United States Environmental Protection Agency

EPA 841-R-21-001 | August 2021

National Coastal Condition Assessment




A Collaborative Survey of the Nation's Estuaries and Great Lakes Nearshore Waters

Acknowledgments

The U.S. Environmental Protection Agency (EPA) would like to thank the many people who contributed their expertise, time, and energy to the development of this report. Without the collaborative efforts and support provided by state environmental agencies, other federal agencies, universities, and other organizations, this National Coastal Condition Assessment would not have been possible. Key participants in this project included field crews, biologists, taxonomists, statisticians, data analysts, program administrators, regional coordinators, project managers, quality control officers, and reviewers. To these many hundreds of participants, EPA expresses its profound thanks and appreciation.

A team of contributors led by Hugh Sullivan, EPA Program Manager, wrote this report, with editorial support from Natalie Auer of Crow Insight. This team included David Bolgrien, Cheryl Brown, Linda Harwell, John Kiddon (retired), and Marguerite Pelletier, EPA Office of Research and Development; Mari Nord, EPA Region 5; Matthew Pawlowski, EPA Great Lakes National Program Office; and Shari Barash, Lareina Guenzel, Susan Holdsworth, Sarah Lehmann, Michelle Maier, Menchu Martinez, Megan O'Brien, Leanne Stahl, and Garrett Stillings, EPA Office of Water. Crow Insight (as a subcontractor to Avanti Corporation and Industrial Economics Inc.) provided layout, graphics and additional editorial support.

State Partners

Alabama Department of Environmental Management
Alaska Department of Environmental Conservation
Connecticut Department of Environmental Protection
Delaware Department of Natural Resources
Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute
Georgia Department of Natural Resources
Hawaii Department of Health
Illinois Environmental Protection Agency
Louisiana Department of Wildlife and Fisheries
Maine Department of Environmental Protection
Maryland Department of Natural Resources
Massachusetts Department of Environmental Protection
Michigan Department of Environmental Quality
Minnesota Pollution Control Agency
Mississippi Department of Environmental Quality
New Jersey Department of Environmental Protection
New York Department of Environmental Conservation
North Carolina Department of Environment and Natural Resources
Ohio Environmental Protection Agency
Oregon Department of Environmental Quality
Pennsylvania Department of Environmental Protection
Rhode Island Department of Environmental Management
South Carolina Department of Health and Environmental Control
South Carolina Department of Natural Resources
Texas Commission on Environmental Quality
Texas Parks and Wildlife Department
Virginia Department of Environmental Quality
Washington Department of Ecology
Wisconsin Department of Natural Resources

Contractor Support

Avanti Corporation
Crow Insight
Dynamac
EcoAnalysts Inc.
Environmental Institute of Houston at University of Houston-Clear Lake
Enviroscience Inc.
Great Lakes Environmental Center Inc.
Industrial Economics Inc.
PG Environmental
Physis
SRA International
Tetra Tech

Acknowledgments (continued)

The following individuals played a pivotal role in this project and lent their expertise to project planning and implementation as well as oversight and data analysis:

Academic, Local, State, Federal and International Partners

Angel Borja, AZTI Tecnalia Marine Research Division
Donald Cadien, Ocean Monitoring Research Group, County Sanitation Districts of Los Angeles County
Paul Carlson, Florida Fish and Wildlife Conservation Commission
Judy Crane, Minnesota Pollution Control Agency
Daniel Dauer, Old Dominion University
Robert Diaz, Virginia Institute of Marine Science
Eva DiDonato, National Park Service
Margaret Dutch, Washington State Department of Ecology
David J. Gillett, Southern California Coastal Water Research Project
Jeffrey L. Hyland, National Oceanographic and Atmospheric Administration, National Ocean Service
Michael Kellogg, Oceanside Biology Laboratory
Peter F. Larsen, Bigelow Laboratory for Ocean Sciences
Jeffrey S. Levinton, Stony Brook University
Roberto Llansó, Versar
Lawrence L. Lovell, Ocean Monitoring Research Group, County Sanitation Districts of Los Angeles County
Paul A. Montagna, Texas A&M University
Christine Olsen, Connecticut Department of Environmental Protection
Valerie Partridge, Washington State Department of Ecology
Dean Pasko, Orange County Sanitation District
Charles A. Phillips, Dancing Coyote Environmental
Chet Rakocinski, The University of Southern Mississippi
J. Ananda Ranasinghe, Southern California Coastal Water Research Project
Denise M. Sanger, South Carolina Department of Natural Resources
Heliana Teixeira, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Water Resources Unit
Robert F. Van Dolah, South Carolina Department of Natural Resources
Ronald G. Velarde, City of San Diego, Marine Biology Laboratory
Catherine Wazniak, Maryland Department of Natural Resources
Stephan B. Weisberg, Southern California Coastal Water Research Project
Kathy Welch, Washington State Department of Ecology
Laura Yarbro, Florida Fish and Wildlife Conservation Commission

EPA

Darvene Adams (retired), Region 2
Ted Angradi, Office of Research and Development
Vince Bacalan, Office of Water
Joe Beamon, Office of Water
Elizabeth Belk, Region 4
Alexandra Bijak (Oak Ridge Institute for Science and Education research participant)
Karen Blocksom, Office of Research and Development
Matthew Bolt, Region 9
Cheryl Brown, Office of Research and Development
Robert Cook, Region 6
Gabriella DiPreta (Oak Ridge Institute for Science and Education research participant)
Kate Drisco, Region 2
Tom Faber, Region 1
Terry Fleming, Region 9
Kendra Forde, Office of Water
Treda Grayson, Office of Water
Danielle Grunzke, Office of Water
Edward Hammer, Region 5
John Healey, Office of Water
Lil Herger, Region 10
Elizabeth Hinchey-Malloy, Great Lakes National Program Office
Amanda Jarvis, Office of Water
Cynthia N. Johnson, Office of Water
Peter Kalla, Region 4
Tom Kincaid, Office of Research and Development
Karolyn Locke, Office of Water
Chris McArthur, Region 4
Richard Mitchell, Office of Water
Walt Nelson (retired), Office of Research and Development
Emily Nering, Region 2
Mari Nord, Region 5
Tony Olsen, Office of Research and Development
Steve Paulsen, Office of Research and Development
Matthew Pawlowski, Great Lakes National Program Office
Dave Peck, Office of Research and Development
Amina Pollard, Office of Water
William Richardson, Region 3
Jill Scharold, Office of Research and Development
Bernice Smith, Office of Water
Elizabeth Smith, Region 4
Marla Smith, Office of Water

Table of Contents

Figures and Tables

Acronyms and Abbreviations

CCE	Calibrator cell equivalents
ELISA	Enzyme-linked immunosorbent assay
EPA	Environmental Protection Agency
M-AMBI	Multivariate AMBI (AZTI Marine Biotic Index)
NARS	National Aquatic Resource Surveys
NCCA	National Coastal Condition Assessment
OTI	Oligochaete trophic index
PCBs	Polychlorinated biphenyls
PFAS	Per- and polyfluoroalkyl substances
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
ppb	Parts per billion
qPCR	Quantitative polymerase chain reaction

Executive Summary

Estuaries and the Great Lakes are vital to American culture and the U.S. economy. These water bodies support commercial fishing, shellfish, tourism and shipping industries, as well as the cultural traditions of local residents. The Great Lakes provide drinking water to nearby cities, while Great Lakes and estuarine wetlands protect our coasts from the effects of storms. Coastal areas also provide important habitat for fish and wildlife. EPA and its partners monitor estuaries and nearshore Great Lakes waters to assess their suitability to support these functions.

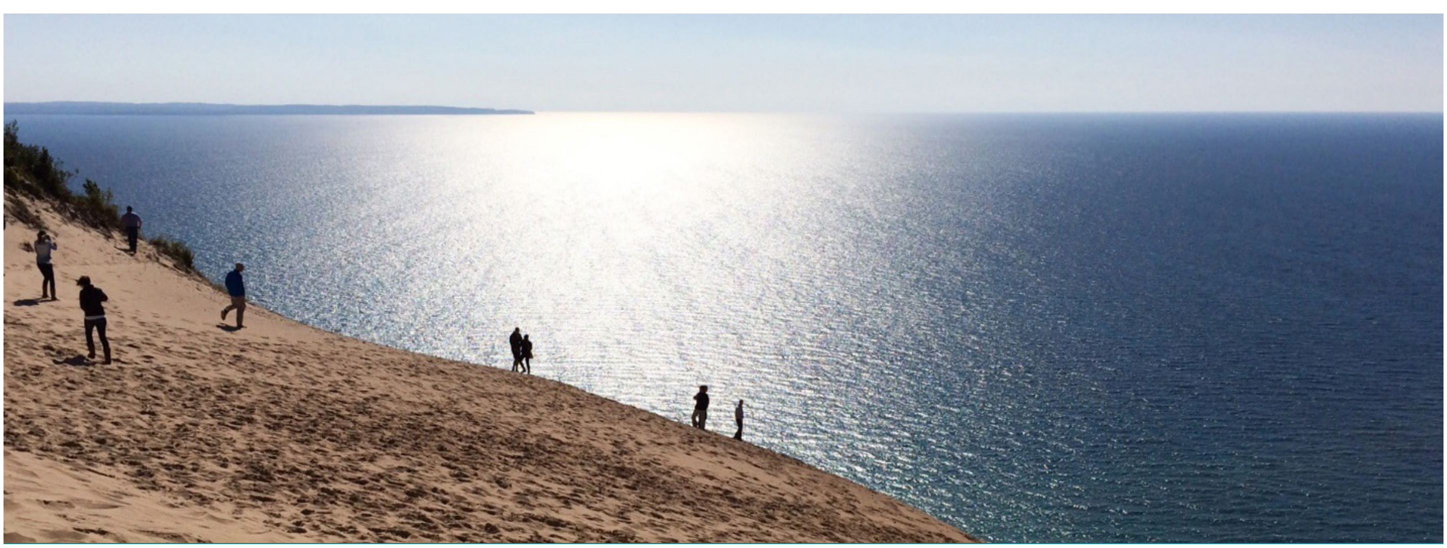
The National Coastal Condition Assessment (NCCA) is one of four National Aquatic Resource Surveys (NARS) designed to assess the condition of America's water resources. The NCCA focuses on estuaries and the Great Lakes due to their ecological and economic importance. The survey helps answer such questions as: what is the condition of the nation's coastal waters, what are key problems in our waters, and are conditions getting better or worse over time? NCCA data help water resource managers evaluate the progress of programs to protect and restore estuaries and the Great Lakes. For example, data from this NCCA have been leveraged by the state of Ohio and the Albemarle-Pamlico National Estuary Program.

NCCA data help water resource managers evaluate progress toward protecting and restoring estuaries and the Great Lakes.

Prior to the NCCA's establishment in the 2000s, there was no national dataset that allowed tracking and comparison of conditions in estuaries and the nearshore Great Lakes over time. The NCCA survey design and standardized monitoring and laboratory protocols ensure that survey results are nationally representative and comparable over time. Data collected through the NCCA can also supplement state and tribal data collection.

HOW WAS THE SURVEY DONE?

In the summer of 2015, EPA and its partners visited a total of 1,060 randomly selected sites in 28 coastal states (excluding Alaska and Hawaii): 699 sites in estuaries and 361 in the Great Lakes, representing about 27,479 square miles and 7,118 square miles of coastal waters, respectively. Survey field crews collected samples and took measurements to characterize the physical, chemical and biological integrity of the nation's coastal waters (see Chapter 2 to learn how these waters were defined). The NCCA did not specifically target areas with known contamination for sampling, although such sites might have been selected for sampling by chance.



At some sites, field crews experienced difficulty collecting fish or sediments (or other samples), hindering EPA's ability to assess condition for one or more indicators. Where samples could not be collected for a particular indicator, the area represented by a given site was considered "not assessed" for that indicator.* EPA and its partners are continuously working on techniques to improve sample collection and minimize the area that is not assessed. See Chapter 2 and Appendix B for more discussion.

Because the ecology and geography of U.S. coastal waters varies, EPA divided estuarine waters into four regions—the Northeast, Southeast, Gulf and West (Coast)—when designing the survey. This ensured that each region included enough sampling sites to be representative of conditions in the region. Regional results allow decision-makers to focus on each region individually. EPA similarly designed the survey to ensure each of the Great Lakes had enough sites to be representative of the condition of each lake. Detailed maps of the regions and Great Lakes are shown in Appendix A. This report summarizes the results of the NCCA nationally and regionally. It also compares conditions for certain indicators to those from the first NCCA (conducted in 2010) and an earlier survey from 2005-06.

WHAT DID THE SURVEY EVALUATE?

The NCCA used four ecological indicators and three human health indicators (below) to characterize conditions in estuaries and the nearshore Great Lakes. Some ecological indicators directly describe the condition of organisms in coastal waters, while others describe environmental conditions that could affect the ability of organisms to survive and reproduce. Several human health indicators were assessed for the first time in 2015. These included enterococci bacteria, microcystins (toxins produced by cyanobacteria, or blue-green algae), and mercury in fish fillet plug samples. In the Great Lakes only, EPA conducted a supplemental study of human health indicators in fish fillet tissue, measuring several contaminants in fillets (EPA collected similar data in 2010 as well). Human health indicators describe conditions that could affect people's recreational use of coastal waters (e.g., for boating, fishing, or swimming).

NCCA Indicators

The NCCA uses four ecological and three human health indicators to assess the conditions in both estuaries and nearshore Great Lakes waters.

Ecological Indicators

- **Biological Condition**. Condition of the community of worms, mollusks and crustaceans living in lake or estuarine sediment, based on diversity, abundance and pollution sensitivity.
- **Eutrophication**. Index based on levels of nutrients, dissolved oxygen, chlorophyll *a* and water clarity.
- **Sediment Quality**. Index assessing contaminant levels in sediment, along with the toxicity of the sediment to live organisms.
- **Ecological Effects of Fish Tissue Contamination**. Index measuring the concentrations of metals and organic contaminants in whole fish to estimate the likelihood of negative effects to wildlife eating these fish.

Human Health Indicators

- **Enterococci.** Enterococci bacteria are used as an indicator of possible fecal contamination.
- **Microcystins.** Microcystins are a group of toxins produced by some types of cyanobacteria (commonly called blue-green algae).
- **Contaminants in Fish Tissue**
  - **Mercury in Fish Fillet Plugs.** Mercury in fish fillet "plug" samples (small samples taken from fish muscle tissue).
  - **Contaminants in Fish Fillet Tissue**. In the Great Lakes only, EPA collected additional fish to assess fillet tissue for polychlorinated biphenyls (PCBs), per- and polyfluoroalkyl substances (PFAS), and mercury, using entire fillets.

*Note that EPA accounted for unassessed area differently for one part of the NCCA—the Great Lakes Human Health Fish Fillet Tissue Study—as described below and in Section 4.8.

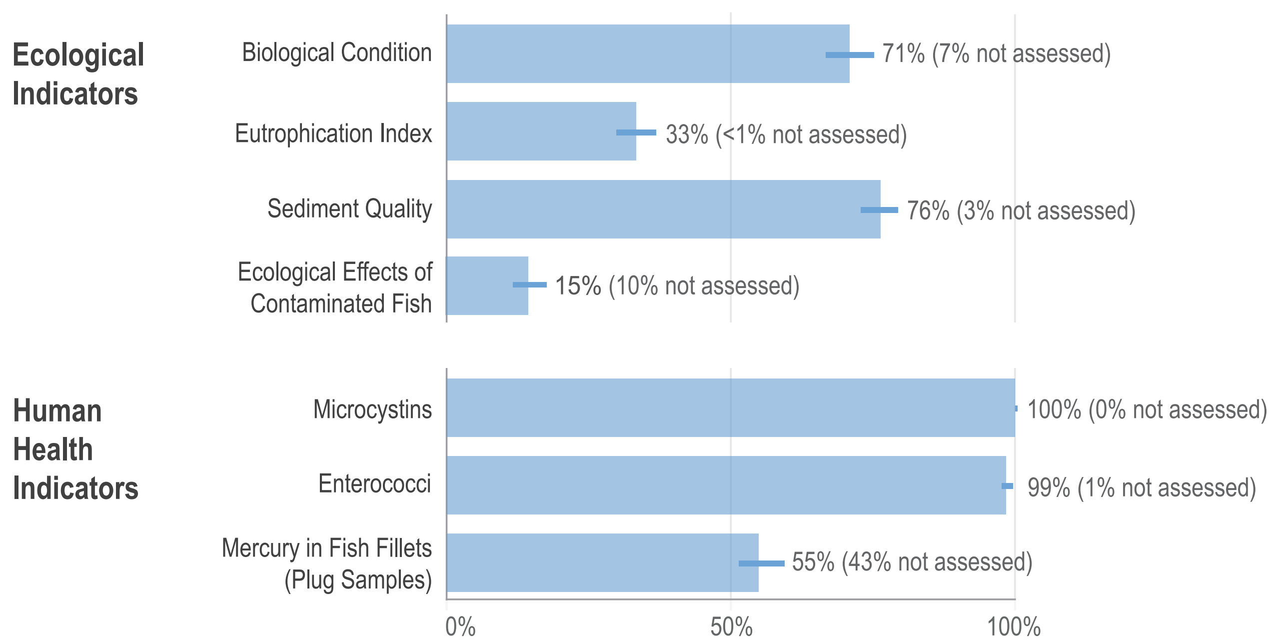
KEY FINDINGS

The key findings for estuaries and nearshore Great Lakes waters are described separately below. Results provided here focus primarily on coastal area in good condition; see Chapters 3 and 4 for more details on each indicator, including estimates of fair and poor condition. These chapters also present regional data. Additional data from the assessment, including underlying parameters used to calculate indicator scores, are available at the NCCA dashboard at https://coastalcondition.epa.gov.

Estuaries

Figure ES.1 summarizes the percentage of estuarine coastal area in good condition for the four ecological indicators and three human health indicators. The percentage of area that was not assessed for each indicator is listed in parentheses. Key findings are discussed below. For additional information about the full range of conditions for these indicators, please see Chapter 3.

Figure ES.1. Percent of Estuarine Coastal Area in Good Condition (2015)



Ecological Indicators

Biological condition was overall good, with 71% of estuarine area in good condition. From 2005-06 to 2015, the percentage of area in good condition increased (from 51% to 71%), while "not assessed" area decreased. Continued assessments will reveal whether this change represents a real improvement in biological condition. Biological condition was worst in the Southeast, where only 62% of area was rated good.

Eutrophication is the most widespread problem in estuaries. Only 33% of estuarine area was rated good. Conditions were worst in the Gulf of Mexico region, where only 18% of area was rated good. Nutrient pollution from the Mississippi River basin could be contributing to poor conditions in the Gulf region. Low levels of dissolved oxygen and high nutrient levels associated with eutrophication can stress or even kill fish and other aquatic organisms. Eutrophication also contributes to harmful algal blooms, some of which produce toxins such as microcystins.

Sediment quality in estuaries was good. Seventy-six percent of estuarine area was rated good nationally, although low levels of metals and polycyclic aromatic hydrocarbons were widely detected. In West Coast estuaries, although most area (67%) was rated good, 12% was rated poor.

Fish tissue contamination could affect predators of fish, such as predatory mammals, birds, or other fish, in most area assessed. Fifteen percent of estuarine area was rated good, and 55% was rated poor (10% of the area was not assessed). The benchmarks used to evaluate these ecological effects are conservative. They indicate that contaminants at low levels may cause effects such as reduced reproductive success in predators. They do not imply risk to people.

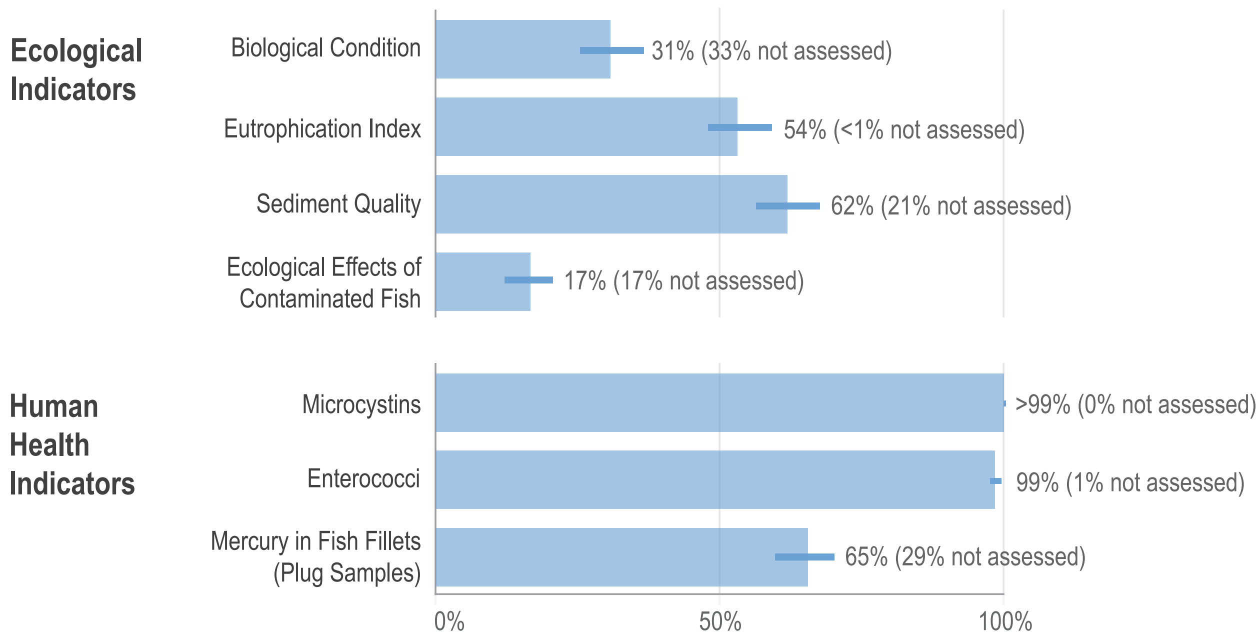
Human Health Indicators

Conditions pose little risk to human health in most estuaries. Human health indicators were assessed for the first time in 2015. In most estuaries, recreational users faced a low risk of exposure to enterococci and cyanotoxins (microcystins); enterococci samples rarely exceeded benchmarks, and microcystins did not at all. Note that results for microcystins do not mean there are never problems—harmful algal blooms are ephemeral and may develop and produce toxins quickly, and other toxins not measured as part of the NCCA may be present. The NCCA also assessed mercury in plug samples taken from fish fillet tissue. Again, the risk to humans was low; while 55% of estuarine area was at or below EPA's human health benchmark for mercury in fish tissue, 43% of estuarine area was not assessed due in part to failure to catch fish of the correct species or size. People should check with their state, tribal or local health department for information about local fish consumption advisories in coastal waters.

Nearshore Great Lakes

Figure ES.2 shows the percentage of Great Lakes coastal area in good condition for the four ecological indicators and three human health indicators (additional information on contaminants in fish fillets is provided later in the executive summary). The percentage of area that was not assessed for each indicator is listed in parentheses. Key findings are discussed below. For more information about the full range of conditions for these indicators, please see Chapter 4.

Figure ES.2. Percent of Great Lakes Nearshore Area in Good Condition (2015)



Ecological Indicators

In 2015, 31% of Great Lakes nearshore area was in good biological condition, but not all area was assessed. Inability to collect samples for analysis of biological condition was a problem in the Great Lakes. Areas with hard lake bottoms or invasive zebra and quagga mussel colonies often prevented crews from collecting a sample, limiting the ability to determine condition in many areas. To help inform future efforts, EPA is investigating the use of underwater video to provide supplemental information about the lake floor and to determine the presence of invasive species.

Eutrophication is a persistent problem in the Great Lakes. The extent of eutrophication in most of the nearshore Great Lakes remained unchanged from 2010 to 2015, except in Lake Huron, where area in good condition declined from 76% to 48% due mainly to increased phosphorus pollution. In Lake Erie, 23% of area was rated good, compared to 54% in the nearshore Great Lakes overall.

Almost two-thirds of the nearshore area in the Great Lakes was in good condition based on sediment quality. Overall, 62% of nearshore area was in good condition for sediment quality, with 21% of area not assessed. Hardpan areas and invasive mussel beds at sampling sites impeded sample collection. Sample collection improved in some lakes, so unassessed area decreased compared to 2010. The NCCA continues to investigate ways to improve sediment assessment.

As with estuaries, fish tissue contamination in the Great Lakes is likely to affect fish-eating predators. Fish tissue contamination potentially leading to adverse predator effects was notable. Only 17% of nearshore area was rated good, and 47% was rated poor (17% was unassessed). Again, the benchmarks used to predict adverse effects on predators do not equate to human health risk.

Human Health Indicators

At the time of sampling in 2015, human health indicators indicated low risk in most of the Great Lakes. Enterococci concentrations in 2015 were below the EPA benchmark in 99% of the Great Lakes nearshore area. Microcystins were also not detected at high levels. They were not detected in 69% of nearshore area; all microcystin samples but one (in Lake Erie) were at concentrations below the EPA benchmark. Note that although the results for microcystins were good, this does not mean the risk was zero. Harmful algal blooms arise quickly, and some less common types of cyanobacteria produce toxins not measured as part of the NCCA. Six percent of nearshore area had fish with mercury levels above the human health benchmark based on analysis of plug samples from fish fillet tissue. However, 29% of nearshore area was not assessed due to failure to catch fish. People should consult state, tribal and local advisories for additional information on human health concerns associated with a particular water body.

Great Lakes Human Health Fish Fillet Tissue Study

All 152 fish fillet tissue samples in the Great Lakes had detectable levels of mercury, PFAS, and PCBs, and PCB levels exceeded the EPA cancer risk benchmark for total PCBs in most samples. In the Great Lakes, EPA conducted an additional study of contaminants in fish fillet tissue using whole fillets rather than fillet plugs. Whole fillet composite samples were analyzed for mercury, PCBs, and PFAS. Mercury results from this study cannot be directly compared to those for the fillet plug indicator because the fish plug analysis includes assessed and unassessed nearshore areas and the whole fillet analysis includes only the assessed nearshore area. See Chapter 2, Section 4.8 and Appendix B for more detail on these differences.

For mercury, EPA found that 13% of the assessed Great Lakes nearshore area contained fish with fillet concentrations above the EPA human health mercury benchmark (300 parts per billion or ppb). For PCBs, EPA found that 53% and 79% of the assessed Great Lakes nearshore area contained fish with fillet concentrations above the EPA human health total PCB benchmarks for noncancer effects (49 ppb) and cancer effects (12 ppb), respectively. For perfluorooctane sulfonate (PFOS), the most common PFAS detected in Great Lakes fish, EPA found that 5% of the assessed Great Lakes nearshore area contained fish with fillet concentrations above the EPA human health PFOS benchmark (46 ppb).

PFAS PRESENCE IN FISH FILLET TISSUE

PFAS are recognized as contaminants of concern. In response, scientists are intensifying efforts to study the occurrence of PFAS in the environment, as well as the sources, levels, and risks of human exposure. PFAS have been used in manufacturing and firefighting and have been detected in some drinking water sources. While levels were low overall, PFAS were detected in every fish fillet sample in the Great Lakes Human Health Fish Fillet Tissue Study. PFAS monitoring like that in the study will be important for documenting the presence of persistent chemicals as their usage changes over time.

CONCLUSION

Eutrophication continues to be the most significant problem in coastal waters, consistent with data from other NARS reports showing elevated nutrient levels in rivers. Many of these rivers feed into estuaries and the Great Lakes. Although NARS reports for lakes and for rivers and streams indicate increased nutrient concentrations since previous surveys, eutrophication condition in estuaries did not reflect these increases, perhaps due to the influence of open waters and associated tidal flushing. The combined results, however, support the need to continue and expand efforts to address sources of nutrient pollution.

The NCCA is invaluable for determining the extent of coastal waters that support healthy biological condition, recreation and fish consumption. Where conditions are good, continued monitoring provides a bellwether to identify whether degradation occurs. Where conditions are poor, the results can help coastal managers develop policies to address problems and determine where further monitoring is needed (see examples in Chapter 5). Changes in nutrient pollution and water temperature can exacerbate eutrophication and harmful algal blooms and affect the survival of marine and aquatic organisms. Programs such as the NCCA are particularly important for detecting these effects.

The NCCA and other NARS findings suggest the need for continued collective efforts to understand and address the many sources of stressors to the nation's aquatic resources. EPA, other federal agencies, tribes and states are collaborating on programs to reduce nutrient and other forms of pollution and to restore and protect U.S. coastal ecosystems. NCCA data will continue to inform the public, resource managers and decision-makers of these programs' progress.

1 Introduction

In the summer of 2015, EPA and states partnered to conduct the National Coastal Condition Assessment (NCCA), a representative survey of estuaries and U.S. Great Lakes nearshore waters in 28 coastal states, excluding Alaska and Hawaii. The survey measured indicators of ecological condition and human health risk.

WHY ARE THESE COASTAL AREAS IMPORTANT?

Estuaries and the Great Lakes contribute to economic prosperity through their commercial fishing, shellfish and shipping industries. Coastal waters are also important to the tourism industry as well as local residents who enjoy boating, fishing and swimming. In addition, the Great Lakes provide drinking water to nearby population centers. Coastal areas also provide important habitat for fish and wildlife, supporting biodiversity necessary to maintain high-functioning ecosystems.

What Is an Estuary?

An estuary is a complex ecosystem between a river and nearshore ocean waters where freshwater and saltwater mix. These brackish areas include water bodies such as bays, mouths of rivers, salt marshes, wetlands, and lagoons and are influenced by tides and currents.[1]

See **https://www.epa.gov/nep/basic-information-about-estuaries** for more information.

WHAT IS THE PURPOSE OF THE SURVEY?

The NCCA assessed the condition of estuaries and the nearshore Great Lakes to support coastal zone decision-making by national, state, tribal and local coastal managers and to inform the public about impacts to those water bodies. To determine condition, the survey examines core indicators of biological condition, water and sediment quality, and fish tissue contamination. A variety of factors can affect the health of these waters, including industrial activity; stormwater, groundwater, and wastewater discharge; changes in land use or fishing activity; invasive species; and climate change. In addition to local discharges, estuaries and the Great Lakes also receive pollutants and sediments from activities within their watersheds.

The 2015 survey follows two others conducted in 2010 and 2005-06 that used a comparable survey design and methodology. This survey and the 2010 survey were conducted as part of the National Aquatic Resource Surveys program (NARS). The NCCA is designed to answer the following questions:

- **Condition of coastal waters.** What is the condition of the nation's estuarine and Great Lakes nearshore waters?
- **Change over time.** Are conditions in these waters getting better, worse or staying the same?
- **Impact of stressors on aquatic and estuarine life**. How widespread are major pollutants and other stressors that affect estuarine and Great Lakes nearshore waters?

To answer such questions, EPA, states and tribes collaborate on national surveys like the NCCA. The NARS program's focus on national waters is unique. Prior to its establishment, there was no national source of data that allowed tracking of conditions over time. While states and tribes collect data under section 305(b) of the Clean Water Act, they design their water quality programs to determine conditions locally, using differing methods that may change with local priorities. These programs are not intended to answer questions about conditions nationally. The NCCA supplements state and tribal data, supporting consistent, nationwide reporting on the condition of coastal waters.[2]

[1] Some people also refer to areas where small tributaries flow into the Great Lakes as estuaries; to avoid confusion throughout this report, "estuary" and its derivatives will only be used to refer to areas where freshwater flows into the ocean.

[2] The NARS program uses data collection and survey protocols that in many cases differ from existing state water quality programs. In addition, it does not assess water bodies against state water quality standards. As a result, state water quality assessment determinations may differ from those of the NARS program.

HOW WAS THE SURVEY DONE?

The NCCA survey design included site selection using stratified random sampling, a method commonly used in scientific and social science studies (see Chapter 2 for details). The NCCA also standardized sample collection and analysis protocols to reduce sampling error. Together these steps ensured that results were nationally representative and comparable over time. In 2015, EPA and its partners visited a total of 1,060 sites during the survey: 699 in estuaries and 361 in the Great Lakes. To maintain the hallmark continuity of the NARS program, EPA trained all NCCA field crews on sampling, processing and shipping protocols. Laboratories underwent review prior to approval to analyze samples, and all field and lab data were scrutinized under a national quality assurance program. EPA scientists then analyzed the data to develop the condition estimates reported here. Every NCCA is conducted during the summer months, so changes in condition across surveys reflect condition during the summer only.

