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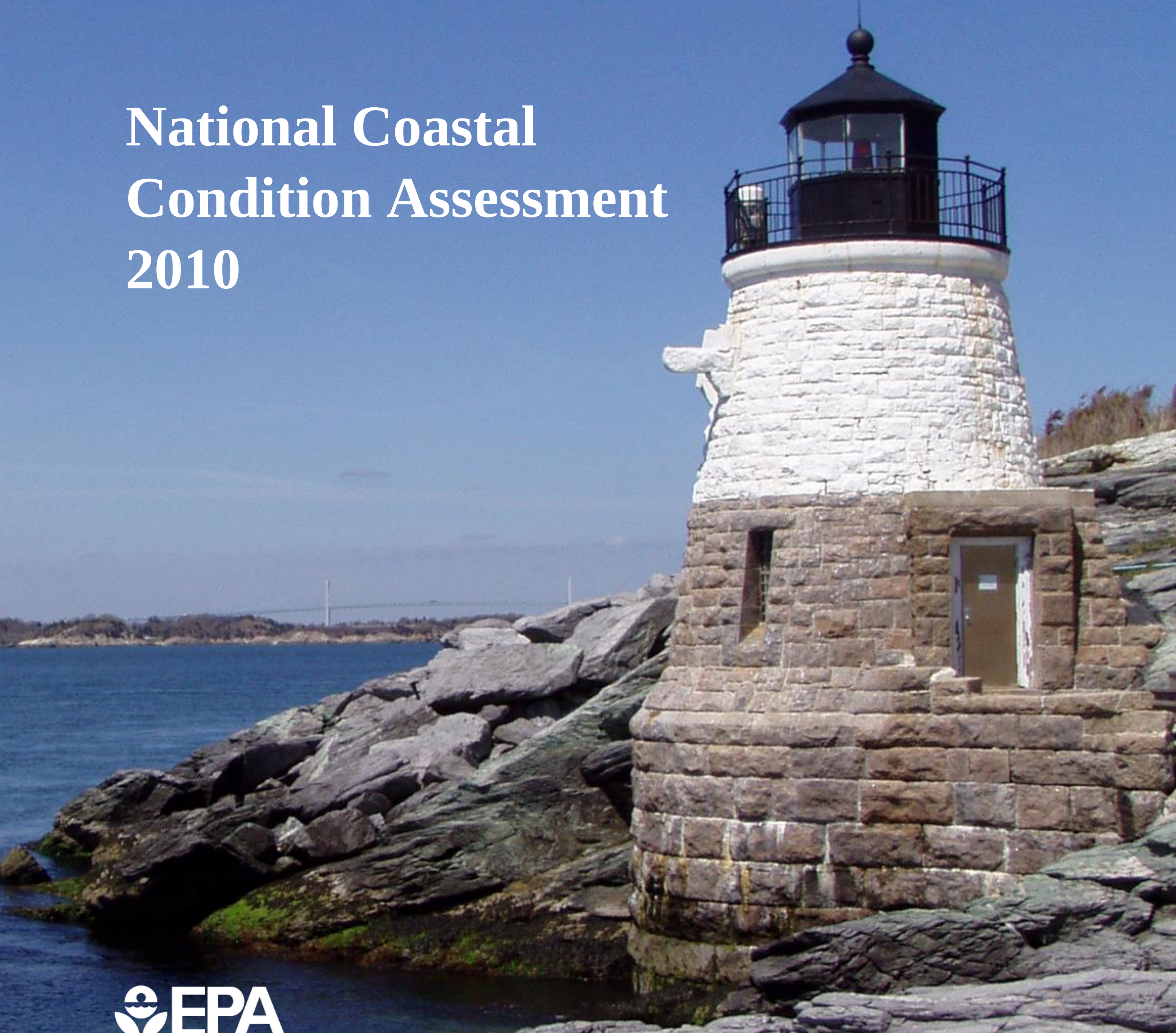
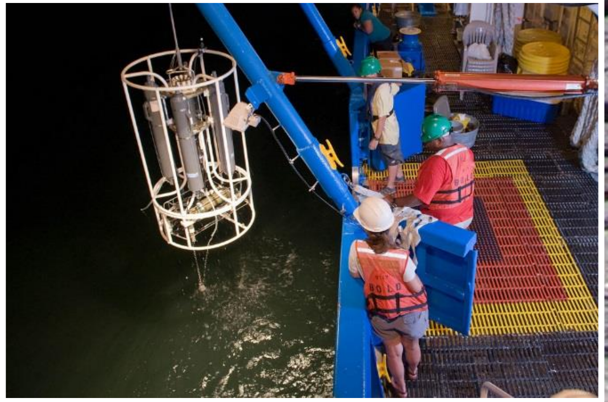
National Coastal Condition Assessment 2010





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http://www.epa.gov/national-aquatic-resource-surveys/ncca

Cover photo: **Castle Rock Lighthouse, Newport, Rhode Island** (Courtesy of United States Coast Guard)

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A team of contributors led by Treda Grayson, EPA Program Manager, wrote this report. This team included Virginia Hansen, Linda Harwell, John Kiddon, and Marguerite Pelletier, EPA Office of Research and Development; Mari Nord, EPA Region 5; and Greg Colianni, Alice Mayio, Sarah Lehmann, and Hugh Sullivan, EPA Office of Water. EnviroScience, Inc. and the Great Lakes Environmental Center provided graphics and editorial support.

State and Other Partners:
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This report is dedicated to the memory of Gregory Colianni of EPA, a colleague and friend who worked tirelessly to protect our nation's coasts. As the lead for the NCCA program, Greg's expertise, guidance, and support set the stage for coastal surveys for years to come. He is deeply missed.

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EXECUTIVE SUMMARY

This *National Coastal Condition Assessment 2010* (NCCA 2010) is the fifth in a series of reports assessing the condition of the coastal waters of the United States, including a vast array of beautiful and productive estuarine, Great Lakes, and coastal embayment waters. It is part of the National Aquatic Resource Surveys (NARS), a series of statistically based surveys designed to provide the public and decision makers with nationally consistent and representative information on the condition of all the nation's waters. The NCCA 2010 answers questions such as: What is the condition of the nation's coastal waters, and is that condition getting better or worse? What is the extent of the stressors affecting them?

This report is based on an analysis of indicators of ecological condition and key stressors in the coastal waters of the Northeast, Southeast, Gulf of Mexico, West, and Great Lakes regions of the conterminous United States. These waters are enormously varied and valuable, including remarkable resources as diverse as Narragansett Bay; the Chesapeake Bay; the subtropical waters of Biscayne Bay and Tampa Bay; San Francisco Bay and Puget Sound; and the nearshore waters of the Great Lakes—the largest expanse of fresh surface water on earth.

In the summer of 2010, the U.S. Environmental Protection Agency (EPA) and state, tribal, and federal partners sampled 1,104 sites in these waters, representing 35,400 square miles of U.S. coastal waters. They used the same methods at all sites to ensure that results would be nationally comparable. This report examines four indices as indicators of U.S. coastal condition: a benthic index, a water quality index, a sediment quality index, and an ecological fish tissue contaminant index. Figure ES-1 summarizes these findings.

Collecting a sediment sample for analysis. (Photo courtesy of Treda Grayson)

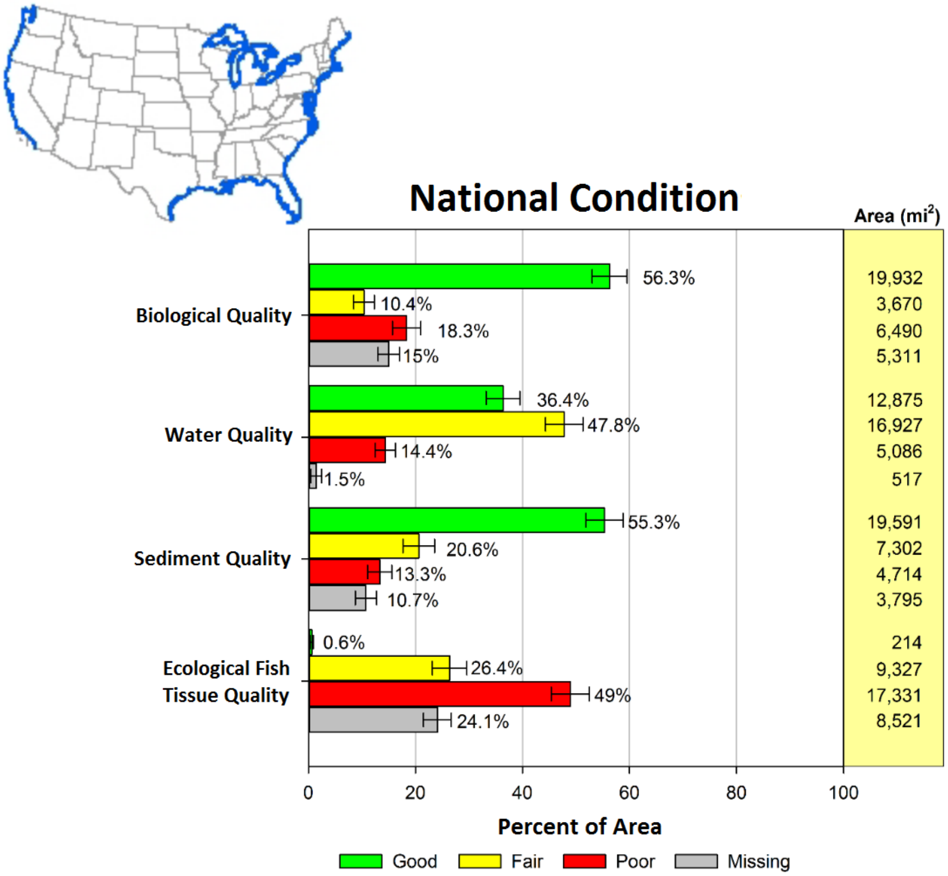


Figure ES-1. Condition of the nation's coastal waters for each of the four NCCA indices (U.S. EPA/NCCA 2010). Note: Percentages may not add up to 100% due to rounding.

Key Findings

Biological Quality

A majority of coastal and Great Lakes nearshore waters support healthy communities of benthic macroinvertebrates (bottom-dwelling creatures such as worms and clams) which are indicators of biological quality. Data show that 56% of the nation's coastal and Great Lakes nearshore waters are rated good for biological quality, 10% are rated fair, and 18% are rated poor based on the benthic index. Data are incomplete or missing for 15% of waters. The Northeast Coast has the highest percentage of waters rated poor for biological quality (27%).

Water Quality

Water quality is rated good in 36% of coastal and Great Lakes nearshore waters, fair in 48%, and poor in 14% based on the water quality index. Components of the water quality index include phosphorus, nitrogen, water clarity, chlorophyll *a*, and dissolved oxygen. The most widespread of these stressors is phosphorus (rated poor in 21% of waters). Too much phosphorus can enter coastal waters from sources such as sewage and fertilizer runoff and result in large algal blooms, increased levels of chlorophyll *a*, and reduced water clarity and dissolved oxygen levels. Of the five regions, the Gulf Coast has the highest percentage of waters rated poor for water quality (24%).

Sediment Quality

A majority (55%) of coastal and Great Lakes nearshore waters have good sediment quality, 21% have fair quality, and 13% have poor quality. This finding is based on an index of sediment quality that has two component indicators: sediment contaminants and sediment toxicity. Overall, 79% of coastal waters are rated good based on low levels of sediment contaminants and 57% of waters are rated good based on the toxicity effects of contaminants. The Gulf Coast and the West Coast have the highest percentage of waters rated poor for sediment quality—about 25%. Nationally, sediment quality data are incomplete or missing for 11% of waters.

Ecological Fish Tissue Quality

This report, which primarily addresses ecological rather than human health conditions in coastal waters, assesses the potential harm that fish tissue contaminants pose to predator fish, birds, and wildlife. Based on this index, less than 1% of coastal and Great Lakes nearshore waters are rated good, 26% are rated fair, and 49% are rated poor. Data are incomplete or missing for the remaining 24% of waters. Selenium is the most widespread contaminant exceeding the fish tissue contaminant thresholds for predators. While selenium occurs naturally and is nutritionally valuable, too much selenium can be toxic. These findings indicate that contaminants in fish may have long-term adverse effects on fish-eating wildlife. With the exception of a supplemental study in the Great Lakes, analysts did not evaluate human health risks.

In 2010, NCCA researchers used a new, highly protective analytical approach for determining ecological fish tissue contaminant ratings that is more conservative than the approach used in the past. Screening values are based on impacts to the most sensitive freshwater or saltwater fish, birds, and wildlife species.

Change in Coastal Condition

The NCCA 2010 uses a consistent set of data from three periods (1999–2001, 2005–2006, and 2010) to evaluate change in coastal condition over time. This analysis includes national and regional findings for the water quality index, sediment quality index, and benthic index for the Northeast, Southeast, Gulf, and West Coast regions over the three periods. Data from past fish tissue collection efforts are not comparable across the three time periods, and therefore are not included in the change analysis. In addition, the change analysis does not include the Great Lakes because they were not part of this survey until 2010.

National findings of the change analysis (Figure ES-2) include the following:

- The percent area rated good for the water quality index decreases significantly by 12% from 1999–2001 to 2005–2006 and does not show a statistically significant change from 2005–2006 to 2010. Changes in most of the components of the water quality index are mixed, reflecting the inherent variability in water quality indicators over time.

- A statistically significant increase of 8% in waters rated good for the sediment quality index between the first and second time periods (1999–2001 to 2005–2006) is followed by a larger decline of 22% in waters rated good between 2005–2006 and 2010.
- For the benthic index, the percent area of waters rated good shows no statistically significant change between 1999–2001 and 2005–2006, followed by a statistically significant increase of 17% in waters rated good between 2005–2006 and 2010.

While these results might appear contradictory, these three indicators do not necessarily respond to stressors in the same manner, nor do the indicators reflect all stressors that impact coastal waters. As additional data are collected and analyzed for the NCCA 2015, clearer trends may emerge.

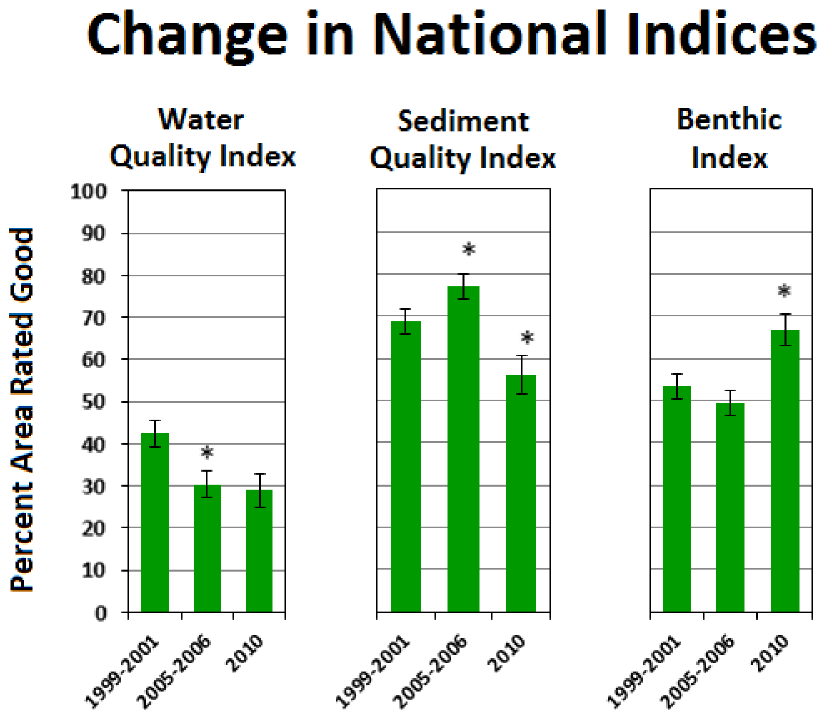
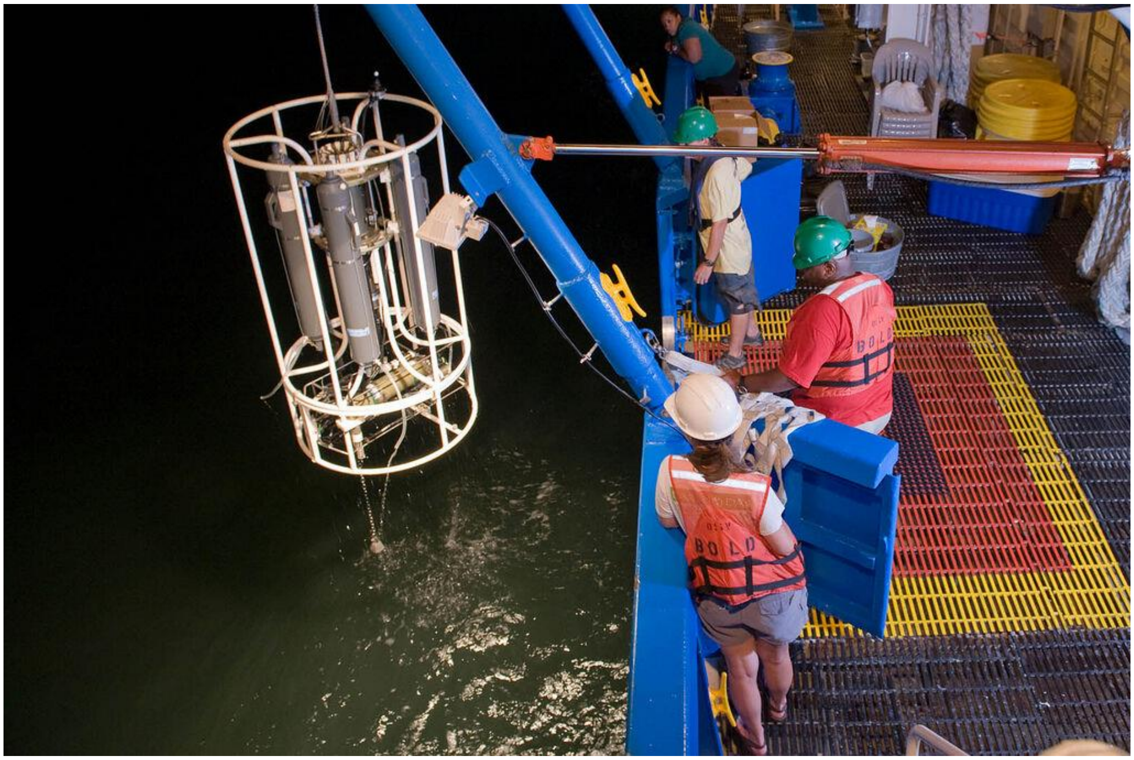


Figure ES-2. Comparison of the percent area rated good for national water quality, sediment, and benthic indices over three periods. Note: Asterisk indicates statistically significant change from the previous period. Change analysis does not include the Great Lakes.

Implications

EPA and its federal, state and tribal partners continue to work together to answer important questions about the condition of the nation's coastal waters. They have revised the way coastal condition indicators are analyzed and assessed, updated indicators to reflect the current state of the science, and gained and shared new expertise in state-of-the-art field monitoring methods. For the first time, the nearshore waters of the Great Lakes have been included in a national probability-based survey. The NCCA 2010 findings support the need for continued attention to coastal stressors at the national, regional, state and watershed scales. In addition, the findings support the need to identify and mitigate challenges where they exist and protect areas that are still in good condition.



Raising samples aboard the EPA research vessel *Bold*. (Photo courtesy of Eric Vance)

CHAPTER 1.

INTRODUCTION

This *National Coastal Condition Assessment 2010* (NCCA 2010) is the fifth in a series of reports that assess the condition of the coastal waters of the United States, which include a vast array of beautiful and productive estuarine, Great Lakes, and coastal embayment waters. Previous publications in this series were known as the *National Coastal Condition Reports I–IV*. These reports were part of EPA's research program and used different methodologies and indicators over time, as well as data from a variety of other monitoring/assessment programs. This NCCA 2010 is now a part of the National Aquatic Resource Surveys (NARS), a series of statistically based surveys designed to provide the public and decision makers with nationally consistent and representative information on the condition of all of the nation's waters. The NCCA 2010 also assesses changes over time using those data from past reports that correspond with the statistical design and indicators now in use.

Purpose of This Report

The NCCA 2010 presents information on the ecological condition of U.S. coastal and Great Lakes nearshore waters and key environmental stressors affecting these waters. Importantly, it provides data that coastal managers can use to determine the future direction of coastal monitoring efforts.

The NCCA 2010 is designed to help us answer questions such as:

- What is the condition of the nation's coastal waters?
- Is that condition getting better or worse?
- What is the extent of the stressors affecting them?

Data are presented nationally (Chapter 3) and at large regional scales (Chapter 4). The NCCA was not designed to represent individual estuaries, embayments, or other local areas, nor does it address all possible indicators.

This report uses monitoring data for a core set of indicators to provide insight into current coastal condition. While it does not track the causes of these stressors, it does provide general background on the types of sources that are often associated with these stressors. The survey also supports a longer-term goal to determine whether our coastal waters are getting cleaner and how we might best invest in their protection and restoration. The findings of this report are not the same as water quality assessments prepared by the states under Section 305(b) of the Clean Water Act (CWA), nor are they impaired water determinations under Section 303(d) of the CWA. Such determinations are made by states on specific waters using state water quality standards and monitoring data.

Why Are Coastal Waters Important?

Coastal Waters Are Valuable and Productive Natural Ecosystems

The waters assessed in this report include nearshore marine coastal waters from the head-of-salt (i.e., the landward extent of tidal incursion) to the confluence with the ocean. These waters include estuaries and bays such as the Chesapeake Bay, Florida Bay, Cape Cod Bay, and Puget Sound; and the nearshore waters and embayments of the Great Lakes, including Green Bay, Saginaw Bay, and Keweenaw Bay.

These waters are enormously varied. Estuaries receive freshwater and sediment influx from rivers and tidal influx from the oceans, thus serving as transition zones between the freshwater of a river and the saline environment of the sea. Many different habitat types are found in and around estuaries, including shallow open waters, freshwater areas, brackish and salt marshes, swamps, sandy beaches, mud and sand flats, rocky shores, oyster reefs, mangrove forests, river deltas, tidal pools, and sea grasses. These environments support wildlife and fisheries and contribute substantially to the economy of ocean coastal areas.

Estuaries and coasts provide essential nesting, resting, feeding, and breeding habitat for 75% of U.S. waterfowl and other migratory birds. They also supply water for industry; support the critical terminals of the nation’s marine transportation system along with U.S. Coast Guard and U.S. Navy facilities; receive point source wastewater discharges from municipalities and industries; and receive pollution from upstream sources, including nonpoint source pollution from urban and agricultural land runoff. Estuaries and coastal wetlands also serve as buffers against storms and sea-level rise.

The nearshore waters of the Great Lakes are included in this coastal assessment because they share many characteristics with marine nearshore waters. Although they are freshwater, they have shallow depths, display changing water levels due to wind-driven “tides,” and act as estuaries where river and lake waters mix. The Great Lakes form the largest surface freshwater system on Earth. More than 30 million people live in the Great Lakes basin, and the impacts of their daily activities, from the water they consume to the waste they return, directly affect the Great Lakes environment. The Great Lakes watershed includes a broad range of habitats, from coniferous forests and rocky shorelines along Lake Superior to the fertile agricultural soils and sandy beaches along Lake Michigan and Lake Erie. The coastal ecosystems of the Great Lakes include forests, wetlands, coastal marshes, sand dunes, savannas, rock barrens, and thousands of islands. Critical coastal habitats provide spawning grounds, nurseries, shelter, and food for finfish, shellfish, and wildlife.

Coastal Populations and Economics

Coastal areas are the most developed areas in the United States. In 2010, 163.8 million people, or 52% of the nation's population, lived in coastal watershed counties (i.e., counties that encompass land areas where water flows into the ocean or Great Lakes) representing less than 20% of the U.S. land area (including Alaska). The population of the nation’s coastal watershed counties increased by 51 million people between 1970 and 2010, constituting a 45% growth rate (compared to 52% for the nation as a whole).

The average population density of coastal watershed counties (319 people per square mile) is more than five times greater than the population density of inland counties. Higher population density is frequently accompanied by increased demand for the benefits our coasts provide. These benefits, also known as ecosystem services, include seafood harvesting, energy production, pollution control, shoreline protection, and recreational opportunities.

The National Oceanic and Atmospheric Administration's (NOAA) State of the Coast report (U.S. Department of Commerce, NOAA, March 2013) provides additional information about the economic value of coastal waters, including the following:

- In 2011, the coastal counties supported 51 million jobs and contributed $6.5 trillion to the U.S. economy.
- 45% of U.S. gross domestic product was generated in the coastal counties along the oceans and Great Lakes in 2011.
- One million jobs are associated with the U.S. commercial fishing industry, yielding over $32 billion in income.

In the Great Lakes alone, beaches, resort communities, and natural areas support a vibrant recreation and tourism industry and enhance the quality of life for residents. Over 4 million recreational vessels are registered in the region, and people spend nearly $16 billion annually on boating trips and equipment. Many millions of people take advantage of the region's Great Lakes-dependent natural resources. The Great Lakes also provide efficient transportation, supporting critical manufacturing and steel production in major U.S. cities. Great Lakes vessels transport an average of 163 million tons of cargo (e.g., iron ore, coal, and grain) each year.

Why Be Concerned About Coastal Condition?

Human activities create environmental pressures that threaten the very resources and services that make coastal living desirable. Rising populations lead to increased solid waste production; higher volumes of urban nonpoint-pollution (i.e., runoff from diffuse sources, such as streets, parking lots, and construction sites); loss of green space for recreation and wildlife habitat; increased impervious surface area in coastal watersheds; and increased demands for wastewater treatment, irrigation and potable water, and energy supplies. Coastal wetlands that provide critical habitat, mitigate floods, and protect shorelines from erosion continue to be lost to residential and commercial development. In addition, the quantity and timing of freshwater flow, which are both critical to riverine and estuarine function, continue to be altered.

Offshore stressors include oil spills, over exploitation of fisheries, potential contamination from ocean dumping and energy development, marine debris, and habitat loss. New pressures resulting from climate change, such as sea level rise, ocean warming, and ocean acidification, also threaten coastal habitats.

The National Aquatic Resource Surveys

Section 305(b) of the Clean Water Act (CWA) requires states to monitor, assess, and report on the condition of their waters, including the extent of waters that support the goals of the Act. Under Section 303(d), states identify waters that are impaired because they do not meet state water quality standards, and then typically develop a Total Maximum Daily Load (TMDL) to define pollution sources and control needs. States use a variety of monitoring and assessment approaches to meet the requirements of the CWA, but all are designed to meet state-specific information and management needs.

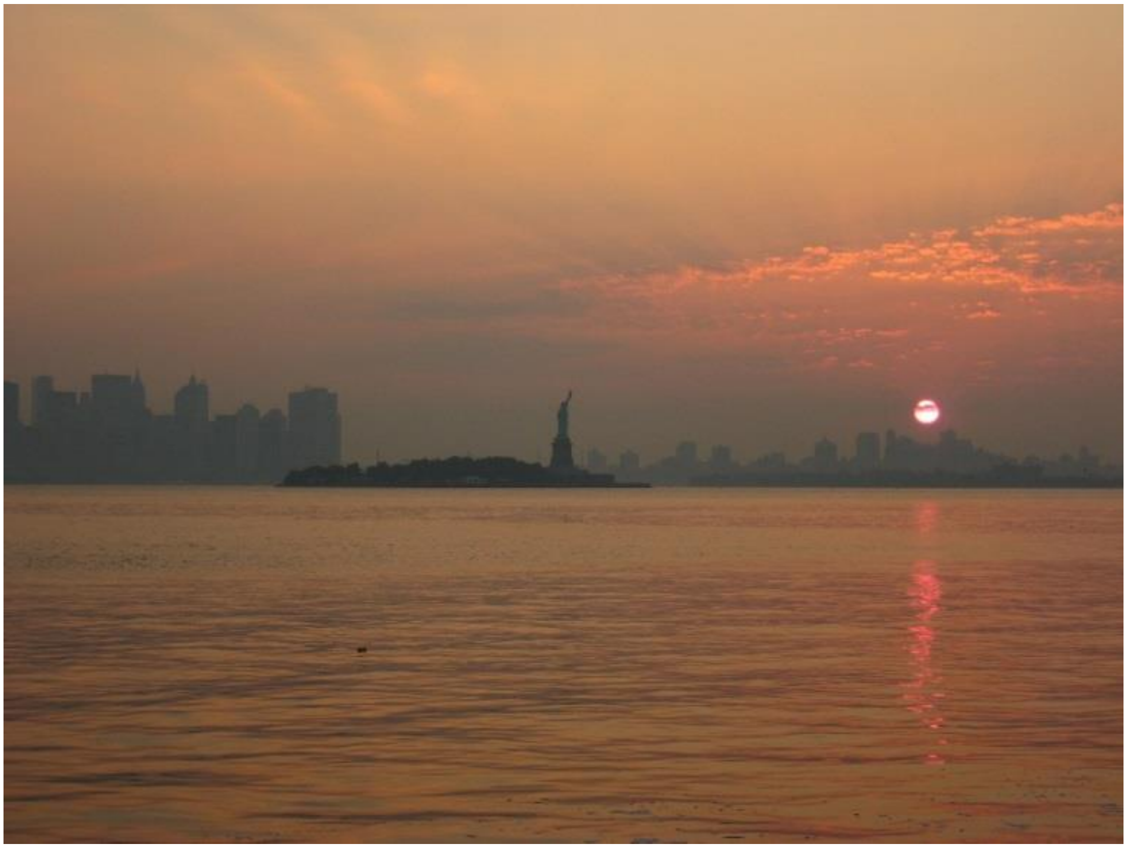
State monitoring programs are not designed to answer national-level questions such as whether or not overall surface water quality is improving in the United States. State methods of collecting and assessing data vary widely among states and may change over time; so too do the state water quality standards used to determine impairment. These differences make it difficult to aggregate this state-level information into a consistent assessment of the condition of the nation's waters as a whole or of changes in condition over time.

In the early 2000s, a series of independent reports identified the need for improved water quality monitoring and analysis at the national scale. For example, the General Accounting Office reported that EPA and states could not make statistically valid assessments of water quality and lacked the data to support key management decisions. To bridge this information gap, EPA and its tribal, state, and federal partners have collaborated to answer national-level questions about water quality, key environmental stressors, and trends over time. The National Aquatic Resource Surveys (NARS) also provide consistent, large-scale data sets that can be used by EPA, states, and others to answer additional water quality questions.

Prior to 2007, EPA research led to the development of national surveys of coastal waters and freshwater systems such as lakes, rivers, and streams. The National Coastal Assessment (NCA) (2000-2006) was the first nationally consistent survey of the condition of estuaries and near coastal waters of the United States. (See box: "Previous Reports in this Series.") The *Wadeable Streams Assessment,* published in 2006, was the first nationally consistent study of the nation's streams. These surveys provided the framework for the statistically based NARS, which have been conducted by EPA, states, and tribes since 2007. NARS reports include the *National Lakes Assessment*, the *National Rivers and Streams Assessment*, the *National Coastal Condition Assessment*, and the *National Wetland Condition Assessment*. These assessments use standardized survey designs, indicators, and field and laboratory protocols, as well as strict quality assurance guidelines. Each survey is designed to generate statistically valid estimates of the ecological health of the nation's waters through sampling indicators of aquatic community health, water quality, human health, and associated ecological data in a representative sample of waters.

The NCCA 2010, while actually EPA's fifth assessment of coastal water quality, is considered the first coastal assessment in the NARS series. Readers will find it significantly different than the previous *National Coastal Condition Reports I–IV,* as it is now designed and written as one of the NARS reports. While key indicators remain similar to those in past coastal reports, the

NCCA 2010 is less detailed and uses very little data external to the NARS program (such as beach closure or fish advisory information). Additionally, based on past comments and to reflect advances in the science, the fish tissue and sediment indices have been revised. Their index scores should not be directly compared to those presented in the pre-2010 *National Coastal Condition Reports I–IV.*



New York/New Jersey Harbor. (Photo courtesy of David Cox)

Previous Reports in This Series

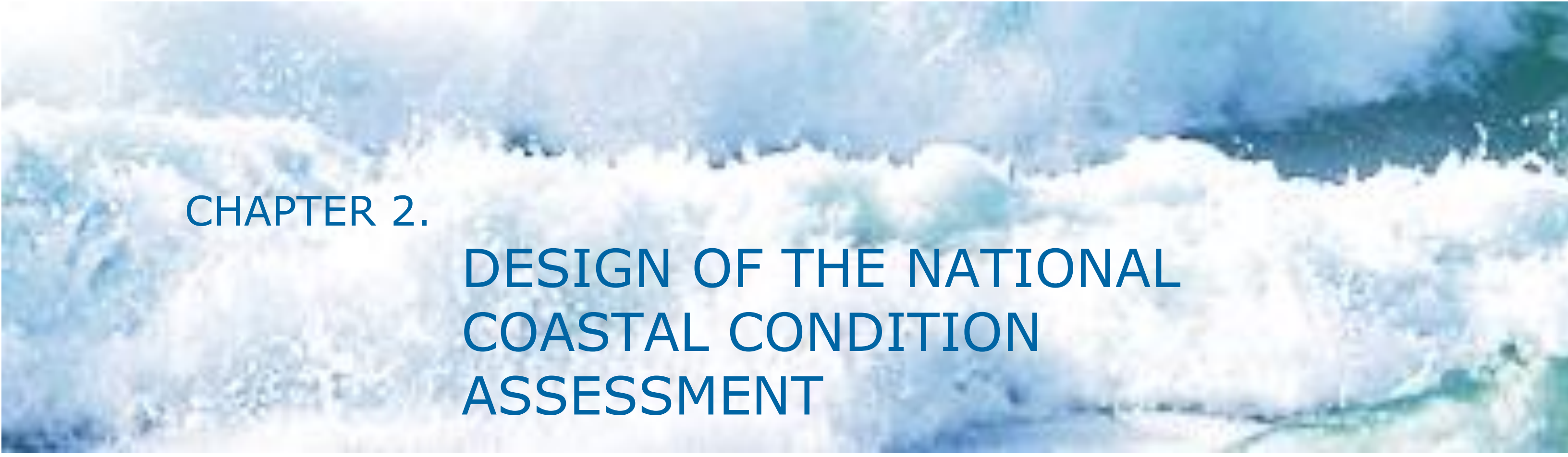
The *National Coastal Condition Report* (NCCR) I assessed the condition of the nation's coastal waters using data collected by several existing coastal programs from 1990 to 1996. These programs included EPA's Environmental Monitoring and Assessment Program (EMAP); the U.S. Fish and Wildlife Service's (FWS) National Wetlands Inventory (NWI) Status and Trends (S&T) program; and the National Oceanic and Atmospheric Administration's (NOAA) National Status & Trends (NS&T) Program.

The NCCR II provided similar information, but contained more recent data (1997–2000) from these monitoring programs, as well as data from EPA's NCA and NOAA's National Marine Fisheries Service (NMFS).

The NCCR III built upon the previous NCCRs and provided assessments based on data collected from 2001 to 2002. It expanded the survey area into the coastal waters of Hawaii and the south central portion of Alaska; provided the status of offshore fisheries, beach advisories, and fish advisories; and assessed national and regional change in coastal condition from the early 1990s to 2002.

The NCCR IV expanded the assessment area to include the coastal waters of American Samoa, Guam, the U.S. Virgin Islands, and the southeastern portion of Alaska, based primarily on NCA data collected in 2003 through 2006. It also provided an assessment of offshore fisheries and examined national and regional change in coastal condition from 2000 to 2006 based on NCA data.

Beginning with this report, EPA is changing the name of this series to the *National Coastal Condition Assessment* (NCCA) to be consistent with other reports in the National Aquatic Resource Surveys (NARS). More information on the NARS is provided at http://www.epa.gov/national-aquatic-resource-surveys.



