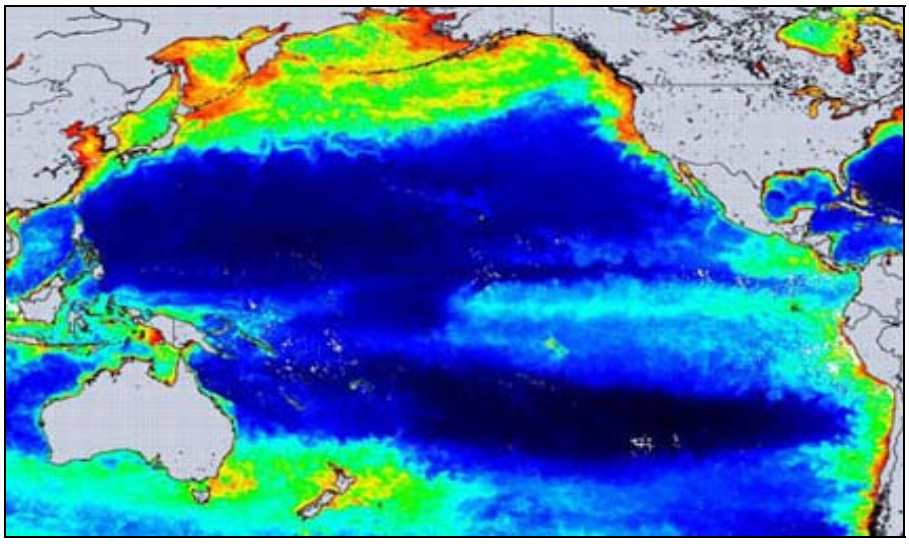
Asia-Pacific
Economic Cooperation

Marine Ecosystem Identification and Mapping in the Asia-Pacific Region

Final Report



APEC Marine Resource Conservation Working Group
September 2008

MRC 03/2007

Printed By:
U.S. Oceanic and Atmospheric Administration
Department of Commerce
14th Street and Massachusetts Avenue, NW
Washington, DC 20205

Produced for:
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace Singapore 119616
Tel: (65) 6891-9600 Fax: (65) 6891-9690
Email: info@apec.org Website: www.apec.org

APEC#208-MR-01.1

Asia-Pacific
Economic Cooperation

Marine Ecosystem Identification and Mapping in the Asia-Pacific Region

Final Report

APEC Marine Resource Conservation Working Group (MRCWG)
September 2008

TABLE OF CONTENTS

List of Figures:

Executive Summary

The Pacific Basin covers over 165 million square kilometers, more than the entire land area of the planet, and supports a wide array of productive and unique ecosystems. Much of the APEC region's economic activity is dependent upon the natural resources and environmental quality of the marine ecosystems of the Pacific Ocean and its nested seas. The challenge for APEC economies is to sustain economic growth while safeguarding and restoring the natural systems that support prosperity.

This project, "Marine Ecosystem Identification and Mapping in the APEC Region," took place under the auspices of the APEC Marine Resources Conservation Working Group (MRCWG), sponsored by the United States and co-sponsored by the People's Republic of China, Mexico, Republic of Korea and the Philippines. Bringing together the results of existing ecosystem management work underway in the region, the project took the initial steps toward examining the marine ecosystems within the meso-scale ocean unit of the APEC region and nested subsystems at other scales. The purpose was to provide APEC economies with an accurate, up-to-date understanding of the marine ecosystems and resources upon which a large portion of their economies depend; and allow them to ensure sustained production potential for goods and services in the region.

The project workshop took place on 14 September 2007, in Qingdao, China, co-chaired by the United States and the People's Republic of China. The workshop was attended by 23 delegates from 10 APEC economies. Building on directives provided by the APEC Bali Plan of Action and Seoul Oceans Declaration, and with the guidance of precedents in the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) and the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem, the group discussed how ecosystem management could be applied in the APEC region, thus producing the findings of this project.

It was determined in the course of this project and during the workshop that a useful scale for considering APEC ecosystems would be equal to approximately 200,000 square kilometers or greater, and would contain smaller, nested subsystems. This area would be large enough to show influences from outside the ecosystem boundaries. For instance, both nitrification and acidification affect herring in the Yellow Sea. The converse is also true, and smaller-scale changes that affect the whole area could also be tracked. Ecological criteria, rather than administrative or political factors, would define the ecosystems, namely 1) bathymetry, 2) hydrography, 3) primary productivity, and 4) trophic linkages. This is already the case in the Humboldt Large Marine Ecosystem (LME), where coastal upwelling, food chains, and El Niño all determine the level of the anchovy stock. Illustrating the wise application of such ecological criteria, the workshop brought out that the Bohai Sea sub-basin has been examined to allow better-informed management of the Yellow Sea ecosystem, though that area is not administratively part of the Yellow Sea.

Based on the factors above, this project produced a map of APEC marine ecosystems that went through several modifications before it became final. Concerning monitoring and assessment indicators to examine the mapped ecosystems, a 5 module approach that includes 1) productivity,

2) fish and fisheries, 3) pollution and ecosystem health, 4) socio-economics, and 5) governance was determined to be useful for adaptive management purposes.

APEC marine ecosystems underpin economic development and facilitate trade in the region and are important to understand to address ecosystem management and marine resource sustainability to meet the socio-economic needs of humans living in the border countries.

After the MRCWG 21 Meeting in Piura, Peru in April 2008, a proposal for Part II of the project was forwarded to the APEC Secretariat that concentrates on assessment, best practices and recommendations for targeted demonstration projects in APEC marine ecosystems. The proposal is listed on the project website at www.edc.uri.edu/lme.

Socio-Economics of APEC Marine Ecosystems

Meeting APEC's objective to facilitate free and open trade, investment, economic development and technical cooperation, this project addresses marine and coastal sustainable economic development concerns and activities in the Asia-Pacific region by providing economic and technical expertise in marine resource conservation. Such expertise is critical given that sustained economic development of marine and coastal resources is a valuable contribution to the region and to the economies' Gross Domestic Products (GDPs). This project supports each economy's ability to facilitate trade, build investments and assets, and achieve further economic development, all based on an understanding of the Asia-Pacific region's ecosystems. The sustainable development of marine resources, tourism, industries, construction, as well as related employment, is the key to generating wealth from private sector investment and trade. As the majority of the world's population lives close to the coast, coastal areas alone contain some of APEC economies' most valuable assets – biological resources, tourism opportunities and other jobs.

The 21 APEC member economies account for approximately 57% of the global GDP, 45% of the global population, 75% of the world's capture fisheries, 90% of world aquaculture production, 70% of the world's global consumption of fish products, and 47% of world trade (Bali Plan of Action). Many of those people live in coastal areas, and much of this economic activity is directly dependent on coasts, estuaries, and oceans. The 2.6 billion people living in the APEC region accounted for approximately 70% of global economic growth between 1989 and 1999 and APEC region includes some of the fastest growing economies in the world. However, much of this economic development has placed additional strain on the natural resources and ecosystem services that support growth. *Nature* has published an estimate that LMEs collectively contribute approximately $12.6 trillion to the global economy (Costanza et al., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260).

Healthy ecosystems are needed to sustain fisheries, and are the basis of providing a safe and adequate supply of seafood for international trade and domestic use. Tourism, transportation, energy development and other activities also occur in the Asia-Pacific region's ecosystems. The value of an ecosystem based management approach is that it supports management for all ecosystem assets, not just for selected resources.