Other National Aquatic Resource Surveys

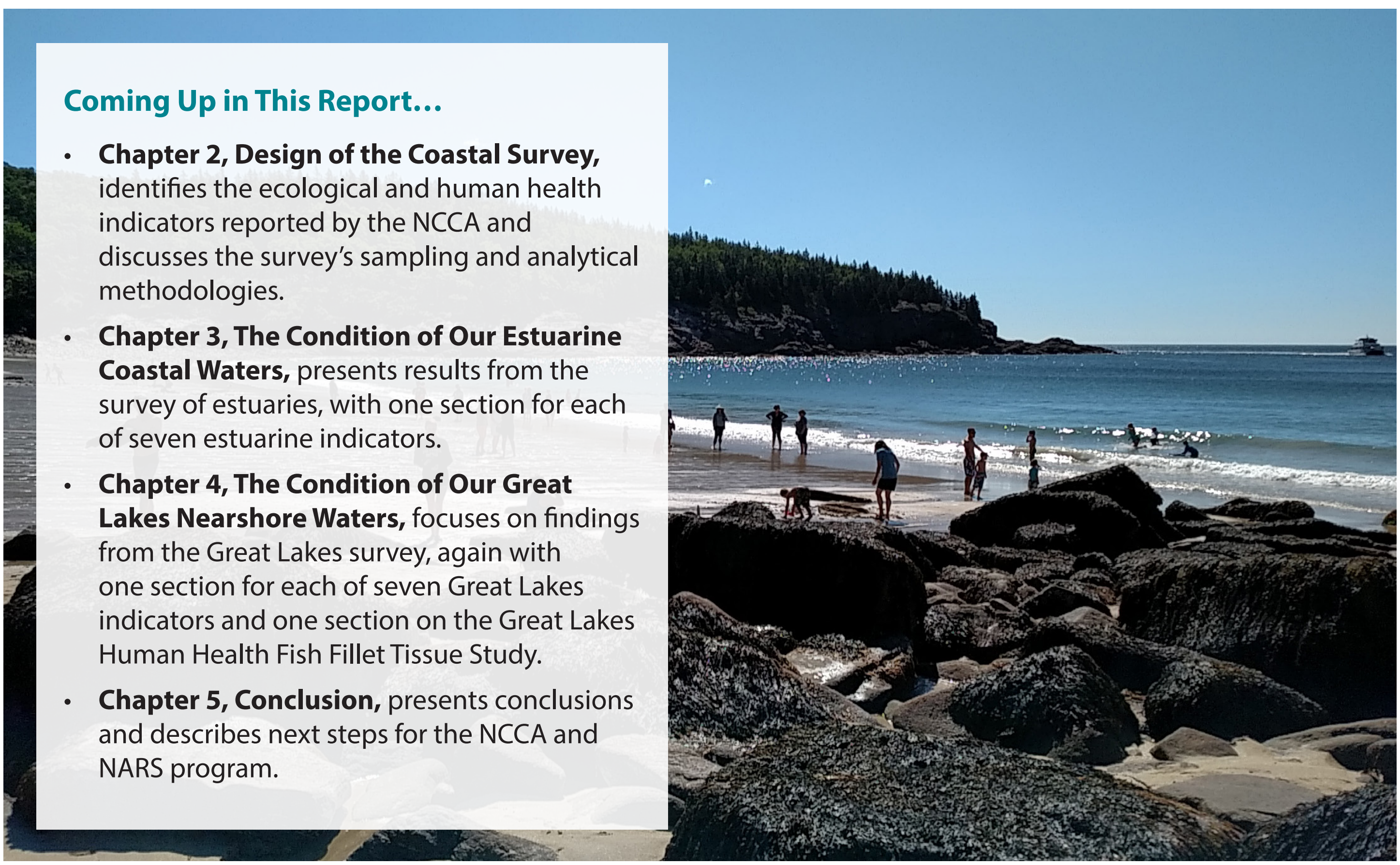
In addition to the coastal survey, the NARS program also includes the following surveys:

- The National Lakes Assessment (2007, 2012 and 2017).
- The National Rivers and Streams Assessment (2008–09, 2013–14 and 2018–19)
- The National Wetland Condition Assessment (2011 and 2016)

Reports on surveys through 2015 are available at **https://epa.gov/national-aquatic-resource-surveys**. EPA will post additional reports and data as they become available.

HOW DOES EPA USE DATA FROM THE SURVEY?

EPA analyzes NCCA data to report on the condition of coastal waters and to determine the success of federal, state, tribal and local investments in water quality programs. This information helps EPA, as well as states and tribes, set priorities for water resource protection and restoration. The NCCA focused on estuaries and Great Lakes waters in the continental United States (except Alaska); however, NARS works with Alaska, Hawaii and U.S. territories to implement related statistical surveys. Some highlights of this work can be found at https://www.epa.gov/national-aquatic-resource-surveys. Additionally, researchers are considering using NCCA protocols to assess the waters that connect the Great Lakes to each other (Wick et al. 2019).



Coming Up in This Report…

- **Chapter 2, Design of the Coastal Survey,** identifies the ecological and human health indicators reported by the NCCA and discusses the survey's sampling and analytical methodologies.
- **Chapter 3, The Condition of Our Estuarine Coastal Waters,** presents results from the survey of estuaries, with one section for each of seven estuarine indicators.
- **Chapter 4, The Condition of Our Great Lakes Nearshore Waters,** focuses on findings from the Great Lakes survey, again with one section for each of seven Great Lakes indicators and one section on the Great Lakes Human Health Fish Fillet Tissue Study.
- **Chapter 5, Conclusion,** presents conclusions and describes next steps for the NCCA and NARS program.

2 Design of the Coastal Survey

The NCCA is a large-scale statistical survey of the condition of U.S. estuaries and the nearshore Great Lakes. Such surveys cost-effectively ensure that data collected from a sample (subset) of waters represent the broader population being surveyed. The NCCA results are representative of these waters on a national and regional scale (this includes being representative of the nearshore Great Lakes as a whole, as well as of individual Great Lakes). However, these national and regional results cannot be used to infer condition at specific estuaries or nearshore Great Lakes locations. As a statistical survey of coastal waters, the NCCA design does not target known contaminated areas.

This chapter describes the elements that make up the NCCA, including the estuarine and nearshore Great Lakes waters available to be assessed (or target populations), site selection procedures, and indicators. It also briefly describes how samples are collected and analyzed and how data are used to develop assessments of condition. For more details on these topics, please see the *NCCA 2015 Technical Support Document* (U.S. EPA 2021).

WATERS SURVEYED BY THE NCCA

EPA chose to focus on estuaries and the nearshore Great Lakes for the NCCA due to these waters' ecological and economic importance. Estuarine and nearshore Great Lakes waters were assessed separately because they have different water chemistry and ecology and are subject to different physical phenomena. See Figure 2.1 for illustrations of the two coastal water types.

EPA defined the upstream boundary of an estuary as the location at which salinity is 0.5 parts per thousand (or ppt), meaning little seawater is present (average salinity in the open ocean is 35 ppt). The boundary with the ocean was defined by an imaginary line drawn between the two outermost land features bordering the estuary. Examples of estuaries include San Francisco Bay and Puget Sound, portions of the Atlantic Intracoastal Waterway, and barrier island lagoon systems such as Santa Rosa Sound in the Florida panhandle.

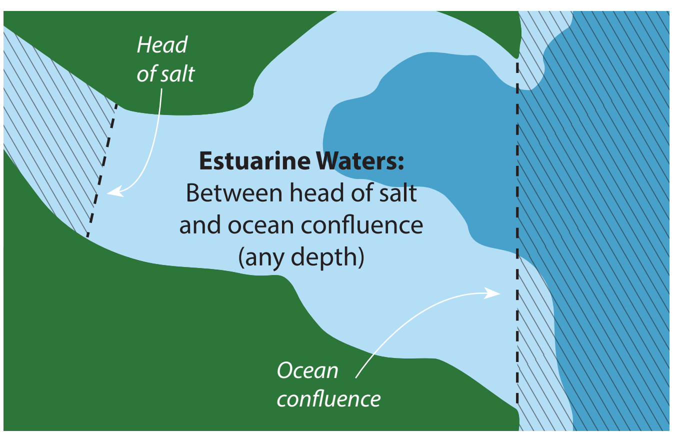
The nearshore Great Lakes were defined as waters up to 30 meters in depth but extending no more than 5 kilometers from shore. The NCCA focused on the nearshore zone because conditions there were expected to be directly influenced by watershed conditions or tributary inflows (Yurista et al. 2016).

Figure 2.1. What Coastal Areas Were Included in the NCCA?

The NCCA assessed estuaries and the Great Lakes separately. The areas covered by these two sets of waters are referred to as the target populations for the survey. Sampling sites were drawn from maps representing these two distinct populations.

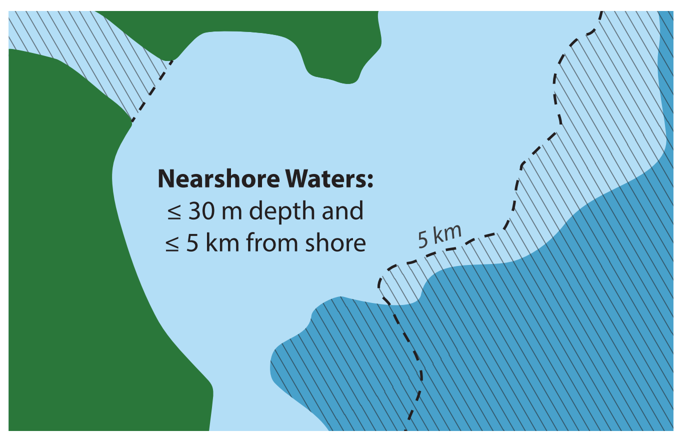
Estuarine Waters
The target population for estuaries included all U.S. estuarine coastal waters bordering the 48 contiguous states.

Within these areas, **estuarine waters** were defined as extending from the head of salt[†] to the ocean confluence.[‡] The image below shows an example of an estuary and its borders as defined for the NCCA.



Great Lakes Waters
The Great Lakes target population included all nearshore Great Lakes waters within U.S. boundaries.

Great Lakes nearshore waters were defined as all waters up to 30 meters in depth but no more than 5 kilometers from shore. The image below shows an example of nearshore waters at a local scale.



Legend ≤ 30 m depth | >30 m depth | Waters excluded from target population

[†] Salinity of 0.5 ppt.
[‡] Delineated by an invisible line drawn between the outermost land features bordering the estuary.

HOW WERE SAMPLING SITES CHOSEN?

As with other NARS surveys, the survey approach estimates the status of the target population (consisting of all estuarine and nearshore Great Lakes waters, as defined above), using a representative sample of comparatively few population members, or sites. EPA statisticians selected sampling locations based on stratified random sampling, an approach often used in ecological, social science and public health surveys. This process divides estuaries and nearshore Great Lakes waters into groups (called strata) based on characteristics such as ecology and geography and allows determination of conditions at regional and national scales.

EPA randomly selected sites with unequal probability of selection within each stratum. EPA sampled new sites, as well as sites randomly selected from those previously sampled in NCCA 2010. Resampling sites from 2010 improved EPA's estimate of changes in estuary and nearshore Great Lakes condition. The survey design requires that estimates presented in the report are weighted means, where the weights account for the stratification and unequal probability of selection.

EPA designed the NCCA to estimate the national condition of coastal waters with a margin of error of ±5% and 95% confidence. That is, enough sites were sampled that one can be 95% confident that the actual coastal area in good condition (or fair or poor condition) was within 5% of the estimated value. The NCCA also allows condition estimates at smaller scales (e.g., at regional scales or for individual Great Lakes), but with a wider margin of error because there are fewer sites per region. Data collected by the NCCA can be used to supplement state and tribal data collection, but they are not intended to be used to assess conditions in areas known to be contaminated, such as those designated as Areas of Concern under the Great Lakes Water Quality Agreement.

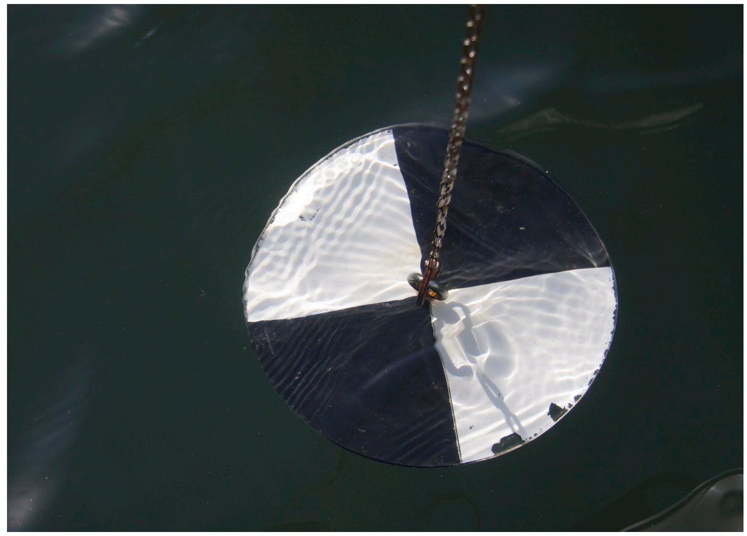
HOW WERE SAMPLING SITES EVALUATED FOR VALIDITY AND AVAILABILITY?

- After site selection, field crews conducted desktop reconnaissance, reviewing maps and geographic information systems to ensure that the selected sites were part of the target population and were in safe and accessible waters.
- Sites that were not dropped as a result of desktop reconnaissance were verified in the field to ensure they met the definition of the target population and were accessible.
- Any site disqualified during the desktop or field evaluation was dropped and replaced with an alternate site in the same stratum; alternate sites came from a separate group of randomly selected replacement sites. Crews followed specific rules when replacing sites to maintain the statistical validity of the survey. In 2015, fewer than 10% of the sites in the original draw needed to be replaced.

An NCCA crew measures light penetration with an underwater light meter.

WHAT DID THE SURVEY MEASURE?

NCCA field crews collected data on water clarity, dissolved oxygen, chlorophyll *a* and pollutants (nutrients, bacteria and microcystins). The NCCA also assessed contamination of sediment and fish tissue and analyzed benthic macroinvertebrate populations.[3] See the descriptions of indicators below.



A Secchi disk used to measure water clarity.

NCCA staff then used these data to calculate values for several ecological and human health indicators, analyzing those values to determine condition. EPA evaluated each ecological indicator by combining data on multiple parameters into one index score or rating. For example, the eutrophication index was based on a combination of water chemistry, water clarity and chlorophyll *a* data. Human health indicator scores were determined by comparing concentrations of individual parameters to scientific or regulatory benchmarks. Note that the NCCA included three different indicators for measuring contaminants in fish tissue (one ecological indicator and two human health indicators). The NCCA indicators are described briefly below, and the methodology for determining indicator ratings is shown later in this chapter.

Ecological Indicators

- **Biological Condition.** Estimates the condition of the benthic macroinvertebrate community, combining measurements of organism diversity, abundance and sensitivity to pollution into one index score.
- **Eutrophication.** Describes the impacts of nutrient over-enrichment, which may lead to conditions associated with different stages of harmful algal blooms. It is based on measurements of nutrients, dissolved oxygen, chlorophyll *a* and water clarity. (Chlorophyll *a* indicates the presence of phytoplankton, such as microscopic algae and cyanobacteria, which under certain conditions can cause such blooms.)
- **Sediment Quality.** Combines two sediment indices, one that measures concentrations of chemical contaminants found in sediment and another that assesses how toxic the sediment is to live organisms.
- **Ecological Effects of Fish Tissue Contamination.** Measures the concentrations of metals and organic contaminants in a whole fish composite sample to estimate the likelihood of negative effects to wildlife eating these fish.

Human Health Indicators

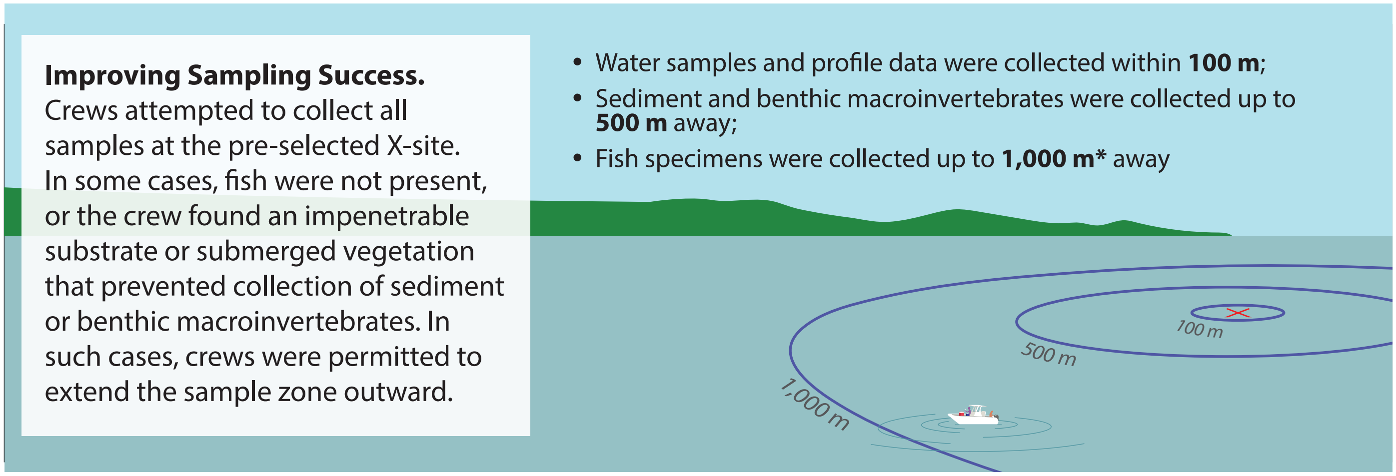
- **Enterococci Contamination.** Enterococci bacteria are used as indicators of possible fecal contamination. This indicator assesses enterococci DNA.
- **Microcystins.** Measures microcystins, a group of naturally occurring toxins produced by some types of cyanobacteria (blue-green algae).
- **Contaminants in Fish Tissue**
    - **Mercury in Fish Fillet Plugs.** Based on fish fillet "plug" samples analyzed for mercury. Uses fish species commonly eaten by recreational anglers. A "plug" is a small (~ 8 mm) biopsy taken from muscle tissue.
    - **Great Lakes Human Health Fish Fillet Tissue Study.** In the Great Lakes only, assesses mercury, polychlorinated biphenyls (PCBs), and per- and polyfluoroalkyl substances (PFAS) in fillets of fish species that are commonly consumed by humans.

[3] Benthic macroinvertebrates are insects, worms, mollusks and crustaceans that live in sediments.

HOW WERE DATA AND SAMPLES COLLECTED?

Sampling Locations. Field crews collected samples and data at the pre-selected sampling coordinates (called the X-site). Protocols allowed sampling from an area with an expanded radius if necessary (see Figure 2.2). Field measurements were recorded electronically and samples were sent to laboratories for analysis. EPA trained and audited each crew to ensure protocols were followed, and 10% of the survey sites were revisited as part of the survey's quality assurance measures. For detailed information on NCCA sample collection and processing, please see the *NCCA 2015 Field Operations Manual* (U.S. EPA 2015) and *NCCA 2015 Laboratory Operations Manual* (U.S. EPA 2016a).

Figure 2.2. Where Did the NCCA Collect Samples?

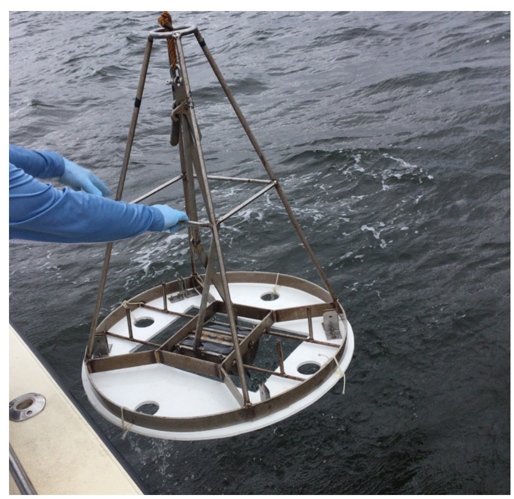


*For Great Lakes Human Health Fish Fillet Tissue Study specimens only, crews could extend the collection radius up to **1,500 meters** from the X-site.

In Situ Measurements. Crews used instruments to determine the depth of the water and to collect profile data for temperature, dissolved oxygen, salinity or conductivity, and pH. They determined water clarity using a Secchi disc and light attenuation using a light meter.[4] At Great Lakes sites only, crews collected video footage of the lake bottom to identify invasive species.

Water Sample Collection and Processing. Field crews collected water samples for total and dissolved nitrogen and phosphorus, chlorophyll *a*, enterococci, and microcystins. They used equipment such as submersible water collection bottles or pumps. Some types of water samples were filtered. All water samples were either shipped chilled overnight or frozen and shipped to laboratories on dry ice.

Sediment Sample Collection and Processing. The objective of sediment collection is to obtain a thin layer of sediment from the sediment/water column interface. Crews collected about 2 to 4 liters of sediment for use in contaminant analysis and toxicity testing. They used a stainless steel grab apparatus, carefully scraping the top 2 centimeters from multiple grabs, and thoroughly mixed the samples into a composite. The mixture was divided into several containers, which were shipped to the laboratories.



A Young-modified Van Veen grab sampler used for sediment collection.

Benthic Macroinvertebrate Sample Collection and Processing. A sediment grab was used to collect invertebrates. The sample was gently rinsed using site water over a 500-micron (0.5-millimeter) sieve to remove sediment but retain organisms. The material remaining on the sieve was placed into a jar with preservative and shipped to the laboratory. Benthic macroinvertebrate specimens were also stained to facilitate identification.

[4] Secchi discs are black and white discs lowered into the water. The point at which they are no longer visible is the Secchi depth, used to measure clarity. The NCCA used light meters that detect light at wavelengths active in photosynthesis (400 to 700 nanometers).

Fish Sample Collection and Processing. At each estuarine and Great Lakes site, crews collected a whole fish composite sample for ecological contaminant analysis and a fish fillet plug sample to analyze for mercury. At Great Lakes sites only, crews collected a third fish sample to analyze fillets for a suite of contaminants that may impact human health. The collection procedures for each indicator are summarized below. For further details, please see the *NCCA 2015 Technical Support Document*.

Whole Fish Composite for Ecological Contaminant Analysis

Whole fish were collected because this analysis looks at the impact on fish predators, which eat the entire fish.

- Fish species collected were targeted from a list of common forage fish.
- The minimum targeted fish size was 100 millimeters (mm); the maximum targeted size was 400 mm, with the smallest fish being no smaller than 75% of the length of the largest fish.
- The minimum targeted composite mass was 300 grams (g).
- The targeted number of specimens in a composite: five to 20.
- Collected fish were composited into one bag and frozen.
- Sometimes the species and size targets could not be met; in such cases, crews collected non-target fish.

Fish Fillet Plug Sample for Mercury Analysis

Fish fillet (muscle) biopsy samples (plugs) were collected to assess human exposure to mercury from fish consumption; this is an inexpensive method for assessing risk and was applied at both estuarine and Great Lakes sites. This method was new for NCCA 2015.

- Fish species were targeted from a list of species consumed by people.
- The minimum length was 190 mm.
- Fish not meeting size or species requirements were released and not sampled.
- An 8-mm biopsy plug was taken from fillet tissue of either two fish of the same species, or both sides of one fish.
- Sometimes plugs could be collected from ecological fish tissue specimens. When they could not, samples were instead collected from live fish that were then treated with antibiotic salve and released.
- Samples were frozen in a glass vial.

Great Lakes Human Health Fish Fillet Tissue Sample for Analysis of Multiple Contaminants

In the Great Lakes only, fish samples were collected for analysis of fillets to assess human exposure to multiple chemical contaminants due to fish consumption. This method accommodates analysis of a number of contaminants in fillets of fish species eaten by people.

- Fish species were targeted from a narrow list of those commonly consumed by people.
- The minimum size was 190 mm, with the smallest fish being no smaller than 75% of the length of the largest fish.
- Fish not meeting size or species requirements were released and not sampled.
- The number of specimens in a fish composite sample was ideally five of the same species, but samples containing one to 10 specimens of the same species were accepted.
- Whole fish samples were frozen on dry ice and shipped to the laboratory for filleting and preparation of fillet composite samples.

HOW DID EPA ANALYZE THE RESULTS?

To characterize coastal conditions, EPA interpreted the data collected by field crews using applicable and available benchmarks. For each ecological indicator, EPA calculated an index score to rate a site good, fair or poor, as described below. For human health indicators, EPA compared the numeric results to human health benchmarks and evaluated condition in relation to the benchmarks (i.e., "at or below" or "above" the benchmark). For details about the analyses described below, please see Appendix B (for ecological indicators) or the *NCCA 2015 Technical Support Document* (U.S. EPA 2021).

In some cases, field crews were unable to collect samples at a site, or the samples that were collected could not be analyzed. EPA considered the area represented by that site to be "unassessed" or "not assessed" for the associated indicator. Appendix B discusses some of the reasons coastal area might not be assessed. With every NCCA, EPA strives to improve sampling and other procedures to reduce the amount of area that is not assessed.

For most NCCA indicators, EPA provides results as a percentage of the target population, where the assessed area (e.g., the sum of area in good, fair and poor condition) and the unassessed area add to 100%. For the Great Lakes Human Health Fish Fillet Tissue Study only, results are provided as a percentage of the assessed area, which is referred to as the sampled population, along with the number of square miles of Great Lakes nearshore area in the sampled population.

Biological Condition. The NCCA assessed the biological condition of estuaries using a new national benthic macroinvertebrate index called the M-AMBI, a modification of an index used in water quality programs in Europe (Pelletier et al. 2018). The index considers the relative abundance of benthic taxa that tolerate degraded conditions, along with measures of overall diversity and species richness.[5] These three metrics are combined to develop an index value. Good sites have a wide variety of species, more diversity, and fewer pollution-tolerant species than fair or poor sites. Scores range from zero to 1, with scores <0.39 indicating poor condition.

In the Great Lakes, the NCCA used an index called the oligochaete trophic index (Milbrink 1983; Environment Canada and U.S. EPA 2014) to assess biological condition. This index relies on the classification of oligochaete species (aquatic worms) by their known tolerance to organic enrichment, taking abundance into account. A higher proportion of species that are tolerant to organic enrichment reflects poorer biological condition. Scores range from zero (indicating more species with low tolerance to enrichment) to 3 (indicating more species with high tolerance). A score >1 indicates poor condition.

Eutrophication. This water quality indicator measures nutrients, chlorophyll *a*, dissolved oxygen and water clarity to characterize the possibility that a water body is experiencing one of three stages of eutrophication: pre-algal bloom, bloom or post-bloom. Using regionally relevant benchmarks, EPA assigned each individual parameter a rating of good, fair or poor. Table 2.1 illustrates how poor condition (shown in pink) for different parameters is associated with each stage.

A site's overall rating depended on the number of good, fair and poor ratings for individual parameters. If any two individual parameters were in poor condition, the site was rated "poor" for the eutrophication index. The site was rated fair if any two parameters were in fair condition or any one was in poor condition.

Table 2.1. Water Quality Characteristics in Each Stage of Eutrophication

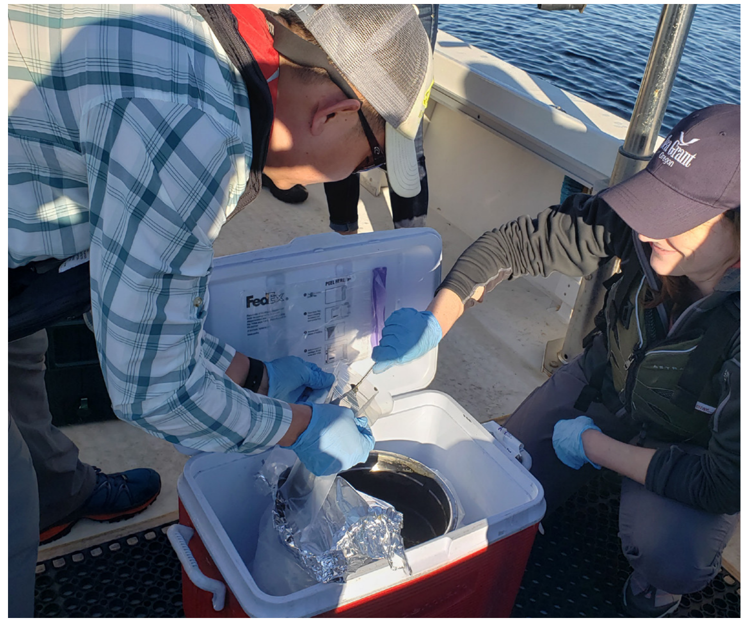
Parameters	Pre-Bloom	Bloom	Post-Bloom
Nutrients†	Excessive	Diminishing	Depleted
Chlorophyll *a*	Normal	Over-abundant	Clearing
Water Clarity	Clear	Low	Low
Dissolved Oxygen	Normal	Normal	Depleted

† The NCCA assesses dissolved inorganic phosphorus and dissolved inorganic nitrogen for estuaries and total phosphorus for the Great Lakes.

[5] Taxa are groups of organisms used for classification. Examples include species, families, and orders. Diversity indices account for the number of species present and the abundance of each species, while species richness refers to just the number of species.

Sediment Quality. The NCCA sediment quality index combines indices of contamination and toxicity to estimate whether sediments have the potential to cause adverse health effects to benthic organisms. For the contaminant index, EPA compared sediment concentrations of metals, PCBs, polyaromatic hydrocarbons and pesticides to benchmarks for adverse effects from scientific literature, including studies by EPA and the National Oceanic and Atmospheric Administration. EPA rated sites good, fair or poor based on whether and by how much they exceeded the benchmarks.

For the toxicity index, the survival of laboratory organisms exposed to sampled sediments was compared to that of organisms exposed to clean uncontaminated sediments. Good, fair and poor ratings were developed based upon the difference in survival between these two groups.

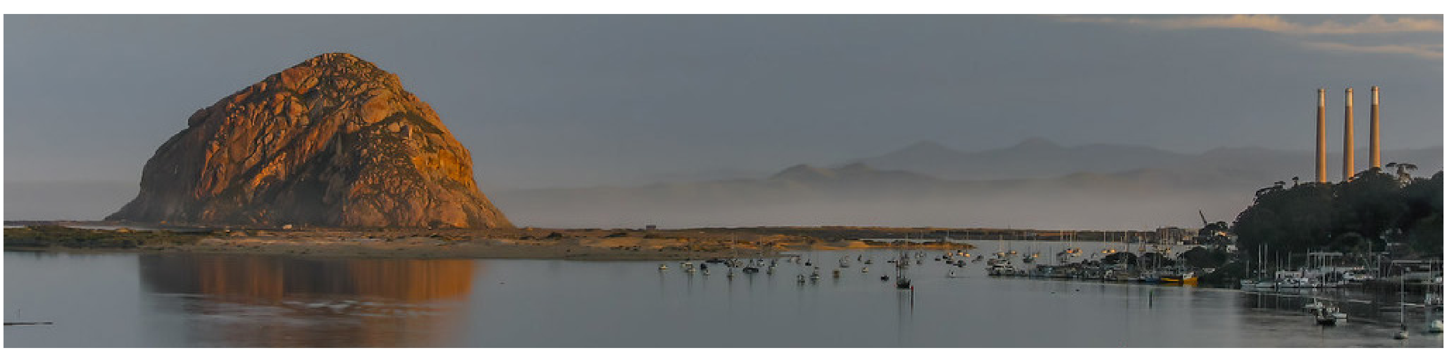


An NCCA crew fills a plastic bag with a sediment sample.

The NCCA combined results of these two indices to give each site a sediment quality condition score of good, fair or poor. Combining the results provides a fuller picture of the sediment quality at a site. The sediment contaminant index accounts for ecological risk for a select group of well-characterized contaminants. The sediment toxicity index accounts for the fact that risk-based thresholds do not exist for most of the thousands of chemicals 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 in the environment.

Ecological Effects of Contamination in Fish. The ecological fish tissue contamination index indicates whether predatory fish, birds or mammals ("receptor groups") could experience adverse, nonlethal effects such as stunted growth or reduced reproductive success from eating contaminated fish. Whole-body fish composites from each site were analyzed for concentrations of metals, pesticides and PCBs. Results were compared to toxicity screening values (concentrations at which contaminants are known to cause adverse effects in receptors, based on lab studies). EPA rated sites good, fair or poor based on the number of receptor groups for which screening values were exceeded. EPA updated the methods used to calculate this indicator to more appropriately account for predator body weights and ingestion rates and applied the update to 2010 and 2015 data. Please see the *NCCA 2015 Technical Support Document* for a description of the update. In addition, the NCCA has compared the concentration of selenium alone in fish composites to EPA's recommended whole-body *Aquatic Life Ambient Water Quality Criterion for Selenium—Freshwater* (2016b), developed under Clean Water Act section 304(a).[6]

Enterococci Contamination. The NCCA used a method called quantitative polymerase chain reaction (qPCR) to detect and quantify enterococci DNA in water from each site. This rapid analysis method produces results expressed in units of calibrator cell equivalents (CCE) per 100 milliliters (mL). Results from each site sample were compared to the benchmark of 1,280 CCE/100 mL from EPA's 2012 recreational water quality criteria document.



[6] EPA applied the freshwater criterion in both the Great Lakes and estuaries. EPA's 1999 saltwater aquatic life criterion for selenium (U.S. EPA n.d.) is based on concentration in water rather than in fish tissue and is not applicable to this analysis.

Microcystins. Microcystins were measured using a technique called enzyme-linked immunosorbent assay (ELISA). Concentrations of microcystins at each site were evaluated against the EPA 2019 recreational water quality criterion benchmark of 8 micrograms per liter (µg/L).

Mercury in Fish Fillet Plugs. EPA's fish-tissue-based human health water quality criterion (2001) for methylmercury is 0.3 milligrams of methylmercury per kilogram of tissue (wet weight), or 300 parts per billion (ppb). Because most mercury in fish tissue is methylmercury, EPA guidance recommends measuring total mercury. The NCCA rated sites by comparing the total mercury concentrations in fish fillet plugs to the 300 ppb benchmark.

The results for mercury in fish fillet plugs (Figures 3.7.1 and 4.7.1) apply to the entire target populations of estuarine and nearshore Great Lakes sites, the same populations defined for the other indicators in this report (except the Great Lakes human health fish fillet indicator, as noted below). Consistent with those other indicators, sites at which plug samples were not collected contribute to estimation of the unassessed area for the indicator, for each target population.

Great Lakes Human Health Fish Fillet Tissue Study. In the Great Lakes only, the NCCA included collection of additional fish composite samples to prepare and analyze fillet composite samples for multiple contaminants in fish that could affect human health. Fillet composite samples were homogenized and analyzed for total mercury, total PCBs, and PFAS. Mercury results were compared to the 300 ppb mercury benchmark described above for plug samples. Results from the PCB and PFAS analyses were compared to EPA human health fish tissue benchmarks that were derived using a 32 g/day (one 8-ounce meal/week) fish consumption rate. These benchmarks are 49 ppb for total PCB noncancer effects, 12 ppb for total PCB cancer effects, and 46 ppb for perfluorooctane sulfonate (PFOS), a common PFAS. The benchmarks are associated with the average consumption rate for people who consume Great Lakes fish. EPA has not established benchmarks for other PFAS.

The sampled population for the Great Lakes Human Health Fish Fillet Tissue Study is the subset of the NCCA Great Lakes nearshore target population assessed for this study. It consists of 6,862 square miles of U.S. Great Lakes nearshore area. The mercury, PCB, and PFAS results for fillet composite samples (Figures 4.8.1, 4.8.2, and 4.8.3) apply to this sampled population. Mercury results from this study should not be compared to Great Lakes fillet plug mercury results because the fillet plug analysis includes assessed and unassessed Great Lakes nearshore areas.

3 The Condition of Our Estuarine Coastal Waters

This chapter summarizes the NCCA's key findings from the 2015 assessment of U.S. estuary condition.

