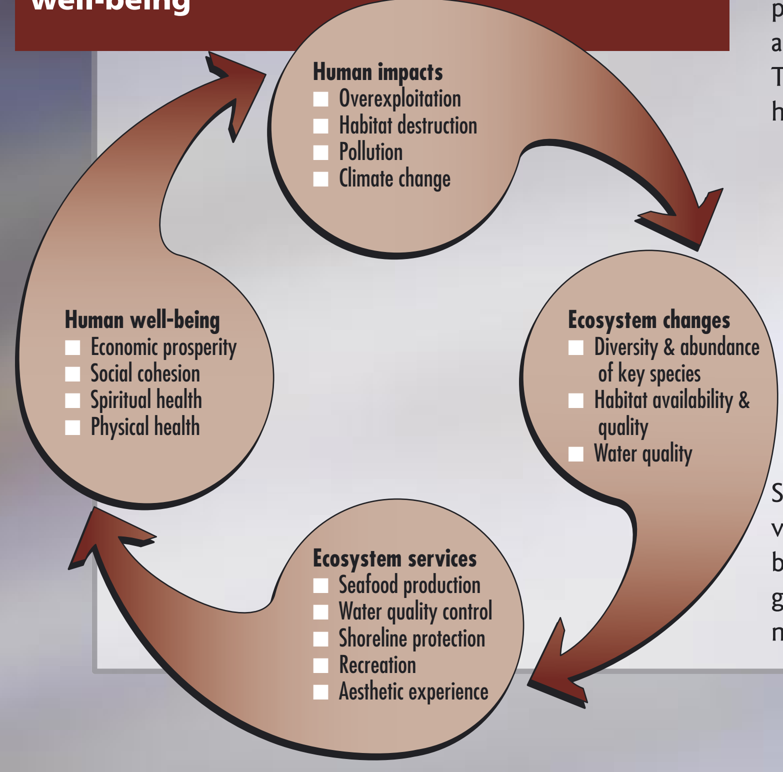
Feedback to humans

As human activities impact SEMS, the ecosystem services provided by these systems are changed, often diminished, with negative effects on human well-being



Ecosystem services include seafood, natural products that can be transformed into new drugs or used for other purposes, water purification, options for recreation, cultural and spiritual services, and shoreline protection and safety. Threats to these services occur across many scales and human-defined boundaries.

In heavily impacted SEMS:

- Seafood becomes scarce or unhealthy for human consumption;
- Recreation is impaired by beach closures, dead zones and toxic algal blooms;
- Cultural and spiritual values are diminished when key species or ecosystems are lost; and
- Reclaimed wetlands and built-up shorelines cannot adapt to enhanced floods and sea-level rise.

Such changes affect individual people living, working or visiting along the coast, as well as local communities, businesses, industries, civil society, regional and national governments and – in a world of globalization – global networks and partnerships.

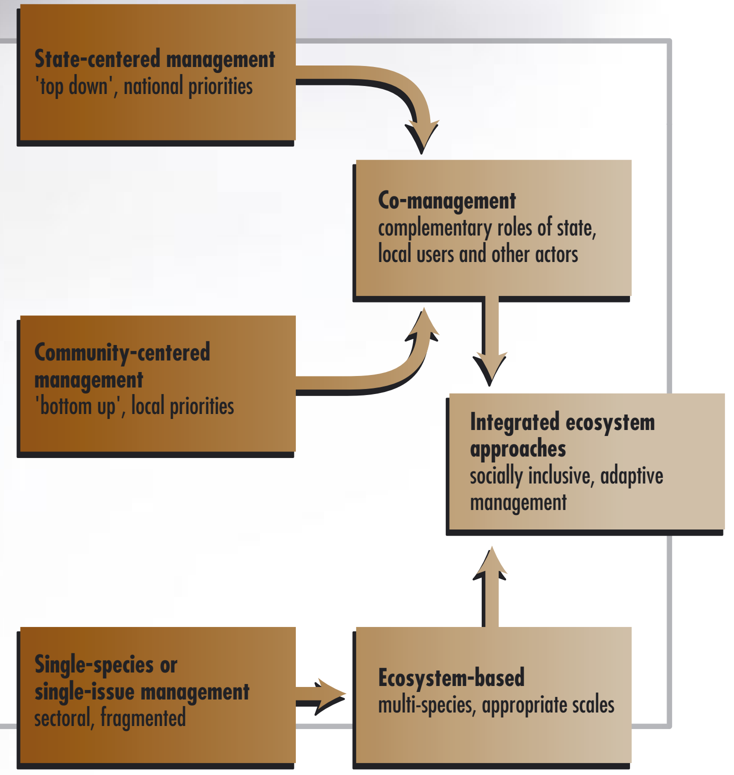
Management and governance

Given the importance of ecosystem services from SEMS, management of coastal areas is vital for individuals and communities around the world

