

Estuarine Algal Conditions

Background

The Division of Water Monitoring & Standards, Bureau of Marine Water Monitoring is responsible for monitoring for harmful algal blooms in estuarine and marine waters, as required by the National Shellfish Sanitation Program, for protection of public health as consuming some algal contaminated shellfish can cause adverse health effects. In addition to effects related to consumption of contaminated shellfish, algal blooms can also cause marine fauna kills, mild toxicity to bathers, and reduced aesthetic water quality (e.g., discoloration). Certain algal species, when found in sufficient density, can produce various tide colors (e.g., red, green, or brown). The most harmful public-health related effects are generally associated with some algal species that produce red tides, but not all red tides have toxins or are harmful. Certain red tide algal species are a public health concern as they can result in paralytic shellfish poisoning and diarrhetic shellfish poisoning. Amnesiac shellfish poisoning, also a public health effect of concern, results from an algal species that produces a brown tide. In addition to affecting human health, algal blooms can be detrimental to ecological health when the algae die and are degraded by bacteria, consuming oxygen in the water column. This oxygen depletion can cause physical stress or even mortality to fish and other marine life.

Since 1978, microscopic analysis of state water samples has identified the presence of toxic algal species, but not at concentrations that threaten public health. In the early 2000's, brown tide blooms, caused by the organism *Aureococcus anophagefferens*, were evident in the Barnegat Bay/Little Egg Harbor Estuary.¹ Every year since 2004, the Barnegat Bay/Little Egg Harbor Estuary has experienced blooms of *Nannochloris sp.* during the summer months. *Nannochloris sp.* creates a yellowish-brown tide that primarily reduces the aesthetic quality of the water. In recent years, blooms caused by both diatoms and dinoflagellates have been found in the Hudson-Raritan Estuary, causing red, brown, and green water discolorations, however no toxin-producing algal species were present.

Phytoplankton identification and composition and chlorophyll *a* analysis are two of the primary measurements used to determine algal conditions. Chlorophyll *a* is a plant pigment used to determine the amount of algal biomass present in a body of water and can help determine areas that need to be watched for harmful algal blooms. Routine estuarine chlorophyll *a* analysis began in 1998.

Currently, the Bureau of Marine Water Monitoring collects water samples for both ecological and public health purposes. Collection covers all estuarine waters from the Raritan Bay to the Delaware Bay, up to the points beyond tidal influence (head of tide). Excessive amounts of chlorophyll *a* indicate an algal bloom that may reduce water clarity and may result in depleted dissolved oxygen levels.

Status and Trends

Statewide Trend

Algal bloom conditions have been defined by routine chlorophyll measurements.² An algal bloom is defined as a chlorophyll concentration of twice the long-term mean or greater than 20 micrograms per liter ($\mu\text{g/L}$) within each of 77 hexagon monitoring units. In this marine ambient water quality monitoring program, chlorophyll concentrations are routinely measured in 77 hexagons covering 100% of the state's estuarine waters.

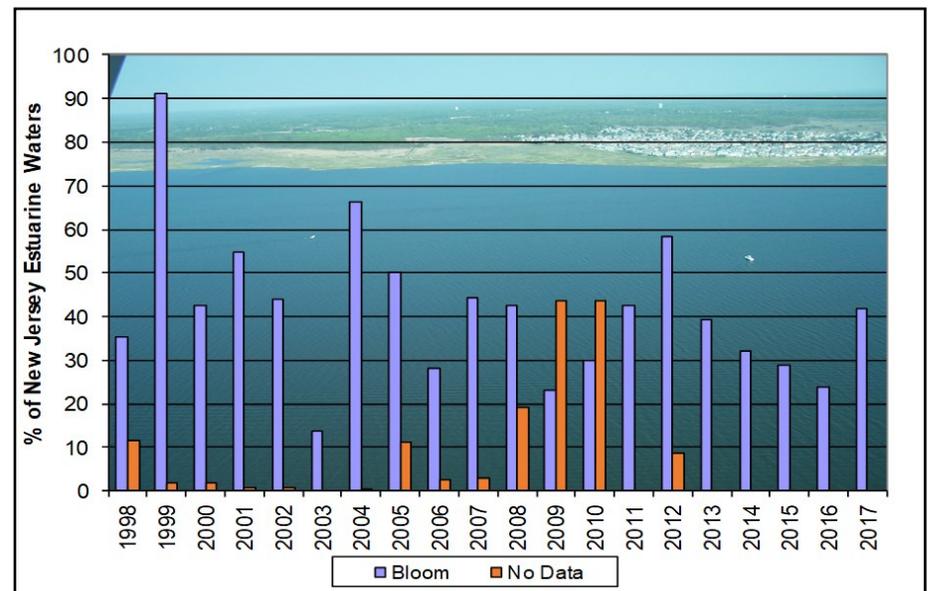


Figure 1. Algal Conditions in New Jersey Estuarine Waters (1998-2017)