CHAPTER 2.

DESIGN OF THE NATIONAL COASTAL CONDITION ASSESSMENT

This chapter discusses the design of the NCCA 2010, including how sampling sites were chosen, what waters were sampled, and how the four indices were used to describe the environmental condition of coastal waters. Also included are two highlights: one on the influence of watersheds on the quality of Great Lakes nearshore waters and embayments, and the other on the use of video sampling in the Great Lakes.

What Is New in This Report?

The goal of documenting change in the condition of the nation's coastal waters over time requires a balance between maintaining consistent assessment protocols that contribute meaningful results, and updating protocols to reflect improvements in the science of monitoring. Several changes have been implemented in this 2010 assessment to strike such a balance.

For the 2010 assessment, the sediment quality and fish tissue contaminant indices used in past reports have been updated. Updates to the sediment quality index allow data from past surveys to be recalculated using the new methodology so that they can be compared to NCCA 2010 assessments. The NCCA 2010 ecological fish tissue contaminant index is derived from new ecological endpoints based upon risk to fish, birds, and wildlife, rather than adapted from human health consumption thresholds as in previous reports. Because of inconsistencies in the type of fish tissue data available from previous surveys, EPA cannot assess changes in the fish tissue contaminant index in this report. More details about these updates are found in the descriptions of the indices in this chapter.

In addition to updating assessment protocols to reflect improved science, indicators are also evaluated to determine the value of the information they provide. For 2010, the coastal habitat index—which measures trends in coastal wetland loss—has been removed from this assessment. An assessment of the quality of coastal wetlands is now included as part of the *National Wetland Condition Assessment*, the newest in the NARS series.

One of the most significant changes in the NCCA 2010 is that, for the first time, EPA and its partners have collected data on the Great Lakes specifically for this program. In previous NCCRs, the overall condition and index ratings for the Great Lakes were derived from information provided by the *State of the Great Lakes* reports developed through a collaborative effort between Environment Canada and EPA. All of the indices used to assess the Great Lakes in this report are being used in this manner for the first time by the NCCA program.

What Waters Are Included in the NCCA?

This report assesses both the marine coastal waters of the conterminous United States and the freshwater coastal waters of the Great Lakes. These waters are the fringing, relatively shallow band of coastal waters most heavily used by humans and most vulnerable to activities within adjacent coastal watersheds. Combined, these coastal waters are referred to as the “sample frame” or the target population of this assessment, and they cover an area of 35,400 square miles.

As in previous coastal assessments, marine coastal waters are defined as those from the head-of-salt (i.e., the landward extent of saltwater incursions) to the confluence with the open ocean. In the Great Lakes, coastal waters are those within three miles of shore that are also 100 feet or less in depth. This unique coastal land-water interface zone includes inland waterways, river mouths, open and semi-enclosed estuaries, bays, embayments, and the more open shallow waters adjacent to East Coast and Gulf Coast shorelines. Excluded are the very deep waters adjacent to steep shorelines along the West Coast, and the connecting channels of the Great Lakes (the St. Lawrence River outlet and waters between the lakes).

For reporting purposes, coastal waters are divided into five regions: 1) the Northeast Coast—Maine through Virginia (including Chesapeake Bay), with an area of 10,700 square miles; 2) the Southeast Coast—North Carolina through south Florida’s Biscayne Bay (4,500 square miles); 3) the Gulf Coast (11,300 square miles); 4) the West Coast (2,200 square miles); and 5) the Great Lakes (6,700 square miles) (see Figure 2-1). This assessment does not include the coastal waters of Alaska, Hawaii, and other islands.

How Were Sampling Sites Chosen?

This coastal assessment is based on data from 1,104 sites sampled during the summer of 2010. The design used to select the sites is a statistical survey approach based on random selection. Similar to designs used for health surveys and election polls, this approach yields statistically valid estimates of the condition of the population of interest (in this case, all coastal waters) with known confidence, based on data from a relatively small number of sites.

This survey design is efficient and cost-effective compared with the alternative of conducting a complete census survey. In the NCCA, sampling sites were selected using a technique called “Generalized Random Tessellation Stratified” (GRTS) survey design, which minimizes clumping of site locations that may result from a purely randomized design. It also provides weighting factors that are used during the analysis stage.

In the GRTS approach, estuarine coasts are divided into nearly fifty non-overlapping sub-regions (strata) based on waterbody location. The Great Lakes are divided into six strata, one for each lake, and a separate non-overlapping stratum representing small embayments. “Base” sampling sites are then distributed uniformly among all strata, thereby ensuring a spatially balanced distribution of sampling sites among the five reporting regions (Figure 2-1). Additional “oversample” locations are identified that could serve as replacement sites in the event a base site is inaccessible or is determined not to meet the definition of coastal water used for NCCA

2010. Oversample locations can also be used to supplement the base sites for potential statewide or other region-wide assessments or enhancements. Finally, GRTS provides weighting factors for each site that are proportional to the area represented by the site. The weights, calculated as the stratum area divided by the number of sites in the stratum, are used to determine the amount of coastal area represented by an individual site during the analysis stage.

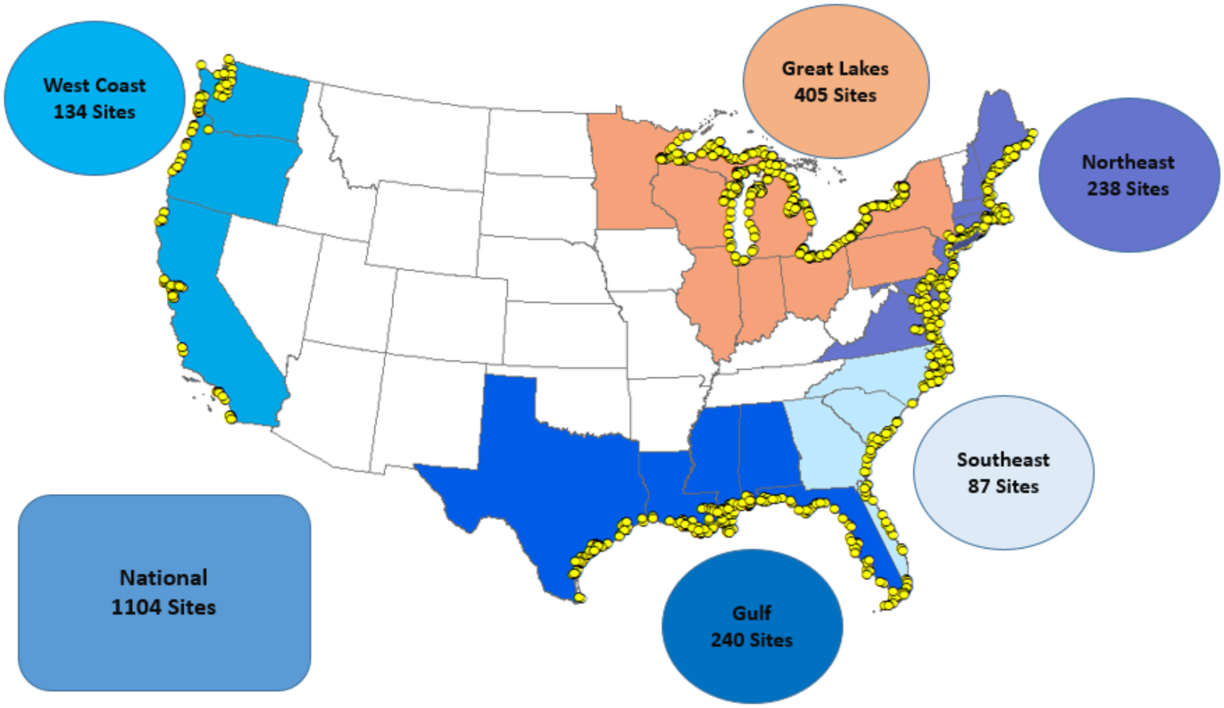


Figure 2-1. Location of NCCA 2010 sampling sites by region.

Why Doesn’t This Assessment Use Other Coastal Data?

Many agencies and organizations conduct detailed assessments in U.S. estuaries and coastal regions; however, data from these studies are not incorporated in this report for several reasons. Most sampling designs used in these assessments are not compatible with the national statistical design used by the NCCA. Other monitoring programs may also assess different parameters and use different methods of data collection, analysis, and evaluation. While these studies provide data sets that are invaluable for assessing the conditions and program goals they are targeting, incompatibility with NCCA data and methods makes it difficult to include outside data sets in this national assessment.

How Were Waters Sampled?

During the 2010 field season, 1,104 sites were sampled once between June and September. Ten percent of sites were revisited for quality assurance purposes. In some cases, sites identified for sampling were dropped and replaced because of logistical issues that precluded sampling. For example, sampling sites were replaced if they were too shallow for a sampling vessel to navigate, or if they were unsafe because they were in the middle of heavily traveled shipping lanes. A dropped site was replaced by selecting a pre-identified “oversample” site, maintaining the spatially balanced random design.

Sampling a statistically selected site once for a survey is appropriate and valid because the goal of the survey is to determine, during the sampling period, what proportion of coastal waters have stressors above or below various thresholds. In this sense, the NCCA is much like human health surveys used to estimate public health issues. For example, in national health surveys, the interest is not in whether an individual is obese at a particular point in time, but rather what proportion of the entire population of people of interest are obese at a particular point in time. The repeat samples (sites revisited at another time during the index period) give analysts an estimate of how different the answer might be if they had sampled the sites at different times during the index period.

Using water chemistry as an example, scientists expect that phosphorus values at any particular site will fluctuate over time. Site X may be high for phosphorus while site Y is low. Several days or weeks later, the situation may be reversed, but the proportion of all coastal waters with high or low phosphorus remains the same.

For the NCCA 2010, nearly 50 trained field crews—composed primarily of state/tribal environmental agency, EPA, and contractor staff—collected samples and information from the water column, sediment, and benthic macroinvertebrate and fish communities. They followed specific protocols detailed in the survey field manual (U.S. EPA 2010a). The sampling procedures were the same as those used in previous coastal assessments.

Field crews collected water samples for nutrients, chlorophyll *a*, and other parameters using specialized collection bottles at a depth of 0.5 meters (i.e., surface waters). They collected sediment and benthic samples using a sediment grab sampler. The grab sampler was lowered to the estuarine or Great Lake floor where it took a “bite” out of the sediment. Field crews either placed the sediment sample directly into a sample bottle or sieved it to collect benthic macroinvertebrates. Crews collected fish using several different methods: some trawled for fish, others used gill or seine nets, and still others used hook and line sampling. Specimens that met the target species and size requirements were frozen and shipped to the lab on dry ice.

In addition to collecting samples to send to labs, crews recorded extensive *in situ* data on field forms, documenting information about the physical characteristics of each site. At all sites, they measured salinity/conductivity, pH, temperature, dissolved oxygen, and other parameters using specialized probes throughout the water column. (Note: The water quality index uses only the DO measurements taken at the bottom of the water column.) They measured water clarity using

Secchi disks and light transmissivity using photosynthetically active radiation meters. In addition, at all Great Lakes sites, crews filmed one-minute videos of the substrate using an underwater video camera system. At all survey sites, field crews used comparable collection and measurement techniques.

What Was Sampled?

The NCCA 2010 uses benthic macroinvertebrates (small animals such as worms and clams that live in and on the bottoms of estuaries, the Great Lakes, and other waters) as biological indicators of ecological condition. Because they are sensitive to disturbances that result from human activities, macroinvertebrates provide an estimate of the biological quality of estuaries and coastal areas. Macroinvertebrate population assessments are included in almost every state and federal aquatic resource-monitoring program.

The NCCA 2010 includes measurements of key stressors to document their relative extent. Stressors are the chemical and physical components of the ecosystem that have the potential to degrade biological integrity. Some of these are naturally occurring and others result only from human activities, but most come from both sources.

Examples of *chemical stressors* are excess nutrients (e.g., nitrogen and phosphorus) and chemical contaminants (e.g., legacy contaminants like DDT and polychlorinated biphenyls [PCBs]). The NCCA 2010 measures nutrients in water samples sent to a laboratory. Concentrations of contaminants in fish tissue are measured because, over time, fish can accumulate chemical contaminants found in their food, the water column, or the bottom sediment. These measurements provide insight into what contaminants are found in coastal waters and the risk presented when these fish are consumed by other wildlife. *Physical stressors* include water clarity and low dissolved oxygen.

In addition to these stressors, the NCCA 2010 measures the levels of mercury, PCBs, polybrominated diphenyl ethers (PBDE), and perfluorinated chemicals (PFC) in fish tissue in the Great Lakes as *human health indicators.* Table 2-1 shows the key indicators evaluated for this report.

Table 2-1. Indicators evaluated for the NCCA 2010.

Biological Indicator	Chemical Indicators	Physical Indicators	Human Health Indicators (Great Lakes Only)
• Benthic macroinvertebrates	• Phosphorus • Nitrogen* • Ecological fish tissue contaminants • Sediment contaminants • Sediment toxicity	• Dissolved oxygen • Salinity • Water clarity • pH • Chlorophyll *a*	• Mercury, PCBs, PBDEs, and PFCs in fish filet tissue

*Nitrogen was measured but not assessed in the Great Lakes.

What Are the Indices of Coastal Condition?

Four primary indices of environmental condition (benthic, water quality, sediment quality, and ecological fish tissue contaminant) are used in this report. Three of the indices—those used to assess benthic quality, water quality, and sediment quality—vary across regions. They were developed and verified by regional experts familiar with natural variability in the chemistry, geomorphology, habitats, and community structures in the five regions highlighted in this report. For example, the rocky coasts of the Northeast are very different from the lagoons, coral reefs, and mangrove forests of the Gulf Coast. Likewise, ecological processes in the freshwater Great Lakes are quite distinct from processes in marine estuaries. All three indices reflect established science and are comparable to indices used in previous assessments, providing consistent indication of change over time.

The fourth index used in the NCCA 2010, the ecological fish tissue contaminant index, is new for this assessment and consists of a single index for all regions. It cannot be compared to similar indices used in previous reports.

Benthic Index

The worms, mollusks, crustaceans and other invertebrates that inhabit the bottom substrates of coastal waters are an important food source for a wide variety of fish, mammals, and birds. Benthic populations and communities serve as reliable biological indicators of coastal environmental quality because they are sensitive to chemical contamination, dissolved oxygen stresses, salinity fluctuations, and sediment disturbances.

To assess biological conditions, EPA and its partners have developed comparable regional benthic indices for the Northeast/Acadian, Northeast/Virginian, Southeast/Carolinian, and Gulf/Louisianan coasts (Table 2-2). These indices reflect changes in benthic community diversity and the abundance of pollution-tolerant and pollution-sensitive macroinvertebrate species. A good benthic index rating means that benthic habitats contain a wide variety of species, including low proportions of pollution-tolerant species and high proportions of pollution-sensitive species. A poor benthic index rating indicates that benthic communities are less diverse than expected and are populated by more pollution-tolerant species and fewer pollution-sensitive species than expected. A list of the macroinvertebrates identified in each region is available on the NARS website at http://www.epa.gov/national-aquatic-resource-surveys.

Table 2-2. Regional benthic indices for the Northeast, Southeast, and Gulf coasts.

Region/ Province	Data Source	Statistical Method	Component Metrics	Index Condition Scale		
				Good	Fair	Poor
Northeast/ Acadian	NCA 2000-2001	Logistic Regression Analysis	Diversity (Shannon H') Pollution Tolerant Taxa Proportion Capitellids	> 5	4 – 5	< 4
Northeast/ Virginian	EMAP 1990-1993	Discriminant Analysis	Diversity (Gleason D) Abundance Tubificids Abundance Spionids	> 0	n/a	≤ 0
Southeast/ Carolinian	EMAP 1993-1994	Cluster Analysis	Abundance Species Richness Dominance Pollution Sensitive Taxa	> 2.5	2 – 2.5	< 2
Gulf/ Louisianan	EMAP 1991-1992	Discriminant Analysis	Diversity (Shannon H') Abundance Tubificids Proportion Capitellids Proportion Bivalves Proportion Amphipods	> 5	3 – 5	< 3

A regional multi-metric benthic index has not been developed for the West Coast, although several local indices have been developed. As in past NCCRs, species richness was used as a surrogate for a West Coast regional benthic index. Analysts compared regional values for species richness with salinity to determine if a significant relationship existed. They found a highly significant relationship for the region, although variability was high. They then calculated a surrogate benthic index for the West Coast by determining the expected species richness from the statistical relationship to salinity and calculating the ratio of observed to expected species richness. Poor condition was defined as less than 75% of the expected benthic species richness at a particular salinity (Table 2-3).

In the Great Lakes, the 2011 State of the Great Lakes Report (Environment Canada and EPA) assesses benthic community condition using an oligochaete trophic index (OTI). The OTI is based on the classification of oligochaete species (i.e., worms) by their known tolerance to organic enrichment. The OTI ranges from 0 to 3, where scores less than 0.6 indicate oligotrophic (good) conditions, scores between 0.6 and 1.0 indicate mesotrophic (fair) conditions, and scores above 1.0 indicate eutrophic (poor) conditions (Table 2-3).

Table 2-3. Thresholds for assessing biological quality based on regional benthic indices for the West Coast and Great Lakes

Region	Good	Fair	Poor
West	Observed species richness is more than 90% of the lower 95% confidence interval of expected species richness for a specific salinity.	Observed species richness is between 75% and 90% of the lower 95% confidence interval of expected species richness for a specific salinity.	Observed species richness is less than 75% of the lower 95% confidence interval of expected species richness for a specific salinity.
Great Lakes	Oligochaete trophic index score is less than 0.6.	Oligochaete trophic index score is between 0.6 and 1.0.	Oligochaete trophic index score is greater than 1.0.

Water Quality Index

Assessing water quality in the nation's coastal waters is a challenging undertaking. No single definition of good or poor water quality applies to all waterbodies. For instance, while people prefer beaches that feature clean and clear waters, a viable fish nursery needs nutrient-rich water with plenty of suspended organic material.

Conditions vary widely by region for natural reasons. Nutrient levels along the Pacific coast are naturally high due to seasonal upwelling of nutrient-rich deep water. Nearshore waters along the Southeast and Gulf coasts are more turbid than elsewhere, reflecting the heavy loads of sediment delivered by rivers meandering over fertile watersheds. Water quality processes in the freshwater Great Lakes differ markedly from those in the coastal estuaries, where salinities range from 0.5 to roughly 35 parts per thousand.

Processes affecting coastal water quality are complex, change quickly, and are highly localized. Figure 2-2 and the box below explain some of the complex cycles occurring in the water column and describe how parameters such as water clarity and dissolved oxygen concentrations can be adversely affected by human activities. The NCCA 2010 addresses these issues of variability and complexity by using slightly different indicators in coastal estuaries and in the Great Lakes, and applying different regional thresholds to reflect the influence of natural processes.

The NCCA 2010 measures several key indicators of water quality to provide a broad perspective on conditions. These include measures of nutrient levels, algal biomass, dissolved oxygen concentration, and water clarity. These indicators often change in a complementary manner. For example, while nutrient levels may drop as an algal bloom develops, chlorophyll levels may rise. One or the other indicator will likely record the degraded condition. Similarly, signals for chlorophyll, water clarity, and dissolved oxygen levels are likely to change in later phases of a bloom event as the excess algal material decays and depletes dissolved oxygen levels. These metrics are combined into an integrated water quality index (WQI) to create a measure of water quality that is more robust than its individual components.

Despite the complex and variable nature of processes affecting water quality, the NCCA assessment process effectively portrays water quality at a national and regional scale. However, the NCCA 2010 does not provide an intensive characterization of localized water quality conditions.

Heading out for a sampling trip. (Photo courtesy of Virginia Department of Environmental Quality)

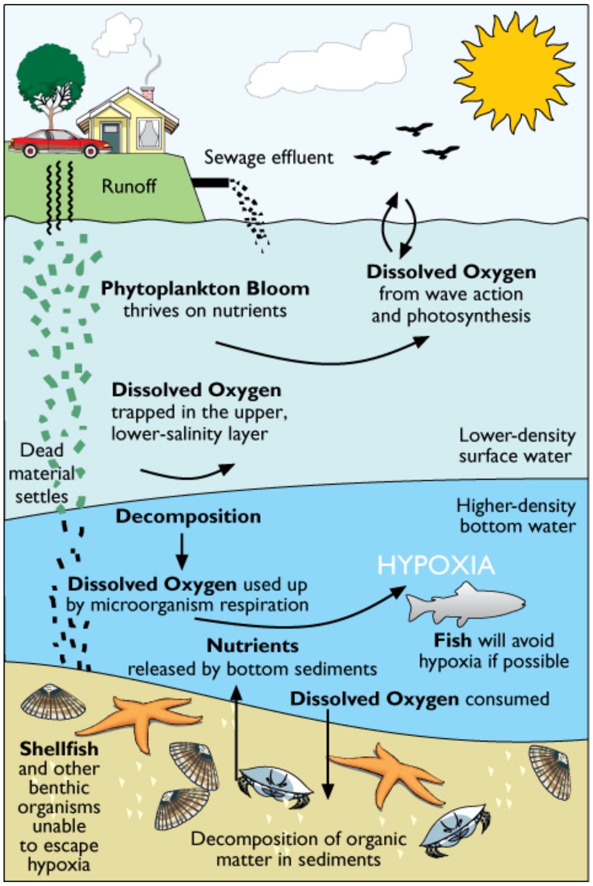


Figure 2-2. Accelerated eutrophication can occur when the concentration of available nutrients increases above normal levels (U.S. EPA/NCA).

Water Column Processes and Eutrophication

Figure 2-2 illustrates the food production cycle in a typical coastal ecosystem. A warm, sunlit upper water layer overlays a denser and darker bottom layer. Seagrass beds in shallow water provide critical nursery habitat for fish and crustaceans and act to stabilize sediments. These grasses need light to flourish. In a healthy system, floating microscopic algae called phytoplankton draw on nutrients and light in the surface layer to generate sporadic “blooms” of plant material that first feed organisms in the upper layer. As organic matter decomposes, it sinks to nourish the organisms living on or in the bottom sediments. In a process termed eutrophication, the amount of organic matter in the system increases over many decades in response to gradually increasing nutrient supplies. This gradual transition allows the systems to adapt and maintain fine-tuned estuarine cycles.

The increasing activity of humans along coastlines can result in accelerated eutrophication. Cities, farms, and industry discharge nutrients to coastal waters more quickly than the ecosystem can process them. Excess bloom material chokes beaches, hampers navigation, and releases toxins that can harm fish, shellfish, birds, and humans. It also blocks light from reaching seagrass beds and, as it decays, depletes oxygen needed by fish and benthic inhabitants.

Thresholds for Interpreting Water Quality Data

Different thresholds are used to evaluate the marine waters of coastal estuaries and the fresh waters of the Great Lakes. Table 2-4 lists the five indicators used to evaluate water quality in coastal estuaries (also used in previous NCCRs):

- Two measures of surface nutrient enrichment—dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphorus (DIP) concentrations;
- An indication of the amount (biomass) of algae—surface chlorophyll *a* concentration; and
- Two indicators of potential adverse effects of eutrophication—water clarity and bottom dissolved oxygen levels.

Table 2-4 also lists the indicators used to evaluate water quality in the Great Lakes. The indicators differ somewhat from those used in coastal estuaries because the physical, chemical, and biological characteristics of estuarine and freshwater environments differ. Nitrogen was measured but not assessed in the Great Lakes because conventional approaches focused on phosphorus as a driver for nutrient enrichment in freshwater. However, recent analyses using national data sets from the draft *National Lakes Assessment* indicate that nitrogen levels are also associated with increased risk of the algal toxin microcystin. Future analyses of NCCA data will explore the role that nitrogen levels play in the health of the Great Lakes. See the *NCCA 2010 Technical Report* for a summary of total nitrogen concentrations in the Great Lakes.

Table 2-4. Water quality indicators used to assess conditions.

Metric	Coastal Estuaries	Great Lakes
Surface Phosphorus	DIP (mg P/L) [a]	TP (mg P/L) [b]
Surface Nitrogen	DIN (mg N/L) [c]	Not used in analysis
Surface Chlorophyll *a*	Chla (µg/L)	Chla (µg/L)
Bottom Dissolved Oxygen	DO (mg/L)	DO (mg/L)
Water Clarity	Transmittance @1m [d]	Secchi depth (m)

[a] DIP: Dissolved Inorganic Phosphorus; PO_4
[b] TP: Total Phosphorus
[c] DIN: Dissolved Inorganic Nitrogen; sum of NO_3, NO_2, and NH_4
[d] Calculated from Photosynthetically Active Radiation (PAR) vs. depth profiles or Secchi depth

Table 2-5 lists the thresholds used to evaluate water quality in coastal estuaries; they vary by region to take natural variability into account. These are the same thresholds used in previous NCCRs, providing continuity when considering change over time. The thresholds were initially set based on published references and the best professional judgment of regional experts (see the *NCCA 2010 Technical Report* for more details).

Table 2-5. NCCA guidelines for evaluating the five component indicators used in the water quality index to assess estuarine coastal condition.

Estuarine Water Quality Thresholds				
	Region	Good	Fair	Poor
Surface Concentrations of Dissolved Inorganic Nitrogen (DIN): Estuaries	Northeast Southeast Gulf	< 0.1 mg/L	0.1 – 0.5 mg/L	> 0.5 mg/L
	West	< 0.35 mg/L	0.35 – 0.5 mg/L	> 0.5 mg/L
	Tropical [a]	< 0.05 mg/L	0.05 – 0.1 mg/L	> 0.1 mg/L
Surface Concentrations of Dissolved Inorganic Phosphorus (DIP): Estuaries	Northeast Southeast Gulf	< 0.01 mg/L	0.01 – 0.05 mg/L	> 0.05 mg/L
	West	< 0.07 mg/L	0.07 – 0.1 mg/L	> 0.1 mg/L
	Tropical [a]	< 0.005 mg/L	0.005 – 0.01 mg/L	> 0.01 mg/L
Surface Concentrations of Chlorophyll *a*: Estuaries	Northeast Southeast Gulf West	< 5 µg/L	5 – 20 µg/L	> 20 µg/L
	Tropical [a]	< 0.5 µg/L	0.5 – 1 µg/L	> 1 µg/L
Water Clarity (percent of incident light remaining after passing through 1 meter of water): Estuaries	Waters with naturally high turbidity	> 10%	5 – 10%	< 5%
	Waters with normal turbidity	> 20%	10 – 20%	< 10%
	Waters that support SAV[b]	> 40%	20 – 40%	< 20%
Bottom Water Concentrations of Dissolved Oxygen: Estuaries	All	> 5 mg/L	2 – 5 mg/L	< 2 mg/L

[a] Tropical refers to NCCA Florida Bay sites. [b] Submerged Aquatic Vegetation.

Table 2-6 lists the assessment thresholds used to evaluate the Great Lakes region. To consider natural variability, the thresholds are specific to each of the eight basins of the Great Lakes region—Lake Superior, Lake Huron, Lake Michigan, Saginaw Bay, Lake Ontario, and the western, central, and eastern basins of Lake Erie. These thresholds follow the guidelines recommended by the Great Lakes International Joint Commission, the organization that regulates shared water uses and investigates and recommends solutions for transboundary issues. These guidelines are currently under review (refer to the *NCCA 2010 Technical Report* for further details).

Table 2-6. Guidelines used to evaluate water quality at sites in Great Lakes basins.

Great Lakes Water Quality Thresholds				
	Lake Area	**Good**	**Fair**	**Poor**
Surface Concentrations of Total Phosphorus (TP): Great Lakes Basins	Superior Huron	< 0.005 mg/L	0.005 – 0.01 mg/L	> 0.01 mg/L
	Michigan	< 0.007 mg/L	0.007 – 0.01 mg/L	> 0.01 mg/L
	Huron/Saginaw Erie/West	< 0.015 mg/L	0.015 – 0.032 mg/L	> 0.032 mg/L
	Erie/Central Erie/East Ontario	< 0.01 mg/L	0.01 – 0.015 mg/L	> 0.015 mg/L
Surface Concentrations of Chlorophyll *a*: Great Lakes Basins	Superior Huron	< 1.3 µg/L	1.3 – 2.6 µg/L	> 2.6 µg/L
	Michigan	< 1.8 µg/L	1.8 – 2.6 µg/L	> 2.6 µg/L
	Huron/Saginaw Erie/West	< 3.6 µg/L	3.6 – 6.0 µg/L	> 6.0 µg/L
	Erie/Central Erie/East Ontario	< 2.6 µg/L	2.6 – 3.6 µg/L	> 3.6 µg/L
Water Clarity (Secchi Depth): Great Lakes Basins	Superior Huron	> 8.0 m	5.3 – 8.0 m	< 5.3 m
	Michigan	> 6.7 m	5.3 – 6.7 m	< 5.3 m
	Huron/Saginaw Erie/West	> 3.9 m	2.1 – 3.9 m	< 2.1 m
	Erie/Central Erie/East Ontario	> 5.3 m	3.9 – 5.3 m	< 3.9 m
Bottom Water Concentrations of Dissolved Oxygen: Great Lakes Basins	All	> 5 mg/L	2 – 5 mg/L	< 2 mg/L

HIGHLIGHT: Watershed Influence on Open Nearshore Waters and Embayments of the U.S. Great Lakes Coastal Zone

In the NCCA 2010 survey design for the Great Lakes, two aquatic resource classes are defined. The first is a nearshore population of waters extending from the shoreline to an outer boundary (as far as 3.1 miles from shore or as deep as the 129-foot depth contour, whichever is reached first). The second resource class is small embayments: semi-enclosed areas formed by the configuration of the shoreline, tucked in along the shore and often more vulnerable to land drainage. Embayment areas are a small portion of the nearshore zone totaling 359 square miles, compared to 6,931 square miles of U.S. Great Lakes nearshore coast.

NCCA 2010 sampling for the Great Lakes Region as a whole was conducted at 251 open nearshore sites and an additional 154 sites in embayment areas. Embayments were expected to show evidence of higher exposure to land drainage because of more sheltered conditions, shallower waters, perhaps longer residence times, and less overall dilution than the more “open” nearshore. Statistical analyses demonstrate that embayments have higher phosphorus concentrations, lower bottom water dissolved oxygen concentrations, shallower measured Secchi depth, and a faster light extinction than the open nearshore. There is no difference between embayment and nearshore chlorophyll *a* and nitrogen levels. It may be that more turbidity (from suspended solids loading and/or wind-driven sediment resuspension in shallower waters in embayments) inhibits plankton growth slightly, in spite of a nearly doubled phosphorus concentration on average.

To assess the potential influence of watershed disturbance upon observed coastal conditions, analysts compared NCCA 2010 data and watershed land use patterns at appropriate lake-basin scales for each of the five Great Lakes (Figure 2-3). This analysis provides evidence of a strong relationship between phosphorus and agricultural intensity in the watershed. When compared to equivalent nearshore areas, the pattern for embayments reflects generally higher phosphorus concentrations as watershed agricultural intensity increases. Phosphorus concentrations are highest in the areas of greatest agricultural intensity in the western basin of Lake Erie. Water quality changes and associated increasing plankton blooms have been seen in the past decade in this basin.

Further analyses of these NCCA 2010 data will study the watershed drivers at play because the effects of agricultural development, human population growth and urban coastal development, forested area declines, and other factors are not fully independent of each other. Nonetheless, the results suggest that embayments are indeed more vulnerable to landscape-derived stressors than the more open nearshore zone and thus may be more sensitive sentinels of water quality changes.

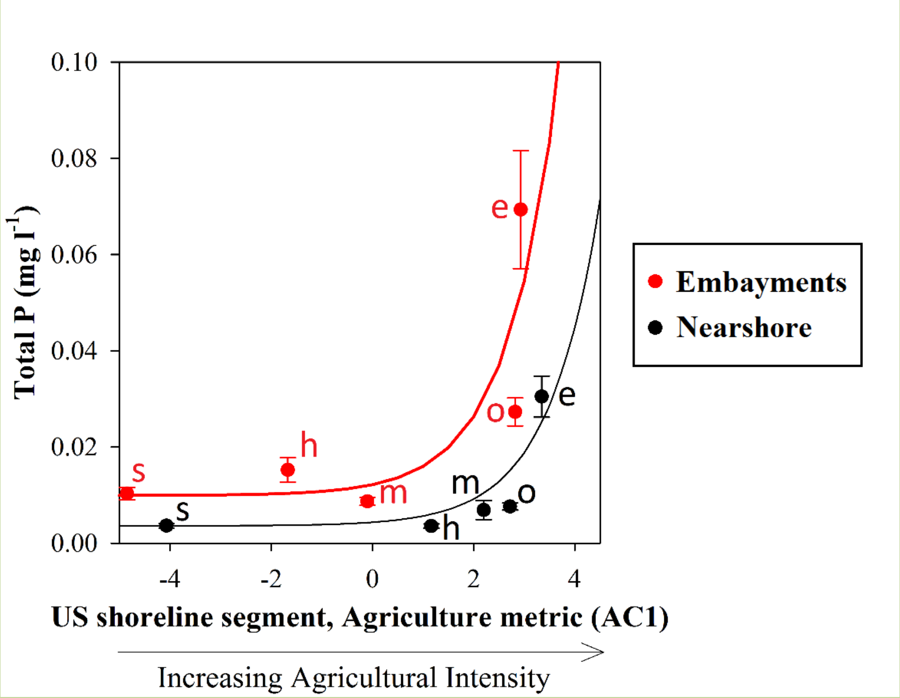


Figure 2-3. Total phosphorus as a function of increasing agricultural intensity shows that embayments have higher levels of TP than nearshore areas. Mean and 95% confidence intervals are shown for NCCA 2010 results by lake (identified by first letter of lake name) for nearshore (in black) and embayment populations (in red). From Kelly et al., 2015.

Calculating the Water Quality Index

The water quality indicators measured in this survey—nutrients, chlorophyll, dissolved oxygen, and water clarity—reflect complex and quickly changing processes occuring in the water column. Excess nutrients promote algal blooms that can create problematic low-oxygen events or inadequate water clarity (Figure 2-2). Not all indicators are likely to record the same conditions at the same time. Therefore, the NCCA 2010 calculates a water quality index (WQI) to suggest whether a site is susceptible to, or is suffering from, water quality problems. This calculation is based upon guidelines established in earlier coastal condition reports that consider the number of component indicators that suggest problems (Table 2-7).

Table 2-7. Guidelines used to evaluate sites for the water quality index (WQI).

Water Quality Index Guidelines		
Good	**Fair**	**Poor**
No component indicators are rated poor, and a maximum of one is rated fair.	One component indicator is rated poor, or two or more component indicators are rated fair.	Two or more component indicators are rated poor.

Note: Component indicators are phosphorus, nitrogen, chlorophyll a, water clarity, and dissolved oxygen.

Sediment Quality Index

Sediments serve as important indicators because they can accumulate contaminants that adversely affect ecosystems and human health. Such contaminants are introduced into the environment by a number of sources, including metal-based marine antifouling paints, nonpoint source pollution from agricultural and urban areas, and industry and atmospheric deposition. Scientists measure sediment contaminants such as metals (e.g., arsenic and lead) and organic substances (e.g., polycyclic aromatic hydrocarbons [PAHs], PCBs, and pesticides) because they are persistent, bioaccumulative, and associated with acute and chronic effects on aquatic life.

Many contaminants adsorb onto suspended particles and accumulate in areas where sediments are deposited. The accumulated contaminants, either individually or in mixtures, may adversely affect sediment-dwelling organisms. As other organisms eat contaminated sediment-dwellers, the contaminants can become concentrated throughout the food web, potentially affecting fish, marine mammals, and humans who consume contaminated fish and shellfish. The NCCA program uses a Sediment Quality Index (SQI) to assess the potential for sediment to adversely affect ecosystems.

