The Cyanobacteria Assessment Network (CyAN)

A Framework to Expand Freshwater Harmful Algal Bloom Monitoring and Forecasting through Satellite Remote Sensing

Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act

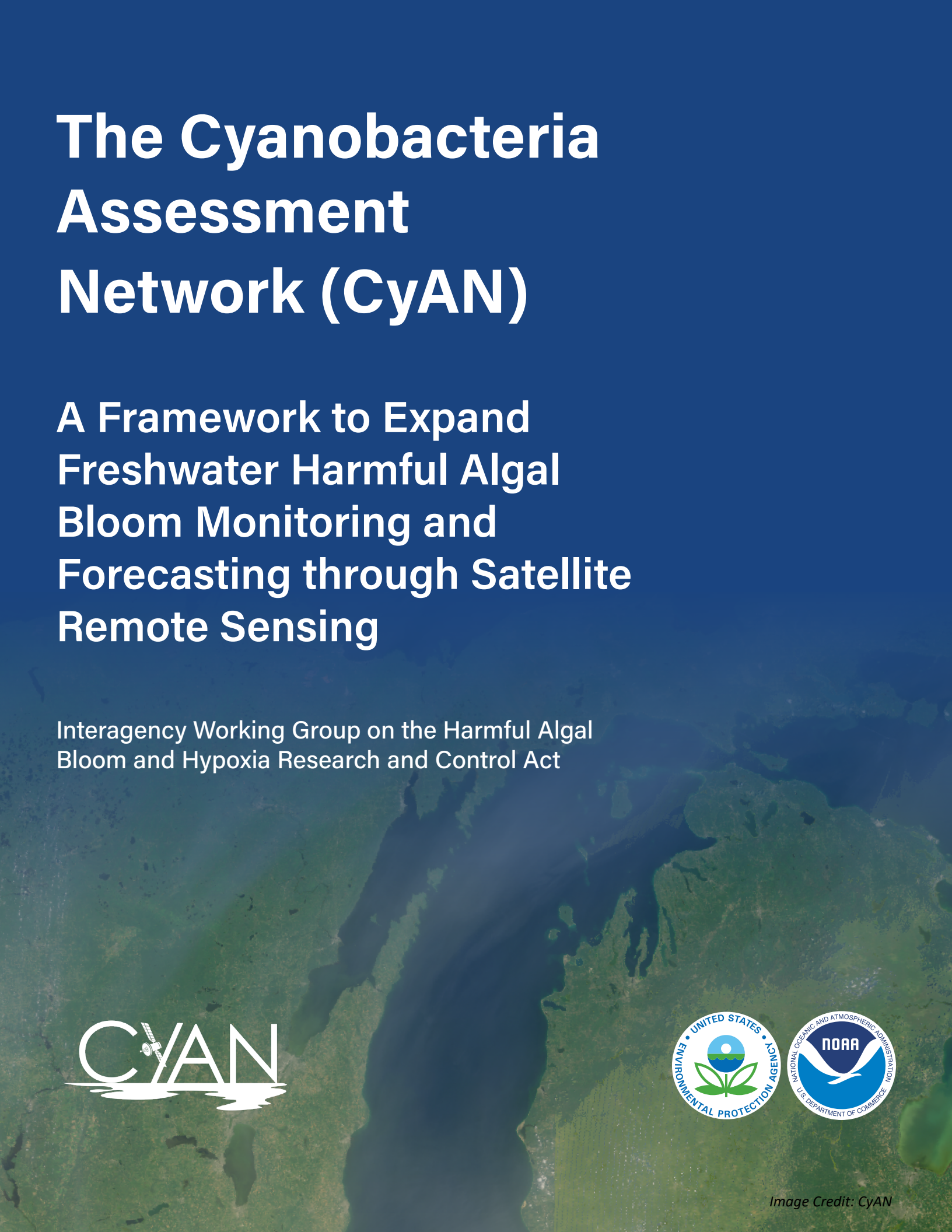


Image Credit: CyAN

Background

Freshwaters across the United States – rivers, streams, lakes, and reservoirs – are threatened by harmful algal blooms (HABs). Increased nutrient pollution has led to favorable conditions for cyanobacteria and algae, resulting in drinking water taste and odor issues, insufficient oxygen for aquatic life, and a potential increase in the presence of toxins that pose a threat to wildlife, pets, and humans. As the impacts of these phenomena become more widespread and severe, there is a need for a coordinated approach to monitoring and forecasting these events in order to protect human and environmental health. Improving detection and early warning of HABs will allow water resource managers to better prepare and provide expedient public health information on the potential impacts to fisheries, recreational waters, and drinking water supplies.

