the Benguela Environment and Fisheries Interaction and Training (BENEFIT) Programme. Jointly the programmes generated, gathered and synthesized a wide range of scientific and technical information and data vital for the management of the large marine ecosystem and its natural resources.

The main outcomes of the BCLME Programme were the establishment of the Interim Benguela Current Commission through an Interim Agreement (IA) signed by the three governments in 2002, the Transboundary Diagnostic Analysis (TDA) and the Strategic Action Programme (SAP). Under the IA the countries agreed to have in place a signed and ratified Convention. The TDA entailed a consultative causal chain analyses to identify and determine the key root causes and threats to the ecosystem. The process guided and facilitated the prioritization of important scientific and technical research to cover data and knowledge gaps that would improve our understanding of the ecosystem. The Strategic Action Programme (SAP) translates the outcomes and recommendations from the TDA into prioritized planning, management and policy actions that can assist in halting the decline of fisheries, degradation of habitats and biodiversity and pollution to name a few. The SAP advocates for an integrated transboundary LME management approach.

Transboundary Diagnostic Analysis Process

In the mid-1990s, when the collaboration between the three countries commenced, existing information and data were gathered, synthesized and compiled into six comprehensive reports on fisheries; oceanography and environmental variability; marine diamond mining; the coastal zone; offshore oil and gas; and socio-economics. Each report identified key issues and threats and gaps in knowledge, thereby setting a baseline not only for environmental and oceanographic parameters but also in terms of available information and data. These reports formed part of the BCLME Programme proposal that was submitted to the GEF and later were consulted and instrumental for the TDA/SAP process.

Two international stakeholder workshops resulted in the development of the TDA for the BCLME; one held in July 1998 in Cape Town, South Africa and a second smaller and more focused one held in April 1999 in Okahandja, Namibia. The first workshop had the objective to bring stakeholders together from regional and from international agencies and institutions. The outcomes of the workshop included cooperative relationships among stakeholders, a coordinated and agreed approach for the way forward and consensus for a coordinated and integrated transboundary LME management approach. The workshop was attended by representatives of all the relevant government ministries and agencies in the three countries. Representatives from the commercial and artisanal fisheries sectors, mining and oil and gas industries, port authorities, tourism, various NGOs, and some donor agencies also participated in the workshop.

The objective of the second workshop was to identify, define and agree on the major elements of the TDA, define and achieve consensus on a framework for the SAP and ensure that the process and outputs met the expectations of the stakeholders.

The workshop used the “Logical Framework Analysis” approach to achieve the necessary results and focused on three main themes, namely: 1) utilization of resources; 2) environmental variability; and 3) pollution and ecosystem health. The essential elements of the TDA were identified, formulated and prioritized by small working groups and their outputs formed the basis for the development of a comprehensive TDA report. In addition, the framework of the SAP was defined by the stakeholders for further development by a small group of experts.

The workshop produced outputs that were applied toward shaping the TDA and developing content while it fostered a spirit of cooperation and goodwill among participants. This workshop was attended by representatives of government, donor agencies, the GEF, and the UNDP.

Formulating the Strategic Action Programme (SAP)

The TDA consultative process proposed corrective or remedial actions as part of the causal chain analysis of identified problems. Hence, these draft proposed actions were revised and phrased to read as policy actions along with key principles and that are necessary to enable an integrated transboundary approach to ocean governance. The draft SAP was produced by a small working group and stakeholders were given opportunities to comment. In addition to ecosystem-related principles and policy actions, the SAP articulates actions pertaining to cooperation, partnerships and wider networking and to securing the necessary resources for the long-term sustainability of the BCC and for SAP implementation. The SAP also highlights training and capacity-building as a high priority matter to address, to meeting skills and capacity required for implementation of Ecosystem Approach to Fisheries (EAF) and an integrated transboundary approach to ocean governance.

It is worth noting that the BCLME is the first LME in the world where the GEF's International Waters (IW) TDA/SAP approach was applied and a SAP resulted for a LME. The SAP was endorsed by seven ministers from the countries by 2000, demonstrating the political commitment for long-term protection and sustainable development of the BCLME. The SAP clearly spells out the challenges facing the region; establishes principles fundamental to the integrated management of the BCLME; and specifies the nature, scope and timetable for the necessary policy actions based on the information contained in the TDA. Crucially, it details the institutional arrangements required to remedy the issues outlined in the TDA and elaborates on general initiatives to facilitate cooperation.