Management becomes more complicated with the number of human activities involved that affect and interact with SEMS.

Governance becomes more complex the larger the system to be managed, the more stakeholders that need to be involved, and the more political boundaries that have to be overcome. In the past, management of resources and coastal areas has often been 'top down' and oriented toward single species or sectoral issues.

Increasingly, however, management is involving affected users and is being broadened to target whole ecosystems.



Source: Urban et al, 2008.

Integrating tools

Information and knowledge need to be integrated across scientific disciplines (e.g. ecology, sedimentology, chemistry, fisheries sciences, sociology, economics, law, etc.), to advance our understanding of the complex dynamics and the multitude of interactions in SEMS.

Conceptual and quantitative models can integrate information about the interactions between SEMS and their water basins, and between local people, the ecosystems, and local and international markets that heavily influence the patterns of resource use. Such model development is a major task requiring good understanding of ecological and social systems, and their interactions, based on research, observations and monitoring.

Although interactions among the various components may be relatively well known in qualitative terms, incorporating them in quantitative models remains an important scientific challenge.

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Readings

Diaz, R. J., M. Selman and Z. Sugg, 2007. Eutrophication: An Overview of Status, Trends, Policies, and Strategies, Report for the David and Lucile Packard Foundation, World Resources Institute, Washington, D.C.
IPCC, 2007: *Climate Change 2007: The Physical Science Basis.*
Lotze, H.K., H.S. Lenihan, B.J. Bourque, R.H. Bradbury, R.G. Cooke, M.C. Kay, S.M. Kidwell, M.X. Kirby, C.H. Peterson, and J.B. C. Jackson. 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas, *Science* 312:1806-1809.
Millennium Ecosystem Assessment. 2005. *Synthesis Report. Millennium Ecosystem Assessment,* http://www.millenniumassessment.org.
Nellemann, C., S. Hain, and J. Alder (eds.). 2008. *In Dead Water. Merging of climate change with pollution, over-harvest, and infestations in the world's fishing grounds. Rapid Response Assessment.* UNEP/GRID-Arendal, Norway
Scheffer, M., S. Carpenter, J.A. Foley, C. Folke, and B. Walker. 2001. Catastrophic shifts in ecosystems, *Nature* 413:591-596.
UNEP, 2007. *Global Environment Outlook, GEO-4*: Environment for Development. United Nations Environment Programme.
Urban, E.R. Jr., B. Sundby, P. Malanotte-Rizzoli, and J. Melillo (eds.). 2008. SCOPE 70, *Watersheds, Bays and Bounded Seas: The Science and Management of Semi-Enclosed Marine Systems,* Island Press, Washington, D.C.
Worm, B., E.B. Barbier, N. Beaumont, J.E. Duffyw, C. Folke, B.S. Halpern, J.B.C. Jackson, H.K. Lotze, F. Micheli, S.R. Palumbi, E. Sala, K.A. Selkoe, J.J. Stachowicz, and R. Watson. 2006. *Impacts of biodiversity loss on ocean ecosystem services, Science* 314:787-790.

Way forward

Recommendations

- **Decision-makers at all levels** should recognize that SEMS are the most threatened, yet critical parts of the global ocean for the livelihoods and well-being of human populations worldwide.
- **Science and management** should jointly identify approaches that increase ecosystem resilience, reduce the potential for adverse consequences and prevent irreversible threshold effects.
- **Regional assessments** should evaluate the state of individual SEMS, identify relevant ecological, economic and social issues, and the prevalent human threats to ecosystem services, in order to develop integrated management and governance options.
- **Management and governance** should follow an integrated approach that (i) considers all human activities and their threats to ecosystem services, and (ii) takes all ecosystem components and their interactions into account.
- **The specific problems of SEMS** highlight the need to overcome traditional boundaries in management and governance. In particular, they suggest a coupling of ocean and coastal zone management with watershed and land-use management.

