

A global approach for recovery and sustainability of marine resources in Large Marine Ecosystems

by Kenneth Sherman and Alfred M. Duda

Large Marine Ecosystems

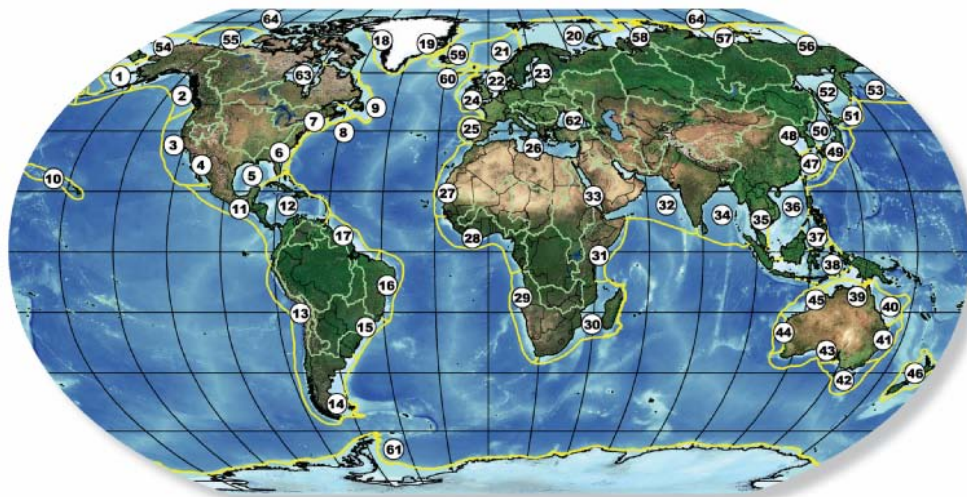
Large Marine Ecosystems (LMEs) are natural regions of ocean space encompassing coastal waters from river basins and estuaries to the seaward boundary of continental shelves and the outer margins of coastal currents. They are relatively large regions of 200,000 km² or greater, the natural boundaries of which are based on four ecological criteria: bathymetry, hydrography, productivity, and trophically-related populations (Sherman, 1994; Sherman and Duda, 2005). The LMEs are areas of the world oceans most stressed from habitat degradation, pollution, and over-exploitation of marine resources. Ninety percent of the usable annual global biomass yield of marine fish and other living marine resources is produced in 64 LMEs (Fig. 1) identified within, and in some cases extending beyond, the boundaries of the exclusive economic zones of coastal nations located around the margins of the ocean basins (Sherman, 1994; Garibaldi and Limongelli, 2003).

Levels of primary production are persistently higher around the margins of the ocean basins, within the boundaries of the LMEs, than in the open-ocean pelagic areas (Fig. 2).

Urban centers with high population density characterize many of these coastal ocean areas, and contribute to nutrient over-enrichment that has its greatest impact on natural productivity cycles through eutrophication, anoxic conditions, and dead zones from high levels of nitrogen and phosphorus effluent from estuaries (Kroeze and Seitzinger, 1998). Toxins in poorly treated sewage discharge, harmful algal blooms, and loss of wetland nursery areas to coastal development are ecosystem-level problems that also need to be addressed (GESAMP, 1990).

Since 1995, the Global Environment Facility (GEF) has provided substantial funding to support country-driven projects for introducing multi-sectoral ecosystem-based assessment and management practices for LMEs located around the margins of the oceans. At present, 116 developing countries and countries in economic transition are engaged in the preparation and implementation of GEF-LME projects, totaling US\$650 million in start-up funding. A total of 16 projects including 85 countries have been approved by the GEF Council, and another 9 GEF international waters projects involving an additional 31 countries are under preparation (www.iwlearn.net).

