50 Years of EPA Lake Monitoring Programs **Under the Clean Water Act**

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Five decades ago, Congress passed the Clean Water Act, which charted a new path for our nation's waters. Americans would no longer accept uncontrolled pollution and demanded the protection and restoration of these critical resources. The Clean Water Act put our nation's water bodies at the forefront to protect all Americans' right to clean water for fishing, and recreation. While anecdotal evidence supports that our waters have been cleaner since the Act passed 50 years ago, the question remains, how do we know if our waters are truly getting better nationwide?

The Clean Water Act and a growing need for monitoring efforts

When the Clean Water Act (CWA) was enacted in 1972, Congress explicitly acknowledged the importance of monitoring and assessing water quality to support the restoration of our waters. However, for several decades after the passage of the CWA, various organizations, including the United States Environmental Protection Agency (EPA) noted the lack of consistent, national data available to assess and report on the quality of our nation's waters.

To address this gap in monitoring and assessment efforts, federal agencies, states, and tribes began working on a number of monitoring efforts. In partnership with states and tribes, EPA began the National Aquatic Resource Surveys (NARS) to provide the public and decision-makers with consistent, statistically valid environmental information on the condition of the nation's waters. The NARS program is a partnership that aims to assess the long-term progress toward the CWA goal of making our waters "fishable and swimmable." NARS includes surveys of four waterbody types: lakes, coastal waters, rivers, streams and wetlands. NARS uses a randomized design and consistent methods for key indicators of the chemical, physical, and biological integrity of water resources. The goal of NARS is to determine:

- What is the condition of the nation's waters?
- What are the most widespread problems?
- Are conditions improving or getting worse?

The first official NARS survey was in the National Lakes Assessment (NLA) 2007. The NLA samples a wide array of lakes, from small ponds and prairie potholes to large lakes and human-made reservoirs, on federal, tribal, state, and private land. Repeated on a five-year cycle, additional surveys were conducted in 2012, 2017, and again this year. Results from the NLA and other NARS have established a national baseline of water quality and key stressors and are tracking changes over time.

An update on the quality of our nation's lakes

For the NLA 2017, 89 field crews collected data at 1005 randomly selected lakes; the results represent approximately 225,000 lakes across the conterminous United States. Trophic condition is a key indicator for lakes. Results of NLA 2017 indicate that hypereutrophic conditions, typically characterized by excess nutrients, high levels of algae growth, and low transparency, were observed in 24 percent of lakes. The percentage of lakes in mesotrophic condition declined from 27 percent to 20 percent from 2012 to 2017 (Figure 1).

In 2017, nutrient pollution was the most widespread stressor. Across the country, 45 percent of lakes were in poor condition with elevated phosphorus levels, and 46 percent were in poor condition with elevated nitrogen levels. Lakeshore disturbance, which reflects the extent and intensity of direct human alteration of the lakeshore itself, was the most widespread physical habitat indicator, with poor conditions in 29 percent of lakes across the country and fair conditions in 45 percent of lakes (Figure 2).

The NLA also includes three biological indicators: benthic macroinvertebrates, zooplankton, and chlorophyll-*a*. Based on benthic macroinvertebrates (e.g., insect larvae, snails, and clams living on the lake bottom), EPA found that 24 percent of lakes were in poor condition and 29 percent of lakes were in fair condition. Based on zooplankton (microscopic animals in the water column), results were similar: 22 percent of lakes were in poor condition, and 23 percent of lakes were in fair condition. The third biological indicator, chlorophyll-*a,* can provide an indication of the amount of microscopic algae and cyanobacteria present in a lake. With the application of ecoregional-based benchmarks, chlorophyll-*a* was at high levels and rated poor in 45 percent of lakes (Figure 2).