The joint SCOPE-IAPSO-SCOR consultation on the dynamics and vulnerability of semi-enclosed marine systems provided the basis for this brief, that has been published with support from the IOC. SCOPE 70, *Watersheds, Bays, and Bounded Seas: The Science and Management of Semi-Enclosed Marine Systems*, by Edward R. Urban, Jr, Bjørn Sundby, Paola Malanotte-Rizzoli, and Jerry M. Melillo (editors) is published by Island Press.

Useful links

United Nations Educational, Scientific and Cultural Organization (UNESCO): http://www.unesco.org
Scientific Committee on Problems of the Environment (SCOPE): http://www.icsu-scope.org
United Nations Environnent Programme (UNEP): http://www.unep.org
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International Association for the Physical Sciences of the Oceans (IAPSO): http://iapso.sweweb.net
Intergovernmental Oceanographic Commission (IOC) of UNESCO: http://ioc-unesco.org/
Island Press: http://www.islandpress.org
Land-Ocean Interactions in the Coastal Zone (LOICZ) project: http://www.loicz.org/
Scientific Committee on Oceanic Research (SCOR): http://www.scor-int.org/

Cover: Phytoplankton blooms in the Black Sea, southeastern Europe. It is fed by a network of rivers in a catchment area dominated by agricultural land. The waters draining to the sea have a high sediment load and also contain nutrients from fertilizer. This has led to enrichment of the sea water and a subsequent proliferation of phytoplankton (microscopic algae) in the sea. The algal blooms appear as plumes of discoloured water. An increase in phytoplankton can cause a decrease in dissolved oxygen content, which can make the water inhabitable. Image obtained on 22nd May 2004 by the Aqua satellite.
NASA/GSFC/SCIENCE PHOTO LIBRARY

Ecological and Earth Sciences in UNESCO

United Nations Educational, Scientific and Cultural Organization
Scientific Committee on Problems of the Environment
United Nations Environment Programme

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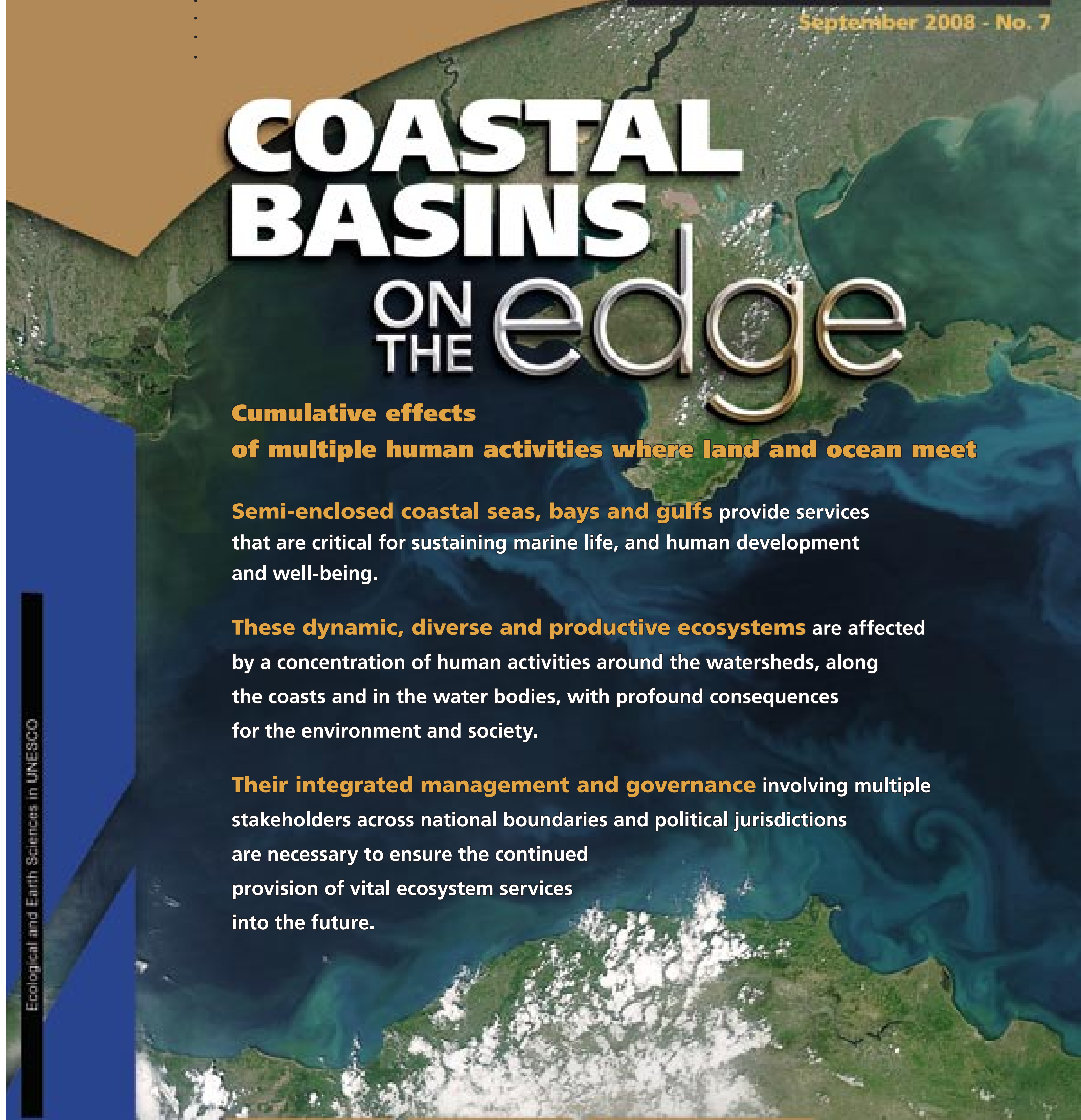