Large Marine Ecosystems of the World and Linked Watersheds



- | | | | | | |
|-------------------------------------|-------------------------|---------------------------|--|----------------------|------------------|
| 1 East Bering Sea | 13 Humboldt Current | 25 Iberian Coastal | 37 Sulu-Celebes Sea | 48 Yellow Sea | 60 Faroe Plateau |
| 2 Gulf of Alaska | 14 Patagonian Shelf | 26 Mediterranean Sea | 38 Indonesian Sea | 49 Kuroshio Current | 61 Antarctic |
| 3 California Current | 15 South Brazil Shelf | 27 Canary Current | 39 North Australian Shelf | 50 Sea of Japan | 62 Black Sea |
| 4 Gulf of California | 16 East Brazil Shelf | 28 Guinea Current | 40 Northeast Australian Shelf-
Great Barrier Reef | 51 Oyashio Current | 63 Hudson Bay |
| 5 Gulf of Mexico | 17 North Brazil Shelf | 29 Benguela Current | 41 East-Central Australian Shelf | 52 Okhotsk Sea | 64 Arctic Ocean |
| 6 Southeast U.S. Continental Shelf | 18 West Greenland Shelf | 30 Agulhas Current | 42 Southeast Australian Shelf | 53 West Bering Sea | |
| 7 Northeast U.S. Continental Shelf | 19 East Greenland Shelf | 31 Somali Coastal Current | 43 Southwest Australian Shelf | 54 Chukchi Sea | |
| 8 Scotian Shelf | 20 Barents Sea | 32 Arabian Sea | 44 West-Central Australian Shelf | 55 Beaufort Sea | |
| 9 Newfoundland-Labrador Shelf | 21 Norwegian Shelf | 33 Red Sea | 45 Northwest Australian Shelf | 56 East Siberian Sea | |
| 10 Insular Pacific-Hawaiian | 22 North Sea | 34 Bay of Bengal | 46 New Zealand Shelf | 57 Laptev Sea | |
| 11 Pacific Central-American Coastal | 23 Baltic Sea | 35 Gulf of Thailand | 47 East China Sea | 58 Kara Sea | |
| 12 Caribbean Sea | 24 Celtic-Biscay Shelf | 36 South China Sea | | 59 Iceland Shelf | |

Fig. 1 Global map showing 64 LMEs and linked watersheds.

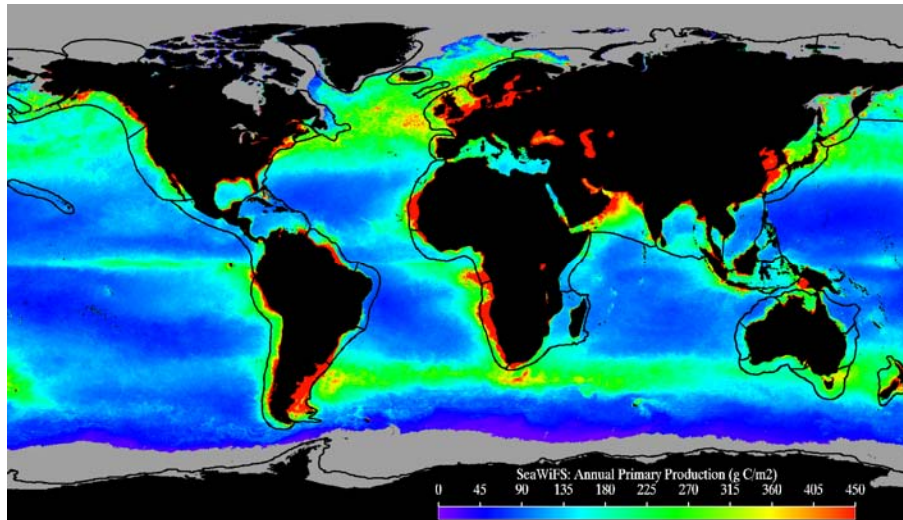


Fig. 2 Global map showing 64 Large Marine Ecosystems (LMEs) and their estimated average annual productivity. Estimates are based on SeaWiFS satellite data collected between September 1998 and August 1999, and the model developed by M. Behrenfeld and P.G. Falkowski (Limnol. Oceanogr. 1997, 42(1): 1–20). The color-enhanced image (provided courtesy of Rutgers University) depicts a shaded gradient of primary productivity from a high of $450 \text{ gCm}^{-2}\text{yr}^{-1}$ in red to less than $45 \text{ gCm}^{-2}\text{yr}^{-1}$ in purple.

A five-module indicator approach to assessment and management of LMEs has proven useful in ecosystem-based projects in the United States, and GEF-supported projects elsewhere (Fig. 3). The modules are adapted to LME conditions through a transboundary diagnostic analysis process to identify key issues and a strategic action program development process for the groups of nations or states sharing an LME to remediate the issues (Wang, 2004). These processes are critical for integrating science into management in a practical way, and for establishing appropriate governance regimes. In a number of these projects, science advisory bodies are utilized to continue providing a science base for management decision-making.