Additional analyses showed that poor biological condition was more likely when nutrient levels were high (rated poor). For example, in lakes where phosphorus was elevated, benthic macroinvertebrate communities were 2.3 times more likely to be in poor condition. In natural lakes (i.e., excluding human-made lakes), this risk increased to 6.9. Atrazine levels exceeded the EPA

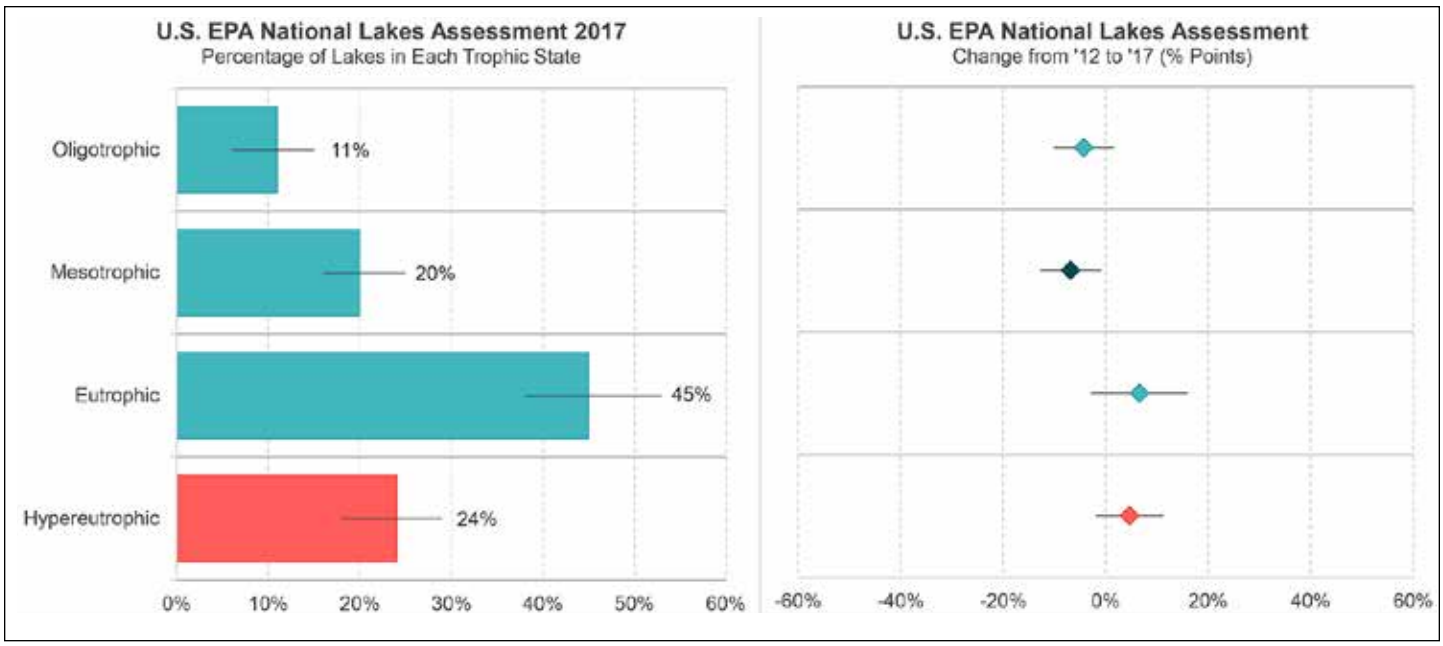

*Figure 1. U.S. EPA National Lakes Assessment results illustrating trophic state in 2017 and change in trophic state between 2012 and 2017 (percent points). *Indicates statistically significant difference (95 percent confidence) between time periods compared. Also represented by a darker-colored diamond in the right-hand column of figure.*