COASTAL BASINS ON THE edge

Cumulative effects of multiple human activities where land and ocean meet

Semi-enclosed coastal seas, bays and gulfs provide services that are critical for sustaining marine life, and human development and well-being.

These dynamic, diverse and productive ecosystems are affected by a concentration of human activities around the watersheds, along the coasts and in the water bodies, with profound consequences for the environment and society.

Their integrated management and governance involving multiple stakeholders across national boundaries and political jurisdictions are necessary to ensure the continued provision of vital ecosystem services into the future.

Scientific Committee on Oceanic Research
International Association for the Physical Sciences of the Oceans
Intergovernmental Oceanographic Commission

SEMI-ENCLOSED MARINE SYSTEMS

SEMS are among the most dynamic, diverse and productive parts of the global ocean

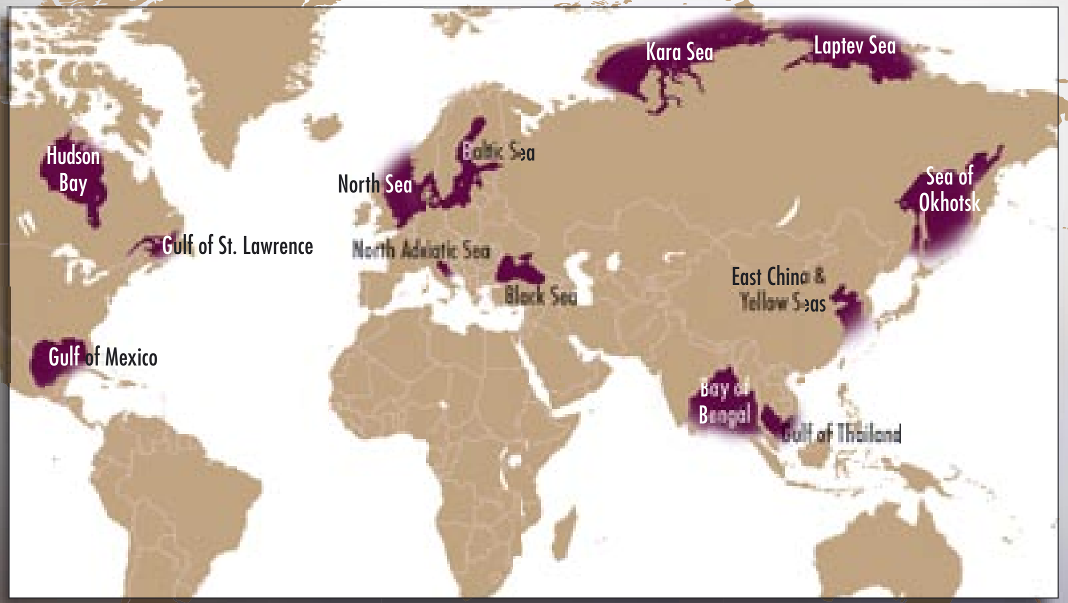
SEMS are coastal seas, bays and gulfs and include coastal basins with physical barriers that limit free exchange of seawater with the open ocean. These barriers can be narrow inlets (e.g. the Baltic and Black Seas), islands (e.g. the Gulf of Mexico, Gulf of St. Lawrence), a shallow water sill (e.g. East China Sea), or strong ocean currents or density fronts (e.g. Bay of Bengal).

