



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
GREAT LAKES NATIONAL PROGRAM OFFICE  
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CHICAGO, IL 60604-3590

Stephen Galarneau, Director  
Office of Great Waters – Great Lakes & Mississippi River  
Wisconsin Department of Natural Resources  
PO Box 7921  
Madison, WI 53707-7921

Dear Mr. Galarneau:

Thank you for your September 9, 2021 request to remove the *Degradation of Phytoplankton and Zooplankton Populations* Beneficial Use Impairment (BUI) from the Sheboygan River Area of Concern (AOC) located near Sheboygan, WI. As you know, we share your desire to restore all the Great Lakes AOCs and to formally delist them.

Based upon a review of your submittal and supporting information, the U.S. Environmental Protection Agency (EPA) approves your request to remove this BUI from the Sheboygan River AOC. EPA will notify the International Joint Commission (IJC) of this significant positive environmental change at this AOC.

We congratulate you and your staff as well as the many federal, state and local partners who have been instrumental in achieving this environmental improvement. Removal of this BUI will benefit not only the people who live and work in the AOC, but all residents of Wisconsin and the Great Lakes basin as well.

We look forward to the continuation of this important and productive relationship with your agency as we work together to delist this AOC in the years to come. If you have any further questions, please contact me at (312) 353-8320 or your staff can contact Leah Medley at (312) 886-1307.

Sincerely,

CHRISTOPHER  
KORLESKI

Digitally signed by  
CHRISTOPHER KORLESKI  
Date: 2021.09.22 12:59:56 -05'00'

Chris Korleski, Director  
Great Lakes National Program Office

cc: Kendra Axness, WDNR  
Brennan Dow, WDNR  
Rebecca Fedak, WDNR

Madeline Magee, WDNR  
Michelle Soderling, WDNR  
Raj Bejankiwar, IJC



September 9, 2021

Mr. Chris Korleski, Director  
Great Lakes National Program Office  
U.S. Environmental Protection Agency  
77 West Jackson Boulevard (G-17J)  
Chicago IL 60604-3507

**Subject: Removal of the Degradation of Phytoplankton and Zooplankton Populations  
Beneficial Use Impairment in the Sheboygan River Area of Concern**

Dear Mr. Korleski:

The Wisconsin Department of Natural Resources (WDNR) requests the U.S. Environmental Protection Agency (U.S. EPA) Great Lakes National Program Office's (GLNPO's) concurrence with the removal of the Degradation of Phytoplankton and Zooplankton Populations Beneficial Use Impairment (BUI) in the Sheboygan River Area of Concern (AOC).

The Wisconsin DNR has assessed the status of the Degradation of Phytoplankton and Zooplankton Populations BUI in accordance with the BUI removal target that was established in 2008. We are pleased to report that all actions associated with this impairment have been completed and the target has been met. The U.S. EPA Technical Review Lead (TRL) has reviewed the BUI removal document and has provided their support for removal of this BUI.

The Sheboygan River AOC Advisory Committee met for an AOC status update on June 16, 2021 and expressed support for the removal. We held a public review and comment period for the BUI removal document from August 10 through September 1, 2021. We received one supportive comment and three letters of support from local stakeholders. As a result, we are recommending that the Degradation of Phytoplankton and Zooplankton Populations BUI be removed from the list of impairments in the Sheboygan River AOC. The enclosed Degradation of Phytoplankton and Zooplankton Beneficial Use Impairment Removal Recommendation document provides the information to support the removal recommendation. Also enclosed are letters of support from the City of Sheboygan, Sheboygan County, and Sheboygan River Basin Partnership.

We value our continuing partnership in the AOC Program and look forward to working closely with U.S. EPA GLNPO in the removal of BUIs and the delisting of Wisconsin's AOCs. If you need additional information, please contact Brennan Dow, WDNR, at 920-366-1371, Rebecca Fedak, WDNR, 920-207-8380, or you may contact me.

Sincerely,

A handwritten signature in black ink, appearing to read "Stephen G. Galarneau", with a long horizontal flourish extending to the right.

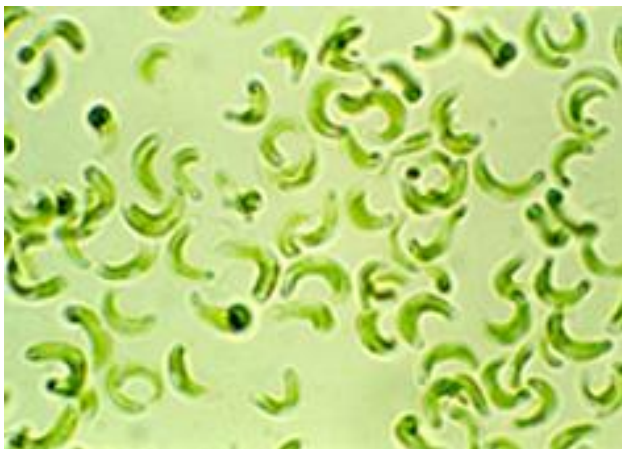
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Enclosures:

Removal Recommendation for the Degradation of Phytoplankton and Zooplankton Beneficial Use  
Impairment in the Sheboygan River Area of Concern

# Removal Recommendation for the Degradation of Phytoplankton and Zooplankton Beneficial Use Impairment in the Sheboygan River Area of Concern



Submitted to:

U.S. EPA-GLNPO  
77 W. Jackson Blvd.  
Chicago, IL 60604

By:

Wisconsin Department of Natural Resources  
September 2021

## Acknowledgments

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The Wisconsin Department of Natural Resources would like to acknowledge the support provided by the Sheboygan Area of Concern stakeholders in the development of the Degradation of Phytoplankton and Zooplankton Beneficial Use Impairment Removal Recommendation Document. Your local input and associated efforts were an invaluable part of the process to remove the Degradation of Phytoplankton and Zooplankton Beneficial Use Impairment and reflects the incredible ongoing efforts that will enable us to continue forging the path to delisting. The Wisconsin Department of Natural Resources and partners continue to work toward the shared goal of a healthy, self-sustaining Sheboygan River for people as well as for fish and wildlife.

Cover photos (left: *S. capricornutum*; right: *C. dubia*) provided by Rebecca Fahney from the Wisconsin State Lab of Hygiene.

## Disclaimer

The Great Lakes Water Quality Agreement (GLWQA) is a non-regulatory agreement between the United States and Canada, and criteria developed under its auspices are non-regulatory. The actions identified in this document were needed to meet beneficial use impairment removal targets leading to the delisting of the AOC.

## Executive Summary

The Sheboygan River was designated as an Area of Concern (AOC) in 1987 under the Great Lakes Water Quality Agreement (GLWQA). The designation came primarily due to contamination from polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). These contaminants were discharged directly into the river from municipal and industrial sources, leading to many contamination-related beneficial use impairments (BUIs) within the AOC. This document recommends removal of one of those BUIs: the Degradation of Phytoplankton and Zooplankton Populations BUI.

Phytoplankton are microscopic, plant-like aquatic organisms that photosynthesize, including algae and photosynthesizing bacteria, that can move freely through the water. Zooplankton are small aquatic animals, mostly crustaceans, that can move freely through the water. Both phytoplankton and zooplankton are at the base of the aquatic food web and are important sources of food for small fish, which feed many other animals and benefit the Sheboygan River ecosystem.

The target to remove this BUI includes three parts:

1. Sources causing nutrient enrichment to the Outer Harbor and near shore waters are identified and controlled if nutrients are the main contributor:  
OR  
Sources resulting in ambient water toxicity in the Outer Harbor and near shore waters are identified and controlled if toxicity is the main contributor.
2. Phytoplankton and zooplankton bioassays confirm no toxicity in ambient waters and the community structure is diverse and contains species indicative of clean water.
3. The phytoplankton and zooplankton communities within the site being evaluated are statistically similar to a reference site with similar habitat and minimal sediment contamination.

The first portion of the target was met by the remedial actions that led to the 2015 removals of both the Eutrophication or Undesirable Algae BUI and the Restrictions on Dredging Activities BUI. The Wisconsin Department of Natural Resources (WDNR) and the United States Geological Survey (USGS) conducted studies to assess whether the second and third portions of the target were being met. WDNR took ambient water samples, which were sent to the Wisconsin State Laboratory of Hygiene (WSLH) and tested for chronic water column toxicity to phytoplankton and zooplankton, and USGS compared the planktonic communities within the AOC to non-AOC reference sites that have comparable characteristics. The results of these studies are discussed in this document and provide evidence in support of BUI removal.

WDNR has concluded that the targets have been met: toxic contamination has been remediated and nutrient enrichment controlled; phytoplankton and zooplankton chronic toxicity tests showed survival, growth, and reproduction in ambient AOC water; USGS

studies indicated similarities between the planktonic communities in the AOC and non-AOC reference sites. Therefore, WDNR is recommending removal of this BUI.



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## Purpose

The purpose of this document is to provide information in support of the recommendation to remove the Degradation of Phytoplankton and Zooplankton Populations Beneficial Use Impairment (BUI) from the Sheboygan River Area of Concern (AOC). This document presents information surrounding the listing of this BUI; the remedial actions taken to address the impairment; the data collected following the completion of remedial actions that support our recommendation to remove this BUI. More information on the AOC can be found on the WDNR website at: <http://dnr.wi.gov/topic/greatlakes/sheboygan.html>.

## Background

### Rationale for AOC Designation

The Sheboygan River was designated as an AOC in 1987 under the Great Lakes Water Quality Agreement (GLWQA) due to severe environmental degradation. The AOC designation was largely established because of sediment contamination in the river. The primary sources of contamination were municipal treatment plants, industries, and agricultural and urban runoff.

In accordance with Annex 1 of the GLWQA, the [1989 Stage 1 Remedial Action Plan](#) (RAP) and [1995 RAP](#) identified the following nine of fourteen possible BUIs in the AOC:

- Fish Tumors or Other Deformities
- Bird or Animal Deformities or Reproductive Problems
- Restrictions on Fish and Wildlife Consumption
- Restrictions on Dredging Activities (removed in 2015)
- Degradation of Benthos (removed in 2020)
- Degradation of Phytoplankton and Zooplankton Populations
- Loss of Fish and Wildlife Habitat
- Degradation of Fish and Wildlife Populations
- Eutrophication or Undesirable Algae (removed 2015)

### AOC Boundary

The AOC is in east central Wisconsin, about 55 miles north of the city of Milwaukee. The Sheboygan River headwaters are located in Fond du Lac County and the river flows approximately 80 river miles before reaching the western shore of Lake Michigan in the city of Sheboygan. The AOC encompasses the lower 14 miles of the Sheboygan River downstream from the Sheboygan Falls Dam, including the entire harbor and nearshore waters of Lake Michigan (Figure 1).