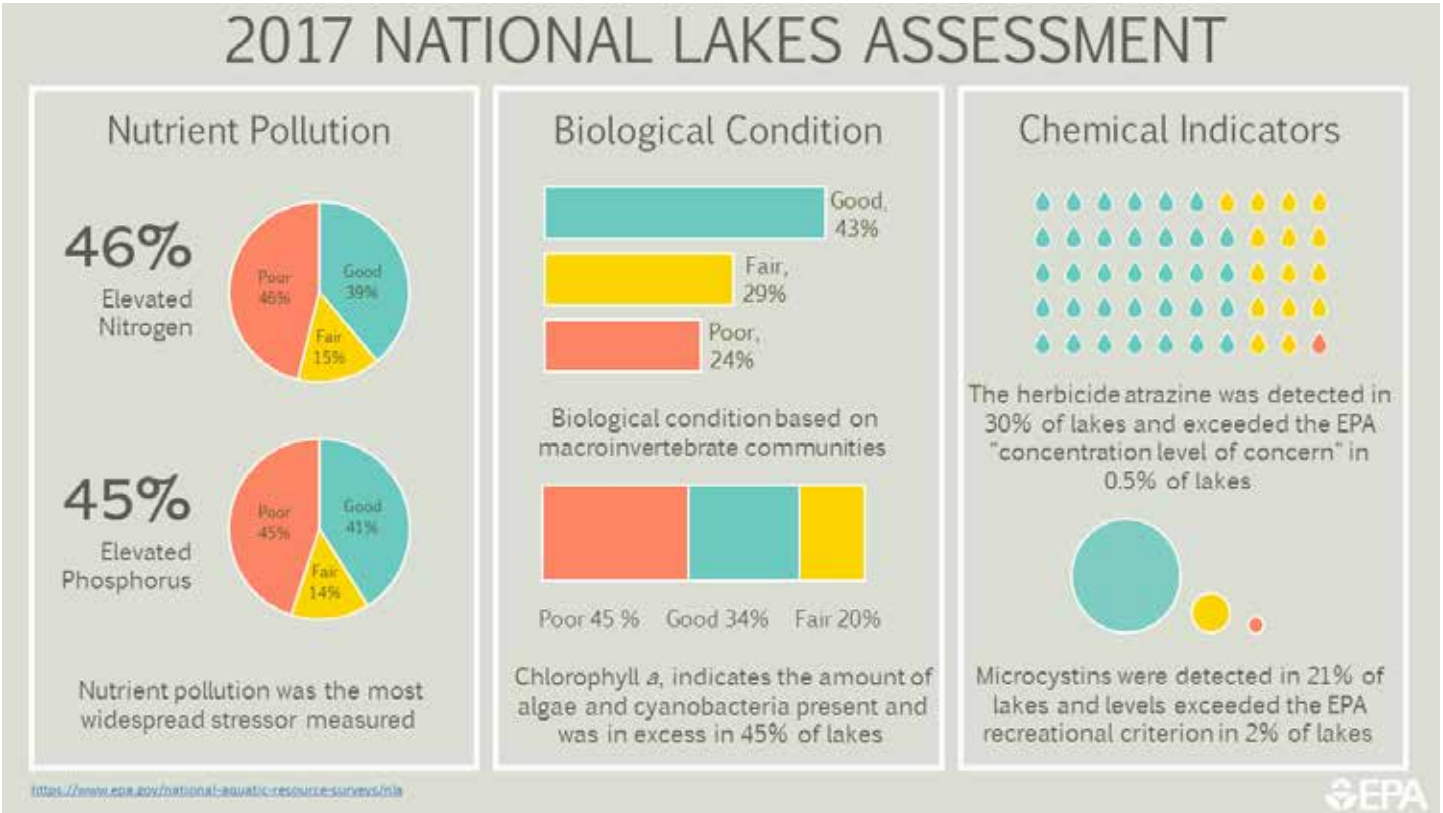

Figure 2. Infographic displaying some results of the 2017 National Lakes Assessment.

benchmark, the "concentration equivalent level of concern" for aquatic plant communities, in 0.5 percent of lakes, representing 1,200 lakes. In reservoirs (but not in natural lakes), poor biological condition was almost three times more likely for benthic macroinvertebrates when atrazine was detected (Figure 2). In terms of public health related indicators, the algal toxins known as microcystins were detected in 21 percent of lakes. Microcystins measured in the open waters exceeded the EPA recommended recreational water quality criterion in 2 percent of lakes, or approximately 4,400 lakes across the nation (EPA 2022b).

Learn more about the National Lakes Assessment and view additional results:

- 2017 Web Report
- 2017 Key Findings
- Data Dashboard
- Lakes Context Tool

Changes in lake quality since 1972: Leveraging the NLA

Although the first to assess *all* lakes in the conterminous U.S., the NLA was not the first large-scale monitoring effort undertaken by EPA to look at lake water quality and condition. In 1972, EPA initiated an effort known as the National Eutrophication Survey (NES), to measure and report on lakes across the nation at risk of experiencing accelerated eutrophication from nutrient pollution (EPA 1972). Over 800 targeted lakes were assessed in the NES between 1972 and 1976 (Figure 3). EPA was concerned with the impacts of the amount of nutrients coming from wastewater treatment plants whose outflow flowed into lakes (EPA 1975, 1976). The NES measured chlorophyll-*a*, Secchi depth, total nitrogen and total phosphorus to assess the trophic state of the selected lakes (EPA 2009) (Figure 4).