The principles underlying the SAP include the adoption of the precautionary principle; reliance on anticipatory actions; the use of clean technologies; public participation and transparency; and the consideration of environmental health in all relevant policies and sectorial plans. The SAP calls on the three countries to actively pursue a policy of co-financing with industry and donor agencies.

To start with the implementation of the BCLME Programme, the institutional arrangements that were put in place included a Programme Steering Committee (PSC), a regional Programme Coordination Unit (PCU) and three Activity Centres (ACs)—one located in each country. The PSC was the highest decision-making body of the BCLME Programme composed of senior government officials/managers from the various sectors. The PCU comprised a Chief Technical Advisory (CTA), an Administrative Officer and an Administrative Assistant who were responsible for the day-to-day implementation and management of the BCLME Programme. The Activity Centres were designed to facilitate the coordination of programme activities with the partner countries. They were supported by special advisory groups made up of scientists and managers with expertise in a particular field.

A key objective of the SAP was the formation of an Interim Benguela Current Commission (IBCC) that would later become a permanent Benguela Current Commission, responsible for the integrated management, sustainable development, conservation and protection of the BCLME.

3. INSTITUTIONALIZATION OF THE BENGUELA CURRENT LME COMMISSION (BCC):

All three countries come from colonial pasts of instability, unrest and inequality. Even though language was an early barrier to effective communication, today both English and Portuguese are official languages of the Commission.

Institutionalizing the BCC entailed establishing the BCC Secretariat and ensuring that its requisite roles and structures are in place. Current focus is on finalizing institution building and finance and administrative instruments such as a Strategic Plan, Business Plan and Resource Mobilization and Partnership Strategy and, operational policies and procedures. Following below are brief summaries of each of the major programmatic areas of the BCC.

Science Programme

This programme encompasses about two dozen scientific projects that seek to advance knowledge and understanding of the ecosystem, its variability and dynamics, living marine resources, environmental health and pollution and conservation management planning. A key milestone from this Programme is the annual transboundary fish stock surveys that provide valuable scientific information and data for stock identification and verification of their transboundary nature, distribution and abundance. Current focus is on completing the scientific projects and prioritizing scientific research for the coming five years. The Science Programme is funded by Norway. A complementary programme, focused on improving stock assessment of shared, commercially exploited fish stocks, is funded by the European Union.

Strategic Action Programme (SAP)

The SAP is the BCC's strategic policy document and was endorsed by all three governments. It comprises agreed-on and prioritized planning, management and policy actions that have been implemented since June 2009 to address the root causes and threats of transboundary problems.

Notable policy actions include the harmonization of policies and legislation particularly for shared fish stocks; establishing regional coastal sensitivity maps and a regional oil spill response framework; better understanding the economic and social value of ecosystem goods and services; and establishing a permanent BCC through a signed Convention. Current focus is the revision and updating of the TDA/ SAP to ensure it serves contemporary development issues and translates the signed Convention objectives and principles into actions. The implementation of the SAP is co-financed by the GEF and the three governments—Angola, Namibia, and South Africa—with implementing and executing support from the United Nations agencies, UNDP and UNOPS, respectively.

Training and Capacity Building (TCB)

The BCC's current TCB Strategy has been under implementation since 2009. It is focused on meeting priority skills and capacity gaps within the national institutions responsible for marine protection, conservation, and the institutions that are responsible for resource custodianship. Since 2011 the BCC has incorporated training and capacity building to improve the understanding and knowledge of planners, managers and policy makers about ocean governance, the EAF management, and empowering fishers, captains and observers with knowledge about "responsible fisheries". Furthermore, the BCC's work on the "Human Dimension of EAF" has enhanced understanding, knowledge and general capacity in the region about the role of humans in the fishing sector. Major milestones include the establishment and operationalization of a Regional Training Advisory Group (RTAG) and the development and adoption of a Training and Capacity Building Policy. Current focus is to revise the TCB Strategy to be in line with the new TCB policy and, to prioritize TCB needs for the next five years. The BCC's TCB Strategy implementation is co-funded by the Icelandic International Development Agency and the SAP Implementation (IMP) Project.