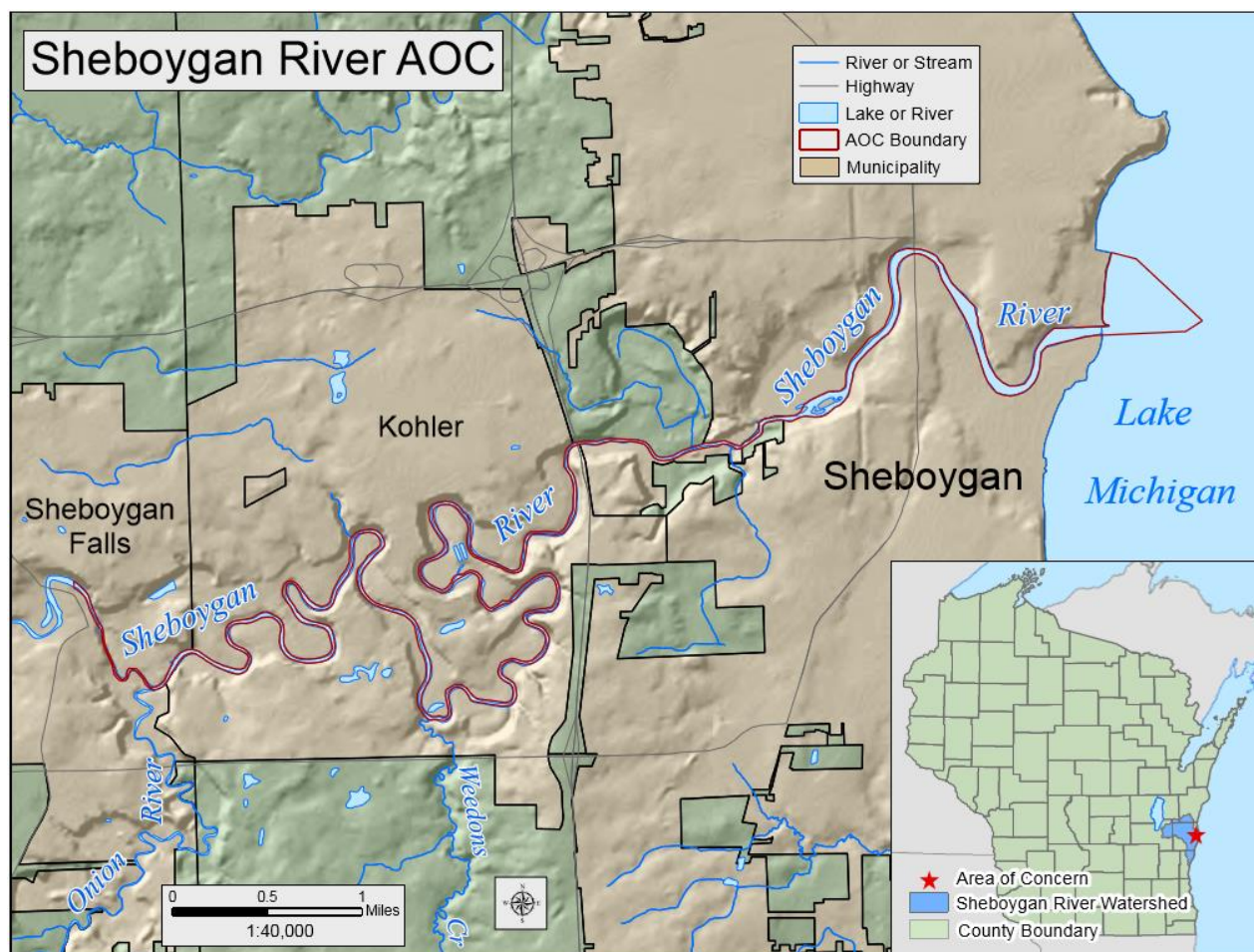


Figure 1: Sheboygan River AOC Boundaries

### Rationale for BUI Listing

Phytoplankton and zooplankton are both very important in aquatic ecosystems.

Phytoplankton are microscopic free-floating aquatic algae and bacteria. Phytoplankton photosynthesize, which means they use energy from the sun to convert dissolved carbon dioxide in the water into oxygen and carbon used to grow. For this reason, they play an important role in the energy and nutrient cycles of water resources.

Phytoplankton are also a primary food source to organisms higher in the food web, which means that they are at the base of the food web and the main source of energy for the Great Lakes food web. The health of many larger animals can be tied back to phytoplankton abundance and community composition. Similarly, zooplankton are small free-floating aquatic animals. Some zooplankton eat phytoplankton, while some feed on other zooplankton. Zooplankton are an important food source for small fish, which are an important food source for larger fish and other animals, including people.

Although it was known that the Sheboygan River had high nutrient inputs and legacy contamination, the Stage 1 RAP (WDNR, 1989) stated that there was no information on phytoplankton and zooplankton populations in the AOC. Despite limited information, it

was assumed that phytoplankton and zooplankton could be negatively impacted by contaminated sediments and high nutrient concentrations from point and nonpoint pollution sources.

## BUI Removal Criteria

Delisting targets for the AOC were developed through a collaborative process that included input from technical experts, local stakeholders, and the public. The process of determining targets included a review of the region's historical background, land use transformations, ecological conditions, and previous progress toward restoration. Developing targets for the AOC also included review of delisting targets prepared for other Great Lakes AOCs for their relevance and applicability to the Sheboygan River.

Based on recommendations from the [2008 delisting targets report](#) (ECT & SEH, 2008), WDNR moved forward with recommendations and set the following removal criteria for the AOC:

Table 1. Target for delisting the Degradation of Phytoplankton and Zooplankton Beneficial Use Impairment from the Sheboygan River Area of Concern

Sources causing nutrient enrichment to the Outer Harbor and near shore waters are identified and controlled if nutrients are the main contributor:  OR  Sources resulting in ambient water toxicity in the Outer Harbor and near shore waters are identified and controlled if toxicity is the main contributor.
Phytoplankton and zooplankton bioassays confirm no toxicity in ambient waters and the community structure is diverse and contains species indicative of clean water.
The phytoplankton and zooplankton communities within the site being evaluated are statistically similar to a reference site with similar habitat and minimal sediment contamination.

## Actions Taken to Restore the BUI

The first portion of the target to delist the Degradation of Phytoplankton and Zooplankton Populations BUI was to identify and control nutrient enrichment or toxicity, depending on which was the main contributor to the BUI. Sources contributing to toxicity in the water included legacy contamination in the sediment (historic PCBs, PAHs and heavy metals) and excess nutrient pollution entering the river from point and nonpoint sources. WDNR worked with federal officials, local stakeholders, and Superfund project



Responsible Parties (RPs) to address sediment contamination. Sheboygan County and other local partners worked with WDNR to identify and address nonpoint pollution. The efforts to address pollution entering the Sheboygan River led to accomplishing two milestones in 2015: removal of the Restrictions on Dredging Activities BUI and the Eutrophication or Undesirable Algae BUI. Many actions took place in order to remove those two BUIs, including projects and controls that lessened excess nutrients and toxicity to the extent that the first portion of the Degradation of Phytoplankton and Zooplankton Populations BUI target has been met. All management actions for the AOC have been completed (Appendix A).

### Completion of Contaminated Sediment Remediation

When the AOC was listed, one of the nine BUIs identified was the Restrictions on Dredging Activities BUI. Sediments in the AOC were contaminated with PCBs, PAHs, and heavy metals, all of which can cause harm to humans and the environment, including aquatic ecosystems. The goal of restoring this beneficial use was to “protect the ecosystem (including humans, wildlife, fish, and other organisms) from the adverse effects (on the reproduction, survival, and health of individuals, and the integrity of interspecies relationships) of toxic substances” (WDNR, 1995).

The removal of the Restrictions on Dredging Activities BUI in 2015 indicated that targets for contaminated sediment remediation were met. For the planktonic community, this means that there are fewer toxic pollutants in the river that could inhibit their growth and reproduction.

Table 2 and Figure 2 summarize contaminated sediment related events and remediation efforts in the Sheboygan River AOC:

Table 2. Summary of sediment removal projects in the Sheboygan River AOC. Table adapted from details found within the [2014 RAP](#) (WDNR, 2014) and the [Restrictions on Dredging Activities BUI Removal](#) (WDNR, 2015).

Project Name	Funding Source(s)	Approximate Cost of Planning and Dredging	Approximate # of Cubic Yards Removed
Sheboygan River and Harbor Superfund Site: Upper River Dredging	Tecumseh Corporation and Pollution Risk Services (PRS)	\$9,000,000	20,700
Sheboygan River and Harbor Superfund Site: Lower River Dredging	Tecumseh Corporation and Pollution Risk Services (PRS)	\$13,500,000	63,700
Camp Marina Former MGP Site	Wisconsin Public Service	\$10,000,000	23,000
Great Lakes Legacy Act Project	GLRI/USEPAGLNPO, State of Wisconsin, Sheboygan County, City of Sheboygan	\$32,776,000	160,000
Sheboygan Harbor Navigational Dredging	GLRI/EPA, State of Wisconsin, Sheboygan County, City of Sheboygan	\$20,797,000	170,000
Total	-	\$86,073,000	437,400

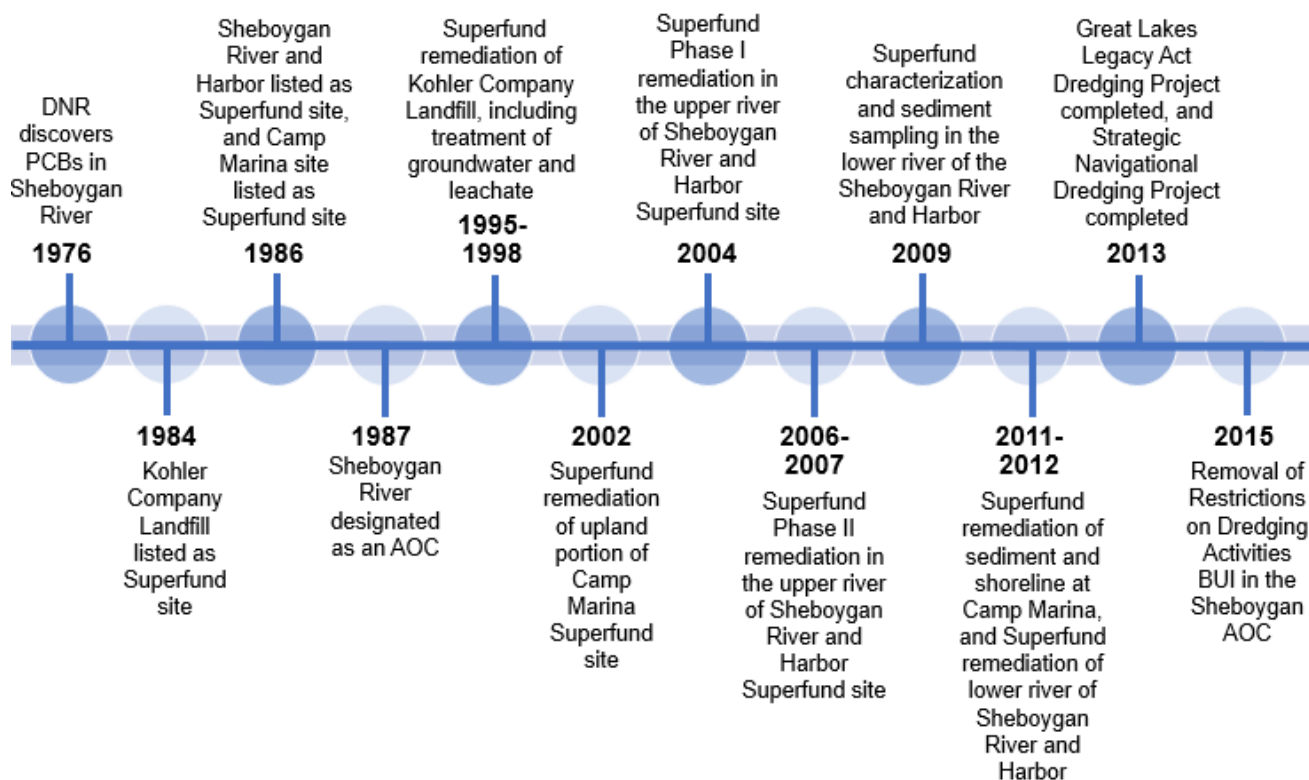


Figure 2. Timeline summarizing contaminated sediment related events and remediation efforts in the Sheboygan River AOC from the time PCBs were discovered in the Sheboygan River to the Restrictions on Dredging Activities BUI removal from the Sheboygan River AOC.