As part of the NLA, EPA and its partners resampled a representative sample of the NES lakes to assess whether water quality conditions got better, got worse, or stayed the same in the NES

Figure 4. Crew sampling Lake Tahoe (Region 9), one of the lakes included in the National Eutrophication Survey.

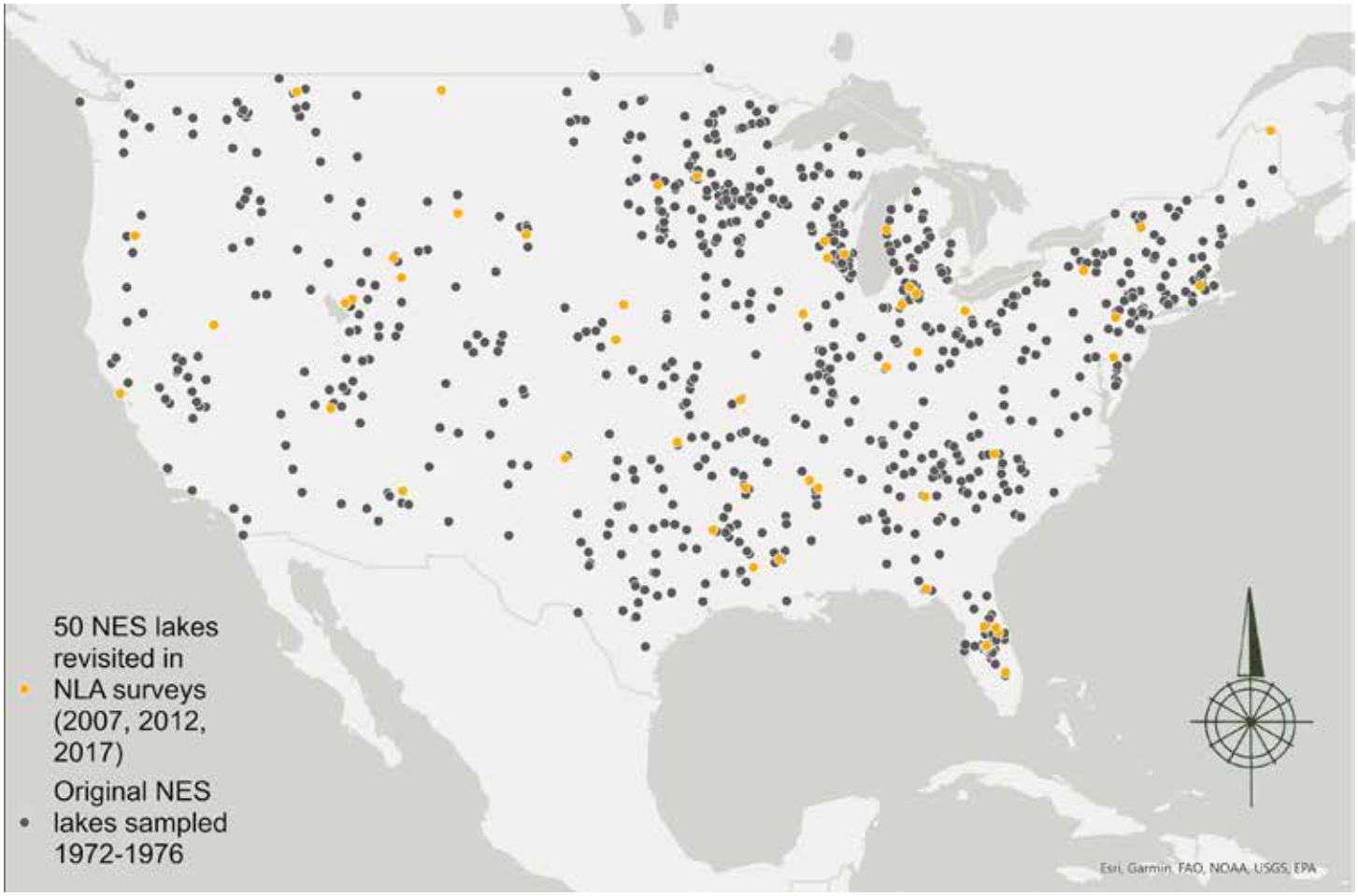

Figure 3. Map of original NES sites and sites sampled in the three NARS surveys.