The GEF-LME projects presently funded or in the pipeline for funding in Africa, Asia, Latin America, and Eastern Europe represent a growing network of marine scientists, marine managers, and ministerial leaders who are pursuing

ecosystem and fishery recovery goals. The annual fisheries biomass yields from the ecosystems in the network are significant, at 44.8% of the global total, and are a firm basis for movement by the participating countries toward the 2002 World Summit on Sustainable Development (WSSD) targets for introducing ecosystem-based assessment and management by 2010, and for recovering depleted stocks and achieving fishing at maximum sustainable yield (MSY) levels by 2015 (Sherman, 2006). The Food and Agriculture Organization of the United Nations (FAO) Code of Conduct for Responsible Fishery Practice (FAO, 2002) is supported by most coastal nations, and has immediate applicability to reaching the WSSD fishery goals. The Code argues for moving forward with a precautionary approach to fisheries sustainability, using available information more conservatively to err on the side of lower total allowable catch levels than has been the general practice in past decades (Freestone and Hey, 1996).

Modular Assessments for Sustainable Development

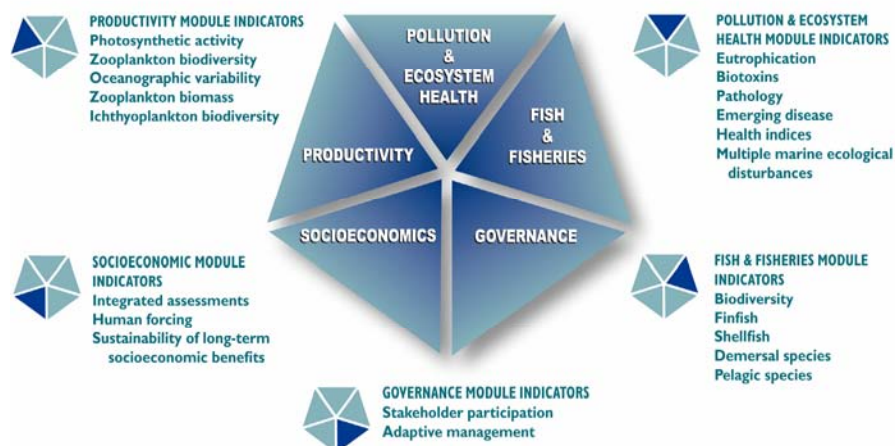


Fig. 3 LME modules as suites of condition indicators for inputs to integrated ecosystem assessments.

2007–2010 GEF support for fisheries recovery and biodiversity conservation

The recent study by Worm *et al.* (2006) reached the conclusion that cumulative catches within the world's LMEs have declined 13% (10.6 million metric tons) since passing a cumulative maximum in 1994. They argue that species average catches in non-collapsed fisheries were higher in species-rich systems and that species robustness to over-exploitation was enhanced in LMEs with high fish species diversity. They further argue that sustainable fisheries management, pollution control, maintenance of essential habitats, and the creation of marine reserves will prove to be good investments in the productivity and value of goods and services that the ocean provides humanity, while business as usual will threaten water quality and ecosystem stability. The US\$60 billion in international trade in marine fisheries products is at risk from this depletion. In an effort to assist developing countries in moving forward to recover and sustain marine fisheries, water quality and habitats, the draft GEF strategy for its International Waters (IW) focal area for the period 2007 to 2010 places a priority on recovering depleted marine fish stocks and implementing selective and less destructive fishing practices than those that are now threatening coastal economies and the communities depending on them, as well as causing adverse impacts on biological diversity. The draft strategy is available on www.iwlearn.net.

The impact of declining fish stocks and destructive fishing practices has serious implications for loss of species and biomass, and of ecosystem structure, integrity, and stability. Consequently, the GEF IW focal area is joining forces with the GEF Biodiversity focal area during the period of 2007 to 2010 to catalyze cost-effective solutions. Already, 116 different states have requested GEF help to work with their neighbors in GEF IW foundational capacity-building projects for 16 of the planet's LMEs that are shared by developing countries, in recognition of these social and economic concerns. GEF-recommended processes are underway toward development of ministerially-agreed collective programs of action that should benefit from use of marine protected areas (MPAs).

