NCCOS
Center for Sponsored Coastal Ocean Research

Hypoxia & Nutrient Pollution Overview

Issue

Hypoxia in aquatic systems refers to waters where the dissolved oxygen concentration is below 2 mg/L. Most organisms avoid, or become physiologically stressed in, waters with oxygen below this concentration. Hypoxia can also kill marine organisms which cannot escape the low-oxygen water, affecting commercial harvests and the health of impacted ecosystems. While hypoxia can occur naturally, it is often a symptom of environments stressed by human impact such as from excess nutrient enrichment from point and non-point sources. Over half of the U.S. estuaries now experience natural or human-induced hypoxic conditions at some time each year and evidence suggests that the frequency and duration of hypoxic events have increased over the last few decades.

The importance and national scale of hypoxia and nutrient pollution in U.S. waters is evidenced by the reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act (HABHRCA) and two national reports which describe the need and identify priorities for research related to nutrient inputs, eutrophication and hypoxia in U.S. coastal waters (i.e. Priority Topics for Nutrient Pollution in Coastal Waters: An Integrated National Research Program for the United States and An Assessment of Coastal Hypoxia and Eutrophication in U.S. Waters). The recently released reports by the U.S. Commission on Ocean Policy and the Pew Oceans Commission Report both identify non-point source pollution in coastal ecosystems as one of the nation's most widespread pollution problems and the greatest pollution threat to coastal marine life.

Approach

Over the past three decades, the U.S. has made substantial progress in reducing water pollution from industrial and municipal facilities. But control of what is called "nonpoint" pollution - such as nutrient, bacterial, and chemical pollution from agricultural fields and from urban areas - remains a continuing challenge. CSCOR-sponsored scientists and their partners in government, academia and industry are seeking ways to better understand links between nutrient over-enrichment and eutrophication and their impacts on human health and estuaries.

An example of the key role which CSCOR is playing to address nutrient enrichment can be found in the Gulf of Mexico where a large area of low oxygen bottom water, known as the "Dead Zone", is a recurrent feature during the summer. The "Dead Zone" immediately became a focal point for considerable scientific and policy attention because of its enormous size and implications for watershed management for more than 40% of the continental United States. Employing a combination of field, monitoring, and modeling studies, within an ecosystem management framework, CSCOR-sponsored research has enabled NOAA to provide key information and tools to coastal managers to help manage and mitigate the size and impact of the annual hypoxic zone in the Gulf of Mexico (see NGOMEX program at: http://www.cop.noaa.gov/stressors/pollution/current/gomex-factsheet.html). CSCOR is now expanding the program to address hypoxia in other coastal, estuarine, and Great Lake regions around the U.S.

CSCOR also has other studies examining the effects of multiple stressors from human activities on natural systems. The Barataria watershed in the Gulf of Mexico is a significant estuary with a large fisheries yield and is currently experiencing large habitat changes and anticipates a doubled nitrogen loading. The watershed is located next to, and exchanges water with, the Mississippi River — the largest river in North America— whose watershed is shifting to a new management regime to reduce its nitrogen load. This long-term, ecosystem scale, study will quantify ecosystem responses to multiple stressors with several indicators being developed to assess the health and sustainability of the coastal wetlands when subject to varying degrees of nutrient inputs.

Management & Policy Implications

CSCOR's intent is to provide timely and high-quality scientific results that can be used in an adaptive management program that connects monitoring, data analysis, and model predictions with management actions to restore and protect coastal ecosystems. CSCOR-sponsored research has enabled NOAA to provide key information and tools to coastal managers to help manage and mitigate the size and impact of the annual hypoxic zone in the Gulf of Mexico. Ongoing research efforts are helping to develop a hierarchical suite of indicators of estuarine habitat health and sustainability which can be used to help evaluate the effectiveness of various estuarine mitigation and restoration strategies.

Accomplishments

Using information and tools developed by CSCOR-sponsored research, coastal managers can now better address the national problems of hypoxia and nutrient pollution and help protect and restore valuable coastal ecosystems. Several examples are described below:

- CSCOR-sponsored scientific investigations have documented the zone off the Louisiana continental shelf with seasonally depleted oxygen levels since 1990. In the summer of 2002, the hypoxic zone reached its largest extent, measuring 22,000 km2, an area greater than the size of Massachusetts. This summer the hypoxic zone covered 15,040 km2 and extended from the Mississippi river delta almost to Texas. Data obtained through these studies is used to calculate a 5-year average size of the hypoxic zone in the Gulf which is a key metric for setting and determining upstream nutrient management strategies. These surveys have been ongoing for 20 years and represent a unique long-term dataset with which to gauge the progress of management actions and to access the accuracy of model forecasts.
- Scientists have used a biophysical model to explore and successfully predict the direct effects of variable nutrient loads on the areal extent of hypoxia in the Gulf of Mexico while also accounting for year-to-year variability in oceanographic conditions. Results from this study indicate that current nutrient load reductions targeted at 30% may not be enough to achieve the management goal for the reduction in hypoxic zone size, but that it could take a reduction of 40-45% to assure the goal is satisfied in most years. Researchers have expanded on these studies to provide an ecological forecasting capability which successfully predicted the size of Gulf of Mexico dead-zone this year. Forecasts such as these will allow for the assessment of alternative management strategies within the context of long-term changes in eutrophication and hypoxia and the impacts on commercially and ecologically important species.
- Scientists have documented the fine-scale distributions of fish and shrimp with respect to hypoxia and have found that the dead-zone may have a negative impact on shrimp growth. Preliminary results of a study indicate that within the seasonal hypoxic (low oxygen) zone that forms each summer in the bottom waters over the Louisiana continental shelf there is a correlation between low oxygen levels and low lipid concentrations in shrimp tissue, which in turn, would be expected to result in lower growth rates. Analyses of shelf-wide size distributions of shrimp from northern Gulf of Mexico fishery surveys is consistent with this prediction, showing a declining trend in shrimp size from the 1980s, when hypoxia was less severe, to the mid to late 1990s, when hypoxia was more severe. The impact of hypoxia on living resources is of great concern and value especially since the northern portion of the Gulf of Mexico ecosystem supports commercial and recreational fisheries which generate 2.8 billion annually.
- CSCOR is assisting the Mississippi River Basin/Gulf of Mexico Hypoxia Task Force in its efforts to reassess the Gulf of Mexico Action Plan. Last year, the Mississippi River Basin/Gulf of Mexico Hypoxia Task Force, (nine Federal members, nine states, and two tribes) approved a Reassessment of the 2001 Gulf of Mexico (GOM) Action Plan, specifying science and management goals for understanding and reducing hypoxia in the Gulf of Mexico. The Action Plan had been prepared in accordance with the Harmful Algal Bloom and Hypoxia Research and Control Act of 1998 (HABHRCA). The results of the Reassessment which will serve to update and synthesize research efforts on the causes and consequences of the dead (hypoxic) zone and progress in implementing nutrient reduction measures in the Mississippi River watershed. The research conducted through CSCOR's hypoxia program will be incorporated into the synthesis of activities within the Gulf of Mexico and NOS/NCCOS will be leading elements of the science reassessment.

Additional CSCOR accomplishments can be found at: http://www.cop.noaa.gov/aboutus/accomplishments.html

For more information, contact:
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