This project improves the capacity of government, the private sector, NGOs, and other segments of society to utilize objective, scientific information to guide more sound economic decisions. The information can be used to prevent economic decisions that do not adequately consider the conditions present in an ecosystem or are based solely on short-term gain; as well as actively direct actions that further the long-term sustainability and productivity of the marine ecosystems. In this way, the APEC region and each economy can make informed choices to fully benefit from the riches of healthy and diverse marine ecosystems.

The strong link between marine resources, trade and investment is demonstrated by the economic valuation of the marine sector in APEC economies. The project MRC 05/2004, "Economic Value of the Marine Sector across APEC Member Economies" produced a report entitled "Summary Record – Round Table Discussion on the Economic Valuation of Marine Sector

Activities Across APEC Economies (Easter Island, Chile, 18 October 2004)" that examined the progress to date on MRC 05/2004. The Summary Record highlighted the available data from past studies, and three profiles of the value of the marine economies in Australia, Canada and the United States were compiled for different years. The values of the marine economies were:

- For Australia (2002-2003), Aus$26.7 billion (3.6% of national gross value added product);
- For Canada (2000), Can$22.7 billion (1.48% of national GDP); and
- For USA (2000), US$118 billion (1.2% of national GDP).

For each APEC member economy, MRC 05/2004 also identified nine components of the marine economy which were considered when arriving at the final economic value of the marine ecosystems. There are a number of other economic benefits, services and potential future industries which were not included in the list due to the difficult nature of measuring their value and the limited nature of MRC 05/2004. The nine components of the marine economy that were considered are:

- Oil and Gas (i.e. minerals)
- Fisheries / Aquaculture (i.e. living resources including sea plants)
- Shipping (i.e. transportation and shipbuilding)
- Defense / Government (i.e. government services)
- Marine Construction (e.g. coastal defenses and restoration)
- Marine Tourism (i.e. leisure services)
- Marine Equipment (i.e. manufacturing)
- Marine Services (e.g. mapping, surveying, consulting)
- Marine Research and Education

In addition to MRC 05/2004, a host of other materials, reports and publications provide illustrative examples of the value of marine ecosystems to APEC member economies, by evaluating the costs of invasive species, oils spills, coastal hazards and Harmful Algal Blooms (HABs) as well as the benefits of tourism and aquaculture.

Invasive Species

An APEC MRCWG Final Report entitled "Development of a Regional Risk Management Framework for APEC Economics for Use in the Control and Prevention of Introduced Marine Pests," offered insight into the marine pest invasion process as well as the costs of eradication. The report estimated that the economic impact of fish pathogens was a loss of US$1.4 billion in the developing countries of Asia alone. Additionally, the report noted specific incidents of pest invasion in Australia, where the *Mytilopsis* species invasion cost over Aus$2 million to eradicate and the black striped mussel threatened the Aus$250 million dollar pearl oyster fishery.

Oil Spills

At the APEC Workshop that took place on Oil Spill Response and Planning on 23 March 2002, information was provided on the recent costs of oil spill remediation in the APEC region. In the welcoming remarks by RADM Liu Tuck Yew, Chief Executive of the Maritime and Port Authority of Singapore, it was noted that the total clean up cost and damages for the October 1997 *Evoikos* spill and the October 2003 *Natuna Sea* spill were approximately US$15 million.

Coastal Hazards
According to the United States National Oceanic and Atmospheric Administration, over 200 tsunami events were observed or caused effects on the coasts of the United States and its territories since 1990. These events caused more than 500 deaths and cost more than US$186 million in damage which included damage to buildings, piers, ferry terminals, and boat harbors. Overall, coastal storms account for 71% percent of recent U.S. disaster losses annually, and each event costs roughly US$500 million. With 14 events in a year, losses can total $7 billion per year (Economic Statistics for NOAA 2006).

Harmful Algal Blooms (HABs)
Estimates of the economic impacts of harmful algal blooms (HABs) in the United States average US$75 million annually over the period 1987-2000, and commercial fishery impacts from HABs, including wild harvest and aquaculture losses, average US$18 million per year (Economic Statistics for NOAA for NOAA 2006).

Tourism
Travel and tourism is the US's largest employer and second largest contributor to the GDP, generating over US$700 billion annually. Beaches are the leading tourist destination, with coastal states earning 85% of all US tourism revenues. Approximately 89.3 million people vacation and recreate along U.S. coasts every year. (Economic Statistics for NOAA). A recent United Nations Environment Programme report indicates that the value of a square kilometer of healthy coral reefs ranges from US$100,000/year in regions away from populated areas to US$600,000/year or more near tourist attractions in Indonesia, US Samoa, Australia, and the Caribbean. A recent APEC MRC project proposal estimates that the highest value for a healthy coral beach in Thailand is US$3.5 million per square kilometer, while the cost for protecting healthy coral reefs is only US$775 per square kilometer (SAKE project proposal in APEC MRC for 2007).

Aquaculture
According to the findings of the APEC MRCWG “Workshop on Environmental Principles and Policies in Aquaculture Administration” held in Chile in September 2004, more than 90% of the world's aquaculture production is carried out and marketed within the APEC region, representing a market value of about US$52 billion dollars in the year 2000.

As evidenced by the socioeconomic information available to date, marine ecosystems are vital to APEC member economies. The Marine Resource Conservation Working Group aims to apply an ecosystem based approach to coastal and marine decision making, to improve cooperation across the APEC region for the responsible care of oceans and coasts, and to develop a clearer understanding of the value of the marine sector. The APEC project Parts 1 and 2 will provide essential scientifically based information for decision makers with a focus on the economic benefits gained from a more sustainable marine resource base. Governance support for ecosystem-based management practices is conducive to stronger trade and investment in the region. The absence of comprehensive, ecosystem-wide marine resource management has major economic and food security implications for the livelihood of coastal communities. Ecosystem-

wide management of marine resources is a long-term means to maintain the living marine resources that benefit the local communities of the APEC economies.

Project Purpose and Methodology

Bringing together the results of existing ecosystem management work underway in the region, this Project took the initial steps toward examining the marine ecosystems at the meso- (LME) scale of the APEC region, including nested subsystems. The purpose is to provide APEC economies with an accurate, up-to-date understanding of the marine ecosystems and resources upon which a large portion of their economies depend; and allow them to ensure sustained production potential for goods and services in the region. The sponsor of this 2007 MRCWG project is the United States, and the People's Republic of China, Mexico, Republic of Korea and the Philippines are co-sponsors.

The Project is consistent with targets and declarations such as the 2005 Bali Plan of Action on ecosystem-based management, the 2002 targets of the World Summit for Sustainable Development, and the 2002 Seoul Oceans Declaration. At the 2005 2nd APEC Oceans-Related Ministerial Meeting, APEC economies agreed upon the Bali Plan of Action (BPA), which reaffirms the APEC commitment to sustainable development and ecosystem-based management, and identifies specific steps that must be taken to achieve these goals. This project addresses the specific mandate in the Bali Plan of Action that

> *"Sustainability of the environment is achieved through a holistic approach, whereby ecosystems are identified and managed as units with a range of interdependent components. There is a need to better understand these systems and manage the impact of human activities on them."*

This holistic approach is needed to address land- and sea-based pollution, marine invasive species, marine debris and derelict fishing gear, and unsustainable farming and harvesting of ocean resources.
The BPA also includes the following guidance:

> *"Develop an agreed set of factors to be applied in defining marine ecosystems in the Asia-Pacific region, and establish a key set of variables to monitor and to assess changes in these ecosystems;"*

The project met this guidance, with the challenge being to select an appropriate way to frame ecosystem-based management in the APEC region, taking into account the appropriate scale for management, as well as the kinds of criteria necessary to map and variables needed to monitor the marine environment. Ultimately, identifying key pollution sources and levels of nitrogen contributing to coastal eutrophication, excessive fishing effort, and the effects of naturally occurring environmental shifts in climate regime, mapping important habitat and trophic linkages, understanding the major environmental and human stressors to marine ecosystems, and building upon existing management successes should allow us to address ecosystem challenges in a comprehensive and integrated manner.

