Mussel Watch Great Lakes Contaminant Monitoring and Assessment: Phase 1

NOAA National Centers for Coastal Ocean Science
Center for Coastal Monitoring and Assessment

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CHASE
FREE PARKING
NELSON BROTHERS

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Executive Summary

Recovery and rehabilitation of the Great Lakes requires the availability of sound water quality data to formulate effective, science-based policies and develop appropriate management actions. The International Joint Commission has identified monitoring as a critical component in the management and protection of the nearshore zone of the Great Lakes. The NOAA National Centers for Coastal Ocean Science (NCCOS) Mussel Watch Program (MWP) is one of the few active biomonitoring programs with a basin-wide presence and a record of consistent monitoring in the nearshore zones for close to two decades. In keeping with the mission of NCCOS to support healthy and resilient coastal communities, MWP initiated monitoring the status and trends of chemical contaminants in the Great Lakes in 1992, using dreissenid mussels as sentinel organisms. Mussels are abundant in the outer harbors on breakwaters and other hard substrates throughout the Great Lakes. These stationary, filter-feeding bottom dwellers accumulate contaminants, possess limited ability to metabolize them, are representative of local conditions, and shed light on availability of contaminants to move up the food chain, thus making them an excellent tool for contamination monitoring and assessment.

Following the inception of the Great Lakes Restoration Initiative (GLRI) to address the significant environmental issues plaguing the Great Lakes region, MWP expanded its regional monitoring activities in the Great Lakes in 2009 to include all U.S. Areas of Concern (AOCs). This enhanced effort falls under the "Toxic Substances and Areas of Concern" focus area outlined in the GLRI Action Plan. The overall objective of the expanded monitoring is to assess remediation effectiveness, and provide relevant biological data to support decision making for "Beneficial Use Impairment" (BUI) removal and subsequent delisting of AOCs. The stated objective is being addressed through a phased approach utilizing a suite of mussel and sediment indicators at newly established sites within AOCs, and by leveraging the long-term monitoring data at reference sites for meaningful interpretation of AOC status and recovery.

Herein, we report the results from the first phase under GLRI, mainly mussel tissue and sediment chemistry data obtained by MWP, with the goal of providing a high-level basin-wide perspective on the relative magnitude and extent of contamination in AOCs. This was achieved by comparing:

1) tissue chemistry from AOCs to reference sites;
2) sediment chemistry from AOCs to both MWP Great Lakes reference sites and coastal marine sites distributed nationwide and;
3) sediment chemistry to relevant thresholds.

Due to the availability of dreissenid mussels on and near breakwaters, this baseline assessment focused on river mouths of AOCs, and provides the foundation upon which subsequent intensive (spatially and temporally) AOC assessments will be carried out. Through numerous partnerships, MWP has begun to incorporate innovative techniques and methods in select AOCs. The results from these intensive sampling efforts will be the focus of subsequent reports. This first report sheds light on the bioavailability of select contaminants from a proven bioindicator and demonstrates the value of long-term monitoring programs in making informed coastal ecosystem management decisions.

Thank you,

The Great Lakes Mussel Watch Team

Project Overview

- With Great Lakes Restoration Initiative funds, NOAA Mussel Watch expanded monitoring activities into all U.S. Areas of Concern (AOCs) and added additional analyses to address Beneficial Use Impairment (BUI) target goals and effectiveness of AOC restoration efforts.
- All U.S. AOCs were sampled for mussel tissue and/or sediment as part of the Phase 1 Great Lakes baseline study.
- Historic Mussel Watch sites, primarily located in shallow (<20 ft) nearshore lake water, were used as reference sites for comparison with AOCs.
- National sediment sites were used to bring perspective to Great Lakes sediment concentrations.
- Mussel contaminant concentrations provided an assessment of bioavailable contamination inside and outside AOC boundaries.

The Great Lakes constitute the largest freshwater system in the world, containing more than 90% of the nation's, and 20% of the world's freshwater supply. The Great Lakes basin is home to over 35 million people and supports numerous economic activities including agriculture, industries, commercial and sport fisheries, tourism, and recreation. Exploitation of the Great Lakes has resulted in multiple environmental challenges and has negatively impacted many beneficial uses of this globally treasured natural resource.