### Reduced Nutrient Enrichment and Water Quality Improvements

When the AOC was listed, one of the nine BUIs identified was the Eutrophication or Undesirable Algae BUI. Eutrophication is nutrient enrichment of water. Excessive nutrient loading in the AOC meant that both phosphorus and nitrogen concentrations in the river were elevated, resulting in undesirable algae blooms being occasionally seen. Algae blooms can have harmful impacts on aquatic ecosystems because the decomposition of large algal blooms consumes oxygen and aquatic animals such as fish cannot survive with too little oxygen.

The specific goal for restoring the Eutrophication or Undesirable Algae BUI was to “control eutrophication (nutrient enrichment of water) for the protection of Lake Michigan” (WDNR, 1989). The 1995 RAP listed the following objectives to meet the target to control eutrophication: controlling nutrient inputs to the Sheboygan River, reducing suspended solids and deposited solids, protecting waterway areas and restoring banks to prevent erosion, and increasing public and official support of nonpoint source issues (WDNR, 1995).

Nutrient inputs were controlled by implementing many projects that addressed agricultural runoff, wastewater improvements, and stormwater runoff improvements; although projects were not done because of the AOC, the AOC benefited. Table 3

highlights significant developments in the effort to control eutrophication of the Sheboygan River.

Table 3. Significant developments in the effort to control eutrophication of the Sheboygan River, listed from the time the Clean Water Act was enacted to the year that the Eutrophication or Undesirable Algae BUI was removed from the Sheboygan River AOC.

Year	
1972	<ul style="list-style-type: none"> <li>• Clean Water Act provided the structure for regulating pollutant discharges into waters and regulating surface water quality standards (USEPA, 2015).</li> <li>• Great Lakes Water Quality Agreement identifies goals and objectives for improving water quality (WDNR, 1989).</li> </ul>
1978	<ul style="list-style-type: none"> <li>• Wisconsin’s Nonpoint Source (NPS) Pollution Abatement Program established. The program improves and protects water quality in many different resources by reducing pollutants from nonpoint sources (WDNR, 1995).</li> <li>• City of Sheboygan wastewater treatment plant upgraded and expanded to provide treatment for Sheboygan Falls, Kohler, and other nearby areas, including the Townships of Lima and Wilson (WDNR, 1989).</li> </ul>
1980	<ul style="list-style-type: none"> <li>• Onion River Priority Watershed implemented nonpoint source control measures (WDNR, 1989).</li> </ul>
1985	<ul style="list-style-type: none"> <li>• Sheboygan River Priority Watershed created with a goal to reduce surface and groundwater pollution caused by nonpoint pollution sources (WDNR, 1989).</li> </ul>
1988	<ul style="list-style-type: none"> <li>• Sheboygan River Basin Water Quality Management Plan identified “water quality goals, problems, improvements, and management needs for lakes and streams in the Sheboygan River Basin.” This plan also studied wastewater treatment facility and management needs for existing and future plants (WDNR, 1989).</li> </ul>
1989	<ul style="list-style-type: none"> <li>• Remedial Action Plan (RAP) included a specific goal to “control eutrophication (nutrient enrichment of water) for the protection of Lake Michigan” (WDNR, 1989).</li> </ul>
1996	<ul style="list-style-type: none"> <li>• Sheboygan County Animal Waste Storage and Feedlot Facility Ordinance was enacted to regulate permitting of “animal waste storage facilities, nutrient management planning, and proper closure of abandoned waste storage facilities” (Sheboygan County, 2010).</li> </ul>

2000	<ul style="list-style-type: none"> <li>The Sheboygan County Land and Water Conservation Department implemented a stream buffer program to improve water quality. The buffer program is an ongoing effort prioritized in the <a href="#">Sheboygan County Comprehensive Plan</a>. Since the program began over 288 tons of sediment have been saved from being washed away and over 30 miles of linear feet of buffer strips have been installed due to the 75 buffers county-wide and the 220.5 acres in the program (<a href="#">Sheboygan County Land and Water Management Plan</a>).</li> </ul>
2001	<ul style="list-style-type: none"> <li>State of the Sheboygan River Basin Report provided an update on water quality conditions in the Sheboygan River Basin including objectives for future actions that would further improve water quality, fisheries, and wildlife (Burzynski, Galarneau, &amp; Hackenberg, 2001).</li> </ul>
2004	<ul style="list-style-type: none"> <li>The Sheboygan County Land and Water Conservation Department worked with WDNR and others on an update to the Sheboygan County Land and Water Resources Management Plan. This plan was required for state funds to be used for implementing agricultural best management practices (ECT &amp; SEH, 2008).</li> <li>Municipal Wisconsin Pollutant Discharge Elimination System (WPDES) storm water permits were issued for the Village of Kohler, Town of Sheboygan, and Town of Wilson. These communities are taking actions to control urban runoff according to their permits (ECT &amp; SEH, 2008).</li> </ul>
2006	<ul style="list-style-type: none"> <li>Sheboygan County adopted an erosion control and storm water management ordinance (ECT &amp; SEH, 2008).</li> </ul>
2010	<ul style="list-style-type: none"> <li>The Mullet River Watershed Plan was updated in 2010. The plan includes a detailed assessment of water quality conditions and recommended actions for restoring wetlands and establishing stream buffers. This plan was developed by the WDNR, UW Extension, and local partners (WDNR, 2010).</li> <li>The Sheboygan County Land and Water Conservation Department worked with WDNR and others on an update to the Sheboygan County Land and Water Resources Management Plan (Sheboygan County, 2010)</li> </ul>
2015	<ul style="list-style-type: none"> <li>The Sheboygan County Land and Water Conservation Department worked with WDNR and others on an update to the Sheboygan County Land and Water Resources Management Plan for the years 2016 to 2025 (Sheboygan County, 2015).</li> <li>The Eutrophication or Undesirable Algae Beneficial Impairment was removed from the Sheboygan River Area of Concern</li> </ul>

After completion of actions to address the impairment, WDNR assessed the water in the Sheboygan River. WDNR evaluated total phosphorus (TP) concentrations, dissolved oxygen (DO), and chlorophyll-a (chl-a) in the Sheboygan River, and determined that the Eutrophication or Undesirable Algae BUI was eligible for removal based on improvements in water quality. Then, in 2015, after determining that the BUI target to eliminate and control excess nutrients entering the Sheboygan River had been met, the Eutrophication or Undesirable Algae BUI was officially removed.

The actions completed in order to remove the Restrictions on Dredging Activities and Eutrophication or Undesirable Algae BUIs will have a lasting positive impact on the water quality and the phytoplankton and zooplankton communities within the Sheboygan River AOC.

***The first portion of the delisting target has been met due to the removal of toxic sediment and nutrient inputs being identified and controlled.***

## **Phytoplankton and Zooplankton Assessments in the AOC**

The second portion of the target to delist the Degradation of Phytoplankton and Zooplankton Populations BUI has two parts:

- 2a. Phytoplankton or zooplankton bioassays confirm no toxicity in ambient waters, and
- 2b. The community structure is diverse and contains species indicative of clean water

The third portion of the target states that:

3. The phytoplankton and zooplankton communities within the site being evaluated are statistically similar to those of a reference site with similar habitat and minimal sediment contamination

WDNR along with technical experts and local AOC stakeholders decided that the following two assessments would be the most appropriate way to evaluate whether the second and third portions of the target for the Degradation of Phytoplankton and Zooplankton Populations BUI were being met:

- Test the ambient river water to see if it is toxic to phytoplankton and zooplankton
- Compare the phytoplankton and zooplankton communities within the AOC to a non-AOC reference site

To perform an assessment of whether the portion of the target stating that phytoplankton and zooplankton bioassays confirm no toxicity in ambient waters was met, WDNR collected ambient river water samples and sent them to WSLH for toxicity tests to determine if phytoplankton and zooplankton would be able to grow and reproduce in AOC river water. Most of the phytoplankton tests and all the zooplankton tests conducted with the ambient AOC water showed no toxicity.

To assess if the community structure is diverse and contains species indicative of clean water, and that the phytoplankton and zooplankton communities within the site are statistically similar to those of a reference site with similar habitat and minimal sediment contamination, USGS conducted studies on the phytoplankton and zooplankton communities in the AOC. They identified species present within the AOC, finding that while some species collected can tolerate environmental degradation, most species present within the AOC are those which are common in freshwater systems and within this region of the Great Lakes basin. USGS also compared AOC populations to those of nearby non-AOC reference sites and found that populations within the AOC did not greatly differ from those within the non-AOC reference sites.

The results from the toxicity tests and USGS studies will be discussed in more detail in the next sections of this document.

### **Water Column Chronic Toxicity Bioassays**

Toxicity tests measure the combined toxic effect to aquatic organisms from all pollutants contained in a water sample. Acute tests determine whether samples cause organisms to die during a short-term exposure under controlled conditions. Acute tests were not conducted in this study because lethality was not expected at these sites. Chronic tests determine whether samples interfere with normal growth or reproductive potential over a longer exposure period that includes the most sensitive life stages of the test organism.

Species chosen for use in toxicity tests must be sensitive to toxic substances, necessary for the overall health of the food chain, and representative of populations present in the area of impact. The organisms used in the chronic toxicity tests to assess the second portion of the Degradation of Phytoplankton and Zooplankton Populations BUI were *Selenastrum capricornutum* (green algae, a type of phytoplankton) and *Ceriodaphnia dubia* (water flea, a type of zooplankton).

Throughout 2016 and 2017, WDNR staff collected six ambient water samples from the Sheboygan River AOC to conduct toxicity tests at the WSLH Environmental Toxicology Lab to determine whether ambient river water was chronically toxic to phytoplankton and zooplankton. Each chronic toxicity test compared organism performance in AOC water samples to that of a lab water control to determine whether the ambient water would interfere with growth (for *S. capricornutum*) or reproduction (for *C. dubia*) of the test organisms. During toxicity testing, temperature is maintained at  $25 \pm 1^\circ$  and light intensity and photoperiod are held constant, in order to simulate a typical summer day/night condition. Dissolved oxygen and pH are monitored throughout the test to make sure that they are not impacting test organisms (DO must be  $\geq 4.0$  mg/l and pH 6.0 - 9.0 s.u., for tests to be acceptable). If test results indicate that reproduction and growth of test organisms in the ambient water are significantly lower than those of the lab control, adverse toxicity conditions may be present in the AOC. If the majority of

samples collected indicate no toxicity in samples, the portion of the target requiring no ambient water toxicity is considered met.

***Selenastrum capricornutum* test results**

During *S. capricornutum* chronic toxicity tests, algae cells were exposed to AOC water for 4 days and then cell growth was determined fluorometrically. At the end of the toxicity test, a general linear model, PROC-GLM in SAS, followed by a multiple comparison, SNK, test were performed to determine if *S. capricornutum* growth in AOC waters was significantly different from a lab control. Significant difference is defined as an AOC reproduction that was statistically lower ( $p \leq 0.05$ ) than the control. A statistically significant difference may indicate underlying issues in toxicity of ambient water quality. Results of chronic *S. capricornutum* tests are summarized in Figure 3 and Table 4.

Table 4. *S. capricornutum* chronic toxicity test results from WSLH. Algal growth was measured across four replicates and mean growth was compared between the lab control and the Sheboygan River sample for each of the six tests. Most algal tests showed no toxicity. Possible toxicity is defined as an AOC growth value that was statistically lower ( $p \leq 0.05$ ) than the control.

