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Assessment of estuarine trophic status

- The majority of estuaries were rated moderate to bad.
- This rating could only be conducted when data for all three factors (influencing factors, OEC, and future outlook) were available. Therefore, only 48 systems out of 141 were rated.

The ASSETS (assessment of estuarine trophic status) rating, a combination of the three components (influencing factors, overall eutrophic condition, future outlook), is created in order to provide one overall score for a system. These scores fall into one of five categories: high, good, moderate, poor, or bad. A system may be rated as good based upon high or good conditions of influencing factors and overall eutrophic condition, even if the system is expected to worsen in the future. Poor and bad grades reflect a range of undesirable influencing factors and overall eutrophic conditions, even if there are management plans for recovery.

As the assignment of an ASSETS rating requires data for all three components, there were only adequate data for determination of an ASSETS rating for 48 systems (Figure 3.11). Only one system was rated as high (Connecticut River), while five were rated as good (Biscayne Bay, Pensacola Bay, Blue Hill Bay, Sabine Lake, Boston Harbor). Eighteen were rated as moderate and 24 systems were rated as poor or bad. The single rating of ASSETS allows simple comparisons between and among systems. It has been applied at a national (this study) and international level (http://www.eutro.org). The intent is to share lessons learned and encourage more pro-active approaches to the maintenance of estuarine health.

Figure 3.11. ASSETS ratings on a national scale.

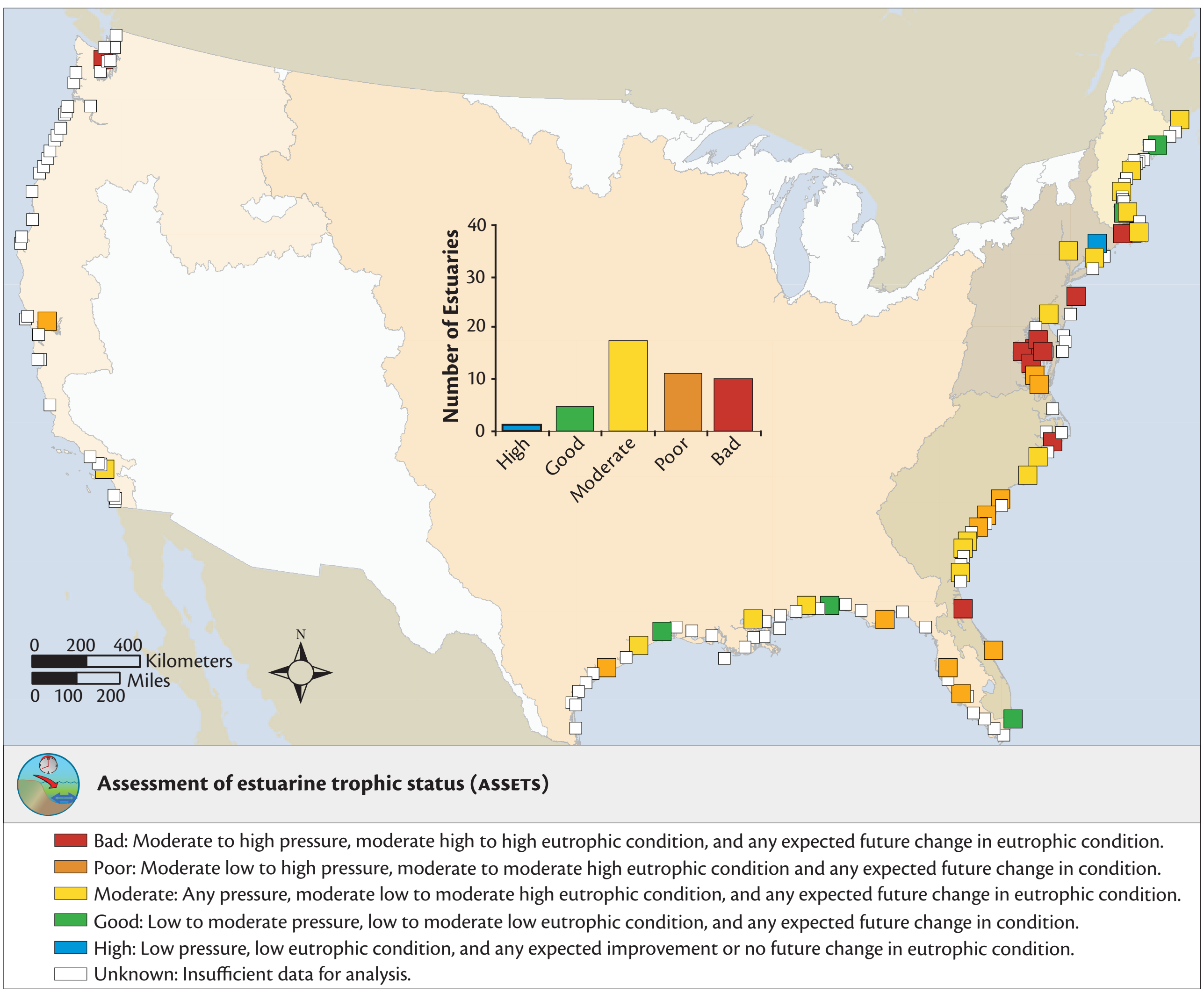

EXHIBIT 10 (AR L.3)

Shih-Nan Chen, University of Maryland Center for Environmental Science

Tourism in the Pacific Coast region has remained unaffected by eutrophication.