In addition to the GEF, partners such as the FAO EAF Nansen Project, Norway, the Icelandic International Development Agency (ICEIDA), and the European Union have played, and still play, a vital role in institutionalizing the Commission by supporting implementation of the BCC Science Programme and its Training and Capacity Building Strategy.

The governments of the three countries have been supporting the operations of the BCC Secretariat financially since 2008 which is commendable testimony of their commitment for sustainable use and management of the BCLME. The evolution of the BCLME science-to-governance model is still in progress but past experiences are demonstrative of the success of establishing collaboration and cooperation at scientific and technical levels and thus gradually involving senior planners, managers and policy makers. In addition, the Interim Agreement (IA) and SAP laid strong foundations for the development of the Convention. Stakeholders who were involved in the BCLME programme and who participated in the convention development process were able to facilitate the negotiation process due to their institutional memory and trust on which the Convention was based.

4. IMPLEMENTING THE BCLME STRATEGIC ACTION PROGRAMME (SAP)

The BCC's four major programmatic areas all contribute to the implementation of the SAP. These include the institutionalization of the Commission that is supported by the three governments, a GEF-financed project focused specifically on implementation of the SAP, the Training and Capacity Building (TCB) Programme and the Science Programmes of the BCC. The TCB and Science Programmes are financed by ICEIDA and Norway respectively.

Institutional Arrangements

A permanent Benguela Current Commission has been in place since August 2008. The Commission comprises a Ministerial Conference, as the highest decision and policy making body, a Management Board comprised of senior government officials and managers and, the Secretariat which is fully operational with all requisite staff, structures and functions.

Other structures and functions established include an Ecosystem Advisory Committee and various Joint Working Groups—Data and Information Management, Training and Capacity Building, Ecosystem Approach to Fisheries, Living Marine Resources, Pollution and Ecosystem Health and, Environmental and Variability and Predictability, for example.

Sustainable Management and Utilization of Living Marine Resources (LMRs)

Annual joint surveys and assessments have been carried out for transboundary commercial fish stocks such as Cape hakes, horse mackerel and sardines since mid 1990's. In 2008 the BCC commissioned its first joint surveys under its Science Programme. Regional aerial seal and seabird surveys are carried out every three years with planning underway for continuation beyond the current Science Programme funding phase. These surveys provide information about the status of commercially exploited fishery resources and ecosystem health.

A number of science projects have been undertaken by the BCLME Programme and by the BCC since 2009 focusing on enhancement of understanding and knowledge of stock dynamics, distribution and abundance and life cycles, among others, to improve planning and management. There are some dedicated research projects to improve stock assessment methodology particularly for transboundary stocks. These focus on improving acoustic surveys by refining target strength and enhancing understanding about trawl survey catchability. In addition, inter-calibration factors were developed to facilitate integration of Cape hakes survey data and, genetics are being used to improve identification of fish stocks and their structure.

Furthermore, an assessment of the impacts of by-catches on the ecosystem was carried out and mitigation measures investigated and proposed. This resulted in a manual that was produced for the identification of by-catch species as well as recommending by-catch mitigation measures. The manual is operational in Namibia and can become a regional standard for the BCC.

Mariculture development is a high priority in development for all three counties. The potential for mariculture to contribute toward job creation and food security remains unrealized with the true potential unknown. Thus, the BCLME Programme produced a draft Regional Mariculture Policy option paper and implementation plan that can be reviewed and considered by the BCC.

The BCLME Programme has produced comprehensive socio-economic and policy related reports with analysis and recommendations on the following; fisheries market analysis, economic integration and policy considerations; a comparative study on legislation and regulations for commercial fishing; recommendations optimizing benefits of commercial fishing activities; desirability of balanced trade and impact of eco-labeling, including guidelines for eco-labeling and beneficiation; and measuring transformation in the fisheries sectors. In addition, a review and analysis of existing fisheries management protocols and a legal analysis of systems of government administration in allocation of rights were carried out; guidelines were developed on cost recovery and revenue raising instruments; and recommendations on harmonizing of fisheries socio-economic policy. From 2011 to 2012 the BCC and the SAP IMP Project carried out an economic valuation of the ecosystem goods and services of the BCLME. In addition to fisheries resources, the study analyzed economic data for marine recreational activities, mariculture, oil and gas exploration and production, coastal marine mining, desalination and ports. The total direct economic benefit from the ecosystem is valued at some $260 billion per annum (Sumaila 2013, unpublished).