Estuaries are particularly productive habitats for fish and wildlife, due to tidal mixing of the nutrients brought downstream by fresh waters. However, estuaries also receive inputs from agriculture, industry and growing coastal cities, which can result in excess nutrients and other pollutants.[7] Rising sea levels and temperatures are also changing estuarine ecology (Sweet et al. 2017; Fleming et al. 2018; Jewett and Romanou 2017).

As described in Chapter 2, for the NCCA, estuaries are defined as the area between the head of salt (where salinity is 0.5 parts per thousand) and the confluence with the ocean. (See Figure 2.1.)

[7] Shore-adjacent counties make up only 18% of U.S. land area but hold 37% of the U.S. population and are growing slightly faster than U.S. cities as a whole (Kildow et al. 2016).

HOW THIS CHAPTER IS ORGANIZED

This chapter presents information pertaining to each of the four NCCA ecological indicators and the three human health indicators (see box).

Each indicator section contains three parts: a brief explanation of why each indicator matters for U.S. estuaries, results from the 2015 survey, and change in condition over time, if data were available.[8] Some sections present additional information about methodology or findings.

NCCA Estuarine Indicators

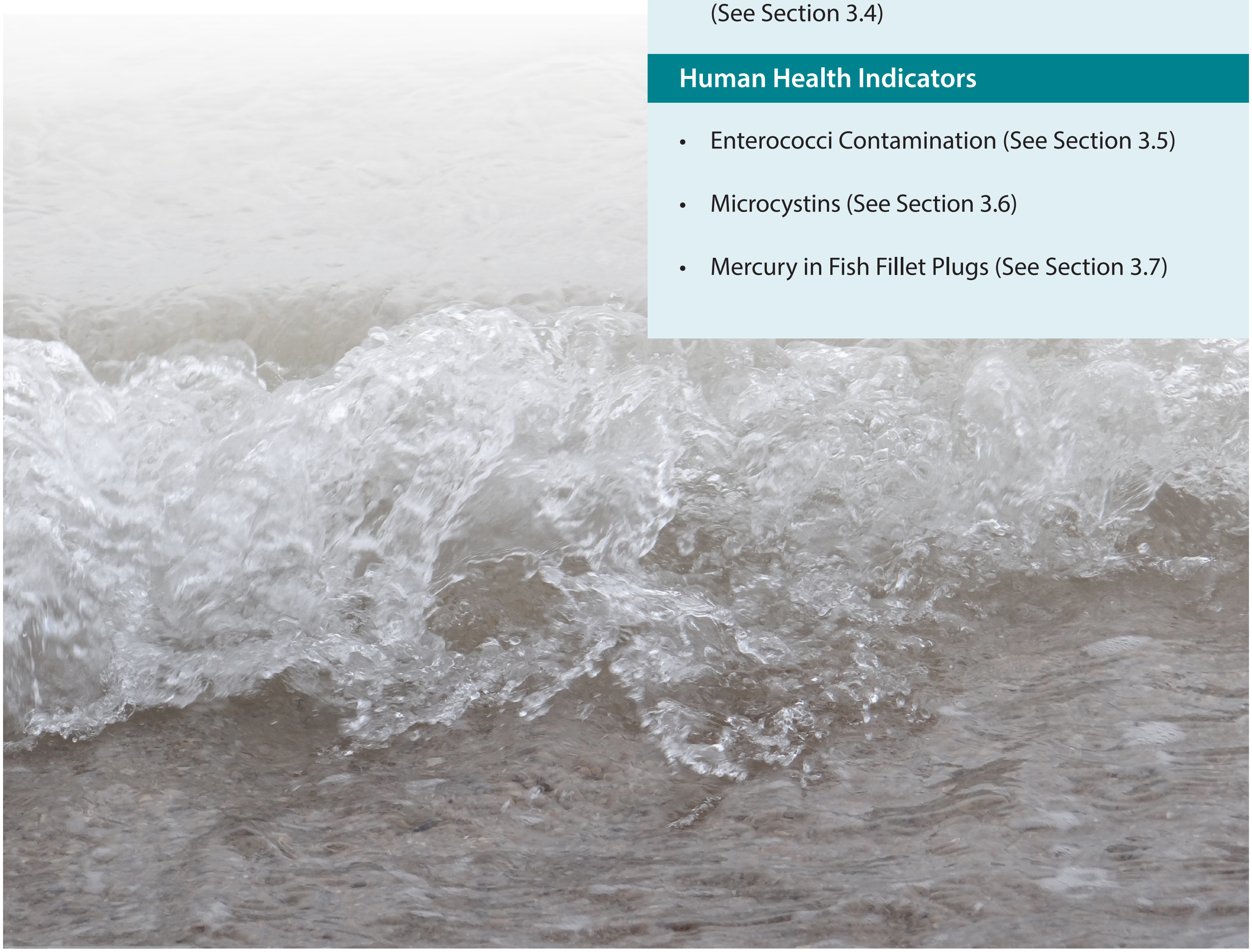
The NCCA uses seven indicators to assess the conditions of estuaries.

Ecological Indicators

- Biological Condition (See Section 3.1)
- Eutrophication (See Section 3.2)
- Sediment Quality (See Section 3.3)
- Ecological Effects of Contamination in Fish (See Section 3.4)

Human Health Indicators

- Enterococci Contamination (See Section 3.5)
- Microcystins (See Section 3.6)
- Mercury in Fish Fillet Plugs (See Section 3.7)

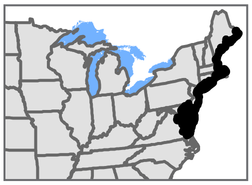


[8] Data on the ecological effects of fish tissue contamination were collected in both 2015 and 2010. Data were collected in 2015, 2010 and 2005-06 for the other three ecological indicators. (For brevity, the 2005-06 assessment is referred to in the bar graphs as simply '05.) The NCCA only began data collection for human health indicators in 2015, so no change analysis is possible at this time for those indicators.

HOW THE RESULTS ARE PRESENTED

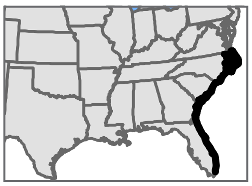
For estuaries, results are reported at the national level and for each of four distinct regions: Northeast, Southeast, Gulf and West (see Figure 3.0.1). For detailed maps of the sampling locations, see Appendix A.

Figure 3.0.1. Characteristics and Sample Size of the NCCA Estuarine Regions



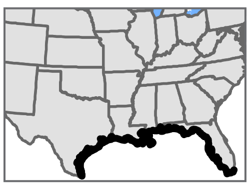
NORTHEAST

- **Extent.** Maine to the Virginia - North Carolina Border
- **Area Assessed.** 9,956 square miles by sampling 252 sites
- **Points of Interest.** The Chesapeake Bay is the largest estuary in the Northeast and in the country as a whole.



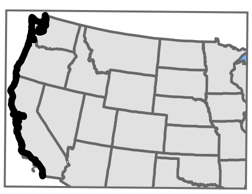
SOUTHEAST

- **Extent.** Virginia - North Carolina Border to Biscayne Bay, Florida
- **Area Assessed.** 4,604 square miles by sampling 86 sites
- **Points of Interest.** Coastal populations in the Southeast have more than doubled since 1970.



GULF

- **Extent.** Florida Bay to the Texas - Mexico Border
- **Area Assessed.** 10,715 square miles by sampling 237 sites.
- **Points of Interest.** Estuaries in Louisiana are disappearing due to sea level rise, land subsidence and reduced sediment input from the Mississippi River (U.S. Geological Survey 2017).



WEST

- **Extent.** Puget Sound, Washington to the California - Mexico Border.
- **Area Assessed.** 2,204 square miles by sampling 124 sites.
- **Points of Interest.** The West has a drier climate and fewer rivers, so overall estuary area is smaller than in other regions. San Francisco Bay is the largest estuary in the West.

The chapter uses bar graphs to compare data across the estuarine regions. Figures 3.0.2 and 3.0.3 describe some of the features of these graphs.

Figure 3.0.2. Data on 2015 Condition

For each indicator, graphs show the percentage of U.S. estuarine area in each condition category. Categories include good, fair, or poor for ecological indicators; not detected, at or below benchmark, or above benchmark for human health indicators; or not assessed when samples could not be collected. Below, for one indicator, we see the percentage in good condition for the estuaries as a whole and for each of the four NCCA estuarine regions. This report contains similar graphs for the other condition categories. Note that, due to rounding, percentages across all condition categories may not always add to 100%.

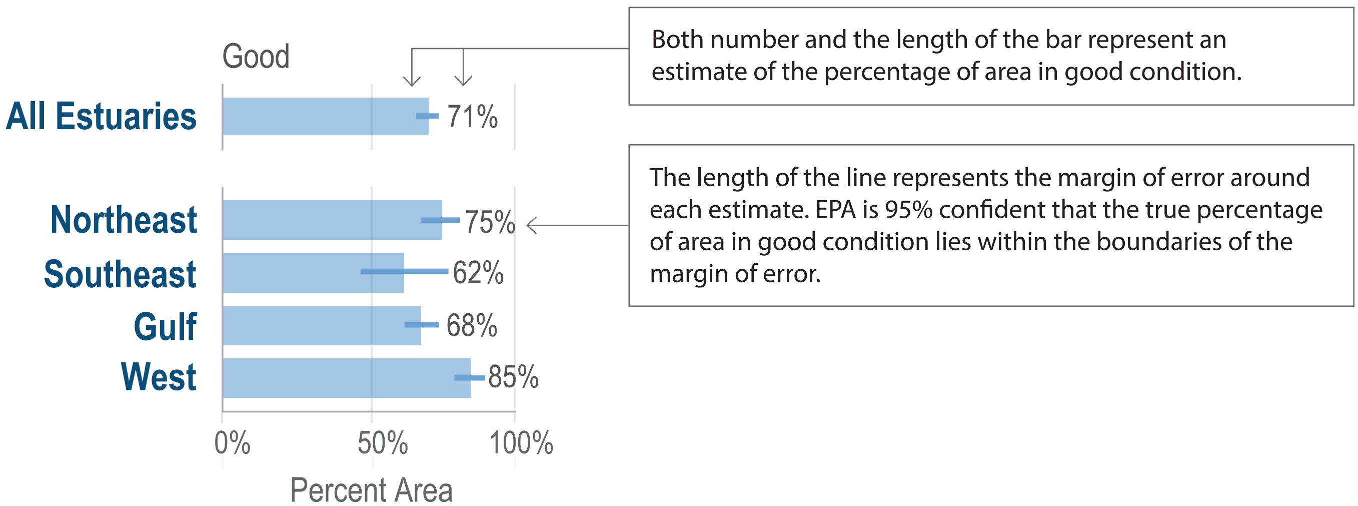
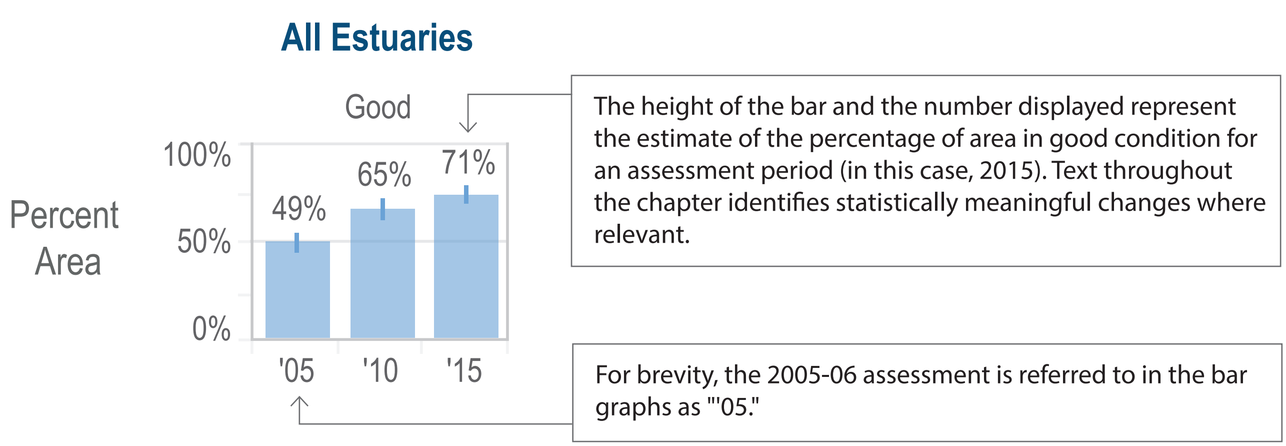


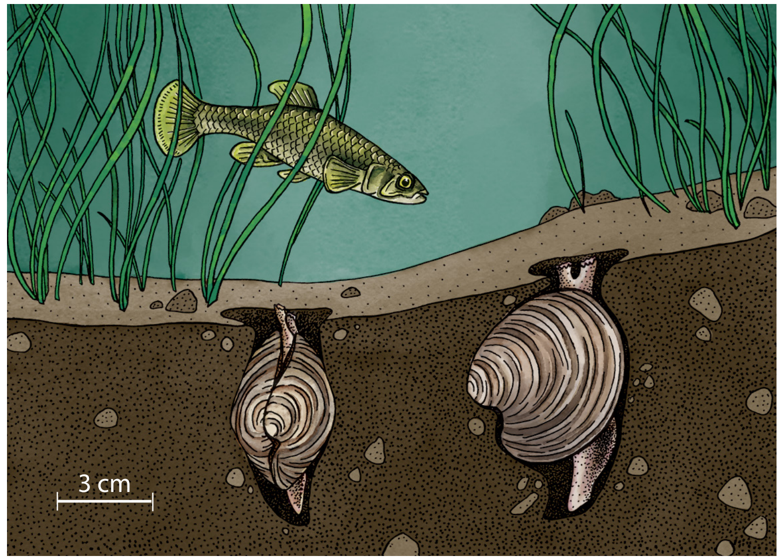
Figure 3.0.3. Data on Change from 2005-06 to 2015

For each ecological indicator, graphs show the change in percentage of estuarine area in each condition category over time. Below we see the change in percentage in good condition for one indicator for U.S. estuaries nationally. (In this case, we can see that the estimated area in good condition has been increasing since the 2005-06 assessment.) The chapter contains similar graphs for the other condition categories and the individual NCCA estuarine regions. Note that, due to rounding, percentages across all condition categories may not always add to 100%.



3.1 Biological Condition

The benthic macroinvertebrates that the NCCA uses to assess biological condition are animals such as worms, mollusks and crustaceans that live in the sediment of the estuary floor. They play an important role cycling carbon and nutrients and are food for many predators in the food web. Benthic macroinvertebrates are used as indicators of biological condition because they are relatively immobile, show signs of stress month to years after exposure and respond predictably to pollution. See Chapter 2 or Appendix B for information about how the NCCA assesses the benthic macroinvertebrate community in estuaries.



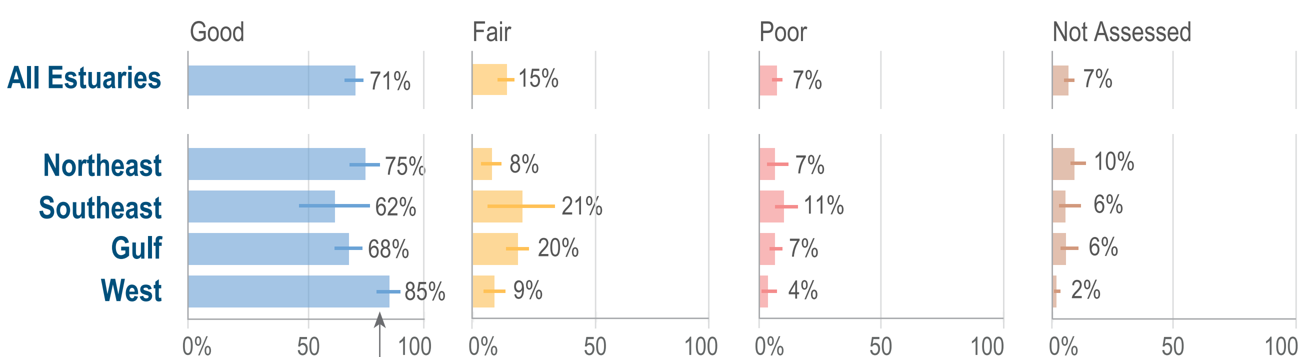
Benthic communities include worms, clams and crustaceans that live on and in the sediment. *Mercenaria mercenaria* (hard clams or quahogs) are bivalve filter feeders that can be a member of these communities. (Also shown: *Fundulus heteroclitus*, a small fish commonly known as a mummichog.)

What Was the Condition in 2015?

Nationally, about 71% of the nation's estuarine waters were in good biological condition based upon the new national index (the M-AMBI, discussed further on the next page). This indicates that, in 2015, most of the nation's estuarine waters supported a healthy benthic community.

Figure 3.1.1. Estuarine Biological Condition

Percent of estuarine area in each condition category (2015)



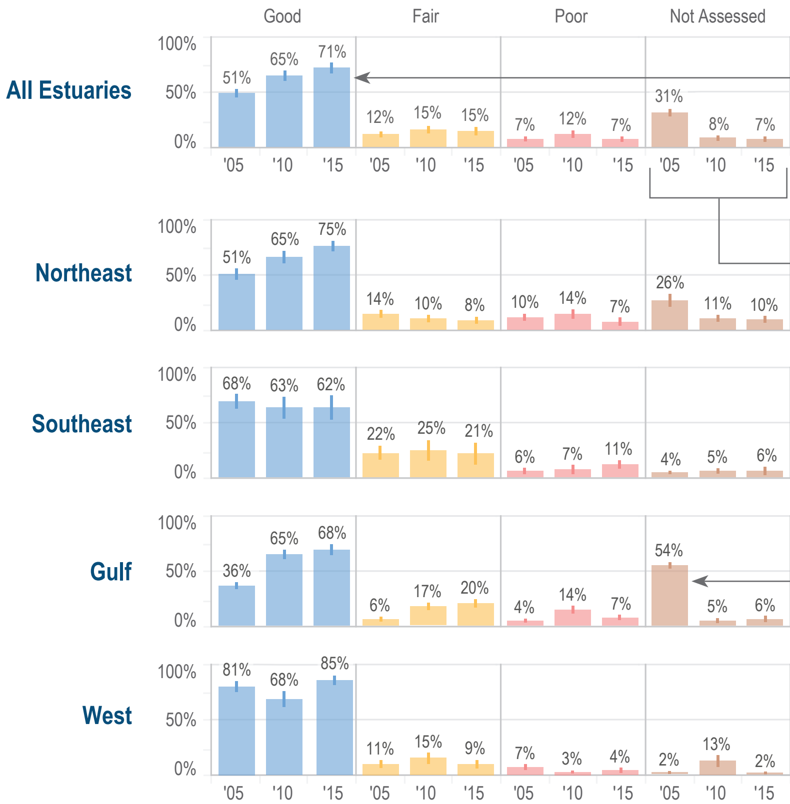
The estuarine waters of the **West Coast** had a higher proportion of area in good condition than other regions of the country, although not significantly different than the Northeast.

Did the Condition Change?

M-AMBI results indicate biological quality has been gradually improving over time in estuaries nationwide.

Figure 3.1.2. Change in Estuarine Biological Condition

Percent of estuarine area in each condition category (2005-2015)



Across **all estuaries** nationally, the NCCA identified a statistically significant increase in area rated good from 2005-06 to 2015, driven by changes in the Northeast and Gulf regions over the same time frame (below). It is possible the improvement was due in part to improved sample collection (i.e., reduction in area that was not assessed) rather than actual improved condition.

There was a significant reduction in area not assessed from 2005-06 to 2010 **nationally**, largely due to increased benthic sampling success across the estuaries of the Gulf Coast and the Northeast.

Hurricane Katrina heavily impacted field sampling efforts during 2005, preventing crews from sampling a large portion of the **Gulf** of Mexico.

Sediment samples are placed on a sieve and washed to remove sediment and expose macroinvertebrates.

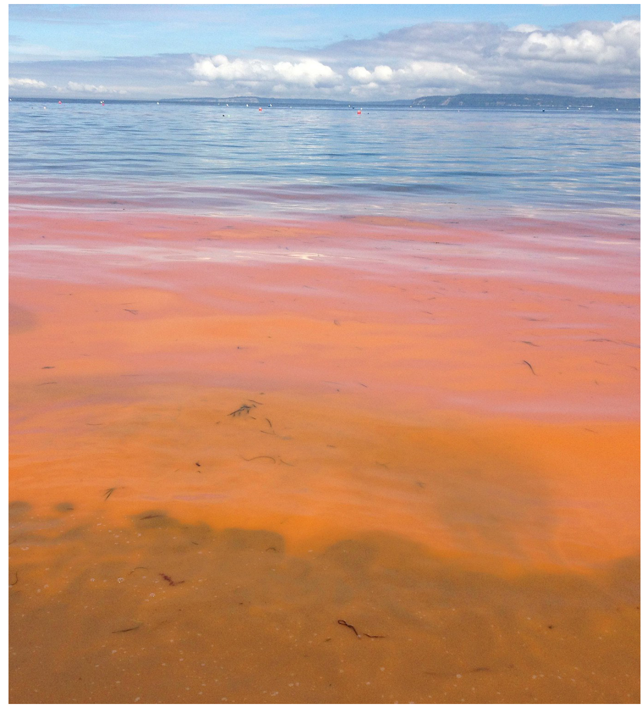
Comparing Benthic Communities Nationwide

Historically, the NCCA used different regional multimetric benthic indices and measures of diversity to assess biological condition. The different methods made it difficult to make national comparisons. To address this issue, scientists worked to develop a nationwide index, adapting a European marine biotic index (AMBI) for use in U.S. coastal waters. The Multivariate AMBI (M-AMBI) used in NCCA 2015 accounts for the biological responses of organisms to salinity. Although the M-AMBI itself is new, the data necessary to calculate M-AMBI scores are available from previous coastal surveys, so the M-AMBI can be used to calculate national estimates of change in biological condition over time, along with comparable regional estimates. For more information about the M-AMBI, please see Appendix B or the *NCCA 2015 Technical Support Document* (U.S. EPA 2021).

3.2 Eutrophication Index

One of the most critical water quality problems in estuaries is eutrophication, a condition caused by an overabundance of nutrients (NOAA National Centers for Coastal Science 2007). Excess nutrients can cause increased growth of phytoplankton (microscopic algae and cyanobacteria), known as harmful algal blooms. Blooms may prevent light from reaching seagrass beds that serve as nursery habitat for marine species. Post-bloom, decaying organic matter then consumes dissolved oxygen, stressing aquatic life and ecosystems. Sources of excess nutrients include urban and agricultural runoff and treated wastewater.

The eutrophication index assesses nutrient, dissolved oxygen and chlorophyll *a* concentrations, as well as water clarity. See Chapter 2 or Appendix B for more information about the eutrophication index and Section 3.6 for more on harmful algal blooms.



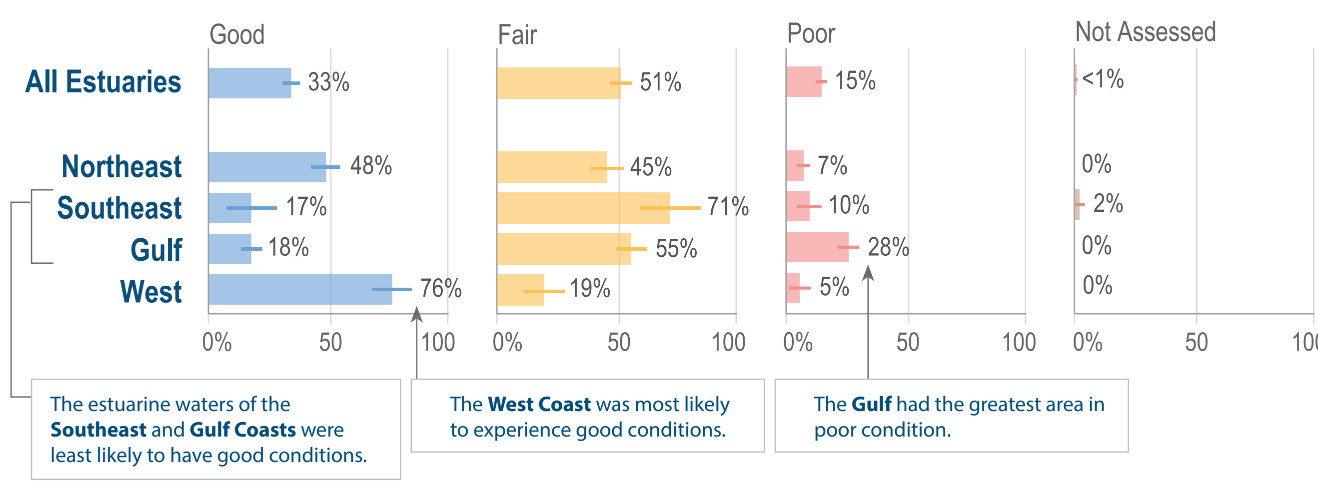
A red tide in Puget Sound, Washington, in 2013. Red tides are a type of harmful algal bloom often associated with eutrophication in estuaries.

What Was the Condition in 2015?

Nationally, results indicate that 66% of estuarine waters have an increased likelihood of being impacted by eutrophication, with about 51% in fair condition and 15% in poor condition. Elevated phosphorus and chlorophyll *a* were the underlying indicators driving fair and poor eutrophication index ratings.

Figure 3.2.1. Estuarine Eutrophication Condition

Percent of estuarine area in each condition category (2015)

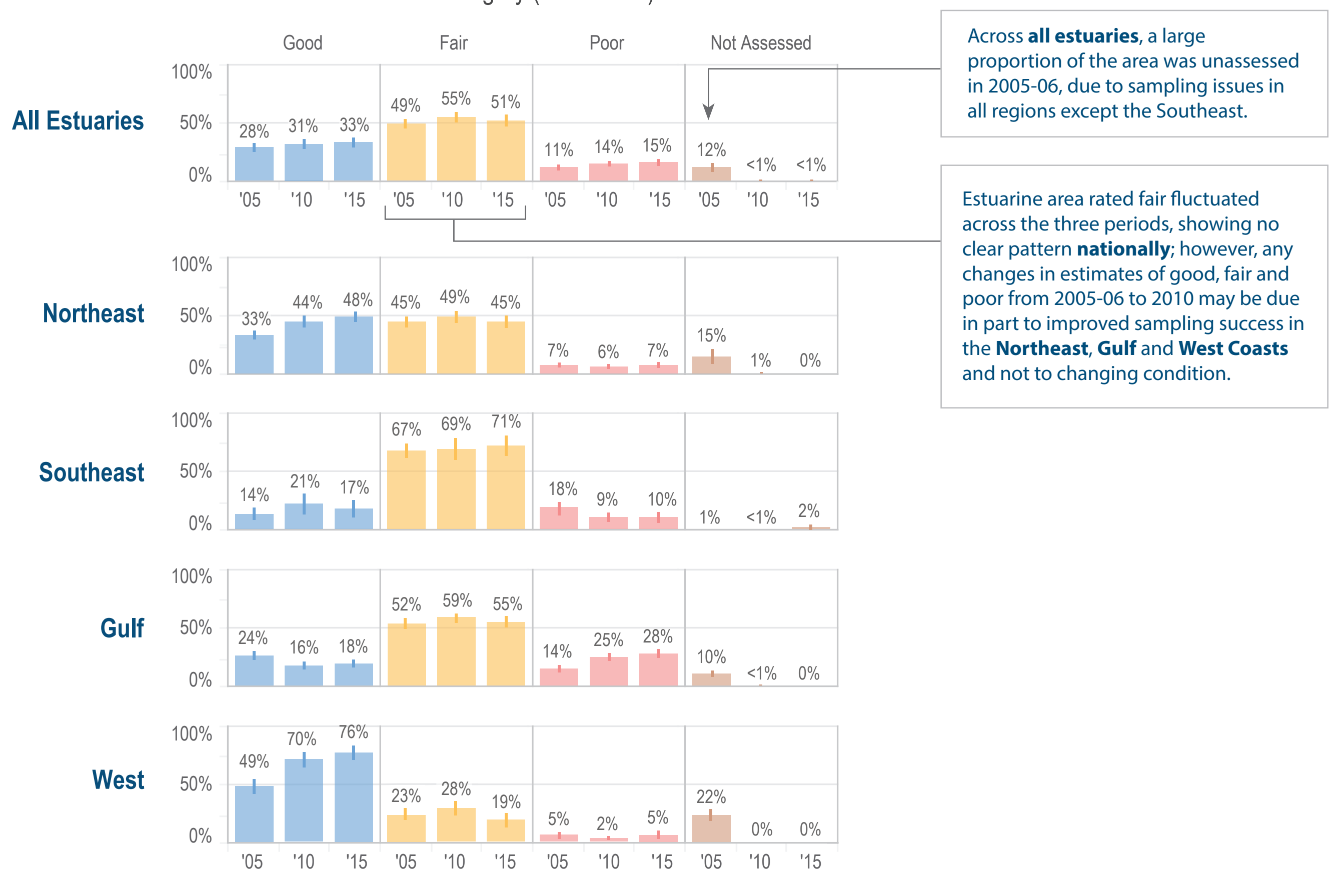


Did the Condition Change?

From 2005-06 to 2010, and from 2010 to 2015, there were no statistically significant changes in national estuarine eutrophication condition.

Figure 3.2.2. Change in Estuarine Eutrophication Condition

Percent of estuarine area in each condition category (2005-2015)



Algal blooms in the Gulf of Mexico.

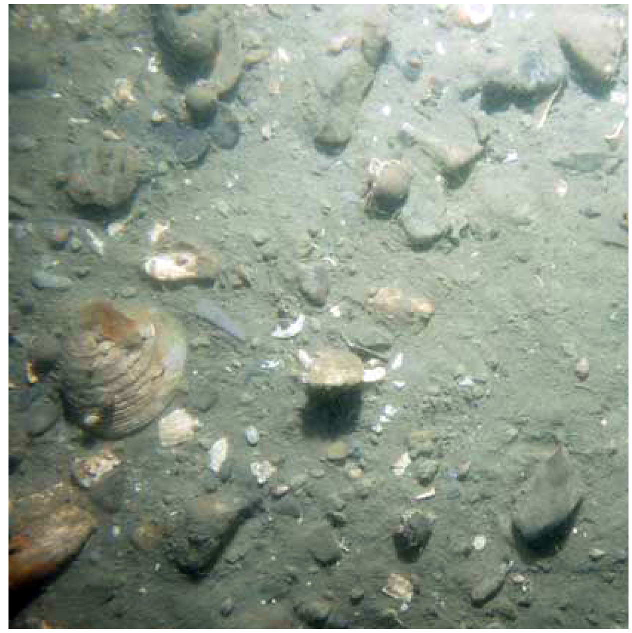
Low Oxygen in the Gulf of Mexico

Eutrophication occurs in estuaries across the country. For example, a hypoxic (low oxygen) zone forms offshore in the northern Gulf of Mexico every year as nutrient-laden water is delivered from the Mississippi/Atchafalaya River Basin. Although most of this "dead zone" forms in open water, estuaries may also be affected. In 2010, more than 400 coastal ecosystems (including some of the Great Lakes) were found to be hypoxic or at risk of hypoxia (U.S. EPA 2020). As part of the U.S. Hypoxia Task Force, EPA supports state members implementing nutrient reduction strategies to reduce the size of the hypoxic zone and improve local waters. EPA collaborates with other federal agencies on this effort. For more information, please visit https://www.epa.gov/ms-htf.

3.3 Sediment Quality

Sediments serve as important indicators of estuarine condition because they can accumulate persistent contaminants. These contaminants may adversely affect bottom-dwelling organisms. As predators eat sediment-dwellers, the contaminants can become concentrated throughout the food web, potentially affecting fish, marine mammals and humans who eat contaminated fish and shellfish.

The NCCA measures sediment contaminant concentrations and overall toxicity. Sediment contaminant tests detect select metals and organic compounds, while toxicity tests assess whether each estuarine sediment sample as a whole is toxic to laboratory organisms. See Chapter 2 or Appendix B for details about the sediment quality index.



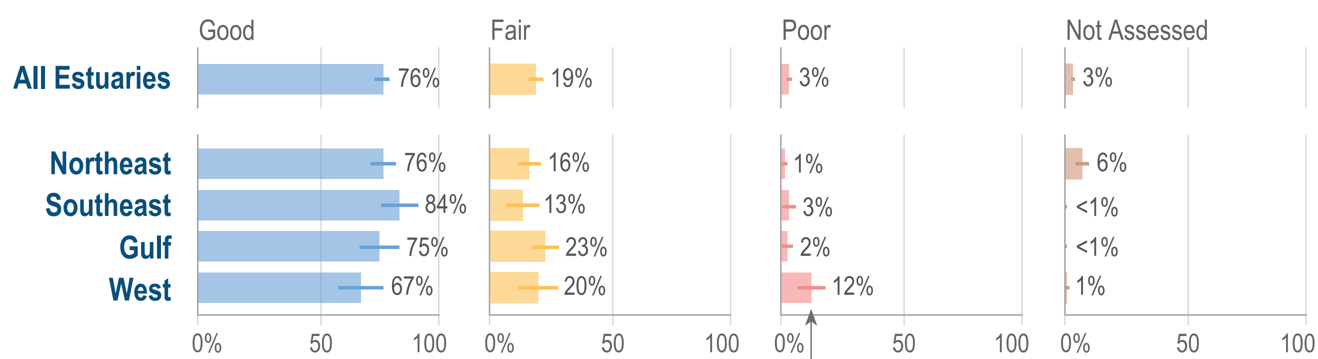
Sediment in Boston Harbor, from a U.S. Geological Survey mapping study.

What Was the Condition in 2015?

More than three-quarters of the estuarine waters were in good condition based on sediment quality, with no significant differences in good or fair ratings among the four NCCA regions.