SEMS represent important mixing and buffer zones between continents and the ocean, where nutrients and organic matter are cycled, stored and used. SEMS are essential habitats for a wide range of ocean life. Because of their proximity to human settlements along the coast and their outstanding productivity, SEMS have long sustained human life and are significant contributors to global seafood production. Moreover, SEMS are sources of natural products useful to humankind and sustain important economic, recreational and cultural services for people around the world.

However, limited exchange with the open ocean makes these ecosystems particularly vulnerable to land-derived materials which become trapped in the SEMS and have direct or indirect adverse effects on human health. Human colonization has led to changes in how, when and where materials are delivered and trapped in the coastal zone and watersheds.

SEMS that receive significant inputs of freshwater from rivers and groundwater are most affected by land-derived sediments, nutrients and chemical pollutants originating from multiple human activities around the watersheds and along the coast. Others are affected by reduced freshwater input from rivers that are diverted for human use.

Added to a baseline of natural variability and extreme episodic events, it is in the SEMS that the effects of global environmental change together with land- and ocean-based human impacts accumulate and lead to adverse consequences for ecosystem functioning and, ultimately, human well-being.



A selection of SEMS representing a span of latitudes from the tropics to polar regions and encompassing different combinations of degree of openness and freshwater influence. Source: Urban et al, 2008.

Major threats

Today, many SEMS are under heavy land- and ocean-based pressures from different types of pollution, transformation and exploitation.

In the near future, climate change will most likely further change many of the present characteristics of SEMS, including average and extreme temperatures of their waters, intensity and timing of precipitation and freshwater input, salinity distribution, patterns of circulation, stratification and mixing, as well as chemical properties.

Human activities result in land-derived nutrient and man-made chemical loading to coastal waters. This can lead to oxygen depletion, dead zones and coastal ecosystem alteration including changes in species abundance and diversity, fisheries, habitat availability, and water quality.

Increasing pressures	Effects on SEMS
GLOBAL CHANGE PRESSURES	
■ Temperature change ■ Sea-level rise ■ Acidification ■ UV radiation ■ Precipitation changes ■ Wind changes	■ Alteration of freshwater, sediments and nutrient inputs ■ Increased water stratification, alterations of ocean circulation and exchange mechanisms ■ Enhanced coastal erosion ■ Reduced sea-ice cover ■ Changing physical, chemical and biological components ■ Physiological stress on marine organisms
LAND-BASED PRESSURES	
■ Changes in land use and cover ■ Fertilizer and pesticide use ■ Chemical discharges ■ Shoreline transformation and fortification ■ Disturbance through activities, noise, light, smell ■ Dam construction and river canalization ■ Freshwater extraction	■ Changing nutrient amounts and ratios ■ Eutrophication leading to algal blooms, oxygen depletion and dead zones ■ Toxic pollution ■ Changes in species abundance, diversity and fisheries ■ Changes in habitat availability and quality ■ Changes in water quality
OCEAN-BASED PRESSURES	
■ Harvesting and over-exploitation of living marine resources ■ Aquaculture operations ■ Introduction of alien, potentially invasive, species ■ Extractive industries (oil, gas, sand, gravel) ■ Disturbance through activities, noise, light, smell ■ Shipping	■ Changes in species abundance and distribution ■ Habitat alteration and destruction ■ Nutrient, chemical and genetic pollution ■ Changes in water quality and environmental health ■ Changes in species diversity ■ Physical and chemical disturbance of species

Human impacts on SEMS can be localized or act at regional or global scales.