<b><i>S. capricornutum</i> Growth Test</b>			Algae growth (relative fluorescence units, RFU)				Mean Growth (RFU)	Possible Toxicity
Month	Year	Sample	1	2	3	4		
July	2016	Lab Control	613	630	627	653	631	
July	2016	Sheboygan River	659	648	642	664	653	No
August	2016	Lab Control	540	555	573	588	564	
August	2016	Sheboygan River	530	562	556	560	552	No
May	2017	Lab Control	691	711	735	711	712	
May	2017	Sheboygan River	682	688	699	693	691	No
August	2017	Lab Control	686	676	703	708	693	
August	2017	Sheboygan River	664	648	633	602	637	Yes
September	2017	Lab Control	691	671	631	685	670	
September	2017	Sheboygan River	529	546	513	557	536	Yes
October	2017	Lab Control	582	583	614	579	590	
October	2017	Sheboygan River	629	645	618	606	625	No

All but two of the tests conducted in 2016 and 2017 showed no statistically significant difference between lab control and AOC water, indicating that no toxicity was present in over half of the samples. The August and September 2017 tests did show a statistically significant decrease in growth in AOC waters when compared to the lab control, indicating that some chronic toxicity was possibly present that was inhibiting algae growth. For the August 2017 sample, the relative difference between the lab control and the AOC test was only 8%, indicating that the magnitude of difference is likely not

biologically relevant to cause concern. Additionally, the control sample for that date was elevated compared to the mean of all control samples. However, the sample from September 2017 is 20% different from the lab control, indicating the sample likely has some biologically-relevant toxicity.

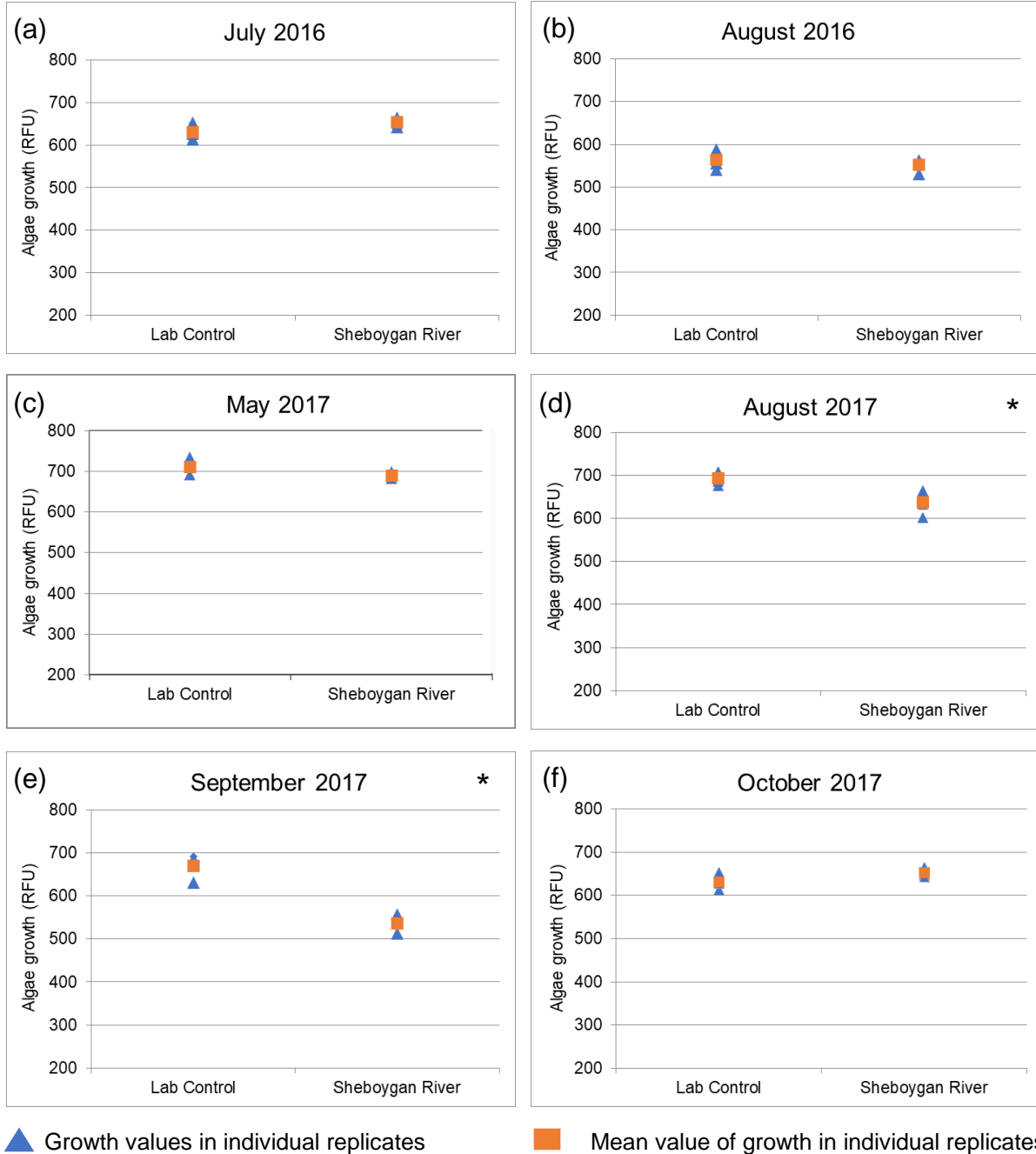


Figure 3. *S. capricornutum* growth; algal growth was measured as relative fluorescence. Blue triangles represent the growth values of individual replicates, and orange squares represent the mean of those individual replicates. Four of the six tests did not show toxicity. The August and September 2017 tests, graphs (d) and (e), did show a statistically significant decrease in growth in AOC waters (indicated with \* on plots) when compared to the lab control. Graphs adapted from those provided to WDNR from WSLH



### **Ceriodaphnia dubia test results**

In *C. dubia* chronic toxicity tests, neonates ( $\leq$  24-hour old at beginning of test) were exposed to AOC water for 7 days and survival and reproduction was recorded daily. At the end of the toxicity test a general linear model, PROC-GLM in SAS, followed by a multiple comparison, Student-Newman-Keuls (SNK), test were performed to determine if *C. dubia* reproduction in AOC waters was significantly different from a lab control. Significant difference is defined as an AOC reproduction that was statistically lower ( $p \leq 0.05$ ) than the control. A significant statistical difference may indicate underlying issues in toxicity of ambient water quality. All but one of the tests conducted in 2016 and 2017 showed no statistically significant difference between lab control and AOC water, indicating that no toxicity was present in those samples (Table 5 & Figure 4).

Table 5: *C. dubia* chronic toxicity test results from WSLH. Table shows the number of individual neonates from ten replicates of Lab Control water and Sheboygan River water samples collected throughout 2016 and 2017. For each of the six tests, mean neonates from the AOC and control were compared. Adult survival was 100% across all tests.

<b>C. dubia Reproduction and Survival Test</b>				Total Neonates Per Replicate										Mean Neonates	Standard Deviation	Possible Toxicity
Month	Year	Sample	% Adult Survival	1	2	3	4	5	6	7	8	9	10			
July	2016	Lab Control	100	35	28	10	19	38	37	17	25	37	34	28	9.4	
July	2016	Sheboygan River	100	40	54	37	37	35	36	33	31	43	40	39	6.1	No
August	2016	Lab Control	100	39	41	45	43	44	39	47	44	40	37	41.9	3.0	
August	2016	Sheboygan River	100	35	35	41	40	35	35	35	37	30	35	35.8	2.9	Yes
May	2017	Lab Control	100	41	33	37	39	34	37	38	19	30	32	34	5.9	
May	2017	Sheboygan River	100	45	44	38	35	38	47	49	42	42	46	42.6	4.2	No
August	2017	Lab Control	100	21	19	24	28	21	19	23	26	24	14	21.9	3.8	
August	2017	Sheboygan River	100	26	23	25	28	27	27	25	28	31	30	27	2.3	No
September	2017	Lab Control	100	21	18	17	21	20	24	24	25	23	22	21.5	2.5	
September	2017	Sheboygan River	100	23	21	20	27	20	15	21	20	25	19	21.1	3.1	No
October	2017	Lab Control	100	38	35	33	31	32	31	36	33	38	39	34.6	2.9	
October	2017	Sheboygan River	100	37	40	40	39	41	28	41	36	39	40	38.1	3.7	No

While the August 2016 test did show a statistically significant difference between the AOC water and the lab control, the control response shown in that test was higher than what is normally seen in *C. dubia* chronic toxicity tests (and also the highest amongst the control means shown in all of the tests being reported here). The difference between the AOC water and lab control is more likely caused by this high control response and is not thought to be indicative of toxicity in the AOC water. The mean neonate/female count of 36 in the August 2016 AOC water treatment is above average in most toxicity tests and indicates toxicity was not present.

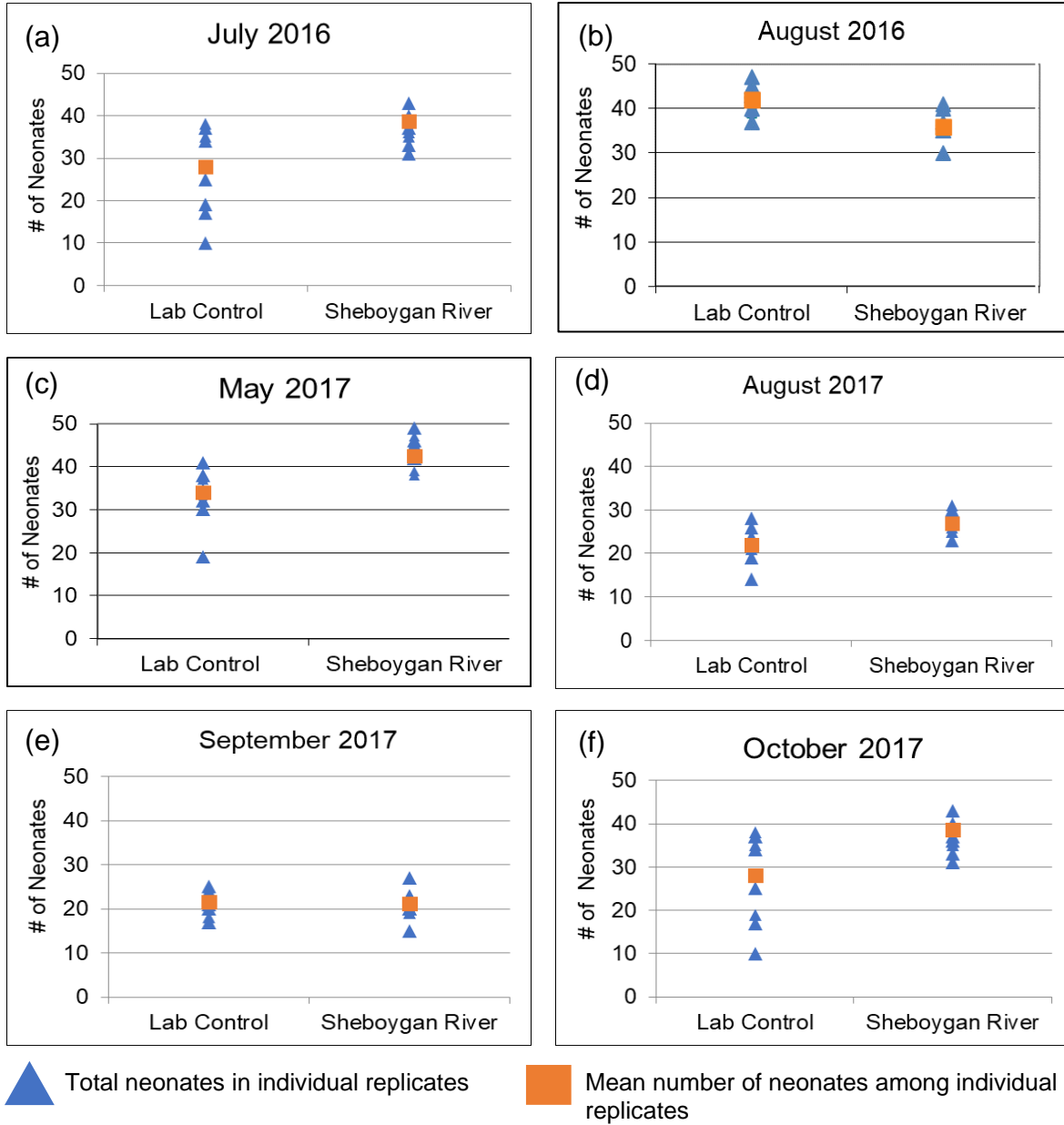


Figure 4. Graphs (a)–(f) show *C. dubia* chronic toxicity test results; graphs adapted from those provided to WDNR from WSLH. The blue triangles represent total neonates within individual replicates, and the orange squares represent the mean of those individual replicates. No *C. dubia* tests are indicative of chronic toxicity.