The chart “Algal Conditions in New Jersey Estuarine Waters (1998 – 2017) (Figure 1) shows the percentage of hexagons in New Jersey’s monitored estuarine waters that experienced at least one bloom condition over a 19-year period based on sampling within the hexagons. For example, at least one bloom was observed in 42% of the representative hexagons in 2017. The sampling design does not allow for continuous monitoring of all estuarine waters; therefore, the absolute frequency of algal blooms cannot be determined. “No data” indicates when samples were not collected in certain areas either due to weather, or in the case of 2009 and 2010, priority monitoring changes. For example, in 1998, 12% of estuarine waters were not sampled.

As can be seen, bloom conditions can vary dramatically from year to year, ranging from an occurrence as low as 13% of hexagons in 2003 to over 90% of hexagons in 1999. Among the possible factors that could be responsible for this trend are inter-annual changes in rainfall, offshore phytoplankton conditions, changes in nutrient loadings into these coastal waters, meteorological factors of wind and cloud cover, and air and water temperatures, the number of locations monitored, or a combination of all .

Aircraft Remote Sensing Statewide

Coastal remote sensing flights are conducted weekly to detect levels of chlorophyll *a* in March through May, then six days a week between Memorial Day and Labor Day, and again weekly September through November. The purpose of these flights, which began in 2007, is to cover large areas of the state to identify any algal blooms and their location for further sampling and species identification. All data is posted daily at <http://njdep.marine.rutgers.edu/aircraft/>. Figure 2 shows an image of a flight from July 9, 2017. This flight takes approximately 2.5 hours and the color indicates the chlorophyll *a* concentration. If concentrations are elevated above 20 µg/L in one area for two consecutive days, water samples will be collected, and species identification performed.

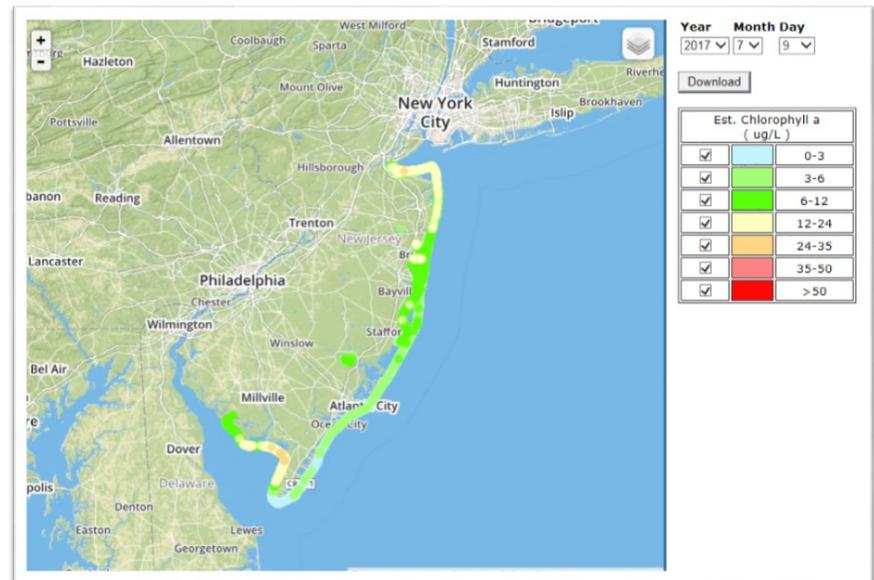


Figure 2. Statewide Coastal Chlorophyll *a* Remote Sensing Flight on July 9, 2017

Highlight: Comparison of Estuaries from Ambient Monitoring

Since 1998, water samples have been collected by boat at predetermined, fixed stations as part of the NJDEP Marine Water Routine Ambient Nutrient Monitoring Program. All the samples from these fixed station programs are analyzed for Chlorophyll *a* throughout the Raritan/Sandy Hook Bay, Barnegat Bay and Delaware Bay. Data is assessed using the threshold values and summertime (July-September) index period described in the USEPA National Coastal Condition Report IV³. The threshold values are: less than 5 µg/l (Good), 5 - 15 µg/l (Fair), and greater than 15 µg/l (Poor).