Figure 3.3.1. Estuarine Sediment Quality

Percent of estuarine area in each condition category (2015)



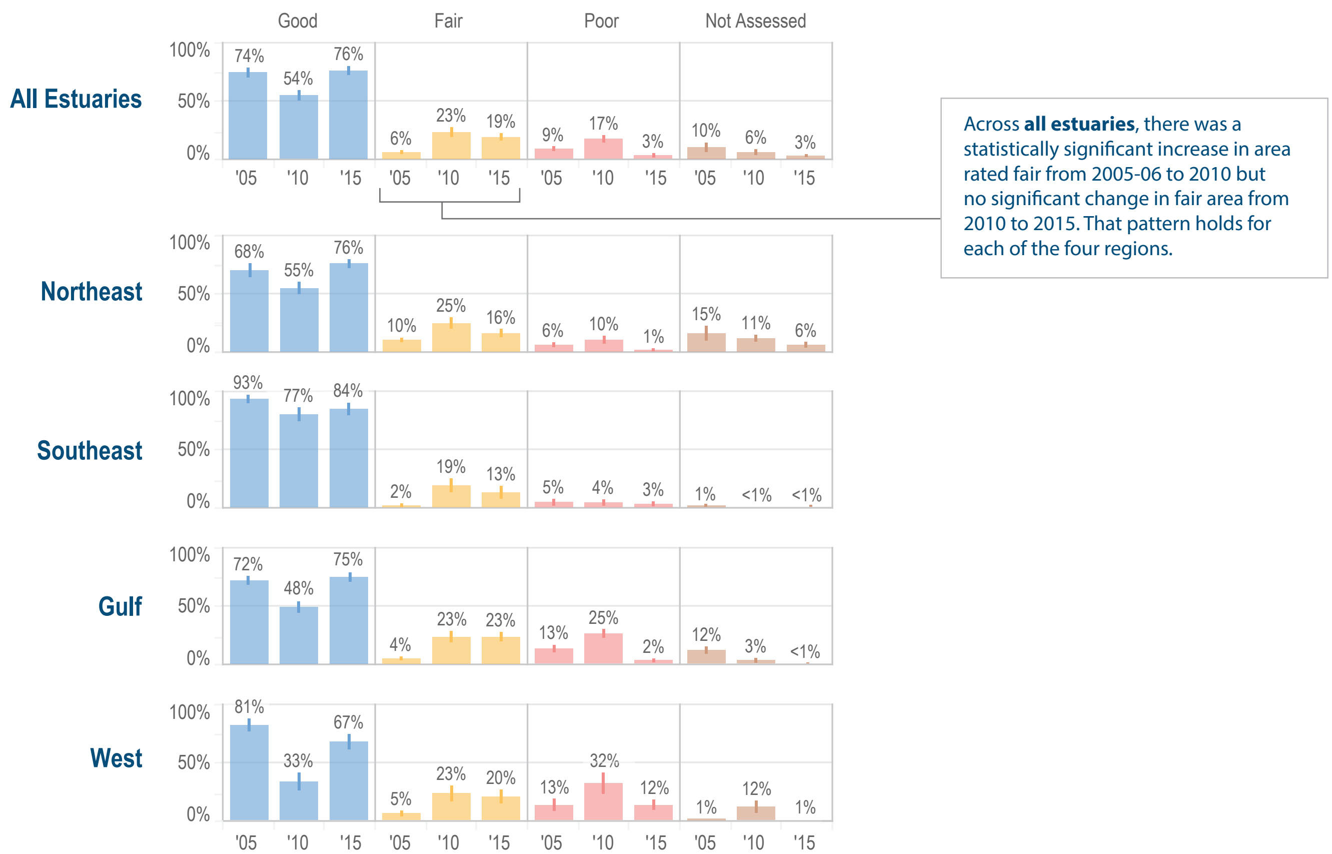
The **West Coast** had the largest proportion of estuarine area in poor condition; this difference was statistically significant. Further study is needed to determine the reason for the difference.

Did the Condition Change?

Nationally, estuarine sediment quality has fluctuated since 2005-06, but there has been no significant change in area rated good or poor since then.

Figure 3.3.2. Change in Estuarine Sediment Quality

Percent of estuarine area in each condition category (2005-2015)

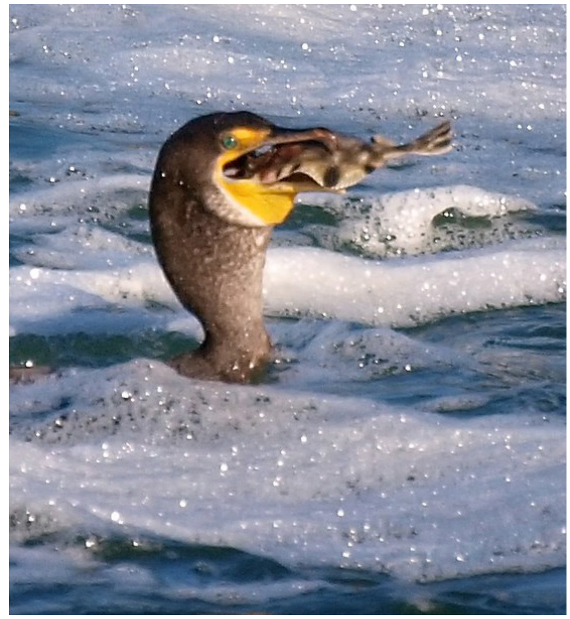



Sediment in good condition harbors benthic macroinvertebrates that serve as prey for organisms such as this scorpionfish in the Florida Keys (left) and these nudibranchs in California (right).

3.4 Ecological Effects of Contamination in Fish

Estuarine organisms at all levels of the food web may absorb chemical contaminants from the environment, although pathways differ depending on the organism. Organisms may take up contaminants directly from water, consume contaminated sediment, or consume contaminated organisms. Contaminants acquired from eating prey tend to remain in tissues and may build up over time. This is known as biomagnification. High contaminant levels can reduce reproductive success or cause death.

This indicator is used to evaluate whether contamination in fish might lead to lethal or nonlethal effects in predators (birds, mammals or other fish). See Chapter 2 or Appendix B for details about how the NCCA assesses ecological effects of fish contamination. Note that a rating of poor here does not equate to a human health risk.



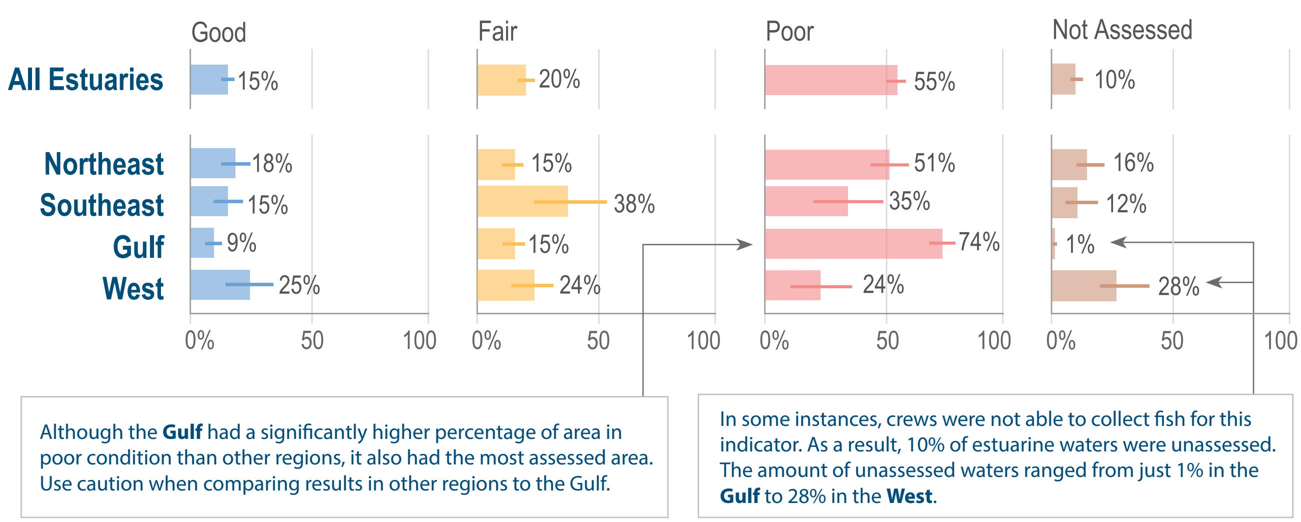
In some estuaries, birds such as this double-crested cormorant (*Phalacrocorax auritus*) could experience adverse effects from eating contaminated prey fish.

What Was the Condition in 2015?

About 15% of estuarine waters had fish tissue in good condition, while 20% were in fair and 55% were in poor condition. Thus, in 75% of estuarine area, wildlife that eat fish from estuaries may experience some level of adverse effects. The benchmarks used to assess condition are very low and are intended to protect wildlife against nonlethal effects. Selenium, arsenic and mercury were the contaminants that most frequently exceeded benchmarks in estuarine fish sample composites.

Figure 3.4.1. Estuarine Fish Contamination (Ecological Effects)

Percent of estuarine area in each condition category (2015)



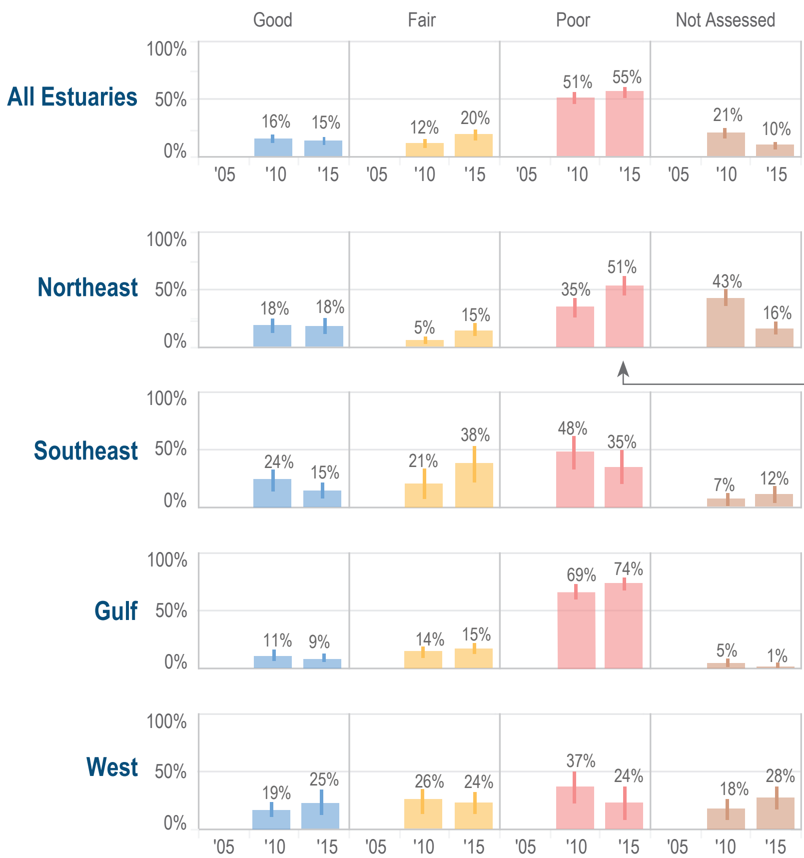
This index is used to assess potential harm to wildlife, not people.

Did the Condition Change?

Area rated fair and poor increased by 7.2 and 4.7 percentage points, respectively. Unassessed area decreased by 10.4 percentage points. This reflects an increase in confidence in the assessment due to improved sampling success, but may not reflect a true change in condition. This indicator was not assessed prior to 2010.

Figure 3.4.2. Change in Estuarine Fish Contamination (Ecological Effects)

Percent of estuarine area in each condition category (2005-2015)



Nationally, crews significantly improved their sampling success in 2015, likely because they sampled a larger radius around the selected coordinates at each site. While sampling success improved nationally, it did not improve in every region.

The **Northeast** saw a significant increase in estuarine area in poor condition for fish quality. It is possible that this may be related to improved sampling techniques.

This index is used to assess potential harm to wildlife, not people.

Assessing Selenium in Fish Tissue

Selenium is a naturally occurring element. It can enter the water through the weathering of rocks and via human activities such as mining, coal combustion and agriculture. Selenium is essential to animals in very small amounts but becomes toxic at higher concentrations. In addition to assessing selenium as part of the indicator described above, EPA also assessed it separately against a different benchmark. Unlike most of the other contaminants assessed above, selenium has a whole-body aquatic life criterion (U.S. EPA 2016b) developed under section 304(a) of the Clean Water Act. The criterion protects prey fish against adverse effects of selenium exposure, whereas the benchmark for the contaminant index above protects fish predators from exposure to multiple contaminants. The whole-body criterion does not address risk to predators.

When compared to the EPA whole-body aquatic life criterion of 8.5 mg/kg dry weight, none of the fish representing estuarine waters had selenium concentrations exceeding the benchmark. This indicates that fish were unlikely to experience negative impacts from the concentrations of selenium within their tissue. That is, 79% of estuarine waters, or 21,594 square miles, were at or below the benchmark, and the remaining 21% of waters, or 21,594 square miles, were not assessed because no fish specimens suitable for analysis were caught.

3.5 Enterococci Contamination

In 2015, the NCCA measured enterococci (a group of bacteria that live in the intestines of humans and other warm-blooded animals) to assess the contamination of estuaries from human and animal waste. While enterococci typically do not cause illness, they can signal the presence of fecal matter and, possibly, disease-causing bacteria, viruses and protozoa in the water. Sources of contamination include wastewater treatment plants, leaking septic systems, urban stormwater and agricultural runoff. The NCCA assesses risk of exposure to enterococci at national and regional levels. For information about risks at specific locations, recreational users should check with local beach monitoring programs. See Chapter 2 for details about how the NCCA assesses enterococci.

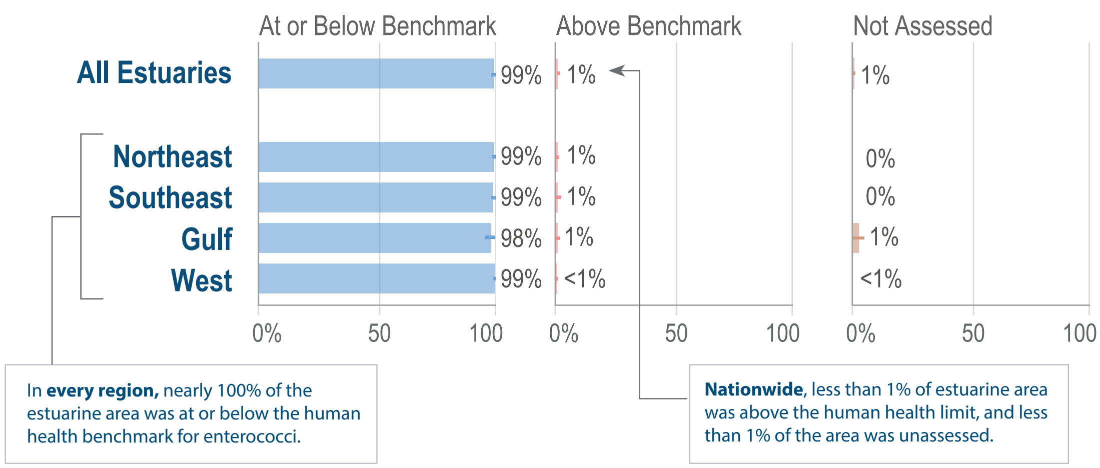
Stormwater runoff often contains fecal pathogens that can sicken those who come into contact with it.

What Was the Condition in 2015?

Nationally, enterococci levels were at or below the EPA limit of 1,280 CCE/100 mL in almost 99% of estuarine waters. This limit was set to protect human health during swimming. For information about risk at local beaches, visit https://www.epa.gov/beaches/find-information-about-particular-us-beach.

Figure 3.5.1. Estuarine Enterococci Condition

Percent of estuarine area in each condition category (2015)



Did the Condition Change?

The NCCA did not report on enterococci levels prior to 2015, so no estimate of change is available.

3.6 Microcystins

Cyanobacteria are one-celled photosynthetic organisms that normally occur at low levels. Under high-nutrient (eutrophic) conditions, they can multiply rapidly and form harmful algal blooms. Not all blooms are toxic, but some may release cyanotoxins such as microcystins into the water. Health effects of exposure include skin rashes, eye irritation, respiratory symptoms, gastroenteritis, and in severe cases, liver or kidney failure and death. Microcystins are potent liver toxins and suspected carcinogens.

During toxic harmful algal blooms, beaches are often closed to protect the public.

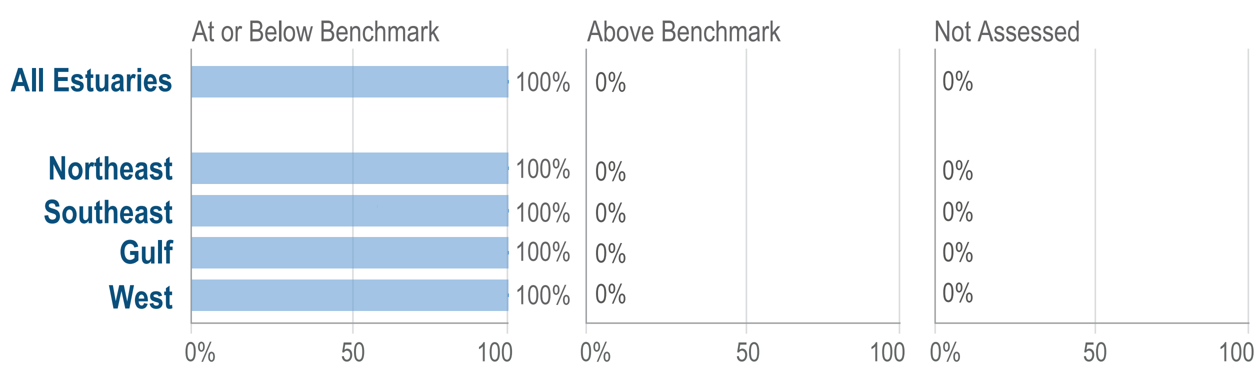
EPA has set a recreational freshwater benchmark of 8 µg/L. No benchmarks exist for marine waters or the brackish water found in estuaries. Therefore, the NCCA compared the estuarine results to the freshwater benchmark. Note that some types of cyanobacteria and algae release other toxins not monitored under the NCCA. The NCCA assesses risk of exposure to microcystins at national and regional levels. For information about risks at specific locations, recreational water users should check with state, tribal or local governments.

What Was the Condition in 2015?

Nationally, microcystins were at or below EPA's 8 µg/L human health benchmark in all estuarine waters. Microcystins were detected in only 6% of these waters.

Figure 3.6.1. Estuarine Microcystins Condition

Percent of estuarine area in each condition category (2015)



Did the Condition Change?

The NCCA did not report microcystin levels prior to 2015, so no estimate of change is available.

3.7 Mercury in Fish Fillet Plugs

Mercury is a toxic metal that occurs naturally in the ecosystem in very small amounts. Human activities such as combustion of fossil fuels release additional mercury into the environment. Mercury in the form of methylmercury is commonly found at detectable levels in fish tissue. Consumption of contaminated fish by pregnant women can lead to vision, hearing and nervous system defects in babies. Methylmercury may also impair brain development in young children and, at elevated levels, can lead to other physiological and cognitive impairments. However, the health benefits of eating fish are widely known. People should consult local fish consumption advisories to find out if fish they have caught are safe to eat.

Although primarily a freshwater species, channel catfish (*Ictalurus punctatus*) can withstand low to moderate salinity. This species was on the target list of species to be sampled for mercury in estuaries.

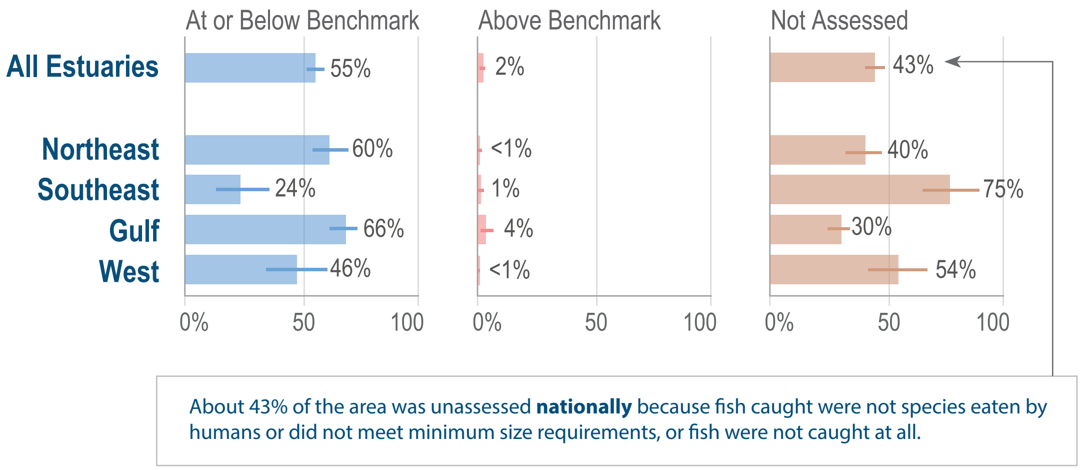
For estuaries, EPA analyzed total mercury in small plugs of fillet tissue. This approach was designed to minimize harm to fish. Where possible, fish were released after plug samples were taken. See Chapter 2 for details.

What Was the Condition in 2015?

Nationally, based on results from fish fillet plugs, almost 55% of estuarine area had mercury concentrations at or below the benchmark value of 300 ppb.

Figure 3.7.1. Estuarine Condition Based on Mercury in Plugs from Fish Fillets

Percent of estuarine area in each condition category (2015)



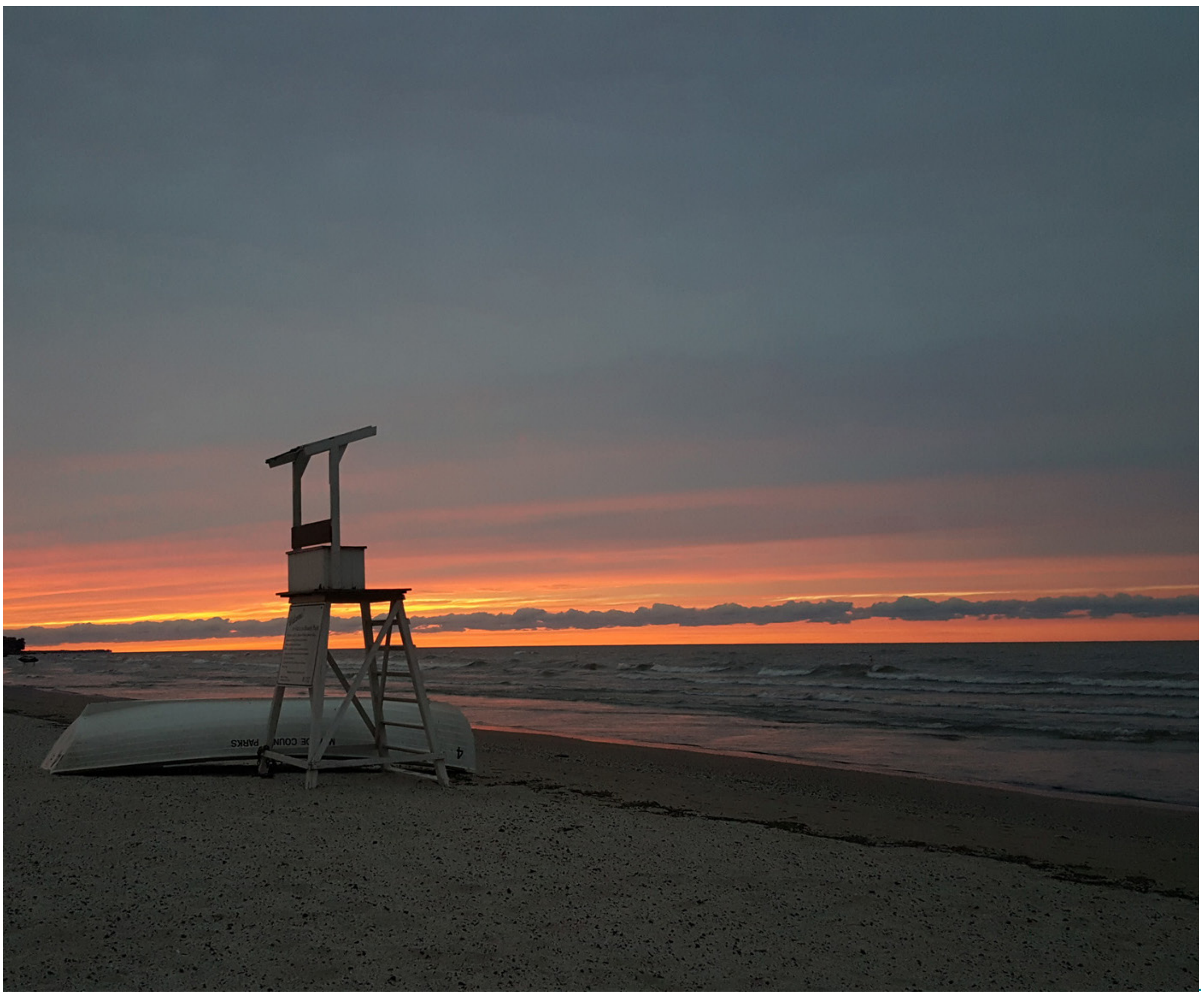
Did the Condition Change?

The NCCA did not measure mercury in plug samples prior to 2015, so an estimate of change is not available.

4 The Condition of Our Great Lakes Nearshore Waters

This chapter summarizes the key findings from the NCCA 2015 assessment of Great Lakes nearshore water conditions in the United States. The Great Lakes form the largest freshwater system on Earth and provide drinking water to many cities in adjacent states. They also provide habitat to wildlife and recreational and commercial opportunities to millions of people. Like estuaries, the nearshore waters of the Great Lakes are impacted by stressors that include fertilizer, animal and human waste, toxins in sediment and fish, and invasive species. However, the Great Lakes have different water chemistry than estuaries, and mixing at the surface is due to waves rather than tides.

As described in Chapter 2, the Great Lakes waters assessed for the NCCA included all U.S. Great Lakes nearshore waters up to 30 meters in depth but no more than 5 kilometers from shore. Impaired sites such as Areas of Concern under the Great Lakes Water Quality Agreement were not specifically targeted. The NCCA began assessing the Great Lakes in 2010 for the ecological indicators and the contaminants included in the Great Lakes Human Health Fish Tissue Study. Enterococci, microcystins and mercury in fish fillet tissue plugs were added to the NCCA in 2015.



HOW THIS CHAPTER IS ORGANIZED

This chapter presents each of the four NCCA ecological indicators and each of the human health indicators. A more detailed discussion is included for the Great Lakes Human Health Fish Fillet Tissue Study.

Each indicator section listed in the box contains three parts: an introduction to the indicator and why it matters for the Great Lakes, results from the 2015 survey, and change in condition from 2010 to 2015 (for the ecological indicators). Some sections present additional information about methodology or findings.

NCCA Great Lakes Indicators

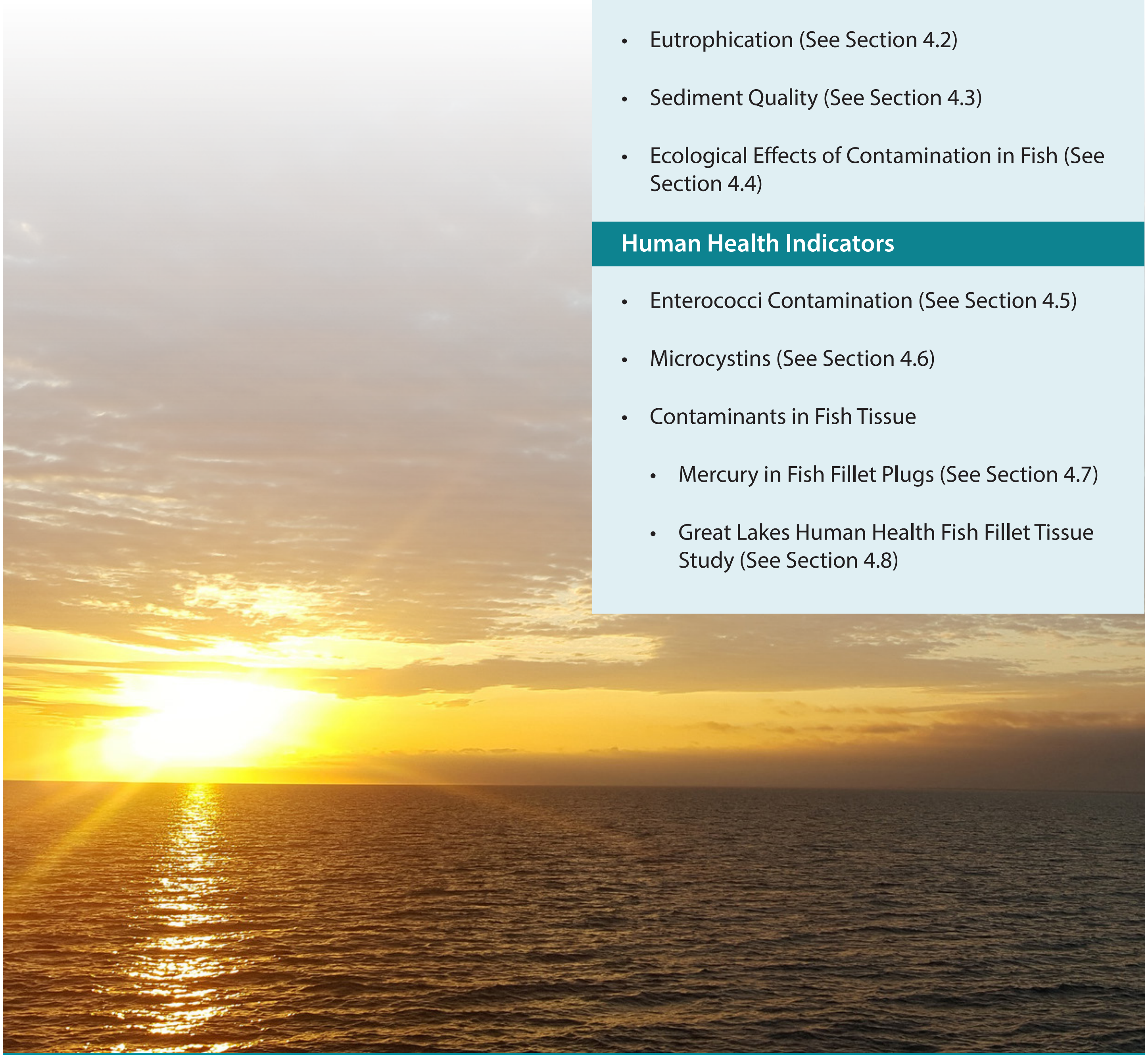
The NCCA uses the same seven indicators for the Great Lakes as it uses for estuaries but includes additional data collection on contaminants in fish tissue as part of the Great Lakes Human Health Fish Fillet Tissue Study.

Ecological Indicators

- Biological Condition (See Section 4.1)
- Eutrophication (See Section 4.2)
- Sediment Quality (See Section 4.3)
- Ecological Effects of Contamination in Fish (See Section 4.4)

Human Health Indicators

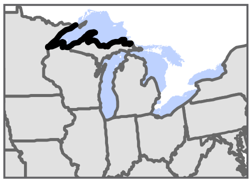
- Enterococci Contamination (See Section 4.5)
- Microcystins (See Section 4.6)
- Contaminants in Fish Tissue
    - Mercury in Fish Fillet Plugs (See Section 4.7)
    - Great Lakes Human Health Fish Fillet Tissue Study (See Section 4.8)



HOW THE RESULTS ARE PRESENTED

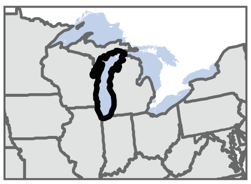
Great Lakes results are reported at the national level and for each of the Great Lakes: Lake Superior, Lake Michigan, Lake Huron, Lake Erie and Lake Ontario. See Appendix A for detailed maps of sampling locations.

Figure 4.0.1. Characteristics and 2015 Sample Size of the Individual Great Lakes



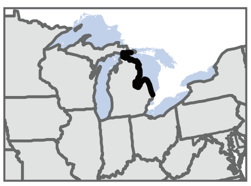
LAKE SUPERIOR

- **Area Assessed.** 1,236 square miles of nearshore waters by sampling 78 sites.
- **Points of Interest.** The largest by both volume and surface area as well as the deepest of the Great Lakes. Its basin is forested and sparsely populated.



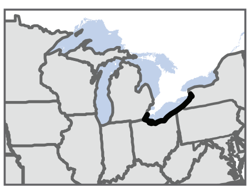
LAKE MICHIGAN

- **Area Assessed.** 3,038 square miles of nearshore waters by sampling 100 sites.
- **Points of Interest.** The second largest lake by volume, it is the only one of the Great Lakes entirely within the United States. Milwaukee and Chicago are on its shores.



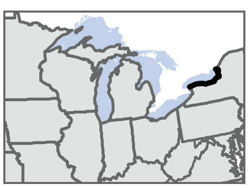
LAKE HURON

- **Area Assessed.** 1,270 square miles of nearshore waters by sampling 67 sites.
- **Points of Interest.** Lake Huron is the third-largest lake by volume. It includes two large bays: Georgian Bay and Saginaw Bay.



LAKE ERIE

- **Area Assessed.** 1,042 square miles of nearshore waters by sampling 57 sites.
- **Points of Interest.** The smallest Great Lake by volume, and the shallowest. It also has the warmest summer surface water temperatures. Its watershed is the most densely populated of all the Great Lakes. Cleveland, Toledo and Buffalo are all located on its shores.



LAKE ONTARIO

- **Area Assessed.** 532 square miles of nearshore waters by sampling 59 sites.
- **Points of Interest.** The fourth-largest lake by volume. It has a steeply sloped lake bed, so its nearshore waters are deeper and colder than the other Great Lakes. Water flows to Lake Ontario from Lake Erie via the Niagara River and from Lake Ontario to the Atlantic via the St. Lawrence.

4.1 Biological Condition

The NCCA assesses biological condition in the nearshore waters of the Great Lakes using an index known as the oligochaete trophic index. Oligochaetes are aquatic worms that live in lake sediments. Different groups of oligochaetes exhibit varying degrees of tolerance or sensitivity to changes in the nutrient concentrations in a lake. The presence of pollution-sensitive species is an indication of good biological condition, while areas dominated by tolerant species may indicate degraded condition. Therefore, EPA developed good, fair and poor ratings by comparing the numbers of pollution-sensitive oligochaetes living in the sediment to the number of more tolerant individuals. For details about the index, please see Chapter 2 or Appendix B.