Other Regional and Global Precedents

The use of Ecosystem Based Management (EBM) originated in the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), the first international ocean management regime to use a set of ecological standards to define ecosystems. Additionally, the 2001 Reykjavik Declaration placed importance in furthering EBM for fisheries management, and the 2002 Johannesburg Plan of Implementation went beyond fisheries, calling for substantial reductions in land-based sources of pollution, introducing an ecosystems approach to marine resource assessment and management by 2010, designating a network of marine protected areas by 2012, along with maintaining and restoring fish stocks to maximum sustainable yield levels by 2015.

The Large Marine Ecosystem Approach

Since 1984, the broad ecosystem strategy of the Large Marine Ecosystem (LME) approach has been designed and developed within the United States National Oceanic and Atmospheric Administration (NOAA). The NOAA LME Program has provided the conceptual framework and scientific basis for the delineation of LMEs and the implementation of 16 LME projects involving 110 countries in Asia, Africa, Latin America, the Caribbean, and Eastern Europe. A global map of 64 Large Marine Ecosystems has been produced and is updated yearly (**Figure 1).**

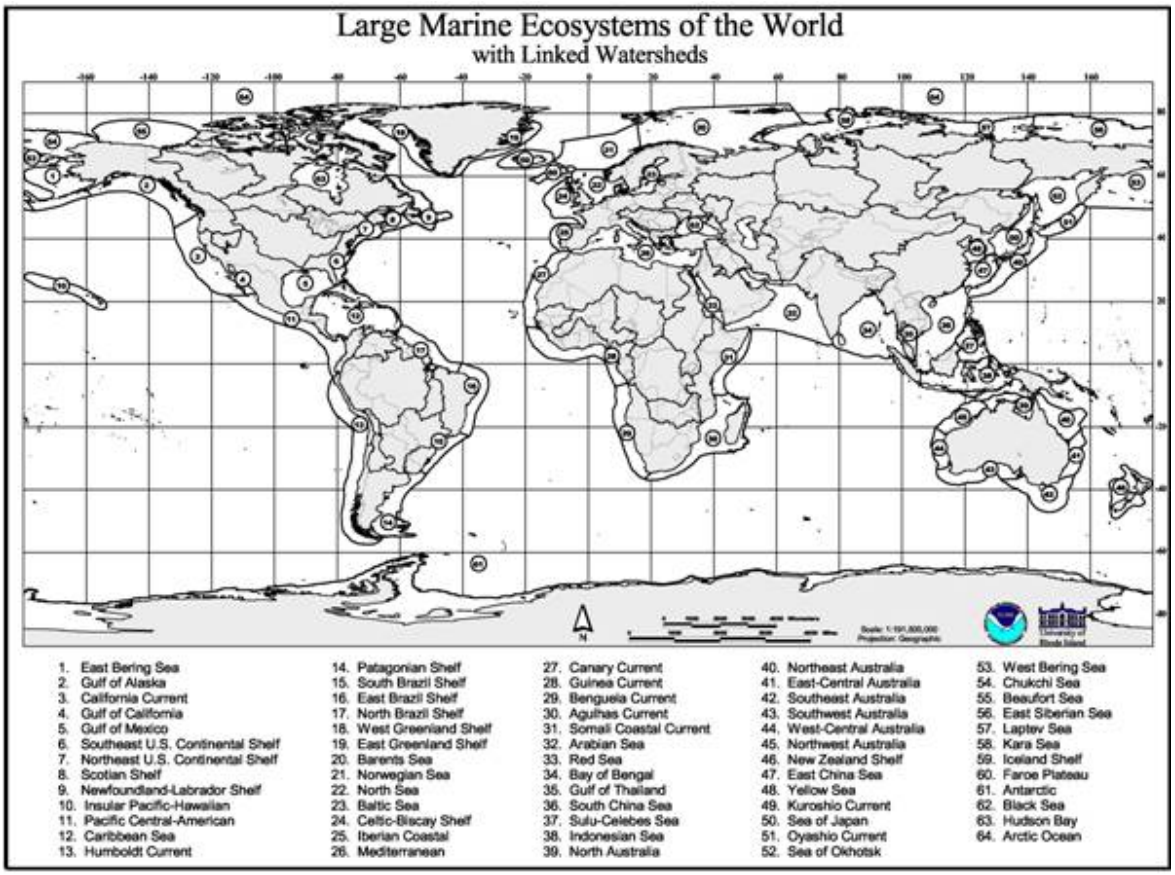


Figure 1. Global Map of 64 Large Marine Ecosystems (LMEs)

Large Marine Ecosystems (LMEs) are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and the outer margins of the major current systems. NOAA has been a leader in the application of the LME approach in the Arctic Region through the Arctic Council's Protection of the Arctic Marine Environment (PAME) program, resulting in the establishment of criteria for ecosystem indicators, the delineation of boundaries, the application of monitoring programs and the production of a map (see **Figure 2** showing the 17 Large Marine Ecosystems of the Arctic Region). This approach is useful in the APEC region, as well, for reasons mentioned in the description on page 1. LMEs provide a comprehensive, integrative, and flexible approach to ecosystem based management at the meso-scale with nested subsystems at other scales.