The BCC has socio-economics and governance high on its agenda and will review, revise and incorporate recommendations from the above work into the updated SAP for the period 2014-2018.

Conservation and management planning is crucial in the BCLME given the reliance on living marine resources and the inherent ecosystem variability and unfavorable environmental events. The Namibia Islands Marine Protected Areas (NIMPA) zone covers over 1 million hectares of marine sea area that includes its ten islands and eight islets and, in South Africa, MPAs comprise relatively large areas of EEZ in pursuit of the 10 percent target as agreed by World Summit on Sustainable Development (WSSD) held in Johannesburg, South Africa. A BCC science project currently underway focuses on marine spatial biodiversity mapping and the identification of sensitive areas and habitats to recommend areas for improved conservation. In line with conservation planning is the development of coastal sensitivity maps (CSMs) to enable effective and mitigating oil spill responses in the BCLME region. Of the three countries, Namibia's CSMs were the last to be updated and the production of a current map showing biodiversity sensitive and important areas further contributes to the mapping of the BCLME. Both the marine spatial biodiversity mapping and the coastal sensitivity mapping contribute toward spatial data available to develop a marine spatial plan for the LME.

The BCC and the three countries have done a commendable job to introduce and implement the EAF management in the BCLME. With support from FAO EAF Nansen, three projects have been implemented since 2010 that include a review of the institutional arrangements for the implementation of EAF in the BCLME region, integrating the human dimension of an EAF into fisheries management in the BCLME region, and conducting Ecological Risk Assessments (ERAs) for commercially important fish stocks in each country. The EAF Institutional Review project delivered recommendations that require revision to render them appropriate and implementable at national level. The countries composed technical teams to review the recommendations in order to revise them to suit national and institutional contexts. The national teams will meet during a regional workshop in the second half of 2013 where the recommendations will be reviewed, discussed and finalized. Following this workshop the national teams will be responsible to table the recommendations to their management authorities for consideration.

Management of Mining and Drilling Activities

During the BCLME Programme, limited research and technical studies were conducted on the minerals and extractive resource sectors of the Benguela Current. When the BCLME Programme commenced, the transboundary biodiversity issue that was of global concern, and pertains to living marine resources, was fisheries, particularly the shared commercially exploited species. Albeit this strong fisheries focus, the BCLME Programme addressed what were regarded as high priority research matters to gain more knowledge and understanding about the impacts of the minerals and extractive resources sectors on the ecosystem. Two projects on cumulative effects assessments were carried out—one focusing on cumulative effects on the southern kelp beds from in-shore and near-shore diamond mining, and one focusing on the impacts of oil and gas exploration and production activities in the BCLME.

Since its inception, the BCC has advanced with integration of non-fisheries sectors in its structures and work programme. The BCC has a Working Group on Mineral and Extractive Resources (MER) in place and has recommended the commissioning of a Strategic Environmental Assessment (SEA) for the BCLME. The SEA would serve as a tool to review current policies, plans and programmes (PPPs) across sectors to determine how best to integrate different sectors into the work of the Commission. A comprehensive draft SEA Scoping Report is in place that defines the temporal and spatial context of the SEA and identifies the key sector issues to be addressed in a full SEA. The study also includes a terms of reference for a full SEA.

Assessment of Environmental Variability, Ecosystem Impacts and Improvements of Predictability

The BCLME region is a very dynamic, high-energy system associated with extreme unfavorable and anomalous environmental events that affect the living marine resources. This inherent variability makes the system extremely unpredictable and thus a challenge for early warning and forecasting. Since its inception, the BCLME Programme has increased efforts, and investments have been made, to improve the monitoring and assessment of the ecosystem. Such improvements include system-wide review of the occurrence of unfavorable environmental events, e.g., occurrence of Benguela Niño's and depleted oxygen in seawater. In addition, the PIRATA buoy real-time monitoring and a regional tidal gauge network were established.