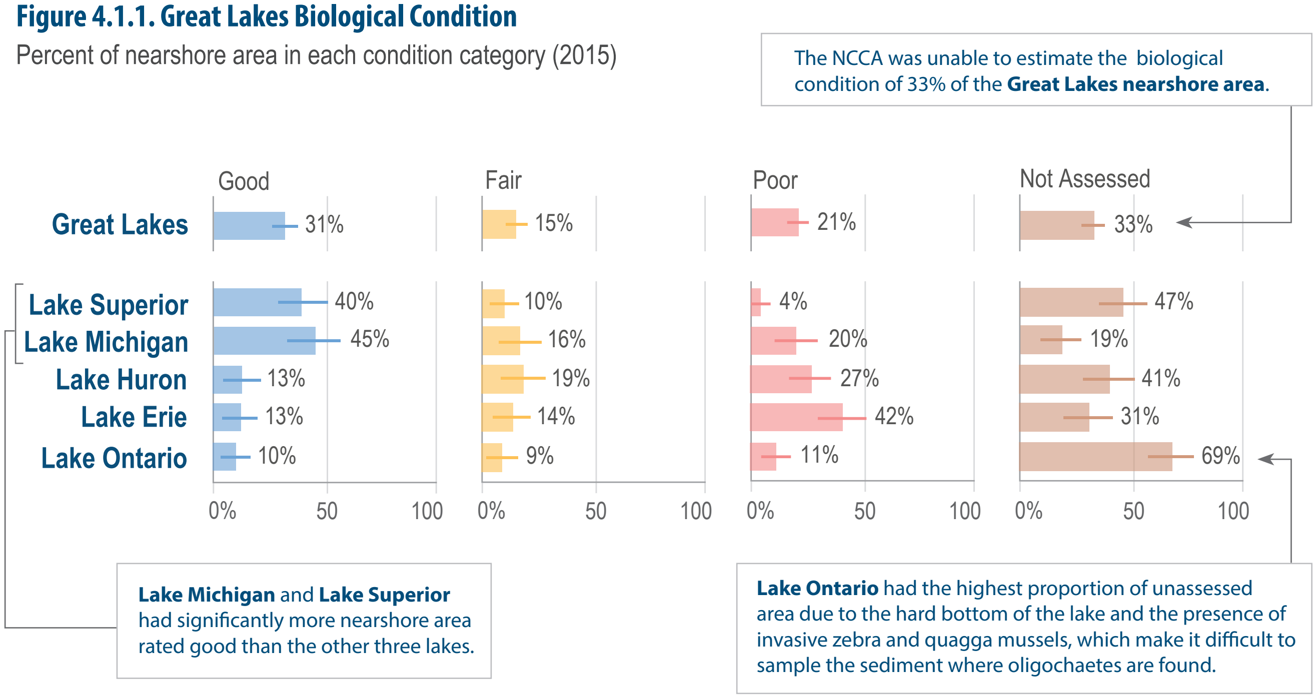
Potamothrix moldaviensis, a nonnative tubificid worm, is one of the species used to calculate values for the OTI.

What Was the Condition in 2015?

In the Great Lakes, the NCCA found that 31% of the total nearshore area was in good condition, 15% was in fair condition and 21% was in poor condition. One-third of nearshore waters could not be assessed because a sample could not be collected, the sample contained no oligochaetes, or the sensitivity of the oligochaetes in the sample to nutrient enrichment was not known. Unassessed area should be considered when interpreting results.

Figure 4.1.1. Great Lakes Biological Condition

Percent of nearshore area in each condition category (2015)

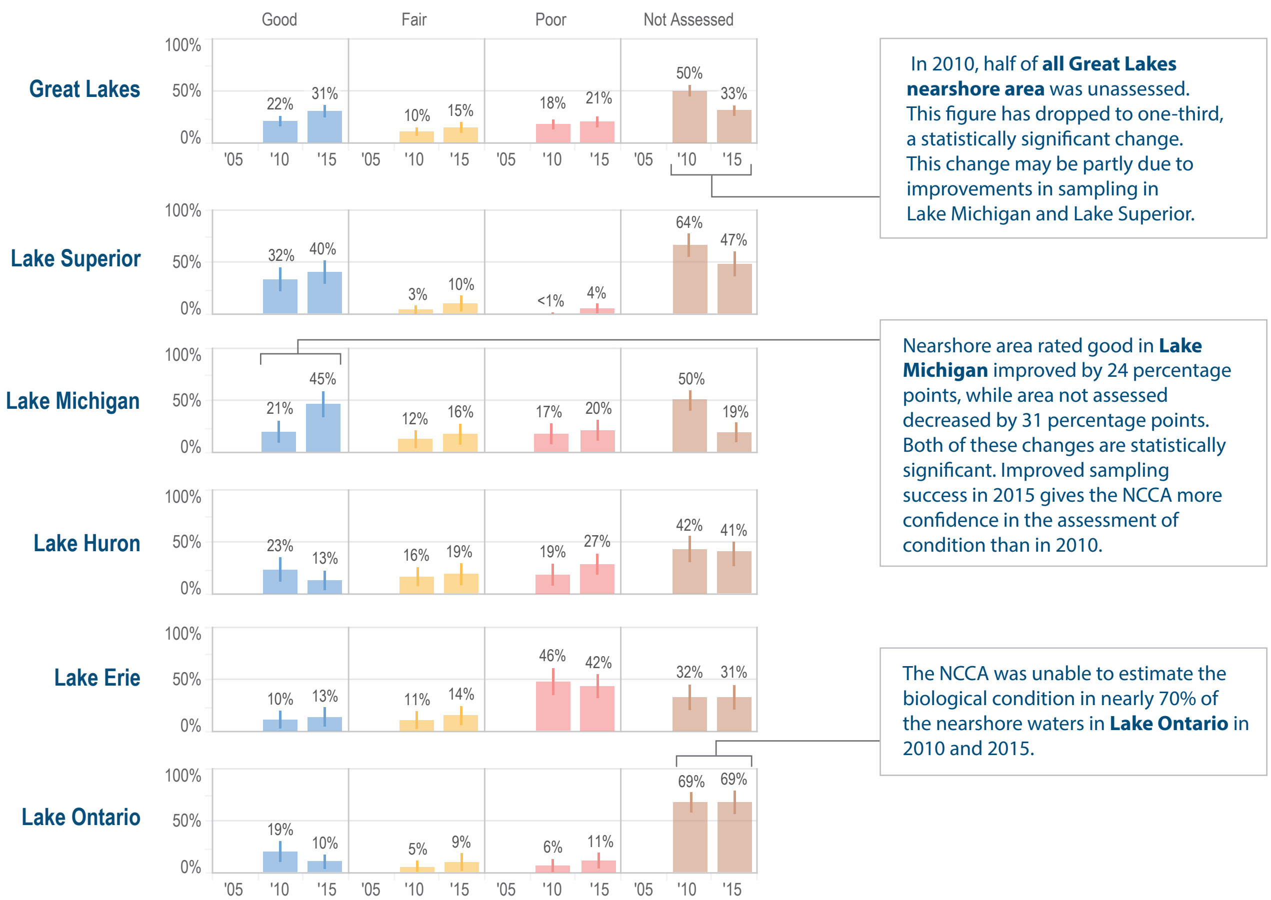


Did the Condition Change?

From 2010 to 2015, there was a statistically significant increase in area rated good in the Great Lakes. Such area accounted for 22% of the nearshore area in 2010 and 31% in 2015. There was no significant change in area rated fair or poor. While there was a significant increase in sampling success, a third of Great Lakes area was not assessed. This should be taken into account while interpreting the changes in other categories.

Figure 4.1.2. Change in Great Lakes Biological Condition

Percent of nearshore area in each condition category (2005-2015)



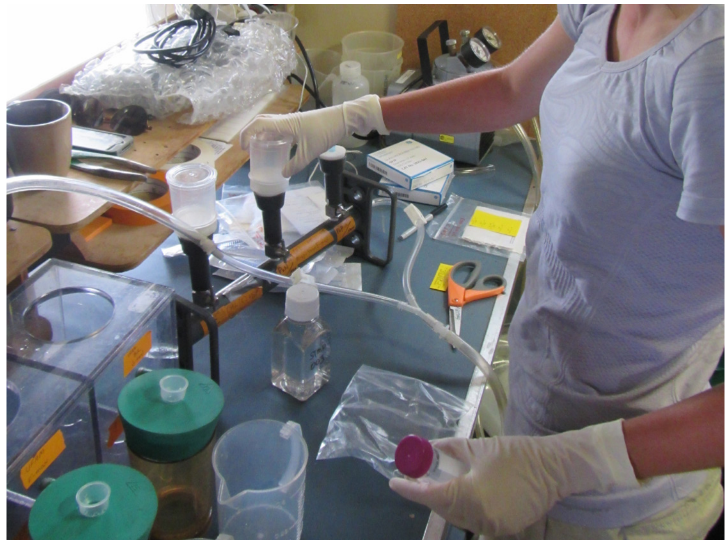
Round goby (*Neogobius melanostomus*) and dreissenid mussels from underwater video collected in the Great Lakes.

Using Underwater Video to Supplement Grab Sampling

Underwater video can provide additional information about benthic habitat at sites where impenetrable substrate prevents grab sampling, along with information on the presence of invasive species. In 2010 and 2015, crews collected video, allowing them to assess the presence of invasive fish and mussels (Wick et al. 2020). Invasive species can cause water quality, habitat, and food web changes that affect coastal condition. Researchers are investigating the use of videos and grab sample data to determine the extent of invasive dreissenid (zebra and quagga) mussels in the Great Lakes nearshore area. EPA has developed a crowdsourcing application called Deep Lake Explorer to help expedite analysis of large video datasets. Learn how to help at: https://www.zooniverse.org/projects/usepa/deep-lake-explorer. View NCCA underwater videos at https://gispub.epa.gov/NCCA/.

4.2 Eutrophication Index

Similar to estuaries, a common water quality problem in the Great Lakes is eutrophication, stemming in large part from nutrient over-enrichment. This condition can result in increased growth of algae. Excess algal growth can impact beaches and hamper navigation. Decomposing organic matter uses up oxygen in the water, stressing and sometimes killing aquatic life. See Section 4.6 for more information on harmful algal blooms. The Great Lakes eutrophication index is based on total phosphorus, chlorophyll *a* concentration, water clarity and dissolved oxygen.



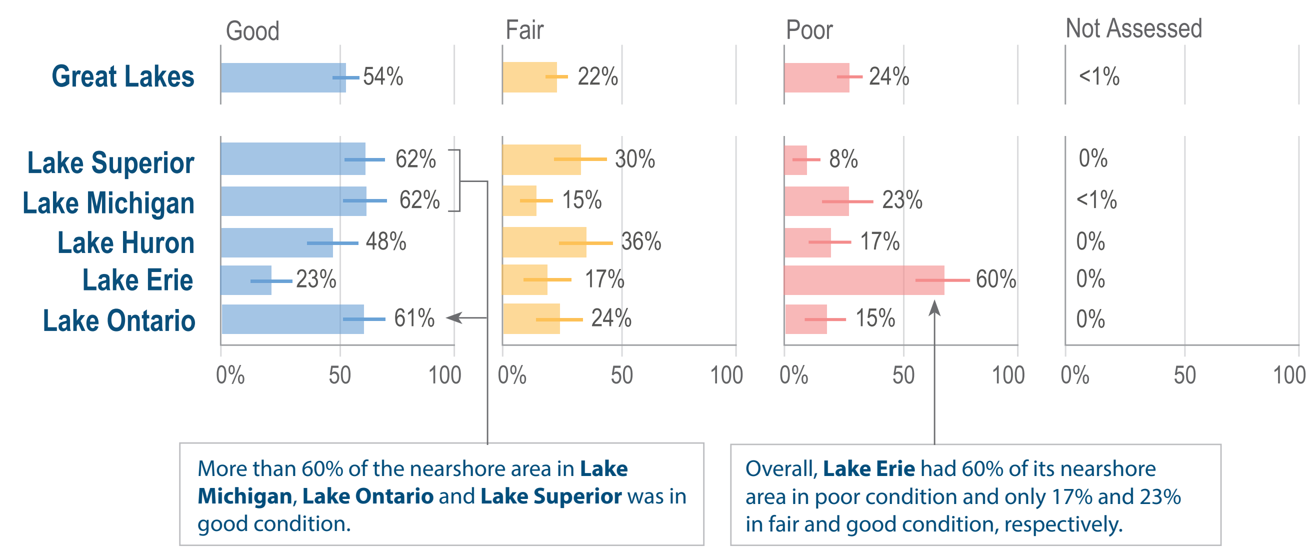
A scientist processing samples on board a research ship in the Great Lakes.

What Was the Condition in 2015?

The NCCA estimates that 54% of the total nearshore area was in good condition based on the eutrophication index. Reduced water clarity and elevated total phosphorus were the drivers behind poor condition (see the NCCA dashboard).

Figure 4.2.1. Great Lakes Eutrophication Condition

Percent of nearshore area by condition category (2015)

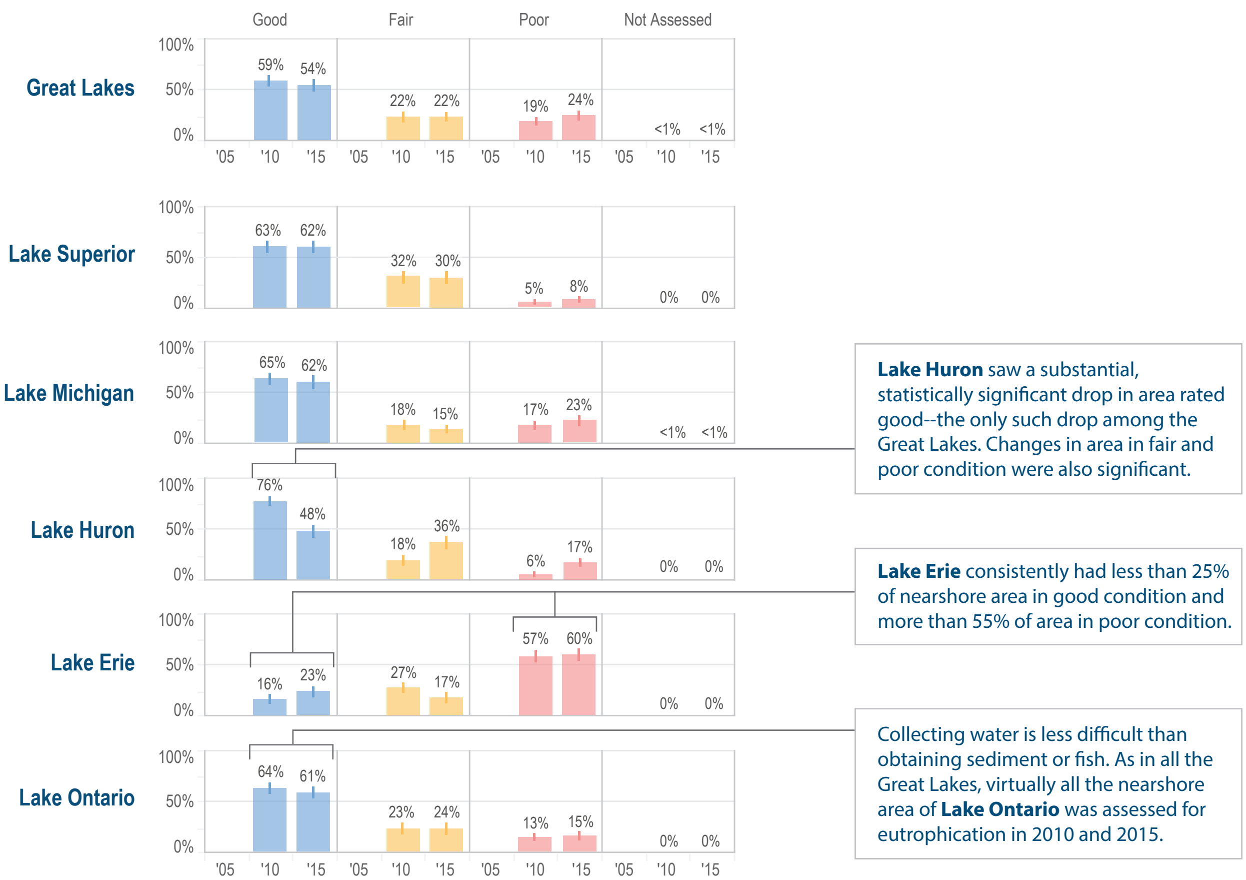


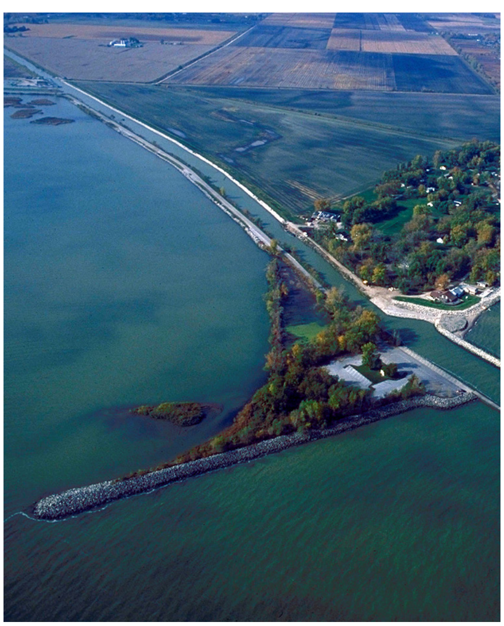
Did the Condition Change?

There was no statistically significant change in the eutrophication index for the combined Great Lakes from 2010 to 2015.

Figure 4.2.2. Change in Great Lakes Eutrophication Condition

Percent of nearshore area in each condition category (2005-2015)





Farmland near the Lake Erie shoreline.

Eutrophication: Lake Erie Case Study

In recent decades, excess eutrophication and harmful algal blooms have become relatively common and widespread in Lake Erie. At the request of EPA's Region 5 office, 33 additional sites were assessed in Lake Erie for eutrophication and cyanotoxin indicators in 2015. This special intensification study was designed to provide a baseline for tracking responses to total phosphorus load reduction implemented under the Great Lakes Water Quality Agreement between Canada and the United States. In addition to assessing Lake Erie as a whole, the intensification study assessed the Western, Central and Eastern Basins of Lake Erie separately.

When data from NCCA base sites and from the Lake Erie special intensification study were combined, more than 50% of Lake Erie nearshore waters were in poor condition for chlorophyll *a*, water clarity and total phosphorus, driven chiefly by results in the Western and Central Basins.

Agriculture is a major source of nutrients in the Lake Erie watershed.

4.3 Sediment Quality

Sediments are habitat for many organisms near the base of the aquatic food web. High concentrations of contaminants can accumulate in sediment and persist over time. Individually or in mixtures, high levels of contaminants can be associated with harmful effects on human health and aquatic life. The NCCA uses a two-pronged approach to assess sediment quality, analyzing sediment samples from each site for contaminant concentrations as well as testing samples for overall toxicity. Sediment toxicity tests compare survival of test organisms placed in an NCCA sediment sample to that of organisms placed in a clean control sample. The two test results are combined to calculate the index. For details about the sediment quality index, please see Chapter 2 or Appendix B.

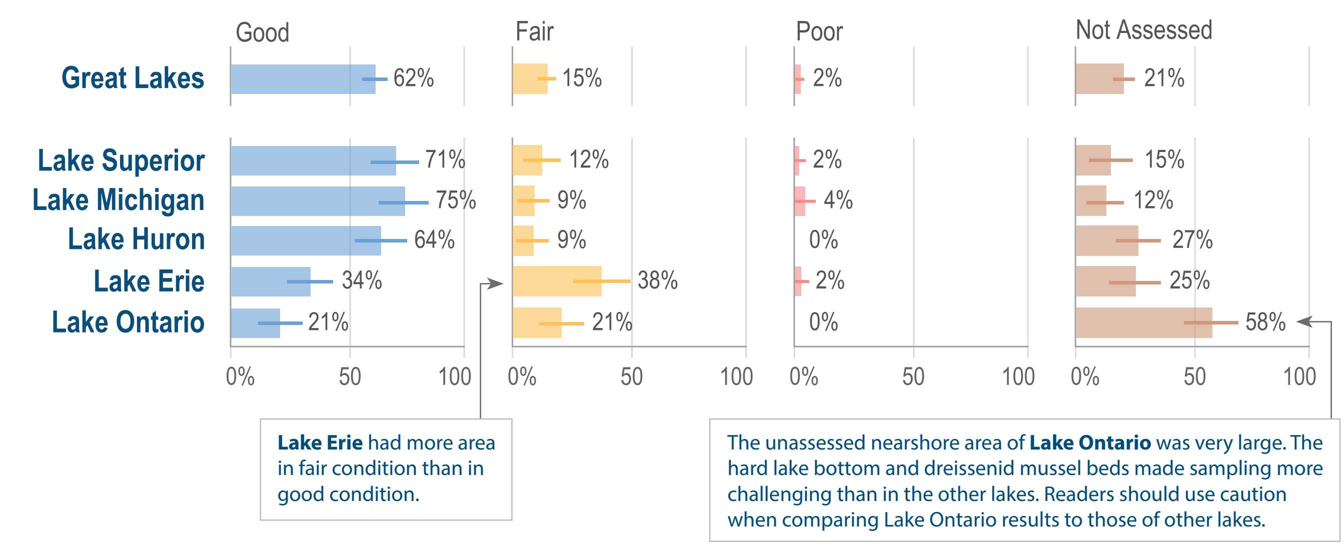
A field crew collects and records field data while sampling a site on the Great Lakes.

What Was the Condition in 2015?

In 2015, the NCCA found 62% of the total nearshore area of the Great Lakes had good sediment quality, while 15% had fair and 2% had poor. Sediment was not assessed in 21% of the area because samples could not be collected.

Figure 4.3.1. Great Lakes Sediment Quality

Percent of nearshore area in each condition category (2015)

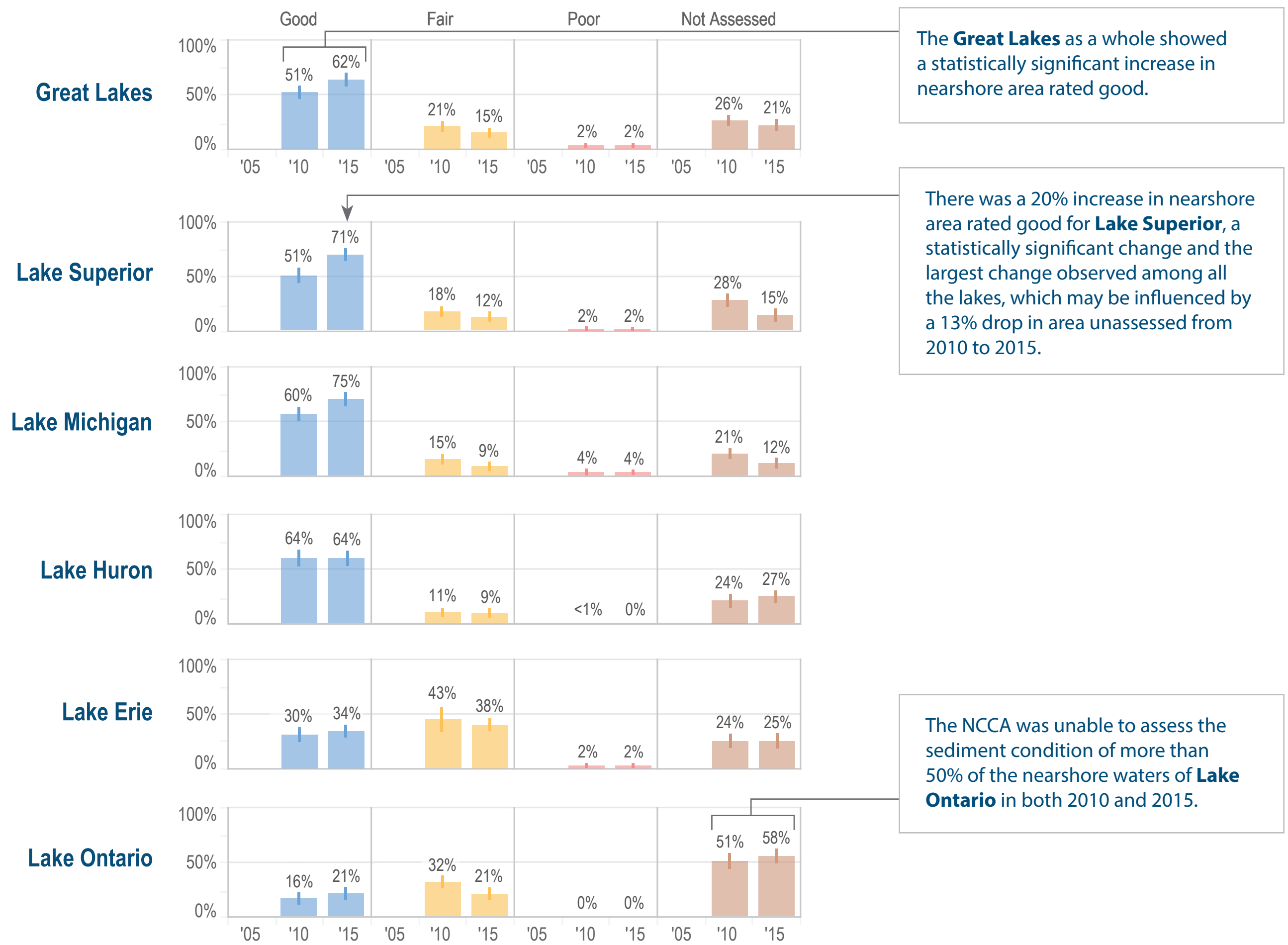


Did the Condition Change?

Great Lakes nearshore area rated good increased by 11 percentage points, which was a statistically significant change. Most other changes from 2010 to 2015 were not statistically significant.

Figure 4.3.2. Change in Great Lakes Sediment Quality

Percent of nearshore area in each condition category (2005-2015)



4.4 Ecological Effects of Contamination in Fish

The ecological fish tissue quality indicator assesses whether predators, including birds, mammals and other fish that predominantly or exclusively eat fish, will be exposed to elevated levels of contaminants. These predators are typically sensitive to low levels of contaminants in the fish they eat. Such exposure can lead to problems including reduced growth, reduced reproductive success (fewer offspring, less viable offspring, sterile offspring) and shorter lifespans. See Chapter 2 or Appendix B for details on how crews collect samples and EPA assesses ecological effects of contamination in fish in the nearshore Great Lakes.

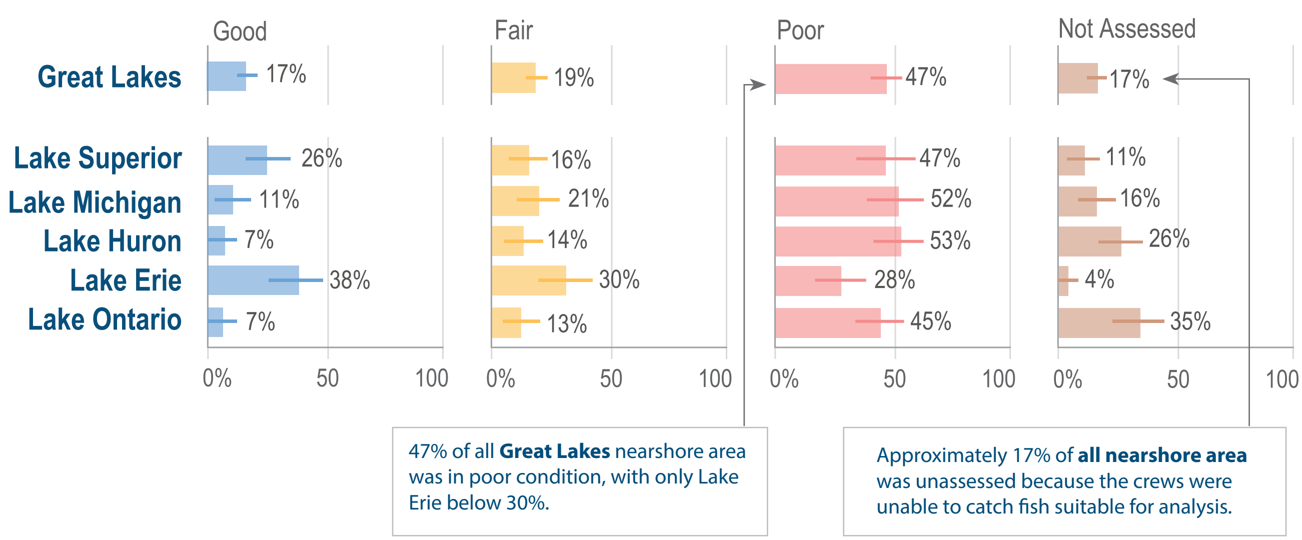
In parts of the Great Lakes, mammals such as this American mink (*Neovison vison*) could experience adverse effects from eating contaminated prey fish.

What Was the Condition in 2015?

Of the Great Lakes nearshore area, 17% was in good, 19% was in fair, and 47% was in poor condition. Thus, in 66% of the nearshore Great Lakes area, wildlife that depend on fish may experience some level of adverse effects. The benchmarks used to assess condition are very low and are intended to protect wildlife againt nonlethal effects. Selenium, arsenic and PCBs were the contaminants that most frequently exceeded benchmarks in fish samples.

Figure 4.4.1. Great Lakes Fish Contamination (Ecological Effects)

Percent of nearshore area in each condition category (2015)



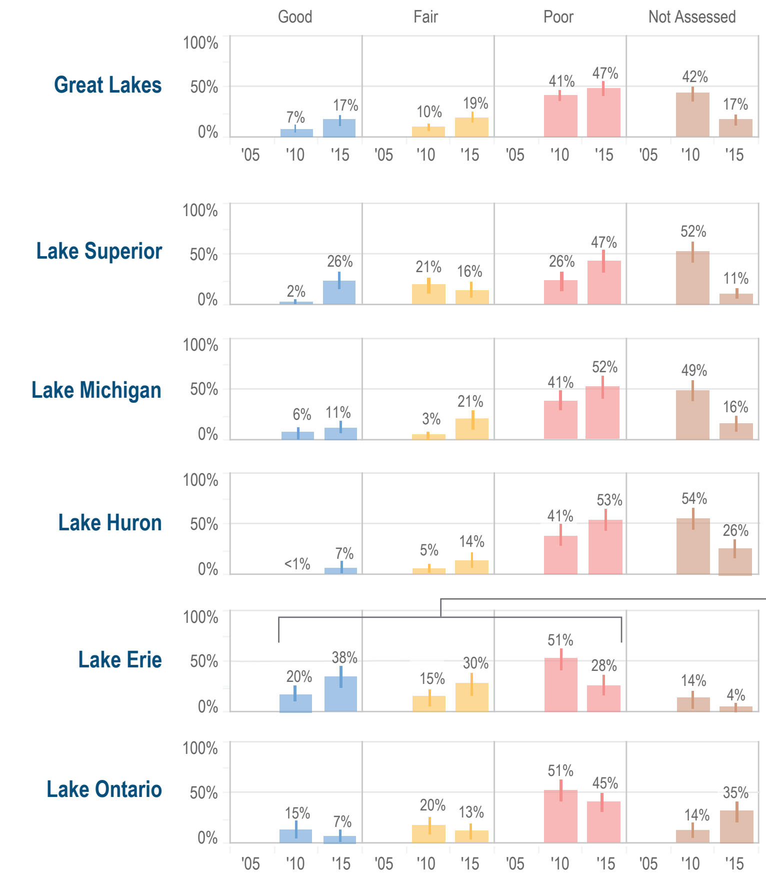
This index is used to assess potential harm to wildlife, not people.

Did the Condition Change?

From 2010 to 2015, the nearshore area rated good increased by 9.3 percentage points, and fair increased by 9.7 percentage points. These changes were statistically significant. The area that couldn't be assessed decreased from 42% to 17%. This reflects an increase in confidence in the assessment due to improved sampling success, but may not reflect a true change in condition. Unassessed area should be considered when interpreting results.

Figure 4.4.2. Change in Great Lakes Fish Contamination (Ecological Effects)

Percent of nearshore area in each condition category (2005-2015)



Condition may have improved in **Lake Erie**, which appears to show area shifting from poor condition to fair and good. The lake saw a 23 percentage point decrease in nearshore area rated poor with an increase in area rated fair and good. Some but not all of this change could be due to a decrease in area that was not assessed.

Lake Ontario alone showed an increase in unassessed area. All other lakes showed dramatic improvements in sampling success rates.

This index is used to assess potential harm to wildlife, not people.

Cisco or lake herring (*Coregonus artedi*) was one of the species collected for tissue analysis.

Assessing Selenium in Fish Tissue

The NCCA assessed selenium in fish tissue composites in the Great Lakes as it did for estuaries, using the NCCA ecological fish tissue contaminants index and the 2016 EPA freshwater aquatic life criterion (see Section 3.4 for details). When compared to the EPA whole-body selenium aquatic life criterion of 8.5 mg/kg dry weight, none of the fish representing Great Lakes waters had selenium concentrations exceeding the benchmark. This indicates that fish were unlikely to experience negative impacts from the concentrations of selenium within their tissue. That is, 5,910 square miles, representing 83% of all Great Lakes nearshore waters, were at or below the benchmark, and the remaining 17% of nearshore area, or 1,209 square miles, was not assessed because no fish specimens suitable for analysis were caught.

4.5 Enterococci Contamination

In 2015, the NCCA first measured enterococci in the nearshore waters of the Great Lakes to assess contamination from human and animal waste. Enterococci are a group of bacteria that live in the intestines of humans and other animals. While enterococci typically do not cause illness, they can signal the presence of pathogens in the water. Sources of contamination include wastewater treatment plants, leaking septic systems, urban stormwater and agricultural runoff. Fecal pathogen levels tend to increase after storms due to inputs from stormwater runoff, and in some areas, combined sewer overflows. The NCCA assesses risk of exposure to enterococci at national and regional levels. For information about risks of exposure at specific locations, recreational users should check with local monitoring programs.