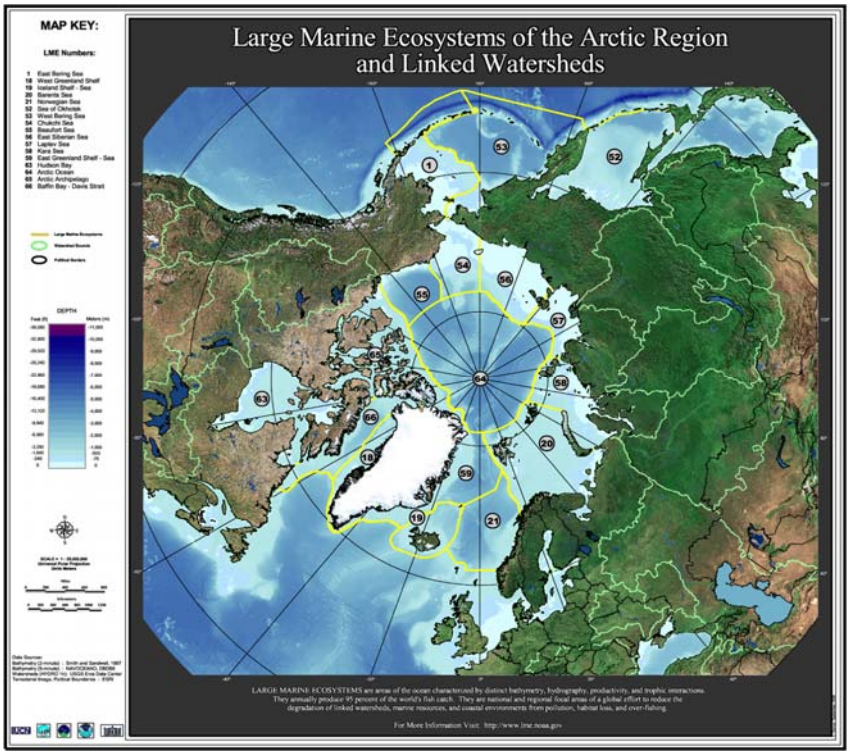


Figure 2. The 17 Large Marine Ecosystems of the Arctic Region

Concerning methodology, this project was modeled on the ecosystem-based approach undertaken for the Arctic region by the eight member states of the Protection of the Marine Environment (PAME). PAME has successfully introduced the ecosystem based approach to the Arctic Council annual planning cycles. The current project is based on the same approach. The eight Arctic Council countries have reviewed and accepted a working map of 17 Arctic LMEs, and the PAME LME working group has started to consider key ecosystem change indicators based on the 5-module LME approach (productivity, fish and fisheries, pollution and ecosystem health, socioeconomics, and governance). The US has been cooperating with other Arctic Council countries in this effort, assisting in the planning of three pilot projects in the West Bering Sea LME, the Barents Sea LME and the Beaufort Sea LME.

The final outcomes of the project include a hard copy and GIS version of the APEC region LME map, in addition to this final report.

Process Undertaken

As the initial phase of the project, a scientific workshop was held in Qingdao, China on 14 September 2007, co-chaired by the People's Republic of China and the United States to discuss identification, mapping and monitoring Large Marine Ecosystems in the Asia-Pacific region. Mr. Thomas L. Laughlin, National Oceanic and Atmospheric Administration (NOAA), United States and Dr. Zhu Mingyuan, State Oceanic Administration (SOA), China, were Co-Chairs of the workshop. The workshop was attended by 23 delegates from the 10 APEC economies of Canada, Chile, People's Republic of China, Indonesia, the Republic of Korea, Mexico, Peru, Thailand, the United States of America, and Viet Nam.

APEC economies were cordially invited to send a representative to the workshop as well as to a preceding 2nd Global Large Marine Ecosystem Conference. The representatives possessed marine policy or scientific expertise in marine ecosystem management for their economy. The participants brought to the workshop an understanding of management of Pacific Ocean areas within their economies, including the scale of various ecosystems, how criteria have been developed and applied to define ecosystems, and what variables have been used to monitor ecosystems.

Building on the directives of the APEC Bali Plan of Action and Seoul Oceans Declaration, and with the guidance of precedents in the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) and the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem, the group discussed how ecosystem management could be applied to the APEC region.

Specifically, the workshop participants discussed: (1) science-based criteria to be used in the identification of marine ecosystems; (2) a set of variables to monitor and assess change; and (3) the creation of a working map of marine ecosystems in the APEC region. The workshop included a discussion of important economic and social data to include in a report concerning APEC marine ecosystems.

After the workshop ended, the project sponsor decided a steering committee was not needed as the workshop participants were pleased at the time to receive and review products. It was determined that no further formality was needed.

Identification of Ecosystems

Discussion of Appropriate Scale

The first major question addressed by the workshop participants was that of scale. It was agreed that it is important to focus on large-scale processes in order to incorporate relationships among species, between species and different environments, and between terrestrial and marine areas. The group discussed the order of magnitude for ecosystems – and noted the utility of the approximately 200,000 square kilometer or greater scale. A key question was raised regarding the value of identifying such a broad area given national-level management, which brought out the point that the LME scale provides a framework for understanding the multiplicity of influences on an ecosystem and its productivity. For example, within the Humboldt Current LME where there is a significant effect of inter-annual climate variability on the anchovy fishery, this variable is being incorporated into models to forecast stock levels, in support of the development of adaptive sustainable fisheries regulations.

It was also emphasized that a "nested" approach is valuable. By nesting smaller, unique subsystems and management units (e.g. watersheds, estuaries, coral reefs) within the larger LME framework, resource management challenges can be addressed at the appropriate level. Further, nesting allows for smaller scale sub-system findings to inform the management of the larger system, and for coordination of local and regional management entities and practices that can conduct EBM at various scales. An example in the Yellow Sea LME is the transboundary resource of herring that is affected by nutrification and acidification -- problems that are addressed at different scales.

The group agreed that even though most management needs to be done locally, the abilities to incorporate both the effects of global and regional forcing on local systems, and vice-versa are a key to successful EBM. The group was comfortable with the equal to or greater than 200,000 square kilometer scale and the concept of area nesting.

Discussion of Criteria Used

Next, the group tackled the issue of determining the appropriate criteria to be used in defining ecosystems. It was agreed that ecological criteria be used in this process. Several members of the group questioned how ecosystems thus defined would mesh with administrative/political boundaries, a question that must be addressed if the ecosystems are to be used as management units. After some discussion, it was agreed that ecosystem units should be defined on the basis of ecological criteria. For purposes of managing human activities, attention should then turn to existing and needed political organizations/instruments covering the defined ecosystem. These organizations and instruments might require coordination or amendment to implement EBM.

The group turned to discussing which specific criteria were most important. Four criteria 1) bathymetry, 2) hydrography, 3) primary productivity, and 4) trophic linkages were proposed as candidates. Several participants cited examples of management initiatives in their economies, and from these accounts, the group was able to see how criteria were applied. For example, in managing Peru's anchovetta fishery, an understanding of coastal upwelling, food chains, and El Niño are critical. The effect of dust storms on primary productivity in the Yellow Sea LME was also mentioned. The group noted the importance of recognizing the characteristics that

differentiate ecosystems from one another -- for example, biodiversity, habitat, degree of enclosure, proximity to land, currents, water temperature and salinity. In generating a framework for defining marine ecosystems, the group agreed that it would be impractical to list all the individual factors that contribute to ecosystem structure and function, and consensus on using the four general criteria emerged. It was also noted that external factors, such as global scale wind patterns, affect ecosystem function, and it was suggested that these be considered in the discussion on monitoring variables.

Mapping of Ecosystems

The next question the group considered was how the agreed-upon set of ecological criteria could be applied to the APEC region. Dr. Zhu (China) presented his work on the Yellow Sea LME, highlighting the importance of scale and nesting for science as well as management. The presentation outlined how primary productivity, bathymetry, and hydrography affect populations of fish, including yellow croaker. Dr. Zhu explained that seasonal shifts in dominant current directions affect fish abundance and migration patterns, thus feeding back into trophic webs.

Significantly, the presentation highlighted the fact that even though cultural and political issues such as the exclusion of the Bohai Sea sub-basin and the absence of neighbouring government participation created practical difficulties, defining the Yellow Sea ecosystem based on ecological criteria allowed for better-informed management. Using a transboundary Diagnostic Analysis (TDA) to better understand the relationship between the Yellow Sea proper and adjacent bodies of water, Dr. Zhu and his colleagues of the Yellow Sea LME project deciphered the ecological role that the Bohai Sea plays.

This case demonstrated the utility and ease of keeping ecosystem definitions unaffected by administrative or project boundaries, and being mindful of the larger processes at work. It was very useful to be able to look at the entire ecosystem to understand the effects on the area of study. The documentation and dissemination of this finding, in particular, can further the ecosystem approach by informing the selection of future project site definitions, management tools, and jurisdictional boundaries.