The impacts of hydrogen sulfide (H_2S) and low oxygen on inshore marine species are being investigated in an ongoing project under the BCC's Science Programme. Other projects include investigating the environmental links to pelagic fish life cycles, abundance and distribution (i.e., determining governing factors); establishing and operationalizing a Coastal Monitoring Network (CMN); the development of Continuous Plankton Recorder (CPR) Survey, and assessment of the impacts of harmful algal blooms (HABs) on the inshore marine environment. The CMN provides real-time information on environmental conditions while CPR provides a snapshot in time about environmental health across a wide spatial scale.

Management of Pollution

During the BCLME Programme a project was implemented to investigate the harmonization of the relevant policies and strategies for oil spill contingency planning (OSCP) in Angola, Namibia and South Africa and, to propose an agreement for the facilitation of cooperation in the event of an oil spill. The work entailed a review of related policies and legislation in each country, current status of National Oil Spill Contingency Plans (NOSCPs), coastal sensitivity maps, response preparedness and, the feasibility of a cooperation framework for spill response.

Based on the findings from this project it was recommended that the BCC formally facilitate a regional oil spill cooperation agreement among the three countries, that the three countries ratify relevant and important regional and international instruments, that transboundary oil spill response plans be put in place, that training and capacity building be provided, that monitoring be augmented to improve response time, and that up-to-date coastal sensitivity maps (CSMs) be created.

As part of SAP implementation, the recommendations from the BCLME Programme were revisited. The BCC, with support from the SAP IMP Project and in partnership with IMO/ GI-WACAF, initiated work to support Namibia to update its CSMs and dialogue with partners to develop a regional oil spill response framework for the BCC.

Since 2010, the BCC and the SAP IMP Project have been collaborating with the Abidjan Convention on matters of mutual interest and of regional development concern. The BCC contributed to the review and finalization of protocols that aim to improve the monitoring, assessment and management of the marine and coastal environments that were endorsed during the Abidjan Convention's 9th Conference of the Parties (COP). Following this initial collaboration, the BCC and the SAP IMP Project supported Namibia to advance in acceding to the Abidjan Convention, as this would strengthen regional coastal and marine resources management. South Africa is currently the only party to this convention while ministers from the Guinea Current Large Marine Ecosystem (GCLME) region agreed to establish a Guinea Current Commission (GCC) under a protocol to the Abidjan Convention. Under this protocol, any country that becomes a party to the GCC would become a party to the Abidjan Convention. This would be relevant particularly to Angola, as this country is also part of the GCLME.

Maintenance of Ecosystem Health and Protection of Biodiversity

The BCLME Programme initiated a project that aimed at identifying and collating available spatial information and data that can be used to map biodiversity hotspots, sensitive areas and important habitats. This project did not produce any maps but collated available spatial data and generated extensive, accessible spatial metadata for the BCLME. The BCC revisited this objective and has a science project that is conducting a spatial biodiversity assessment to recommend improved spatial management of resources including the establishment of marine protected areas (MPAs).

The BCC has a science project on the development of acoustic methodology for zooplankton biomass assessment. Zooplankton (e.g. copepods and euphausiids) are important prey for fish and other predatory organisms in marine food webs and are used to assess the health of an ecosystem.

Namibia and South Africa produced strategic management plans for the Orange River Mouth (ORM) estuary, a Ramsar site, with support from the BCC and the SAP IMP Project. The ORM estuary has been listed on the Montreux Record, which implies that the health and status of the wetland is sub-optimal for the maintenance of biodiversity. The management plan for South Africa was largely funded by the Department of Environmental Affairs (DEA) with support from the BCC and SAP IMP Project for consultations with Namibian line ministries. The draft management plan for Namibia awaits approval by the Ministry of Environment and Tourism (MET). The area offshore the ORM estuary is important for transboundary commercially exploited fish stocks, such as Cape hakes, Cape monk and west coast rock lobster (ORASECOM 2012).

Capacity Strengthening

The BCLME and BENEFIT Programmes left behind a legacy of having invested huge resources in providing training and capacity building (TCB) to improve skills, knowledge and understanding as required. More than 1,000 people benefitted from this TCB with approximately 20 percent of people graduating with bachelors, masters and doctoral degrees.