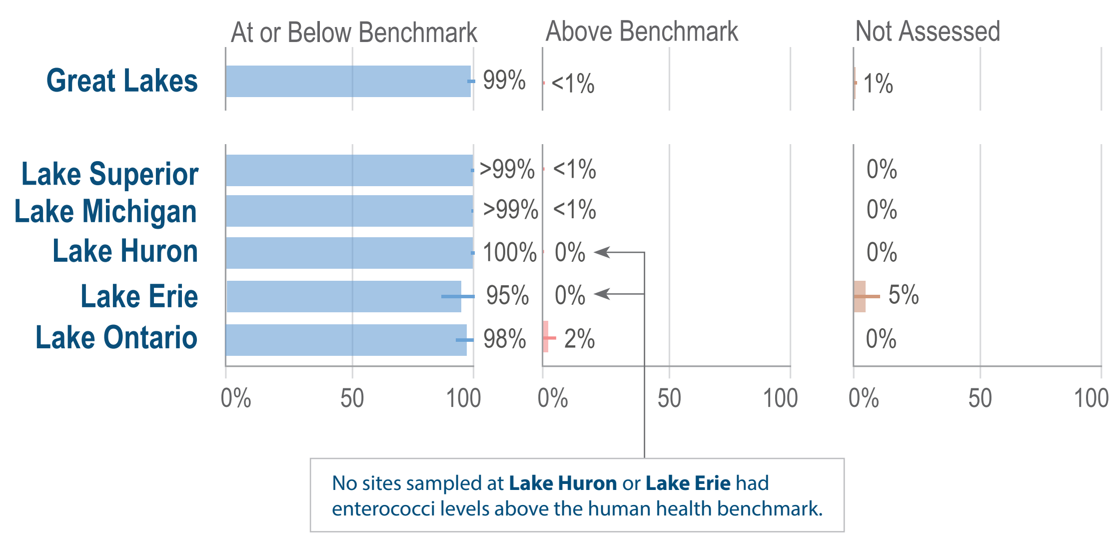
Local water quality alerts keep recreational users informed about water safety.

What Was the Condition in 2015?

Enterococci levels in 99% of the Great Lakes nearshore waters were at or below the 1,280 CCE/100 mL EPA benchmark. This limit was set to protect human health during swimming. For information about local beaches, visit https://www. epa.gov/beaches/find-information-about-particular-us-beach.

Figure 4.5.1. Great Lakes Enterococci Condition

Percent of nearshore area in each condition category (2015)



Did the Condition Change?

The NCCA did not measure enterococci levels prior to 2015, so no estimate of change is available.

4.6 Microcystins

Under high-nutrient conditions, cyanobacteria can reproduce rapidly, causing harmful algal blooms. Under some conditions, cyanobacteria release toxins that can harm aquatic organisms, wildlife and humans. The NCCA assessed Great Lakes nearshore waters for microcystins, one class of cyanotoxins. Health effects of exposure include skin rashes, eye irritation, respiratory symptoms, gastroenteritis, and in severe cases, liver or kidney failure and death. Microcystins are potent liver toxins and suspected carcinogens. EPA has set a recreational freshwater benchmark of 8 µg/L. Note that some cyanobacteria and microscopic algae may release toxins not measured under the NCCA. For details about how the EPA assesses microcystins, see Chapter 2.

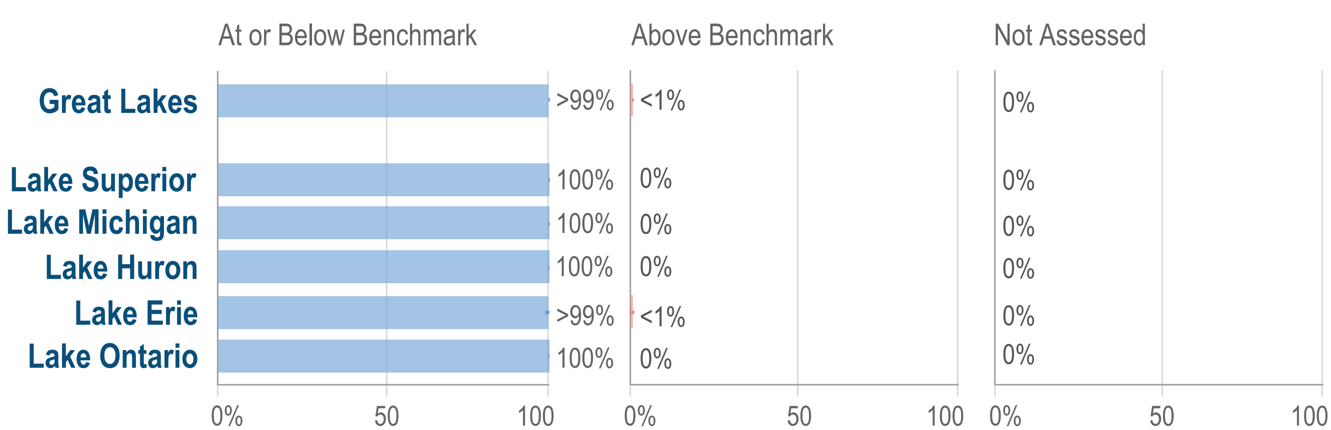
A cyanobacterial bloom on the shore of Lake Erie.

What Was the Condition in 2015?

The NCCA found just one site (on Lake Erie) with concentrations above the 8 µg/L human risk benchmark EPA set to protect people from recreational exposure. Microcystins were detected in 31% of Great Lakes nearshore waters.

Figure 4.6.1. Great Lakes Microcystins Condition

Percent of nearshore area in each condition category (2015)



Did the Condition Change?

The NCCA did not measure microcystins levels prior to 2015, so no estimate of change is available.

4.7 Mercury in Fish Fillet Plugs

Mercury is a toxic metal that occurs naturally in the ecosystem in very small amounts; however, human activities such as fossil fuels combustion and some types of manufacturing release additional mercury into the environment. Fish accumulate a form called methylmercury in their tissues. Consumption of contaminated fish by pregnant women can lead to vision, hearing, and nervous system defects in babies. Methylmercury may also impair brain development in young children and, at elevated levels, can lead to other physiological and cognitive impairments. Fish are part of a healthy diet, but people should consult local fish consumption advisories to determine if fish they have caught are safe to eat.

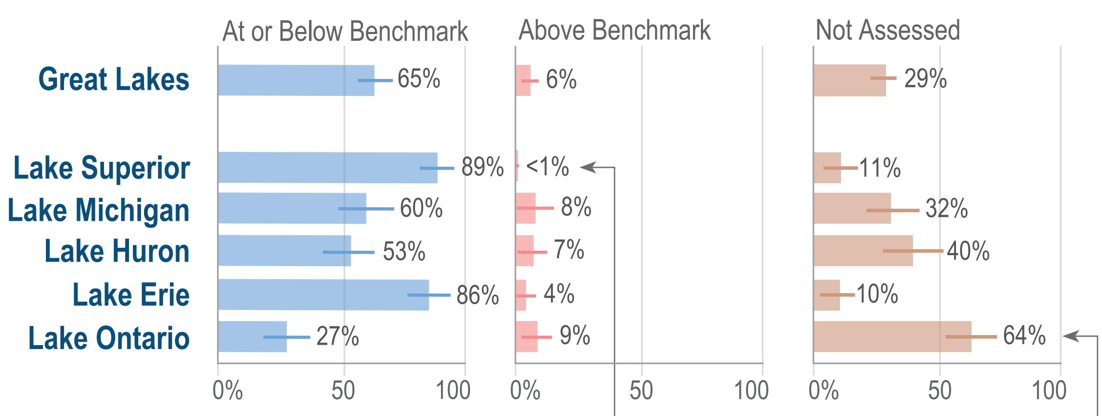
The NCCA assessed total mercury levels in small plugs of tissue taken from fish fillets and compared against EPA's benchmark of 300 ppb (U.S. EPA 2010). See Section 4.8 for the results of additional Great Lakes mercury and contaminant testing conducted using a different sampling approach.

What Was the Condition in 2015?

In 65% of the nearshore area of the Great Lakes, mercury concentrations in fish fillet plugs were at or below the benchmark of 300 ppb. In 6% of the area, fish were above the benchmark. The remaining 29% of nearshore waters were not assessed because crews were unable to collect suitable fish samples.

Figure 4.7.1. Great Lakes Condition Based on Mercury in Plugs from Fish Fillets

Percent of nearshore area in each condition category (2015)



Lake Superior in particular stands out, with almost no nearshore area above the human health benchmark.

Lake Ontario had a much larger unassessed area than any other lake, at 64%, so use caution when interpreting its ratings. NCCA is continually reviewing its field procedures to improve sampling for this indicator.

Did the Condition Change?

The NCCA did not measure mercury in plug samples prior to 2015, so an estimate of change is not available.

4.8 Great Lakes Human Health Fish Fillet Tissue Study

As part of the NCCA 2015, EPA conducted the second statistically based Great Lakes Human Health Fish Fillet Tissue Study to assess toxic chemicals in composite samples of fish commonly consumed by humans.[9] Fish were collected from 152 NCCA Great Lakes nearshore sampling locations (about 30 fish composite samples per lake) representing 6,862 square miles of nearshore area. Fish fillet composites were analyzed for total mercury, all 209 PCB congeners, and 13 PFAS. Results in this section show the occurrence of these chemicals in fish and identify which chemicals may be a health concern for people who eat Great Lakes fish, based on a comparison against relevant human health fish tissue benchmarks.[10]

Consuming fish can be an important part of a balanced diet. Fish provide protein, are low in saturated fat, are rich in many micronutrients, and provide certain omega-3 fatty acids that the body cannot make and that are important for normal growth and development. However, fish tissue may also contain contaminants; at high enough levels, these contaminants may contribute to a variety of human health impacts in consumers. These impacts can disproportionately affect consumers who eat more than the average amount of fish. These contaminants enter the aquatic environment via human activity and natural processes and can then accumulate in fish.

[9] For the NCCA 2015 survey, a composite sample was formed by combining fillet tissue from up to five adult fish of the same species and similar size from the same site. Use of composite sampling for screening studies is a cost-effective way to estimate average contaminant concentrations while also ensuring that there is sufficient fish tissue to analyze for all contaminants of concern.

[10] Each human health fish tissue benchmark represents the chemical concentration in fish tissue that, if exceeded, may adversely impact human health, based on fish consumption.

TARGETED FISH TISSUE CONTAMINANTS

Mercury. About 80% of all fish consumption advisories in the United States involve mercury. People are exposed to methylmercury (the most toxic form of mercury) primarily by eating fish and shellfish. Fetal or early childhood exposures to mercury transmitted from pregnant and nursing mothers can lead to impaired neurological development affecting 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 impaired speech and hearing. EPA applies the conservative assumption that all mercury in fish is methylmercury and therefore measures total mercury in fillet tissue to be most protective of human health.[11]

PCBs. PCBs accumulate in the tissues of aquatic organisms and are known to cause cancer in animals. Based on those findings and additional evidence from human studies, EPA classifies PCBs as probable human carcinogens. Other potential human health effects, which are known as noncancer endpoints, include liver disease and reproductive impacts, along with neurological effects in infants and young children.

PFAS. PFAS are a group of synthetic chemicals used in the manufacture of many products, including non-stick cookware, food packaging, waterproof clothing and stain-resistant carpeting. PFAS are toxic and persistent in the environment. Research has shown that a majority of people living in industrialized nations have PFAS in their blood. Elevated PFAS levels have been linked to health effects such as decreased sperm count, low birth weight and thyroid disease. Some studies estimate that PFAS in food may account for more than 90% of human exposure to perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). PFOS is the predominant PFAS in fish tissue, and it is the only frequently detected PFAS for which EPA has been able to establish a fish tissue human health benchmark. Great Lakes results for the 13 PFAS that were analyzed are included in the *NCCA 2015 Technical Support Document* (U.S. EPA 2021); only PFOS results are described in this section.

WHAT WAS THE CONDITION IN 2015?

Chemical results from the 2015 Great Lakes Human Health Fish Fillet Tissue Study show that mercury, PCBs and PFOS were detected in 100% of the 152 fish fillet composite samples (see Table 4.8.1). However, the percentages of the sampled population of Great Lakes nearshore area containing fish with fillet concentrations above the relevant human health fish tissue benchmarks for each contaminant are very different. Statistical results from this study are described below in Figures 4.8.1 to 4.8.3, and they indicate that PCBs occurred most frequently at levels above human health protection benchmarks for fish consumption. The benchmarks EPA used are described following the table.

Table 4.8.1. Summary of Detections and Contaminant Concentrations in 152 Great Lakes Fish Fillet Composite Samples
(EPA 2015 Great Lakes Human Health Fish Fillet Tissue Study)

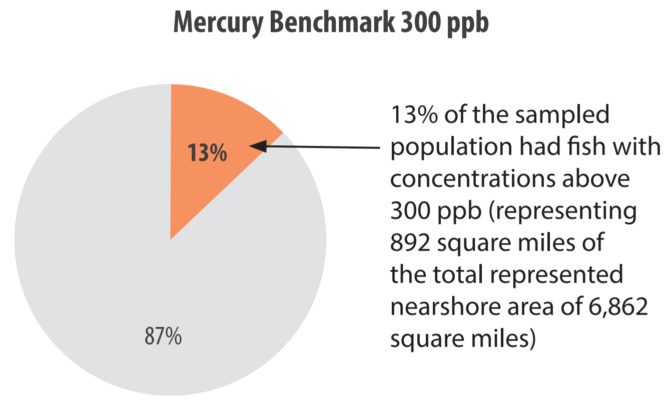
Chemical	Number of Detections	Minimum Concentration[a] (ppb)	Median Concentration[b] (ppb)	Maximum Concentration[a] (ppb)
Mercury (Total)	152	26	123	557
Total PCBs[c]	152	3	50	1,168
PFOS	152	<1	11	64

a. Observed data (minimum and maximum concentrations) measured in 152 Great Lakes fish fillet samples.
b. Statistical estimates of the median fish fillet composite concentrations for the nearshore Great Lakes sampled population of 6,862 square miles.
c. Total PCB concentrations are the sum of the concentrations of the 209 PCB congeners.

[11] EPA analyzes fish tissue samples for total mercury (using EPA method 1631 Revision E) since the major pathway for human exposure to methylmercury is consumption of contaminated fish and practically all mercury in fish tissue is methylmercury. See U.S. EPA (2001) and Bloom (1992).

For mercury, EPA used its human health fish-tissue-based water quality criterion for methylmercury as the benchmark. Since EPA does not currently have fish-tissue-based water quality criteria for PCBs or PFOS, EPA used the equations found in its *Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories* (U.S. EPA 2000) to develop benchmarks. These incorporated updated body weights from EPA's *Exposure Factors Handbook* (U.S. EPA 2011) and a nutritionally focused fish consumption rate consistent with the U.S. Department of Agriculture and Department of Health and Human Services' *Dietary Guidelines for Americans, 2020-2025*, of 32 grams/day (equivalent to one 8-ounce meal of fish and shellfish per week). EPA notes that it is not using the national default fish consumption rate of 22 grams/day from EPA's *Estimated Fish Consumption Rates for the U.S. Population and Selected Subpopulations* (2014) that is used to calculate EPA's national ambient water quality human health criteria recommendations. The default rate reflects the national fish consumption rate at the 90th percentile of the adult population and includes both fish consumers and nonconsumers.

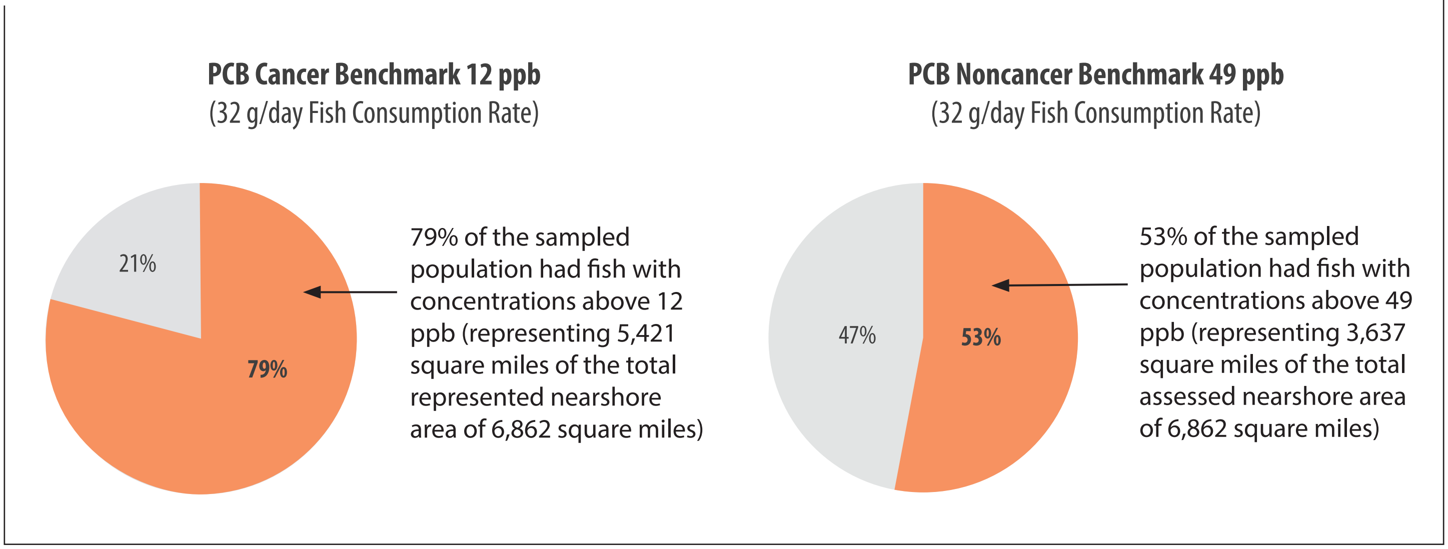
Figure 4.8.1. Percentage of the Great Lakes Nearshore Sampled Population Containing Fish with Fillet Mercury Concentrations Above the EPA Human Health Fish Tissue Benchmark



The fish consumption rate of 32 grams/day better reflects the role and purpose of fish advisory programs because it is in line with nutrition-based goals for dietary consumption and is also consistent with the rate used in fish advisory programs across the Great Lakes. EPA acknowledges this rate does not reflect "high frequency consumers" such as subsistence fishers or those who eat several meals of fish per week, which often includes individuals in underserved communities. In an effort to provide information to state, territorial, or tribal programs with populations of frequent fish consumers, EPA has provided an analysis in the Technical Support Document for this report (U.S. EPA 2021) that includes estimated benchmark exceedances for PCBs and PFOS using fish consumption rates that are more typical of such populations.

Mercury in Great Lakes Fish Fillets. The mercury levels in fillet composite samples (and in fish fillet plug samples discussed in Section 4.7) were compared to EPA's fish-tissue-based water quality criterion for mercury of 0.3 milligrams of methylmercury per kilogram of tissue (wet weight), or 300 ppb (U.S. EPA 2001). Mercury results from the NCCA 2015 Great Lakes Human Health Fish Fillet Tissue Study show that 13% of the Great Lakes nearshore sampled population contained fish with mercury concentrations above this benchmark (see Figure 4.8.1). Comparisons of fillet composite results for mercury between NCCA 2010 and NCCA 2015 did not reveal statistically significant differences.

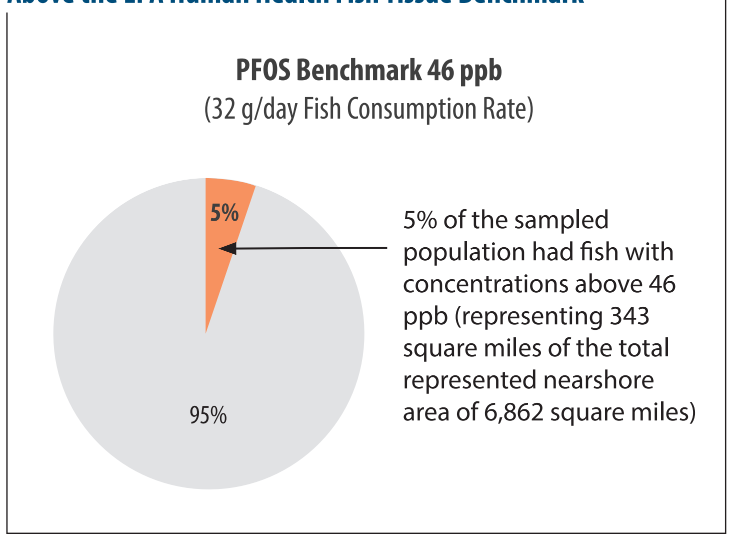
Figure 4.8.2. Percentages of the Great Lakes Nearshore Sampled Population Containing Fish with Fillet Total PCB Concentrations Above EPA Human Health Fish Tissue Benchmarks



PCBs in Great Lakes Fish Fillets. Total PCB results from the NCCA 2015 Great Lakes Human Health Fish Fillet Tissue Study (see Figure 4.8.2) show that 53% of the Great Lakes nearshore sampled population contained fish with total PCB fillet concentrations above the EPA total PCB noncancer benchmark of 49 ppb (based on a 32 g/day fish consumption rate). The results also show that 79% of the Great Lakes nearshore sampled population contained fish with total PCB fillet concentrations above the EPA total PCB cancer benchmark of 12 ppb (also based on a 32 g/day fish consumption rate). Comparisons of fillet composite results between NCCA 2010 and NCCA 2015 show PCB concentrations may have decreased across the Great Lakes when samples from all species are combined. Comparisons of fillet composite results within the most abundant and commonly consumed species (e.g., lake trout to lake trout, walleye to walleye) showed no statistically significant decrease in PCB levels.

PFAS in Great Lakes Fish Fillets. PFOS was the most commonly detected PFAS in the Great Lakes fillet composite samples. PFOS results from the NCCA 2015 Great Lakes Human Health Fish Fillet Tissue Study (see Figure 4.8.3) show that 5% of the Great Lakes nearshore sampled population contained fish with PFOS fillet concentrations above the EPA PFOS benchmark of 46 ppb (based on a 32 g/day fish consumption rate). Comparisons of fillet composite results for PFOS between NCCA 2010 and NRSA 2015 did not reveal statistically significant differences.

Figure 4.8.3. Percentage of the Great Lakes Nearshore Sampled Population Containing Fish with Fillet PFOS Concentrations Above the EPA Human Health Fish Tissue Benchmark



5 Summary and Next Steps

This report describes a national assessment of estuarine and nearshore Great Lakes waters and changes over time.[12] EPA, states and other federal agencies collaborated throughout the design and implementation of the survey.

The national and regional estimates of condition in this report offer coastal managers insight into how well coastal conservation efforts are working. The recurring nature of the NCCA and the use of consistent methodology over time result in valuable information about current conditions as well as change since previous surveys.

The sections below summarize these NCCA results and compare coastal waters to NARS results for rivers and streams, lakes, and wetlands. Such comparisons are useful because the same factors that affect coastal water quality and condition can affect these other waters, and local or regional water quality managers may choose to target all waters simultaneously. A holistic approach to addressing stressors can benefit all waters. In addition, some of these NARS reports provide information about water bodies that feed into estuaries and the nearshore Great Lakes. Taken as a whole, these data inform government agencies about the condition of coastal waters, condition of waters influencing coastal waters, and the stressors impacting both.

Beside releasing the NCCA report, EPA is also sharing NCCA and NARS data and information with the public through its website, fact sheets and other materials. This information can help people take action in their own neighborhoods to protect and conserve downstream coastal resources.

KEY RESULTS AND COMPARISONS TO OTHER NARS ASSESSMENTS

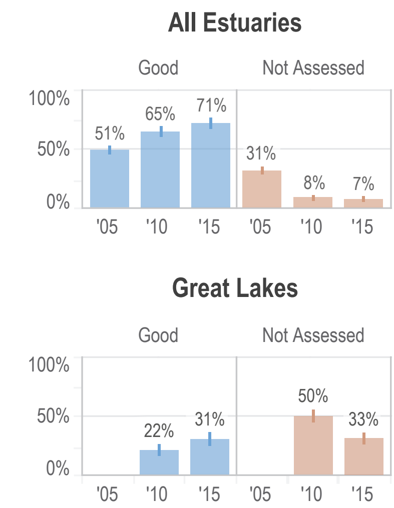
The paragraphs below describe NCCA results and their similarities and connections to other NARS results. Each of these assessments includes information on biological, chemical and physical indicators. While the specific indicators chosen are those most suited to the particular water body type and are not necessarily exactly the same, we can look across these assessments to get a broad picture of the health of waters across the country.

[12] Several estuarine assessments were conducted prior to the establishment of the NCCA. Of those, the 2005-06 assessment is comparable to the NCCA and is used as a baseline for comparison. Three other, earlier reports also assessed estuarine resources, but differing designs and/or methods did not allow EPA to compare results to the current assessment. The first Great Lakes assessment was conducted in 2010.

Biological Condition

To assess biological condition, each of the surveys under NARS used indicators appropriate to the water body type (e.g., estuaries, the nearshore Great Lakes, lakes, and rivers and streams used benthic macroinvertebrate indices appropriate to the aquatic resource types, while wetlands used a vegetation index).[13] Based on information from the most recent reports in the NARS program, estuarine waters had the most area in good condition at 71% (see Figure 5.1), followed by wetlands with 48%. Approximately one-third of lakes, river and stream miles, and Great Lakes nearshore area were in good condition based on biological indicators.[14] The area rated good in estuaries has increased from 51% to 71% since 2005, and the area in good condition in the Great Lakes has shown improvement since 2010 as well. It should be noted, however, that change in condition across those intervals coincides with improved sampling success, so further studies are needed to find the underlying reasons for the increase in area in good condition.

Figure 5.1. Change in Estuarine and Great Lakes Biological Condition As Assessed With Benthic Macroinvertebrate Indices



Eutrophication

NCCA results indicate that 33% of estuarine waters and 54% of Great Lakes waters were in good condition based on eutrophication index scores. While other NARS reports do not assess eutrophication the same way, they all report nutrient concentrations in one form or another, and the lakes assessment uses chlorophyll *a* as a eutrophication indicator. In the rivers and streams survey, only 18% of river and stream miles were in good condition for phosphorus, and 32% for nitrogen. Similar to findings from other assessments, the NCCA found that elevated nutrient levels are widespread stressors.

Sediment Quality

The NCCA found that the majority of estuarine and nearshore Great Lakes sediments were in good condition (76% and 62%, respectively). While other NARS reports have not included an indicator of sediment condition in the past, the next National Lakes Assessment will report results of a sediment contamination analysis on the NARS website. Additionally, the wetlands assessment collects soils and analyzes for a wide array of constituents. Sediment and wetland soils data are available on the NARS website (https://www.epa.gov/national-aquatic-resource-surveys).

[13] The lakes assessment also used zooplankton as an indicator of biological condition. The rivers and streams assessment used fish populations as a second indicator of biological condition.
[14] Thirty-three percent of nearshore Great Lakes area could not be assessed.

Ecological Effects of Fish Tissue Contamination

The ecological fish tissue indicator assesses the likelihood that predators of fish such as birds, mammals, and other fish will experience adverse yet nonlethal effects from contaminants in the fish that they consume. EPA began measuring this indicator during the 2010 NCCA and updated the way it was calculated in 2015. Fifty-five percent of estuarine area and 47% of Great Lakes nearshore area was in poor condition according to this sensitive indicator. Although condition appears to have declined (that is, area rated poor and fair has increased), the decline coincides with a decline in area that was not assessed. Thus, the extent of area in poor and fair condition in 2010 might have been obscured by failure to collect fish for samples. Elements (particularly selenium, arsenic and mercury) and PCBs were the contaminants that most frequently occurred in fish at levels that may adversely affect fish-eating predators. When selenium concentrations were compared to EPA's freshwater aquatic life use criterion, no estuarine area and Great Lakes nearshore area exceeded the criterion.

Human Health Indicators

Human health indicators generally indicated more coastal waters were in good condition (i.e., concentrations of the contaminant were not above benchmarks and posed few risks to human health) than other types of water bodies. Enterococci data from the NCCA showed that 99% of both estuary and Great Lakes nearshore area were below the benchmark value, while 69% of rivers and streams were at or below the benchmark. Exceedances of the microcystins benchmark were nonexistent or very rare in all waters. However, that does not mean microcystins were never detected. They were detected at or below benchmark levels in 6% of estuarine area and in 31% of nearshore Great Lakes waters. In comparison, microcystins were detected at or below the benchmark in 39% of lakes and in 37% of river and stream miles.[15] Continued research will help us understand formation and transport of microcystins and other algal toxins in the two types of coastal waters. Mercury in fish fillet plugs was also low in estuaries and the nearshore Great Lakes, with 2% and 6% of area, respectively, exceeding EPA benchmarks, compared to 7% in rivers and streams. However, 65% of river and stream miles were unassessed due to failure to catch fish, while only 43% of estuaries and 29% of nearshore Great Lakes were unassessed. The lakes and wetland assessments did not include evaluation of fish fillet plugs for mercury.

Great Lakes Human Health Fish Fillet Tissue Study

In the Great Lakes, the EPA Office of Science and Technology led an additional collaborative study with Great Lakes states and the EPA Great Lakes National Program Office. This study analyzed fish fillet tissue contaminants, comparing concentrations of mercury, PCBs and PFOS to human health fish tissue benchmarks. Each of the three types of contaminants was found in every one of the 152 fillet composite tissue samples analyzed in 2015.

[15] The lakes assessment used a different benchmark than the NCCA. Future NARS reports will use the updated EPA benchmark.

WHAT WAS NEW FOR NCCA 2015?

The new M-AMBI was used to assess biological condition in estuaries, allowing estuarine results to be compared nationally for the first time. The ecological fish tissue contaminant index was updated to more appropriately account for predator body weights and ingestion rates.

HOW ARE THE REPORT AND UNDERLYING DATA USED?

The Lake Erie water snake (*Nerodia sipedon insularum*) lives on the islands of western Lake Erie and on the Catawba-Marblehead peninsula on the mainland. It feeds primarily on fish.

In addition to using NCCA data to evaluate current restoration and protection efforts, coastal managers can place site-specific data into a broader context and initiate additional research into why certain patterns or changes occur. Already, states and others are using NCCA data to plan coastal management actions, supplement their existing coastal water monitoring programs and address Clean Water Act reporting requirements. See examples below.

Beyond addressing the core NCCA questions, results and data from the survey are used to support other priorities and programs. For example, the 2014 reauthorization of the Harmful Algal Bloom and Hypoxia Research and Control Act recognizes the importance of expanding monitoring efforts to address harmful algal blooms and hypoxia. The addition of microcystins to NCCA 2015, as well as NCCA research with the U.S. Geological Survey on a broader suite of algal toxins, will contribute to improved ability to detect and understand harmful algal blooms.

Data generated by the NCCA can be used to measure the effectiveness of efforts to improve the health of aquatic resources. For example, the Southeast Conservation Adaptation Strategy (SECAS) is an initiative that spans the Southeastern United States and Caribbean. Information from the coastal survey is being used in measuring SECAS' progress toward its goal of "a 10% or greater improvement in the health, function and connectivity of Southeastern ecosystems by 2060" (SECAS, n.d.).

States and participants in the National Estuary Program have built on the NCCA to expand their own monitoring and assessment capabilities. The state of Ohio built on NCCA to develop a new Lake Erie monitoring program, while the Albemarle-Pamlico National Estuary Program added sites to provide statistically significant findings to inform decision-makers about the quality of the estuary system as a whole.

Data from the survey can also be used in research into possible effects of climate change. For example, in 2017, EPA scientists Hale et al. published findings indicating that "centers of abundance for 60% of the benthic species studied shifted north along the U.S. Atlantic coast during the period 1990–2010, in concordance with increasing water temperatures." EPA anticipates the release of the NCCA 2015 data and results will further contribute to scientific advancements.

EPA researchers have also used NCCA data to develop tools to quantify the economic benefits that healthy ecosystems offer to coastal communities.

Taken together, NCCA and other NARS findings suggest the need for continued collective efforts to address the many sources of stressors. With the assistance of EPA and other federal agencies, states are adopting numeric phosphorus and nitrogen water quality criteria and developing and implementing programs that reduce excess nutrients in waterways. For example, see the writeup on eutrophication in the Gulf of Mexico in Section 3.2. These activities, which are designed to improve the condition of upstream waters, will likely benefit the estuaries and Great Lakes into which they flow.

WHAT'S NEXT FOR THE NCCA?

As this report was being written and reviewed, the NCCA 2020 field season had begun. During June through September 2020, crews from states, tribes, EPA and other federal agencies sampled more than 1,000 sites in estuarine and Great Lakes nearshore waters. Challenges from the COVID-19 pandemic left about 20% of the planned sites unsampled; crews will complete sampling of those sites between June 1 and September 30, 2021. The NCCA team applied a variety of lessons learned from NCCA 2015 as well as other NARS for 2020 and 2021. Among other improvements, field crew training now includes video demonstrations of sampling methods. All NCCA crews collected and submitted field data using an electronic tablet, reducing opportunities for transcription errors and reducing the time it takes to publish the data. NCCA 2020 includes several research indicators as well. These include total alkalinity in water and microplastics and nitrogen isotopes in sediments.[16] In addition, several states and estuary programs are adding sites to allow for smaller-scale assessments, and EPA is working with states and estuary programs to test new ways to identify relationships between stressors and biological condition, such as modeling and analyzing differences in condition in large and small estuaries. Finally, EPA will continue to review how the NCCA assesses coastal condition. Areas of continued research include the following:

- Evaluating coastal waters where underwater grasses may grow and whether water clarity benchmarks should be updated in those areas (EPA uses different benchmarks for water clarity in such waters when calculating eutrophication index scores).
- Reevaluation of total nitrogen and phosphorus benchmarks, and
- Updating the methods that the NCCA uses to assess contaminants in whole fish and cyanotoxins in coastal environments.

The NCCA 2015 report would not have been possible without the assistance of hundreds of dedicated scientists working for state, federal and tribal agencies and universities across the country. These partners helped plan and design the survey, select and refine indicators, train field crews, conduct sampling, track samples, review data for quality control, analyze data, and review and write up the findings. Future coastal surveys will continue to rely on this close collaboration between EPA and its partners.

[16] The isotopes present in sediment can help researchers determine whether nitrogen comes from manmade or naturally occurring sources.

References

Bloom, N.S. 1992. On the chemical form of mercury in edible fish and marine invertebrate tissue. *Canadian Journal of Fisheries and Aquatic Sciences* 49(5):1010-1017.