A primary goal of the Interagency Working Group on the Harmful Algal Bloom and Hypoxia Research and Control Act (IWG-HABHRCA) is to advance the research, development, and application of methods and technologies to monitor and forecast HABs and hypoxia. Observations and measurements of HABs, toxins, and related parameters are critical to support early warning and forecasting systems. Progress has been made to coordinate efforts to expand monitoring and forecasting in some marine waters and the Great Lakes. However, the sheer number of freshwaters that require sampling to support sustained monitoring is staggering – in the US, lakes alone number in the hundreds of thousands. This creates an enormous resource burden for local and state water resource management groups and constrains the development of a national freshwater HAB monitoring and forecasting product. One way that the IWG-HABHRCA is coordinating federal action to expand monitoring and forecasting of freshwater HABs is through the application of satellite remote sensing technology.

Image Credit: NOAA

Cyanobacteria Assessment Network (CyAN)

Leveraging the expertise and resources of multiple IWG member agencies, the Cyanobacteria Assessment Network (CyAN) effort is a major step toward overcoming the challenges of national-scale cyanobacterial HAB monitoring. CyAN utilizes satellite remote sensing information to develop an early warning indicator system to detect cyanobacteria blooms. Formed in 2015, the CyAN project is a collaboration between researchers at the Environmental Protection Agency (EPA), the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA), and the United States Geological Survey (USGS). The goal of CyAN is to provide freshwater stakeholders with near real-time data and annual metrics of cyanobacteria focused in 2,192 of the largest lakes and reservoirs across the US as well as approximately 5,000 lakes in Alaska. CyAN also provides information for larger estuaries, some smaller lakes, and a few of the largest rivers in near real-time.

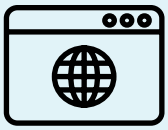
Over the past decade, CyAN has enabled water resource managers to access near real-time HAB data as well as software and training on the CyAN data and tools. This includes the delivery of annual cyanobacterial summary metrics (i.e. spatial extent, temporal frequency, magnitude, and occurrence) of HABs in each of the covered lakes as well as summaries at the regional and national scales. CyAN directly informs lake management decisions without the significant added costs of field sampling. The annual potential avoided costs associated with increasing the availability of remotely sensed chlorophyll-a values were estimated at $5.7 million per year.[1]

The CyAN products are particularly useful because they can guide taste-and-odor and toxin testing (which is currently field-based) to the location of bloom events as they are happening.

These data are served through a variety of avenues by participating agencies to ensure that the general public and technical stakeholders have access to CyAN data in appropriate formats.

CyAN Data Resources

The EPA distributes real-time data via the CyAN Web and *How's my Waterway* applications; and annual metrics via EnviroAtlas (individual lake scale) and metrics and trends via the Report on the Environment indicator (region and national scale).



NASA generates and provides near real-time data via the Ocean Color DAAC website, algorithm QA, and SeaDAS open-source software.

NOAA provides the RSTools software for ArcMAP and ArcPRO and algorithm improvements.

The USGS provides land surface temperature application ready data.

All agencies provide publicly available trainings on data, software, and metrics.

1 Papenfus, M., Schaeffer, B., Pollard, A.I., Loftin, K. (2020). Exploring the potential value of satellite remote sensing to monitor chlorophyll-a for US lakes and reservoirs. Environmental Monitoring and Assessment 192, 808. https://doi.org/10.1007/s10661-020-08631-5

Cyanobacteria Assessment Network (CyAN)

From the success and experience gained through CyAN, the CyAN team developed a framework to continue to advance national HAB monitoring and forecasting into the future by applying the business model framework of the Collins Flywheel.[2] This framework establishes specific strategic goals and guides the enhancement of ongoing federal, state, Tribal, and municipal monitoring and forecasting efforts. CyAN data and available summary metrics can be used by stakeholders and collaborators to prioritize waters based on temporal frequency, spatial extent, magnitude, and the change in those metrics over time.