lakes during the past 50 years. About 200 NES lakes were randomly selected from the original 800 and resampled in the 2007 NLA (Figures 5 and 6). When NES lakes were evaluated in 2007, trophic status based on chlorophyll-*a* had improved in one-quarter (26 percent) and remained stable in half (51 percent) of those lakes (EPA 2009). While the NLA 2022 data are not yet available, EPA has initiated an analysis to look back 50 years at whether this subset of lakes has changed. EPA's analysis will focus on questions such as the following:

- Has eutrophication status changed for the NES lakes since the 1970s?
- Are changes in certain environmental and anthropogenic variables associated with changes in lake eutrophication?
- Do we observe broad long-term trends in trophic state of lakes or are changes lake specific?

Since these surveys were conducted up to 50 years apart, field methods have differed slightly between the NES and NLA. In conducting this analysis, EPA is accounting for these differences to make the data comparable across surveys. The complete NES dataset was made publicly available by Stachelek et al. (2018). The NLA data are available on the EPA NARS website.

Advancements in the NLA

To provide consistent and comparable data and information on improving or declining lake conditions, most aspects of NLA have remained the same. However, new partnerships, priorities, and technological advancements fuel the need for change. Just as the NES applied novel approaches to collect data at lakes in the 1970s, NLA has continued to adopt new technologies and to support new science.

The 2022 field season presented several opportunities to leverage the NLA to address additional indicators and contaminants of concern (EPA 2022a). For the first time, crews documented visual observations of potentially harmful cyanobacterial (cyanoHABs) blooms on site. Observations were made at 12 locations in each lake and visible blooms were reported to state and local harmful algal bloom (HABs) coordinators using BloomWatch or other state-specific crowd sourcing apps. These observations supplement existing NLA analysis of microcystin, chlorophyll-*a*, and phytoplankton. NLA 2022 added the fecal indicator enterococci (consistent with other NARS surveys) and analysis of contaminants in fish tissue, including mercury, polychlorinated biphenyls, and per- and polyfluoroalkyl substances.

In addition to the more established indicators, the NLA supports other research efforts. For example, in 2017 dissolved gases were collected for the purpose of informing the EPA's research on the magnitude of methane, carbon dioxide, and nitrous oxide emission from lakes and reservoirs in the U.S. In the past two NLAs, water samples for environmental DNA (eDNA) have been collected to assess fish species presence with expanded sampling in 2022 to account for multiple habitat types. Discussions about potential research

Figure 5. EPA Region 4 crew member taking a water sample using an integrated sampler in Lake Okeechobee.

Figure 6. EPA Region 4 crew member lowering a Secchi disk to assess water clarity in Lake Okeechobee.

indicators for NLA 2027 will begin in 2024.

Under NARS, NLA has incorporated the use of electronic field forms for collecting data in the field, revised training to incorporate the use of videos that can be reviewed by field crews at any time, and implemented new automated quality checks of data. Additionally, innovative applications of NLA data and methodologies (e.g., EPA's numeric nutrient water quality criteria recommendations for lakes and reservoirs, cyanobacteria assessment network (CyAN)) expand our understanding of current conditions and support efforts to protect and restore the nation's lakes. Data and methodologies collected and developed during the NLA support research and contribute to a broader shared goal to better understand lakes. Some of these publications can be viewed on EPA's website.

Over the past 50 years, the CWA has significantly improved water quality. It established the National Pollutant Discharge Elimination System (NPDES) permitting program for discharges to navigable waters, required states to establish water quality standards for their waterbodies, required municipal facilities to meet secondary treatment standards, and required industrial facilities to meet technology standards. As work continues under the Act, monitoring and assessment efforts, including NLA, will be critical for helping to provide resource managers and decisionmakers with the information they need to continue to progress toward achieving the CWA goals.

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