Borja, A, J. Franco, and V. Perez. 2000. A marine biotic index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. *Marine Pollution Bulletin* 40(12):1100-1114.

Environment Canada and the U.S. Environmental Protection Agency. 2014. *State of the Great Lakes 2011*. Cat No. En161-3/1-2011E-PDF. EPA 950-R-13-002. Environment Canada, Ottawa, ON, and U.S. Environmental Protection Agency, Washington, DC. https://archive.epa.gov/solec/web/pdf/sogl-2011-technical-report-en.pdf

Fleming, E., J., W. Payne, W. Sweet, M. Craghan, J. Haines, J.F. Hart, H. Stiller, and A. Sutton-Grier, 2018: Coastal effects. In *Impacts, risks, and adaptation in the United States: fourth National Climate Assessment, volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, 322–352. https://doi.org/10.7930/NCA4.2018.CH8

Hale, S.S., H.W. Buffum, J.A. Kiddon, and M.M. Hughes. 2017. Subtidal benthic invertebrates shifting northward along the U.S. Atlantic coast. *Estuaries and Coasts* 40:1744–1756. https://doi.org/10.1007/s12237-017-0236-z

Jewett, L. and A. Romanou, 2017. Ocean acidification and other ocean changes. In: *Climate science special report: fourth National Climate Assessment, volume I* [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, 364-392, https://doi.org/10.7930/J0QV3JQB

Kildow, J. T., C. S. Colgan, P. Johnston, J. D. Scorse, and M. G. Farnum, 2016: State of the U.S. ocean and coastal economies: 2016 update. National Ocean Economics Program, Monterey, CA, 31 pp. https://www.midatlanticocean.org/wp-content/uploads/2016/03/NOEP_National_Report_2016.pdf

Milbrink, G. 1983. An improved environmental index based on the relative abundance of oligochaete species. *Hydrobiologia* 102:89-97.

NOAA National Centers for Coastal Ocean Science. 2007. National estuarine eutrophication assessment update. National Centers for Coastal Ocean Science, Silver Spring, MD. https://coastalscience.noaa.gov/project/national-estuarine-eutrophication-assessment-update/

Pelletier, M.C., D. J. Gillett, A. Hamilton, T. Grayson, V. Hansen, E.W. Leppo, S.B. Weisberg, and A. Borja. 2018. Adaptation and application of multivariate AMBI (M-AMBI) in U.S. coastal waters. *Ecological Indicators* 89:818-827. https://doi.org/10.1016/j.ecolind.2017.08.067

SECAS (Southeast Conservation Adaptation Strategy). No date. Our goal. https://secassoutheast.org/our-goal. Accessed July 9, 2021.

Sweet, W.V., R. Horton, R.E. Kopp, A.N. LeGrande, and A. Romanou, 2017: Sea level rise. In: *Climate sciences special report: fourth National Climate Assessment, volume I* [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, 333-363, https://doi.org/10.7930/J0VM49F2

U.S. Department of Agriculture and U.S. Department of Health and Human Services. 2020. *Dietary guidelines for Americans. 2020-2025*. https://www.dietaryguidelines.gov/sites/default/files/2020-12/Dietary_Guidelines_for_Americans_2020-2025.pdf

U.S. Environmental Protection Agency. 2000. *Guidance for assessing chemical contaminant data for use in fish advisories. Volume 2: Risk assessment and fish consumption limits. Third edition.* EPA 823-B-00-008. https://nepis.epa.gov/Exe/ZyPDF.cgi/20003P11.PDF?Dockey=20003P11.PDF

U.S. Environmental Protection Agency. 2001. *Water quality criterion for the protection of human health: methylmercury.* EPA-823-R-01-001. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC. https://www.epa.gov/sites/production/files/2020-01/documents/methylmercury-criterion-2001.pdf

U.S. Environmental Protection Agency. 2010. *Guidance for implementing the January 2001 methylmercury water quality criterion.* EPA-823-R-10-001. U.S. Environmental Protection Agency, Office of Science and Technology, Washington, DC. https://nepis.epa.gov/Exe/ZyPDF.cgi/P1007BKQ.PDF?Dockey=P1007BKQ.PDF

U.S. Environmental Protection Agency. 2011. *Exposure factors handbook 2011 edition (final report)*. EPA/600/R-09/052F. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC, . https://www.epa.gov/expobox/about-exposure-factors-handbook

U.S. Environmental Protection Agency. 2012. *Recreational water quality criteria.* EPA 820-F-12-058. U.S. Environmental Protection Agency, Office of Water, Washington, DC. https://www.epa.gov/sites/production/files/2015-10/documents/rwqc2012.pdf

U.S. Environmental Protection Agency. 2014. *Estimated fish consumption rates for the U.S. population and selected subpopulations (NHANES 2003-2010). Final report.* EPA-820-R-14-002. https://www.epa.gov/sites/production/files/2015-01/documents/fish-consumption-rates-2014.pdf

U.S. Environmental Protection Agency. 2015. *National coastal condition assessment 2015 field operations manual*. EPA-841-R-14-007. U.S. Environmental Protection Agency, Office of Water, Washington, DC. https://www.epa.gov/sites/production/files/2016-03/documents/national_coastal_condition_assessment_2015_field_operation_manual_version_1.0_1.pdf

U.S. Environmental Protection Agency. 2016a. *National coastal condition assessment 2015 laboratory operations manual*. Version 2.1. EPA-841-R-14-008. U.S. Environmental Protection Agency, Office of Water, Washington, DC. https://www.epa.gov/sites/production/files/2016-03/documents/ncca_2015_lom_version_2.0_july_2015.pdf

U.S. Environmental Protection Agency. 2016b. *Aquatic life ambient water quality criterion for selenium – freshwater*. EPA 822-R-16-006. U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology, Washington, DC. https://www.epa.gov/sites/production/files/2016-07/documents/aquatic_life_awqc_for_selenium_-_freshwater_2016.pdf

U.S. Environmental Protection Agency. 2019. *Recommended human health recreational ambient water quality criteria or swimming advisories for microcystins and cylindrospermopsin.* EPA-822-R-19-001. U.S. Environmental Protection Agency, Office of Water, Health and Ecological Criteria Division, Washington, DC. https://www.epa.gov/sites/production/files/2019-05/documents/hh-rec-criteria-habs-document-2019.pdf

U.S. Environmental Protection Agency. 2020. Documented hypoxia and associated risk factors in estuaries, coastal waters, and the Great Lakes ecosystems. https://www.epa.gov/nutrient-policy-data/documented-hypoxia-and-associated-risk-factors-estuaries-coastal-waters-and

U.S. Environmental Protection Agency. 2021. *National coastal condition assessment 2015 technical support document*. EPA 841-R-21-002. https://www.epa.gov/national-aquatic-resource-surveys/national-coastal-condition-assessment-2015-technical-support

U.S. Environmental Protection Agency. No date. National recommended water quality criteria - aquatic life criteria table. https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table. Accessed July 9, 2021.

U.S. Geological Survey. 2017. Louisiana's rate of coastal wetland loss continues to slow: Louisiana's changing wetlands. Department of the Interior, U.S. Geological Society, Office of Communications and Publishing, Reston, VA. https://www.usgs.gov/news/usgs-louisiana-s-rate-coastal-wetland-loss-continues-slow

Wick, M., T.R. Angradi, M. Pawlowski, D. Bolgrien, J. Launspach, J. Kiddon, and M. Nord. 2019. An assessment of water quality in two Great Lakes connecting channels. *Journal of Great Lakes Research* 45(5): 901-911. https://doi.org/10.1016/j.jglr.2019.08.001

Wick, M., T.R. Angradi, M. Pawlowski, D. Bolgrien, R. Debbout, J. Launspach, M. Nord. 2020. Deep Lake Explorer: A web application for crowdsourcing the classification of benthic underwater video from the Laurentian Great Lakes *Journal of Great Lakes Research* 46(5): 1469-1478. https://doi.org/10.1016/j.jglr.2020.07.009

Yurista, P.M, J. R. Kelly, and J. V. Scharrold. 2016. Great Lakes nearshore–offshore: Distinct water quality regions. *Journal of Great Lakes Research* 42(2): 375-385. https://doi.org/10.1016/j.jglr.2015.12.002

Image Credits

Page	Description	Location	Credit
Cover	Point Loma Lighthouse sunset, entrance to San Diego Bay	Point Loma, CA	Patrick Kelley, U.S. Coast Guard, DVIDS
Cover	Swamp rose mallow	Cape Hatteras National Seashore, NC	Hugh Sullivan, EPA
Cover	Pelican	Key Colony Beach, FL	Hugh Sullivan, EPA
Cover	The *Lake Explorer II*	St. Marys River, MI	EPA
Banner	Point Loma Lighthouse	Point Loma, CA	Henry Dumphy, U.S. Coast Guard, DVIDS
Banner	Ospreys roosting on pier	Currituck Sound, NC	Hugh Sullivan, EPA
Banner	Loggerhead Key Light	Loggerhead Key, FL	Jennifer Johnson, U.S. Coast Guard, Wikipedia
1	Lake Michigan Overlook	Sleeping Bear Dunes National Lakeshore, MI	Ken Bosma, Flickr (CC BY 2.0), cropped
5	Aerial view of a series of small islands, boat slips, and roadways leading to Miami, Florida	Biscayne Bay, FL	Carol Highsmith, Library of Congress
6	Milwaukee skyline from a sailboat	Milwaukee, WI	Mike Strande, Flickr (CC BY 2.0), cropped
7	Thomas Point lighthouse	Chesapeake Bay, MD	Pete Milnes, U.S. Coast Guard
9	Sand Beach	Acadia National Park, ME	Hugh Sullivan, EPA
10	San Francisco Bay, from El Cerrito	San Francisco Bay, CA	Natalie Auer
11	Lake Michigan, sailboats and students	Evanston, IL	Natalie Auer
12	Taking a light meter reading	Gulf Breeze, FL	Great Lakes Environmental Center
13	Secchi disk		Minnesota Pollution Control Agency, Flickr (CC BY-NC 2.0)
14	Young modified Van Veen sediment grabber	Pensacola Bay, FL	Hugh Sullivan, EPA
17	Collecting a sediment sample		EPA
17	Sunrise on the rock	Morro Bay, CA	David Seibold, Flickr (CC BY-NC 2.0), cropped
18	Mackinac Bridge	Mackinaw City, MI	James Marvin Phelps, Flickr, (CC BY-NC 2.0)
19	Marsh vegetation	Duck, NC	Mike Crow
20	Small waves on Chesapeake Bay shore	Chesapeake Bay	Mike Crow
21	Boardwalk to salt marsh		Mike Crow
23	*Mercenaria mercenaria* illustration		Mary Koger, Crow Insight

Page	Description	Location	Credit
24	Benthic macroinvertebrate sample after sediment is washed away	Pensacola Bay, FL	Hugh Sullivan, EPA
25	Algae bloom in Puget Sound near Edmonds	Edmonds, WA	Washington State Dept. of Ecology, Flickr (CC BY-NC 2.0)
26	Gulf of Mexico algal bloom	Satellite image	NASA
27	Sediment, Boston Harbor, Station 110	Boston, MA	U.S. Geological Survey
28	Scorpionfish in seagrass	Florida Keys National Marine Sanctuary, FL	National Oceanic and Atmospheric Administration, Wikimedia
28	Nudibranch (*Acanthodoris hudsoni*)	Humboldt Bay, CA	Robin Agarwal, Flickr (CC BY-NC 2.0)
29	Luck at the locks [cormorant eating a fish]	Ballard Locks, Seattle, WA	Ingrid Taylar, Flickr (CC BY-NC 2.0), cropped
33	Channel catfish (*Ictalurus punctatus*)	Virginia Living Museum, Norfolk, VA	Will Parson, Chesapeake Bay Program, Flickr (CC BY-NC 2.0), cropped
34	Sunset on Lake Ontario	Lake Ontario, NY	EPA
35	Sunrise on Lake Erie	Lake Erie	EPA
36	North shore of Lake Superior	Lake Superior, MN	EPA
37	Tubificid worm, *Potamothrix moldaviensis*		Susan Daniel, Great Lakes Center, NOAA
38	Round goby and dreissenid mussels on underwater video		EPA
39	Processing samples on the boat		EPA
40	The Lake Erie shore at Reno Beach-Howard Farms	Reno Beach, OH	Ken Winters, U.S. Army Corps, Wikipedia
41	Collecting field data	St. Marys River, MI	EPA
42	Underwater rocks	Presqu'ile Park, Lake Ontario, ON	Andres Musta, Flickr, (CC BY 2.0)
43	American mink	Lake Erie	Jan Den Ouden, Pixabay (Pixabay license)
44	Cisco captured at the Les Cheneaux Islands, Lake Huron	Les Cheneaux Islands, Cedarville, MI	U.S. Fish and Wildlife Service, Flickr (CC BY-NC-ND 2.0)
45	Lake Michigan paddleboarders	Evanston, IL	Natalie Auer
46	Harmful algal bloom. Bolles Harbor, Monroe, MI, Lake Erie.	Monroe, MI	NOAA Great Lakes Environmental Research Laboratory, Flickr
48	Fishing on Lake Huron	Lake Huron, MI	EPA
50	The *Lake Explorer II*	St. Marys River, MI	EPA
51	Gulls on Lake Ontario	Lake Ontario, NY	EPA

Page	Description	Location	Credit
52	Buffalo skyline	Buffalo, NY	Sean Marshall, Flickr (CC BY-NC 2.0)
53	Dutch Island Lighthouse	Rhode Island	Don Cobb, EPA
54	Buffalo water crib intake	Buffalo, NY	Charles W. Bash, Flickr (CC BY-NC 2.0), cropped
55	Lake Erie water snake	Lake Erie, OH	Donna Braig, Ohio Sea Grant, Flickr (CC BY-NC 2.0)
56	Chesapeake Bay beach	Bevery Triton Beach Beach Park, Edgewater, MD	Matthew Beziat, Flickr (CC BY-NC 2.0), cropped

Appendix A: Sampling Locations for NCCA 2015

For NCCA 2015. EPA divided the target population for estuaries by region because each region has different ecology, water chemistry, and geography. EPA did the same for the Great Lakes. Regional divisions were also important for determining condition. For some indicators, the benchmarks EPA used to determine condition also differed by region (see Appendix B).

For estuaries, a total of 699 sites representing 27,479 square miles of estuarine area was sampled. For the Great Lakes, 361 sites were sampled, representing 7,118 square miles of nearshore area.

This appendix shows the sampling locations for NCCA 2015; a list of maps is shown below.

- All Estuaries, Figure A.1
  - Northeast, Figure A.2
  - Southeast, Figure A.3
  - Gulf, Figure A.4
  - West, Figure A.5
- All Great Lakes, Figure A.6
  - Lake Superior, Figure A.7
  - Lake Michigan, Figure A.8
  - Lake Huron, Figure A.9
  - Lake Erie, Figure A.10
  - Lake Ontario, Figure A.11