Two sediment quality indicators (sediment toxicity and sediment contaminants) are evaluated separately and combined into the SQI. Sediment toxicity is evaluated because risk-based thresholds do not exist for most of the thousands of chemicals that are introduced into the environment through human or natural activities. In addition, sediment toxicity tests show the additive and synergistic effects of chemical combinations on the ability of organisms to survive and reproduce in the environment. Scientists assess sediment toxicity by measuring the survival of estuarine and freshwater amphipods (*Leptocheirus plumulosus* and *Eohaustorius estuarius* for estuarine sediments*; Hyallella azteca* for freshwater sediments). They expose organisms to field-collected sediments for ten days and compare survival rates to the survival rates of organisms exposed to control sediments. They then calculate control-corrected survival percentages for both estuarine and freshwater sediments. In addition, for estuarine samples, analysts calculate the statistical significance ($p < 0.05$) of the difference between the control and test results. Because the standard method for freshwater sediments uses fewer test organisms and fewer replicates than the standard method for estuarine sediments, statistical signficance for freshwater sediment toxicity tests is not calculated.

Sediments are analyzed for a wide variety of chemical contaminants. Analysts use sediment quality guidelines (SQGs) to assess sediment contamination. The SQG used in estuarine waters is called the mean Effects Range Median Quotient (mERM-Q); the SQG used to assess Great Lakes sediment contaminants is the mean Probable Effects Concentration Quotient (mPEC-Q). Both approaches are similar in that they assess the relative degree of sediment contamination and estimate the probability of toxicity to benthic organisms from sediment contaminants. In addition to the mERM-Q, estuarine sediments are also evaluated using the Logistic Regression Model (LRM). The LRM calculates the probability of observing a toxic effect based on individual contaminant concentrations and the maximum probability (Pmax) of observing toxicity from all contaminants in a sample. The weight of evidence from mERM-Q and LRM gives the best possible evaluation of sediment contamination in estuaries. The LRM has not been developed for the freshwaters of the Great Lakes, however, so the mPEC-Q is the only method used to assess Great Lakes sediment contamination.

Concentrations of total organic carbon in the sediment samples and sediment grain size are analyzed and used as ancillary information to help further explain effects, but they are not a component of the SQI. EPA updated the SQI used for the NCCA 2010 to reflect the current practices for marine and freshwater sediments. The *NCCA 2010 Technical Report* describes how these indicators are calculated and applied to past data sets from previous reports to examine change in sediment quality.

Table 2-8 lists the thresholds used to rate sites in marine and Great Lakes coasts as good, fair, or poor for sediment quality. Thresholds vary between marine and freshwater sediments due to the different approaches that were used. For each region, analysts determine what percentage of a region’s area is rated good, fair, or poor for individual indicators.

Table 2-8. NCCA guidelines for the two component indicators used in the sediment quality index.

Ecological Condition by Site			
	Good	**Fair**	**Poor**
Sediment Contaminants: Great Lakes	mean PEC-Q ≤ 0.1	Mean PEC-Q > 0.1 but < 0.6	mean PEC-Q ≥ 0.6
Sediment Contaminants: Marine	mean ERM-Q < 0.1 and LRM P_{max} ≤ 0.5	mean ERM-Q > 0.1 but < 0.5 or LRM P_{max} > 0.5 but < 0.75	mean ERM-Q ≥ 0.5 or LRM P_{max} ≥ 0.75
Sediment Toxicity: Great Lakes	≥ 90% control-adjusted survival	≥ 75% but < 90% control-adjusted survival	< 75% control-adjusted survival
Sediment Toxicity: Marine	Test not significantly different from control ($p > 0.05$) and ≥ 80% control-adjusted survival	Test significantly different from control ($p < 0.05$) and ≥ 80% control-adjusted survival or Test not significantly different from control ($p > 0.05$) and < 80% control-adjusted survival	Test significantly different from control ($p < 0.05$) and < 80% control-adjusted survival

See Technical Report for details on calculation of sediment contaminants index and sediment toxicity index.
mean ERM-Q = mean Effects Range Median Quotient
LRM P_{max} = Logistic Regression Model Maximum Probability
mean PEC-Q = mean Probable Effects Concentration Quotient
$p > 0.05$ or $p < 0.05$ = probability value of test statistic being greater than or less than 0.05

The NCCA 2010 uses guidelines established in earlier coastal condition reports to determine the SQI rating for a site, based on the condition of its two component metrics (Table 2-9). It evaluates the likelihood that sediments at a site will adversely affect benthic organisms.

Table 2-9. Guidelines used to evaluate sites for the sediment quality index*.

Sediment Quality Index Guidelines		
Good	**Fair**	**Poor**
Both indicators are rated good.	At least one indicator is rated fair and none are rated poor.	At least one indicator is rated poor.

*This index is based on measurements of two sediment condition indicators—sediment contaminants and sediment toxicity.

Ecological Fish Tissue Contaminant Index

Chemical contaminants may enter an aquatic organism in several ways: direct uptake from contaminated water, consumption of contaminated sediment, or consumption of previously contaminated organisms (Figure 2-4). Once these contaminants enter an organism, they tend to remain in its tissues and may build up over time. When predators consume contaminated organisms, they may accumulate the levels of persistent contaminants present in those organisms. Environmentally persistent contaminants, including some pesticides, PCBs and mercury, can contribute to ecological degradation and pose a threat to human health.

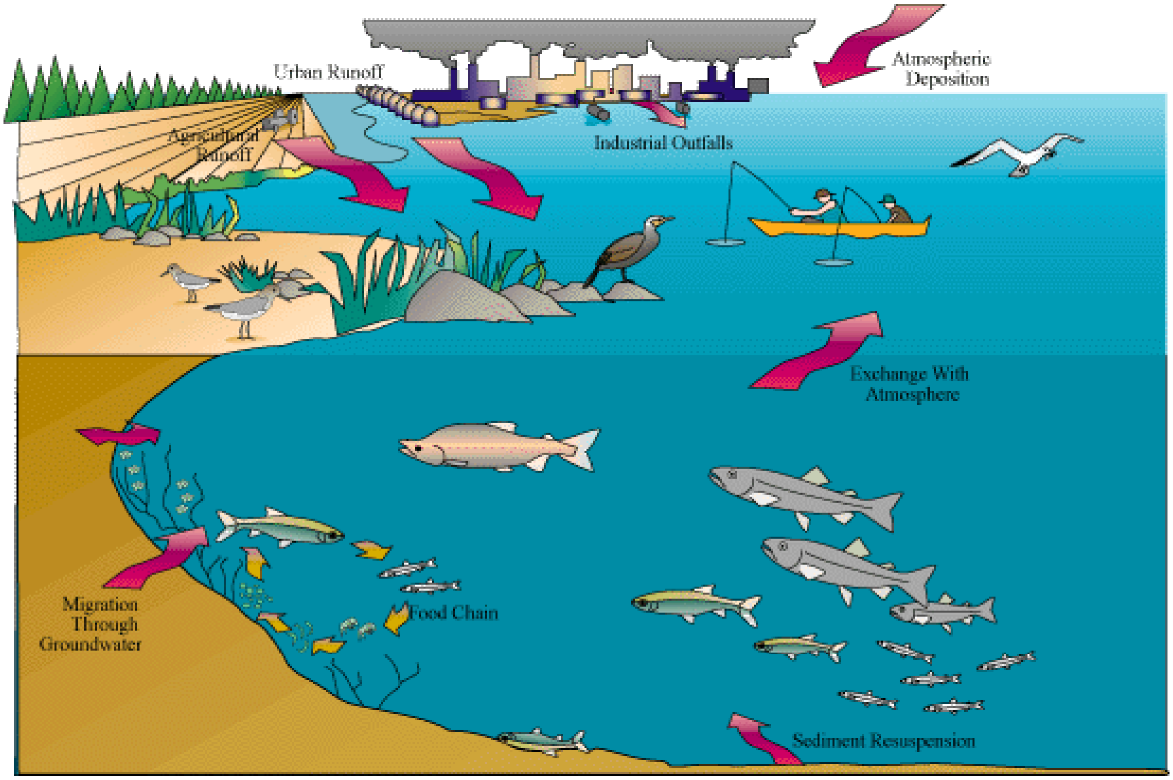


Figure 2-4. Sources of and pathways for pollution in aquatic ecosystems (U.S. EPA GLNPO).

In previous reports, impacts on wildlife were estimated by comparing contaminant concentration values to human health fish-consumption advisory thresholds. For this report, a new approach for calculating the fish tissue contaminant index uses *ecological* risk-based thresholds, rather than human health-related advisories. Ecological risk-based thresholds better align the indicator with the ecosystem focus of the NCCA 2010. This method assesses contaminant levels in whole-body fish tissue using an approach based on EPA's *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (1997). The approach evaluates whether environmental concentrations of contaminants in soil, sediment, water, and fish tissue pose a potential risk to fish and wildlife (referred to as receptors of concern).

For this assessment, threshold values are calculated to examine fish tissue contaminant concentrations using established toxicity reference values (TRVs) for predatory fish and fish-eating birds and mammals (receptor groups). Within each of these groups, the lowest observed adverse effect level (LOAEL) estimates are derived from TRVs associated with a number of specific species (receptors), such as great blue heron, osprey, harbor seal, mink, largemouth bass, swordfish, and bluefin tuna. The LOAEL screening value for the most sensitive receptor within each receptor group is selected to evaluate measured contaminant concentrations (Table 2-10). This approach helps ensure that the fish tissue contaminant assessment is nationally applicable, ecologically relevant, and conservatively protective of most potential receptors.

Tissue sample collection methods were revised for NCCA 2010 to specify consistent sample collection guidelines. Analysts developed a regionally-calibrated species list to identify target specimens for tissue analysis. Specimens were selected for contaminant analyses using size standards (i.e., 100–400 mm), and a single species per sampled site was retained for laboratory analysis. The NCCA 2010 does not evaluate changes in tissue concentrations from 2000–2010 because different fish tissue collection and assessment methods were used in the past.

Table 2-10. Potential ecological risk-based thresholds for receptors of concern (calculated).

Contaminant	Whole-Body Tissue Concentration (µg / dry g) by Receptor Group		
	Lowest Observed Adverse Effect Level (LOAEL)		
	Mammal [a]	Avian	Fish [b]
Arsenic (Inorganic)	3.81	9.2	0.69
Cadmium	32.13	13.97	3828.13
Mercury (methyl)	1.12	0.13	1.41
Selenium	2.31	0.57	33.6
Chlordane	55.38	2.87	-
DDTs	28.03	1.59	7.12
Dieldrin	1.2	0.33	1.64
Endosulfan	42.84	43.15	0.003
Endrin	5.56	0.11	3.92
Heptachlor epoxide	7.46	6.26	81.12
Hexachlorobenzene	14.01	0.6	0.044
Lindane	280.25	2.36	375.78
Mirex	4.6	0.72	9.91
Toxaphene	280.25	3.59	0.03
PCBs	3.93	1.29	1.95

[a] Two mammal receptor group threshold values calculated. The more sensitive freshwater mammal group was used for assessment.

[b] Two fish receptor group threshold values calculated. The more sensitive freshwater fish group was used for assessment.

Table 2-11 lists the criteria for rating all coastal and Great Lakes nearshore sites as good, fair, or poor for potential risk of contaminant exposure to predatory fish and fish-eating wildlife. An indicator rating is assigned to each site based on LOAEL contaminant threshold exceedances across receptor groups (mammal, avian, and fish). The regional assessment estimates the percentage of area within the region that meets or exceeds tissue contaminant threshold values. The *NCCA 2010 Technical Report* provides further discussion of these particular indicators and thresholds

Table 2-11. Guidelines used to evaluate sites for the ecological fish tissue contaminant index.

Ecological Fish Tissue Contaminant Index Guidelines		
Good	**Fair**	**Poor**
None of the measured contaminant concentrations exceed LOAEL for any receptor group.	At least one measured contaminant concentration exceeds LOAEL for one receptor group.	At least one measured contaminant concentration exceeds LOAEL for two or more receptor groups.

Isle Royale, in Lake Superior. (Photo Courtesy of Great Lakes Environmental Center, Inc.)

HIGHLIGHT: An Underwater View

The Potential Utility of Video Sampling in Assessing Coastal Condition

In 2010, researchers added underwater video to the NCCA sampling protocol in the Great Lakes to evaluate whether video can supplement traditional benthic sampling. Video sampling is simple and can provide rapid visual feedback, a historical archive, and sometimes a different perspective on local conditions. More specifically, researchers expected that video sampling would accurately show the presence or absence of invasive species such as dreissenid mussels (zebra and quagga mussels) and round gobies (bottom-dwelling fish). These invasives can cause ecological changes that affect coastal condition.

Traditionally, deep water benthic sampling is conducted using a grab sampler, such as a Ponar or Ekman dredge, lowered from a boat to the bottom of the waterbody. Processing benthic grab samples takes time and expertise. Grab samplers are also limited to sampling soft sediments, such as sand, silt, clay, or mud. For Great Lakes video sampling, a SeaViewer Sea-Drop color camera 950 with Unified Sea-Light™ LED light and a Sea-DVR: Mini Digital Video Recorder were used. Once a clear image of the station bottom was observed on the Sea-DVR screen, researchers held the camera as still as possible and began recording. Recording duration was at least one minute, and 309 videos were collected.

Some of the findings of this video sampling pilot in the Great Lakes include the following:

- Video sampling can be more effective than a grab sampler in detecting mussels on rocky substrate that is not amenable to dredge grab sampling (Figure 2-5).
- When mussel or vegetation distribution is variable or dispersed, video sampling can provide a better estimate of the presence or absence of mussels and vegetation than a single grab sample at that site (Figures 2-6 and 2-7).
- Video sampling detected dreissenid mussels at 8 sites where grab sampling did not, and at 17 sites where grab sampling was unsuccessful. At 32 sites, video sampling did not detect dreissenids despite grab sample data showing they were present. Video was better able to detect mussels as their abundance increased.
- 45% of videos are rated as marginal or poor in quality, either because of controllable reasons such as the view not being close enough to the bottom, or because of uncontrollable reasons such as poor visibility due to high suspended solids or chlorophyll a concentrations.
- Because video sampling provides a broad site view, researchers were occasionally treated to glimpses of passing native fish (Figure 2-8).

- To get a broader understanding of a sample site’s dreissenid and vegetation density and distribution, taking a video in addition to a grab sample provides more comprehensive data.

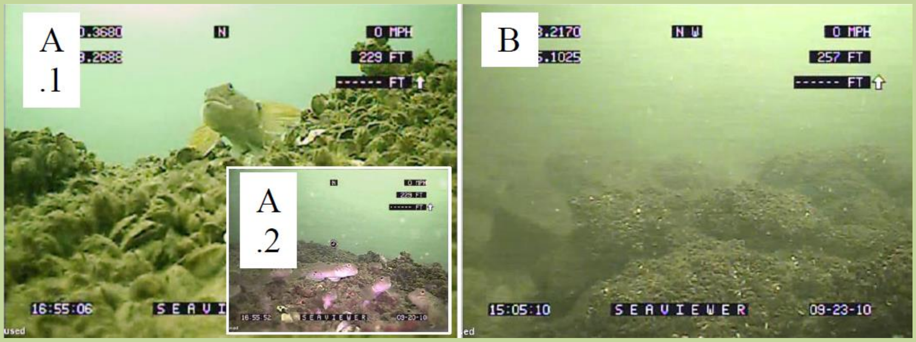


Figure 2-5. Video screen shots from sites in Lake Ontario where grab sampling was not successful. Site A shows colonization by dreissenid mussels (A.1) and round gobies (A.2). Site B shows large rocks encrusted with dreissenid mussels, a substrate not effectively sampled by grab techniques. .

Figure 2-6. A video screen shot in Lake Huron where grab sampling collected no dreissenid mussels. Dreissenid mussels are visible on the left-hand side of the image.

Figure 2-7. Video screen shots from sites in Lake Huron (A) and Lake Michigan (B & C) where grab sampling collected no vegetation. Sites A & C shows patchy vegetation on sediment, while Site B shows vegetation only on rock.

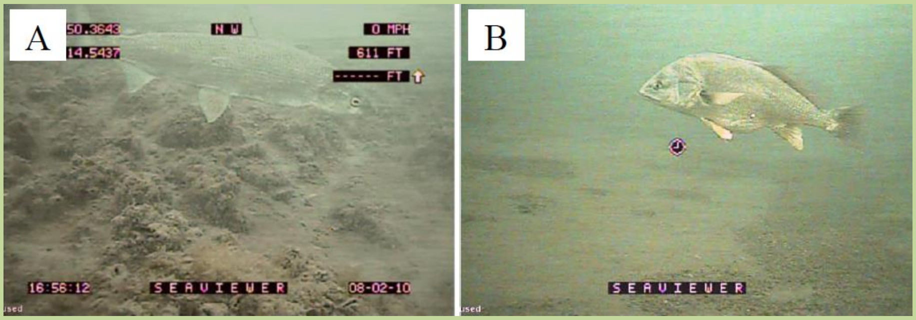


Figure 2-8. Video screen shots of a lake whitefish in Lake Huron (A) and a freshwater drum in Lake Ontario (B).

Conclusion

Grab and video sampling have unique strengths and weaknesses as sampling techniques; when paired together, they are complementary and appear to provide a more complete benthic data set that can be used for purposes beyond the NCCA analysis.The “landscape” perspective provided by video sampling creates a useful visual archive. In fact, having images from the same area over time could be a new way for researchers to document change in coastal resources.

CHAPTER 3.

NATIONAL COASTAL CONDITION

This chapter examines national findings for each index and for each of the components that make up the water quality and sediment quality indices. It includes information on national change in coastal conditions based on a comparison of three time periods (1999–2001, 2005–2006, and 2010). All results from the NCCA 2010 cannot be compared directly to results reported in earlier NCCRs because of changes in methods and indicators between coastal surveys. Analyses of change in coastal conditions are presented only when indicators and target populations are comparable across the three time periods. This chapter also includes highlights on interpreting coastal condition graphics; on the findings of an EPA Great Lakes human health fish tissue study; and on Gulf of Mexico offshore surveys conducted by NOAA.

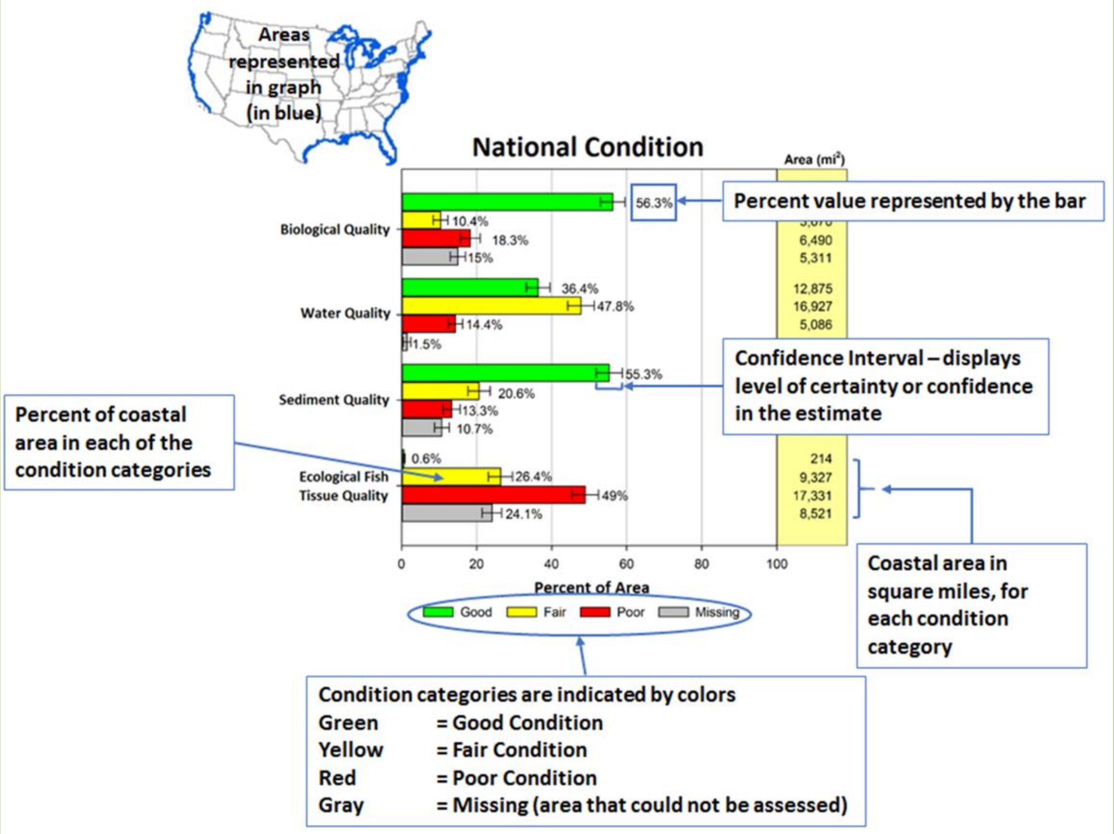
Summary of National Findings

For the NCCA 2010, findings for the four indices of condition (as shown in Figure 3-1) are as follows:

- 56% of the nation’s coastal waters are rated good for biological condition based on the benthic index;
- 36% of coastal waters are rated good for the water quality index;
- The sediment quality index is rated good in 55% of coastal waters; and
- Less than 1% of coastal waters are rated good based on ecologically relevant levels of fish tissue contamination (i.e., based on potential harm to other fish and wildlife that consume the fish).

Highlight: Interpreting Coastal Condition Graphics

This highlight provides the reader with information on understanding and interpreting the primary graphics in this report.



What is a Confidence Interval?

Results generated by any sampling effort are estimates of the true condition. Surveys such as the NCCA are designed to quantify the uncertainty in the estimates. Uncertainty is reported as a confidence interval. For example, the national water quality findings in 2010 indicate that 36 ± 4% of the nation’s coastal area is in good condition, meaning that we are 95% certain that the true value is between 32% and 40%. The confidence interval is displayed by thin “error bars” on the graphics throughout this report.

Missing Data?

Gray bars in many of the summary graphics in this report represent sites that were visited but could not be assessed for some indicators. Reasons for the missing data include natural conditions (e.g., powerful ocean currents and the prevalence of rocky or hard substrates that prevent collection of sediment); the inability to collect target fish or benthic invertebrate species; and laboratory analytical concerns. In some regions, a large percentage of waters are unassessed for certain indicators, which could affect the reliability of results. The areas in good, fair, and poor condition are distributed in unknown proportions within the unassessed areas. See Chapter 5 for a discussion of how EPA is working with its partners to address the issue of missing data in future surveys.

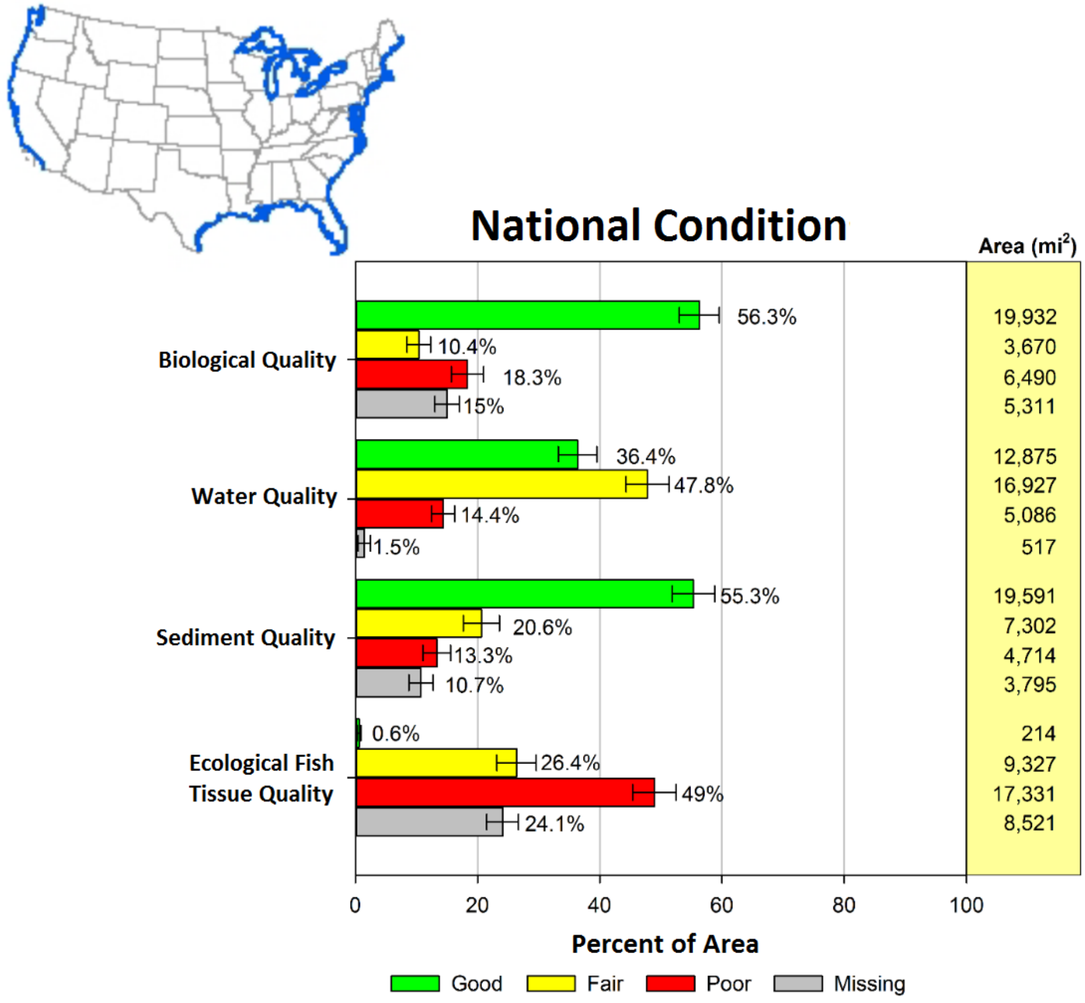


Figure 3-1. Condition of the nation's coastal waters for each of the four NCCA indices (U.S. EPA/NCCA 2010).

Fish tissue contamination findings are based on ecological guidelines designed to evaluate the potential harm that contaminant concentrations in fish tissue pose to predator fish and wildlife. Human health risks due to fish consumption are not evaluated nationally in this report. EPA has implemented a supplemental study in the Great Lakes looking at mercury, PCBs, and other compounds in fish tissue fillets to identify concentrations above those established in human health criteria for the edible portion of fish. This information is presented later in this chapter (see "Highlight: Great Lakes Human Health Fish Tissue Study.")

National Coastal Condition Indicators

Benthic Index

Invertebrates such as crustaceans, clams, and worms that live in and on the bottom (i.e., benthic) substrates of coastal estuaries and the Great Lakes are useful indicators of condition. Many of these benthic macroinvertebrates are sensitive to stresses caused by chemical contamination, fluctuating or low dissolved oxygen levels, changes in salinity and water clarity, and sediment disturbance. Other macroinvertebrates are more tolerant of pollution stresses. Benthic indices used in the NCCA 2010 vary by region because of differences in prevailing temperatures, salinities, and the silt-clay content of sediments. The benthic indices used in this assessment are generally based on multi-metric indices—that is, they incorporate a variety of individual measures (metrics) such as taxa composition, diversity, richness, abundance, and pollution tolerance. Exceptions occur in the West and the Great Lakes, where regional multi-metric benthic indices have not yet been developed (see Chapter 2 for a discussion of benthic indices).

The NCCA 2010 finds that 56% (19,932 square miles) of coastal and Great Lakes waters are rated good for the benthic index; 10% (3,670 square miles) are rated fair; and 18% (6,490 square miles) are rated poor (Figure 3-2). Another 15% of the waters (5,311 square miles) could not be assessed because of missing or incomplete data. The rating of poor applies when benthic communities have lower-than-expected diversity, are populated by more pollution-tolerant species than expected, or contain fewer pollution-sensitive species than expected, as measured by regional multi-metric benthic indices.

Marina at Smith Island, Maryland. (Photo courtesy of Eric Vance)

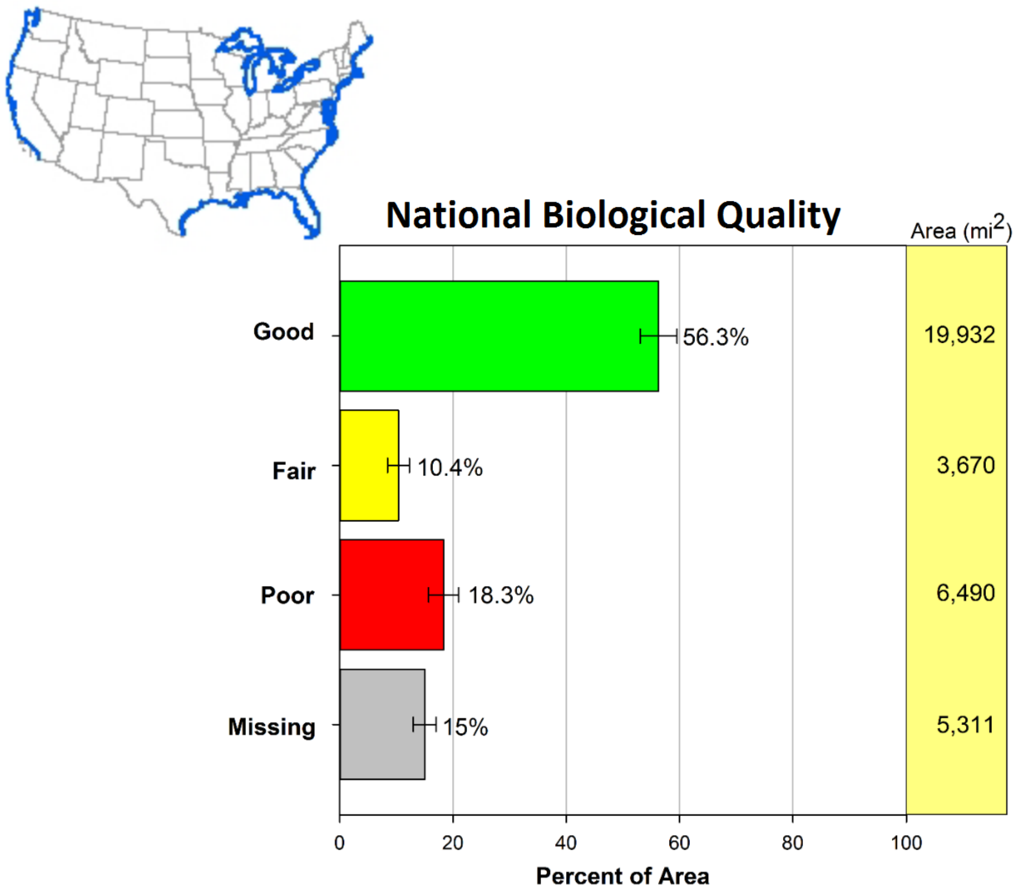


Figure 3-2. Biological quality of the nation's coastal waters based on the benthic index (U.S. EPA/NCCA 2010).

Water Quality Index

The water quality index is rated good in 36% (12,874 square miles) of coastal and Great Lakes waters; fair in 48% (16,927 square miles); and poor in 14% (5,086 square miles) (Figure 3-3). In coastal estuaries, the water quality index is determined based on measurements of five component indicators: nitrogen, phosphorus, chlorophyll *a*, water clarity, and dissolved oxygen (discussed below). Nitrogen was measured but not included in the index for the Great Lakes. This accounts for the amount of missing data for nitrogen nationally.

Nutrients: Nitrogen and Phosphorus

Nitrogen and phosphorus are necessary and natural nutrients required for the growth of algae, which is the base of the food web in coastal waters. However, excessive levels of these nutrients from sources such as sewage and fertilizers can result in accelerated eutrophication, a process characterized by large, undesirable algal blooms, increased chlorophyll *a* concentrations, reduced water clarity, and lower concentrations of dissolved oxygen. Nitrogen is not assessed in the Great Lakes because it historically has not been considered to be a controlling nutrient in freshwater environments and because currently there are no established nitrogen assessment thresholds for the Great Lakes. Future reports may include nitrogen assessments for this region.

The NCCA 2010 shows that phosphorus is found at low levels (rated good) in 40% (14,233 square miles) of coastal and Great Lakes waters; at moderate levels (rated fair) in 38% (13,315 square miles); and at high levels (rated poor) in 21% (7,393 square miles).

Nitrogen is found at low levels (rated good) in 69% (24,398 square miles) of the nation's coastal waters; at moderate levels (rated fair) in 7% (2,442 square miles); and at high levels (rated poor) in 4% (1,426 square miles). Nitrogen data are missing for 20% of coastal waters (primarily because nitrogen data were collected but not assessed in the Great Lakes).

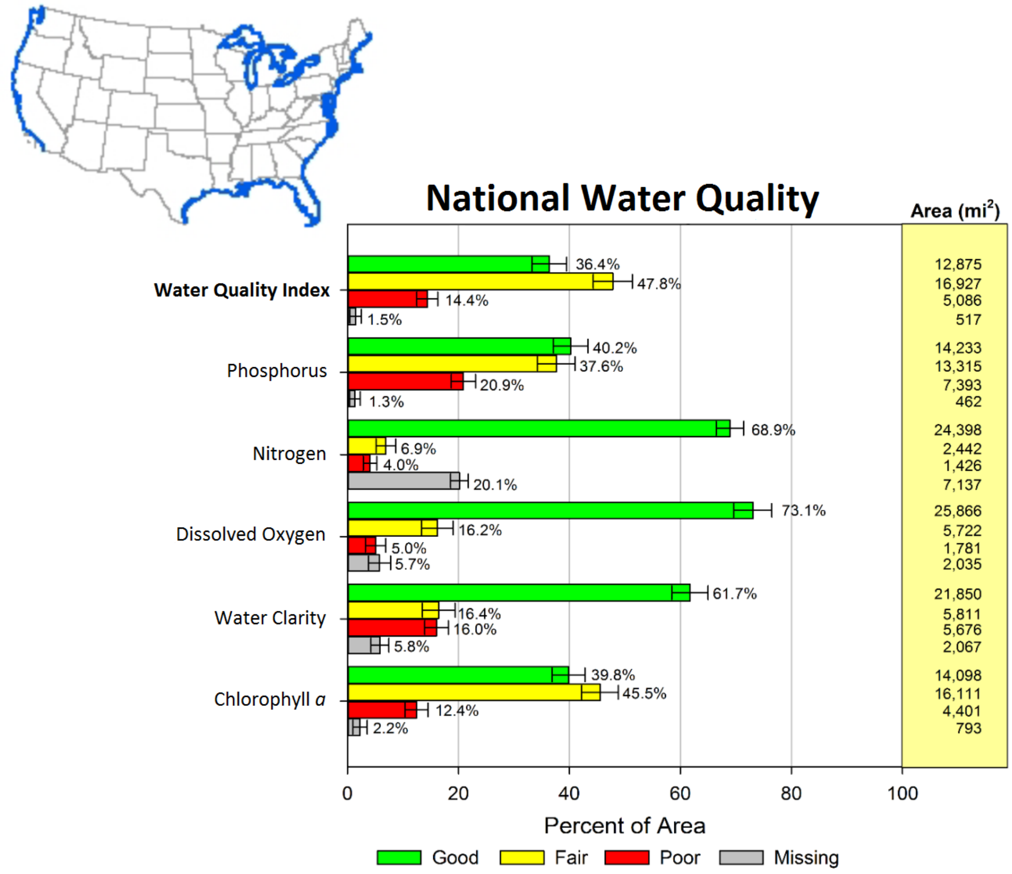


Figure 3-3. Coastal water quality based on the water quality index (U.S. EPA/NCCA 2010).
Note: Nitrogen was measured but not evaluated as part of the water quality index in the Great Lakes. This accounts for the large percentage of missing results for nitrogen at the national scale.