Trend

As can be seen in Figures 3, 4 and 5, showing chlorophyll *a* concentrations and percent of samples in Raritan/Sandy Hook Bay, Barnegat Bay, and Delaware Bay (1998 – 2017), chlorophyll *a* concentrations vary dramatically from year to year and from estuary to estuary. Many factors, including those listed previously, can affect the algal concentrations.



Figure 3. Raritan/Sandy Hook Bay Chlorophyll a Concentrations and Percent of Samples within USEPA National Coastal Condition Assessment Thresholds (1998-2017)

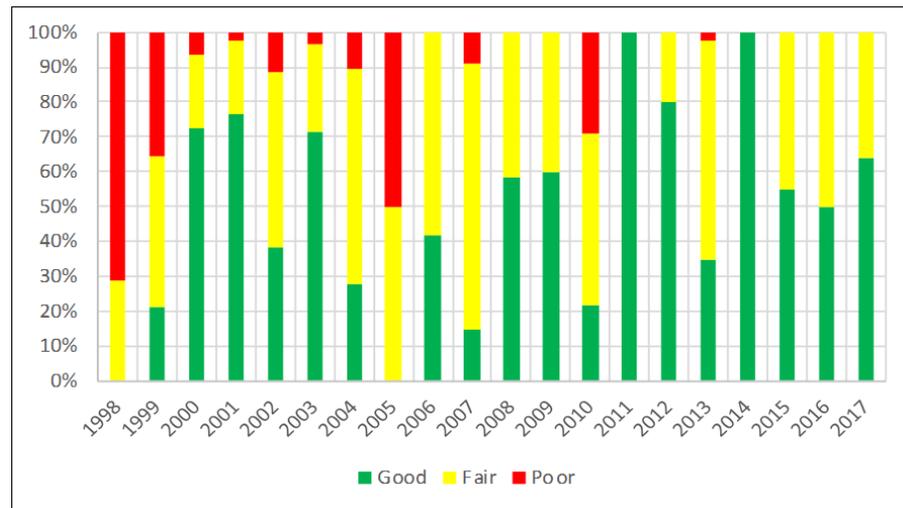


Figure 4. Barnegat Bay Chlorophyll a Concentrations and Percent of Samples within USEPA National Coastal Condition Assessment Thresholds (1998-2017)

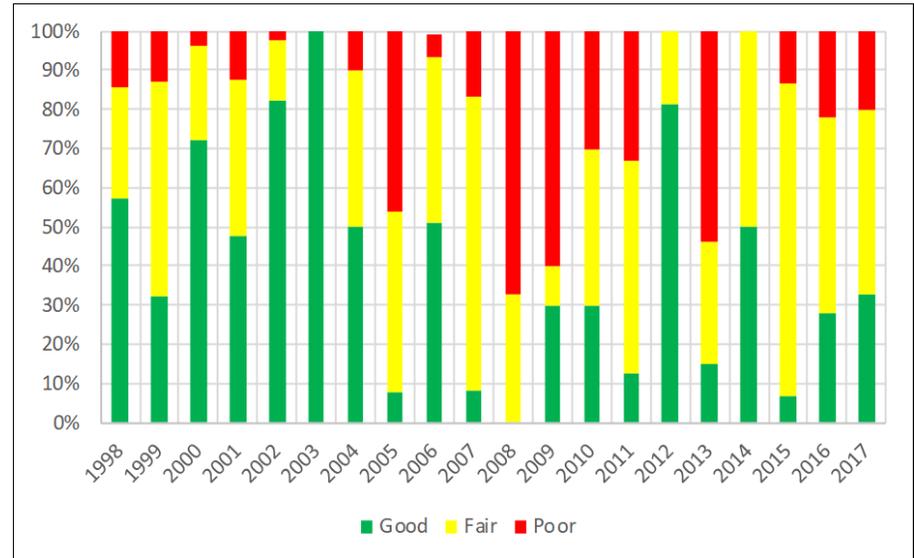


Figure 5. Delaware Bay Chlorophyll a Concentrations and Percent of Samples within USEPA National Coastal Condition Assessment Thresholds (1998-2017)

Aircraft Remote Sensing Assessment

As previously mentioned, boat sampling from the Ambient Nutrient Monitoring Program is conducted at fixed locations that are distributed throughout the estuaries and cannot fully assess the spatial coverage of chlorophyll *a* concentrations or algal blooms due to many miles between the stations. Aircraft remote sensing provides a better picture of the spatial coverage of algal blooms by collecting a chlorophyll *a* data point every two seconds while flying over New Jersey coastal waters. As described above, flights occur 6 days per week. In 2017, over 98,000 data points were collected and assessed over the three estuaries described above using the same threshold values and summertime (July-September) index period described above for the boat-collected data. The 2017 data is currently being processed.