In 2009, the Great Lakes Restoration Initiative (GLRI) was signed into law to restore and rehabilitate the designated areas in the Great Lakes. This initiative is guided by an action plan created by a task force of 11 federal agencies (GLRI Action Plan, 2010) and identifies five focus areas:

1. Toxic substances and Areas of Concern;
2. Invasive species;
3. Nearshore health and nonpoint source pollution;
4. Habitat and wildlife protection and restoration; and
5. Accountability, education, monitoring, evaluation, communication and partnerships.

While considerable progress has been made in improving the condition of the Great Lakes through environmental legislation and the Great Lakes Water Quality Agreement between the United States and Canada (GLWQA, 2012), pollutant loadings from point and non-point sources, and legacy contaminants in sediment continue to impair the Great Lakes ecosystem. This report focuses on the legacy contamination in U.S. AOCs, which are defined in the GLWQA as "a geographic area designated by the Parties where significant impairment of beneficial uses has occurred as a results of human activities at the local level." There are 31 AOCs on the U.S. side (5 of those shared with Canada) with one or more Beneficial Use Impairments (Table 1; Figure 1). BUIs have to be removed for the AOCs to be delisted. AOC specific BUIs are too numerous to list here but can be found online at http://www.epa.gov/glnpo/aoc/.

The National Oceanic and Atmospheric Administration (NOAA) Mussel Watch Program (MWP) administered by the National Centers for Coastal Ocean Science (NCCOS) has used dreissenid mussels to monitor contaminants in the nearshore zones of the Great Lakes since 1992. This contaminant monitoring effort in the Great Lakes is part of a larger contaminant monitoring program that began in 1986 and currently includes more than 300 sites nationwide (Figure 2). In the Great Lakes, MWP established 7 sites in the inaugural year and more sites were added in the initial years after the invasion and proliferation of Ponto-Caspian mussels *Dreissena polymorpha* and *Dreissena rostriformis bugensis* (zebra and quagga mussels, respectively) that became established in the region in the late 1980s (Carlton 2008; Mills et al., 1993; Robertson and Lauenstein, 1998). The abundance and widespread distribution of dreissenid mussels in the nearshore areas of the Great Lakes (except Lake Superior) renders them ideal candidates for routine contaminant monitoring.

Dreissenid mussels are widely used as bioindicators in Europe and their native Ponto-Caspian region, because of their high filtering rates, high lipid content and the ability to bioaccumulate contaminants from water, algae and suspended sediments (de Kock and Bowmer 1993; Bervoets et al., 2005; Berny et al., 2003; Gossiaux et al., 1998; Reeders and bij de Vaate 1992). Other favorable characteristics of dressenids as biomonitors include ease of collection, abundance, sessile life cycle, limited ability to metabolize lipophilic contaminants, and utility in effects-based monitoring. In addition, the recognition of dressenid mussels as keystone species of the Great Lakes ecosystem (Vanderploeg et al., 2002),reinforces its critical value in the assessment of the overall health and ecological forecasting of the Great Lakes.

Table 1. There were 31 U.S. Areas of Concern (AOCs) in the U.S. Great Lakes suffering 1 or more of 14 Beneficial Use Impairments (BUIs) listed. MWP provides data and information to potentially support the decision making to remove select BUIs.

Restrictions on fish & wildlife consumption	Eutrophication or undesirable algae
Tainting of fish and wildlife flavor	Restrictions on drinking water
Degradation of fish & wildlife populations	Beach closings
Fish tumors or other deformities	Degradation of aesthetics
Bird or animal deformities or reproduction problems	Added costs to agriculture or industry
Degradation of benthos	Degradation of phytoplankton & zooplankton populations
Restrictions on dredging activities	Loss of fish & wildlife habitat

Project Approach for Phase 1: Basin-Wide Baseline Assessment

- Established sites in all U.S. AOCs, and assessed contaminants in mussels and sediments in these new sites;
- Leveraged data, information, and knowledge from long-term Mussel Watch sites in Great Lakes (1992-present) and nation (1986-2009) and evaluated the extent and magnitude of pollution in AOCs relative to long-term Mussel Watch monitoring sites (i.e. reference sites).
- Determined baseline chemical contaminant levels at AOCs and reference sites, to compare regional, lake-wide, and local progress toward AOC chemical reduction targets.