Dissolved Oxygen

Dissolved oxygen is essential for all aquatic life. Low concentrations (less than 2 mg/L) can lead to hypoxia, which is detrimental to most organisms. Oxygen levels can change rapidly in response to physical and biological processes (e.g., temperature changes, wind and wave action, and photosynthesis and respiration). Levels may also change more gradually in response to large algal blooms that sink to the bottom, where bacteria use oxygen as they degrade the algal mass. Hypoxia can also result from stratification due to strong freshwater river discharge on the surface, which overrides the heavier, saltier bottom water of a coastal waterbody. This assessment incorporates dissolved oxygen measurements from the bottom of the water column to develop water quality index ratings.

Overall, 73% (25,866 square miles) of coastal area is rated good, with high dissolved oxygen concentrations; 16% (5,722 square miles) is rated fair, with moderate dissolved oxygen levels; and only 5% (1,781 square miles) is rated poor, with low dissolved oxygen concentrations (i.e., hypoxic conditions may be present) (Figure 3-3). Data on dissolved oxygen levels are missing or incomplete for 6% (2,035 square miles) of coastal and Great Lakes waters.

Interpretation of Instantaneous Dissolved Oxygen Information

The NCCA 2010 results suggest that low dissolved oxygen concentrations are not a pervasive problem nationwide. In interpreting these results, it is important to keep in mind that the NCCA is not designed to detect and track the magnitude and duration of low dissolved oxygen events (hypoxia) at particular sites over time. Rather, the NCCA estimates the condition of the nation’s near coastal waters as a whole using a wide range of parameters, including dissolved oxygen concentrations. The duration, frequency, and location of coastal hypoxic episodes can vary widely.

Other investigations with different objectives have focused on tracking long-term trends in the frequency and areal extent of low oxygen events in targeted coastal areas, which may or may not overlap the areas assessed for the NCCA. For example, extensive year-round or seasonal monitoring over multiple years in the Gulf of Mexico and Chesapeake Bay documents widespread and recurring hypoxia in these systems. These hypoxic zones threaten valuable commercial and recreational fisheries and the overall health of these waters. The NCCA 2010 does not cover any part of the 2010 Gulf hypoxic zone. For more information on the Gulf of Mexico hypoxic zone, see http://www.epa.gov/ms-htf.

Water Clarity

Clear water is important for sunlight to reach and support submerged aquatic vegetation; this vegetation, in turn, provides essential habitat for fish and other aquatic organisms and helps oxygenate the water. Water clarity is affected by physical factors such as wind, which suspends sediments and particulate matter in the water; by chemical factors that influence the amount of colored dissolved organic matter; and by biological factors such as algae levels in the water. Naturally turbid waters can support healthy and productive ecosystems by supplying sediment for coastal wetlands and food and protection to resident organisms. However, excessively turbid waters can be harmful to coastal ecosystems if sediment loads bury benthic communities, adversely affect filter feeders such as clams, or block sunlight needed by submerged aquatic vegetation.

Water clarity is rated good in 62% (21,850 square miles) of coastal and Great Lakes waters; fair in 16% (5,811 square miles); and poor in another 16% (5,676 square miles) (Figure 3-3). In 6% of coastal waters (2,067 square miles), data on water clarity from the NCCA 2010 are missing or incomplete.

Chlorophyll a

Chlorophyll *a* is a photosynthesizing green pigment in plants and algae. The concentration of chlorophyll *a* in water indicates the amount of microscopic algae (i.e., phytoplankton) growing in a waterbody. High concentrations, often caused by excess nutrients, can indicate the overproduction of algae (algal blooms).

As noted in Figure 3-3, 40% of coastal area (14,098 square miles) is rated good, with low chlorophyll *a* concentrations; 46% (16,111 square miles) is rated fair, with moderate chlorophyll *a* concentration; and 12% (4,401 square miles) of coastal area is rated poor, with high chlorophyll *a* concentrations.

Sediment Quality Index

Overall, 55% (19,591 square miles) of coastal and Great Lakes area has good sediment quality based on the sediment quality index; 21% (7,302 square miles) has fair quality; and 13% (4,714 square miles) has poor sediment quality (Figure 3-4). Data are missing or incomplete in another 11% of waters (3,795 square miles). The sediment quality index is based on two component indicators: sediment contaminants and sediment toxicity.

Sediment Contaminants

Environmentally persistent contaminants from urban, industrial, and agricultural sources from inland, upstream, and coastal areas can settle in coastal sediments. These contaminants include a wide variety of toxic chemicals, such as metals, pesticides, and PAHs. When contaminants accumulate in the tissues of organisms such as clams and crabs that live in or on sediments, they pose a risk to fish and other animals—including humans—who consume them.

Overall, 79% (27,859 square miles) of coastal area is rated good based on low levels of sediment contamination. Moderate concentrations are observed in 11% (3,700 square miles) of coastal area, which is rated fair. High concentrations are observed in less than 1% (49 square miles) of coastal area, which is rated poor. In 11% of coastal waters (3,795 square miles), sediment contaminant data are incomplete or missing (Figure 3-4).

Sediment Toxicity

To determine the aggregate impacts of multiple contaminants accumulating over time in coastal bottom sediments, researchers looked at sediment toxicity by measuring the survival of shrimp-like crustaceans (known as amphipods) exposed to sediments that were collected at NCCA sites. The amphipods were exposed to the sediments for ten days under laboratory conditions to determine their rate of survival and provide important information on sediment toxicity. Overall, 57% (20,111 miles) of coastal area is rated good for sediment toxicity; 13% (4,689 square miles) is rated fair; and 13% (4,698 square miles) is rated poor (Figure 3-4). In 17% of coastal waters (5,905 square miles), sediment toxicity data are incomplete or missing.

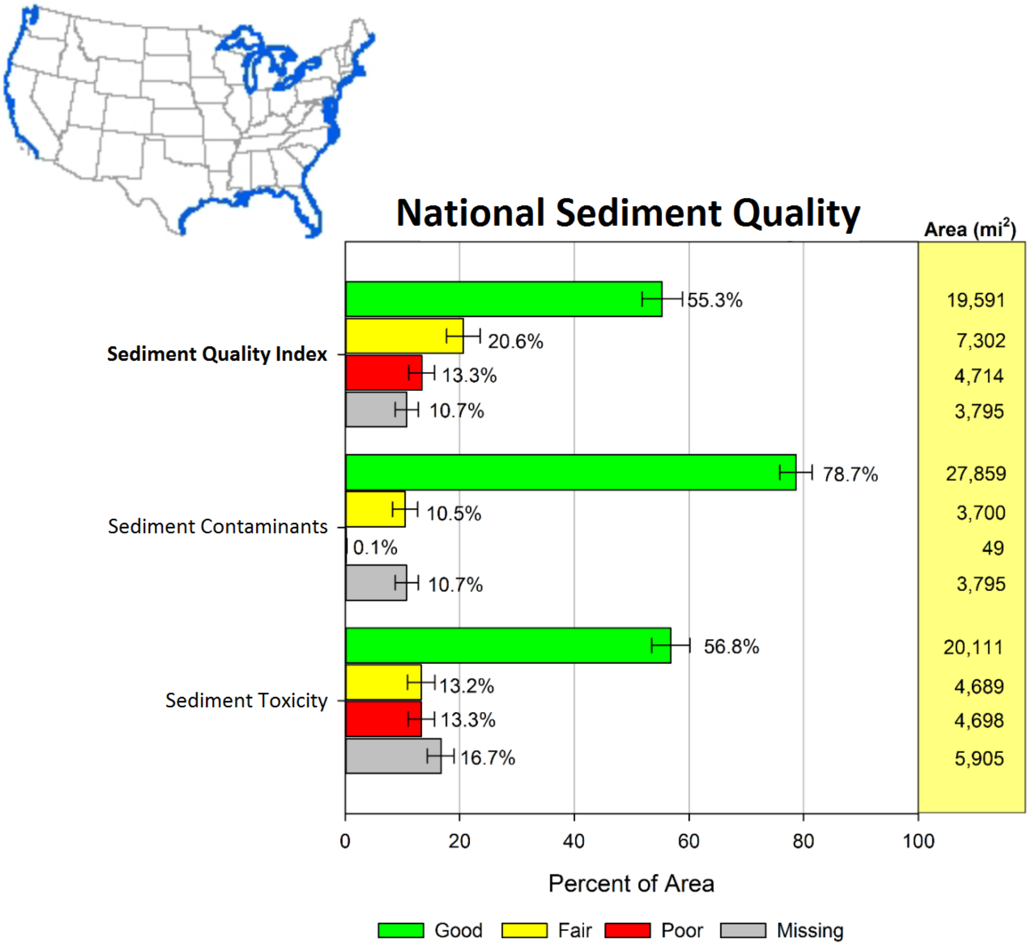


Figure 3-4. Sediment quality in the nation's coastal waters based on the sediment quality index (U.S. EPA/NCCA 2010).

Ecological Fish Tissue Contaminant Index

When contaminants such as arsenic, mercury, selenium, DDT and PCBs enter an organism, they tend to remain in its tissues and may build up over time. Such build-up, known as bioaccumulation, poses a health risk to predators who consume the contaminated organisms. For the NCCA 2010, whole-body fish samples are used to determine contaminant levels. Fish tissue contamination findings are based on ecological guidelines designed to evaluate whether concentrations of contaminants in fish tissue pose a potential to harm predator fish and fish-eating wildlife. With the exception of a supplemental study in the Great Lakes, human health risks have not been not evaluated for the NCCA 2010 (see the highlight: "Great Lakes Human Health Fish Tissue Study").

Based on the ecological fish tissue contaminant index, less than 1% (214 square miles) of coastal area is rated good; 26% (9,327 square miles) is rated fair; and 49% (17,331 square miles) is rated poor, where fish tissue demonstrated contaminant exceedances of the LOAEL. In 24% (8,521 square miles) of coastal area, fish tissue contaminants cannot be assessed because data are missing (Figure 3-5). Sites in poor and fair condition are dominated by tissue samples exhibiting elevated concentrations of selenium.

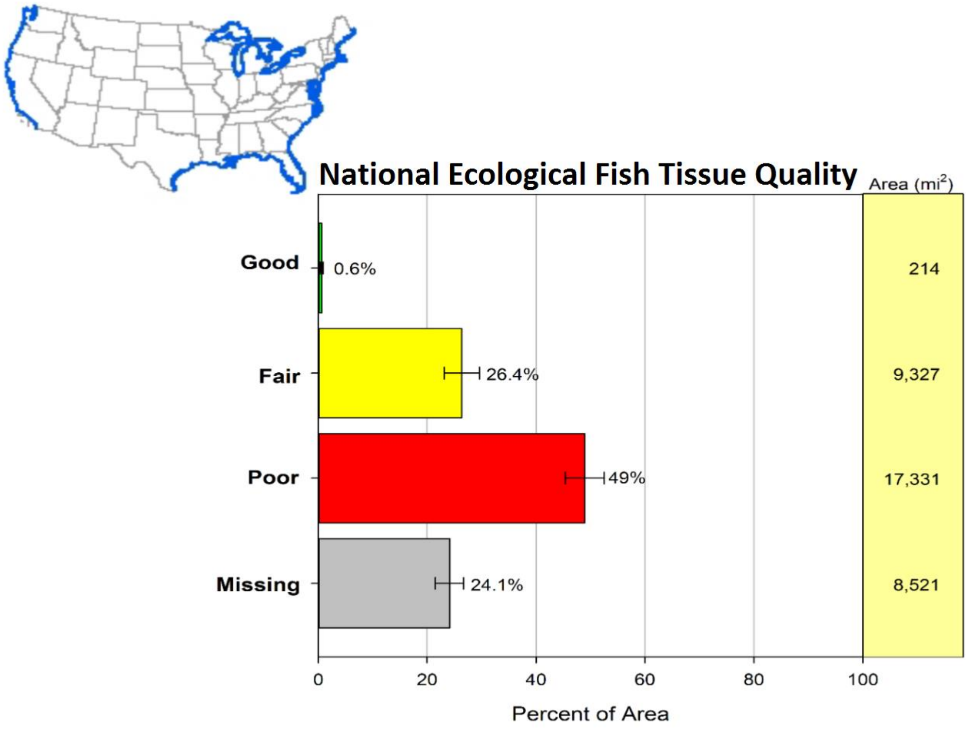


Figure 3-5. Ecological fish tissue quality for the nation's coastal waters based on the ecological fish tissue contaminant index (U.S. EPA/NCCA 2010).

The poor tissue quality conditions in 2010 reflect the use of ecologically-oriented threshold values for whole fish. (See the *NCCA 2010 Technical Report* for more detail.) These results provide one measure of the potential harm to birds, fish, and other wildlife from the consumption of contaminated fish. Using three receptor groups to help estimate conditions associated with fish tissue is particularly important because only a limited number of wildlife-related threshold values are available. Because wildlife consume the whole fish, whole-body fish samples, rather than fillets, are used to determine contaminant levels. Figure 3-6 shows the distribution of LOAEL exceedances for each of the three receptor groups based on the thresholds in Table 2-10. Almost 75% of coastal area shows at least one contaminant level in fish that could harm birds that consume them.

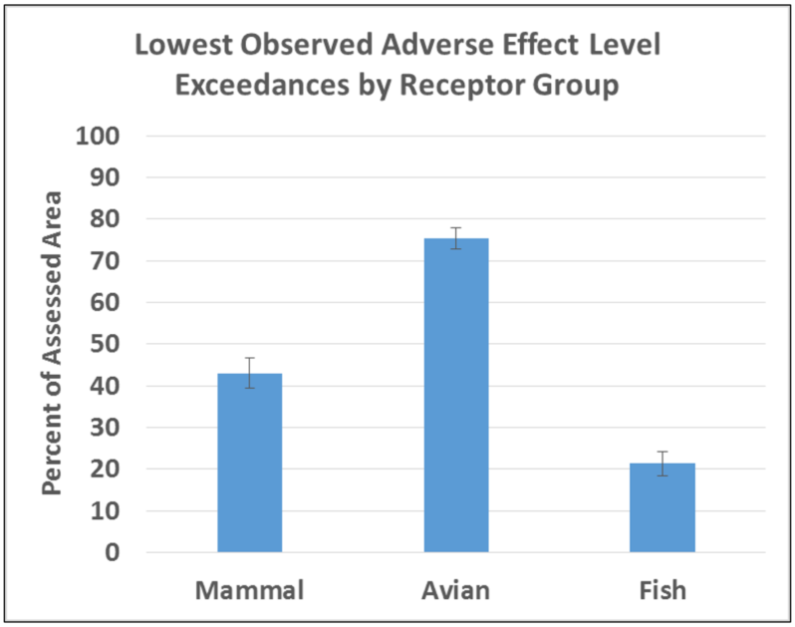


Figure 3-6. Percent of assessed area of the nation's coastal waters in which at least one fish tissue contaminant exceeds upper threshold levels in at least one receptor group. Twenty-four percent of waters have missing ecological fish tissue contaminant data and are unassessed.

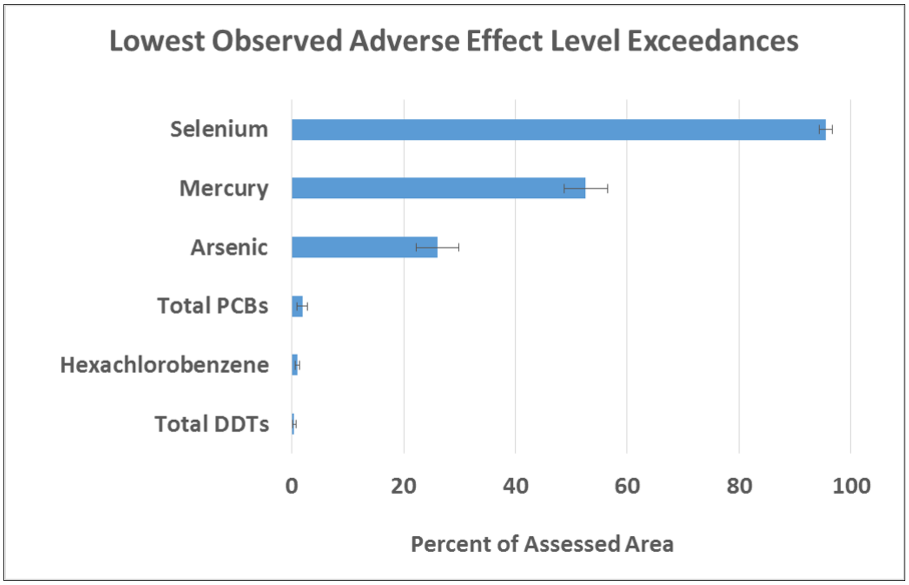


Figure 3-7. Percent of assessed area of the nation's coastal waters that exceed LOAEL levels for each of six measured fish tissue contaminants. Twenty-four percent of coastal waters have missing ecological fish tissue contaminant data and are unassessed.

Selenium is the most widespread contaminant exceeding the fish tissue contaminant thresholds for predators. While selenium occurs naturally and is nutritionally valuable, too much selenium can be toxic. Current literature suggests that more research is needed to clarify the differences between beneficial and harmful concentrations of selenium. Figure 3-7 identifies the contaminants that most frequently exceed the LOAEL threshold and are therefore most responsible for the fair and poor ratings for the ecological fish tissue contaminant index.

A Word about Selenium

Selenium (Se) is a naturally occurring element. It is found globally in petroleum source rocks and organic-rich marine sedimentary rocks such as black shales. In limited amounts, selenium is important for nutritional health in wildlife. However, too much selenium adversely affects reproductive success and, over time, biodiversity—from fish and amphibians to birds and mammals. Certain chemical forms of selenium are considered more bioaccumulative and toxic than others. The scientific community suggests that human activities may be increasing the amount of selenium that is bioavailable in the environment.

HIGHLIGHT: The Great Lakes Human Health Fish Tissue Study

Studying Chemicals in Great Lakes Fish to Protect Human Health

As part of the NCCA 2010, EPA has conducted the first human health-related study to provide statistically based data on toxic chemicals in Great Lakes fish. For this Great Lakes Human Health Fish Tissue Study, EPA collected samples of fish commonly consumed by humans at 157 of the statistically representative 225 Great Lakes nearshore sampling locations (about 30 fish samples per lake) and analyzed the fillet (muscle) tissue for toxic chemicals. EPA analyzed the tissue samples for total mercury, all 209 congeners of PCBs, 52 PBDE congeners, and 13 PFCs. The results identify which chemicals pose greater risks to people who eat Great Lakes fish. The following section briefly describes the contaminants examined and associated human health risk concerns.

The Targeted Contaminants

PCBs

Polychlorinated biphenyls (PCBs) bioaccumulate in the tissues of aquatic organisms, and people can be exposed to potentially harmful levels of PCBs through fish consumption. Animal studies have established that PCBs cause cancer. Based on those findings and additional evidence from human studies, EPA classifies PCBs as probable human carcinogens. Other potential health effects include suppression of the immune system, reproductive effects (e.g., lower birth weight and reduced periods for fetus development), thyroid-function impacts, and effects on nervous system development related to short-term memory and learning.

Mercury

People are exposed to methylmercury primarily by eating fish and shellfish. Monitoring mercury levels in fish is critical because about 80% of all fish consumption advisories in the United States involve mercury. Fetuses and young children can be exposed to harmful amounts of methylmercury when pregnant women and nursing mothers eat fish with elevated mercury concentrations. These exposures can lead to impairments in neurological development that may impact cognitive and fine motor skills. Exposure to unsafe levels of methylmercury can also affect adult health, leading to cardiovascular disease, loss of coordination, muscle weakness, and impairment of speech and hearing.

PBDEs

A number of studies conducted since 2000 confirm that polybrominated diphenyl ethers (PBDEs), often referred to as brominated flame retardants, biomagnify (increase in concentration from one level in a food chain to another) in aquatic environments and accumulate in fish. In 2003, EPA began testing fish for the presence of PBDEs because they are persistent, bioaccumulative, toxic chemicals with widespread distribution in the environment. Potential human health impacts include endocrine disruption (e.g., thyroid function effects) and neurodevelopmental toxicity.

PFCs

Perflourinated compounds (PFCs) are a large group of synthetic chemicals used in the manufacture of a wide variety of commercial products, including non-stick cookware, food packaging, waterproof clothing, and stain-resistant carpeting. They have emerged as contaminants of concern due to their toxicity, global distribution, and persistence in the environment. Studies have shown that a majority of people living in industrialized nations have detectable concentrations of a number of PFCs in their blood serum. Higher concentrations of PFCs in human blood have been linked to potential health effects, such as decreased sperm count, low birth weight, and thyroid disease. Recent studies estimate that PFC contamination in food may account for more than 90% of human exposure to perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), and they indicate that fish from contaminated waters may be the primary source of exposure to PFOS.

Results

Results from this Great Lakes study show that all 157 fish fillet samples contained detectable levels of mercury, PCBs, PBDEs and PFCs. PCBs and mercury occur most frequently in these samples at levels exceeding human health thresholds for fish consumption. Tables 3-1 and 3-2 present a summary of the analytical and statistical results.

Of note, nearly 99% of the Great Lakes nearshore area sampled (or 4,227 square miles) exceed the 12 ppb human health screening value for PCBs (Table 3-2). There are currently fish consumption advisories in all of the Great Lakes because of the presence of toxic contaminants in fish. States, tribes, and the province of Ontario have extensive fish contaminant monitoring programs and issue advice to their residents on which fish are safe to eat and how much of each identified variety can be safely consumed.

Table 3-1. Summary of detections and contaminant concentrations in 157 Great Lakes fish fillet samples (EPA GLHHFT Study).

Chemical	Number of Detections	Minimum Concentration[a] (ppb)	Median Concentration[b] (ppb)	Maximum Concentration[a] (ppb)
PCBs	157	6	179	2,379
Mercury (Total)	157	23	139	956
PBDEs (Summed)	157	< 1	13	227
PFOS	157	2	15	80

[a] Observed data (minimum and maximum concentrations) measured in 157 Great lakes fish fillet samples.

[b] Statistical estimates of the median fish fillet concentrations for the nearshore Great lakes sampled population of 4,282 square miles.

Table 3-2. Human health screening value exceedances for contaminants in Great Lakes fish (EPA GLHHFT Study).

Chemical	Human Health Screening Value (SV)	Total Sampled Population	Percentage of Sampled Population Exceeding the SV	Nearshore Area of Sampled Population Exceeding the SV
PCBs	12 ppb EPA cancer health threshold	4,282 mi^2	98.7%	4,227 mi^2
	60 ppb Great Lakes Sport Fish Advisory Task Force non-cancer threshold	4,282 mi^2	81.7%	3,499 mi^2
Mercury (Total)	300 ppb EPA tissue-based water quality criterion for methylmercury	4,282 mi^2	10.9%	467 mi^2
	110 ppb Great Lakes Sport Fish Advisory Task Force non-cancer threshold	4,282 mi^2	59.5%	2,548 mi^2
PBDEs (Summed)	210 ppb California Environmental Protection Agency non-cancer threshold	4,282 mi^2	< 1%	28 mi^2
PFOS	40 ppb Minnesota Department of Health Fish Consumption Advisory Program non-cancer threshold	4,282 mi^2	9.0%	385 mi^2

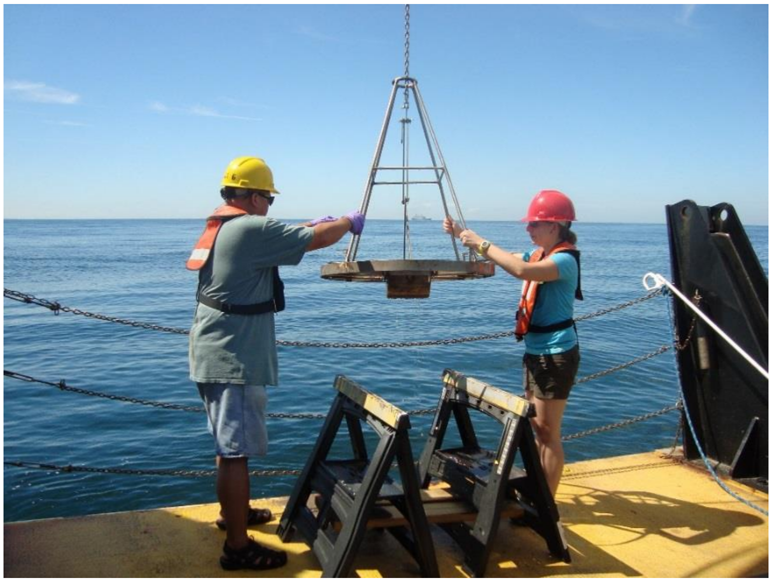
Changes in Coastal Condition

Among the long-term goals of the NARS is detecting trends over time in the condition of U.S. waters and in the stressors that affect them. This information can help policymakers evaluate the effectiveness of national and regional programs and policies, and can allow them to determine whether different approaches are needed to meet water quality goals.

For the NCCA 2010, analysts evaluate change in U.S. coastal condition using a comparable subset of data from each of three periods: 1999–2001, 2005–2006, and 2010. This change analysis looks at the Northeast, Southeast, Gulf, and West Coast regions. The Great Lakes are not included in the analysis because they were not surveyed using NARS protocols prior to 2010. Some coastal areas are excluded from the change analysis because they were not included in the sample frame in all three time periods. Change results for the nation are presented here, and change results for the different regions are presented in Chapter 4.

The analysis of change in condition includes findings for the water quality index, sediment quality index, and benthic index. Analysts could not calculate the ecological fish tissue contaminant index comparably in all three time periods because of differences in fish collection and analysis. Results are presented using bar charts showing the percent area in good condition for each time period (Figures 3-8 and 3-9), and in tables showing percent changes in good, fair, and poor conditions (Tables 3-3 and 3-4). Statistically significant changes are highlighted with an asterisk.

While index results (especially for sediment and benthos) in this report might appear contradictory, they do not necessarily respond to stressors in the same manner. The indices also do not reflect all stressors that may impact coastal waters. As additional data are collected and analyzed for the NCCA 2015, clearer patterns may emerge.



Preparing to lower a grab sampler to the ocean floor.
(Photo courtesy of Treda Grayson)

Changes in Water Quality

The percent area rated good for the overall water quality index decreases significantly from 1999–2001 (42% rated good) to 2005–2006 (30% rated good). There is no significant change from 2005–2006 to 2010 (Figure 3-8). For the components of the water quality index, there is no clear improvement or degradation (Figure 3-8 and Table 3-3). For example, between 1999–2001 and 2005–2006, phosphorus and dissolved oxygen show a statistically significant decline in area rated good, but they do not continue that decline in 2010. Nitrogen and water clarity show no significant change from 1999–2001 to 2005–2006, but both show an increase in area rated good in 2010.

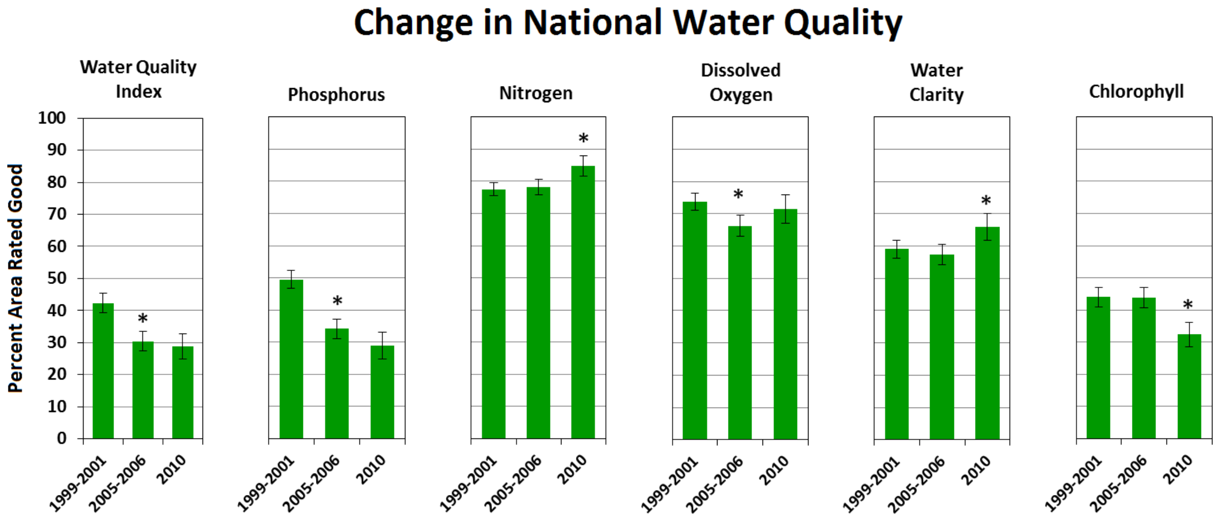


Figure 3-8. Comparison of the percent area rated good for national water quality indicators over three periods. Note: Asterisks indicate statistically significant change from the previous period. Change analysis does not include the Great Lakes.

Table 3-3. Change in national condition status for water quality indicators.

Indicator	Status	% Area 1999–2001	% Area 2005–2006	% Area 2010	Change in % Area 1999–2001 to 2005–2006	Change in % Area 2005–2006 to 2010
Water Quality Index	Good	42	30	29	-12.0*	-1.5
	Fair	40	51	56	+10.4*	+5.6
	Poor	10	11	13	+1.3	+1.5
	Missing	7	7	2	+0.3	-5.6*
Phosphorus	Good	50	34	29	-15.4*	-5.1
	Fair	30	39	44	+9.0*	+4.9
	Poor	12	14	25	+1.9	+11.0*
	Missing	8	12	2	+4.5*	-10.8*
Nitrogen	Good	77	78	85	+0.7	+6.6*
	Fair	10	6	9	-3.9*	+2.8
	Poor	5	2	5	-2.7*	+2.6*
	Missing	8	13	2	+5.9*	-12.0*
Dissolved Oxygen	Good	74	66	71	-7.5*	+5.2
	Fair	18	22	21	+4.9*	-1.2
	Poor	2	6	3	+4.2*	-3.3*
	Missing	7	5	4	-1.5	-0.8
Water Clarity	Good	59	57	66	-1.7	+8.5*
	Fair	11	16	14	+5.4*	-1.9
	Poor	16	18	13	+2.3	-4.8*
	Missing	14	8	6	-6.0*	-1.8
Chlorophyll	Good	44	44	32	-0.2	-11.5*
	Fair	40	42	55	+2.8	+12.2*
	Poor	7	7	10	0.0	+3.0
	Missing	9	7	3	-2.7*	-3.7*

Note: The sum of percent area for each indicator may not add up to 100% due to rounding. Asterisks indicate statistically significant change from the previous period. Change analysis does not include the Great Lakes.

Changes in Sediment Quality

In the period from 1999–2001 to 2005–2006, the percent area rated good for the sediment quality index increases from 69% to 78%, a statistically significant change. At the same time, the percent area rated good for the sediment contaminants indicator also increases significantly. However, from 2005–2006 to 2010, the percent area rated good for the sediment quality index decreases significantly from 78% to 56%; the area rated good for sediment contaminants decreases from 89% to 83%; and the area rated good for sediment toxicity decreases from 72% to 55% (Figure 3-9 and Table 3-4). Review of the regional results shows that the national changes from 2005–2006 to 2010 are shaped by changes in the Gulf Coast and, to a lesser extent, the West Coast.

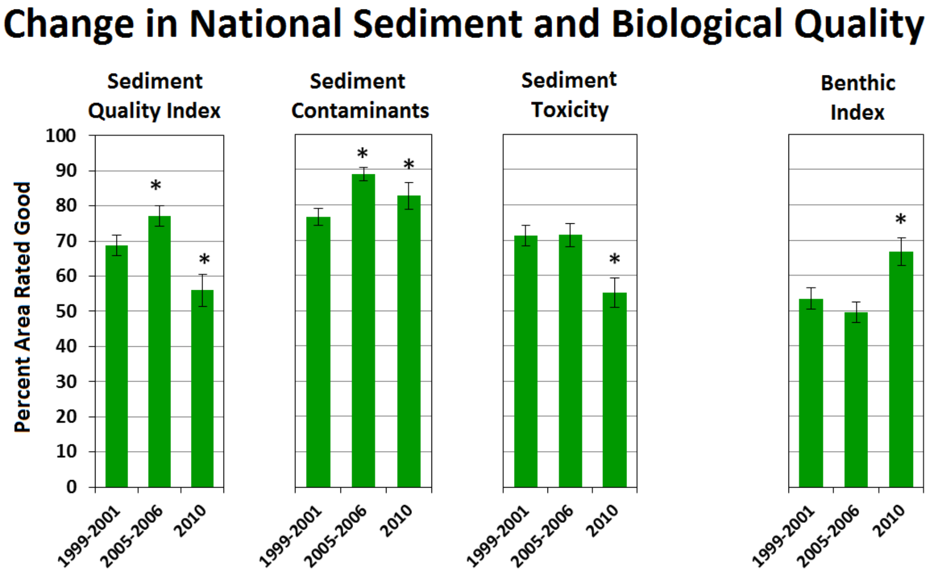


Figure 3-9. Comparison of the percent area rated good for national sediment quality and biological quality over three periods, based on the sediment and benthic indices. Note: Asterisks indicate statistically significant change from the previous period. Change analysis does not include the Great Lakes.

Changes in Biological Quality

For the benthic index, the area of waters rated good shows no significant change between 1999–2001 and 2005–2006, followed by a statistically significant increase from 50% to 67% in waters rated good from 2005–2006 to 2010 (Figure 3-9 and Table 3-4). More benthic data are missing from the 2005–2006 period than from either of the two other periods. A portion of the observed change may be associated with the differences in missing data between the periods.

Table 3-4. Change in national condition status for sediment quality and biological quality.

Indicator	Status	% Area 1999–2001	% Area 2005–2006	% Area 2010	Change in % Area	
					1999–2001 to 2005–2006	2005–2006 to 2010
Sediment Quality Index	Good	69	78	56	+8.3*	-21.7*
	Fair	17	7	21	-10.3*	+14.7*
	Poor	4	10	15	+5.8*	+4.9*
	Missing	10	5	7	-3.7*	+2.2
Sediment Contaminants	Good	77	89	83	+12.0*	-7.0*
	Fair	12	4	10	-8.4*	+6.0*
	Poor	1	< 1	< 1	-1.0*	-0.0
	Missing	10	6	7	-2.7*	+0.9
Sediment Toxicity	Good	71	72	55	+0.2	-17.0*
	Fair	7	3	15	-4.0*	+12.2*
	Poor	3	10	15	+6.7*	+4.9*
	Missing	18	15	15	-3.0	+0.0
Benthic Index	Good	53	50	67	-3.9	+16.9*
	Fair	18	11	11	-7.0*	-0.2
	Poor	18	15	16	-2.6	+1.2
	Missing	11	24	6	+13.5*	-17.9*

Note: The sum of percent area for each indicator may not add up to 100% due to rounding. Asterisks indicate statistically significant change from the previous period. Change analysis does not include the Great Lakes.

HIGHLIGHT: NOAA Gulf of Mexico Offshore Surveys

Between 2007 and 2011, NOAA conducted surveys to assess the ecological condition of the coastal-ocean (shelf) waters of the northwestern (NW), northeastern (NE), and southeastern (SE) Gulf of Mexico (GOM). The study area encompassed a total of 89,280 square miles, with each of the regions (NW, NE, SE) covering 29,180 square miles, 27,050 square miles, and 33,050 square miles, respectively. These surveys, extending beyond the NCCA nearshore design, provide additional information to describe ocean condition further offshore.

NOAA's offshore surveys incorporated a probabilistic sampling design similar to the NCCA and included stations distributed randomly throughout each of the three Gulf regions (Figure 3-10). They also included similar measures of water quality, sediment quality, benthic condition, and fish-tissue contamination. Along with NCCA data, these measures can be used to provide a framework for evaluating future changes due to natural or human-induced disturbances. The following is a general description of results for selected parameters. More-detailed reports on results of these individual Gulf offshore assessments are provided in the references at the end of this report.