As part of the development of the BCLME SAP IMP Project a TCB Strategy was developed for the Commission in April 2008. This Strategy was done by the BENEFIT Programme and is based on training needs analysis done in consultation with stakeholders. The process identified all the priority scientific and technical training needs for the coming five years to meet capacity and skills gaps.

TCB have focused mainly on improving capacities needed for fisheries and marine ecosystem research such as, training in acoustic surveying and stock assessment, fish age determination and multivariate analysis. Since 2009 the BCC has incorporated a more multi-sectorial approach through delivery of TCB in EAF and "Responsible Fisheries" and sensitizing stakeholders about the human dimension of fisheries under the EAF Human Dimension project. Of particular note was a one-week pilot workshop on social-ecological systems for fisheries managers and scientists, dubbed "fisheries management mis-matches" that took place in October 2011 in partnership with the University of Victoria, British Columbia Canada. The session targeted managers from governments involved in fisheries monitoring, assessment, planning and management. The training made stakeholders aware of the social dimension of fisheries and sensitized people to the classic "mis-matches" found in fisheries management that affect decision-making.

In addition, the GEF-financed interventions have raised the awareness, understanding and knowledge of stakeholders in the region about ocean governance, the application of ocean policy as a tool to harmonize policies and laws, EAF and an integrated transboundary approach to ocean governance. In October 2011 the BCC's Regional Training Advisory Group (RTAG) was established. Since then the RTAG has been very instrumental in developing a TCB Policy for the Commission that was adopted in November 2012.

National Strategic Action Plans

Since 2008 the BCC has been implementing the SAP and in 2012 commenced a consultative process to revise and update the Transboundary Diagnostic Analysis (TDA), SAP and Science Programme.

The national consultations were conducted as part of the review and revision of these instruments. The BCC will facilitate consultations in July 2013 to review and finalize these instruments, including draft national strategic actions plans.

Finance and Review

Since 2008, the three governments have committed to sustainably financing the operations of the BCC Secretariat through annual membership contributions. In addition, Norway and the EU support the implementation of the Science Programme, UNDP-GEF supports the implementation of the SAP, and Training and Capacity Building is funded by ICEIDA. In 2012, the GEF approved a project identification form (PIF) submitted by the BCC in partnership with FAO for climate change and adaptation.

As mentioned above, in preparation for the long-term financial and resource sustainability of the BCC, a draft Strategic Plan, Business Plan and Resource Mobilization and Partnership Strategy are in place. Once approved by the Management Board, the Secretariat will implement these instruments to proactively attract resources and partners.

Wider Cooperation

The BCC recognizes the importance and potential benefits that can accrue from partnerships and networks with regional and international institutions and organizations. The following are examples of current partnerships and networks the BCC have engaged in or fostered over the years.

- NansClim Project is an initiative supported by Norway that looks at the climate effects on biodiversity, abundance and distribution of marine organisms;
- Geochemistry in nutrient-rich upwelling system (GENUS) Project focuses on marine geochemistry and relations to climate variability and capacity building supported by a consortium of German universities;
- World Wildlife Fund (WWF South Africa) for the implementation of EAF Projects;
- Danish Technical University (DTU) on improving and complementing existing stock assessment methodologies;
- Support for the sub-regional implementation of and compliance with SADC policies and protocols, e.g. Protocols on Fisheries and Shared Watercourses;
- National universities such as University of Namibia, Cape Town, Western Cape and Stellenbosch for research, training and capacity building;
- University of Bergen, Norway for marine research and training activities;
- Scottish Association for Marine Science (SAMS), Scotland for ecosystem modeling and training activities;
- Collaboration with the University of Victoria (fisheries management training for managers and senior scientists);
- ODIN Africa for improvements in data acquisition and management;
- Namibian Fisheries Institute (NAMFI) on EAF and responsible fisheries training for fisherfolks;
- BCC is the founding chair and a member of the African LME Caucus which is a network that collaborates on issues of common interest within the continent on LME activities;
- National Oceanographic and Atmospheric Administration (NOAA) of the USA for operational oceanography and access to high resolution satellite information and data;
- British Petroleum (BP) invited the BCC for a meeting to become familiar with the Commission in relation to offshore oil exploration and production activities. BP shows interest in the work of the Commission and agreed to start collaborating on the sharing of data;

- The executive management of De Beers Marine Namibia (DBMN), a diamond mining company, hosted the BCC and SAP IMP Project for an introductory meeting in May 2013. DBMN shows interest in the work of the Commission and confirmed interest in exploring a partnership. Prior to this meeting, staff from DBMN and its sister company, NamDeb Diamond Corporation, have been participating in the Annual Science Forum (ASF) and technical work of the BCC.