Currently, there are 25 long-term Mussel Watch sites in the Great Lakes from Duluth, MN on Lake Superior at the mouth of the St. Louis River to Cape Vincent, NY where Lake Ontario flows into the St. Lawrence River. The majority of these sites were established away from known impacted areas, following the overall program directive to measure contamination at sites that represent ambient concentrations. These long-term monitoring sites thus served as reference sites for contamination assessment in highly impacted areas (e.g., AOCs) in the Great Lakes.

Aligning with the focus of GLRI, MWP expanded its monitoring activities in the region to include all U.S. AOCs (Figure 1). The overall objective of the expanded monitoring was to provide relevant biomonitoring data to potentially support decision making for BUI removal and subsequent delisting of U.S. AOCs. The stated objective is being addressed through a two phase approach utilizing mussel and sediment indicators. Phase 1 effort, the basin-wide assessment of mussels and sediment at newly established sites within U.S. AOCs and long-term Mussel Watch sites (i.e. reference sites) is presented in this report. Phase 2 has two ongoing parts consisting of intensive mussel sampling in select U.S. AOCs (where remediation is imminent or has already occurred) for improved spatial coverage, and probabilistic ecosystem assessments to characterize sediment quality in select AOCs. As part of the Phase 2 intensive mussel sampling initiative, newer biomonitoring approaches including the use of caged mussels for contaminant source tracking and effects-based monitoring to assess mussel health have been incorporated.

In this report, we summarize contaminant chemistry data in mussels and sediment for the Phase 1 basin-wide assessment and leverage two decades of historic Mussel Watch Program data from the Great Lakes and the Nation (Figure 2) for comparison.