2 Cooley, S., Jenkins, A., Schaeffer, B., Bormann, K.J., Abdallah, A., Melton, F., Granger, S., Graczyk, I. (2022). Paths to research-driven decision making in the realms of environment and water. Technology in Society, 70. https://doi.org/10.1016/j.techsoc.2022.101994.

Expanding CyAN Monitoring with Higher Resolution Satellite Data (CyAN-S2)

A priority for CyAN is to expand the current set of monitored lakes. Using satellite derived data, CyAN has benefitted state agencies by providing readily accessible near real-time monitoring information for freshwaters that would otherwise be too time and cost intensive to acquire. However, the current iteration of CyAN has a 300-meter spatial resolution, and therefore, is restricted to use in the larger lakes and reservoirs. The CyAN-S2 project aims to utilize Sentinel-2 higher spatial resolution data, 10- to 60-meters, which would expand the monitored lake population and deliver near real-time chlorophyll data for more than 270,000 lakes across the country.[3]

The United States Army Corps of Engineers (USACE) recently joined CyAN and is the sponsor of the CyAN-S2 pilot phase. The current pilot project is focused on developing the initial CyAN-S2 workflow and demonstrating its potential to monitor lake chlorophyll levels initially in Florida, Ohio, and Oregon. Centered on USACE managed waterbodies, this collaborative federal project with partners from USACE, EPA, NOAA, NASA, and USGS will serve to resolve fundamental science and technology questions underpinning the development of a higher spatial resolution national chlorophyll monitoring product in freshwaters. NOAA National Environmental Satellite, Data, and Information Service (NESDIS) has agreed to operationally host the CyAN-S2 chlorophyll product.

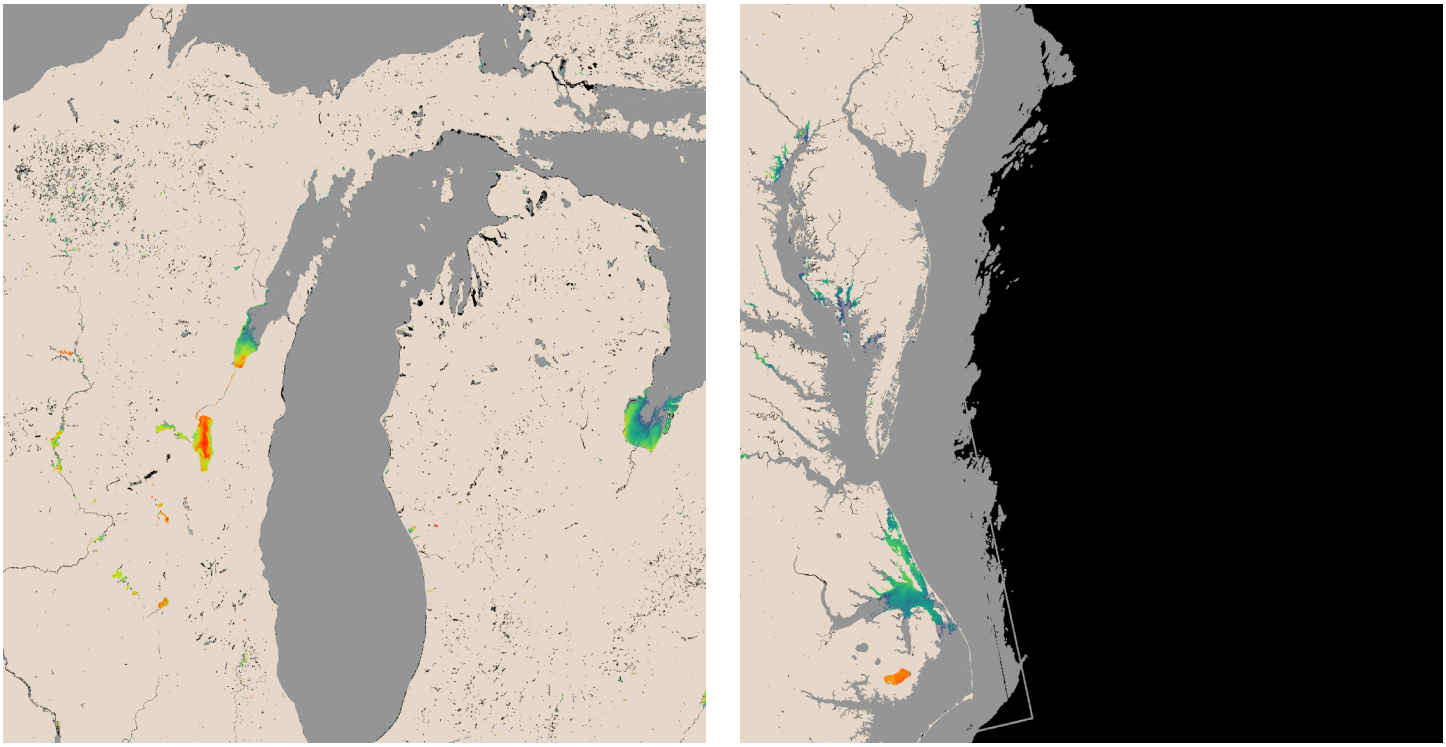
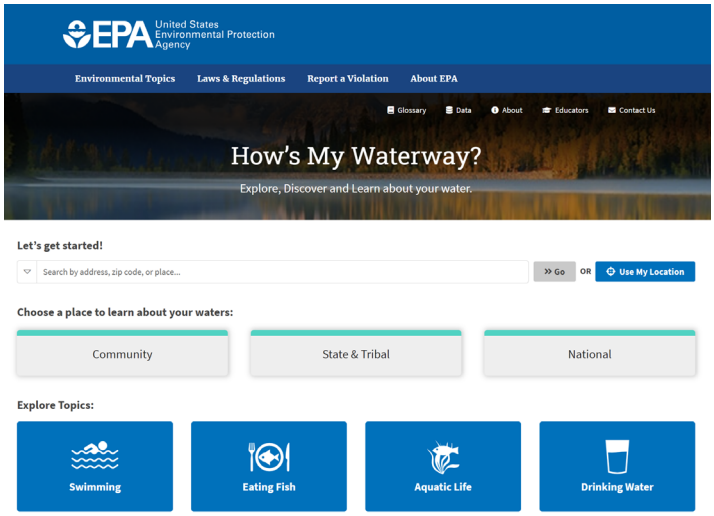