5. REGIONAL AND INTERNATIONAL CONTEXT OF THE BENGUELA CURRENT CONVENTION

Central to the BCLME Programme's objective and still high on the agenda of the Commission, is to encourage the countries to comply with key international and regional conventions. Notable agreements include the United Nations (UN) Convention on the Law of the Sea (UNCLOS); the UN Conference on Environment and Development (UNCED), Agenda 21, Rio, 1992; the UN Convention on Biological Diversity (1992); the UN Fish Stock Agreement (1982); and Kyoto Declaration (1995); the FAO Code of Conduct for Responsible Fisheries (1995); the MARPOL 73/78 Agreement; Declaration on the Protection of the Marine Environment from Land-Based Activities (1995); the SADC Protocol on Mining; the World Summit for Sustainable Development (2002); the Millennium Development Goals (2000); and the UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks (2006). All the above-mentioned agreements have been ratified by Angola, Namibia and South Africa over the last fifteen years and some of the targets for compliance have already been achieved. In addition to these, there are more than 30 other regional and international instruments of which the majority has been ratified by all three countries (*See Annex 1*).

At the signing of the Benguela Current Convention on 18 March 2013, the ministers produced a formal Ministerial Communiqué that draws extensively on the outcomes and pledges of the Rio+20 Summit. Furthermore, points from the Communiqué also overlap with objectives and goals from other international and regional instruments, such as the Code of Conduct for Responsible Fisheries, the SADC Protocol on Fisheries and the Johannesburg Plan of Implementation (JPOI).

6. **THE WAY FORWARD FOR THE BENGUELA CURRENT COMMISSION**

The BCC currently enjoys commendable political support and guidance in the BCLME region. The three ministers from the countries who signed the Benguela Current Convention established a permanent regional mechanism for the cooperative and coordinated use and management of the ecosystem (Benguela Convention document signed 19 March 2013 is available at www.DLIST-Benguela.org). Through the detailed public *Communique,* released on 18 March 2013, the Ministers of the BCC committed themselves to ratify the Convention speedily and implement it to the fullest extent. The Commission has finance, procurement, and personnel policies in place and a Finance and Administration Committee (FAC) that was established in November 2012. A draft Strategic Plan, Business Plan and Resource Mobilization and Partnership Strategy also exist for the Commission and await finalization pending the adoption of the revised and updated TDA/SAP and Science Programme.

Also in 2013, the Commission produced a scoping report for a Strategic Environmental Assessment (SEA) of the BCLME and, concluded national and regional consultations to revise and update the Transboundary Diagnostic Analysis/ Strategic Action Programme (TDA/SAP), Science Programme and Training and Capacity Building (TCB) Strategy.

The ministers have recognized that that climate change is one of the greatest developmental challenges of our time and commit to better understand the impacts, vulnerabilities and cost and, to support mitigation and adaptation programmes. They further reiterated commitment to implement ecosystem-based management of the BCLME by mainstreaming all ocean sectors, by using the best available scientific evidence to inform management, and by applying the precautionary approach principles. The ministers reiterated BCC's position of embracing stakeholders' participation and promoting public-private partnerships to improve ocean governance and sustainable development. The Ministerial Conference has prioritized the use of contemporary conservation planning and management tools to improve ecosystem protection and biodiversity conservation (e.g. marine spatial planning, MPAs) as BCC priorities and vowed to continue investing in individual, institutional and system training and capacity building in order to strengthen capacities for marine environmental sciences and ocean governance. Joint monitoring, assessment, and management of shared fish stocks stand high in the agenda for the BCC and, as a leading LME in the implementation of an ecosystem-based management approach, the BCC shall endeavor to share its experiences and best practices with staff members of other LME projects in Africa and elsewhere.