APEC LME Map

A working map of delineated LMEs for the APEC region was presented by Dr. Sherman (United States), and a discussion ensued on how the boundary lines were drawn. An LME conference had taken place in 1994 to conduct peer review of case studies in the region, and the result was the original LME map. Since then, scientific assessments have been conducted in accordance with the LME framework in 16 funded projects. A yearly LME consultative committee meeting reviews the global LME map based upon new evidence. Dr. Sherman provided an overview of the LMEs of the APEC region, noting scientific characteristics and whether any government or GEF activities were taking place.

Discussion turned to the working map. It was agreed that further work was needed to describe the area north of Papua New Guinea, and that Oceania should not be included as it is not part of APEC. The group proposed several modifications to the working map: 1) deleting Antarctica;

2) adding the Australian west coast LMEs; 3) adding the Bay of Bengal LME; and 4) changing the title to reflect the APEC region. The modifications were incorporated and the working map with the changes thus far is shown in **Figure 3**.

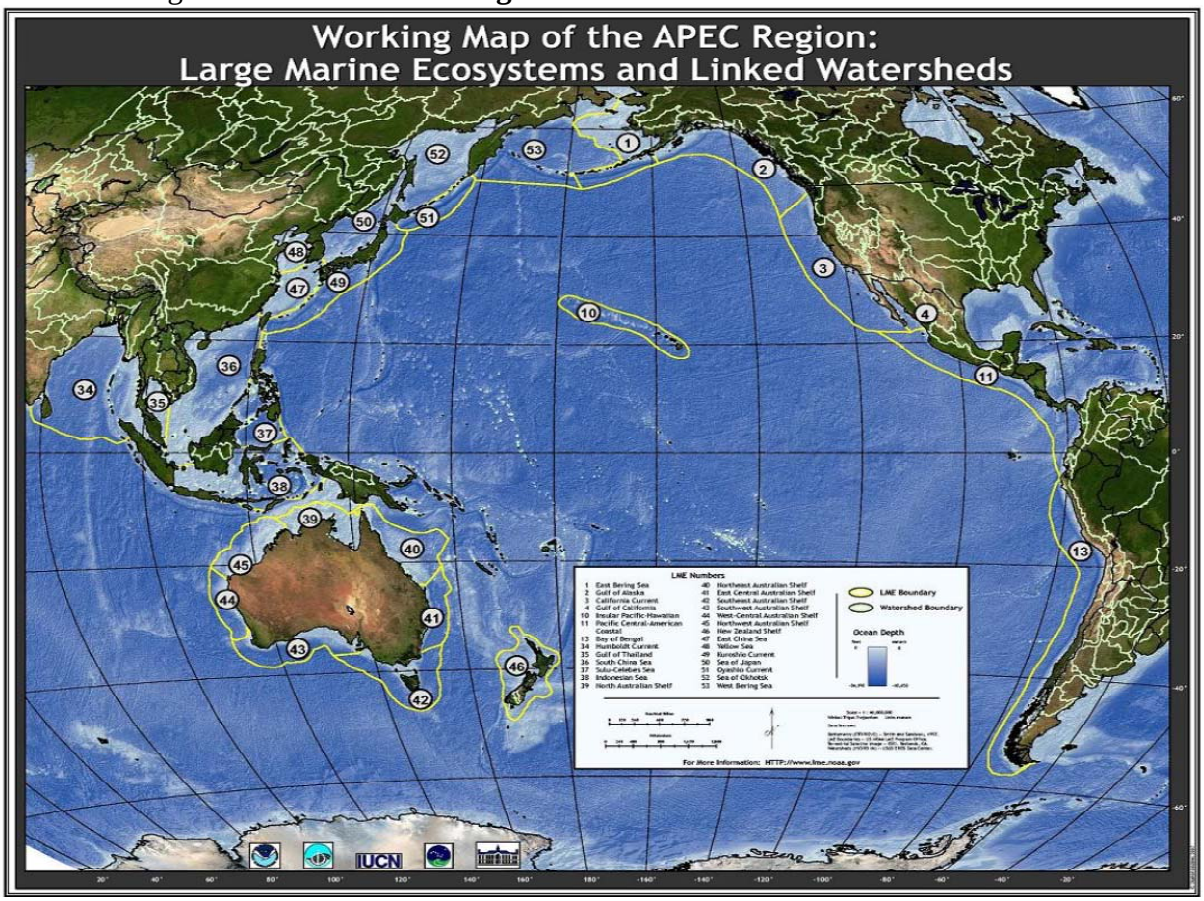


Figure 3. The APEC Large Marine Ecosystems Map

Monitoring of Ecosystems

Several organizing concepts were presented by Dr. Sherman (United States), with the foremost being the five indicator modules used in the LME approach – 1) productivity, 2) fish and fisheries, 3) pollution and ecosystem health, 4) socio-economics, and 5) governance. The group considered using these in the APEC region and whether they covered all factors to be examined. One comment was that these generic "baskets" were a useful structure for adaptive management. On the question of whether each economy would be required to monitor all of these, it was noted that this was just an illustrative list to guide efforts and policy discussions. The group discussed a figure illustrating the five LME modules with suites of condition indicators for each module (**Figure 4**). Mammals could be monitored under fish and fisheries, within biodiversity. Habitat could be examined under fish and fisheries, also. Inorganic pollutants would be included as pollution and ecosystem health indicators. Governance was interpreted as laws, institutions, public participation and markets. The group was invited to have further discussions on the utility of the figure.

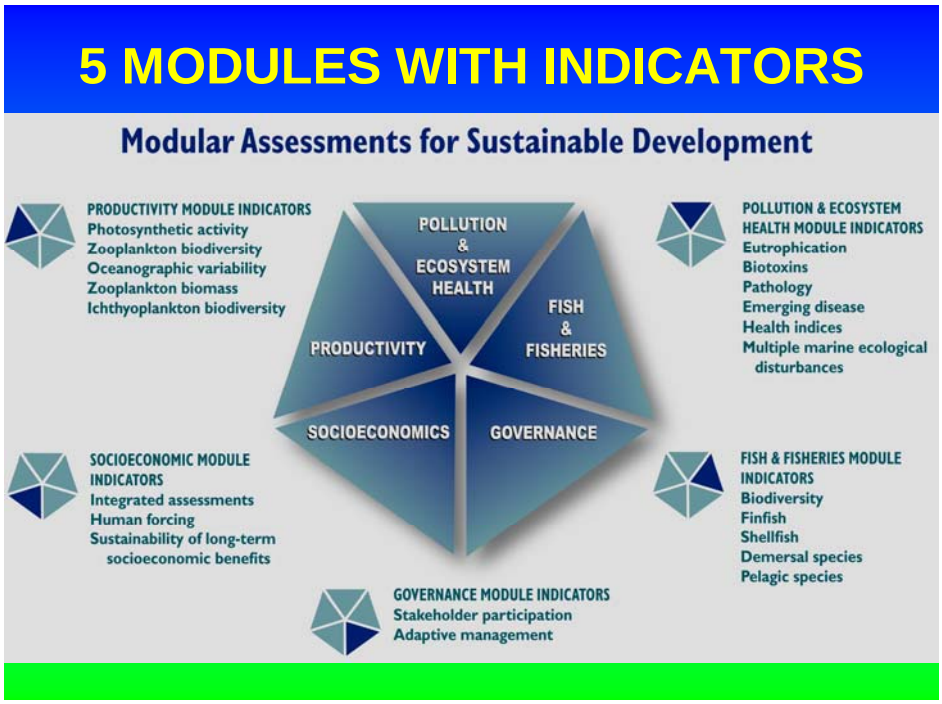


Figure 4. Five LME Modules with suites of condition indicators

The group also considered three goals important to ecosystem based management: to reduce coastal pollution (1), restore damaged habitats (2), and recover depleted fishing stocks (3), which will be explored further in the final report, along with why the LME framework is useful in addressing them. Five principal causes of ecosystem degradation (ecosystem drivers) -- 1) fishing, 2) pollution, 3) mechanical habitat destruction, 4) introductions, and 5) climate change were weighed, with an eye to using these to examine whether things are getting better or worse in APEC ecosystems.