Figure A.1. Sampling Locations—All Estuaries

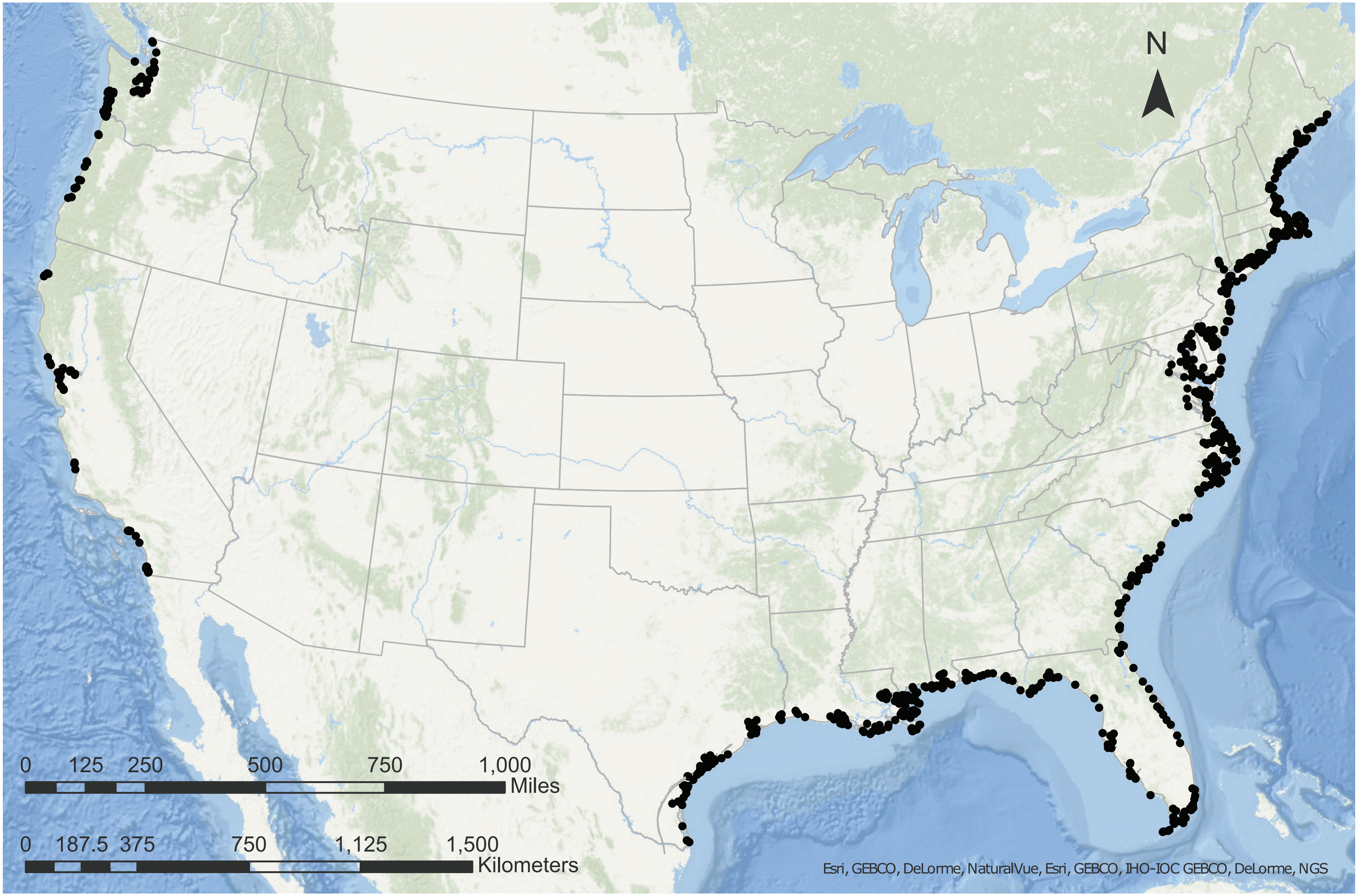


Figure A.2. Sampling Locations—Northeast

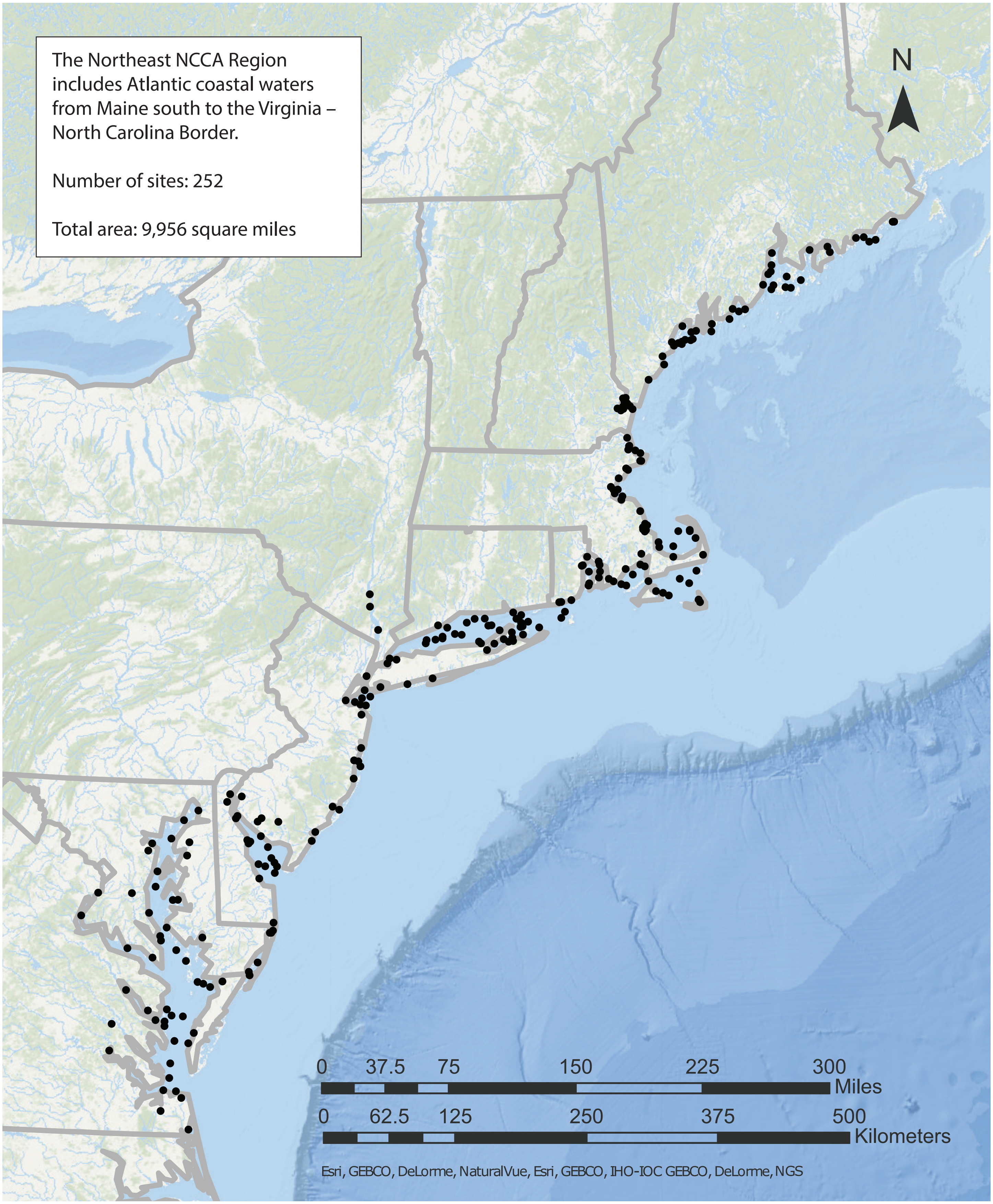


Figure A.3. Sampling Locations—Southeast

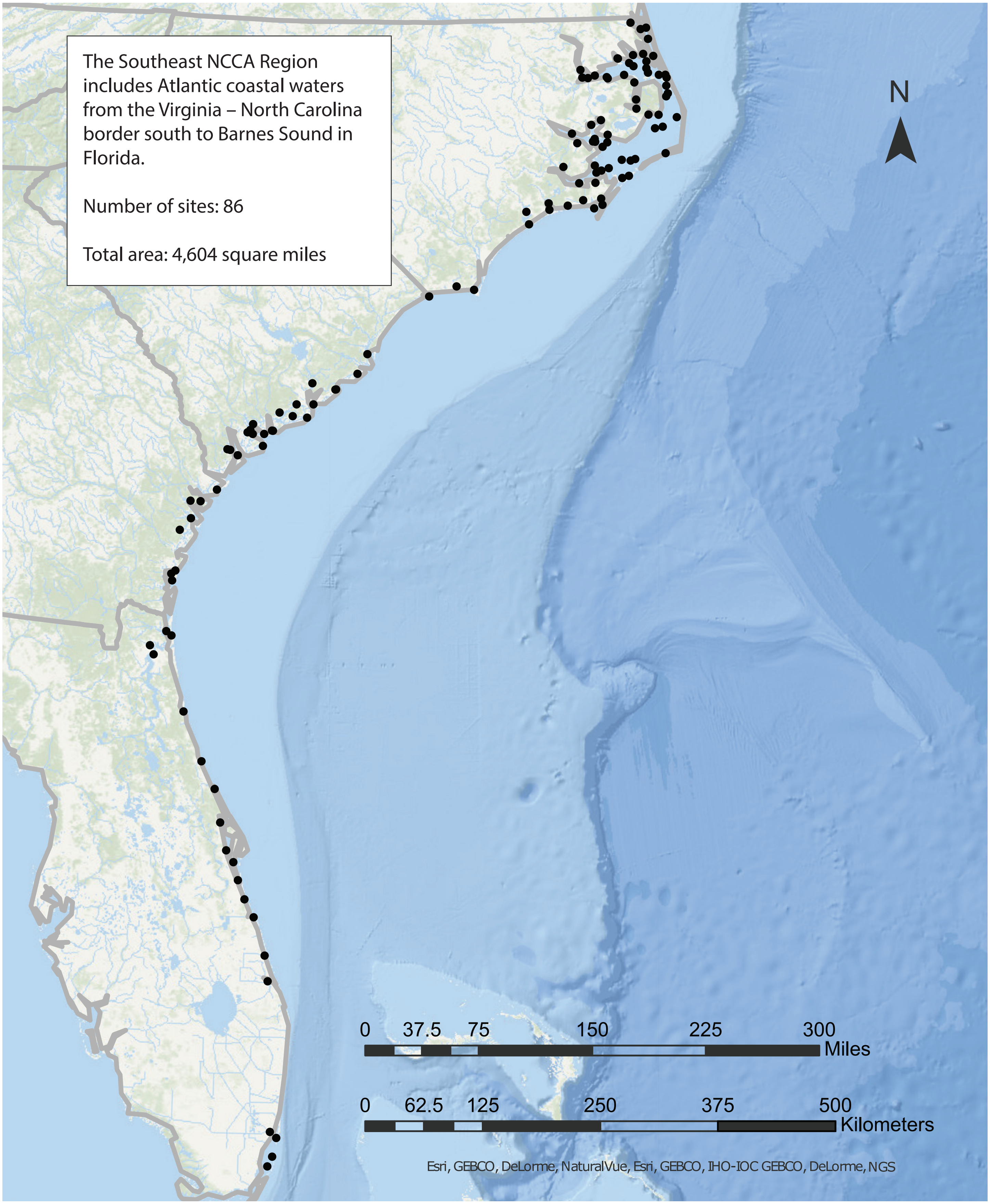


Figure A.4. Sampling Locations—Gulf

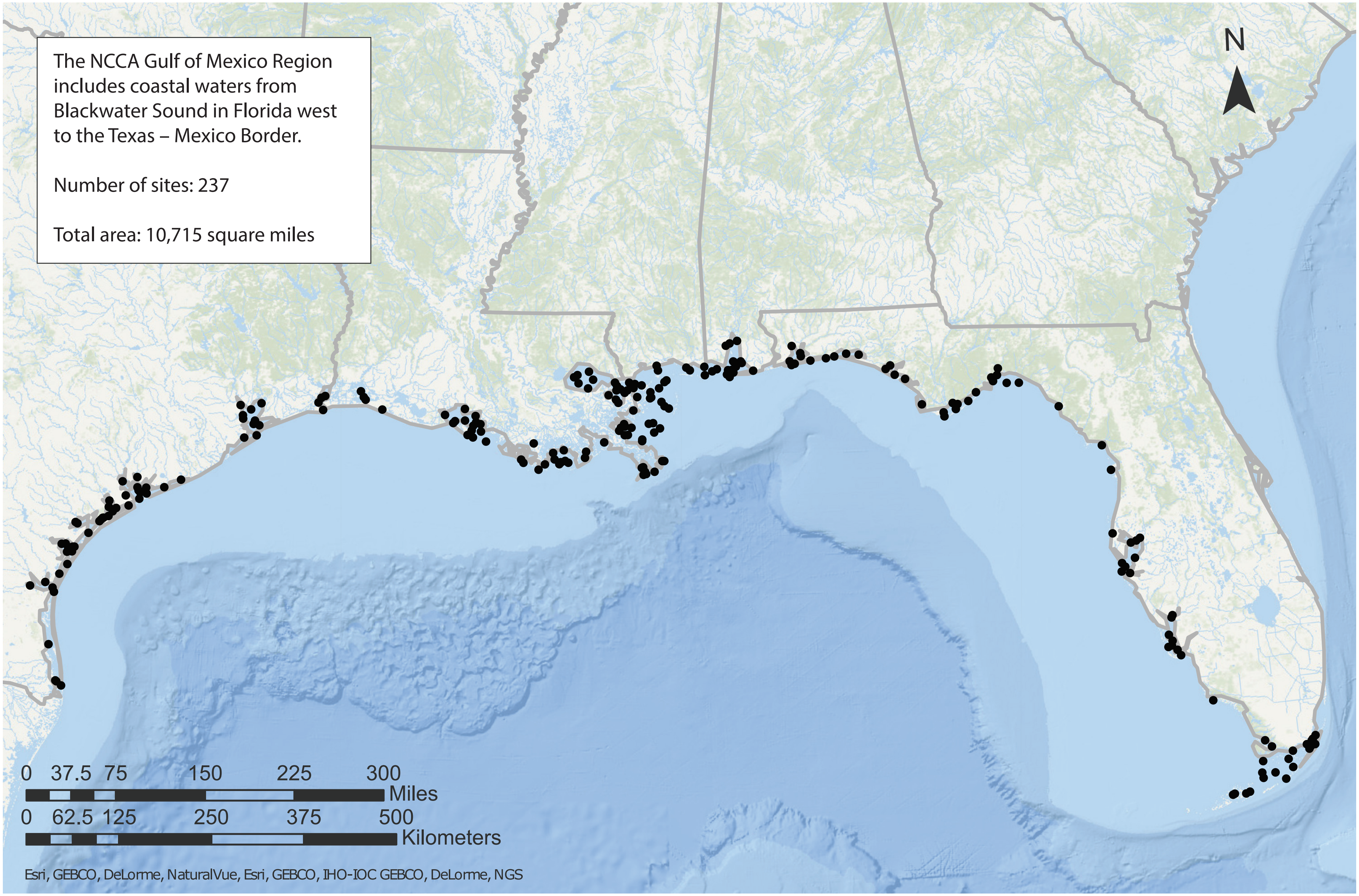


Figure A.5. Sampling Locations—West

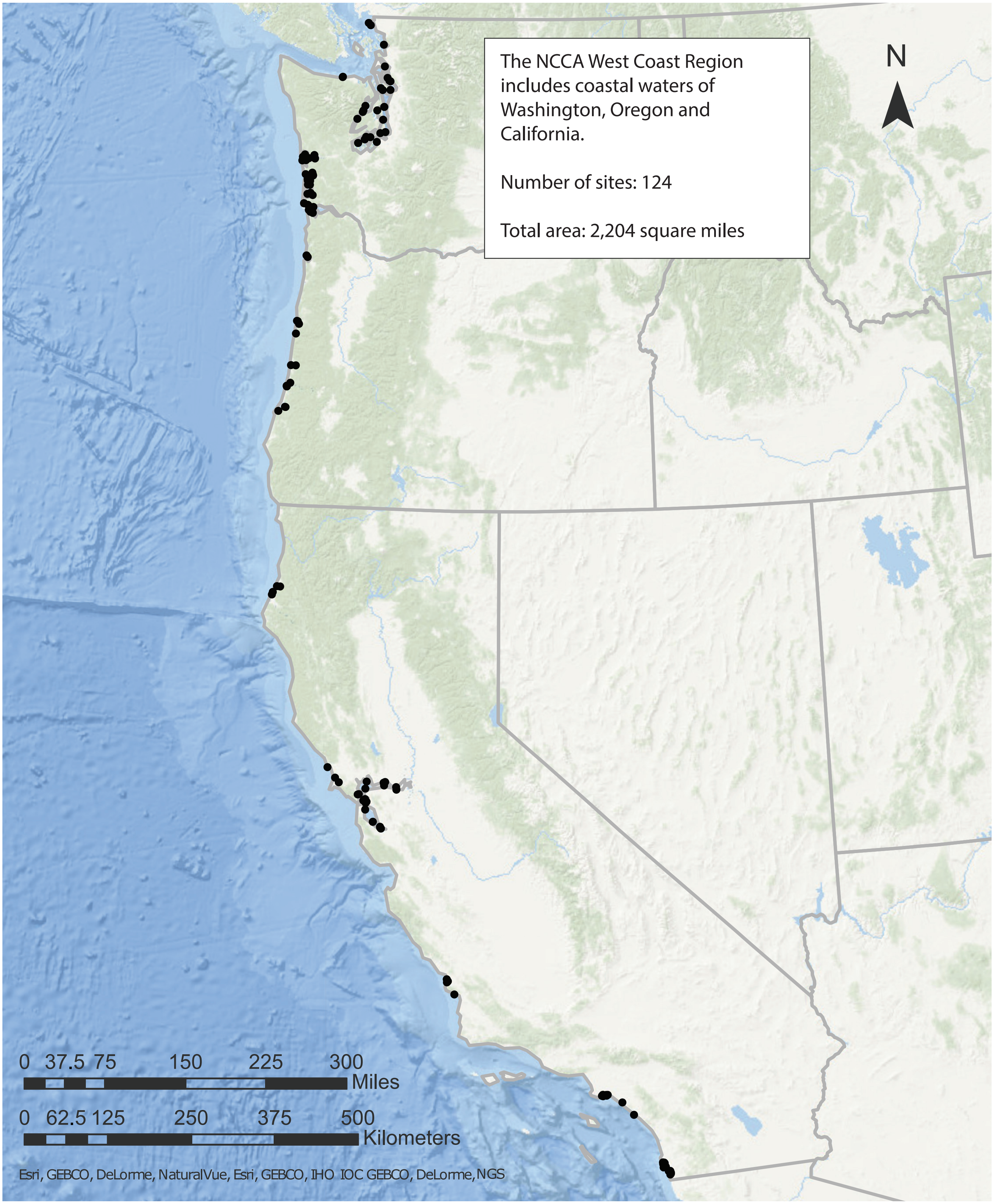


Figure A.6. Sampling Locations—All Great Lakes

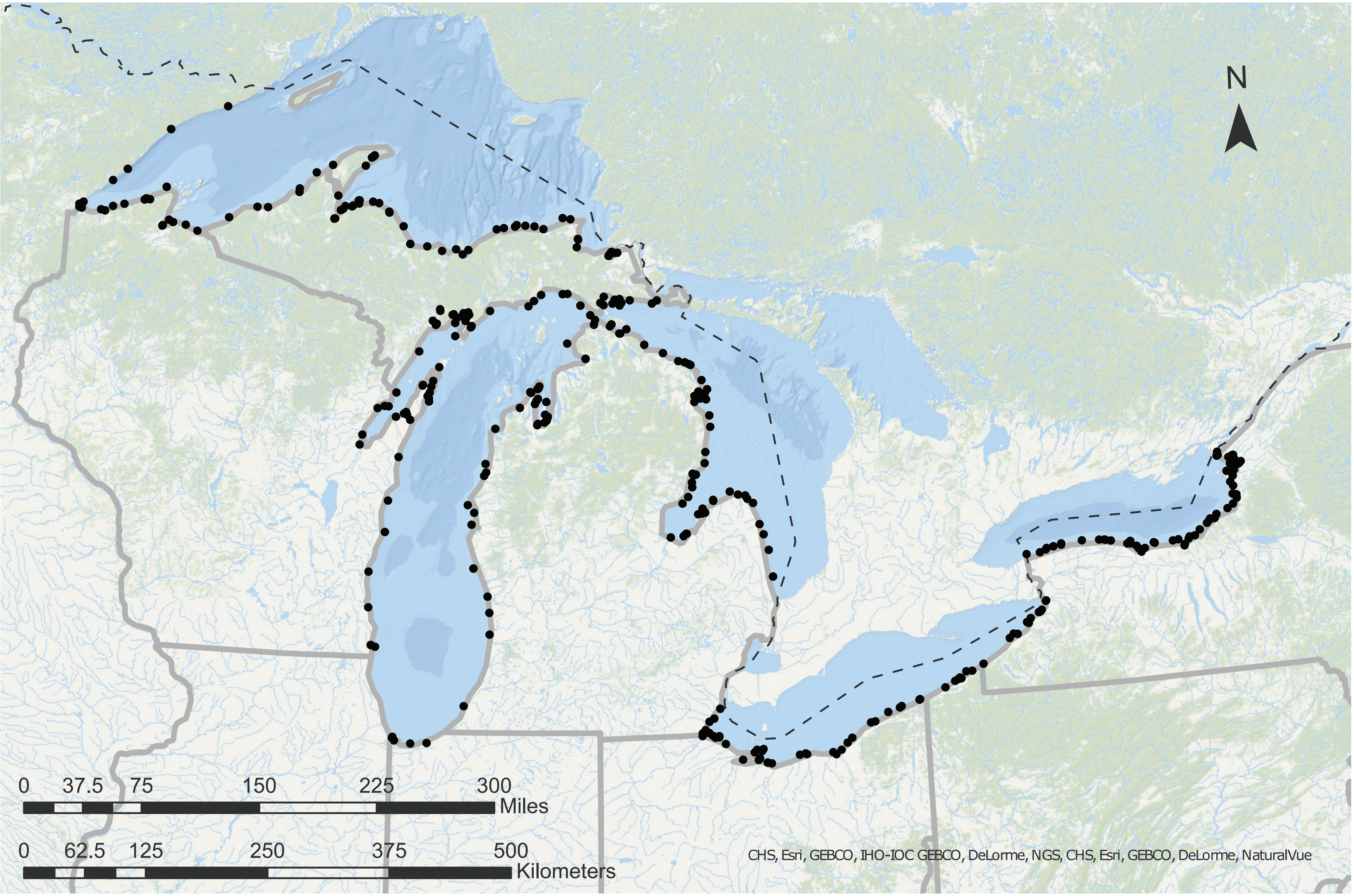


Figure A.7. Sampling Locations—Lake Superior

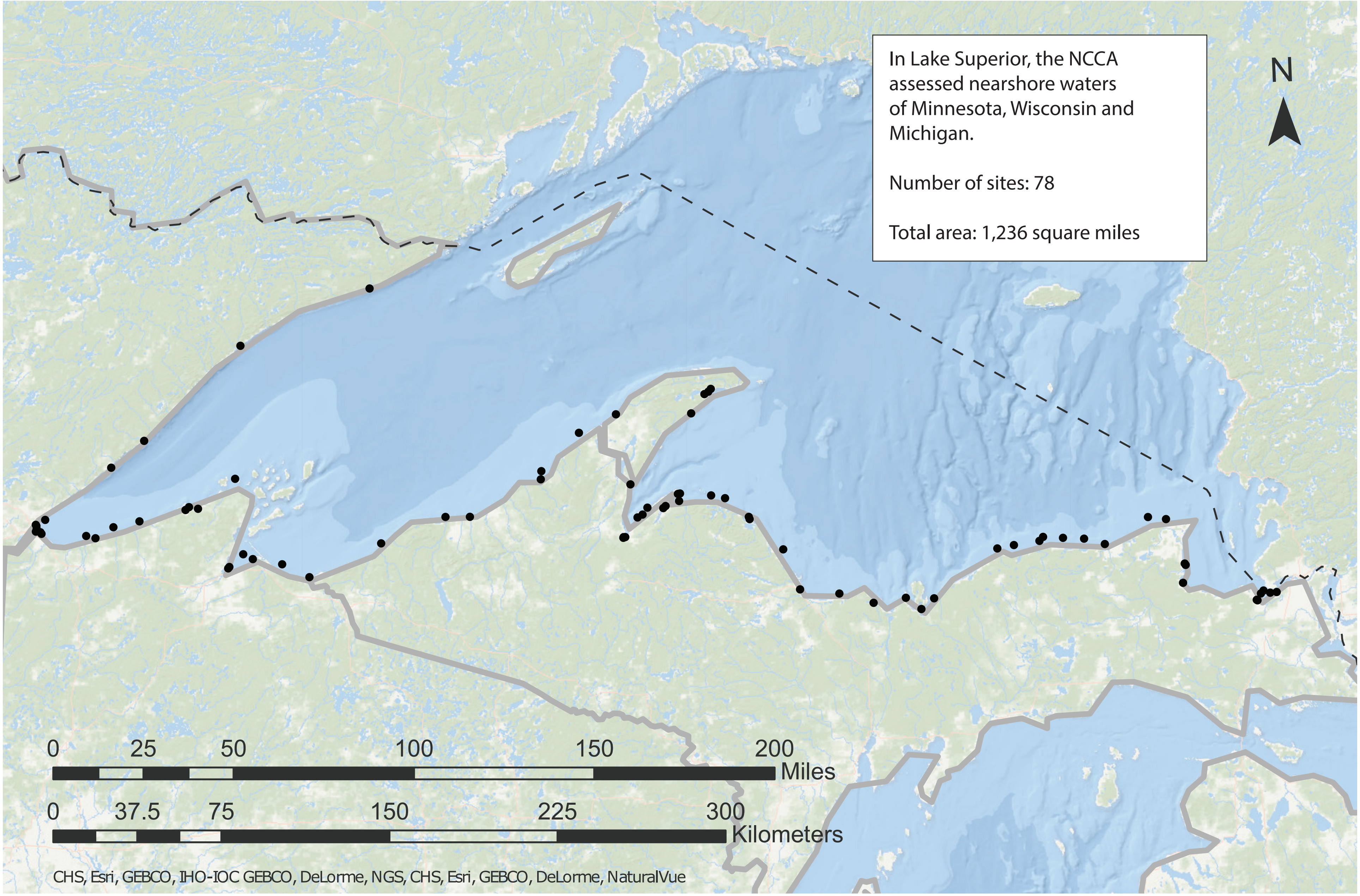


Figure A.8. Sampling Locations—Lake Michigan

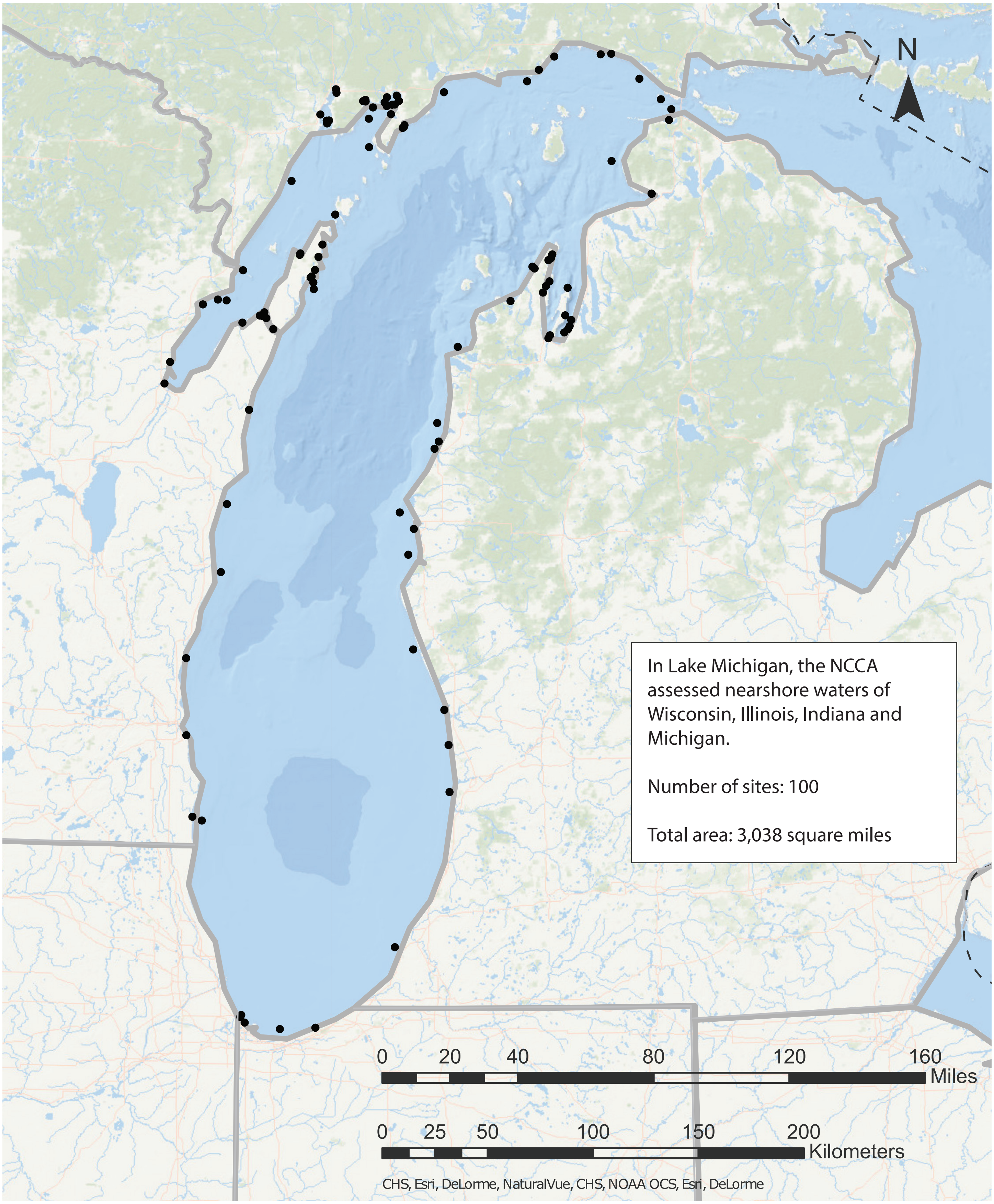


Figure A.9. Sampling Locations—Lake Huron

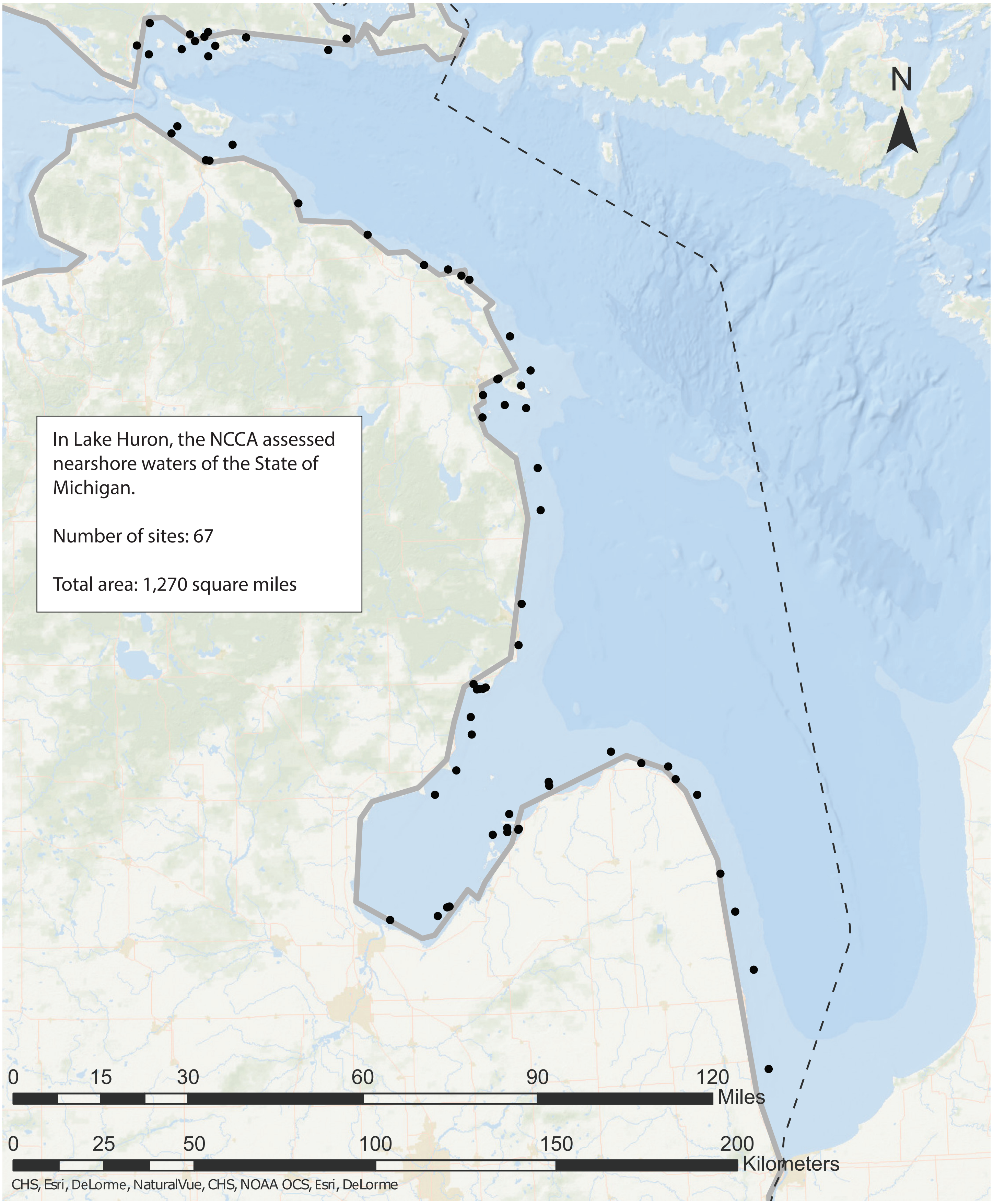


Figure A.10. Sampling Locations—Lake Erie

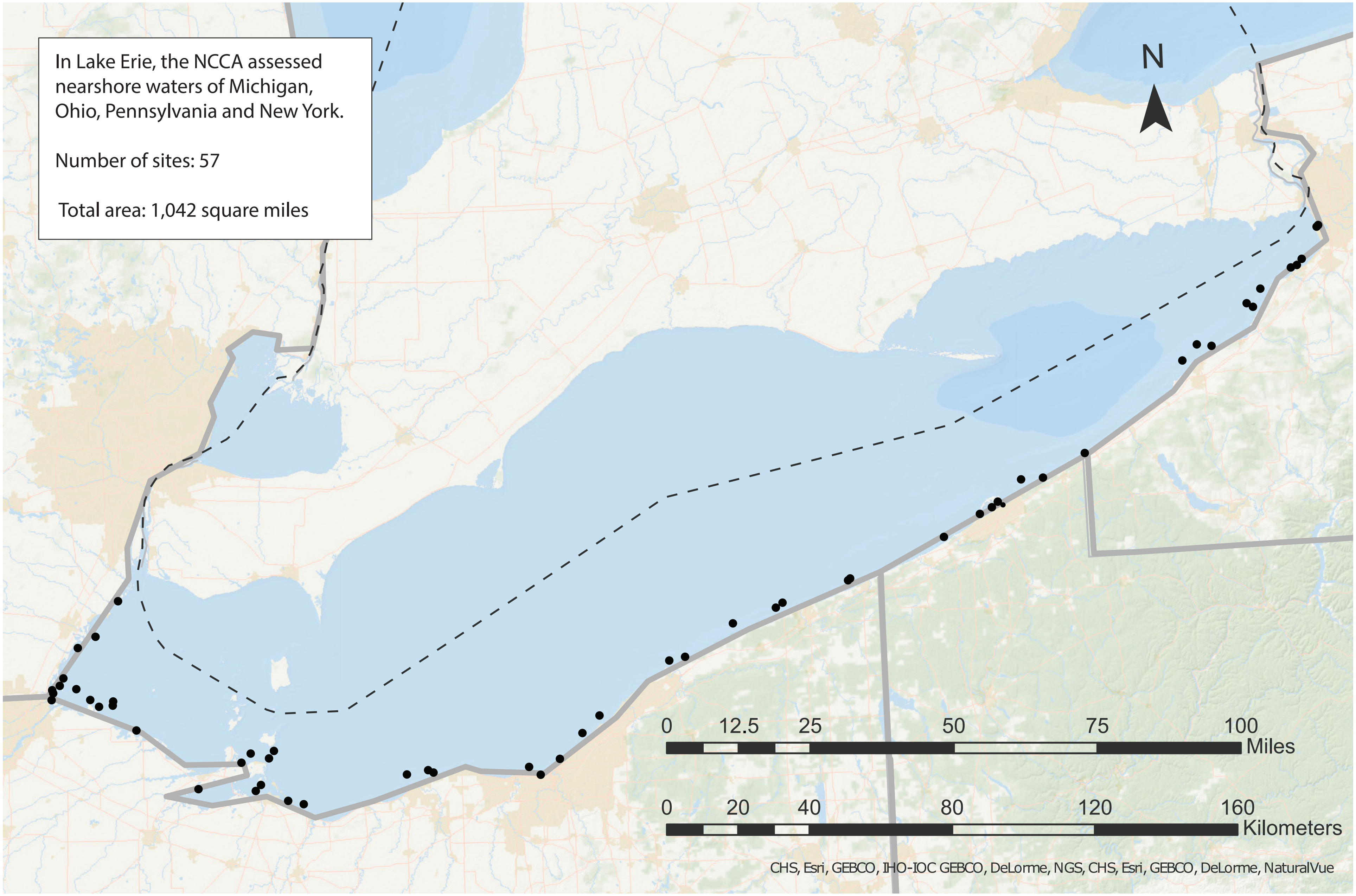
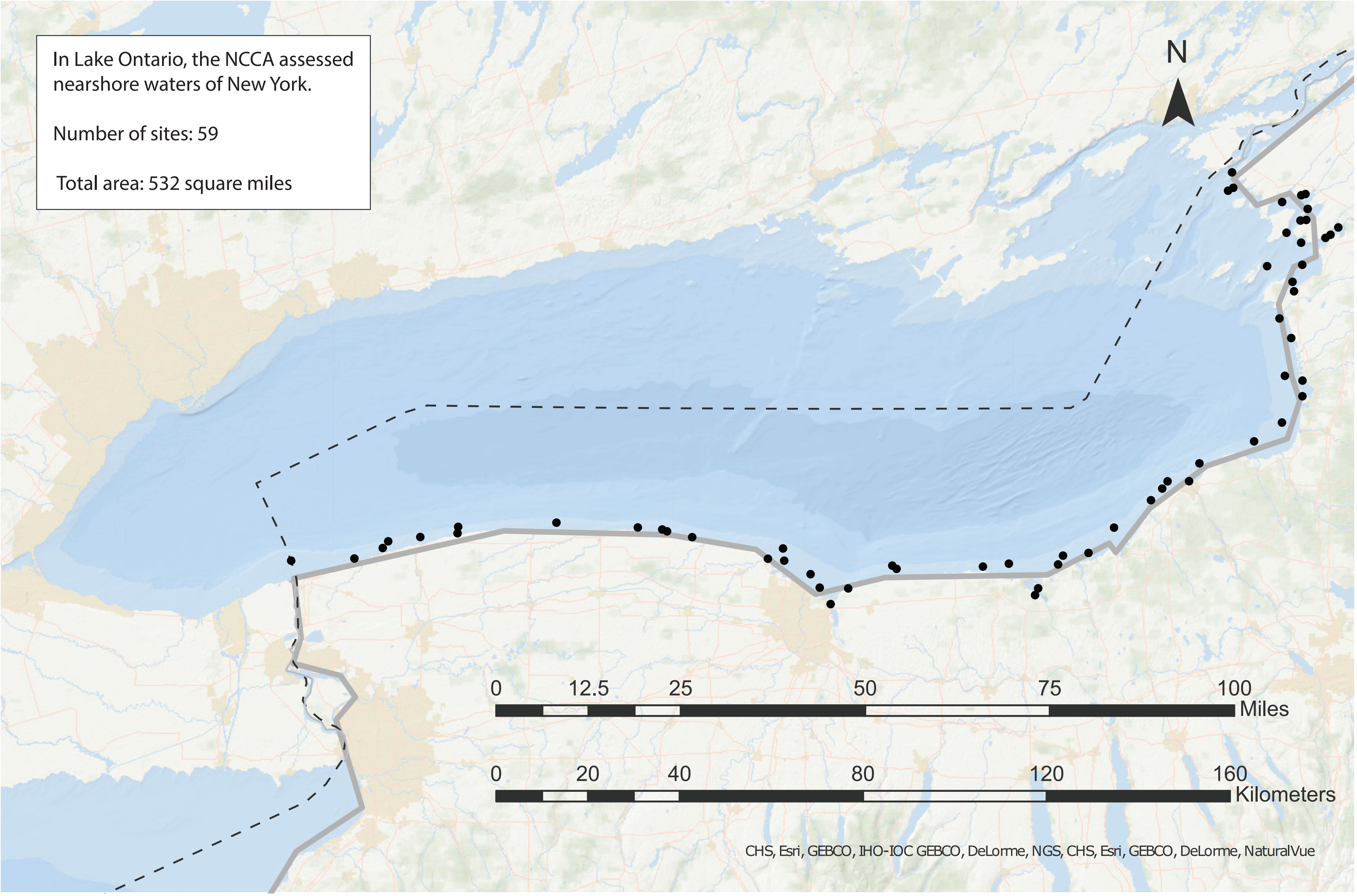


Figure A.11. Sampling Locations—Lake Ontario



Appendix B: Determining Good, Fair, and Poor Condition and Area Not Assessed

BIOLOGICAL CONDITION

Estuarine Biological Condition

The M-AMBI used in estuarine waters incorporates AMBI (an abundance-weighted tolerance index; Borja et al. 2000), the Shannon Wiener diversity index, and species richness into a single index value that ranges from 0 to 1, where higher scores indicate better condition.[1,2] Sites rated good have a wide variety of species, including low proportions of pollution-tolerant species and high proportions of pollution-sensitive species. Poor sites are less diverse and are populated by more pollution-tolerant species and fewer pollution-sensitive species. See Table B.1 for M-AMBI benchmarks, and Section 4.4.1 of the *NCCA 2015 Technical Support Document* (U.S. EPA 2021) for more information.

Table B.1 Benchmarks for NCCA Estuarine Benthic Index (M-AMBI)

Condition	Index Value
Good	M-AMBI ≥ 0.53
Fair	M-AMBI < 0.53 and ≥ 0.39
Poor	M-AMBI < 0.39

Nearshore Great Lakes Biological Condition

The oligochaete trophic index (OTI) classifies oligochaete worms in the Great Lakes into groups according to their tolerance to organic enrichment and calculates an index score based upon the relative abundance of more tolerant and less tolerant species. For the OTI, higher scores indicate worse condition. Poor sites had a greater relative abundance of tolerant organisms and scores above 1, while good sites had a higher relative abundance of intolerant organisms and scores closer to 0. See Table B.2 for OTI benchmarks, and the Technical Support Document (Section 4.4.2) for more information.

Table B.2 Benchmarks for NCCA Great Lakes Benthic Index (OTI)

Condition	Index Value
Good	OTI < 0.6
Fair	OTI ≥ 0.6 and ≤ 1
Poor	OTI > 1

[1] This diversity index accounts for both the number of species present and the percentage of the total community each species represents. Species richness is defined as the number of species present.

[2] In the tidal freshwater habitat, percent oligochaetes, the number of oligochaetes divided by the total number of organisms in the sample multiplied by 100, was substituted for species richness in the calculation of M-AMBI.

EUTROPHICATION INDEX

Eutrophication index ratings were based on the underlying ratings for several component indicators. The estuarine index includes five components, while the nearshore Great Lakes index includes four. The benchmarks for the underlying indicators differed in some cases depending on naturally occurring conditions in the estuary or with location. The overall index rating guidelines are shown in Table B.3, the benchmarks for the component indicators in estuaries are in Tables B.4 to B.8, and the benchmarks for the nearshore Great Lakes are in Tables B.9 to B.12. See Chapter 5 of the Technical Support Document for more information.

Table B.3 Eutrophication Index Rating Guidelines (Estuaries and Nearshore Great Lakes)

Condition	Eutrophication Index Combined Ratings
Good	A maximum of one indicator is rated fair; no indicators are rated poor.
Fair	One of the indicators is rated poor; or two or more indicators are rated fair.
Poor	Two or more of the component indicators are rated poor.
Not Assessed	Two indicators are missing, and the available indicators do not suggest a fair/poor rating.

Estuarine Eutrophication Index

Table B.4 Benchmarks for Estuarine Eutrophication Index—Dissolved Inorganic Nitrogen (Surface Concentration) (mg/L)

Condition	Northeast, Southeast and Gulf	West	South Florida*
Good	< 0.1	< 0.35	< 0.05
Fair	0.1 – 0.5	0.35 – 0.5	0.05 – 0.1
Poor	> 0.5	> 0.5	> 0.1

*South Florida is a subregion of the Gulf region that includes the Florida Keys and Florida Bay.

Table B.5 Benchmarks for Estuarine Eutrophication Index—Dissolved Inorganic Phosphorus (Surface Concentration) (mg/L)

Condition	Northeast, Southeast and Gulf	West	South Florida
Good	< 0.01	< 0.07	< 0.005
Fair	0.01 – 0.05	0.07 – 0.1	0.005 – 0.01
Poor	> 0.05	> 0.1	> 0.01

Table B.6 Benchmarks for Estuarine Eutrophication Index—Dissolved Chlorophyll a (Surface Concentration) (µg/L)

Condition	Northeast, Southeast, Gulf and West	South Florida
Good	< 5	< 0.5
Fair	5 - 20	0.5 – 1
Poor	> 20	> 1

Table B.7 Benchmarks for Estuarine Eutrophication Index—Water Clarity (Percent of Incident Light Remaining After Passing Through 1 Meter of Water)

Condition	Waters With Naturally High Turbidity	Waters With Normal Turbidity	Waters That Support Submerged Aquatic Vegetation
Good	> 10%	> 20%	> 40%
Fair	5% – 10%	10% – 20%	20% – 40%
Poor	< 5%	< 10%	< 20%

Table B.8 Benchmarks for Estuarine Eutrophication Index—Dissolved Oxygen (mg/L)

Condition	All Regions
Good	> 5
Fair	2 – 5
Poor	< 2

Nearshore Great Lakes Eutrophication Index

Table B.9 Benchmarks for Great Lakes Eutrophication Index—Total Phosphorus Concentration (µg/L)

Condition	Lake Superior	Lake Michigan	Lake Huron	Saginaw Bay	Western Lake Erie	Central Lake Erie	Eastern Lake Erie	Lake Ontario
Good	≤ 5	≤ 7	≤ 5	≤ 15	≤ 15	≤ 10	≤ 10	≤ 10
Fair	> 5 and ≤ 10	> 7 and ≤ 10	> 5 and ≤ 10	> 15 and ≤ 32	> 15 and ≤ 32	> 10 and ≤ 15	> 10 and ≤ 15	> 10 and ≤ 15
Poor	> 10	> 10	> 10	> 32	> 32	> 15	> 15	> 15

Table B.10 Benchmarks for Great Lakes Eutrophication Index—Chlorophyll a Concentration (µg/L))

Condition	Lake Superior	Lake Michigan	Lake Huron	Saginaw Bay	Western Lake Erie	Central Lake Erie	Eastern Lake Erie	Lake Ontario
Good	≤ 1.3	≤ 1.8	≤ 1.3	≤ 3.6	≤ 3.6	> 2.6	> 2.6	> 2.6
Fair	> 1.3 and ≤ 2.6	> 1.8 and ≤ 2.6	> 1.3 and ≤ 2.6	> 3.6 and ≤ 6	> 3.6 and ≤ 6	> 2.6 and ≤ 3.6	> 2.6 and ≤ 3.6	> 2.6 and ≤ 3.6
Poor	> 2.6	≤ 2.6	≤ 2.6	≤ 6	≤ 6	≤ 3.6	≤3.6	≤ 3.6

Table B.11 Benchmarks for Great Lakes Eutrophication Index—Secchi Depth (in meters)

Condition	Lake Superior	Lake Michigan	Lake Huron	Saginaw Bay	Western Lake Erie	Central Lake Erie	Eastern Lake Erie	Lake Ontario
Good	> 8	> 6.7	> 8	> 3.9	> 3.9	> 5.3	> 5.3	> 5.3
Fair	≤ 8 and > 5.3	≤ 6.7 and > 5.3	≤ 8 and > 5.3	≤ 3.9 and > 2.1	≤ 3.9 and > 2.1	≤ 5.3 and > 3.9	≤ 5.3 and > 3.9	≤ 5.3 and > 3.9
Poor	≤ 5.3	≤ 5.3	≤ 5.3	≤ 2.1	≤ 2.1	≤ 3.9	≤ 3.9	≤ 3.9

Table B.12 Benchmarks for Great Lakes Eutrophication Index—Dissolved Oxygen Concentration (mg/L)

Condition	All Great Lakes
Good	> 5
Fair	≤ 5 and > 2
Poor	≤ 2

SEDIMENT QUALITY INDEX

The NCCA sediment quality index is based on two component indices, the sediment contaminant index and the sediment toxicity index. These indices are calculated differently for estuaries and the Great Lakes; see Chapter 6 of the Technical Support Document for details on calculation.

Table B.13 Sediment Quality Index Rating Guidelines (Estuaries and Nearshore Great Lakes)

Condition	Sediment Quality Index Combined Ratings
Good	Both indicators are rated good.
Fair	At least one indicator is rated fair, and none are rated poor.
Poor	At least one indicator is rated poor.

Table B.14 Benchmarks for Estuarine Sediment Quality Index Components

Condition	Sediment Contaminant Index Values	Sediment Toxicity Index Values
Good	mean ERM-Q < 0.1 and LRM P_{max} ≤ 0.5	Test not significantly different from control ($p > 0.05$) and ≥ 80% control adjusted survival
Fair	mean ERM-Q > 0.1 but < 0.5 or LRM P_{max} > 0.5 but < 0.75	Test significantly different from control ($p \leq 0.05$) and ≥ 80% control adjusted survival, or Test not significantly different from control ($p > 0.05$) and < 80% control adjusted survival
Poor	mean ERM-Q ≥ 0.5 or LRM P_{max} ≥ 0.75	Test significantly different from control ($p \leq 0.05$) and < 80% control adjusted survival

mean ERM-Q = mean effects range median quotient
LRM P_{max} = logistic regression model maximum probability
$p > 0.05$ or $p \leq 0.05$ = probability of test statistic value being greater than or less than 0.05

Table B.15 Benchmarks for Nearshore Great Lakes Sediment Quality Index Components

Condition	Sediment Contaminant Index Values	Sediment Toxicity Index Values
Good	mean PEC-Q ≤ 0.1	≥ 90% control adjusted survival
Fair	mean PEC-Q > 0.1 but < 0.6	≥ 75% but < 90% control-adjusted survival
Poor	mean PEC-Q ≥ 0.6	< 75% control adjusted survival

mean PEC-Q = mean probable effects concentration quotient

ECOLOGICAL EFFECTS OF CONTAMINATION IN FISH

The NCCA measures concentrations of select contaminants in whole-fish tissue composites to assess the biologically available contaminant levels in the nation's coastal waters. Tissue contaminant results are compared to a suite of screening values to evaluate whether exposure could lead to adverse effects for sensitive fish, birds or mammals that eat fish as a primary food source (i.e., predatory wildlife receptor groups). Ratings of good, fair or poor are based upon the degree to which contaminants are found in fish composite samples and the number of wildlife receptor groups potentially affected. Note that EPA updated the screening values for the 2015 report. See Section 7 of the Technical Support Document for details about these changes and how this indicator is assessed.

Table B.16 Fish Contamination Index (Ecological Effects) Rating Guidelines

Condition	Fish Contamination Index Condition
Good	All of the measured contaminant concentrations < screening value for all receptor groups.
Fair	At least one measured contaminant concentration ≥ screening value for one receptor group.
Poor	At least one measured contaminant concentration ≥ screening value for two or more receptor groups.

UNASSESSED AREA

The NCCA is a complex scientific endeavor that involves multiple steps for collecting and analyzing environmental data. As a result, there are a variety of reasons that coastal area could be "unassessed" for an indicator:

- Malfunctioning field equipment prevented sample collection.
- Samples were delayed (and thus spoiled) or were lost in shipment.
- Organisms required for assessment were not collected (e.g., no fish of the appropriate size or species were collected, no fish were collected at all because they were not present on the day of sampling, or the type of oligochaetes used in the OTI were not present in the collected sediment).
- Hard or soft substrate prevented sediment or benthic macroinvertebrate sampling in some areas.

Regardless of the reason, the NCCA, like other surveys in the NARS program, does not extrapolate condition from the proportion of the assessed area in good, fair or poor condition to the proportion of the area that is not assessed. Instead, the NCCA presents the proportion of area that is unassessed. EPA and its partners continue to look for ways to reduce the number of sites where samples are not collected.