Comparison of the 2016 remote sensing results, seen in Figures 6, 7, and 8, showing the percent of 2016 remote sensing samples in Raritan/Sandy Hook Bay, Barnegat Bay and Delaware Bay (pie charts), with the 2016 fixed station results (bar charts above) does not show a correlation in the sampling methodology for chlorophyll *a*. Remote sensing data shows mixed results when compared to fixed monitoring data in the Delaware Bay, and in Barnegat Bay the fixed monitoring does not accurately detect the good (<5 µg/l) category; this difference is most likely due to the large number of data points from the remote sensing and the large spatial coverage of the bay.

This information shows that elevated chlorophyll *a* concentrations, and resulting algal blooms, can be very localized and small in spatial extent. Therefore, it is likely that the fixed monitoring is not adequate to fully classify the algal conditions of the bay.

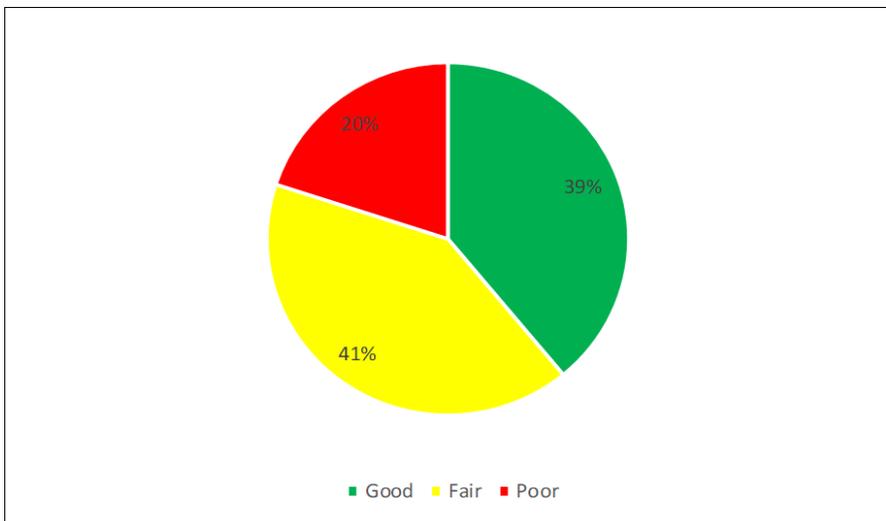


Figure 6. Raritan/Sandy Hook Bay Percent of 2016 Remote Sensing Samples within USEPA National Coastal Condition Assessment Thresholds

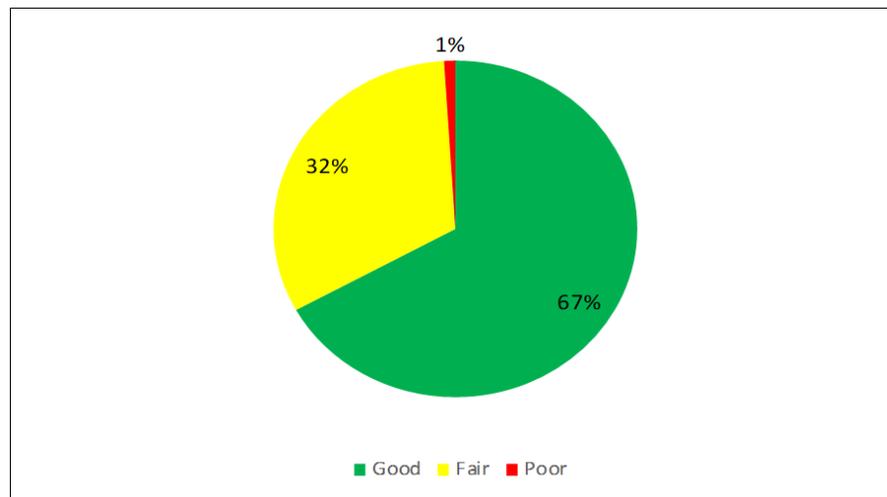


Figure 7. Barnegat Bay Percent of 2016 Remote Sensing Samples within USEPA National Coastal Condition Assessment Thresholds