Although the Commission is a fairly new institution, it has made strides in becoming an appropriate mechanism for LME management, and has made attempts to engage all levels of society and sectors into the sustainable development movement, from local to national and from projects to programmes. An important consequence is that through increased stakeholder involvement, the BCC has secured increased regional ownership.

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Annex 1

Benguela Current Convention related to regional and international conventions and treaties

Category	International/Regional Instrument	South Africa	Namibia	Angola
Legal	UN Convention on the Law of the Sea (UNCLOS), 1982	Ratified	Ratified	Ratified
Fisheries	UN Fish Stocks Agreement for the Conservation and Management of Straddling Stocks and Highly Migratory Stocks	Ratified	Ratified	Ratified
	FAO Code of Conduct for Responsible Fisheries	Ratified	Ratified	Ratified
	International Plan of Action to Prevent, Deter and Eliminate illegal, unreported and unregulated fishing	Ratified	Ratified	Not Ratified
	International Plan of Action for the Conservation and Management of Sharks	Ratified	Ratified	Not Ratified
	International Plan of Action for the Management of Fishing Capacity	Ratified	Ratified	Not Ratified
	International Plan of Action for Incidental Catch of Seabirds	Ratified	Ratified	Not Ratified
	SADC Protocol on Fisheries	Ratified	Ratified	Ratified
	Commission for the Conservation of Southern Blue-fin Tuna	Cooperating Non-Member	Not Member	Not Member
	International Commission for the Conservation of Atlantic Tuna	Contracting Party	Contracting Party	Contracting Party
	Commission for the Conservation of Antarctic Marine Living Resources	Member	Member	Not Member
Biodiversity	Convention on Biological Diversity (CBD)	Ratified	Ratified	Ratified
Large marine ecosystem management	Agulhas Current Large Marine Ecosystem (ACLME)	Member	NA	NA
	Gulf of Guinea Large Marine Ecosystem (GGLME)	NA	NA	Member
	Benguela Current Large Marine Ecosystem (BCLME)	Member	Member	Member
Safety & Environment	International Convention for the Safety of Life at Sea	Ratified	Ratified	Ratified
	United Nations Convention on Climatic Change (UNFCC)	Ratified	Ratified	Ratified
	Declaration on the Protection of the Marine Environment from Land-Based Activities, 1995	Ratified	Ratified	Ratified
	Convention on the Conservation of Migratory Species of Wild Animals, 1979	Ratified	Ratified	Ratified
	Convention on International Wet Lands recognized as Important Habitats for as Aquatic Birds (Ramsar)	Ratified	Ratified	Not Ratified
	International Convention for the Regulation of Whaling	Ratified	Ratified	Not Ratified
	Convention for the Protection of the Ozone Layer	Ratified	Ratified	Ratified

	Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (Nairobi Convention)	Ratified	NA	NA
	Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region	Ratified	Not Ratified	Not Ratified
	SADC Protocol on Mining	Ratified	Ratified	Ratified
	SADC Protocol Related to the Conservation of Fauna and Law Applications	Ratified	Ratified	Ratified
	SADC Protocol on Shared Watercourses	Ratified	Ratified	Ratified
Trade	Convention on International Traffic of exotic species of Fauna and Flora on risk of extinction (CITES)	Ratified	Ratified	Ratified
Pollution	Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, 1972	Ratified	Ratified	Ratified
	International Convention of 1973 for Pollution Prevention caused by Navigation and Protocol of 1978 (MARPOL)	Ratified	Ratified	Ratified
	International Convention on Civil Responsibility and Compensation of Damage Caused by Potentially Harmful and Dangerous Substances at Sea (HNS 96)	Ratified	Not Ratified	Ratified
	Stockholm Convention on Persistent Organic Pollutants (POPs)	Ratified	Ratified	Ratified
	Cartagena Protocol on Bio-safety	Ratified	Ratified	Ratified
	Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	Ratified	Ratified	Ratified
	Protocol on Substances that Deplete the Ozone Layer	Ratified	Ratified	Ratified
	International Convention on Civil Liability for Oil Pollution Damage	Ratified	Ratified	Ratified

It is inevitable that the 7,120,055,900 people who inhabit the planet as of October 2013 will leave their mark.

It is still possible to make individual and collective choices that will result in restoring and sustainably developing the ocean's full potential for present and future generations.