Next Steps for Part II of the Project

Part I of this project laid the groundwork by producing a map of the APEC ecosystems and identifying indicators and variables to monitor. Part II of this project was proposed at the MRCWG 21 Meeting in Piura, Peru in April 2008, and aims to provide APEC economics with the opportunity to continue to build their understanding of marine ecosystems and resources. The overall approach will focus on the economic benefits gained from a more sustainable resource base, upon which a large portion of APEC economies depend, and will also provide stakeholders and stewardship interests with legal and administrative support for ecosystem-based management practices. In Part II, economy policy-makers and scientific experts will use LME information sources to prepare a desk-top assessment, which will include an ecosystem assessment of the APEC region as well as a recommended approach to the best assessment and management practices. A scientific workshop will also be undertaken late in the first year, in conjunction with another planned event that involves ecosystem policy-makers and scientists. The workshop will explore the findings contained in the products of this two part project including: the marine ecosystems map produced in Part 1, and the ecosystem assessment and recommended approach to best assessment and management practices produced in this Part 2. The workshop will discuss how APEC economies can utilize these products, including making recommendations for targeted work to improve marine ecosystem sustainability and productivity, as well as identifying opportunities for possible future pilot projects based on the findings and available funding.

Project Steps

Scientific/Management Work

Economy policy-makers and scientific experts will use LME information sources to prepare a desk-top assessment of the region. The following steps will be taken:

1) Conduct an information inventory to come up with an existing baseline for the 27 LMEs in the APEC region. This will be a desk-top exercise that will not require additional scientific inquiry.

2) Consider the five suites of indicators (variables), as guided by the LME five-module indicator approach and discussed at the Qingdao workshop (September 2007), and measure these against this baseline.

3) Identify pertinent strategies for assessing and improving ecosystem conditions based on best practice approaches.

As a guide, the project overseer and other experts will compile an inventory of existing ecosystem-based approaches and projects in use in the APEC region. This will contribute to a "best practices" discussion at the second workshop, and guide the development of additional projects.

2nd Workshop

There will be a 2nd workshop for APEC economies, perhaps in spring 2009, that will take place in conjunction with another planned event that involves ecosystem policy-makers and scientists.

This overlap will strengthen linkages to the larger scientific community and be cost-efficient. Using the products produced between the sessions and meetings, the participants will:

1) Explore the findings contained in the three products – the map produced in Part 1 of this project, the assessment, and the strategy based on best practices in already-implemented LME projects. Discussion will help identify areas and issues needing to be prioritized and addressed.

2) Plan how the APEC economies and regional organizations will utilize these products to ensure productive and sustainable ecosystem services.

3) Identify opportunities for three demonstration projects/pilot studies based on the findings; and opportunities for international donors to fund this and larger endeavors.

Final Report

The Project Overseer will be responsible for a final report on an assessment of the ecosystems of the APEC region, a strategy based on best practices, and recommendations for projects that focus on ecosystem-based strategies that provide countries with a sustainable marine resource base that can meet the nutritional, social, economic, and developmental needs of humans living in the APEC economies. Hard copies of the report will be distributed to the MRCWG representatives and other beneficiaries. The report also will be available on disk and be downloadable from a website which is to be developed along with this project.

APPENDIX A—Summary Record of Qingdao Workshop

ASIA PACIFIC ECONOMIC COOPERATION
Marine Resource Conservation Working Group (MRCWG)

Workshop on Marine Ecosystem Identification and Mapping in the Asia-Pacific Region
Co-chaired by the United States and China
14 September 2007, Qingdao, China

SUMMARY RECORD OF WORKSHOP

The workshop on Marine Ecosystem Identification and Mapping in the APEC Region was held on 14 September 2007 in Qingdao, China, attended by 23 delegates from 10 APEC economies: Canada, Chile, People's Republic of China, Indonesia, the Republic of Korea, Mexico, Peru, Thailand, the United States of America, and Viet Nam.

Mr. Thomas L. Laughlin, National Oceanic and Atmospheric Administration (NOAA), United States and Dr. Zhu Mingyuan, State Oceanic Administration (SOA), China, were Co-Chairs of the workshop.

Opening Remarks

Mr. Liu (China) opened the workshop noting the high level of APEC activity and impact in the world as evidenced by the Leaders meeting in Sydney in September 2007. Mr. Liu noted that it was beneficial that APEC was undertaking activities regarding the region's marine ecosystems, and that assessing and taking further steps would be very relevant. The Large Marine Ecosystem (LME) concept has been well accepted in this regard. He noted that the First Institute of Oceanography, SOA would be pleased to contribute to the effort.

Dr. Huh (Korea - project co-sponsor) noted that the 2002 World Summit on Sustainable Development (WSSD) reaffirmed the great importance of the oceans and that it has become a central agenda of the 21st Century. A radical shift in thinking is taking place on how marine ecosystems are managed, and collective efforts are being made on the sustainability of the ocean. This is bringing forward ecosystem-based management (EBM) of living marine resources for sustainable development. He noted the relevance and timeliness of the workshop, underscoring the importance of cooperative activities to address human activities and ecosystem changes. He saw the workshop as a great opportunity to come up with tangible solutions for economies to undertake regarding APEC's marine ecosystems.

Dr. Diaz de Leon Corral (Mexico - project co-sponsor) recalled both APEC Ocean Ministerials and the resulting Seoul Oceans Declaration (SOD) and Bali Plan of Action (BPA). Dr. Diaz de Leon noted the BPA's three main objectives, stating that these were the framework of the

workshop. He added that Mexico, with its 5 LMEs, is an advocate of the approach. He raised concerns regarding the tsunami early warning system that is noted in the BPA, emphasizing that, regrettably, there still are only two deep-ocean buoys in the Indian Ocean. Mexico, taking the threat of tsunamis seriously, has visited the NOAA/NWS/National Data Buoy Center to learn how to build an observing system, a feature that also would be useful in mapping ecosystems. He asked all economies to consider this need for action.

Overview Presentation

Mr. Laughlin (United States) provided a brief presentation outlining major international efforts toward EBM of the oceans. EBM's use originated in the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), the first international ocean management regime to use a set of ecological standards to define ecosystems. He also touched on the 2001 Reykjavik Declaration's importance in furthering EBM for fisheries. He noted that the 2002 Johannesburg Plan of Implementation goes beyond fisheries, calling for a broader commitment to ecosystem-based assessment and management by 2010. Specific to APEC, the group was reminded that: 1) the SOD highlighted the transboundary implications of the EBM approach; 2) Australia held an EBM workshop in 2003; and 3) in the BPA, ecosystems are identified as management units. After this brief history, the presentation ended with a series of questions designed to frame and encourage discussion on how to begin applying EBM principles in the APEC region.