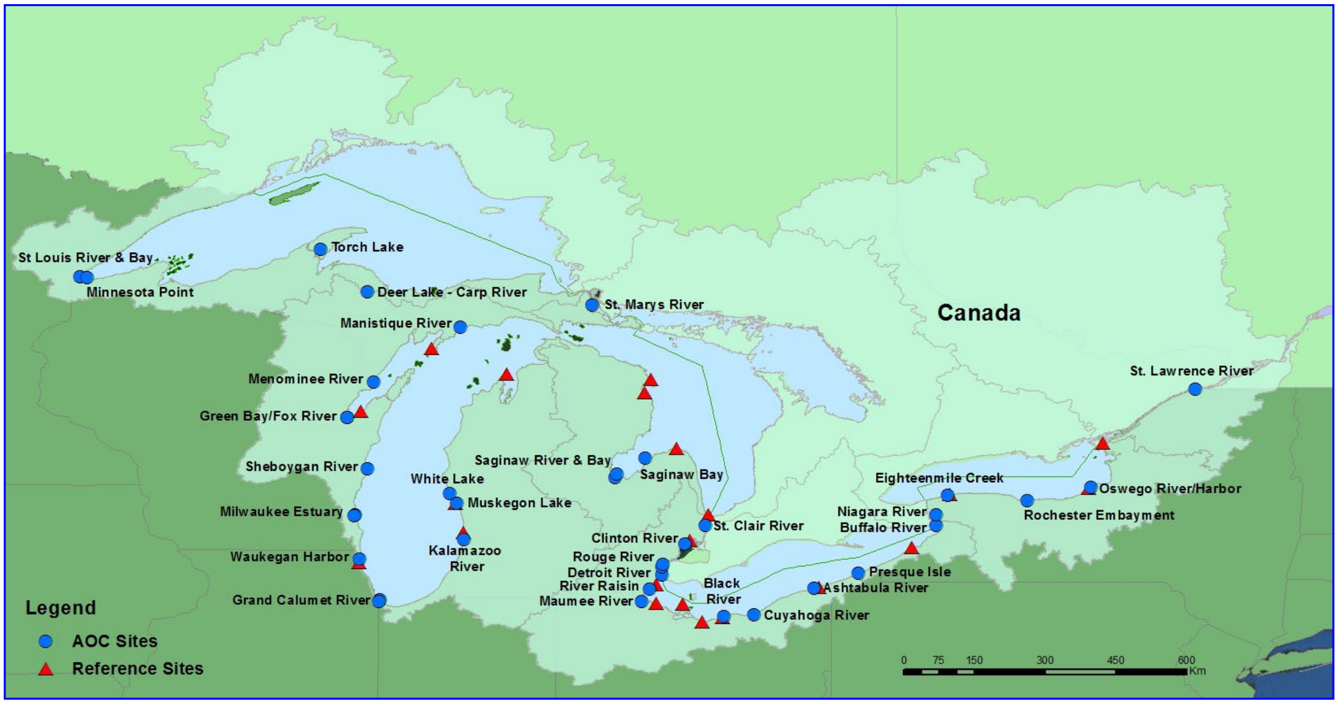


Figure 1. Mussel Watch Great Lakes baseline assessment U.S. AOC sites (labeled).