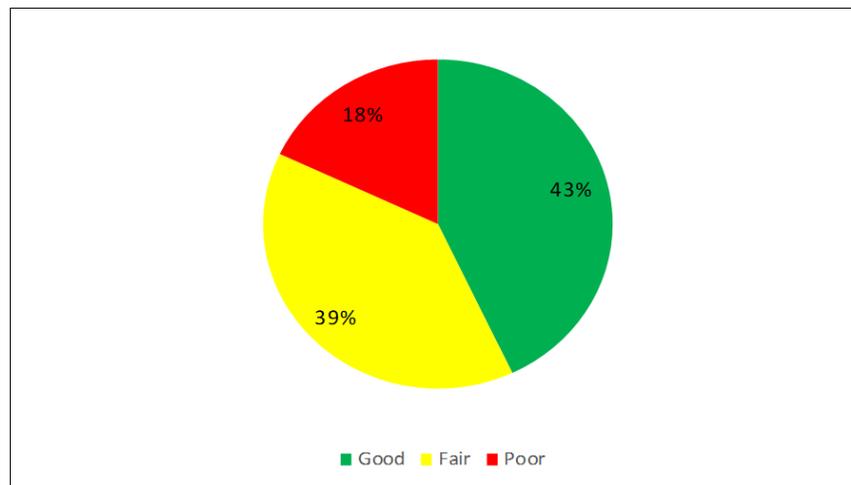


Figure 8. Delaware Bay Percent of 2016 Remote Sensing Samples within USEPA National Coastal Condition Assessment Thresholds

Outlook and Implications

Algal blooms routinely occur in areas with nutrient over-enrichment. Examples include the NY/NJ Harbor and the Delaware Bay which experience frequent algal blooms, especially after precipitation which increases nutrient loads. These two estuaries are very productive and support economically important shellfish harvests.

Near shore algal blooms are typically associated with ocean upwelling which brings nutrient rich waters from the ocean floor to the surface. These blooms are not associated with anthropogenic nutrient loads. The use of statewide remote sensing has found that algal blooms can be very small in areal coverage and has allowed for targeted sampling of waters to identify algal species.

It is important to control nutrient loadings from fertilizer and treated sewage to protect aquatic life such as fish and shellfish. In 2011, the state enacted the NJ Fertilizer Law, which has a three-pronged approach.⁴ It requires the use of best management practices to reduce the impacts of fertilizers on waterways, a certification program for professional fertilizer applicators, and the reformulation of fertilizers to contain at least 20% slow-release nitrogen and 0% phosphorus (unless a soil test demonstrates a need for phosphorus to be added). In addition, there are annual blackout dates for fertilizer use where homeowners may not apply fertilizer between November 15 and March 1, and commercial applicators may not apply fertilizer between December 1 and March 1. In order to address nutrient loadings from sewage treatment plants, the Department imposes effluent limitations for phosphorus and nitrogen in wastewater permits when appropriate.

More Information

Additional information can be obtained by contacting NJDEP's Bureau of Marine Water Monitoring at (609) 748-2000 or by visiting www.nj.gov/dep/bmw. Remote sensing data can be accessed directly at: <http://njdep.marine.rutgers.edu/aircraft/>.

References

¹Gastrich, M. D.; R. Lathrop, S. Haag, M.P. Weinstein, M. Danko, D. A. Caron, R. Schaffner. 2004. Assessment of brown tide blooms, caused by *Aureococcus anophagefferens*, and contributing factors in New Jersey coastal bays: 2000-2002. Harmful Algae, Special issue: Brown Tides - Edited by M. Lomas and C. Gobler. Vol 3: 305-320.

²Cosper, E.M. 1995. Assessment of Historical Phytoplankton Characteristics and Bloom Phenomena in the New York Harbor Estuarine and New York Bight Ecosystems. Preliminary Report. E.M. Cosper, Coastal and Environmental Studies, Inc., Bohemia, NY. May 4, 1995.

³United States Environmental Protection Agency, Office of Research and Development/ Office of Water, EPA 842-R-10-003, April 2012.

⁴New Jersey Department of Environmental Protection, Healthy Lawns Healthy Water, Accessed May 17, 2018.