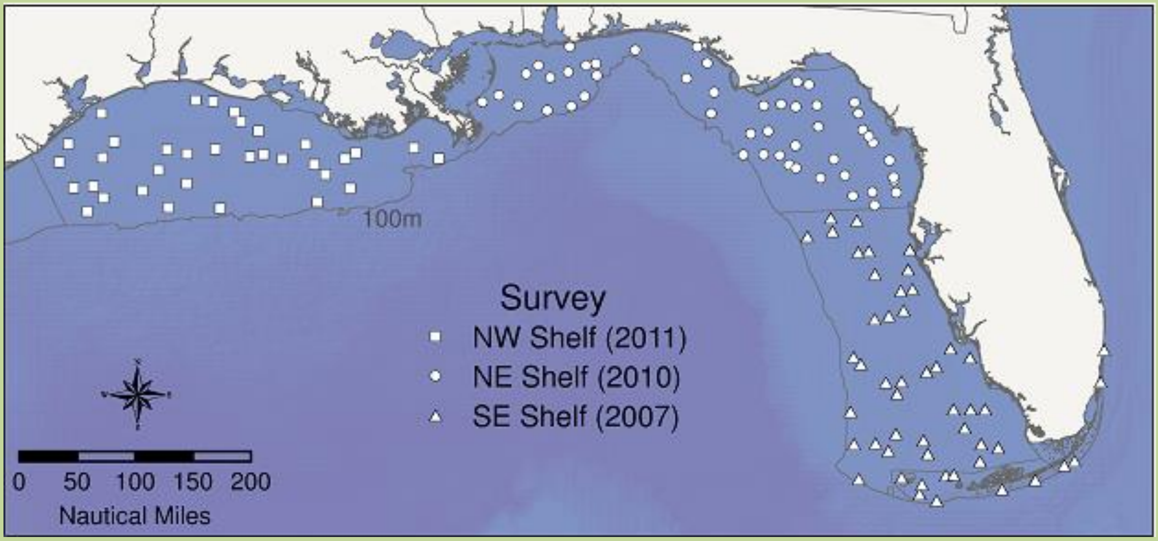


Figure 3-10. Map of sampled station locations in the NW, NE, and SE shelf portions of the Gulf.

Water Quality

Nutrients: Nitrogen and Phosphorus

The average concentration of nitrogen (DIN: nitrate + nitrite + ammonium) in Gulf offshore surface waters ranges from 0.005 mg/L in SE shelf waters to 0.026 mg/L in the NW shelf waters (Figure 3-11). Water-quality assessment thresholds for nitrogen have not been established for ocean waters; however, using NCCA thresholds for estuaries for comparison, 100% of the GOM shelf survey area would be rated good for surface-water nitrogen and none of the area would be rated poor. Bottom water levels of nitrogen tend to be higher, exceeding surface water concentrations by roughly a factor of two. By comparison, surface levels of nitrogen in the offshore Gulf waters are about 1.8–8 times lower than those measured in offshore shelf waters in the South Atlantic Bight (Cooksey et al., 2010) and the Mid Atlantic Bight (Balthis et al., 2009).

Average phosphorus (DIP: orthophosphate) concentrations in surface waters vary between 0.002 mg/L and 0.004 mg/L (see Figure 3-11). As with nitrogen, there are no available water-quality assessment thresholds for rating phosphorus in coastal-ocean waters. However, using NCCA estuarine thresholds for comparison, more than 90% of the survey area would be rated good (SE Shelf = 91%, NE Shelf = 98%, NW Shelf = 94%), and the remaining area would be rated fair. As a further comparison, phosphorus concentrations in offshore surface waters of the South Atlantic Bight (Cooksey et al., 2010) and Mid Atlantic Bight (Balthis et al., 2009) are an order of magnitude higher.

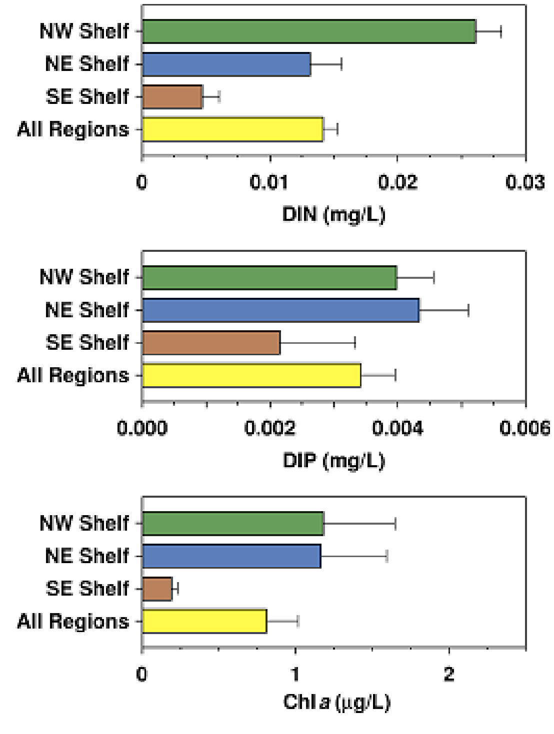


Figure 3-11. Mean concentrations of nitrogen, phosphorus, and chlorophyll *a* in Gulf surface waters (NOAA).

Additionally, nitrogen/phosphorus ratios were calculated as an indicator of which nutrient may be controlling primary production. A ratio above 16 indicates that phosphorus is the limiting nutrient, whereas a ratio below 16 is indicative of nitrogen limitation (Geider and La Roche, 2002). Average nitrogen-to-phosphorus ratios for offshore surface waters range from 2.3–7.3, with calculated ratios at all stations throughout the three survey areas indicating a nitrogen-limited environment (i.e., there is proportionally less nitrogen than phosphorus).

Chlorophyll a

Concentrations of chlorophyll *a* in surface waters of the SE Shelf, NE Shelf, and NW Shelf average 0.19, 1.16, and 1.19 µg/L, respectively (Figure 3-11). As with nutrients, there are no available water-quality assessment thresholds for rating chlorophyll *a* in coastal-ocean waters. Overall, 97% of the combined survey area has chlorophyll *a* concentrations below the NCCA threshold of 5 µg/L, which indicates good water quality for estuaries. The average concentration Gulf-wide (0.8 µg/L) is about 2–4 times higher than the concentrations observed in the offshore waters of the South Atlantic Bight and Mid Atlantic Bight.

Dissolved Oxygen

Near-bottom concentrations of dissolved oxygen in offshore waters average 5.6 mg/L overall, with 83% of the study area having dissolved oxygen in the good range (> 5 mg/L), 12% in the fair range (2-5 mg/L), and 5% in the hypoxic range (< 2 mg/L), which is considered poor based on NCCA thresholds for bottom water dissolved oxygen in estuaries. The highest proportion of low dissolved oxygen is observed in the NW Shelf (Figure 3-12) in an area off the Louisiana coast known for experiencing annual hypoxia from spring to early fall. For the NW Shelf region, 15% of the area is rated poor, 15% fair, and 70% good. In NE Shelf waters, 2% of the area is rated poor, 22% fair, and 76% good. Dissolved oxygen in the hypoxic to intermediate range in the NE Shelf is concentrated mostly in an area slightly east of the Mississippi River delta, in the vicinity of Chandeleur Sound and the Mississippi Bight, where there is also a documented record of seasonal hypoxic events. Low dissolved oxygen is not a problem in SE Shelf waters, where 99% of the area is rated good and the remaining 1% fair.

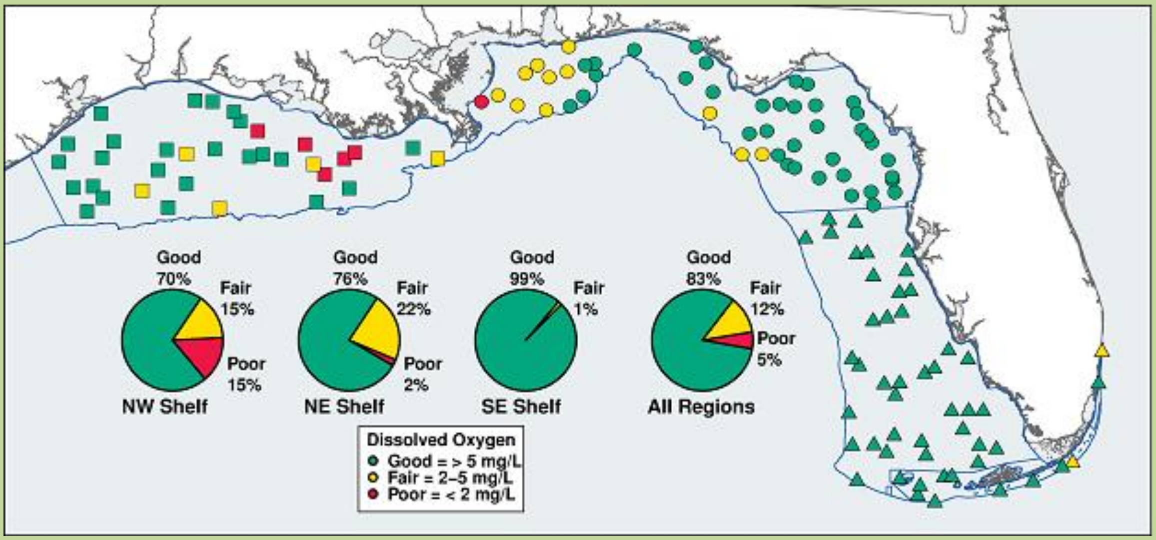


Figure 3-12. Dissolved oxygen data from the Gulf.
Note: Pie charts compare dissolved oxygen levels among regions using NCCA thresholds for rating categories.

Sediment Quality

Sediment Contaminants

Shelf sediments of the Gulf appear to be relatively uncontaminated. Based on the two NCCA sediment chemistry measures, 99% of the offshore Gulf survey area is rated good for the sediment contaminant indicator and 1% fair (Figure 3-13). None of these offshore sampling sites have individual chemical contaminants in sediments above their respective sediment quality guidelines.

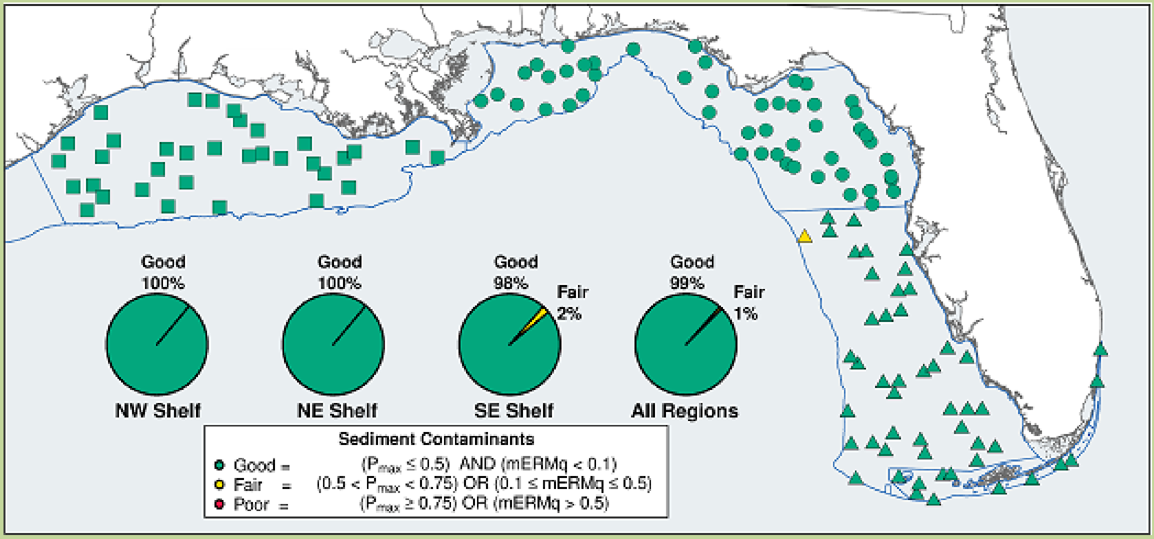


Figure 3-13. Sediment contaminant data from the Gulf.
Note: Pie charts compare contaminant levels among regions using NCCA thresholds for rating categories.

Benthic Condition

Benthic community characteristics (richness, density, and diversity) vary notably between the eastern and western regions of the Gulf (Figure 3-14). The NE Shelf and SE Shelf are similar to one another, but benthic community characteristics are all lower for the NW Shelf. Polychaete worms are the dominant taxa, both by percent abundance and percent taxa, followed by crustaceans.

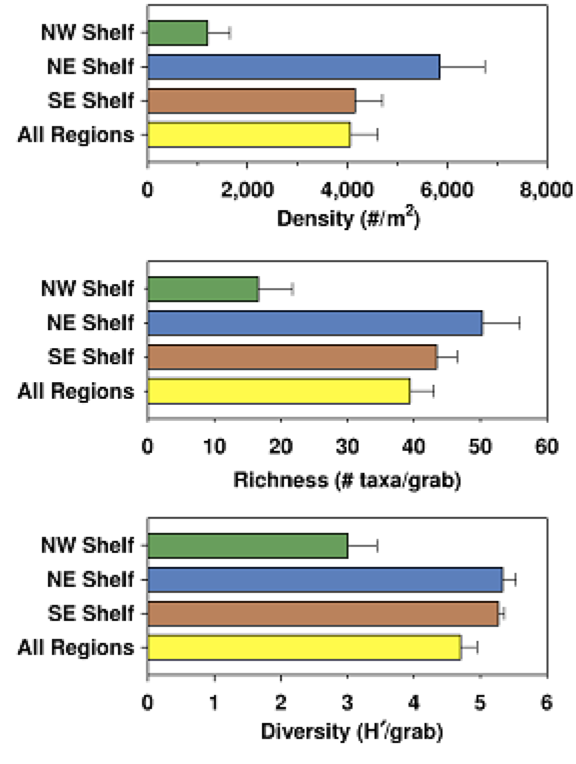


Figure 3-14. Species density, richness, and diversity data from the Gulf.

Although related benthic condition indices have been developed for Gulf estuaries and near coastal waters, there is currently no such index available for coastal-ocean (shelf) applications. Therefore, potential stressor impacts in these offshore waters were assessed by looking for co-occurrences of reduced values of key biological attributes and indicators of poor sediment or water quality, similar to the approach used for assessing offshore condition in the NCCR IV. Low, moderate, and high values of benthic attributes were defined as the lower 10th, 10th-to-50th, and upper 50th percentiles of observed values, respectively. Evidence of poor sediment quality was defined using the following metrics and thresholds: probability of sediment toxicity (P_{max}) ≥ 0.75, or mean ERM quotient (Long et al., 1995) > 0.5, or total organic carbon > 5%. Evidence of poor water quality was defined as dissolved oxygen in near-bottom water < 2.0 mg/L. Areal percentages of non-degraded, intermediate/indeterminate, and degraded biological condition were estimated using the combination of thresholds defined in Figure 3-15. Using this approach, 84% of the Gulf offshore ocean survey area is rated non-degraded, 2% is degraded, and 14% is intermediate/indeterminate (Figure 3-15

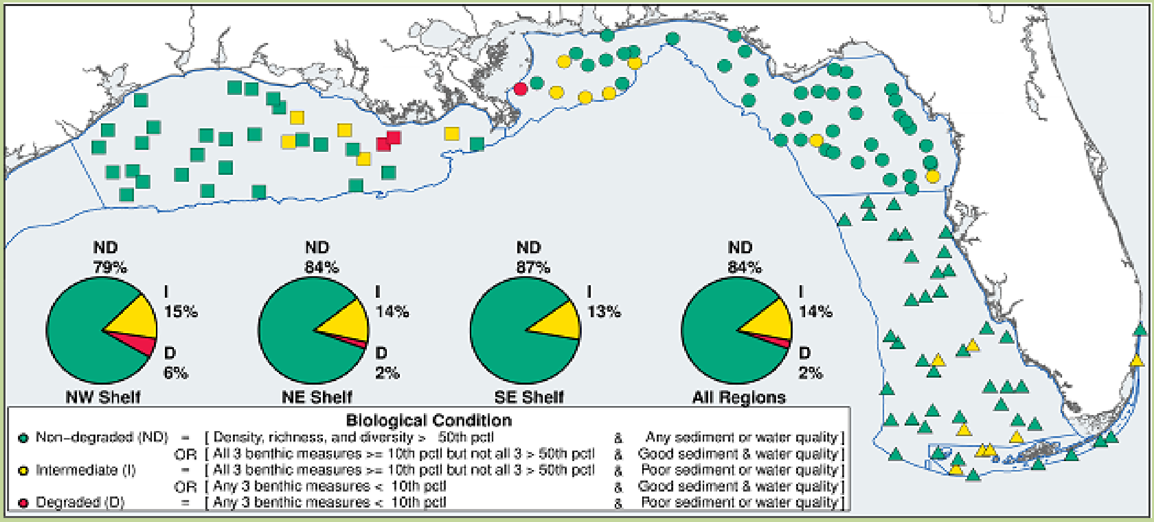


Figure 3-15. Estimated percent area of non-degraded, intermediate/indeterminate, and degraded benthic condition based on various combinations of key biological attributes and synoptically measured indicators of sediment and water quality.

Fish Tissue Contaminants

Analysis of chemical contaminants (metals, pesticides, PAHs, PCBs) in fish tissues was performed on homogenized fillets (including skin) from 146 samples of 21 fish species. Contaminant concentrations were compared to EPA's risk-based human-health advisory values for recreational fishers using the same approach applied in the NCCR IV. Of the 74 stations where fish were caught, 24.3% are rated poor, 32.4% are rated fair, and 43.3% are rated good based on non-cancer health endpoints. The most prevalent contaminant region-wide is methylmercury, which is found above advisory guidelines in 67 of the 146 fish measured. Only two other contaminants are found in excess of guidelines: PCBs in one fish from the NW Shelf and one fish from the SE Shelf, and inorganic arsenic in one fish from the SE Shelf. This approach is different from the NCCA ecological assessment of fish tissue contaminants presented elsewhere in this report that focuses on potential harm to predatory fish and wildlife.

Summary

These NOAA Gulf survey results suggest that the majority of these offshore shelf waters (an estimated 84% overall) are in good condition based on present sampling, with the notable exception of impacts coinciding with the well-documented hypoxic "dead zone" in the Mississippi River delta area. In an effort to be consistent with the underlying concepts and protocols of earlier programs, the indicators used in these offshore assessments include measures of stressors (e.g., chemical contaminants and symptoms of eutrophication), which are often associated with adverse biological impacts in shallower estuarine and inland ecosystems. However, there may be other sources of human-induced stress in these coastal-ocean systems, particularly those causing physical disruption of the seafloor (e.g., commercial bottom trawling, oil pipeline and platform placements, and minerals extraction) that may pose risks to living resources and that have not been captured adequately here.

CHAPTER 4.

REGIONAL COASTAL CONDITION

This chapter presents results for the four indices and their component indicators for each of five geographic regions of the United States: the Northeast Coast, the Southeast Coast, the Gulf Coast, the West Coast, and the Great Lakes. Figures 4-1 through 4-4 show summary results for each of the overall indices for all geographic regions. This illustrates the geographic variability in coastal conditions across the nation.

This chapter has a separate section for each coastal region. Each section includes a brief discussion of the geographic setting that defines the region, in order to help illustrate the variety of conditions and stressors affecting the nation's diverse coastal resources. Results should not be extrapolated to an individual state or waterbody within a geographic region (e.g., Tampa Bay) because the NCCA 2010 was not intended or designed to characterize conditions at these finer scales. This chapter also includes highlights on the 2010 oil spill in the Gulf of Mexico; on a condition assessment conducted by the state of Alaska in the Chukchi Sea, off Alaska's northwest coast; and on a study of cyanobacteria in the nearshore waters of the Great Lakes.

Filtering and preserving a sample aboard the EPA Ocean Survey Vessel *Bold*. (Photo courtesy of Eric Vance)

Biological Quality

Nationally, 56% of coastal waters are in good condition for the benthic index used to measure biological quality. In estuarine regions, the proportion rated good varies from 61% to 77% (Figure 4-1). Findings are less clear in the Great Lakes, where data are classified as missing for half the nearshore waters due to the absence of suitable substrate or appropriate test organisms. Chapter 2 and the *NCCA 2010 Technical Report* provide more detail on the benthic indices applied to each biogeographic region.

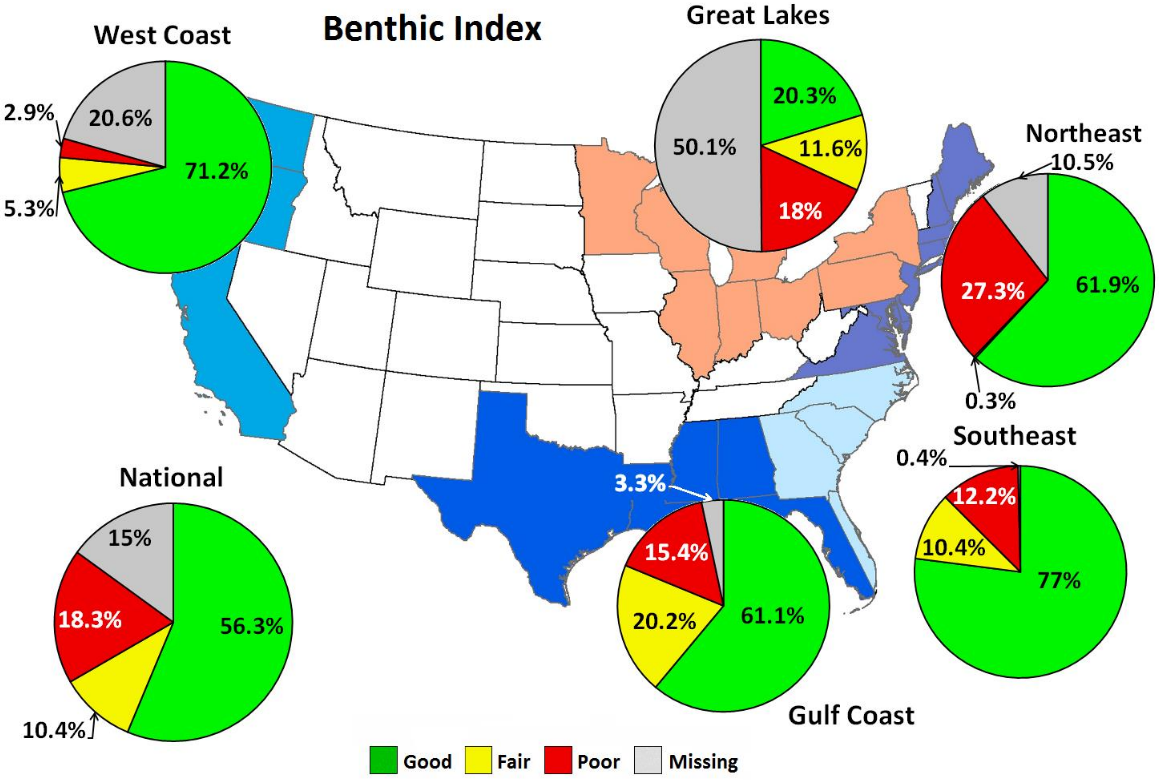


Figure 4-1. Biological quality of the nation's coastal waters, by region, based on the benthic index (NCCA 2010).

Water Quality

Findings for the water quality index (which includes dissolved oxygen, water clarity, chlorophyll a, and nutrients) show a wide range of results among the regions (Figure 4-2). Nationally, 36% of coastal waters are in good condition for the water quality index. The proportion of waters in good condition for water quality ranges from only 16% in the Gulf Coast to 60% or more in the Great Lakes and the West Coast. Large proportions of waters—half or more—are rated fair in the Gulf, Southeast, and Northeast coasts.

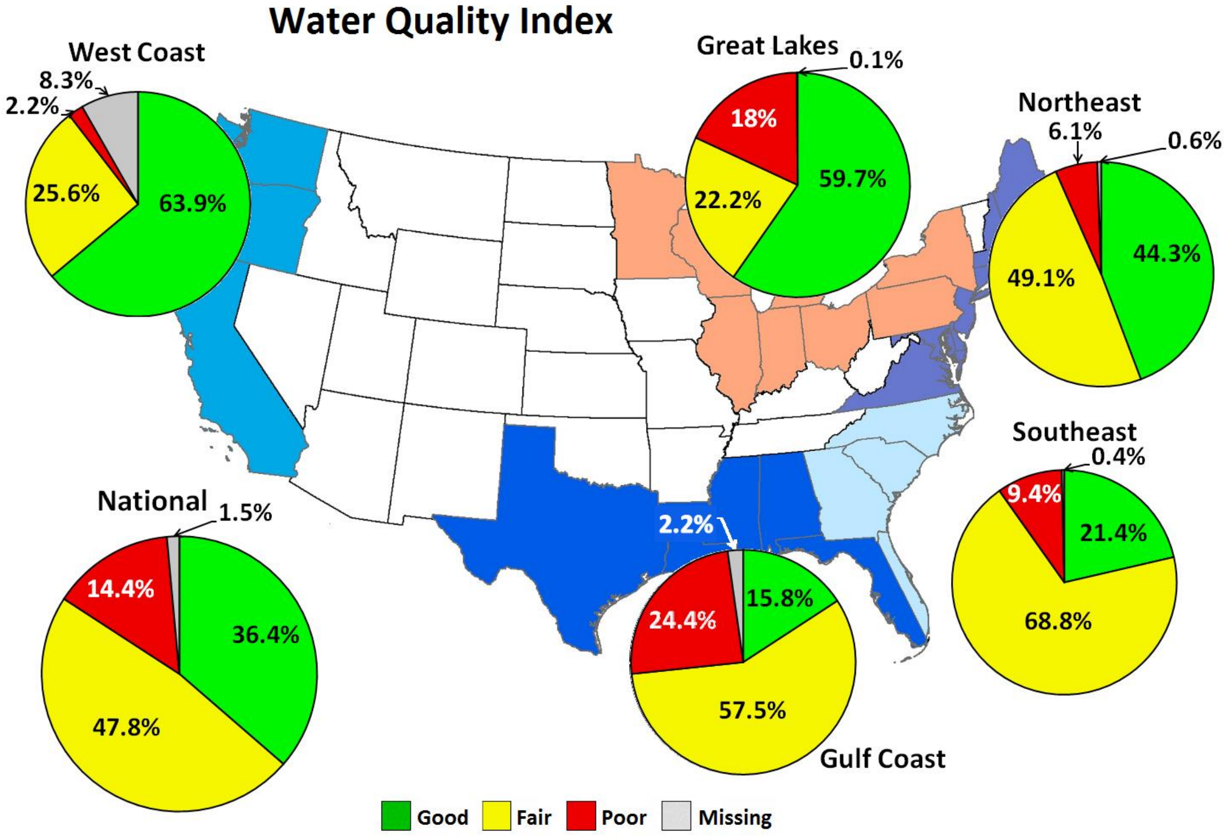


Figure 4-2. Quality of the nation's coastal waters, by region, based on the water quality index (NCCA 2010).

Sediment Quality

Findings for the sediment quality index (which includes indicators of sediment contaminants and sediment toxicity) show that over half the waters are rated good in four of the five regions (Figure 4-3). In the Gulf Coast and the West Coast, approximately one quarter of coastal waters are rated poor for sediment quality. One fifth of the waters in the West Coast and about one quarter of waters in the Great Lakes have no data for sediment quality. Data are missing due to a combination of reasons, ranging from laboratory analytical concerns to field conditions that make sediment sampling difficult.

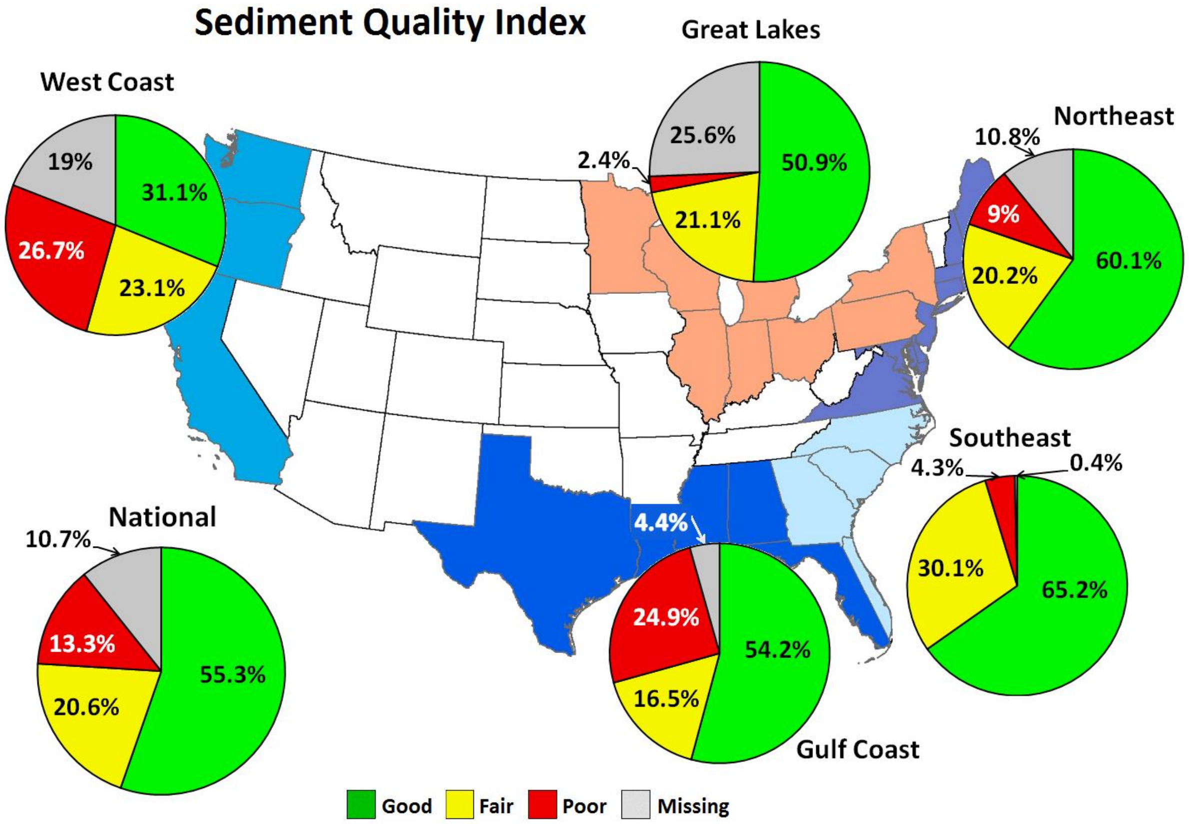


Figure 4-3. Sediment quality for the nation's coastal waters, by region, based on the sediment quality index (NCCA 2010).

Ecological Fish Tissue Quality

Nationally, 49% of coastal waters are in poor condition based on the ecological fish tissue contaminant index. Regional findings for this index illustrate the widespread nature of contamination—primarily by selenium and mercury —in fish nationwide. The proportion of waters rated poor for the ecological fish tissue contaminant index ranges from 33% in the Northeast to 69% in the Gulf Coast (Figure 4-4). Very few waters are rated good. In the West Coast, Northeast Coast, and Great Lakes, data are missing for a large percentage of waters because target fish were not caught. Coastal waters are rated here based on ecological risk-based thresholds, not human health thresholds.

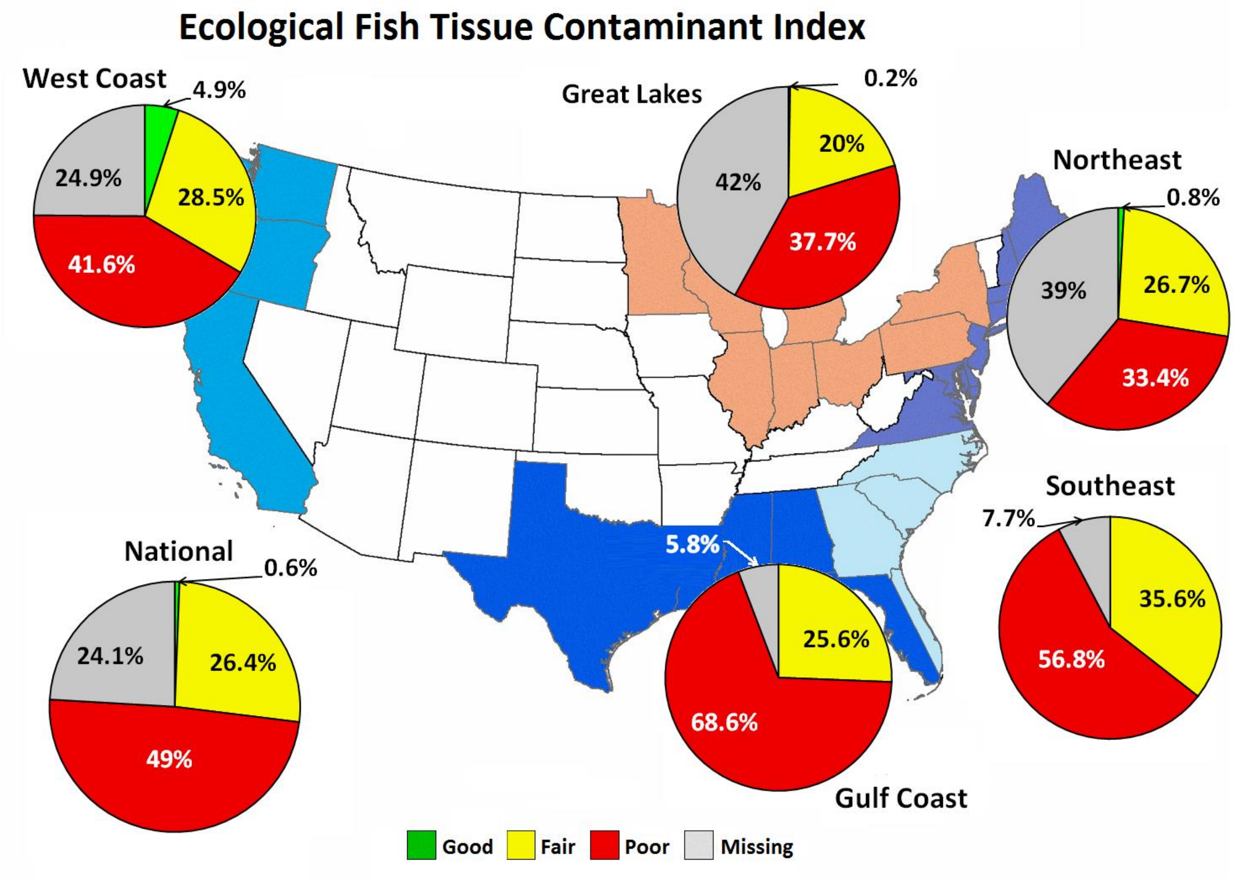


Figure 4-4. Ecological fish tissue quality for the nation’s coastal waters, by region, based on the ecological fish tissue contaminant index (NCCA 2010). The index reflects the risk of contaminant exposure to fish and wildlife through fish consumption.

The Northeast Coast

Setting

The Northeast Coast refers to the coastal waters of Maine through Virginia, including the Chesapeake Bay. A wide variety of coastal environments are found in the region, including rocky coasts, drowned river valleys, estuaries, salt marshes, and city harbors, accounting for a total of approximately 10,700 square miles. This coastline is divided into two biogeographical provinces. The Acadian Province—lying north of Cape Cod, Massachusetts—features smaller watersheds, rocky coasts, and open, well-flushed estuaries. Population density is concentrated in a few urban areas along the coast, and modern-era industrialization is light. In contrast, the Virginian Province—Cape Cod to the Chesapeake Bay—consists of larger watersheds that are drained by riverine systems such as the Hudson, Delaware, and Susquehanna rivers that empty into relatively shallow and poorly flushed estuaries. The estuaries of the Virginian Province are very vulnerable to the pressures of a highly populated and industrialized coastal region.