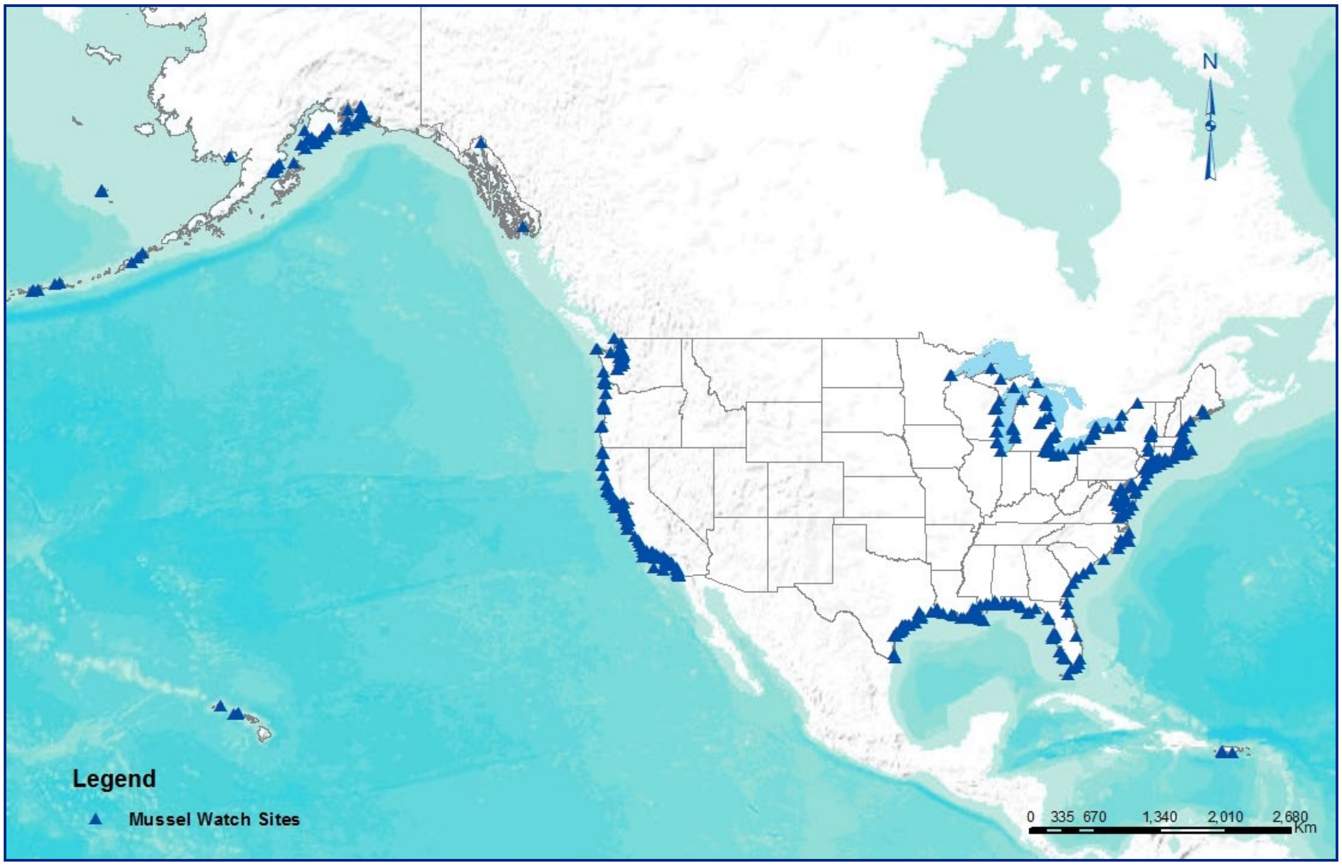


Figure 2. National Mussel Watch sites.

The basin-wide baseline data presented here can be used by stakeholders and resource managers for AOC remediation effectiveness assessment and as an additional biological line of evidence to support BUI removal. Specifically, mussel tissue concentrations could potentially be used to set target chemical reduction goals for remediation purposes as these mussels are robust indicators of biovailable contamination. Further, mussels serve as a potential additional line of evidence to support decision making with respect to "Restriction on fish and wildlife consumption" BUI. Unlike fish, which move in and out of AOC boundaries, mussels bioaccumulate and integrate contaminant exposure at the specific location where they are found in an AOC. More importantly, mussels have limited ability in metabolizing xenobiotics, including PAHs and PCBs, compared to fish (Farrington, 1983).

The role of dreissenid mussels in contaminant cycling and biomagnification of pollutants (indirectly via deposition of feces and psuedofeces, and directly via predation in the food chain) in the Great Lakes is well documented (Bruner et al., 1994a, b; Morrison et al., 1998; Marvin et al., 2000; Cho et al., 2004). Monitoring contaminants in dreissenids can thus not only reflect ambient contamination levels, but can also further our understanding of trophic transfer and biomagnification.

Recently, the International Joint Commission (IJC 2011) emphasized the need for a greater understanding of nearshore zone processes and management, subsequent offshore effects, and the health of the lakes as a whole. To these ends, monitoring of chemical, biological, and toxicological indicators in dreissenid mussels provides a means to further assess temporal trends, biological uptake, and ultimate fate of many contaminants.

Current & Future Work

Our baseline monitoring effort in 2009/2010 was in essence an expansion of the fixed sampling design of traditional Mussel Watch and provides a synoptic view of the relative magnitude and extent of contamination in the harbor areas of AOCs and reference sites. In order to better address contamination and remediation issues of specific AOCs, Mussel Watch has adopted multi-parameter assessments and incorporated newer techniques and approaches to the existing methods. For mussels, we have intensified sampling, both spatially and temporally, in select AOCs (e.g., Sheboygan River AOC; Figure 3) to provide a more robust measure of bioavailable contamination, have utilized deployment of caged mussels to source track contaminants in areas where extant mussels beds are not found (Figure 4), and have incorporated effects-based monitoring to complement body burden

Figure 3. Densification of mussel and sediment samples temporally and spatially.

measurements. For the sediment matrix, probabilistic sediment quality assessment was carried out to report on sediment chemistry, benthos and sediment toxicity, which could directly address Degradation of Benthos BUI. These focused efforts in select AOCs have been implemented through successful partnerships and collaborations with the local, state and federal entities. The results from these ongoing and future work will be the focus of subsequent reports.

Figure 4. Caged mussels, passive samplers and Hester Dendys being retrieved after deployment for 6 weeks in Manistique River AOC.

Methods

- Mussel Watch sampled sites in all U.S. AOCs under GLRI.
- In the eastern Great Lakes (downstream from Detroit), one mussel station (when available) and one sediment station were established per site in 2009.
- In the western Great Lakes, additional resources allowed establishment of one mussel station (when available) and up to three sediment stations per site in 2010.

