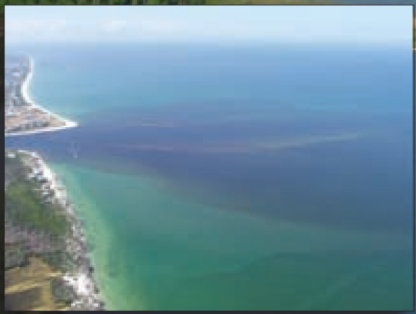
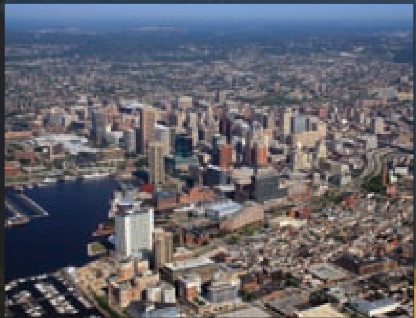
EFFECTS OF NUTRIENT ENRICHMENT IN THE NATION'S ESTUARIES:
A Decade of Change





National Estuarine Eutrophication Assessment Update

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Effects of Nutrient Enrichment In The Nation's Estuaries:
A Decade of Change

Assessing change in eutrophic condition
from the early 1990s to 2004

National Estuarine Eutrophication Assessment Update

EFFECTS OF NUTRIENT ENRICHMENT IN THE NATION'S ESTUARIES: *A DECADE OF CHANGE*

National Estuarine Eutrophication Assessment

National Estuarine Eutrophication Update

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FOREWORD

In 1999, the National Estuarine Eutrophication Assessment described the scale, scope, and characteristics of nutrient enrichment and eutrophic conditions in the Nation's estuaries. At the time, it was the most comprehensive examination ever reported of nutrient-related water quality impacts, their causes, and expected changes in condition in U.S. coastal water bodies. The results showed that most estuarine systems exhibited some level of eutrophication impact in the early 1990s. One of the main aims of the report was to develop a national strategy to limit the nutrient enrichment problems affecting U.S. estuarine and coastal water bodies.

This updated 2007 report continues to examine eutrophic conditions into the 2000s. It attempts to look at changes that occurred in the past decade, and analyze the Nation's progress in addressing what we now see as a ubiquitous problem. Coastal eutrophication is a global problem not limited to U.S. coastal waters. This report highlights the nutrient contamination in selected coastal systems throughout the U.S., Europe, Australia, and China in an effort to share what we know about the development of eutrophication, and to provide successful solutions to better manage the problem.

In addition to gaining a broader view of the issue, this report has enhanced and improved upon earlier work in other ways. The innovative assessment approach using the experience and knowledge base of experts from around the Nation has been transformed into a web-enabled tool. This web-based tool allows investigators to share data and information effectively and communicate in a standardized manner. This represents one of few instances where web-based communication has been accomplished for ecological monitoring on such a large scale (accessible at *http://ian.umces.edu/neea* or *http://www.eutro.us*). Effective communication is vital because the assessment will be updated on a periodic basis. The development of a complementary human use/socioeconomic indicator is also a significant enhancement designed to bridge the gap between scientific and public interest.

Additionally, this report provides a valuable context for a number of ongoing and planned activities designed to address estuarine eutrophication such as the multi-agency National Coastal Condition Report and the Gulf of Mexico Alliance Governors' Action Plan.

We encourage you to use this work to stimulate further scientific and management efforts to protect our precious coastal resources.

John H. Dunnigan
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for Ocean Services and
Coastal Zone Management

Dr. Donald F. Boesch
President
University of Maryland,
Center for Environmental Science

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LOOE KEY, FL: Nutrients and climate change pose threat to coral reefs

Brian Lapointe, Brad Bedford, and Rex Baumberger, Harbor Branch Oceanographic Institution

Looe Key is a coral reef approximately 0.3 km^2 in area, located 7 km south of Big Pine Key in the lower Florida Keys. Increasing sewage discharges from development in the Florida Keys and stormwater runoff from agricultural areas of South Florida have increased nutrient concentrations at Looe Key over the past two decades, affecting optical clarity essential for coral health and increasing prevalence of macroalgae.

Brian Lapointe, Harbor Branch Oceanographic Institution

Nutrient enrichment and coral reefs

Coral reefs worldwide are threatened by a variety of human activities, including land-based nutrient pollution, the eutrophic effects of which may be exacerbated by climate change (e.g., precipitation, hurricanes). Looe Key, a National Marine Sanctuary since 1983, has experienced significant eutrophication as a result of human activities in its watershed (Lapointe et al. 2002). A significant increase in water column dissolved inorganic nitrogen (DIN) in the early and mid-1990s correlated with increased water deliveries and nitrogen loads from Shark River Slough which drains a significant portion of the Everglades Agricultural Area south of Lake Okeechobee (Figure 5.17a,b). The resulting eutrophication in the 1990s included blooms of phytoplankton (Figure 5.17b) and macroalgae, as well as a 250% increase in the incidence of coral diseases, including 'white pox' which afflicts elkhorn coral (*Acropora palmata*) and is caused by the fecal coliform bacterium, *Serratia marcescens* (Patterson et al. 2002).