Coastal activities account for an important share of the Northeast's economy. Commercial and recreational fishing are key industries, particularly in the Chesapeake Bay and on Georges Bank off the New England coast. Crop and livestock production are major components of the mid-Atlantic coastal economy, but they can also be sources of negative environmental impacts associated with the runoff of nutrients, pesticides, and eroded soil. The coastal estuaries provide indispensable habitat for juvenile fish, shellfish, and wintering waterfowl, and they function as buffers against coastal storms and sea level rise.

The Northeast Coast region is the most populous coastal region in the United States. In 2010, the region was home to 54.2 million people, representing about a third of the nation's total coastal population. The population in this area has increased by ten million residents since 1970, a rise of about 23%.

Summary of NCCA 2010 Findings

A total of 238 NCCA sites were sampled to assess approximately 10,700 square miles of Northeast Coast waters. The assessment findings are shown in Figure 4-5.

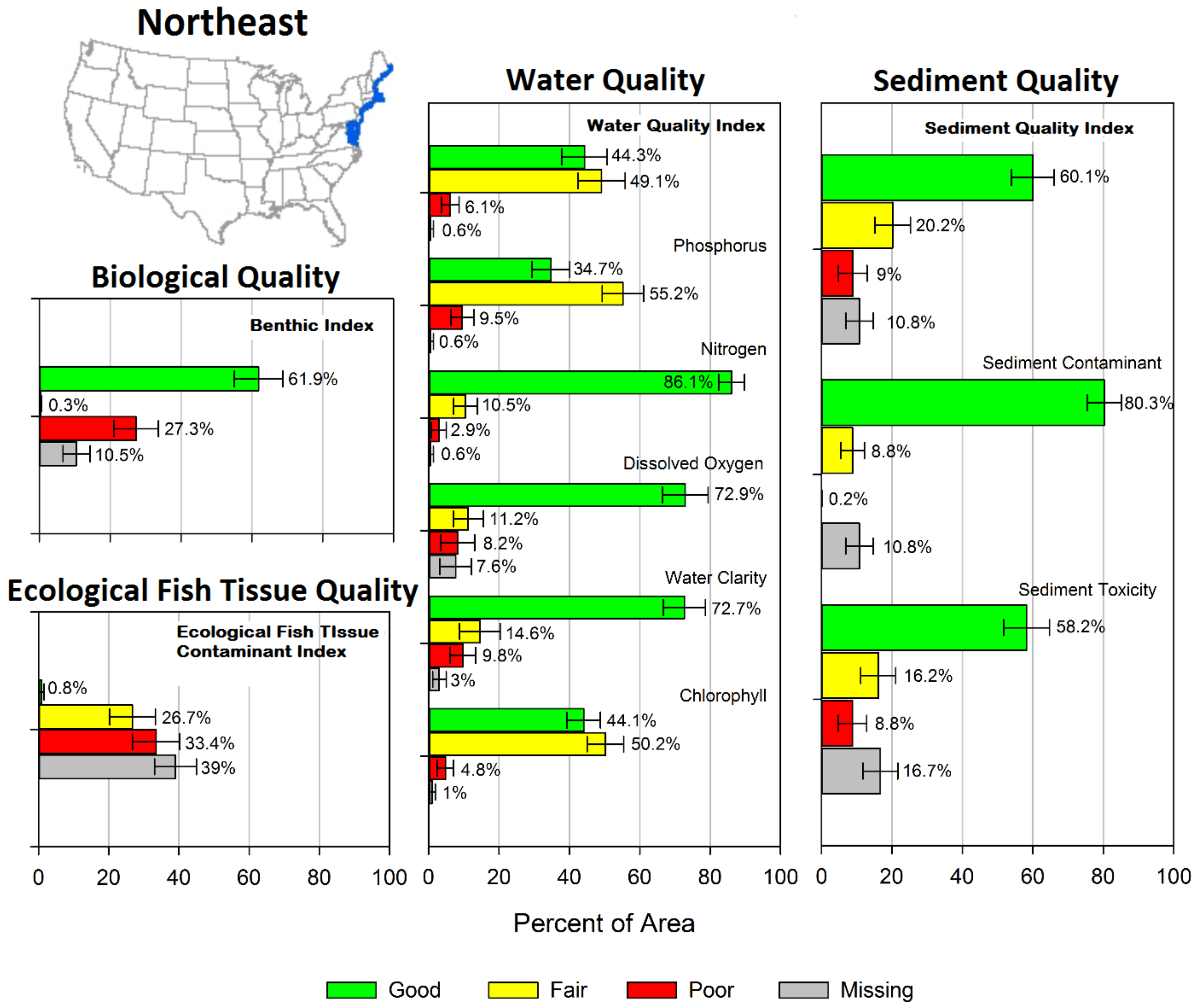


Figure 4-5. NCCA findings for the Northeast Coast. Bars show the percentage of coastal area within a condition class for a given indicator. Error bars represent 95% confidence levels. Note: The sum of percent of area for each indicator may not add up to 100% due to rounding.

Biological Quality

Biological quality is rated good in 62% of the Northeast Coast region based on the benthic index. Poor biological conditions occur in 27% of the coastal area. About 11% of the region reported missing results, due primarily to difficulties in collecting benthic samples along the rocky Acadian coast.

Water Quality

Based on the water quality index, 44% of the Northeast Coast is in good condition, 49% is rated fair, and 6% is rated poor. Fair ratings for phosphorus and chlorophyll *a* contribute most to the fair water quality index scores for this region. The ratings of the component indicators are included below:

- Phosphorus is found at low levels (rated good) in 35% of waters in the Northeast Coast, at moderate levels (rated fair) in 55%, and at high levels (rated poor) in 10%.
- Nitrogen is found at low levels (rated good) in 86% of waters, at moderate levels (rated fair) in 11% of waters, and at high levels(rated poor) in 3% of Northeast Coast waters.
- For dissolved oxygen (DO) 73% of waters have high levels (rated good), 11% have moderate levels (rated fair), and 8% have low levels (rated poor).
- Water clarity is rated good in 73% of waters in this region, fair in 15%, and poor in 10%.
- Chlorophyll *a* is found at low levels (rated good) in 44% of coastal area, at moderate levels (rated fair) in 50%, and at high levels (rated poor) in 5%.

Sediment Quality

Based on the sediment quality index, in the Northeast Coast 60% of coastal area is in good condition, 20% is in fair condition, and 9% is in poor condition. Missing results were reported in 11% of the region, primarily along the rocky Acadian coast where sediments could not be collected. For sediment contaminants, 80% of Northeast Coast sediments are in good condition, 9% are in fair condition, and less than 1% are in poor condition. Results are missing in 11% of the Northeast Coast region. Sediment toxicity tests indicate that 58% of coastal sediments are rated in good condition, 16% are in fair condition, and 9% are in poor condition. Sediment toxicity results are missing for 17% of coastal sediments in the area.

Ecological Fish Tissue Quality

Compared to ecological risk-based thresholds for fish tissue contamination, less than 1% of the Northeast Coast is rated as good, 27% is rated fair, and 33% is rated poor. Researchers were unable to evaluate fish tissue for 39% of the region, including almost the entire Acadian Province, because target species were not caught for analysis. The distribution of good, fair, and poor conditions is not known in the unassessed areas. The contaminants that most often exceed the LOAEL (or poor) thresholds in the assessed areas of the Northeast Coast are selenium, mercury, arsenic, and, in a small proportion of the area, total PCBs.

Change in Northeast Coastal Condition

Change in Water Quality

For the overall water quality index and two of its component indicators—dissolved oxygen and water clarity—the Northeast Coast shows consistent increases over time in the amount of area ranked in good condition. For chlorophyll a, nitrogen, and phosphorus, results are mixed over the three time periods, though statistically significant increases in the percent area rated good are evident in almost all indicators from 1999–2001 to 2005–2006 (Figure 4-6 and Table 4-1).

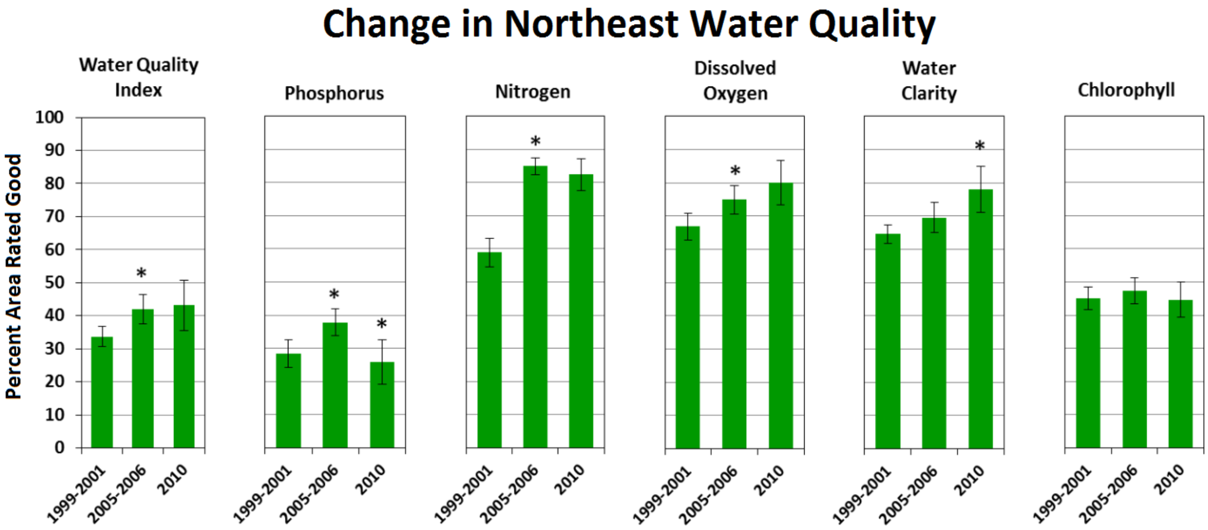


Figure 4-6. Comparison of the percent area rated good for water quality indicators over three periods in the Northeast Coast. Note: Asterisks indicate statistically significant change between periods.

Acadia National Park, Maine. (Photo courtesy of Hugh Sullivan)

Table 4-1. Change in condition status for water quality indicators in the Northeast Coast.

Indicator	Status	% Area 1999–2001	% Area 2005–2006	% Area 2010	Change in % Area	
					1999–2001 to 2005–2006	2005–2006 to 2010
Water Quality Index	Good	34	42	43	+8.2*	+1.2
	Fair	36	46	50	+10.3*	+4.2
	Poor	10	7	6	-2.8*	-0.9
	Missing	20	5	< 1	-15.7*	-4.5*
Phosphorus	Good	28	38	26	+9.5*	-11.9*
	Fair	40	46	62	+6.0*	+15.5*
	Poor	9	10	12	+1.0	+1.9
	Missing	22	6	< 1	-16.5*	-5.4*
Nitrogen	Good	59	85	82	+26.0*	-2.5
	Fair	11	7	13	-4.2*	+6.2*
	Poor	9	3	4	-5.9*	+1.7
	Missing	22	6	< 1	-15.9*	-5.4*
Dissolved Oxygen	Good	67	75	80	+8.0*	+5.2
	Fair	12	17	14	+5.3*	-2.9
	Poor	1	3	2	+1.5	-1.2
	Missing	20	5	4	-14.9*	-1.1
Water Clarity	Good	65	69	78	+4.9	+8.4*
	Fair	5	13	10	+7.4*	-2.1
	Poor	12	13	9	+1.5	-4.6
	Missing	18	5	3	-13.9*	-1.7
Chlorophyll	Good	45	47	45	+2.3	-2.
	Fair	27	37	51	+10.3*	+13.5*
	Poor	6	5	4	-1.0	-1.2
	Missing	22	10	1	-11.6*	-9.6*

Note: The sum of percent area for each indicator may not add up to 100% due to rounding. Asterisks indicate statistically significant change between periods.

Change in Sediment and Biological Quality

The sediment quality index and benthic index display improvement from 1999–2001 to 2005–2006, as indicated by large, statistically significant increases in the percentage area rated good. From 2005–2006 to 2010, the percent area rated good declined for sediment quality and showed no significant change for the benthic index. The overall sediment quality index is most strongly influenced by the sediment toxicity indicator (Figure 4-7 and Table 4-2).

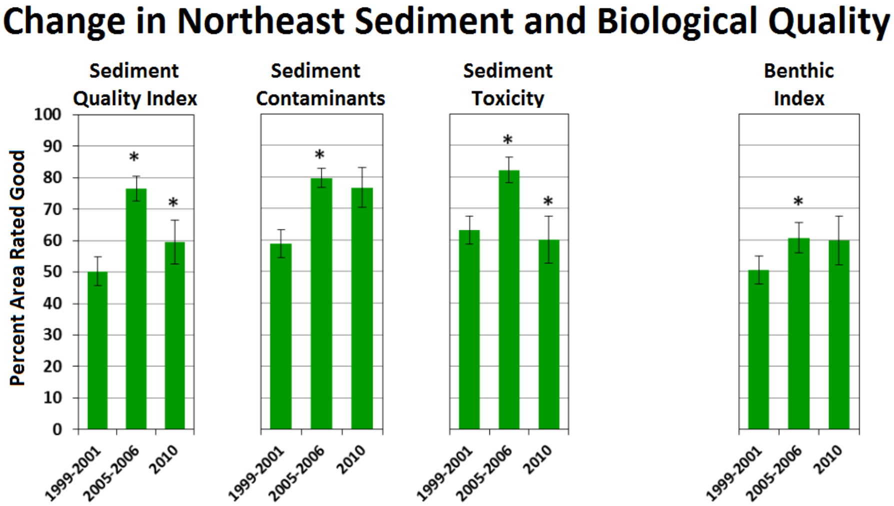


Figure 4-7. Comparison of the percent area rated good for sediment and biological quality over three periods in the Northeast Coast. Note: Asterisks indicate statistically significant change between periods.

Table 4-2. Change in condition status for sediment and biological quality in the Northeast Coast.

Indicator	Status	% Area 1999–2001	% Area 2005–2006	% Area 2010	Change in % Area	
					1999–2001 to 2005–2006	2005–2006 to 2010
Sediment Quality Index	Good	50	76	60	+26.2*	-16.9*
	Fair	16	12	22	-3.9	+9.6*
	Poor	10	6	7	-4.0*	+0.9
	Missing	24	5	12	-18.3*	+6.4*
Sediment Contaminants	Good	59	80	77	+20.8*	-3.1
	Fair	14	11	12	-3.3	+0.6
	Poor	3	< 1	< 1	-2.2*	-0.2
	Missing	24	9	12	-15.2*	+2.8
Sediment Toxicity	Good	63	82	60	+19.1*	-22.1*
	Fair	5	2	16	-2.5	+13.8*
	Poor	7	6	7	-1.8	+1.1
	Missing	25	10	17	-14.8*	+7.2*
Benthic Index	Good	51	61	60	+10.1*	-0.8
	Fair	1	< 1	1	-0.9	+1.1
	Poor	22	21	30	-0.7	+9.1*
	Missing	26	18	9	-8.5*	-9.4*

Note: The sum of percent area for each indicator may not add up to 100% due to rounding. Asterisks indicate statistically significant change between periods.

The Southeast Coast

Setting

The Southeast Coast stretches from the Virginia–North Carolina border south to Biscayne Bay, Florida. Southeast coastal waters are located within two biogeographical provinces: the Carolinian Province and the West Indian Province. The Carolinian Province extends from the Virginia–North Carolina border to the Indian River Lagoon in Florida. It reflects a warm, temperate climate similar to the northern Gulf. The West Indian Province reaches from the Port St. Lucie Inlet to Biscayne Bay, Florida, and represents a more subtropical environment.

Southeast estuarine resources are diverse and extensive, covering an estimated 4,500 square miles. They feature a variety of habitats, including salt marshes, tidal rivers, coastal lagoons, and open-water embayments and sounds. As one of the largest estuary systems in the United States, the Albemarle–Pamlico estuary is a prominent feature in the southeastern coastline. The scenic waters of the Indian River Lagoon stretch along 40% of the length of Florida's east coast.

The Southeast Coast provides a wealth of economic and ecosystem services that sustain local economies and quality of life. These services include storm-surge and sea-level protection, maritime transportation and trade, commercial and recreational fisheries, and tourism. In 2010, over 15 million people called this area home. Between 1970 and 2010, the population in the southeastern coastal counties increased by 127%, the greatest percent increase among the coastal regions.

Summary of NCCA 2010 Findings

Eighty-seven sites were sampled to characterize the condition of waters in the Southeast Coast region. The assessment findings are shown in Figure 4-8.

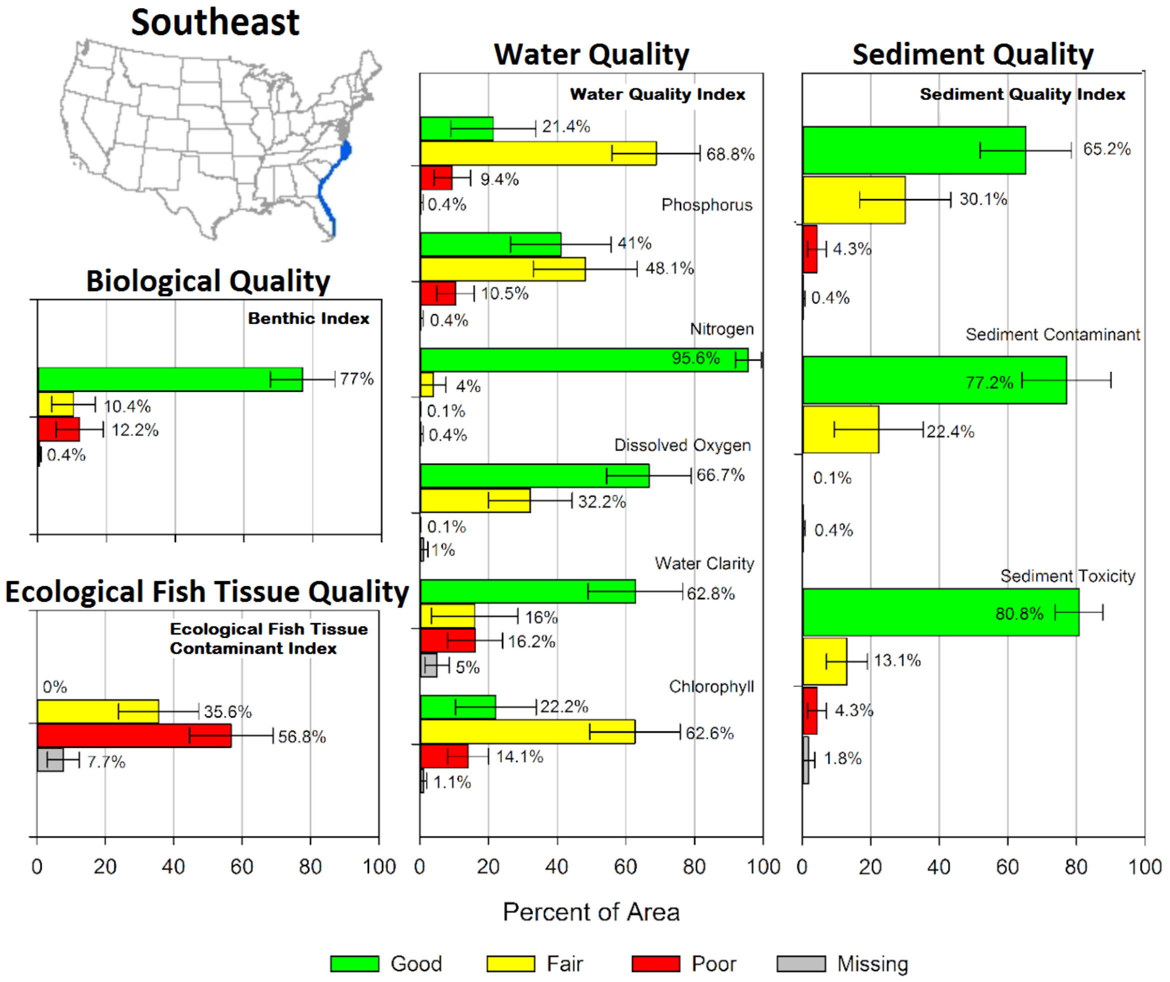


Figure 4-8. NCCA 2010 survey results for the Southeast Coast. Bars show the percent of coastal area within a condition category for specific indicators. Error bars represent 95% confidence intervals. Note: The sum of percent of area for each indicator may not add up to 100% due to rounding.

Biological Quality

Biological quality is rated good in 77% of waters in the Southeast Coast region, based on the benthic index. Fair biological conditions occur in 10% of the coastal area, while 12% of the area is rated poor.

Water Quality

In the Southeast, 21% of the coastal area is in good condition based on the water quality index, 69% is in fair condition, and 9% is in poor condition. Ratings for chlorophyll *a* and phosphorus contribute most to the region’s fair and poor water quality scores. The ratings of the component indicators are included below:

- Phosphorus is found at low levels (rated good) in 41% of waters, moderate levels (rated fair) in 48%, and high levels (rated poor) in 11%.

- Nitrogen is found at low levels (rated good) in 96% of Southeast Coast waters, moderate levels (rated fair) in 4%, and high levels (rated poor) in less than 1%.

- DO is found at high levels (rated good) in 67% of waters, moderate levels (rated fair) in 32%, and low levels (rated poor) in less than 1%.

- Water clarity is rated good in 63% of waters, fair in 16%, and poor in 16%. Water clarity data are missing for 5% of waters.

- Chlorophyll *a* is found at low levels (rated good) in 22% of coastal area, at moderate levels (rated fair) in 63%, and at high levels (rated poor) in 14%.

Sediment Quality

Based on the sediment quality index, 65% of the Southeast Coast region is rated good for sediment conditions, 30% is rated fair, and 4% is rated poor. Sediment contaminant analyses indicate that 77% of the area is in good condition, 22% is in fair condition, and less than 1% is in poor condition for contaminants. Sediment toxicity findings indicate that 81%, 13%, and 4% of Southeast coastal waters are in good, fair, and poor conditions, respectively.

Ecological Fish Tissue Quality

Based on the ecological fish tissue contaminant index, 57% of the coastal area in the Southeast is rated poor and 36% is rated fair. None of the area is rated good. The contaminants that most often exceed the LOAEL (or poor) thresholds are selenium, mercury, arsenic, and (in rare instances) total DDTs.

Change in Southeast Coastal Condition

Change in Water Quality

Between 1999–2001 and 2005–2006, the area rated good based on the water quality index declines significantly by 27% in the Southeast Coast (Figure 4-9 and Table 4-3). Dissolved oxygen and water clarity seem to be primary drivers for this decrease in quality. Between 2005–2006 and 2010, there is a modest increase in the percent area rated good based on the water quality index. A significant rise in the percent area rated good for dissolved oxygen and water clarity conditions and a small but significant change in nitrogen conditions contribute to the improvement in 2010.

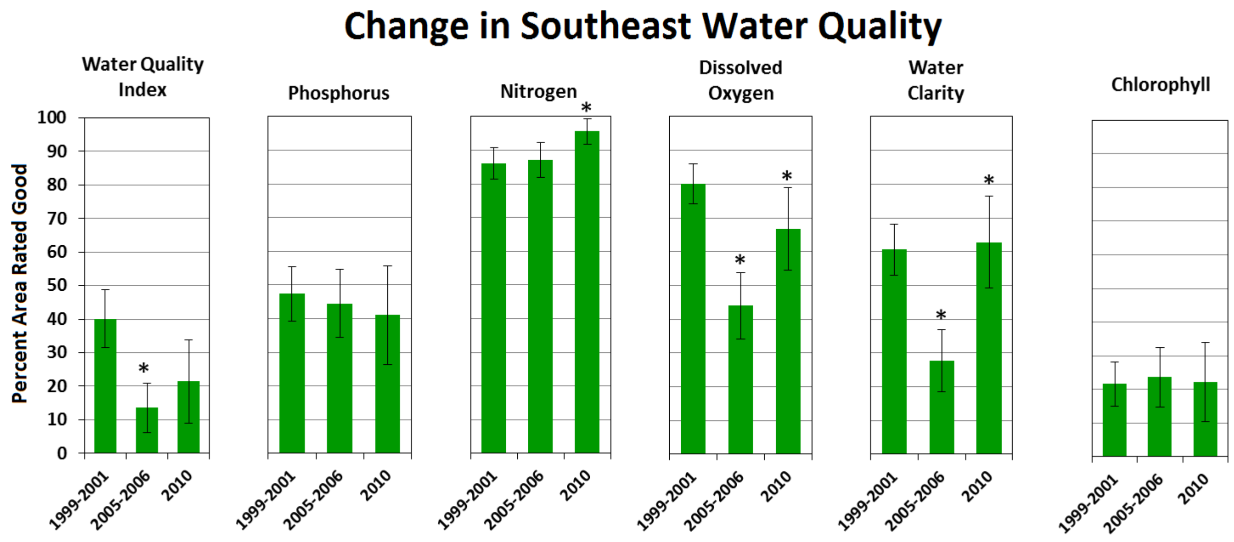


Figure 4-9. Comparison of the percent area rated good for water quality indicators over three periods in the Southeast Coast. Note: Asterisks indicate statistically significant change between periods.

Enjoying a sunny day on the water. (Photo courtesy of Eric Vance)

Table 4-3. Change in condition status for water quality indicators in the Southeast Coast.

Indicator	Status	% Area 1999–2001	% Area 2005–2006	% Area 2010	Change in % Area	
					1999–2001 to 2005–2006	2005–2006 to 2010
Water Quality Index	Good	40	14	21	-26.5*	+7.8
	Fair	48	68	69	+19.6*	+1.3
	Poor	12	18	9	+6.4	-8.9
	Missing	-	1	< 1	-	-0.2
Phosphorus	Good	47	45	41	-2.8	-3.5
	Fair	37	45	48	+7.8	+3.1
	Poor	15	10	10	-5.4*	+0.6
	Missing	< 1	1	< 1	+0.4	-0.2
Nitrogen	Good	86	87	96	+1.0	+8.5*
	Fair	13	9	4	-4.7	-4.8*
	Poor	< 1	< 1	< 1	+0.1	-0.3
	Missing	< 1	4	< 1	+3.7	-3.5
Dissolved Oxygen	Good	80	44	67	-36.1*	+22.7*
	Fair	16	37	32	+20.8*	-4.9
	Poor	4	18	< 1	+14.1*	-17.7*
	Missing	-	1	1	-	-0.2
Water Clarity	Good	61	28	63	-32.9*	+35.1*
	Fair	17	24	16	+6.6	-7.9
	Poor	20	40	16	+19.5*	-23.9*
	Missing	2	8	5	+6.8*	-3.3
Chlorophyll	Good	22	24	22	+2.1	-1.5
	Fair	65	66	63	+1.6	-3.5
	Poor	9	10	14	+0.6	+4.5
	Missing	5	1	1	-4.2*	+0.5

Note: The sum of percent area for each indicator may not add up to 100% due to rounding. Asterisks indicate statistically signficant change between periods.

Change in Sediment and Biological Quality

There is a significant decrease of 27% in the area rated good for sediment quality between 2005–2006 and 2010. The sediment contaminants indicator appears to be the driver for this change, while the sediment toxicity indicator shows an opposite result. For the benthic quality index, there is a large, statistically significant increase of 14% in waters rated good between 2005–2006 and 2010 (Figure 4-10 and Table 4-4). While these results might appear contradictory, the sediment and benthic indicators do not necessarily respond to stressors in the same manner. As additional data are collected and analyzed for the NCCA 2015, clearer patterns may emerge.

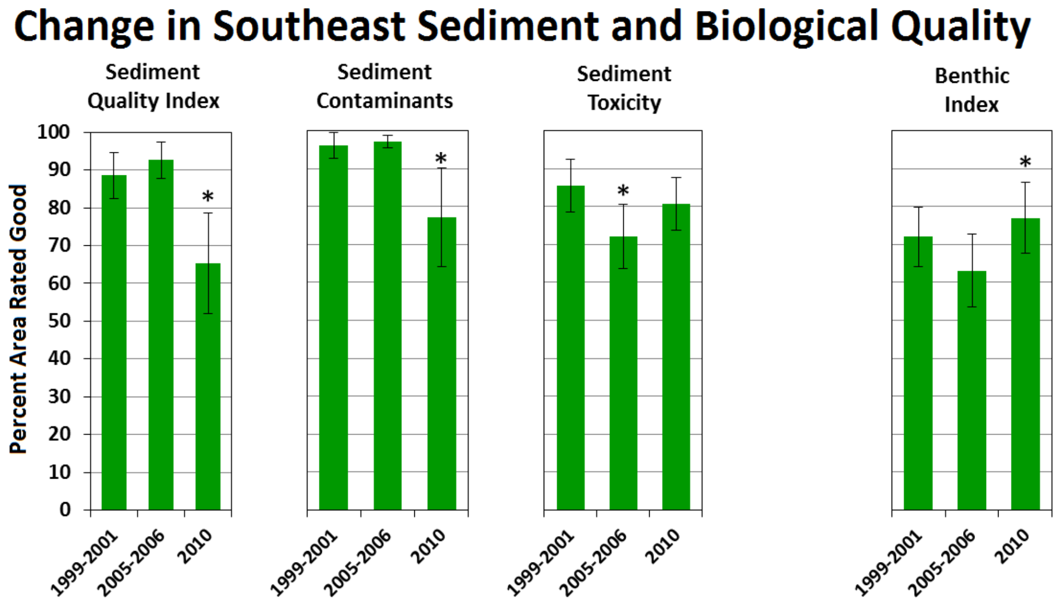


Figure 4-10. Comparison of the percent area rated good for sediment and biological quality over three periods in the Southeast. Note: Asterisks indicate statistically significant change between periods.

Table 4-4. Change in condition status for sediment quality and biological quality in the Southeast Coast.

Indicator	Status	% Area 1999–2001	% Area 2005–2006	% Area 2010	Change in % Area	
					1999–2001 to 2005–2006	2005–2006 to 2010
Sediment Quality Index	Good	89	93	65	+4.0	-27.3*
	Fair	9	2	30	-7.7*	+28.4*
	Poor	2	5	4	+2.4	-0.2
	Missing	-	1	< 1	-	-0.9
Sediment Contaminants	Good	96	97	77	+1.1	-20.0*
	Fair	4	1	22	-3.2	+21.7*
	Poor	-	-	< 1	-	-
	Missing	-	2	< 1	-	-1.8*
Sediment Toxicity	Good	86	72	81	-13.4*	+8.7
	Fair	5	1	13	-4.5	+12.1*
	Poor	2	5	4	+2.4	-0.2
	Missing	7	22	2	+15.5*	-20.6*
Benthic Index	Good	72	63	77	-8.9	+13.9*
	Fair	15	19	10	+3.7	-8.5
	Poor	11	17	12	+5.5	-4.5
	Missing	2	1	< 1	-0.3	-0.9

Note: The sum of percent area for each indicator may not add up to 100% due to rounding. Asterisks indicate statistically signficant change between periods.

The Gulf Coast

Setting

The Gulf of Mexico coastal region comprises more than 750 estuaries, bays, and sub-estuary systems associated with larger estuaries. The total area of these estuaries, bays, and sub-estuaries is 11,300 square miles. The waters of the Gulf Coast are located in two biogeographical provinces: the Louisianian Province and the West Indian Province. The Louisianian Province extends from the Texas–Mexico border east to Anclote Key, Florida, and is similar to warm-temperate latitudes on the southeastern U.S. Atlantic coast. The West Indian Province portion extends from Tampa Bay to Florida Bay in Florida and is more representative of subtropical latitudes.

Gulf Coast estuaries, bays, and wetlands provide critical feeding, spawning, and nursery habitat for a rich assemblage of fish and wildlife, including essential habitat for commercially and recreationally important fish, shrimp, and birds. The Gulf Coast is also home to a diverse array of unique coastal ecosystems, including hypersaline lagoons, coral reefs, and mangrove forests. More than half of the coastal wetlands in the conterminous United States occur along the Gulf Coast, providing a wide range of ecosystem services, such as fishery support, storm-surge and sea-level protection, water quality improvement, wildlife habitat provision, recreational opportunities, and carbon sequestration.

The waters of the Gulf Coast region are essential to building local economies, providing recreational experiences, and sustaining overall quality of life. In 2010, the Gulf Coast was home to approximately 21 million people, representing 13% of the U.S. population residing in coastal watershed counties and 37% of the total population in Gulf Coast states. Between 1970 and 2010, the population in coastal watershed counties more than doubled in the Gulf Coast region, growing from 10 million to 21 million people.

Summary of NCCA 2010 Findings

A total of 240 NCCA sites were sampled during the summer of 2010 to characterize the condition of waters in the Gulf Coast region. An overview of the findings is presented in Figure 4-11.

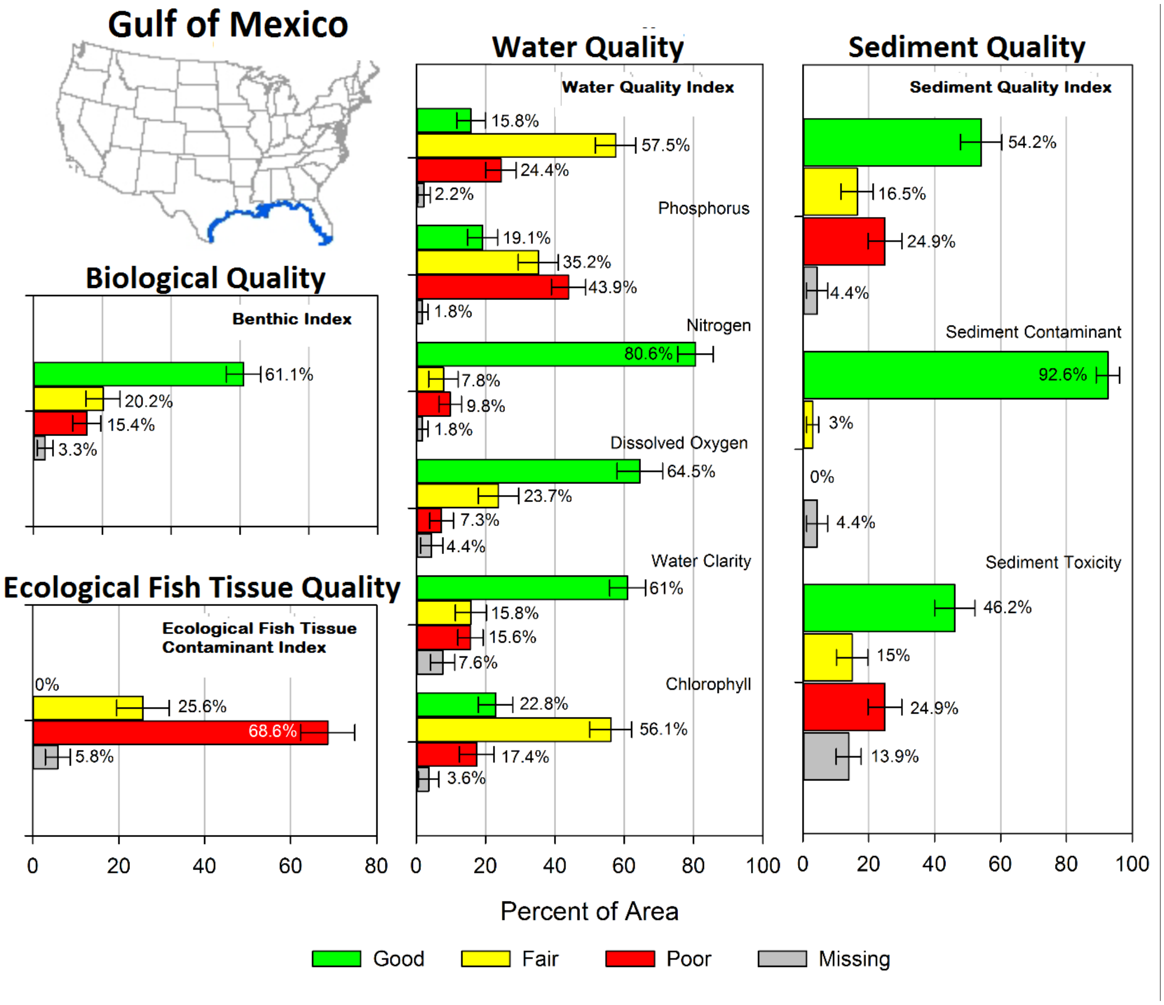


Figure 4-11. NCCA findings for the Gulf Coast. Bars show the percentage of coastal area within a condition class for a given indicator. Error bars represent 95% confidence levels. Note: The sum of percent of area for each indicator may not add up to 100% due to rounding.