**Since 5/6 of algal (growth) tests and all *C. dubia* (reproduction) tests performed with ambient AOC river water showed no toxicity, WDNR considers the Sheboygan River AOC water not toxic to the phytoplankton and zooplankton communities. The first part of the second portion of the target has therefore been met.**

## USGS Wisconsin Lake Michigan AOC Studies

In 2012 and 2014, USGS studied the phytoplankton, zooplankton, and benthos communities in all of Wisconsin's Lake Michigan AOCs, as well as in non-AOC reference sites ([Scudder Eikenberry et al., 2019](#)). In 2016, USGS completed an additional study on the zooplankton communities in the Sheboygan AOC and reference sites ([Olds et al., 2017](#)).

For all USGS studies, the Sheboygan AOC was compared to two non-AOC reference sites: the Manitowoc River and the Kewaunee River. The less degraded non-AOC reference sites were chosen because they were never designated as AOCs and have otherwise similar environmental conditions to the Sheboygan AOC. The analysis completed by USGS was done under the assumption that biological assemblages at the reference sites are similar to what would be in place in the AOC if it were not severely degraded.

During each year of the study samples were taken in the spring, summer, and fall, and in each year the results showed that there were variations in richness and in diversity values, as well as in dominant taxa. Although there were differences between the years and seasons, phytoplankton assemblages were similar between the AOC and non-AOC comparison sites (Scudder Eikenberry et al., 2019). Diatoms were the dominant algal group in 2014 and in second greatest abundance were green algae (Scudder Eikenberry et al., 2019), both of which are an important source of food for the entire food web and often abundant in aquatic systems and common worldwide. While some planktonic species collected are tolerant to poor conditions, most species collected are commonly found throughout this region of the Great Lakes basin; and while species may live in poor conditions, they do not necessarily indicate poor conditions.

Despite temporal differences in zooplankton community assemblages, a one-way analysis of similarities (ANOSIM) test showed no significant difference between communities of the AOC and non-AOC comparison sites (Olds et al., 2017). Rotifers made up a large portion of the zooplankton community in all years of sampling at the AOC and non-AOC sites; some seasons were dominated by dresenid veligers; a smaller percentage of the zooplankton population usually included copepods (mostly nauplii), which are common in Lake Michigan (Vanderploeg et al., 2012), and cladocerans (Scudder Eikenberry et al., 2019; Olds et al., 2017).

Rotifers are important components of environmental food webs (Gannon & Stemberger, 1978) and can be sensitive to changes in environmental conditions (Stemberger, 1979). In the Laurentian Great Lakes region, most rotifer species exist under a wide range of environmental conditions and population dynamics are complex with many factors at play (Gannon and Stemberger, 1978). Among the commonly collected rotifers found within the AOC were *Polyarthra sp.*, *Synchaeta sp.*, *Brachionus sp.*, and *Euchlanis sp.* (Scudder Eikenberry et al., 2019; Olds et al., 2017). While some *Polyarthra sp.* can be considered pollution tolerant (Gannon and Stemberger, 1978), it is also a major rotifer species across the Great Lakes (Stemberger, 1979), in part because some *Polyarthra*

*sp.* are able to tolerate a wide range of temperatures and can inhabit both eutrophic and oligotrophic waters (Slideek, 1983). An abundance of *Synchaeta sp.* were collected in the spring (Olds et al., 2017), which was not surprising as many *Synchaeta sp.* are known to have strong seasonal patterns (Stemberger, 1979) and some *Synchaeta sp.* are even known to live in oligotrophic waters (Yin et al., 2018). *Brachionus sp.* are known to do well where there are excess nutrients (Stemberger, 1979), however some are known to dominate in mesotrophic environments (Yin et al., 2018). *Euchlanis sp.* can do well in eutrophic waters (Stemberger, 1979), but have also been used as a biomonitor due to sensitivity to pollutants (Glime, 2017).

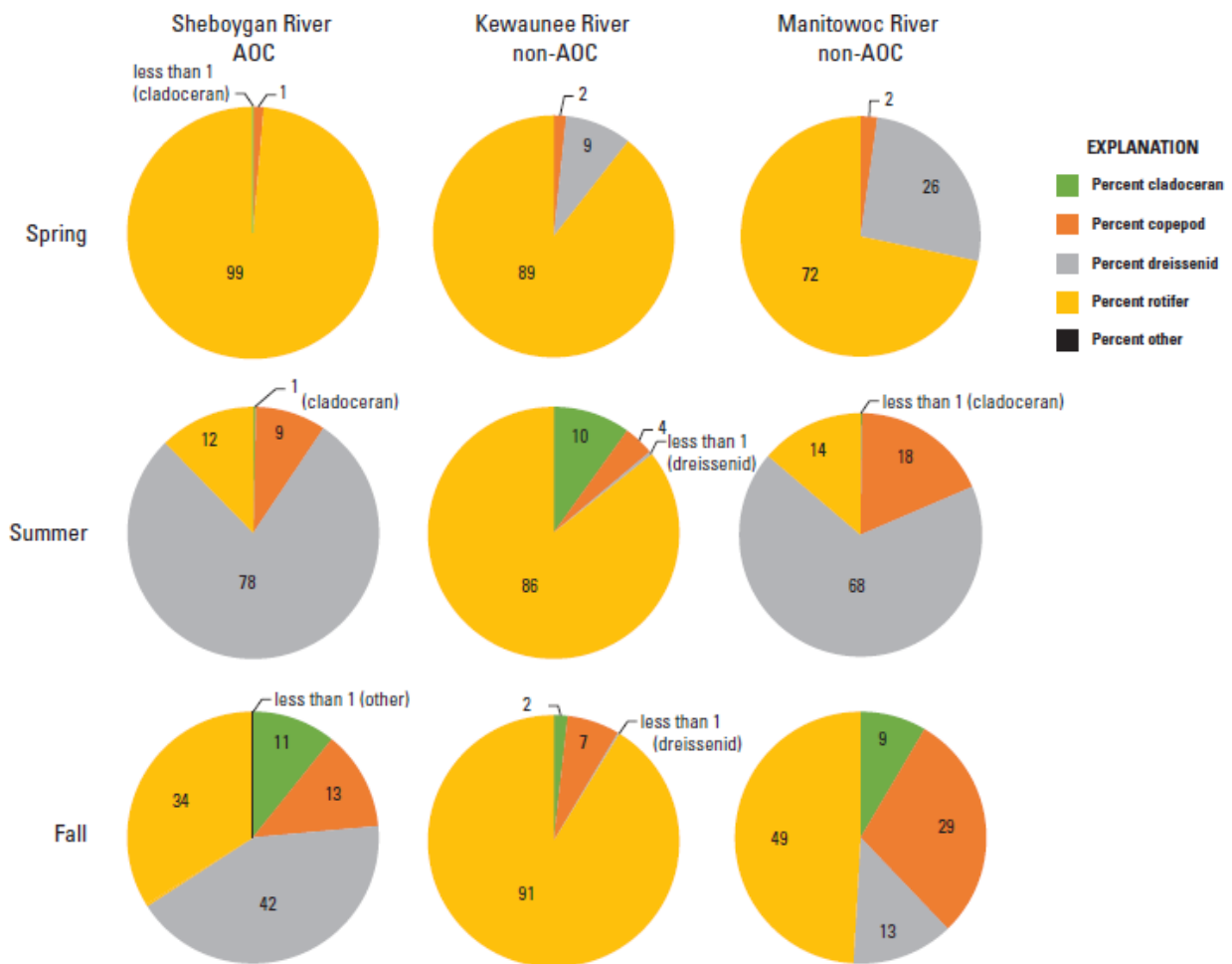


Figure 5: The percentage of each type of zooplankton taxa in samples collected at the Sheboygan AOC and two non-AOC comparison sites, the Kewaunee and Manitowoc Rivers, in western Lake Michigan in 2016. Reprinted from [Olds et al., 2017, p8, Figure 3](#). Despite differences, a one-way ANOSIM test showed no significant difference between communities of the AOC and non-AOC comparison sites.

Overall, spatial, seasonal, and yearly variations occur in communities throughout aquatic ecosystems (Grothe & Grothe, 1977), and species found within the Sheboygan AOC consist of species known to be able to survive a variety of environmental conditions.

***Many species found by USGS are pollution tolerant, but do not necessarily indicate poor conditions because they can live in a variety of conditions and are common across the Great Lakes. Therefore, the second part of the second portion of the target, stating “the community structure is diverse and contains species indicative of clean water” has been met.***

### **Phytoplankton Assessment**

In the 2014 study, which compared the 2012 and 2014 results, an ANOSIM test for combined phytoplankton (soft algae and diatoms) indicated no significant difference between the communities of the Sheboygan River AOC and the two non-AOC comparison sites. The biomass and density of phytoplankton collected was not found to be different between the AOC and non-AOC sites in 2014 (Skudder Eikenberry et al., 2019). Multi-dimensional scaling (nMDS) ordination plots were used to assess similarity between the AOC and non-AOC reference sites; when using MDS ordination plots, sites closer in multidimensional space are more similar in community composition. The combined phytoplankton MDS ordination plot with seasons combined shows similarity between the Sheboygan River AOC assemblage and assemblages at its two non-AOC reference sites (Figure 6). Mean richness and diversity results are shown in Table 6.

Diatoms were the dominant algal group in the phytoplankton in the AOC in 2014 (Skudder Eikenberry et al., 2019). Since diatoms are energy rich, they are an important source of food for the entire food web – from zooplankton and small fish, to larger fish and anything that eats fish from turtles to birds to people. The second-most dominant phytoplankton was green algae, which are often abundant in aquatic systems and common worldwide.