Scale

The first major question addressed by the workshop participants was that of scale. It was agreed that it is important to focus on large-scale processes in order to incorporate relationships among species, between species and different environments, and between terrestrial and marine areas. The group discussed the order of magnitude for ecosystems – and noted the utility of the 200,000 square kilometer scale. A key question was raised regarding the value of identifying such a broad area given national-level management, which brought out the point that the LME scale provides a framework for understanding the multiplicity of influences on an ecosystem and its productivity. For instance, in the Humboldt Current where there is a tremendous effect of interannual climate variability on the anchovy fishery, this variable can be incorporated into models that forecast stock levels, allowing development of adaptive regulations.

It was also emphasised that a "nested" approach is valuable. By nesting smaller, unique systems and management units (e.g. watersheds, estuaries, coral reefs) within the larger framework, resource management challenges can be addressed at the appropriate level. Further, nesting allows for smaller scale system findings to inform management of the larger system, and for coordination of local and regional management entities and practices that can conduct EBM at various scales. An example is the transboundary resource of herring in the Yellow Sea LME that is affected by nutrification and acidification -- problems that are addressed at different scales.

The group agreed that even though most management needs to be done locally, the abilities to incorporate both the effects of global and regional forcings on local systems, and vice-versa are a

key to successful EBM. The group was comfortable with the 200,000 square kilometer scale and the concept of nesting.

Criteria

Next, the group tackled the issue of determining the appropriate type of criteria to be used in defining ecosystems. It was agreed that ecological criteria be used in this process. Several members of the group questioned how ecosystems thus defined would mesh with administrative/political boundaries, a question that must be addressed if the ecosystems are to be used as management units. After some discussion, it was agreed that ecosystem units should be defined on the basis of ecological criteria. For purposes of managing human activities, attention should then turn to existing and needed political organizations/instruments covering the defined ecosystem. These organizations/instruments might require coordination or amendment to enable EBM.

The group turned to discussing which specific criteria were most important. The criteria 1) bathymetry, 2) hydrography, 3) primary productivity, and 4) trophic linkages were proposed as candidates. Several participants cited examples of management initiatives in their economies, and from these accounts, the group was able to see how criteria were applied. For example, in managing Peru's anchovetta fishery, an understanding of coastal upwelling, food chains, and El Nino are critical. The effect of dust storms on primary productivity in the Yellow Sea LME was also mentioned. The group noted the importance of recognizing the characteristics that differentiate ecosystems from one another -- for example, biodiversity, habitat, degree of enclosure, proximity to land, currents, water temperature and salinity. In generating a framework for defining ecosystems, the group agreed that it would be impractical to list all the individual factors that contribute to ecosystem structure and function, and consensus on using the four general criteria emerged. It was also noted that external factors, such as global scale wind patterns, affect ecosystem function, and it was suggested that these be considered in the monitoring variables discussion.

Application of Criteria

The next question the group considered was how the agreed-upon set of ecological criteria could be applied to the APEC region. Dr. Zhu (China), presented his work in the Yellow Sea LME, highlighting the importance of scale and nesting for science as well as management. The presentation outlined how primary productivity, bathymetry, and hydrography affected populations of fish, including yellow croaker. Dr. Zhu explained that seasonal shifts in dominant current directions affected fish abundance and migration patterns, thus feeding back into trophic webs.

Significantly, the presentation highlighted the fact that even though cultural and political issues such as the exclusion of the Bohai Sea sub-basin and the absence of neighbouring government participation created practical difficulties, defining the Yellow Sea ecosystem based on ecological criteria allowed for better-informed management. Using a transboundary Diagnostic Analysis (TDA) to better understand the relationship between the Yellow Sea proper and

adjacent bodies of water, Dr. Zhu and his colleagues of the Yellow Sea LME project deciphered the ecological role that the Bohai Sea plays.

This case demonstrated the utility and ease of keeping ecosystem definitions unaffected by administrative or project boundaries, and being mindful of the larger processes at work. It was very useful to be able to look at the entire ecosystem to understand the effects on the area of study. The documentation and dissemination of this finding, in particular, can further the ecosystem approach by informing the selection of future project site definitions, management tools, and jurisdictional boundaries.

Mapping

A working map of delineated LMEs for the APEC region was presented by Dr. Sherman (United States) and a discussion ensued on how the boundary lines were drawn. A conference had taken place in 1994 to conduct peer review of case studies in the region, and the result was the original LME map. Since then, there have been many scientific assessments within the general LME framework, and every year, a workshop is held to revise the map based upon new evidence. Dr. Sherman provided an overview of the APEC region LMEs, noting scientific characteristics and whether any government or GEF activities were taking place.

Discussion turned to the working map. It was agreed that further work was needed to describe the area north of Papua New Guinea, and that Oceana should not be included as it is not part of APEC. The group proposed several modifications to the working map: 1) deleting Antarctica; 2) adding the Australian west coast LMEs; 3) adding the Bay of Bengal LME; and 4) changing the title to reflect the APEC region. The issue of inserting and/or making the inland watershed boundary lines clearer was raised, thus, technical work will be undertaken. There will be several more comment rounds on the map.

Monitoring and Assessment

Several organizing concepts were presented by Dr. Sherman (United States), with the foremost being the five indicator modules used in the LME approach – 1) productivity, 2) fish and fisheries, 3) pollution and ecosystem health, 4) socio-economics, and 5) governance. The group considered using these in the APEC region and whether they covered all factors to be examined. One comment was that these generic "baskets" were a useful structure for adaptive management. On the question of whether each economy would be required to monitor all of these, it was noted that this was just an illustrative list to guide efforts and policy discussions. The group discussed a monitoring module figure with illustrative sub-categories under the five indicators (**Figure 4**). Governance was interpreted as laws, institutions, public participation and markets. The group was invited to have further discussions on the utility of the figure.

The group also considered three goals -- 1) reduce coastal pollution, 2) restore damaged habitats, and 3) recover depleted fishing stocks – which will be explored further in the final report, along with why the LME framework is useful in addressing them. Five principal causes of ecosystem degradation -- 1) fishing, 2) pollution, 3) mechanical habitat destruction, 4) introductions, and 5)

climate change were weighed, with an eye to using these to examine whether things are getting better or worse in APEC ecosystems.

Project Final Report and Steering Committee

Ms. Denning (United States) provided a draft outline of the project final report for comment. Following on a comment by Dr. Huh (Korea) on describing the usefulness of ecosystems, the idea of including socio-economics was posed given APEC's purpose of facilitating open trade and investment and encouraging economic and technical cooperation. APEC coastal areas alone contain some of the region's most valuable assets, as well as population. A point was raised that such socio-economic data were mandatory given the APEC context and should be highlighted up front. Further, Nature has published an estimate that LMEs collectively contribute $12.6 trillion to the global economy and a figure for the APEC region could be derived.

The idea of an open-ended Steering Committee of approximately 10 members was presented to the group. Its purpose would be to apply expertise to products (e.g. final report and map) and be involved in forwarding Part II of the project on monitoring and assessment to the APEC MRCWG. A draft Terms of Reference for the committee was presented and there were no comments. Economies were welcomed to express interest in the committee.

Closing

In closing, Dr. Zhu (China) stated that the 21st Century is the ocean century. Sustainable development of the coasts is very important, as 40% of China's GDP is in those areas. A 30% decline in fisheries by the year 2020 is predicted that would result in a shortage of 10 million pounds (over 4.5 million KG) of seafood. He stated that the LME approach provides an opportunity to solve problems such as these.