During the period 2007 to 2010, the GEF IW focal area plans to support developing countries bordering LMEs in Africa, Asia, Latin America, and Eastern Europe to introduce an ecosystem-based approach for moving toward the recovery and sustainability of depleted fish stocks, the control of over-enriched coastal waters, the restoration of habitats, the protection of biodiversity, and adaptation to climate change. Participating countries may also be eligible to request GEF funding for addressing land-based sources of marine pollution and habitat conservation, including support for (1) barrier removal in improving wastewater treatment and using low cost constructed wetlands for sewage treatment, (2) wetlands restoration, (3) integrated coastal management and community-based

fisheries, and (4) transitional support to fishers for alternative livelihood activities for near-coastal fisheries that are overcapitalized, over-fished, and under stock rebuilding management regimes.

LME approach to World Summit targets

Since 1993, the U.S. NOAA Fisheries Service has been cooperating with GEF, the World Conservation Union (IUCN), Intergovernmental Oceanographic Commission (IOC) of UNESCO, and several other United Nations (UN) agencies, including the UN Industrial Development Organization, UN Development Program, UN Environment Program, and FAO, to assist developing countries in planning and implementing ecosystem-based management focused on LMEs as the principal assessment and management unit for near-coastal ocean resources. NOAA contributes scientific and technical assistance and expertise to aid developing countries in reaching the targets of the 2002 WSSD (Duda and Sherman, 2002). The targets, agreed on by officials of more than 100 countries, call for the achievement of "substantial" reductions in land-based sources of pollution, introduction of the ecosystems approach to marine resource assessment and management by 2010, designation of a network of marine protected areas by 2012, and the maintenance and restoration of fish stocks to MSY levels by 2015. The GEF-LME strategy supports the WSSD targets for addressing coastal and marine issues by jointly analyzing scientific information on transboundary problems and their root causes, and setting priorities for action on these problems.

Reforms are taking place among the participating countries in operationalizing this ecosystem-based approach to managing human activities in the different economic sectors that contribute to place-specific degradation of the LMEs and adjacent waters. The WSSD target for introducing ecosystem-based assessment and management practices by 2010 can still be met by many of the countries constituting the existing LME network. It is unlikely that the WSSD target for maintaining and restoring fishery resources to MSY levels by 2015 will be met. However, progress is being made in the recovery of depleted fish stocks through mandated reductions in fishing effort (Sherman *et al.*, 2002). With regard to the target for control and reduction of land-based sources of pollution, considerable additional effort will be required to achieve "substantial reductions", whereas good progress has been made in designating MPAs within the GEF-LME project network. The U.S. Ocean Action Plan, published on December 17, 2004, by the Office of the President in response to the U.S. Commission on Ocean Policy's final Report (USCOP, 2004), supports the LME concept and strategy for ecosystem-based management within the UN regional seas programs and by international fisheries bodies (EOPUS, 2004):

The United States will promote, within the Environment Program's regional seas programs and

by international fisheries bodies, the use of the Large Marine Ecosystems (LME) concept as a tool for enabling ecosystem-based management to provide a collaborative approach to management of resources within ecologically bounded transnational areas. This will be done in an international context and consistent with customary international law as reflected in the 1982 Convention on the Law of the Sea.

Additional information on NOAA's contributions to the global LME movement toward ecosystem-based management and resource sustainability is available from the LME Program Office, Northeast Fisheries Science Center, Narragansett Laboratory, Narragansett, Rhode Island, and from the LME website: www.lme.noaa.gov. Additional information on the GEF International Waters focal area is found at www.iwlearn.net.

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Dr. Alfred M. Duda serves as Senior Advisor, International Waters, for the Global Environment Facility (GEF) Secretariat in Washington, DC. He has been posted for the last 13 years in a number of management positions at the GEF following his appointment to the World Bank Group in 1991. Following completion of his doctoral work at Duke University, Dr. Duda worked in a series of supervisory positions in the water quality regulatory agency of the State of North Carolina and then at the corporate environment staff of the Tennessee Valley Authority. In 1987, he was named by the U.S. Department of State as Director and Chief of Diplomatic Mission of the Great Lakes Office of the International Joint Commission (Canada and U.S.) in Windsor, Ontario. The Commission has responsibilities to resolve, and avoid where possible, water disputes along the border under the Boundary Waters Treaty of 1909. Dr. Duda's work at the World Bank and GEF continues to address relations among sovereign nations in sharing benefits from transboundary water systems such as LMEs and shared surface or groundwater systems. The GEF is a multi-billion dollar financial mechanism that unites 178 member governments in addressing global environment issues while supporting sustainable development. The GEF has provided over \$1 billion in grants in its International Waters Focal Area to 135 developing countries for projects related to LMEs and shared freshwater basins.