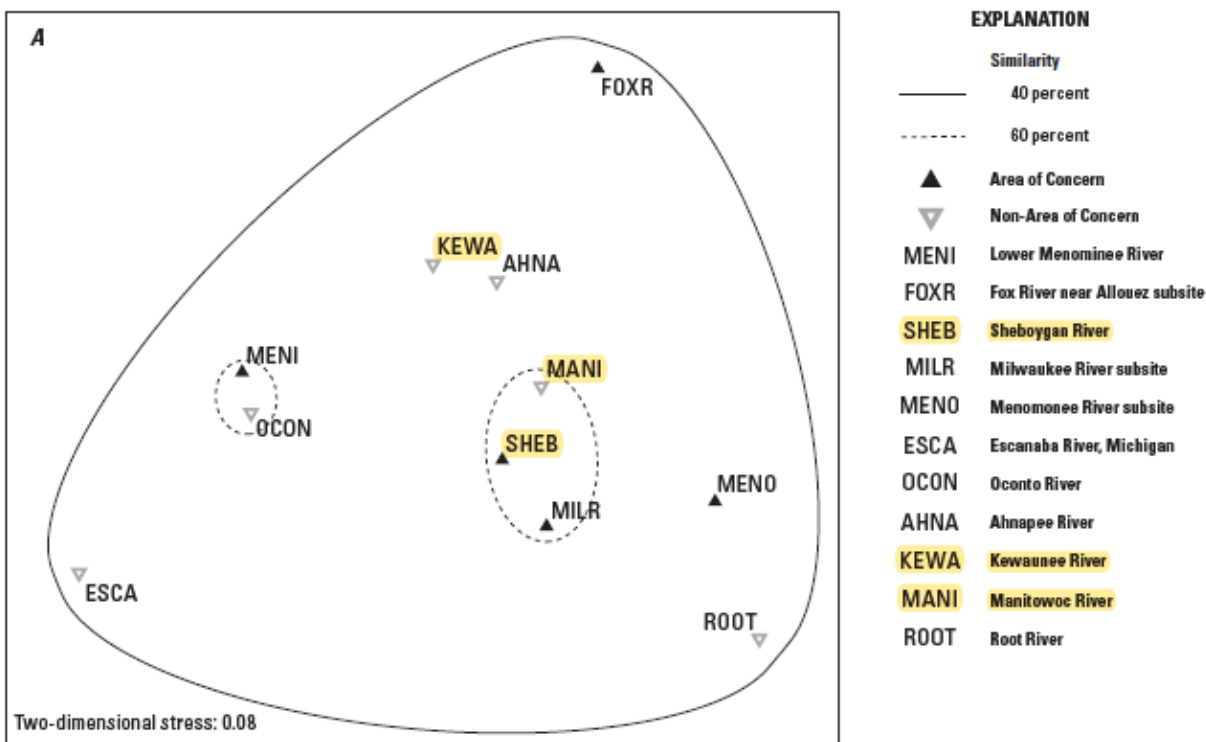


Figure 6. Multidimensional scaling ordination plots for combined phytoplankton (soft algae and diatoms) with seasons combined at 4 Lake Michigan Areas of Concern and 6 non-Area of Concern comparison sites, based on relative abundance (fourth-root transformed) with no rare or ambiguous taxa. Reprinted from *Scudder Eikenberry et al., 2019, p34, Figure 7A*. Sheboygan AOC and reference sites highlighted.

Table 6: Mean richness and diversity measurements for combined phytoplankton (soft algae + diatoms); adapted from *Scudder Eikenberry et al., 2019*. AOC results did not significantly differ from non-AOC comparison sites.

Year	Sampling Site	Mean Richness	Mean Diversity
2012	Sheboygan River AOC	57.0 (±18.5)	2.7 (±0.3)
2012	Kewaunee River non-AOC	49.7 (±30.4)	2.6 (±0.5)
2012	Manitowoc River non-AOC	33.3 (±7.4)	2.4 (±0.3)
2014	Sheboygan River AOC	75.3 (±23.0)	3.0 (±0.6)
2014	Kewaunee River non-AOC	81.0 (±12.8)	3.1 (±0.2)
2014	Manitowoc River non-AOC	83.3 (±12.1)	3.2 (±0.3)

### Zooplankton Assessment

USGS researchers compared the AOC community to the non-AOC communities including an assessment of assemblage similarity, species richness and diversity.

Non-metric multi-dimensional scaling (nMDS) ordination plots were used to assess similarity between the AOC and non-AOC reference sites. When using nMDS ordination plots, sites closer in multidimensional space are more similar in community composition.

An nMDS ordination plot for zooplankton in 2014 showed that spring samples for the AOC and two non-AOC reference sites were similar, and the AOC was similar to the Manitowoc River non-AOC site in the summer and fall (Figure 6; Scudder Eikenberry et al., 2019). In 2016, an nMDS plot showed the AOC zooplankton community was similar to the non-AOC Manitowoc River site (Figure 7; Olds et al., 2017).

When looking at zooplankton assemblages in 2014, an ANOSIM test indicated that the zooplankton assemblage within the AOC site did not differ from the two non-AOC reference sites, and metrics for zooplankton did not differ between the AOC and the mean of all non-AOCs (Scudder Eikenberry et al., 2019). 2016 results showed zooplankton communities being on average 50 percent similar and did not show significant differences between the Sheboygan River AOC site and the Manitowoc River and the Kewaunee River non-AOC reference sites (Olds et al., 2017).

Species richness is computed as the number of unique taxa in a sample. A test to compare the variation among two or more means, analysis of variance (ANOVA) test, was used to calculate richness for each site across all three seasons samples. If an ANOVA result showed significant values ( $p < 0.05$ ), the test was followed by a Bonferroni test to determine if the difference was between specific sites or seasons. Richness did not significantly differ between the AOC and non-AOC comparison sites (Scudder Eikenberry et al., 2019). Additionally, in 2016, richness at the Sheboygan River AOC was higher than the two non-AOC sites and considered not-degraded (Olds, et al., 2017). Mean richness results are displayed in Table 6.

Diversity is calculated by taking richness (the number of different species) as well as abundance (the number of individuals of a species present) into a single calculation. Diversity was calculated by using the Shannon Diversity Index (Shannon, 1948). Differences were examined between the AOC and reference sites by using a similarity percentage analysis to assess differences in relative abundances of taxa at each site, and by using ANOVA. Mean diversity values are shown in Table 6.

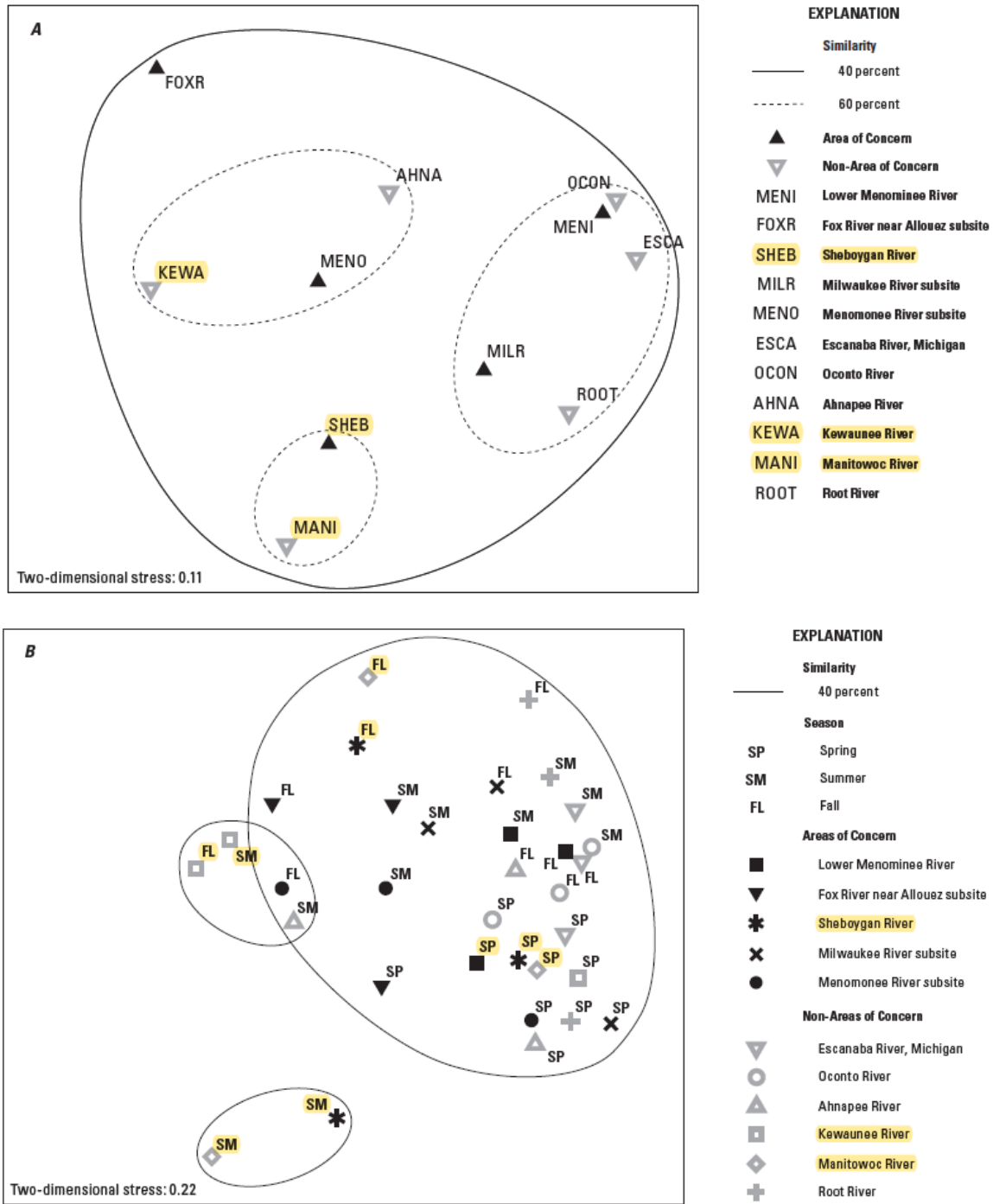


Figure 7: Multidimensional scaling ordination plots for zooplankton at 4 Lake Michigan AOCs and 6 non-AOC comparison sites, based on relative abundance (fourth-root transformed) with no rare or ambiguous taxa. A, seasons combined; B, seasons separate. Reprinted from [Scudder Eikenberry et al., 2019](#), p31, Figure 5. Sheboygan AOC and reference sites highlighted.



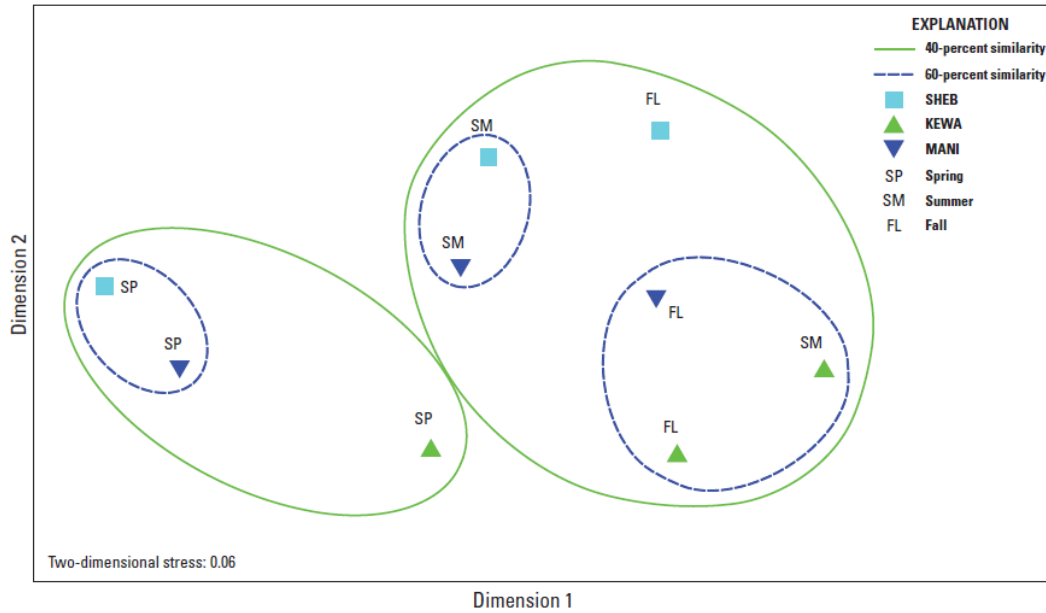


Figure 8: Zooplankton communities collected at the Sheboygan River AOC and two non-AOC comparison sites. Reprinted from [Olds et al., 2017](#), p9, Figure 4.