This figure illustrates the major threats to ecosystem services in SEMS and the spatial scales at which they operate.

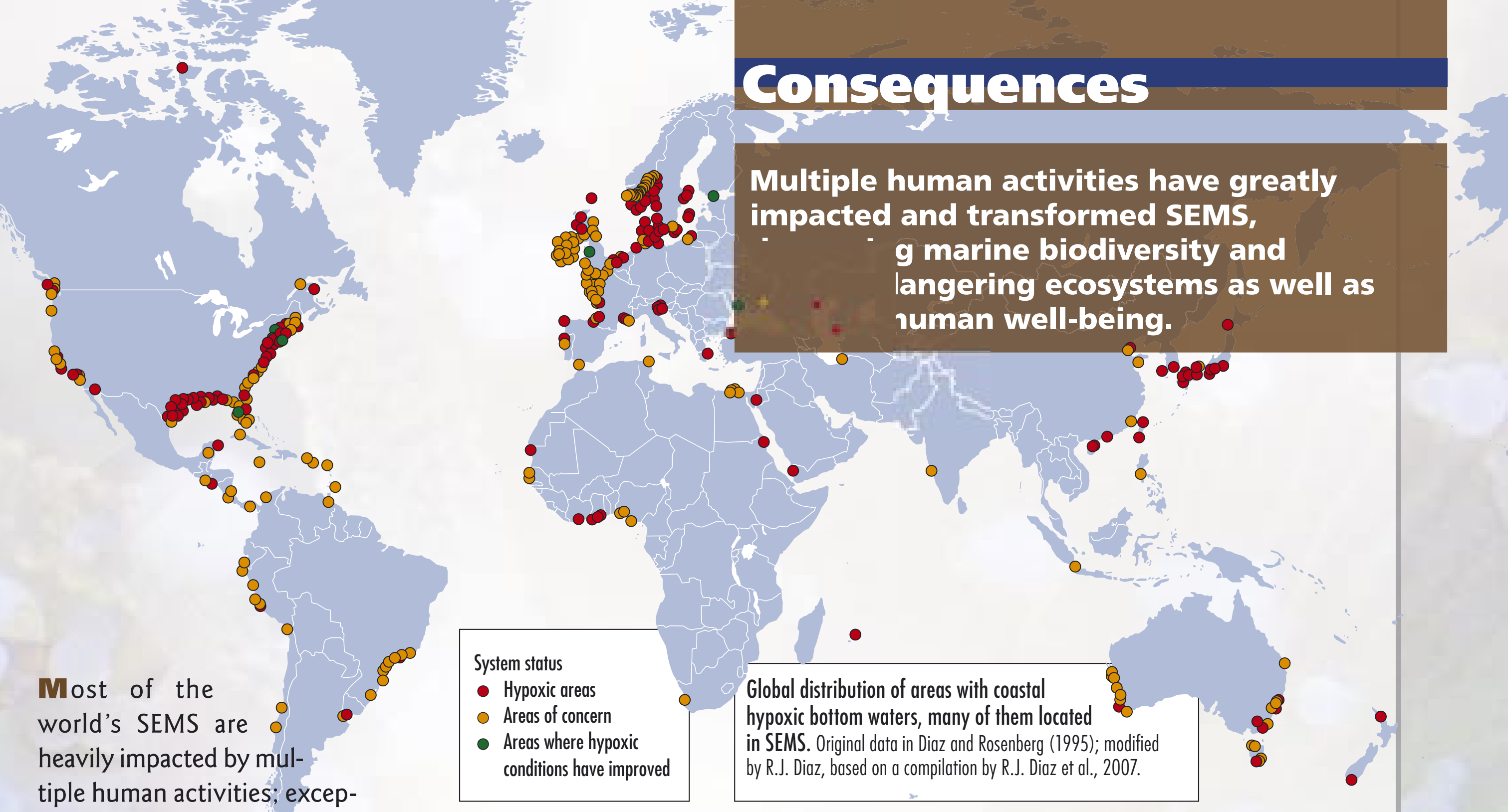
It provides a relative comparison of the importance and spatial dimension of different threats within a set of thirteen representative SEMS.