Image Credit: CyAN

3 USACE. Cyanobacteria Assessment Network: Pilot study with Sentinel-2 derived chlorophyll data (CyAN-S2). (2023). https://ansrp.el.erdc.dren.mil/pdfs/gantt-pdfs/2023_Internal/37_Cyan2-opt.pdf

CyAN Forecasts

Information on timing and location of potential HABs is critical to water resource managers working to proactively protect public health and the environment. Although freshwater HAB forecasts have been developed for select individual lakes, no tool exists for broad-scale forecasts. Recent work by EPA researchers, however, has demonstrated an approach to integrate satellite data into statistical models and produce seven-day forecasts of HAB risk for CyAN monitored lakes (i.e., 2,192 lakes) with 90% overall accuracy.[4] This work fills an important gap to provide timely, standardized, and cost-effective HAB forecasting information for communities across the US. The EPA is currently working to operationalize these forecasts and exploring avenues to deliver them to state and Tribal partners through the *How's My Waterway* application. At this time operational beta testing of the seven-day forecast is demonstrated in the application. This service provides early warning HAB forecasts that will help states proactively mobilize monitoring and warning services.



Source: EPA

Next Steps

Summer 2024 – Operationalize CyAN 7-day forecasts and disseminate via public interfaces. View the beta demonstration.

Fall 2025 – Finalize the CyAN-S2 pilot project report and disseminate CyAN-S2 pilot chlorophyll products via NOAA's NESDIS.

Future – Transition of the CyAN-S2 pilot project to full national capabilities of satellite resolved estuaries, lakes, and rivers would require approximately $3 million in research over the next three years for all five agencies to achieve this goal. Additional research funds would be required to integrate the S2 resolvable water bodies into the forecasting model in project years 4 and beyond.

4 Schaeffer, B., Reynolds, N., Ferriby, H., Salls, W., Smith, D., Johnston, J. M., Myer, M. (2024). Forecasting freshwater cyanobacterial harmful algal blooms for Sentinel-3 satellite resolved U.S. lakes and reservoirs. Journal of Environmental Management, 349. https://doi.org/10.1016/j.jenvman.2023.119518.