Table 7: 2012, 2014, and 2016 Mean Zooplankton Community Richness and Diversity (plus or minus standard deviation), adapted from Scudder Eikenberry et al., 2019 and Olds et al., 2017.

Year	Sampling Site	Mean Richness	Mean Diversity
2012	Sheboygan River AOC	20.3 ( $\pm 3.2$ )	2.0 ( $\pm 0.2$ )
2012	Kewaunee River non-AOC	21.0 ( $\pm 6.6$ )	1.8 ( $\pm 0.0$ )
2012	Manitowoc River non-AOC	20.7 ( $\pm 5.9$ )	1.6 ( $\pm 0.7$ )
2014	Sheboygan River AOC	27.0 ( $\pm 8.7$ )	1.1 ( $\pm 0.6$ )
2014	Kewaunee River non-AOC	29.7 ( $\pm 9.0$ )	2.2 ( $\pm 0.3$ )
2014	Manitowoc River non-AOC	21.3 ( $\pm 11.5$ )	1.7 ( $\pm 0.9$ )
2016	Sheboygan River AOC	16.0 ( $\pm 6.0$ )	1.1 ( $\pm 0.9$ )
2016	Kewaunee River non-AOC	13.3 ( $\pm 5.0$ )	1.4 ( $\pm 0.5$ )
2016	Manitowoc River non-AOC	11.3 ( $\pm 5.5$ )	1.7 ( $\pm 0.1$ )

Diversity at the Sheboygan River AOC was not significantly different ( $p < 0.05$ ) from the Manitowoc or Kewaunee River non-AOC comparison sites in 2012. However, AOC diversity was lower than the non-AOC sites in 2014 and 2016 even though richness was higher in the AOC site over the same time period (Scudder Eikenberry et al., 2019; Olds et al., 2017).

One likely reason for the lower diversity in the AOC zooplankton community could be rotifer dominance, and another reason might be an abundance of invasive dreissenid veligers in the samples (Scudder Eikenberry et al., 2019). In 2016, the zooplankton community in the Manitowoc River was similar to the community in the Sheboygan River AOC; two similarities include their water temperatures and the amount of invasive dreissenid veligers (Olds et al., 2017). Dreissenid veligers are the early stage of zebra

and quagga mussels that are tiny and planktonic. These exotic species were often in high abundance in the AOC samples and are thought to be having a significant impact on the AOC's reduced zooplankton diversity (Olds et al., 2017). Despite their presence within the AOC, invasive dreissenid veligers are a lake-wide and regional issue, not an AOC issue.

USGS concluded that post-remediation recovery can often be complicated by non-AOC stressors such as invasive species, which could result in the slow recovery of zooplankton communities within the AOC (Olds et al., 2017). The remediation efforts and management actions for the Sheboygan River AOC have been completed and the system continues to improve; in 2016, the zooplankton communities were still likely in the process of recovering from the removal of contaminated sediment and the disturbance from dredging activities. With many of the USGS results indicating no significant differences between the AOC zooplankton community and those of non-AOC reference sites, and variations and stressors beyond the control of the AOC program taken into consideration, WDNR has concluded that the zooplankton communities are no longer considered severely degraded and the AOC target has been met.

***The phytoplankton and zooplankton communities were evaluated to be statistically similar to non-AOC reference sites, and WDNR has concluded that the third portion of the target has been met.***

## **Public Involvement and Stakeholder Recommendations**

Based upon results of the studies described in this BUI removal, WDNR convened the Sheboygan Advisory Committee in September 2020 and June 2021 to discuss the proposed BUI removal. Participants of the Advisory Committee expressed support for the removal of this BUI. WDNR held a public review and comment period for the BUI removal document from August 10 through September 1, 2021. We received one supportive comment. See Appendix B for Letters of Support provided for the BUI removal, and Appendix C for the GovDelivery Announcement for Public Comment Period.

## **Conclusion**

The first portion of the Degradation of Phytoplankton and Zooplankton Populations BUI removal target was met through the completion of contaminated sediment remediation and the many projects and programs that were implemented to address nutrient inputs.

The first part of the second portion of the Degradation of Phytoplankton and Zooplankton Populations BUI removal target was demonstrated to be met by the results of the chronic water toxicity testing conducted by the Wisconsin State Lab of Hygiene (WSLH). The majority of toxicity testing results did not result in chronic toxicity compared to the controls, and there was survival, growth, and reproduction in all samples. The second part of the second portion of the Degradation of Phytoplankton and Zooplankton Populations BUI removal target was met upon evaluation of species

present in USGS samples. Species present are commonly found in this region and are able to live under a variety of environmental conditions.

The third portion of the Degradation of Phytoplankton and Zooplankton Populations BUI removal target was demonstrated to be met by the USGS assessment of the planktonic community within the AOC compared to two non-AOC reference sites. The assessment did not reveal significant statistical differences between the phytoplankton and zooplankton communities in the AOC in comparison to the reference sites.

All three portions of the delisting target have been met.

### **All Portions of Delisting Target Have Been Met**

As a result of the remedial actions which have been completed and the outcomes of the studies conducted by WDNR and USGS, WDNR has concluded that all three sections of the target to remove this BUI are being met:

- Sources of contaminants within the AOC have been controlled or eliminated.
- Toxicity testing resulted in growth and reproduction of phytoplankton and zooplankton in ambient AOC river water.
- Communities present are diverse and represent species indicative of clean water.
- Phytoplankton and zooplankton communities are statistically similar between the AOC and non-AOC reference sites.

### **Removal Statement**

The Wisconsin Department of Natural Resources recommends the removal of the Degradation of Phytoplankton and Zooplankton Beneficial Use Impairment from the Sheboygan River Area of Concern.

## List of Acronyms

ANOSIM	Analysis of similarity
ANOVA	Analysis of variance test
AOC	Area of Concern
BUI	Beneficial Use Impairment
chl-a	Chlorophyll-a
DO	Dissolved oxygen
GLNPO	Great Lakes National Program Office
GLWQA	Great Lakes Water Quality Agreement
nMDS	non-metric multi-dimensional scaling
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
RAP	Remedial Action Plan
RP	Responsible Party
TP	Total phosphorus
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WSLH	Wisconsin State Lab of Hygiene
WPDES	Wisconsin Pollution Discharge Elimination System

## Definitions

**Algae:** simple aquatic microorganisms that photosynthesize

**Ambient:** relating to the current and immediate conditions and surroundings

**ANOSIM test:** ANOSIM stands for “analysis of similarities” and is used to statistically test whether there is a significant difference between two or more groups of sampling units.

**ANOVA test:** ANOVA stands for “analysis of variance test” and is used to statistically analyze the differences among means, essentially assessing the variation among groups

**Area of Concern:** A region where legacy pollution— from industrial, agricultural, and urban sources—severely interferes with the public’s use of water resources for activities such as swimming and fishing. Defined by Annex 2 of the 1987 Protocol to the U.S.- Canada Great Lakes Water Quality Agreement as “geographic areas that fail to meet the general or specific objectives of the Agreement where such failure has caused or is likely to cause impairment of beneficial use of the area’s ability to support aquatic life.” These areas are the “most contaminated” areas of the Great Lakes, and the goal of the AOC program is to bring these areas to a point at which they are not environmentally degraded more than other comparable areas of the Great Lakes. When that point has been reached, the AOC can be removed from the list of AOCs in the Annex, or “delisted.”

**Beneficial Use Impairment:** A "beneficial use" is any way that a water body can improve the quality of life for humans or for fish and wildlife (for example, providing fish that are safe to eat). If the beneficial use is unavailable due to environmental problems (for example if it is unsafe to eat the fish because of contamination) then that use is impaired. The International Joint Commission provided a list of 14 possible beneficial use impairments in the 1987 Great Lakes Water Quality Agreement amendment.

**Bonferroni test:** A Bonferroni test is used in biological statistical analysis, and it can be used when comparing multiple groups in order correct the statistics for false positives, which protects the data from incorrectly appearing to be statistically significant

**Bioassay:** A bioassay is an analytical method to determine concentration or potency of a substance by its effect on living cells or tissues.

**Contaminant:** a polluting or poisonous substance that makes something impure

**Diatoms:** a major group of algae

**Diversity:** calculated by taking richness (the number of different species) as well as abundance (the number of individuals of a species present) into account

**Dredging:** Dredging is the operation of excavating material from an aquatic environment. In this document, dredging refers to excavating sediment from the river bottom.

**Eutrophication:** excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of plant life and death of animal life from lack of oxygen

**Mean (in statistics):** the average in a collection of numbers

**Microcrustaceans:** tiny crustaceans (e.g. cladocerans and copepods)

**nMDS ordination plots:** when using nMDS ordination plots, information is condensed from multi-dimensional data into a two-dimensional representation and the closer the points are together, the more similar the communities are.

**Nutrient:** Substances such as nitrogen or phosphorus which are necessary for life and therefore promote the growth of plants and algae

**Phytoplankton:** Microscopic plant-like aquatic organisms that photosynthesize, including algae and photosynthesizing bacteria, that can move freely through the water

**Pollution:** The presence of materials or energy whose nature, location, or quantity produces undesired environmental effects.

**PROC-GLM:** [PROC-GLM](#) is a program to analyze data using general linear models in statistical software called SAS; the GLM procedure can be used for many different analyses.

**Remedial:** Tending to remedy something, to restore to natural conditions, to correct or improve.

**Remedial Action Plan:** According to the 1987 Protocol to the U.S.-Canada Great Lakes Water Quality Agreement, a RAP is a document that provides “a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses in Areas of Concern...” RAPs are required to be submitted to the International Joint Commission at three stages: Stage 1: Problem definition Stage 2: When remedial and regulatory measures are selected Stage 3: When monitoring indicates that identified beneficial uses have been restored. Note that a renegotiated Great Lakes Water Quality Agreement was signed in 2012 by the U.S. and Canada which removed the “stage” terminology from the AOC Annex, and simply requires Remedial Action Plans to be “developed, periodically updated, and implemented for each AOC.”

**Richness:** the number of unique taxa in a sample

**Rotifers:** a minute multicellular aquatic animal of the phylum *Rotifera*.

**Shannon Diversity Index:** The Shannon diversity index (H) is another index that is commonly used to characterize species diversity in a community. Shannon's index accounts for both abundance and evenness of the species present.

**Student–Newman–Keuls:** The Student-Newman-Keuls, or SNK, test is a procedure used to identify whether multiple sample means are significantly different from one another, and can identify which specific pairs of means are different

**Superfund:** Superfund is the common name given to the law called the Comprehensive Environmental Response, Compensation and Liability Act of 1980, or CERCLA.

Superfund is also the trust fund set up by Congress to handle emergency and hazardous waste sites needing long-term cleanup

**Toxicity:** the quality of being toxic or poisonous

**Water column:** a vertical expanse of water stretching between the surface and the floor of a body of water

**Zooplankton:** plankton consisting of small animals and the immature stages of larger animals.

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## **Appendices**

**Appendix A: Letter on the Completion of Management Actions**

**Appendix B: Letters of Support**

**Appendix C: GovDelivery Announcement for Public Comment Period**

## **Appendix A – Letter on the Completion of Management Actions**



July 6, 2015

Mr. Chris Korleski, Director  
United States Environmental Protection Agency  
Great Lakes National Program Office  
77 West Jackson Boulevard (G-17J)  
Chicago, IL 60604-3511

Subject: Completion of Management Actions for the Sheboygan River Area of Concern

Dear Mr. Korleski:

This letter serves to document the completion of management actions for the Sheboygan River Area of Concern. The AOC has nine beneficial use impairments:

- Restrictions on dredging activities;
- Restrictions on fish and wildlife consumption;
- Degradation of benthos;
- Degradation of fish and wildlife populations;
- Loss of fish and wildlife habitat;
- Bird or animal deformities or reproduction problems;
- Fish tumors or other deformities;
- Degradation of phytoplankton and zooplankton populations; and,
- Eutrophication or undesirable algae.