Biological Quality

Biological quality is rated good in 61% of Gulf Coast waters, based on the benthic index. Fair biological quality occurs in 20% of these waters, and poor biological quality occurs in 15%.

Water Quality

Based on the water quality index, 16% of Gulf Coast waters are in good condition, 58% are rated fair, and 24% are rated poor. Phosphorus and chlorophyll *a* contribute most to the fair and poor water quality index scores in this region. The ratings of the component indicators are included below:

- Phosphorus is found at low levels (rated good) in 19%, at medium levels (rated fair) in 35%, and at high levels (rated poor) in 44% of Gulf Coast waters.

- Nitrogen is found at low levels (rated good) for 81%, moderate levels (rated fair) in 8%, and at high levels (rated poor) in 10%.
- DO is found at high levels (rated good) in 65%, moderate levels (rated fair) in 24%, and low levels (rated poor) in 7%.
- Water clarity is good in 61% of Gulf Coast waters, fair in 16%, and poor in 16%. Data are missing for 8%.
- Chlorophyll *a* is found at low levels (rated good) in 23% of coastal area, at moderate levels (rated fair) in 56%, and at high levels (rated poor) in 17%.

Sediment Quality

Based on the sediment quality index, 54% of Gulf Coast waters are in good condition, 17% are in fair condition, and 25% are in poor condition. For the Gulf Coast region, sediment contaminant analyses indicate that 93% of coastal waters are in good condition, 3% are in fair condition, and none are in poor condition. Sediment toxicity tests indicate that 46% of Gulf Coast waters are in good condition, 15% are in fair condition, and 25% are in poor condition. Sediment toxicity data are missing for 14% of Gulf Coast waters.

Ecological Fish Tissue Quality

Based on the ecological fish tissue contaminant index, 69% of the Gulf Coast area is in poor condition, 26% is in fair condition, and 0% is in good condition. Of the total area, 6% has not been assessed for fish tissue contaminants. The contaminants that most often exceed the LOAEL (poor) thresholds in the Gulf Coast are selenium, mercury, and arsenic.

Change in Gulf Coastal Condition

Change in Water Quality

The Gulf Coast shows statistically significant decreases in the percent area rated good for the water quality index across all three periods, from 1999–2001 to 2005–2006 (16%) and from 2005–2006 to 2010 (10%). Phosphorus, chlorophyll *a*, and (to a lesser extent) dissolved oxygen contribute most to this change. Other components of the water quality index show mixed change from one period to the next or change that is not statistically significant (Figure 4-12 and Table 4-5).

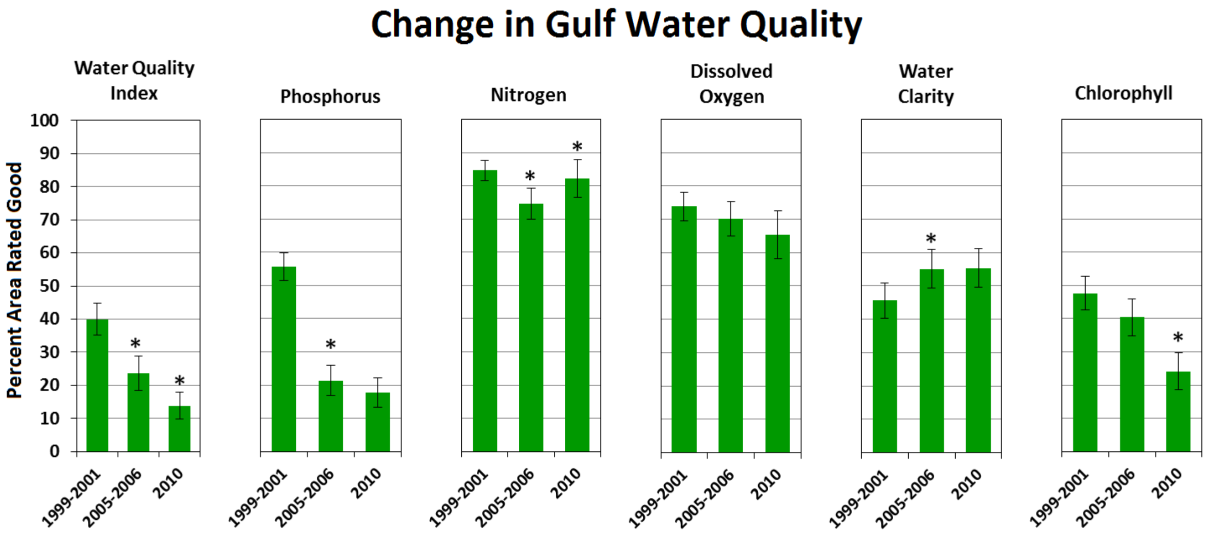


Figure 4-12. Comparison of the percent area rated good for Gulf Coast water quality indicators over three periods. Note: Asterisks indicate statistically significant change between periods.

The end of a sampling day in the Gulf of Mexico. (Photo courtesy of The Environmental Institute of Houston, University of Houston-Clear Lake)

Table 4-5. Change in condition status for water quality indicators in the Gulf Coast.

Indicator	Status	% Area 1999–2001	% Area 2005–2006	% Area 2010	Change in % Area	
					1999–2001 to 2005–2006	2005–2006 to 2010
Water Quality Index	Good	40	24	14	-16.3*	-9.9*
	Fair	48	55	62	+7.2	+7.0
	Poor	10	13	22	+3.4	+8.6*
	Missing	2	8	2	+5.7*	-5.8*
Phosphorus	Good	56	21	18	-34.3*	-3.5
	Fair	28	43	36	+15.4*	-7.1
	Poor	13	19	44	+5.9*	+25.4*
	Missing	3	16	2	+13.0*	-14.7*
Nitrogen	Good	85	75	82	-10.0*	+7.6*
	Fair	10	6	8	-3.8	+2.2
	Poor	2	1	8	-0.7	+6.5*
	Missing	3	18	2	+14.5*	-16.2*
Dissolved Oxygen	Good	74	70	65	-3.8	-4.7
	Fair	22	20	24	-1.8	+4.0
	Poor	2	5	6	+2.9	+0.9
	Missing	2	5	5	+2.7	-0.2
Water Clarity	Good	46	55	55	+9.4*	+0.4
	Fair	15	20	18	+4.8	-1.6
	Poor	21	17	18	-3.6	+0.7
	Missing	18	8	8	-10.6*	+0.5
Chlorophyll	Good	48	40	24	-7.2	-16.3*
	Fair	39	43	58	+4.2	+14.8*
	Poor	9	9	14	-0.1	+5.4
	Missing	5	8	4	+3.2	-3.9

Note: The sum of percent area for each indicator may not add up to 100% due to rounding. Asterisks indicate statistically signficant change between periods.

Change in Sediment and Biological Quality

The percent area rated good for the Gulf Coast sediment quality index decreases consistently over the three periods, with the 15% change from 2005–2006 to 2010 being statistically significant. This change is primarily due to sediment toxicity, which shows a 25% decline in area rated good during from 2005-2006 to 2010. For sediment contaminants, results show a different pattern of change (a consistent increase in the area rated good), although this change is statistically significant only between 1999–2001 and 2005–2006. Changes in the benthic index over time are variable, primarily due to the change in the percent area with missing data (Figure 4-13 and Table 4-6).

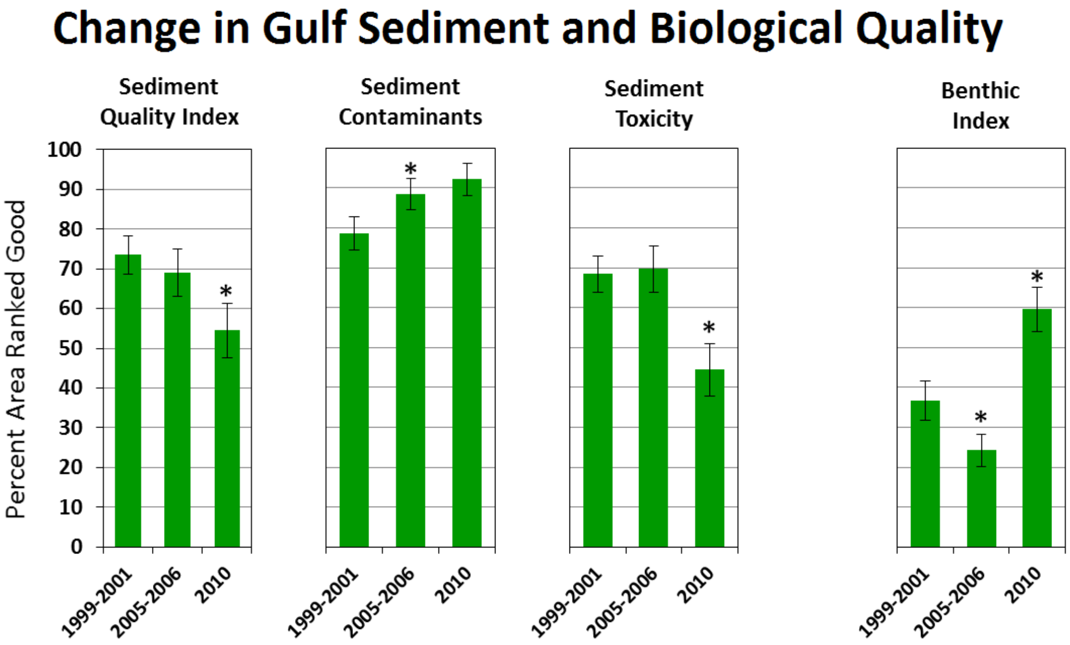


Figure 4-13. Comparison of the percent area rated good for Gulf Coast sediment quality and benthic indicators over three periods. Note: Asterisks indicate statistically significant change between periods.

Table 4-6. Change in condition status for sediment and biological quality in the Gulf Coast.

Indicator	Status	% Area 1999–2001	% Area 2005–2006	% Area 2010	Change in % Area	
					1999–2001 to 2005–2006	2005–2006 to 2010
Sediment Quality Index	Good	74	69	55	-4.5	-14.5*
	Fair	17	5	17	-11.7*	+11.3*
	Poor	2	15	24	+12.7*	+9.0*
	Missing	7	11	5	+3.5	-5.9*
Sediment Contaminants	Good	79	88	92	+9.9*	+3.7
	Fair	14	1	3	-12.8*	+2.2
	Poor	< 1	-	-	-	-
	Missing	7	11	5	+3.5	-5.9*
Sediment Toxicity	Good	68	70	44	+1.3	-25.3*
	Fair	7	5	15	-2.5	+10.7*
	Poor	2	15	24	+13.3*	+9.0*
	Missing	23	11	16	-12.1*	+5.6
Benthic Index	Good	37	24	60	-12.5*	+35.4*
	Fair	37	17	20	-17.7*	+3.5
	Poor	22	12	18	-9.3*	+5.1
	Missing	7	47	3	+39.5*	-44.0*

Note: The sum of percent area for each indicator may not add up to 100% due to rounding. Asterisks indicate statistically signficant change between periods.

HIGHLIGHT: The Gulf of Mexico Oil Spill

Sediment Findings from the NCCA 2010

Background

On April 20, 2010, the *Deepwater Horizon* (DWH) oil rig exploded in the Gulf. Eleven people lost their lives. The rig was on fire for 36 hours before it sank, and the well continued to leak for another 87 days, resulting in the largest marine oil spill in U.S. history. Millions of barrels of oil leaked into the Gulf before the well was sealed. The U.S. Coast Guard, NOAA, EPA, and other federal, state, and local agencies immediately responded and began remediation efforts in the open waters of the Gulf. However, oil, oil-related compounds, and oil-dispersant mixtures accumulated along hundreds of miles of coastline. Beaches, wetlands, bays, and estuaries from the Florida Panhandle to western Louisiana were fouled by these contaminants.

In addition to oil spill response efforts, EPA and state partners conducted routine sample collection in the Gulf during the summer of 2010 as part of the NCCA. (Not specifically designed to address oil spill issues, the NCCA collects water, sediment, benthic macroinvertebrates, and fish tissue samples to assess the condition of coasts in the conterminous United States.) Earlier iterations of the survey used comparable methods to collect samples from over 1,600 sites in the Gulf between 2000 and 2006. Sixty-five percent of those historical sites were within the boundaries of the area impacted by the DWH oil spill (from the Florida panhandle to western Louisiana). In 2010, 143 sites fell within the “impact area.” Comparable sampling methods and boundaries among survey years allow post-DWH spill conditions in 2010 to be compared to earlier, pre-DWH spill conditions.

Some of the analytes targeted by the NCCA in 2010 and by the NCA in earlier years were oil-related compounds. However, the NCCA 2010 analyses did not target all of the compounds necessary to confirm the presence or absence of either oil released from the DWH spill or of dispersants used in subsequent remediation efforts. For this report, EPA used the available historical data collected during earlier NCA surveys to represent baseline conditions pre-spill and compared them to conditions from 2010 data collected post-spill.

This highlight section presents an assessment of one aspect of ecological condition in the Gulf —sediment quality—based on analysis of the NCA baseline data collected in 1999–2001 and 2005–2006, compared to findings from the NCCA 2010. Findings are based on two sediment condition indicators: sediment toxicity and sediment contaminants (not on oil-related constituents alone). See Chapter 2, “Design of the NCCA 2010,” for more information on how the NCCA assesses sediment condition.

Comparison of NCCA 2010 data to earlier NCA findings shows that the percent area rated good for sediment toxicity declined in 2010 in U.S. coastal waters overall, while the area rated fair and poor increased over time (Figure 4-14). The Northeast, Gulf, and West coasts display this pattern of change.

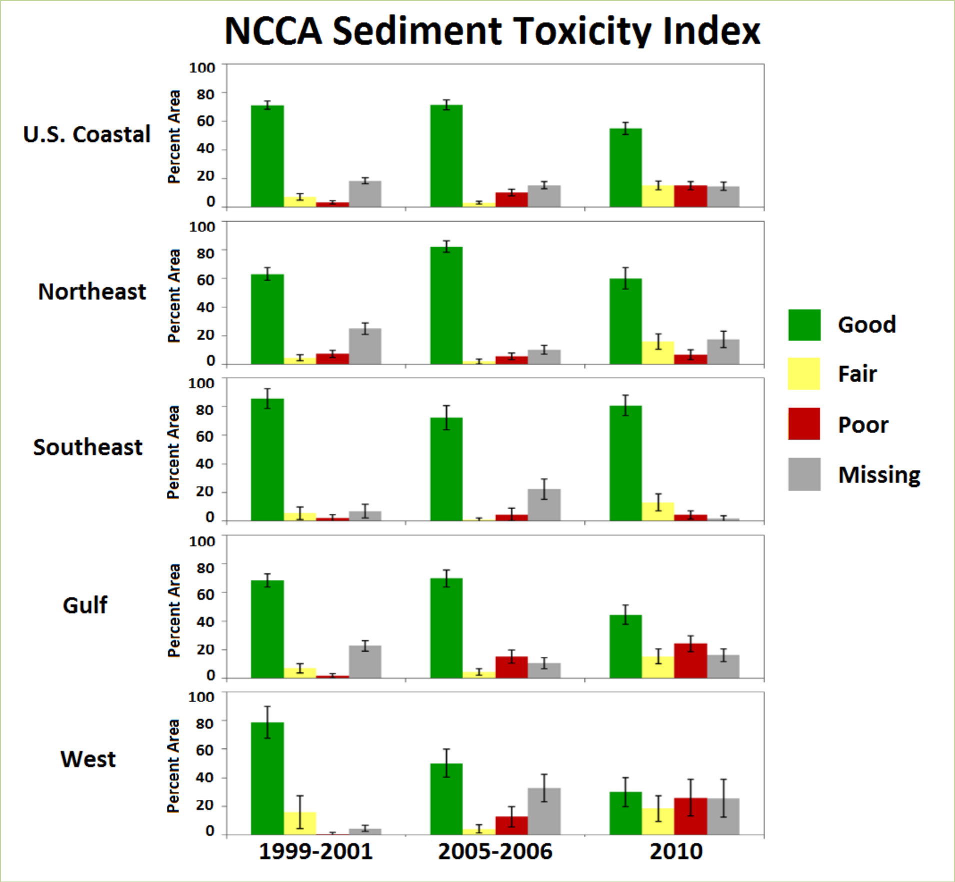
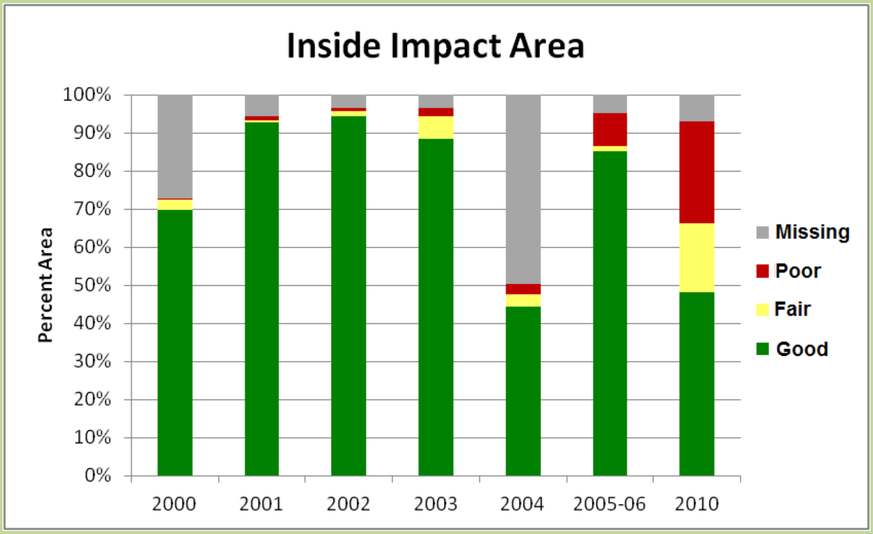


Figure 4-14. NCCA sediment toxicity results for the nation's coastal waters and for each coastal region. Gulf scores are for the entire Gulf of Mexico.

In the section of the Gulf impacted by the DWH oil spill, the area rated poor for sediment toxicity increased from approximately 8% in 2005-06 to about 27% in 2010. The increase in sediment toxicity inside the DWH impact area was consistently observed whether the NCCA sediment toxicity index was used or whether toxicity thresholds applied by the Operational Science Advisory Team (an advisory group of various agency representatives under the direction of the U.S. Coast Guard) were used. The increase in the area rated poor for sediment toxicity was more significant within the impact area than in other portions of the Gulf (Figure 4-15).

In contrast to sediment toxicity results, the sediment contaminants results for the area impacted by the DWH oil spill in 2010 did not indicate a corresponding increase in the percent area rated poor.



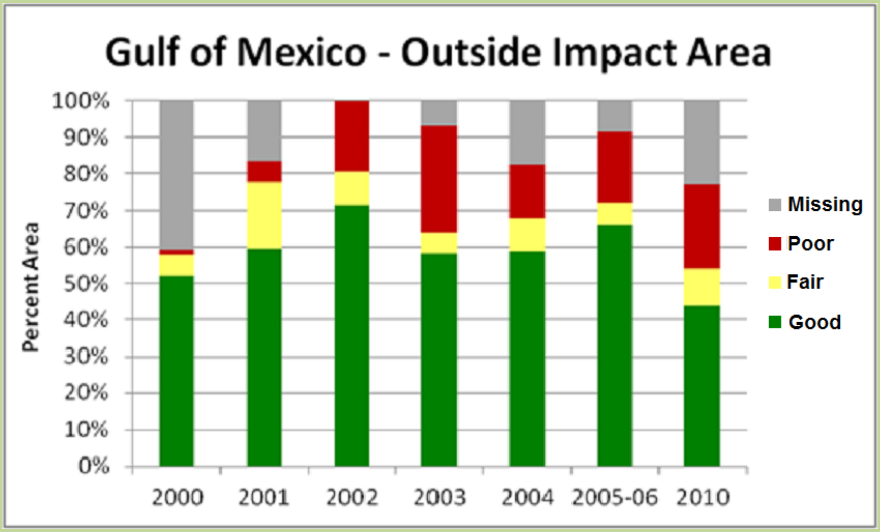


Figure 4-15. Sediment toxicity results for Gulf area inside and outside the DWH impact zone. Toxicity increased significantly inside the impact area between 2005–2006 and 2010.

Conclusion

Data show a significant increase in sediment toxicity in the DWH oil spill impact area from 2005-06 to 2010. This same pattern is seen nationally. Sediment contaminant data from the same area reveal no significant change. Because the NCCA sediment toxicity index reflects the cumulative, synergistic, and additive effects of all contaminants in sediment, it is not possible to establish a cause-effect relationship between the DWH oil spill and the increase in percent area rated poor for sediment toxicity. The suite of contaminants analyzed in each sediment sample does not include all of the constituents needed to confirm the presence or absence of oil released by the DWH spill or of dispersants used in subsequent remediation efforts.

The West Coast

Setting

The total area of the West Coast's 410 estuaries, bays, and sub-estuaries is 2,200 square miles. More than 60% of this area consists of three large estuarine systems—the San Francisco Estuary, Columbia River Estuary, and Puget Sound (including the Strait of Juan de Fuca). Sub-estuary systems associated with these large systems make up another 27% of the West Coast. The remaining West Coast waterbodies, combined, compose only 12% of the total coastal area of the region.

There are major transitions in the distribution of human population along the West Coast, with increased population density occurring in the Seattle–Tacoma area of Puget Sound, around San Francisco Bay, and around most of the coastal waters of southern California. In contrast, the section of coastline north of the San Francisco Bay through northern Puget Sound (excluding the Seattle–Tacoma area) has a much lower population density.

The majority of the population in the West Coast states of California, Oregon, and Washington lives in coastal counties. In 2010, the West Coast was home to approximately 40 million people, representing 19% of the U.S. population residing in coastal watershed counties and 63% of the total population in West Coast states. Between 1970 and 2010, the population in the coastal watershed counties of the West Coast region almost doubled, growing from 22 million to 39 million people.

Summary of NCCA 2010 Findings

A total of 134 NCCA sites were sampled to characterize the condition of West Coast waters. An overview of the findings is presented in Figure 4-16.

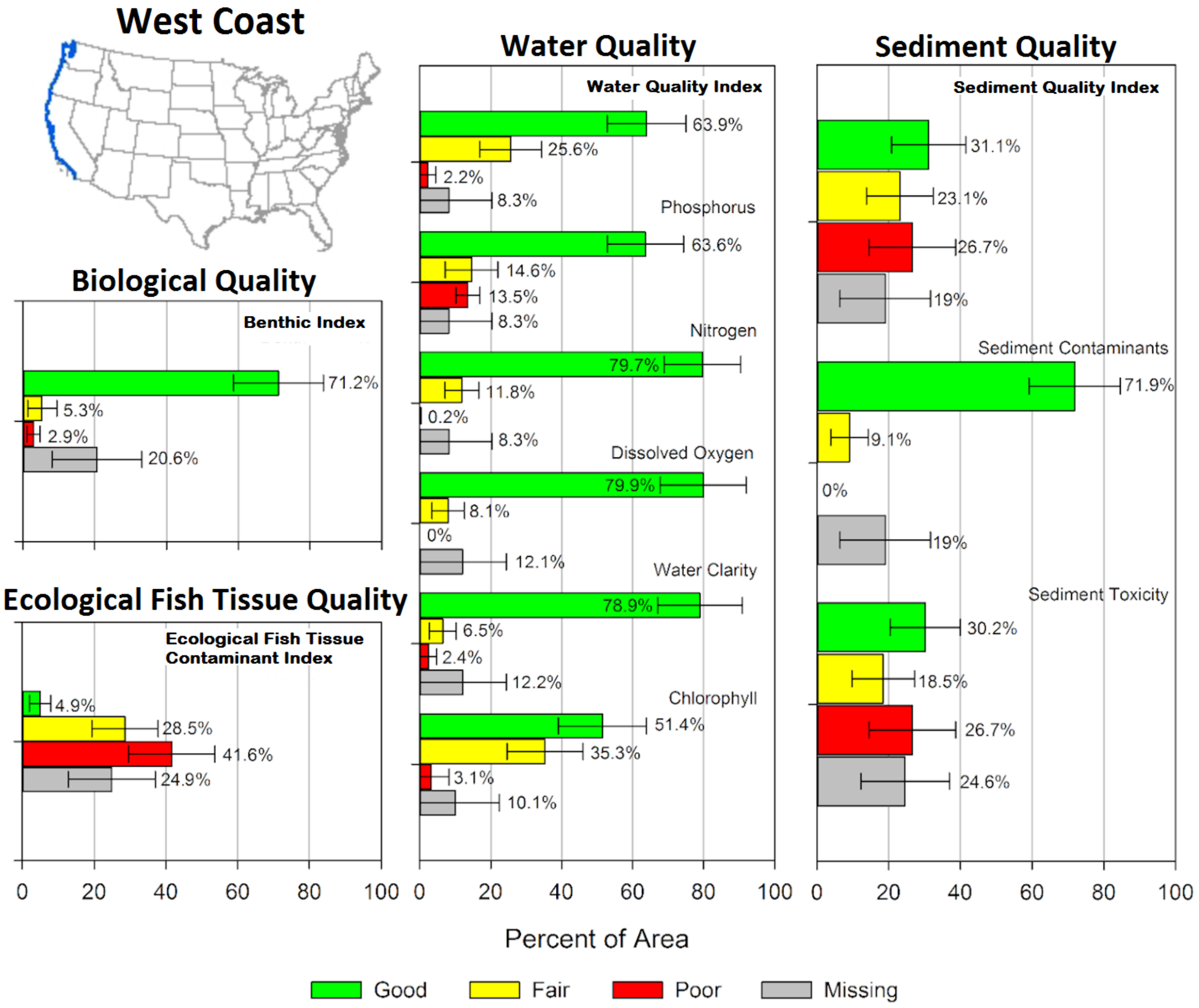


Figure 4-16. NCCA findings for the West Coast. Bars show the percentage of coastal area within a condition class for a given indicator. Error bars represent 95% confidence levels. Note: The sum of percent of area for each indicator may not add up to 100% due to rounding.

Biological Quality

Biological quality is rated good in 71% of West Coast waters, based on the benthic index. Fair biological quality occurs in 5% of these waters, and poor biological quality occurs in 3%. Biological data are missing or incomplete for an additional 21% of waters due to difficulty in obtaining successful sediment grab samples.

Water Quality

Based on the water quality index, 64% of waters in the West Coast region are in good condition, 26% are rated fair, and 2% are rated poor. Chlorophyll *a* and phosphorus contribute most to the fair and poor water quality index scores for this region. The ratings of the component indicators are included below:

- Phosphorus is found at low levels (rated good) in 64% of West Coast waters, at moderate levels (rated fair) in 15%, and at high levels (rated poor) in 14%. Phosphorus data are missing for 8% of waters.

- Nitrogen is found at low levels (rated good) in 80% of waters, at moderate levels (rated fair) in 12%, and at high levels (rated poor) in less than 1%. Nitrogen data are missing for 8% of West Coast waters.

- DO is at high levels (rated good) in 80% of waters and at moderate levels (rated fair) in 8%. Data are missing or incomplete for 12% of waters.

- Water clarity is rated good in 79% of waters, fair in 7%, and poor in 2%. Water clarity data are missing for 12% of waters in the West Coast region.

- Chlorophyll *a* is found at low levels (rated good) in 51% of West Coast area, at moderate levels (rated fair) in 35%, and at high levels (rated poor) in 3%. Data are missing or incomplete for 10% of waters.

Sediment Quality

In the waters of the West Coast, 31% of the area is in good condition, 23% is in fair condition, and 27% is in poor condition based on the sediment quality index. Sediment samples were not available for 19% of the region due to difficulty in obtaining successful sediment grab samples. For sediment contaminants, 72% of coastal waters are in good condition, 9% are in fair condition, and 0% are in poor condition. Data are missing or incomplete for 19% of waters in this region. For sediment toxicity, 30% of coastal waters are in good condition, 19% are in fair condition, and 27% are in poor condition. Sediment toxicity data are missing or incomplete for 25% of waters in the West Coast region.

Ecological Fish Tissue Quality

Based on the ecological fish tissue contaminant index, 42% of West Coast waters are in poor condition, 29% in fair condition, and 5% in good condition. Data are missing or incomplete for 25% of the West Coast area. The contaminants that most often exceed the LOAEL (poor) thresholds are selenium, mercury, arsenic, and, in a very small proportion of the area, hexachlorobenzene.

Change in West Coastal Condition

Change in Water Quality

The water quality index for the West Coast shows mixed changes, with a statistically significant decline (25%) in waters rated good from 1999–2001 to 2005–2006, followed by a smaller increase of 15% in waters rated good from 2005–2006 to 2010. Similar mixed findings are seen in phosphorus, nitrogen, and dissolved oxygen. Chlorophyll *a* is the only indicator that shows an opposite pattern, with the area rated good increasing significantly from 1999–2001 to 2005–2006 and declining from 2005–2006 to 2010. Water clarity is the only indicator with a consistent decline in area rated good for all periods, although the decline is not statistically significant from 2005–2006 to 2010 (Figure 4-17).

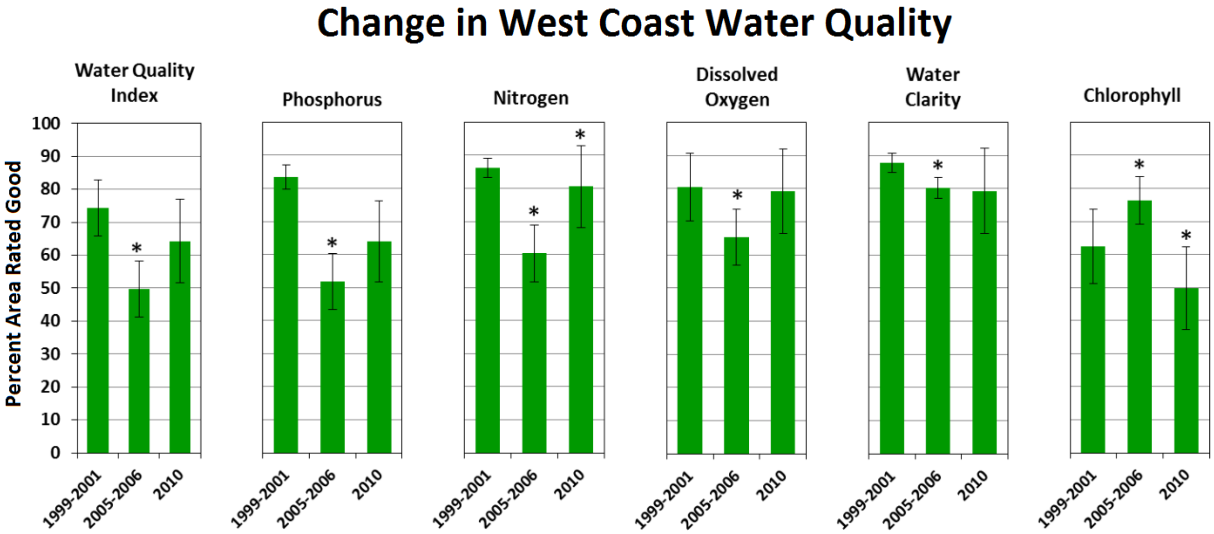
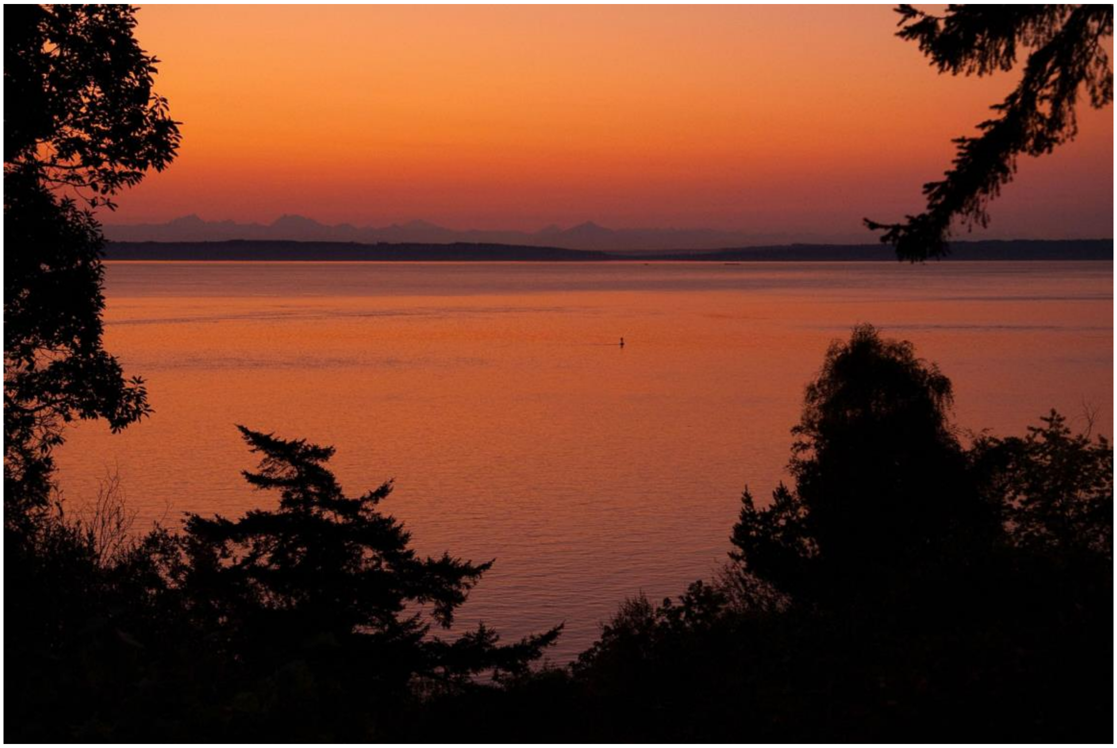


Figure 4-17. Comparison of the percent area rated good for West Coast water quality indicators over three periods. Note: Asterisks indicate statistically significant change between periods.



Admiralty Inlet, Port Townsend, Washington. (Photo courtesy of Eric Vance)

Table 4-7. Change in condition status for water quality indicators in the West Coast.

Indicator	Status	% Area 1999–2001	% Area 2005–2006	% Area 2010	Change in % Area	
					1999–2001 to 2005–2006	2005–2006 to 2010
Water Quality Index	Good	74	50	64	-24.7*	+14.6
	Fair	16	23	25	+7.4	+1.5
	Poor	8	5	2	-3.3	-2.8
	Missing	1	22	9	+20.6*	-13.3
Phosphorus	Good	83	52	64	-31.7*	+12.1
	Fair	5	2	14	-3.0*	+11.9*
	Poor	12	13	14	+1.9	+0.5
	Missing	< 1	33	9	+32.7*	-24.6*
Nitrogen	Good	86	60	81	-25.9*	+20.2*
	Fair	4	2	11	-1.9	+8.5*
	Poor	10	4	< 1	-5.4*	-4.1*
	Missing	-	33	9	-	-24.6*
Dissolved Oxygen	Good	80	65	79	-15.1*	+13.8
	Fair	19	21	8	+2.1	-12.6*
	Poor	1	1	-	-0.1	-
	Missing	< 1	13	13	+13.1*	-0.6*
Water Clarity	Good	88	80	79	-7.6*	-0.9
	Fair	1	1	6	+0.8	+4.4*
	Poor	3	< 1	2	-2.1*	+2.0
	Missing	9	18	12	+9.0*	-5.5
Chlorophyll	Good	62	76	50	+14.0*	-26.6*
	Fair	36	18	37	-18.0*	+18.4*
	Poor	< 1	2	3	+2.1	+1.0
	Missing	1	3	10	+1.9*	+7.3

Note: The sum of percent area for each indicator may not add up to 100% due to rounding. Asterisks indicate statistically signficant change between periods.