History of coral reef impacts in this region

Coral reefs are biologically diverse ecosystems well known to be sensitive to low-level nutrient concentration increases. In South Florida, drainage of wetlands, increasing urbanization, and agricultural activity have increased nutrient loads to coastal waters in recent decades. During the early 1980s and again in the 1990s, South Florida water managers dramatically increased flows of nutrient-rich fresh water from agricultural areas of the northern Everglades to the Florida Bay/Florida Keys region (Figure 5.17b). Following these increased nitrogen loads, macroalgae and phytoplankton blooms increased in duration, frequency, and magnitude. Outflows of turbid, nutrient-enriched water from Florida Bay have negatively impacted coral reef communities of the Florida Keys National Marine Sanctuary (FKNMS), including Looe Key. Between 1996 and 1999, living coral cover in the FKNMS declined by 38%, to an average of 6.4% coverage, and elkhorn coral populations that once dominated the shallow fore reef at Looe Key have decreased by more than 95% (Porter et al. 2002). This loss of coral cover has resulted primarily from eutrophication, expressed as algal blooms (phytoplankton, macroalgae, turf algae, cyanobacteria), coral diseases (including black-band, yellow-band, and white-pox disease), and decreased water clarity, though these impacts may have been exacerbated by climate change.

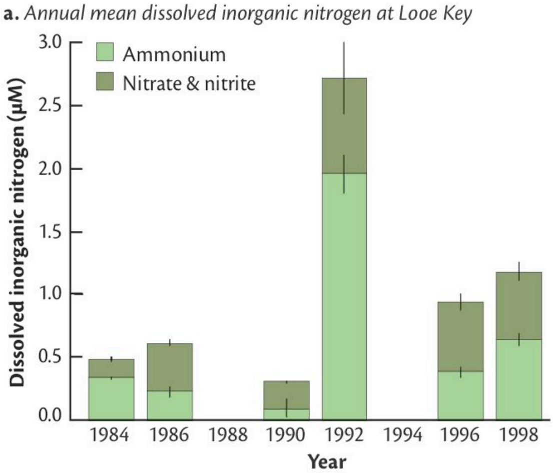
Reef building corals require optically clear water ($K < 0.18\ m^{-1}$) and high levels of downwelling irradiance (Yentsch et al. 2002), but optical clarity of water in the Florida Keys has diminished in recent decades, as evidenced by higher average water column light attenuation coefficients ($K\ m^{-1}$) than were observed in the past. This reduced light availability, stemming from degradation of water quality, has presented an additional threat to coral survival. The increase in nutrient concentrations in recent decades has supported increased macroalgal growth and reproduction at Looe Key. For example, blooms of the green alga *Codium isthmocladum*, a well-known nutrient indicator species not found at Looe Key before the early 1980s, have appeared in recent years and continue to develop in response to increasing nutrients. Stable nitrogen isotope data have also been used to demonstrate that land-based nitrogen enrichment from sewage in the Florida Keys and from agricultural sources in South Florida have supported macroalgal blooms at Looe Key in recent years (Lapointe et al. 2004). Nitrogen-enhanced macroalgal growth has also overwhelmed the ability of herbivores to control macroalgal biomass at Looe Key, despite high rates of grazing by large populations of parrotfish and surgeonfish.

Future outlook

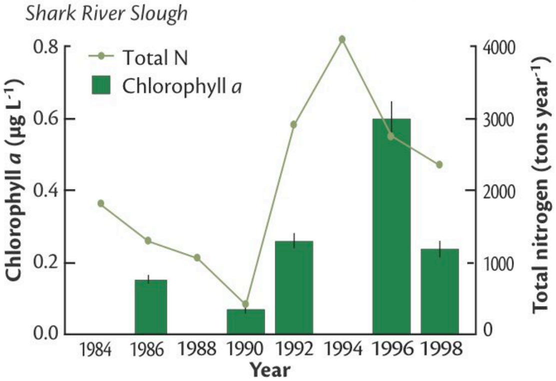
Because of the influences of expected increases in residential population growth and climate change in the Florida Keys and South Florida, the issues associated with eutrophication and coral reef degradation will become more pressing. Because coral reefs are subject to the effects of climate change, which has increased the frequency of mass coral bleaching events globally (Buddemeier et al. 2004), coral bleaching is likely to become a chronic source of stress for Caribbean reefs in the near future (McWilliams et al. 2005). These combined stresses may work in a synergistic manner to hasten the loss of coral reefs at Looe Key. The Everglades Restoration Plan in particular includes policies that could increase water flow and nitrogen loads to western Florida Bay and the Florida Keys. A better understanding of the combined pressures contributing to this problem will be required if it is to be managed effectively, and new approaches must include methods for the removal of nitrogen from Shark River Slough before discharge into coastal waters.

Figure 5.17. Nutrient enrichment in Looe Key reef.*

a. *Annual mean dissolved inorganic nitrogen at Looe Key*



b. *Annual chlorophyll* a *and total nitrogen flux from Shark River Slough*



***While unusual in many systems, ammonium was higher than nitrate & nitrite periodically, especially during a big spike in '92 following a release of large amounts of ammonia-based fertilizers used on sugarcane fields.**

Implications for other systems

As part of the FKNMS, Looe Key has been a 'No-take Zone' protected from overfishing since 1983. As such, it is a prime location for the study of eutrophication impacts on reef fish assemblages in the absence of local fishing pressure. Comparisons among fish censuses conducted in the early 1980s (Bohnsack et al. 1987) and in 2002 indicated that snapper, grouper, and grunt populations had decreased by more than 75% during that time, whereas herbivorous fish populations such as parrotfish and surgeonfish had doubled. These data illustrate the importance of water quality to the survival of coral reef habitat and to the sustainability of associated reef fish populations.

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