Dr. Diaz de Leon Corral (Mexico) provided a presentation on how Mexico is working on regionalization in ocean policy by applying the LME approach in the Gulf of California LME. Pressures on the coasts were mapped and a vulnerability index of pressure and fragility was constructed. Rigorous agency processes, public participation, and application of scientific and customary knowledge were essential in the process.

Mr. Laughlin (United States) thanked the group for their valuable contributions and closed the meeting.

Figure 5. Participants in the Qingdao Workshop

APPENDIX B—Qingdao Workshop participants

Participant List – APEC Marine Ecosystem Workshop – September 14, 2007						
Economy and Participant	**Organization**	**Title**	**Phone**	**Email**	**Fax**	**Address**
Canada						
Sauve, Mrs. Renee	Fisheries and Oceans Canada	A/Director, International Oceans and Biodiversity Policy	613-991-6740	sauver@dfo-mpo.gc.ca	613-990-9574	200 Kent Street, Station 14W095, Ottawa, ON K1A 0E6 Canada
Chile						
Moreno, Ms. Paula	Marine Biogeochemistry Laboratory, Catholic University of Valparaiso	Graduate Researcher	56-32-2274266	paula.moreno.s@mail.ucv.cl	56-32-2274206	Laboratorio de Biogeoquímica Marina, Pontificia Universidad Católica de Valparaíso, Casilla # 1020, Valparaíso Chile
China						
Chen, Dr. Shang	First Institute of Oceanography, SOA	Research Professor	86 532 8896 7476	qdcs@163.com	86 532 8896 7548	6 Xianxialing Road Laoshan District Qingdao 266061 China

Jin, Dr. Xianshin	Yellow Sea Fisheries Research Institute, CAFS	Director of Fishable Resources and Ecosystem Management Division	86 532 85849430	jin@ysfri.ac.cn	86 532 85849430	106 Nanjing Road Qingdao 266071 China
Liu, Dr. Baohua	First Institute of Oceanography, SOA	Research Scientist	86 532 8896 7468		86 532 8896 5544	6, Xianxialing Road, Hi-Tech Industrial Park Qingdao, Shandong 266061 China
Tang, Ms. Dongmei	Department of International Cooperation, SOA	Program Officer	86 10 6804 7671	tdm@soa.gov.cn	86 10 6804 8051	1 Fuxingmenwai Street Beijing 100860 China
Tan, Gong-Ke	Office of International Affairs, First Institute of Oceanography, SOA	Director	86 532 8896 5290	gongke_tan@fio.org.cn	86 532 8896 75 48	6, Xianxialing Road, Hi-Tech Industrial Park Qingdao, Shandong 266061 China
Ye, Dr. Shufeng	East China Sea Environmental Monitoring Center, SOA	Senior Engineer	86 21 51095863 ext. 8403	ysf6@vip.sina.com	86 21 58673946	630 Dongtang Road, Pudong New District Shanghai 200137 China
Zhu, Dr. Mingyuan	First Institute of Oceanography, SOA	Professor	86 532 88967447	myzhu@public.qd.sd.cn	86 532 88967548	6 Xianxialing Road, Hi-Tech Industrial Park Qingdao, Shandong 266061 China

Indonesia						
Napitu, Ms. Amsi	Center for Ocean Research and Monitoring	Researcher	62-36544266	asminapitu@ppk.itb.ac.id	62-36544278	Br. Dangin Berawah, Perancak, Bali – Indonesia
Korea						
Huh, Dr. Hyung Tack	Korea Ocean R&D Institute		82-31-400-6201	hthuh@kordi.re.kr	82-31-408-5934	P.O. Box Ansan 29 Seoul 426-744, Korea
Mexico						
Diaz de Leon Corral, Dr. Antonio J.	Secretaria de Medio Ambiente y Recursos Naturales (SEMARNAT)	Director Gen. de Política Ambiental e Integración Regional y Sectorial	(+5255) 5628 07 49, 5628 07 50	adiazdeleon@semarnat.gob.mx	(5255) 5628 0750	Blvd. Adolfo Ruíz Cortines No. 4209 Fracc. Jardines en la Montaña CP. 14210, México D.F.
Peru						
Guevara-Carrasco, Mr. Renato	Instituto del Mar (IMARPE)	Scientific Director	511 4535053	rguevara@imarpe.gob.pe	511 4535053	Esq. Gamarra y Valle S/N Chucuito, Callao PERU
Soldi, Admiral Hector	Instituto del Mar (IMARPE)	President, Peru Fisheries Institute	00511 4296600	presidencia@imarpe.gob.pe	00511 4293931	Esq. Gamarra y Gral Valle S/N. Chucuito, Callao PERU

Thailand						
Khokiattiwong, Dr. Somkiat	Department of Marine and Coastal Resources	Senior Researcher	66-76-391128	somkiat@e-mail.in.th	66-76-391127	Phuket Marine Biological Center P.O.Box 60, Phuket 83000 Thailand
Phongsuwan, Mr. Niphon	Phuket Marine Biological Center	Researcher	076-391128	niphonph@gmail.com	076-391127	51 Sakdidet Rd. Muang District, Phuket, 83000 Thailand
United States						
Aquarone, Dr. Marie-Christine	NOAA-NEFSC		1-401-782-3288	mc.aquarone@noaa.gov	1-401-782-3201	Narragansett Laboratory, 28 Tarzwell Drive Narragansett, RI 02882
Cyr, Dr. Ned	NOAA-Fisheries	Supervisory Biologist	(301) 713-2363 ext. 159	Ned.Cyr@noaa.gov	(301) 713-1875	NOAA/NMFS HQ Bldg. SSMC3, Rm. 12555, 1315 East-West Highway Silver Spring, MD 20910-3282
Denning, Ms. Elaine	NOAA-OIA	International Affairs Specialist	(202) 482-2652	elaine.j.denning@noaa.gov	(202) 482-4307	1401 Constitution Ave, NW Washington, DC 20230
Laughlin, Mr. Thomas L.	NOAA-OIA	Deputy Director, International	(202) 482-5118	tom.laughlin@noaa.gov	(202) 482-4307	1401 Constitution Ave, NW Washington, DC

		Affairs				20230
Sherman, Dr. Kenneth	NOAA-NEFSC	DRO, Narragansett Laboratory	1-401-782-3211	kenneth.sherman@noaa.gov	1-401-782-3201	Narragansett Laboratory, 28 Tarzwell Drive Narragansett, RI 02882
Strickler, Mr. Matthew	NOAA-OIA	Sea Grant Fellow	(202) 482-5144	matthew.strickler@noaa.gov	(202) 482-4307	1401 Constitution Ave, NW Washington, DC 20230
Viet Nam						
Nguyen Quang, Mr. Hung	Research Inst. for Marine Fisheries	Department Head	(+84)31.3767277	nqhung@rimf.org.vn	(+84)31.3836812	224, Lelai, Ngo Quyen, Haiphong, Viet Nam

MRC 03/2007

Printed By:
U.S. Oceanic and Atmospheric Administration
Department of Commerce Printing Service
14th Street and Massachusetts Avenue, NW
Washington, DC 20205

Produced for:
Asia-Pacific Economic Cooperation Secretariat
35 Heng Mui Keng Terrace Singapore 119616
Tel: (65) 6891-9600 Fax: (65) 6891-9690
Email: info@apec.org Website: www.apec.org

APEC#208-MR-01.1