Following designation as an AOC in 1987, many partners worked together to make progress toward restoring the Sheboygan River. In particular, notable progress was made in addressing point and nonpoint sources of nutrients to address eutrophication issues. Important groundwork was laid for the eventual cleanup of contaminated sediment sites, with state and federal agency staff engaging responsible parties in discussions about cleanup.

In 2011, Wisconsin DNR's Office of the Great Lakes (OGL) worked with local stakeholders and U.S. EPA's Great Lakes National Program Office to identify a final set of actions that would address the remaining sources of impairment. The management actions that were identified and subsequently completed include the following:

- Camp Marina Superfund Alternative Remediation\*
- Sheboygan Harbor Navigational Improvement Dredging
- Sheboygan River & Harbor Superfund Remediation\*
- Sheboygan River Great Lakes Legacy Act Project
- In-Stream Habitat Improvements
- Kiwanis Park Shoreline Restoration
- Schuchardt Property Conservation Planning & Invasive Species Management Planning
- Shoreline Stabilization in Problem Areas
- Targeted Invasive Species Control

- Taylor Drive & Indiana Ave Riparian Area and Wetland Restoration
- Wildwood Island Area Restoration

\*This work was completed in the field by the responsible parties. The EPA Superfund program has not yet issued final completion documents for these projects and some long term responsibility will remain for the foreseeable future.

Completing these management actions would not have been possible without strong partnerships between DNR, U.S. EPA's Great Lakes Legacy Act program, City of Sheboygan, Sheboygan County, and many others. We are grateful for the efforts of all of the partners and for the funds provided by the Great Lakes Restoration Initiative.

While we have completed the management actions that we believe were necessary to delist the AOC, we are undertaking verification monitoring to ensure that AOC targets have been met. We have documented the achievement of targets for the Restrictions on Dredging Activities and Eutrophication or Undesirable Algae BUIs and will propose them for removal in 2015. PCBs are a pollutant of concern in this AOC and they are persistent in the environment. Natural attenuation of PCBs was part of the approach the EPA Superfund program employed in their record of decision for portions of the river. BUIs related to PCB contamination will need time for the system to recover. The state will be reviewing the results of verification monitoring to determine the appropriate timeframes for considering additional BUIs for removal.

We thank you for your support in completing the identified management actions and look forward to your continued support and collaboration in monitoring and documenting progress in the AOC. If you have any questions about the management actions, verification monitoring, or BUI removals, please contact me at (608) 266-1956 or by e-mail at [Stephen.Galarneau@Wisconsin.gov](mailto:Stephen.Galarneau@Wisconsin.gov); or you may contact Vic Pappas, Lake Michigan Team Leader, at (920) 893-8512 or by e-mail at [Victor.Pappas@Wisconsin.gov](mailto:Victor.Pappas@Wisconsin.gov).

Sincerely,



Stephen Galarneau, Director  
Office of the Great Lakes

Cc: Vic Pappas, WDNR  
Camille Bruhn, WDNR  
Kendra Axness, WDNR  
Ted Smith, USEPA  
Marc Tuchman, USEPA

## **Appendix B – Letters of Support**



City of

**Sheboygan**

spirit on the lake.

August 25, 2021

Brennan Dow, Sheboygan River AOC Coordinator  
Wisconsin Department of Natural Resources  
1027 W St. Paul Avenue  
Milwaukee, WI 53233

Dear Mr. Dow,

The City of Sheboygan, Department of Public Works, is pleased to support the Wisconsin Department of Natural Resources (WDNR) in the decision to remove of the Degradation of Phytoplankton and Zooplankton Beneficial Use Impairment (BUI) from the Sheboygan River Area of Concern (AOC).

The Sheboygan River AOC community partnered with many local, state and federal agencies, non-governmental organizations, business groups, community leaders, and volunteers to clean up toxic sediments and to implement many projects and programs to address nutrient inputs.

The results from the studies summarized within the BUI Removal Recommendation indicate that the targets have been achieved. We appreciate the efforts of the many partners who helped to carry out the sediment cleanups, address nutrient pollution, and evaluate the status of the phytoplankton and zooplankton populations. We concur that the Degradation of Phytoplankton and Zooplankton impairment has been adequately addressed and we look forward to celebrating the removal of this BUI.

Sincerely,

David H. Biebel  
City of Sheboygan  
Director of Public Works  
David.Biebel@sheboyganwi.gov

DEPARTMENT OF  
PUBLIC WORKS

2026 NEW JERSEY AVE.  
SHEBOYGAN, WI  
53081-4790

920/459-3440  
FAX 920/459-3443



WISCONSIN

# SHEBOYGAN COUNTY

**Vernon Koch**  
*Chairman of the Board*

**Adam N. Payne**  
*County Administrator*

08/26/2021

Brennan Dow, Sheboygan River AOC Coordinator  
Wisconsin Department of Natural Resources  
1027 W St. Paul Avenue  
Milwaukee, WI 53233

Dear Mr. Dow,

Sheboygan County is pleased to support the Wisconsin Department of Natural Resources (WDNR) in the decision to remove of the Degradation of Phytoplankton and Zooplankton Beneficial Use Impairment (BUI) from the Sheboygan River Area of Concern (AOC).

The Sheboygan River AOC community partnered with many local, state and federal agencies, non-governmental organizations, business groups, community leaders, and volunteers to clean up toxic sediments and to implement many projects and programs to address nutrient inputs.

The results from the studies summarized within the BUI Removal Recommendation indicate that the targets have been achieved. We appreciate the efforts of the many partners who helped to carry out the sediment cleanups, address nutrient pollution, and evaluate the status of the phytoplankton and zooplankton populations. We concur that the Degradation of Phytoplankton and Zooplankton impairment has been adequately addressed and we look forward to celebrating the removal of this BUI.

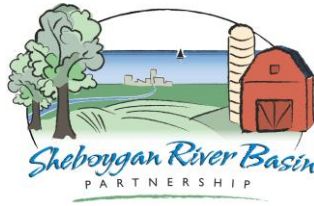
Sincerely,

Vernon Koch  
County Board Chair

Adam Payne  
County Administrator

Aaron Brault  
Planning & Conservation Director





*Improving the Health of our Rivers and Lakes*

September 2, 2021

Brennan Dow, Sheboygan River AOC Coordinator  
Wisconsin Department of Natural Resources  
1027 West St. Paul Avenue  
Milwaukee, WI 53233

Dear Mr. Dow,

Since its formation in 1998, when it was known as Sheboygan Land and Waters Partners, our organization has been devoted to improving the health of our rivers and lakes. More recently referred to as the Sheboygan River Basin Partnership (SRBP), the dedicated volunteers that make up our group continue to build partnerships and reach out to individuals in the community in order to care for our waters.

SRBP has been supportive throughout the Sheboygan River remediation and restoration project and is pleased to support the Wisconsin Department of Natural Resources (WDNR) in the decision to remove of the Degradation of Phytoplankton and Zooplankton Beneficial Use Impairment (BUI) from the Sheboygan River Area of Concern (AOC).

The results from recent studies summarized within the BUI Removal Recommendation indicate that the targets have been achieved. We appreciate the efforts of the many partners who helped to carry out the sediment cleanups, address nutrient pollution, and evaluate the status of the phytoplankton and zooplankton populations. We concur that the Degradation of Phytoplankton and Zooplankton impairment has been adequately addressed and we look forward to celebrating the removal of this BUI.

We thank everyone for their time to remove this BUI which enables us to continue to protect the waters of the Sheboygan River Basin.

Sincerely,

Jon Gumtow  
SRBP President

## **Appendix C – GovDelivery Announcement for Public Comment Period**



# Sheboygan River Area Of Concern

## Public Invited To Comment On Proposal To Remove Impairment in Sheboygan River AOC

*Comments Due Sept. 1*



*Plankton sampling with U.S. Geological Survey crew. / Photo Credit: Wisconsin DNR*

The Wisconsin Department of Natural Resources (DNR) is seeking public comments on the recommendation to remove the Degradation of Phytoplankton and Zooplankton Populations Beneficial Use Impairment from the [Sheboygan River Area of Concern](#).

After the Sheboygan River was listed as an Area of Concern (AOC) in 1987, the Remedial Action Plan identified degradation of phytoplankton and zooplankton populations as one of nine environmental problems, called Beneficial Use Impairments or BUIs, in the AOC program.

Phytoplankton are microscopic, free-floating, plant-like aquatic organisms and zooplankton are small free-floating aquatic animals. Both phytoplankton and zooplankton communities are at the base of the aquatic food web and are essential sources of food for small fish, which feed many other animals and benefit the Sheboygan River ecosystem.

The lower 14 miles of the Sheboygan River downstream from the Sheboygan Falls Dam, including the entire harbor and nearshore waters of Lake Michigan, were identified as an AOC primarily due to contamination from polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and heavy metals. These toxins were discharged directly into the river from municipal and industrial sources and settled to the river bottom, leading to many contamination-related impairments within the AOC. Excess nutrient pollution also entered the river from municipal and industrial sources and watershed runoff sources. Phytoplankton and zooplankton communities were harmed by the toxins, excessive nutrient loading, poor water quality and low dissolved oxygen.

To address the harm to these plankton communities, several sediment remediation projects were completed to remove the sources of toxic pollutants in the AOC. In addition, Sheboygan County and other local partners worked with DNR to control excessive nutrient pollution by implementing many projects that addressed agricultural runoff, wastewater discharges and stormwater runoff.

Monitoring was then conducted to confirm if pollution cleanup and plankton community recovery goals have been met. The monitoring results showed that removal targets are being met and multiple lines of evidence support a recommendation to remove this impairment from the AOC. The results of these studies, along with review from a team of technical experts, agency partners and stakeholders support this recommendation.

The removal recommendation document is available for public review and comment now until September 1, on the [Wisconsin DNR website](#).

Questions and comments can be sent to:

[Brennan Dow](#)

Sheboygan River and Milwaukee Estuary AOC Coordinator

[brennan.dow@wisconsin.gov](mailto:brennan.dow@wisconsin.gov) or 920-366-1371.

To date, three of the nine impairments have been removed in this AOC: Eutrophication or Undesirable Algae, Restrictions on Dredging Activities and

Degradation of Benthos. Once all impairments have met their targets and are removed, the Sheboygan River can be removed from the list of most polluted sites on the Great Lakes.

The Sheboygan River was designated as one of 43 sites on the Great Lakes with significant environmental damage by the United States and Canada under the Great Lakes Water Quality Agreement. Federal [Great Lakes Restoration Initiative](#) funding, first launched in 2010, helps communities clean up pollution in AOCs and restore waterways.



Wisconsin Department of Natural Resources | [dnr.wi.gov](http://dnr.wi.gov)

Call 1-888-936-7463 (TTY Access via relay - 711) from 7 a.m. - 10 p.m.



Thank you for your patience as we go through COVID-19 together. Update your subscriptions, modify your password or email address, or stop subscriptions at any time on your [Subscriber Preferences Page](#). You will need to use your email address to log in. If you have questions or problems with the subscription service, please visit [subscriberhelp.govdelivery.com](http://subscriberhelp.govdelivery.com).