Brown polygons indicate scales at which threat is most predominant. Blue shading illustrates the spatial dimension of SEMS, where local is defined as a single bay, regional refers to the scale of a semi-enclosed marine system, and global is defined as ocean scale. Bar height indicates perceived magnitude of threat at the different scales.

Source: Urban et al, 2008.

Consequences

Multiple human activities have greatly impacted and transformed SEMS, [illegible]g marine biodiversity and [illegible]langering ecosystems as well as [illegible]human well-being.



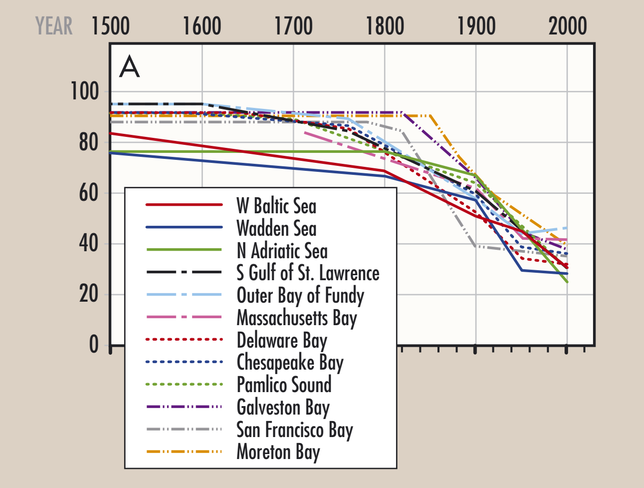
Global distribution of areas with coastal hypoxic bottom waters, many of them located in SEMS. Original data in Diaz and Rosenberg (1995); modified by R.J. Diaz, based on a compilation by R.J. Diaz et al., 2007.

Most of the world's SEMS are heavily impacted by multiple human activities; exceptions are primarily in high latitudes (e.g. Hudson Bay, and Kara and Laptev Seas). However, models predict that these polar areas will be among the first to show changes in ocean chemistry (acidification) caused by the increase in CO_2 concentrations due to climate change.

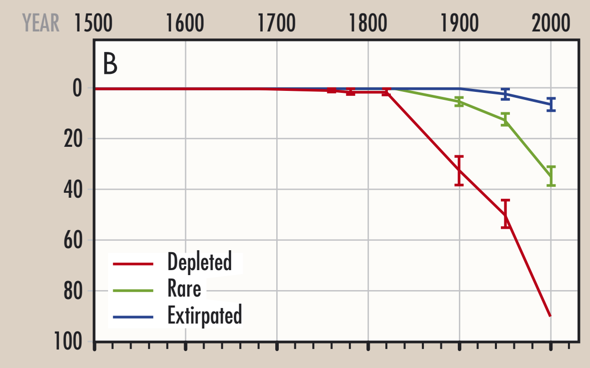
In some cases, natural or human-induced trends in environmental factors change ecosystems in a gradual, reversible way. In others, however, **thresholds** occur. When such thresholds are passed, abrupt and dramatic changes take place, which are difficult or impossible to reverse. The system may not return to its previous state, or it may return only slowly when the forcing conditions are reduced, e.g. thresholds in nutrient levels that produce hypoxia, which is a condition that is more prevalent in SEMS because of reduced exchange with oxygen-rich open ocean water.

Long-term changes in estuarine and coastal ecosystems, many of them located in SEMS. Adapted from Lotze et al. 2006, Worm et al. 2006.

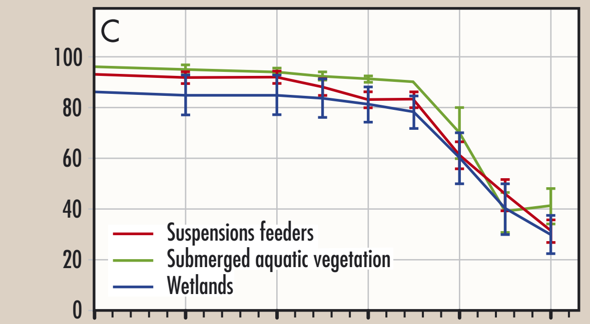
(A) Average relative abundance of 30-80 species in 12 study systems.



(B) Percent of fisheries that were depleted (>50% decline), rare (>90% decline), and extirpated (100% decline).



(C) Average relative abundance of filtering and habitat-providing species.



(D) Relative changes in water quality.