Impaired uses

- Systems with moderate to high impacts also exhibited moderate to high overall eutrophic conditions.
- The top use impairments reported for all regions were to commercial and recreational fishing, shellfish harvesting, fish consumption, swimming, and aesthetics.
- The top four causes of impairments were agriculture (crops and animal operations), wastewater treatment plants, urban runoff, and atmospheric deposition.

The finding that about two thirds of the estuaries assessed have moderate to high expression of eutrophication is of considerable importance. Eutrophic symptoms may negatively impact estuarine resources in a variety of ways. For instance, fish kills associated with low dissolved oxygen and nuisance/toxic blooms impact commercial fishery landings. Declines in tourism occur when noxious smells (caused by hypoxia or anoxia) and floating algal mats create unfavorable aesthetic conditions. Additionally, risks to human health increase when the toxins from algal blooms accumulate in edible fish and shellfish. Furthermore, when toxins become airborne, they may cause respiratory problems after inhalation. While this report does not directly address economic losses, an additional socioeconomic indicator is currently under development (see *Chapter 6*). This indicator may also address the detriment to seasonal economies when eutrophic symptoms occur during the height of the tourist and/or fishing seasons.

Although the magnitude of impacts to living resources and human uses of these water bodies cannot currently be quantified, the survey asked participants to identify impacts they suspected to be caused by eutrophic symptoms. Out of the 48 systems with adequate data, 14 noted considerable impacts to living resources while 17 noted moderate impacts. Seventeen reported slight to no impact. Those with reported impacts were mostly located in the mid-Atlantic, South Atlantic, and Gulf of Mexico regions. The majority of systems with moderate to considerable impacts generally exhibited moderate to high overall eutrophic conditions. Top use impairments reported for all regions were commercial and recreational fishing, shellfish harvesting, fish consumption, swimming, and aesthetics. Some South Atlantic and Gulf of Mexico systems also noted tourism as being impaired.

The overall top four causes of these use impairments were listed as agriculture (crops and animal operations), wastewater treatment plants, urban runoff, and atmospheric deposition. Animal operations and crop agriculture were noted mostly for systems in the mid- and South Atlantic regions while exurban development (outside boundaries of urban areas) was reported in the South Atlantic region. Combined sewer overflow and onsite septic tanks were problematic mainly for the Gulf of Mexico region, and to a lesser degree in the North and mid-Atlantic regions.

Considerations for management actions

It is important to manage from a watershed perspective, focusing on sources of nutrients which are controllable for the system in question. It is also importatnt that the level of susceptibility, eutrophic condition, and future outlook be used to set management priorities. On a national basis, the most frequently noted management targets are wastewater treatment, urban runoff, onsite septic tanks, and atmospheric deposition. In all regions except for the North Atlantic, non-point sources remain a primary focus.

Notable among point sources were combined sewer overflows in the North Atlantic region and wastewater treatment plants in all regions. Animal operations and crop agriculture were named as management targets for systems in the mid-Atlantic, South Atlantic, and Gulf of Mexico regions. Forestry activities were named for the Pacific Coast region. Of the non-point sources, atmospheric deposition and urban runoff were among the most frequently named management targets for all regions.

Data gaps and research needs

Monitoring

Currently, the greatest monitoring need is for data which better characterize the levels of eutrophic symptoms in estuaries (see box below). Helping to fulfill this need are the following recommendations:

- Long-term comprehensive monitoring programs incorporating typology and minimum sampling frequencies for each indicator (see *Chapter 6*).
- *In situ* sampling should be coordinated with user-driven, integrated programs designed for routinely providing satellite and remote sensing information such as the U.S. Integrated Ocean Observing System (IOOS) and the National Water Quality Monitoring Network (NWQMN).
- Internally, the web-based data entry format should also be refined so that data summaries can be automatically calculated and disseminated.
- Better monitoring of living resources.

Research

Nutrient loads are critical to the development of the nutrient input-estuarine response relationships, without which management measures cannot be planned or implemented. A large effort should go toward improving the ability to estimate loads in a timely manner (only 64 systems in this assessment had load data available). Other recommendations are:

- Identify and quantify nutrient sources.
- Gain a greater understanding of nuisance macroalgae as an indicator (i.e., key taxa for specific systems) and problem level thresholds.
- Define a more robust metric for monitoring SAV biomass and spatial coverage.
- Evaluate nuisance/toxic blooms with respect to shifts in phytoplankton community composition.
- Investigate estuarine boundaries, susceptibility, and typology to improve assessment accuracy by modifying indicator thresholds by system type.
- Investigate the link between eutrophication and impacts to living resources and/or human uses of estuaries and incorporate this into the assessment in order to promote public awareness and support for management (see *Chapter 6*).
- Investigate the potential influences of climate change on eutrophication.