Mussel Watch sampled sites in 31 U.S. AOCs as part of the basin-wide baseline assessment under GLRI (Figure 1) in 2009 and 2010. All mussel sites were established at river mouths or outer harbor areas where stone breakwaters provided a colonizing substrate for dreissenid mussels. When available, one mussel station and one sediment station per site were collected from each site in the eastern Great Lakes (downstream from Detroit) in 2009. In the western Great Lakes, one mussel station and up to three sediment stations were collected per site in 2010. The Grand Calumet River and St. Louis River AOC are the exception, each had 2 baseline mussel sites. One composite sample comprising 50-100 mussels was sampled from each sation. Only sediment samples were collected at Torch Lake, Carp River, St. Marys River, Kalamazoo River and Rouge River.

Contaminant monitoring of mussels and sediment in the Great Lakes by MWP began in 1992. Prior to GLRI, MWP was monitoring 25 sites routinely in the Great Lakes. Data from long-term MWP sites that were located in AOCs (Milwaukee Estuary, Niagara River, Rochester Embayment, Saginaw River and Bay, and Grand Calumet River) were included in AOC results throughout this document. Long-term MWP sites located outside of AOCs were used as reference sites and were compared to AOCs (Figure 5). The reference sites were located within watersheds that represented a variety of land uses and occured within the shallow, nearshore zones (< 20 ft).

Within a MWP site, sediment stations were co-located with mussel stations. Some sites did not have fine-grained (percent silt-clay) sediments and hence sediment sites were relocated nearby, consistent with procedures of the National Coastal Assessment Quality Assurance Project Plan 2001-2004 (US EPA 2001). Sites were sampled on a biennial basis; Lakes Ontario and Erie sites were sampled in odd years, and Lakes Huron, Superior and Michigan sites in even years.

Sample Collection

Mussels were collected from natural substrates by diving or dredging. Upon collection, mussels were rinsed with site water to remove debris, placed in freezer bags, packed on water ice and shipped to laboratories within two days. Samples for sediment chemistry, toxicity, and the benthic community analyses were collected concurrently with a Young-modified, van Veen grab sampler (0.04 m^2) deployed from a small boat. Protocols for sample collection, preparation and analysis are found in the Quality Assurance Project Plan and in Lauenstein and Cantillo (1998 and references therein), Kimbrough and Lauenstein (2006), Kimbrough et al., (2006), and available online at http://coastalscience.noaa.gov/projects/detail?key=179

