

Five LME Modules are used to assess the changing states of Large Marine Ecosystems. Each of the 5 modules has its own suite of indicators to assess changes in the LMEs and determine whether an LME is improving or deteriorating.

(iii) The Pollution and Ecosystem Health Module

POLLUTION AND ECOSYSTEM HEALTH MODULE INDICATORS

In several LMEs, pollution and eutrophication have been important driving forces of change in biomass yields. Assessing the changing status of pollution and health of an entire LME is scientifically challenging. Ecosystem health is a concept of wide interest for which a single precise scientific definition is difficult. The health paradigm is based on multiple-state comparisons of ecosystem resilience and stability, and is an evolving concept. To be healthy and sustainable, an ecosystem must maintain its metabolic activity level and its internal structure and organization, and must resist external stress over time and space scales relevant to the ecosystem.

In the United States, the pollution and ecosystem health module measures pollution effects on the ecosystem through the monitoring strategy of the U.S. Environmental Protection Agency (EPA). The EPA has developed a suite of five coastal condition indices -- water quality, sediment quality, benthic communities, coastal habitat, and fish tissue contaminants -- as part of an ongoing collaborative effort with NOAA, the U.S. Fish and Wildlife Service, the U.S. Geological Survey, and other agencies representing states and tribes (**Figure 1**). The EPA's "National Coastal Condition Report III" includes results from the EPA's analyses of coastal condition indicators and NOAA's fish stock assessments by LMEs aligned with EPA's national coastal assessment regions (USEPA 2008). Other pollution indicators include the pathobiological examination of fish and fish tissue, estuarine and nearshore monitoring of contaminants and contaminant effects in the water column, substrate, and selected groups of organisms. Where possible, bioaccumulation and trophic transfer of contaminants are assessed, and critical life history stages and selected food web organisms are examined for indicators of exposure to, and effects from, contaminants. Effects of impaired reproductive capacity, organ disease, and impaired growth from contaminants are measured. Assessments are made of contaminant impacts at both species and population levels.

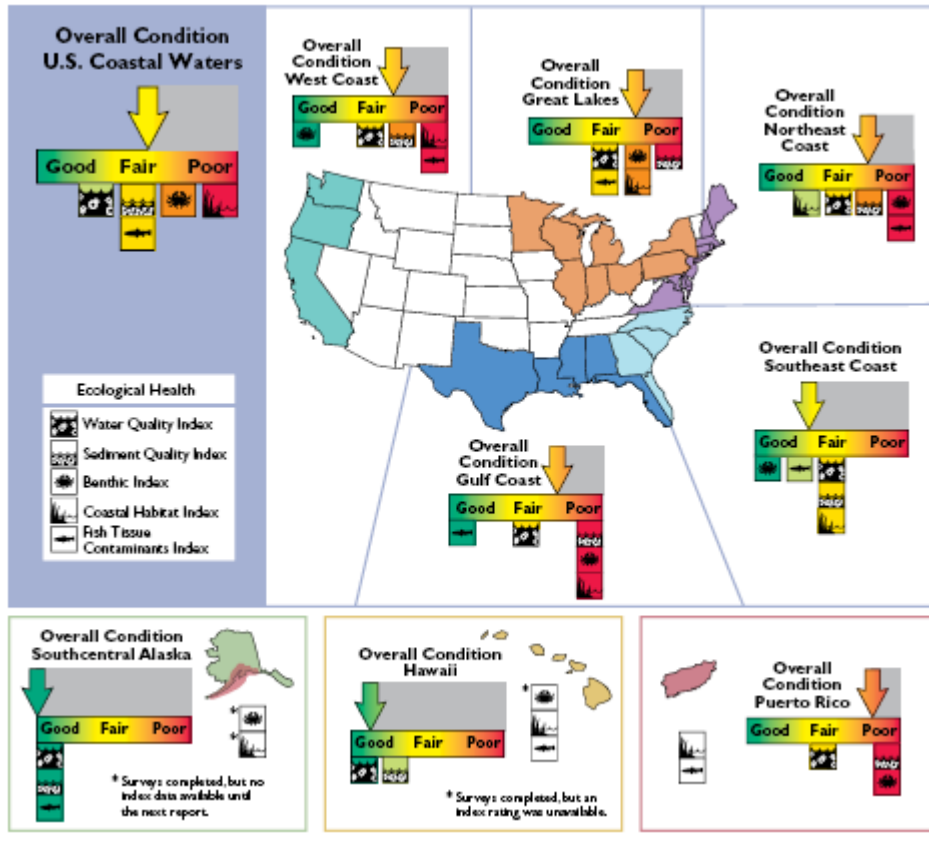


Figure 1. Indicators from US EPA's (USEPA 2008) National Coastal Condition Report III. Overall national and regional coastal condition based on data collected primarily in 2001 and 2002.