Management

A challenge to the management community is to address the eutrophic status of systems and approach the issue on a local to regional scale. The following are options or tools to improve the management of eutrophic systems:

- Develop templates for regular "report cards" that are accessible, easy to understand, and disseminated on a regular basis.
- Establish a link between air and water regulatory programs, as atmospheric deposition is one of the top noted targets for nutrient management.
- Foster partnerships between NOAA and EPA to improve current national assessments, particularly the assessment methods.
- Total Maximum Daily Load (TMDL) and non-point Source (NPS) programs should continue efforts to reduce nutrient loads from both point and non-point sources.
- Develop public support through outreach and education on best management practices (BMPs) and other locally implementable actions.

For the following 42 estuaries, there was insufficient data to assess overall eutrophic conditions:

Alamitos Bay	Englishman Bay	Pamlico/Pungo Rivers
Albemarle Sound	Humboldt Bay	Saco Bay
Anaheim Bay	Kennebec/Androscoggin River	San Diego Bay
Apalachee Bay	Klamath River	San Pedro Bay
Aransas Bay	Lower Laguna Madre	Santa Monica Bay
Atchafalaya/Vermilion Bays	Mermentau Estuary	Sheepscot Bay
Baffin Bay	Merrimack River	Siletz Bay
Bogue Sound	Mission Bay	Siuslaw River
Brazos River	Monterey Bay	South Ten Thousand Islands
Calcasieu Lake	Muscongus Bay	St. Andrew Bay
Casco Bay	Narraguagus Bay	St. Catherines/Sapelo Sounds
Columbia River	Nehalem River	Terrebonne/Timbalier Bays
Drakes Estero	Netarts Bay	Tillamook Bay
Eel River	Pamlico Sound	Tomales Bay

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EUTROPHICATION AND CLIMATE CHANGE

As this chapter illustrates, the Nation's estuaries are under stress from nutrient loads which have led to a range of eutrophic symptoms. Survey respondents predicted that in many regions these pressures will increase in the future, leading to worsening conditions. However, these predictions did not account for the effects of climate change. The factors associated with climate change that are expected to have the greatest impacts on coastal eutrophication are: increased temperatures, sea level rise, and changes in precipitation and freshwater runoff.

Temperature

Increased temperatures will have several effects on coastal eutrophication. Most coastal species are adapted to a specific range of temperatures. Increases in water temperatures may lead to expanded ranges of undesirable species. Higher temperatures may also lead to increased algal growth and longer growing seasons, potentially increasing problems associated with excessive algal growth and nuisance/toxic blooms. Additionally, warmer waters hold less dissolved oxygen, therefore potentially exacerbating hypoxia. Temperature-related stratification of the water column may also worsen, having a further negative effect on dissolved oxygen levels.

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Marsh erosion and inundation are just some of the potential impacts expected to exacerbate eutrophication. Marshes act as a major nutrient sink, without which loads will be even greater.

Sea level rise

Climate change models predict increased melting of polar icecaps and changes in precipitation patterns, leading to sea level rise and changes in water balance and circulation patterns in coastal systems. Sea level rise will gradually inundate coastal lands, causing increased erosion and sediment delivery to water bodies, and potentially flooding wetlands. The increased sediment load and subsequent turbidity increase may cause submerged aquatic vegetation loss. The positive feedback between increased erosion and algal growth (as erosion increases, sediment associated nutrients also increase, stimulating growth) may also increase turbidity. The loss of wetlands, which act as nutrient sinks, will further increase nutrient delivery to estuaries.

Precipitation and freshwater runoff

Changes in precipitation may affect: runoff from land, stratification, oxygen concentrations in bottom waters, and water circulation patterns. Decreased precipitation and freshwater runoff may alter food webs by decreasing nutrient loads, thereby reducing algal growth. Although reduced river flow causes decreased inputs, it also increases residence time. Therefore, eutrophic problems may increase near the sources of nutrients that are not a function of river flow, such as from point sources (i.e., sewage treatment plants). Potential excessive algal blooms near point source outfalls may also lead to local incidents of hypoxia in bottom waters. In contrast, increased rainfall and runoff may increase nutrient loads, leading to stimulation of algal growth and density-driven stratification. However, the increase in freshwater inflow would also reduce residence time, reducing the probability of blooms in some systems. In regions of engineered water flow (e.g., South Atlantic and Gulf of Mexico), the impacts of changes in the amount of runoff will depend on how water management strategies control regional hydrology.

Level of certainty

Predictions concerning the effects of climate change have varying degrees of certainty. There is a moderate degree of certainty in predictions of how increases in temperature will affect plant physiology, aquatic oxygen concentrations, and effects of sea level rise on flooding of wetlands and erosion. There is less certainty regarding temperature's influence on water circulation patterns and the effects of climate change on precipitation (IPCC 2001, Kennedy et al. 2002).