Change in Sediment and Biological Quality

The sediment quality index shows a statistically significant rise of 14% in area rated good from 1999–2001 to 2005–2006, and a much larger 49% decline in area rated good from 2005–2006 to 2010. Sediment contaminants exhibit a similar, though less marked, pattern, with a statistically significant (14%) rise in quality during the first period and a statistically significant decline of 28% in the second. On the other hand, the sediment toxicity index shows a consistent, statistically significant decline in area rated good of 29% from 1999-2001 to 2005-2006, and of 20% from 2005-2006 to 2010. The benthic index shows significant decline (15%) only from 2005–2006 to 2010 (Figure 4-18 and Table 4-8).

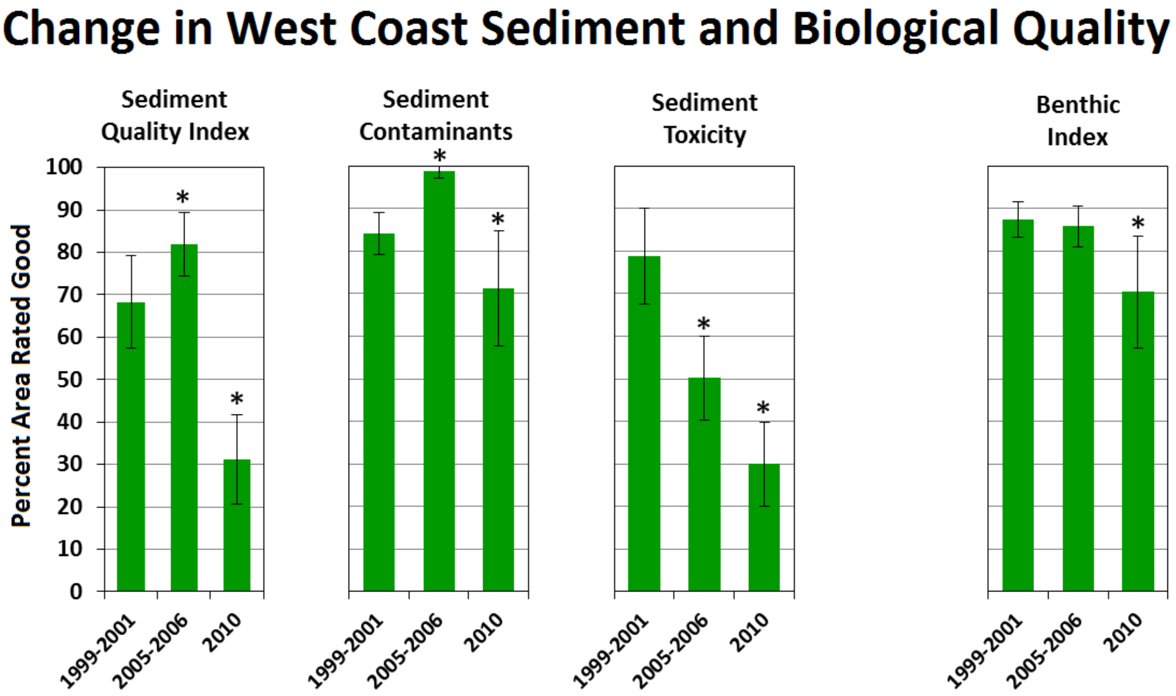


Figure 4-18. Comparison of the percent area rated good for West Coast sediment quality indicators over three periods. Note: Asterisks indicate statistically significant change between periods.

Table 4-8. Change in condition status for sediment and biological quality in the West Coast.

Indicator	Status	% Area 1999–2001	% Area 2005–2006	% Area 2010	Change in % Area	
					1999–2001 to 2005–2006	2005–2006 to 2010
Sediment Quality Index	Good	68	82	33	+13.6*	-49.0*
	Fair	30	5	21	-25.1*	+16.2*
	Poor	1	13	26	+11.3*	+13.2
	Missing	-	< 1	20	-	+19.6*
Sediment Contaminants	Good	84	99	70	+14.4*	-28.4*
	Fair	15	1	10	-13.8*	+8.7*
	Poor	1	< 1	< 1	-0.8	+0.1
	Missing	-	< 1	20	-	+19.6*
Sediment Toxicity	Good	79	50	30	-28.7*	-20.2*
	Fair	16	4	18	-11.8*	+14.3*
	Poor	1	13	26	+12.1*	+13.2
	Missing	5	33	26	+28.3*	-7.4
Benthic Index	Good	87	86	70	-1.8	-15.2*
	Fair	9	6	5	-2.6	-0.6
	Poor	4	6	3	+2.7	-3.4
	Missing	< 1	2	21	+1.7*	+19.2*

Note: The sum of percent area for each indicator may not add up to 100% due to rounding. Asterisks indicate statistically signficant change between periods.

HIGHLIGHT: Monitoring in Alaska’s Northeastern Chukchi Sea, 2010–2012

The Alaska Department of Environmental Conservation (DEC) and the University of Alaska established the Alaska Monitoring and Assessment Program (AKMAP) in 2004. This program focuses on conducting surveys of Alaska’s waters. One of the most recent AKMAP surveys was in the Chukchi Sea, off the northeastern coast of Alaska in the Arctic Ocean.

With funding from the Coastal Impact Assistance Program, AKMAP and NOAA’s National Status and Trends Program conducted the Northeastern Chukchi Sea Survey from 2010 to 2012. This survey focused on the nearshore environment from Point Lay to Barrow, in water depths of 10–50 meters. It was conducted during open-water time periods, typically August or September.

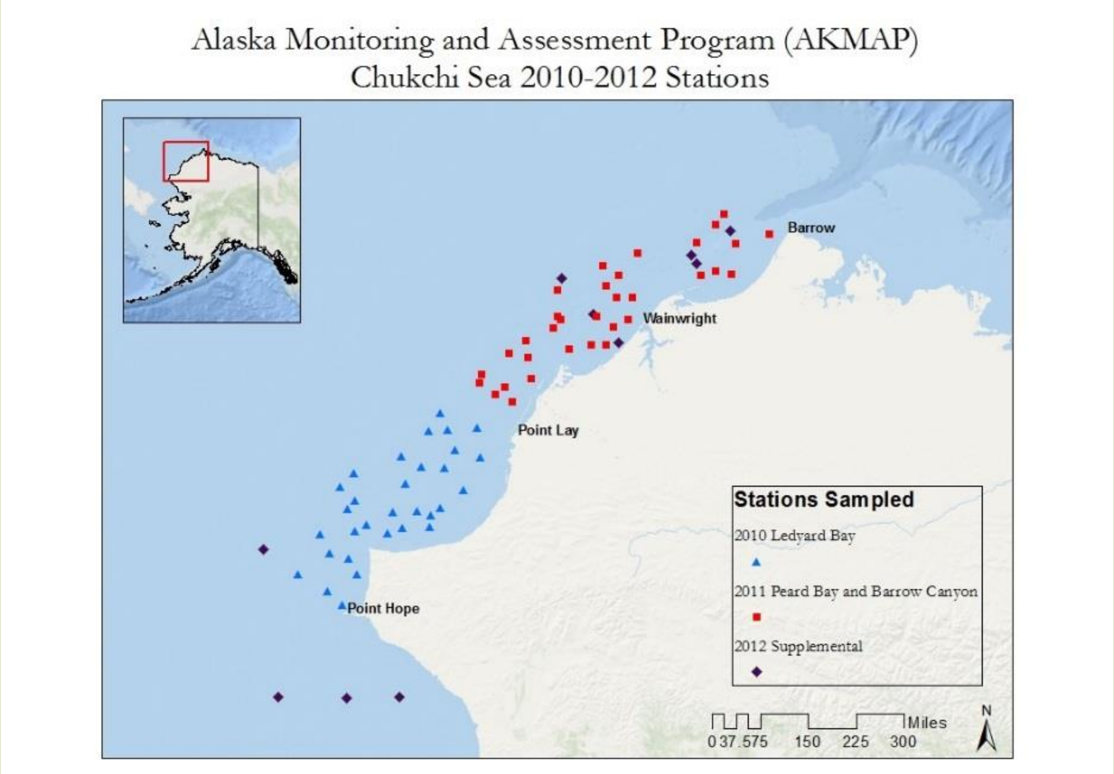


Figure 4-19. Alaska Monitoring and Assessment Program.

The Chukchi Sea lies between the Arctic Ocean and the Bering Sea. It is a shallow shelf system affected by four water masses: the Alaska Coastal Current, the Bering Sea, the Siberian Coastal Current, and the Beaufort Gyre. The convergence of these masses creates a rich and dynamic environment, with one of the highest rates of primary production of any of the world's oceans.

Similar to the NCCA, the Chukchi Sea Survey was designed to assess ecological conditions based on several measured indicators of marine environmental quality and to establish baseline measurements to evaluate future changes in condition.

This survey used NCCA 2010 methodology and sampling parameters. Additionally, scientists sampled for ocean acidification, air hydrocarbon analysis, fish stomach contents, zooplankton abundance and biomass, and benthic contaminants; they also observed marine mammal and seabird populations. They sampled 71 randomly selected nearshore sites in 2010 and 2011. Because randomly selected sites in Alaska tend to be in reference or near-reference condition due to Alaska's small population and remoteness, ten targeted sites were also sampled in 2012 (Figure 4-19).

Survey results are in various stages of completion. Data from stations sampled in 2010 and 2011 have undergone quality assurance reviews and are final. Results from 2012 will be finalized in 2015.

Findings to date include the following:

- Total petroleum hydrocarbon concentrations of sediments were below NOAA benchmark concentrations (Screening Quick Reference Tables, Effects Range – Low) by a factor of 10, with the highest concentrations being in the southern area (Figure 4-20). Further investigations will assess the individual Polycyclic Aromatic Hydrocarbon profiles, sediment grain size, and total organic carbon.

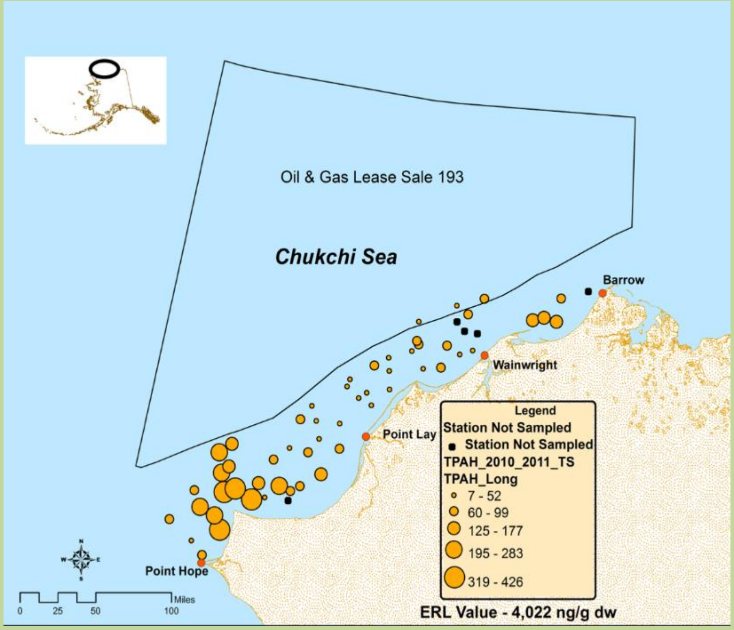


Figure 4-20. Results of AKMAP sampling for petroleum hydrocarbons in sediments.

- Equilibrium partitioning sediment benchmarks toxicity units (ESBTU) were used to assess the toxicity of PAH mixtures to benthic organisms. Overall, sediment PAH concentrations were found to be acceptable for the protection of benthic organisms. Only one station, with a value of 1.06 ESBTU, exceeded values that may affect sensitive benthic organisms. The threshold value is 1. The ratios suggest PAHs originate primarily from the rocky substrate of the sea floor.

Preliminary results suggest a healthy ecosystem that supports its many uses. Wind stress, the only stressor identified thus far, is a natural phenomenon that may affect the distribution of physical, chemical, and biological indicators. Few previous studies have occurred in this region, so trend analysis is not possible at this time. Comparisons to outer continental shelf surveys in the Chukchi Sea are planned.

The scenario for most of Alaska's coastal aquatic resources is not one of existing degradation from agricultural, industrialization, and urbanization, but one of possible large-scale changes due to climate change and future resource development. Climate change has the potential to affect nearshore ecosystems through water temperature change, variations in upwelling nutrient input, and ocean acidification. As the Arctic ice pack recedes and the Northern Sea routes open up, a major increase in shipping through this region is expected. Activities from oil and gas exploration increase the risk of hydrocarbon or other spills that can affect nearshore ecosystems. Information gathered from this survey will be useful in supporting the protection and restoration of coastal marine environments, mitigating damage to the marine ecosystem, and implementing discharge-monitoring requirements of industry.

Sea ice in the Chukchi Sea. (Photo courtesy of Alaska Department of Environmental Conservation)

The Great Lakes

Setting

The Great Lakes basin ecosystem covers 295,000 square miles, with nearly 11,000 miles of shoreline. The Great Lakes nearshore and embayment area assessed as part of the NCCA 2010 totals approximately 6,700 square miles. The Great Lakes are the largest system of fresh surface water on earth, containing an estimated 18% of the world's total supply. Only the polar ice caps contain more freshwater. Because of the large size of the watershed, physical characteristics such as climate, soils, and topography vary across the basin.

To the north, the climate is cold and the terrain is dominated by granite bedrock called the Canadian (or Laurentian) Shield under a generally thin layer of acidic soils. Conifers dominate the northern forests and the area is sparsely populated. In the southern areas of the basin, the climate is much warmer and the soils are deeper, with layers or mixtures of clays, silts, sands, gravels and boulders deposited as glacial drift or as glacial lake and river sediments. The original deciduous forests have been replaced by agriculture and sprawling urban development.

Although part of a single system, each Great Lake is different. Lake Superior is the largest by volume and surface area, and its basin is mostly forested and sparsely populated. The temperate southern basin of Lake Michigan, the second-largest Great Lake by volume, is among the most urbanized in the system and is home to Milwaukee, Wisconsin, and Chicago, Illinois. Lake Huron is the third-largest Great Lake by volume and includes Georgian Bay and Saginaw Bay. Major urban industrial centers (including Hamilton and Toronto in Ontario) are located on the shores of Lake Ontario, the fourth-largest Great Lake by volume. Lake Erie, the smallest Great Lake by volume, is the shallowest, warmest, and most biologically productive of the Great Lakes. It is the most densely populated of all the Great Lake basins and has several large cities within it, including Detroit, Michigan; Toledo and Cleveland, Ohio; and Buffalo, New York. Agriculture is the predominant land use (66%) in Lake Erie's Western Basin.

In addition to supporting recreation, tourism, and freight transportation for the region, the coastal Great Lakes provide spawning grounds, shelter, and food for fish, shellfish, and wildlife. The coastal counties of the U.S. Great Lakes region represent the third-largest coastal population in the nation. In 2010, the Great Lakes region was home to approximately 27 million people, representing 17% of the U.S. population residing in coastal watershed counties. The Great Lakes coastal watershed counties have a fairly stable population, with a population growth rate of 4% since 1970.

Summary of NCCA 2010 Findings

A total of 405 NCCA sites were sampled in the summer of 2010 to characterize the condition of the Great Lakes nearshore coastal waters. An overview of the findings is presented in Figure 4-21. Change analysis could not be conducted for the Great Lakes because they were first assessed as part of this survey series in 2010.

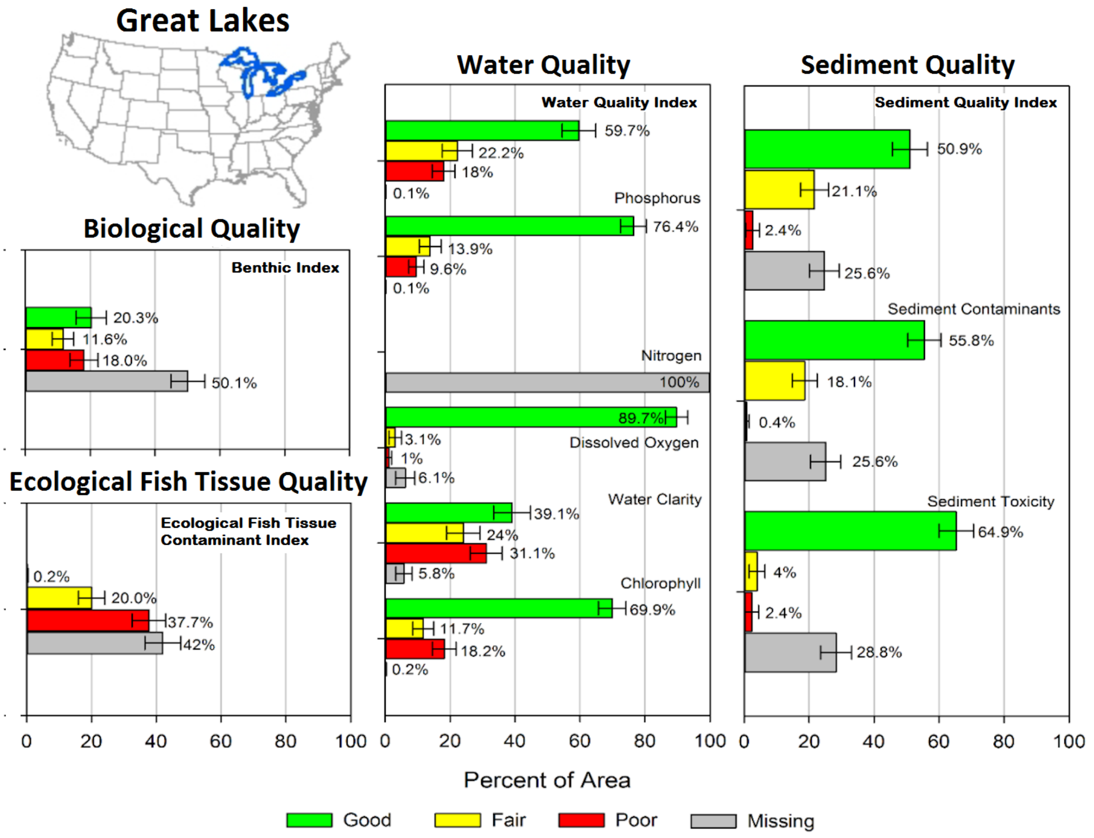


Figure 4-21. NCCA findings for the Great Lakes Coast. Bars show the percentage of area within a condition class for a given indicator. Error bars represent 95% confidence levels. Note: The sum of percent of area for each indicator may not add up to 100% due to rounding. Nitrogen was measured but not used in the assessment of Great Lakes waters; therefore, it is labeled as missing.

Biological Quality

For the Great Lakes, biological quality is determined using an oligochaete trophic index (oligochaetes are benthic aquatic worms). Based on this index, biological quality is rated good in 20% of the nearshore Great Lakes coastal waters, fair in 12%, and poor in 18%. However, half of the Great Lakes nearshore area has not been assessed because of missing data points. These data are missing because of unsuitable substrate conditions or because the necessary species of oligochaetes are not found in the samples. Therefore, care should be taken in interpreting these results or when comparing them with other regions.

Water Quality

Based on the water quality index, 60% of Great Lakes nearshore waters are rated good for water quality, 22% are rated fair, and 18% are rated poor. (See the Great Lakes watershed highlight in Chapter 2 for a discussion of higher phosphorus concentrations in embayments compared to nearshore waters.) Water clarity contributes most to the fair and poor water quality scores for this region. There may be instances where invasive mussel species are filtering nutrients, increasing the water clarity rating and altering the nutrient cycling and ecology of the ecosystem. The ratings of the component indicators are included below:

- Phosphorus is found at low levels (rated good) in 76% of nearshore waters, at moderate levels (rated fair) in 14%, and at high levels (rated poor) in 10% of nearshore waters.
- DO levels are high (rated good) for 90% of the nearshore waters, moderate (rated fair) in 3% of the waters, and low (rated poor) in 1%. Data are missing or incomplete for 6% of waters.
- Water clarity is rated good in 39% of nearshore waters, fair in 24%, and poor in 31%. Data are missing for 6% of waters.
- Chlorophyll *a* is found at low levels (rated good) in 70% of the area, at moderate levels (rated fair) in 12%, and at high levels (rated poor) in 18%.

Sediment Quality

The sediment quality index for the Great Lakes nearshore coastal region shows that 51% of nearshore area is in good condition, 21% is in fair condition, and 2% is in poor condition. Crews attempted to collect samples at all sites, but due to the prevalence of invasive mussel species and rocky or hard substrates, 26% of the nearshore area cannot be assessed for sediment quality. For sediment contaminants, 56% of the Great Lakes coastal sediments are in good condition and 18% are in fair condition. Less than 1% are in poor condition. Data for sediment contaminants are missing or incomplete for 26% of the nearshore coastal area. For sediment toxicity, 65% of Great Lakes coastal sediments are rated good, 4% are rated fair, and 2% are rated poor. Data are missing or incomplete for 29%.

Fish Tissue Quality

Based on the ecological fish tissue contaminant index, 38% of waters are rated poor, 20% are rated fair, and less than 1% are rated good. Crews attempted to collect fish at all sites, but were unable to obtain fish in 42% of the Great Lakes nearshore coastal area. The contaminants that most often exceed the LOAEL (poor) thresholds are selenium, mercury, and (to a lesser extent) total PCBs, hexachlorobenzene, and total DDTs.

The values used for ecological fish tissue assessment for PCBs and mercury are much higher than the human health cancer and non-cancer values used in the Great Lakes Human Health Fish Tissue Study (see Chapter 3). For example, the ecological fish tissue value for PCBs for the avian group is 1.29 ppm (or 1,290 ppb), while the human health cancer value is 0.012 ppm (or 12 ppb). As such, a lower percentage of waters exceed the values established for ecological assessments. Values used to assess ecological fish tissue for the NCCA 2010 are higher than the values used in the Great Lakes Region for assessment. Canada and the U.S. use the 2012 Great Lakes Water Quality Agreement General Objective 9, which is essentially the no observed adverse effect level. As a result, the findings of this report will differ from assessments conducted by the governments in the Great Lakes Region.

HIGHLIGHT: Cyanobacteria in Nearshore Waters of the Great Lakes

For the Great Lakes portion of the NCCA 2010, analyses of phytoplankton (free-floating algae) were conducted to examine potential risks to human health through recreational exposure. Some phytoplankton are known as blue-green algae or cyanobacteria because they have characteristics of both algae and bacteria. Some cyanobacteria species produce toxins that can affect the health of animals and humans. Cyanobacteria are generally found at low cell counts, but occasionally conditions are right for populations to “bloom” to high cell concentrations; under extreme conditions, they can form visible green scum coating the surface of the water. High nutrient levels, other water quality measures, and certain weather conditions can trigger phytoplankton (and, potentially, cyanobacteria) blooms.

The World Health Organization (WHO) published guidelines for potential human health risks based in part on cyanobacteria cell counts (Table 4-9). The guidelines are intended as general alert levels.

Table 4-9. Cyanobacteria guidelines for safe practice in managing freshwaters for recreation use (modified from World Health Organization, 2003, Table 8.3, p. 150).

Guidance Level or Situation	Health Risks
Relatively low probability of adverse health effects	
20,000 cyanobacteria cells/mL or 10 µg chlorophyll *a* /L with dominance of cyanobacteria	• Short-term adverse health outcomes (e.g., skin irritations, gastrointestinal illness)
Moderate probability of adverse health effects	
100,000 cyanobacterial cells/mL or 50 µg chlorophyll *a* /L with dominance of cyanobacteria	• Potential for long-term illness with some cyanobacterial species • Short-term adverse health outcomes (e.g., skin irritations, gastrointestinal illness)
High probability of adverse health effects	
Cyanobacterial scum formation in areas where whole body contact and/or risk of ingestion/aspiration occur	• Potential for acute poisoning • Potential for long-term illness with some cyanobacterial species • Short-term adverse health outcomes (e.g., skin irritations, gastrointestinal illness)

The NCCA 2010 survey data indicate that a relatively small percentage of Great Lakes nearshore areas have cyanobacteria levels warranting alert actions. The U.S. nearshore area occupies 7,290 square miles. Of this nearshore area, 12% ± 3% exceeds the threshold for a low WHO guideline risk and < 2.4% (± 1.8%) exceeds the moderate WHO guideline risk category. No area exceeds the high risk category as delineated by WHO guidelines.

Figure 4-22 displays results from 371 sites where phytoplankton samples were collected and analyzed. Alert levels were concentrated in small clusters of sites, particularly within the lower lakes (lower Lake Huron, western Lake Erie, and Lake Ontario), as well as Green Bay within Lake Michigan. Sites were sampled once from May through September; estimates of risk might have been higher if all sampling had occurred in late summer when peak chlorophyll/bloom conditions often occur.

Both embayment and nearshore sites are affected; however, embayments on average have slightly higher cyanobacterial counts than the open nearshore sites. In general, the pattern confirms a number of historically known problem areas where phytoplankton blooms have occurred, including those dominated by cyanobacteria (western Lake Erie/Maumee Bay, Saginaw Bay, Green Bay, and southeastern Lake Ontario). Some of these areas receive regular remote sensing and intensive field sampling for harmful algal bloom species, including sensing and field sampling by NOAA's Watch Program.

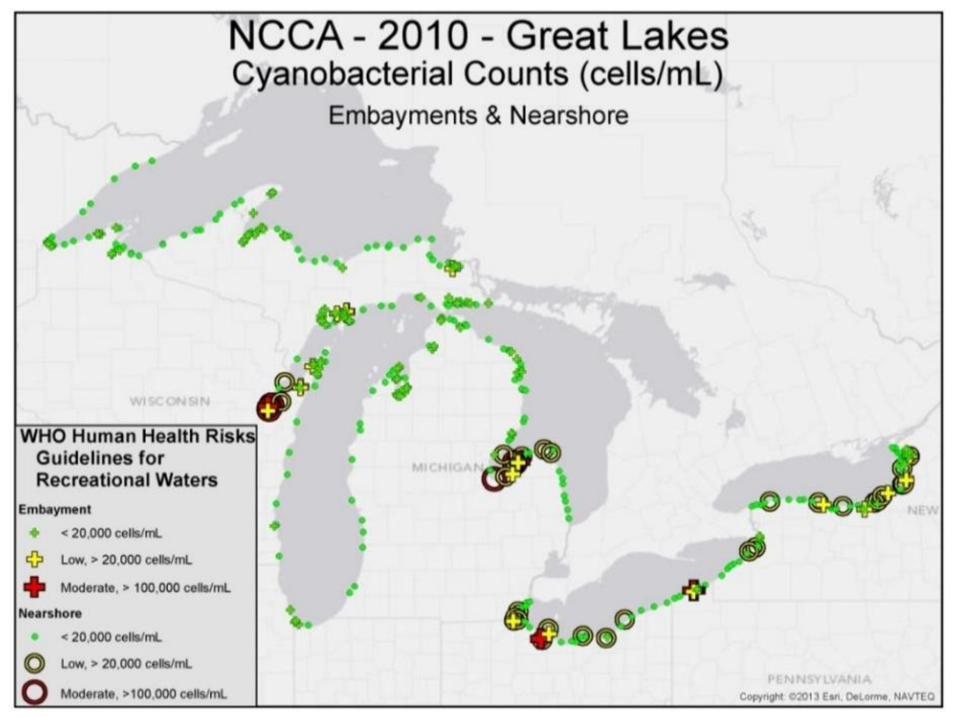


Figure 4-22. Sampled sites categorized by WHO alert levels according to cyanobacteria cell counts.

One of the benefits of the NCCA 2010 survey style of sampling, illustrated by Figure 4-22, is a broad-scale picture of where certain problems are likely. The NCCA survey thus complements more intensive and/or frequent local surveillance of cyanobacteria, yet offers additional information to help view local trends in a broader context. This view may assist in setting priorities among different environmental protection and restoration issues.

CHAPTER 5.

SUMMARY AND NEXT STEPS

The waters assessed in this report include nearshore marine coastal waters of the conterminous United States, its estuaries and bays, and the coastal waters and embayments of the Great Lakes. These ecosystems support varied habitat types, wildlife populations, and fisheries, and they contribute substantially to the nation’s economy.

In the summer of 2010, field crews sampled over a thousand sites for the NCCA in order to provide information on ecological condition and key stressors in the coastal waters of the Northeast, Southeast, Gulf, Great Lakes, and West Coast regions. As it is repeated over time, this assessment will track trends in coastal condition, helping EPA and its partners evaluate the collective successes of management efforts to protect, preserve, and restore U.S. coastal waters.

Condition of the Nation’s Coastal Waters

This NCCA reports on national and regional coastal condition using indicators of biological quality, water quality, sediment quality, and ecological contaminants in fish tissue. Findings for 2010 indicate that over half of the nation’s coastal waters are in good biological and sediment quality condition. For water quality, slightly over a third of the nation’s coastal waters are rated good. The leading factors associated with fair and poor water quality are elevated levels of phosphorus and chlorophyll *a*, both of which are indicators of eutrophication. For ecological fish tissue quality, less than 1% of waters are rated good, and half are rated poor based on thresholds set to protect sensitive fish and wildlife species. This poor rating is mainly due to concentrations of selenium, mercury, and arsenic that are high enough to pose a risk to sensitive wildlife that eat fish. It should be noted, however, that the fish tissue data set is not a complete one, which could affect the reliability of these results.

An important objective of the NCCA is to track changes in the condition of coastal waters over time. This report includes an analysis of change in coastal condition using a consistent set of data from three periods: 1999–2001, 2005–2006, and 2010.

For the nation as a whole, several NCCA indicators show statistically significant change compared to previous periods. The percent area rated good for the water quality index shows statistically significant decline from 1999–2001 to 2005–2006. From 2005–2006 to 2010, nitrogen and water clarity, which are two components of the water quality index, improve significantly. Biological quality improves 17% from 2005–2006 to 2010. Sediment quality declines by 22% during the same period, primarily due to changes in sediment toxicity. While these results might appear contradictory, these three indicators do not necessarily respond to stressors in the same manner, nor do the indicators included in the NCCA reflect all stressors that impact coastal waters.

The NCCA 2010 findings, along with the change analysis, support the need for continued management attention to coastal stressors at the national, regional, state, and watershed scales to mitigate problems where they exist and protect those areas that are still in good condition.

Moving the Science Forward

Many of the contributions of the NCCA 2010 go beyond the findings discussed in this report. EPA and its partners revised the way coastal condition indicators are analyzed and assessed, updating the sediment quality and fish tissue contaminant indicators to reflect the current state of the science. Partners gained—and shared—new expertise in state-of-the-art field monitoring methods and probability-based surveys, including, for the first time, the nearshore waters of the Great Lakes. Transferring NCCA methods and technology to state and tribal programs is a key aspect of moving the science forward.

EPA scientists and partners continue to evaluate and improve the indicators that are the core of the NCCA. A current focus is an advanced method to assess the benthic macroinvertebrate community using the Multivariate AZTI Marine Biotic Index (M-AMBI), a benthic assessment tool developed and widely used in Europe. This approach combines knowledge about pollution tolerance and stressor sensitivity of benthic species with measures of diversity to rank sites on a disturbance scale (highly disturbed to not disturbed). NCCA scientists published supplemental benthic analyses using the M-AMBI and set the stage for incorporating this procedure into the next NCCA report.

Another important aspect in moving the science forward is reducing the amount of missing data in future NCCAs. In the NCCA 2010, benthic data are missing for 15% of the coastal waters, sediment data are missing for nearly 11% of the coastal waters, and fish contaminants data are missing for 24% of the coastal waters represented by this survey.

EPA and states have developed several strategies for addressing this challenge in the 2015 sampling season. For example, in the Great Lakes, benthic data are missing in large part due to the absence of key benthic organisms (oligochaetes) in the collected sediment samples. EPA is investigating whether a more inclusive benthic index—one that assesses condition based upon a wider array of organisms—may solve this problem.

For sediments, data are missing at some sites due to rocky substrates that make sediment collection at the target location difficult. The 2015 Field Operation Manual directs crews to collect sediment from a larger radius around the sampling location. Some of the missing 2010 sediment data resulted from procedural failures in the laboratory that disqualified sediment data from certain samples; laboratory procedures have been corrected for future analyses.

It can be difficult to collect fish for tissue analysis at some locations. Similar to the changes made for sediment sampling, the Field Operation Manual directs crews to expand the sampling radius for fish whenever they are unable to obtain fish at the initial collection site. By allowing field crews greater latitude to determine the best locations to collect sediment and fish, and by continuing best practices in laboratory processing, EPA made changes to decrease the amount of missing data and increase the percentage of the target population assessed for each indicator in future surveys.

EPA continues to look at ways to expand upon and improve the ecological and recreational/human health assessment of coastal waters. Examples highlighted in this document include use of underwater video in the Great Lakes to supplement benthic grab sampling, the Great Lakes Human Health Fish Tissue Study that characterizes toxic chemicals in fish that are consumed by people, and a NOAA Gulf offshore survey. Interpretation of fish tissue findings in this report may lead researchers to study additional approaches to assessing ecological fish tissue contaminants. EPA and its partners continue to evaluate other indicators that provide important baseline information related to ecological concerns and human health. Additionally, EPA continues to investigate state-of-the-science indicators, particularly indicators that integrate ecological condition with indicators of human health and well-being, ecosystem services, economics, and climate change.

Next Steps

EPA completed field sampling for the 2015 survey using updated protocols to reduce the incidence of missing data. In addition to the core set of indicators, researchers are analyzing data on new indicators, including microcystins and other algal toxins, mercury in fillets from fish taken in coastal and Great Lakes nearshore waters, and the types and extent of land-based trash in the water. EPA also implemented efficiencies in data reporting, quality assurance and analyses to reduce the time between collection and publication.

EPA, in partnership with states, tribes, and other federal agencies, produces national water quality assessments on a regular cycle under the NARS program. Other NARS reports include the first national wetlands condition assessment based on 2011 field sampling, a second national lakes assessment based on sampling conducted during the summer of 2012, and a second national rivers and streams assessment based on sampling during 2013–2014.

As these national assessments continue, many states are developing and conducting their own regional- and state-scale probability surveys of their rivers and streams, lakes, wetlands, and coastal waters. EPA continues to explore ways to best support states as they sample, analyze, and report on their waters using these surveys. For example, EPA is working to build and refine tools that states can use to assess survey data at different scales, and is exploring options for providing direct technical support. As a first step, EPA will make available the statistical analysis codes that were used to develop the coastal indicators and thresholds for assessment. EPA is also piloting in-person training on the statistical tools and methods that are used in the NARS programs.

In Closing

This survey would not have been possible without the assistance and collaboration of hundreds of scientists and water quality professionals working for state, federal, and tribal agencies and universities across the country. These scientists helped plan and design the survey, select sites and indicators, develop and improve monitoring methods, train crew members, conduct sampling, track samples, screen and analyze results, and review and write up the findings. Working together on future national-, regional-, and state-scale surveys of similar design, EPA and its partners will continue developing high quality information on coastal waters that can be used to evaluate the nation’s progress in protecting and restoring these critically important resources.

Marina at sunset. (Photo courtesy of Eric Vance)

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