Implementation of protocols to assess the frequency and effect of harmful algal blooms, emergent diseases (Epstein 1993), and multiple marine ecological disturbances (Sherman and Epstein 2001) are included in the pollution module. A summary of nitrogen and phosphate over-enrichment values for the world's 64 LMEs is given in Seitzinger and Lee 2008, **Figure 2**.

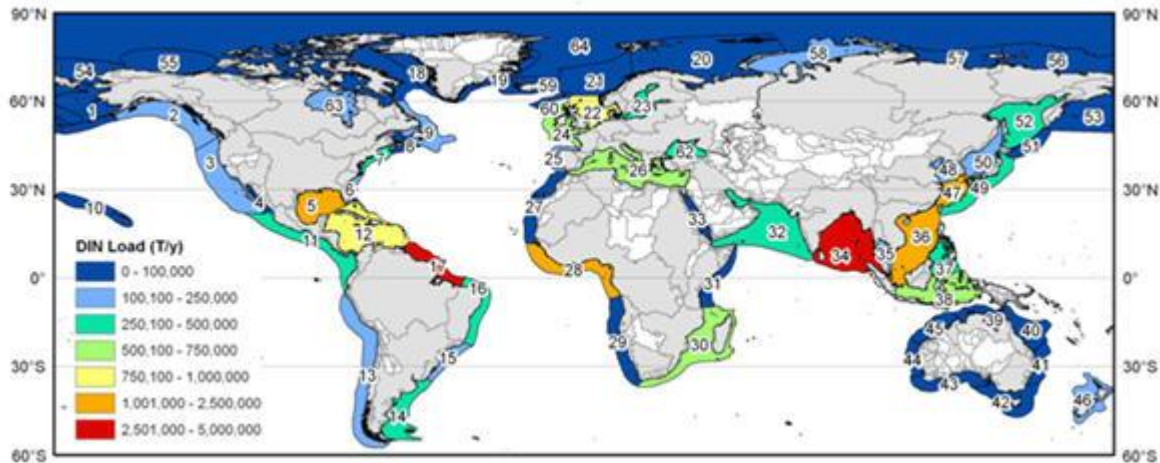


Figure 2. DIN inputs to LMEs from land-based sources predicted by the NEWS DIN model. Watersheds discharging to LMEs are grey; watersheds with zero coastal discharge are white. Units: Tons N/y. (Figure from Lee and Seitzinger 2008).

The UNEP Large Marine Ecosystem Report (2008) provides information on nutrient over-enrichment and coastal eutrophication. Nutrient over-enrichment leads to increasing frequency and extent of eutrophication, hypoxia, and dead zones. Quantitative estimates are provided for amounts of nitrogen introduced into the Large Marine Ecosystems in relation to specific sources and amounts from atmospheric deposition, manure, sewage, fertilizer, natural fixation, and agricultural fixation.

Selected Fish and Fisheries Indicators Module Publications

Seitzinger, S., Lee, R. 2008. Land-based sources of nutrients to large marine ecosystems. 81-98 in Sherman, K. and Hempel, G. (Editors). 2008. The UNEP Large Marine Ecosystem Report: A perspective on changing conditions in LMEs of the world's Regional Seas. UNEP Regional Seas Report and Studies No. 182. United Nations Environment Programme. Nairobi, Kenya

Seitzinger S, Sherman K, Lee R. 2008. Filling Gaps in LME Nitrogen Loadings Forecast for 64 LMEs, Intergovernmental Oceanographic Commission Technical Series 79. Paris, France: UNESCO.

Sherman BH, Epstein PR. 2001. Past anomalies as a diagnostic tool for evaluating multiple marine ecological disturbance events. *Human and Ecological Risk Assessment* 7(5):1493-1517.

USEPA. 2008. National Coastal Condition Report III. Washington, DC: United States Environmental Protection Agency.

The UNEP Large Marine Ecosystem Report: A perspective on changing conditions in LMEs of the world's Regional Seas. 2008. Sherman K, Hempel G, eds. UNEP Regional

Seas Report and Studies No. 182. United Nations Environment Programme. Nairobi, Kenya. 872 p.