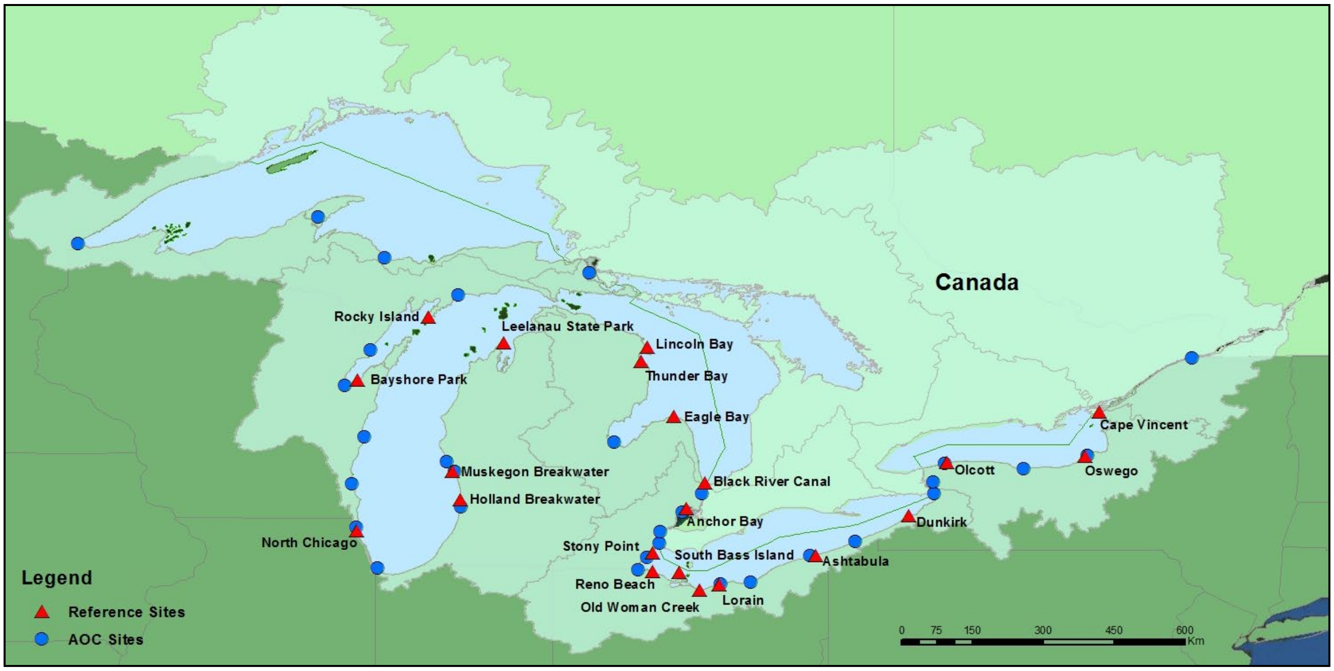


Figure 5. Mussel Watch reference sites (labeled).

Table 2. Contaminants summarized as part of the Expanded Great Lakes MWP. The complete list of contaminants and associated method detection limits can be downloaded at http://coastalscience.noaa.gov/projects/detail?key=179

Compound class	Compound
Trace elements	Arsenic, cadmium, copper, lead, methyl mercury, mercury, zinc
Chlordane	Alpha-chlordane
Chlorpyrifos	Chlorpyrifos
Dichlorodiphenyltrichloroethane and metabolites (DDT)	2,4'-DDD; 2,4'-DDE; 2,4'-DDT; 4,4'-DDD; 4,4'-DDE; 4,4'-DDT
Heptachlor	Heptachlor
Hexachlorobenzene	Hexachlorobenzene
Mirex	Mirex
Polycyclic aromatic hydrocarbons (PAHs)	Benzo[a]pyrene, benzo[e]pyrene
Polychlorinated biphenyls (PCBs)	PCB8/5, PCB18, PCB28, PCB 29, PCB31, PCB44, PCB45, PCB49, PCB52, PCB56, PCB66, PCB70, PCB74, PCB87, PCB95, PCB99, PCB101/90, PCB105, PCB110, PCB118, PCB128, PCB138, PCB146, PCB149, PCB151, PCB153/132/168, PCB156, PCB158, PCB170/190, PCB174, PCB180, PCB183, PCB187, PCB194, PCB195/208, PCB199, PCB201, PCB206, PCB209

Contaminants

The recently established AOC sites together with long-term MWP reference sites provide relevant data to aid in the cleanup and subsequent delisting of AOCs. All sites were monitored for a wide array of contaminants, including trace elements and legacy organic contaminants. For the purpose of this report, only select and relevant analytes are presented (Table 2); however, data for additional analytes can be downloaded (http://coastalscience.noaa.gov/projects/detail?key=179). Ancillary measurements for mussels and sediment were also recorded. For mussels, these consisted of gonadal index, wet weight, dry weight, percent lipid, and shell length and volume. For sediment, these consisted of grain size (percent sand, silt and clay) and total organic carbon.

Data Quality

The Mussel Watch Program used a performance based quality assurance process to ensure data quality. This effort has been in operation since 1985 and is designed to document sampling protocols, analytical procedures and laboratory performance. Analytical laboratories used by the Mussel Watch Program are required to participate in exercises with assistance from the National Institute of Standards and Technology (NIST) and the National Research Council of Canada (NRC) to ensure data are comparable in accuracy and precision (Willie, 2000; Schantz et al., 2000).

Statistical Analysis

Tissue and sediment contaminant concentrations from all the AOC and reference sites were assigned to a concentration range (high, medium and low) using hierarchical Wards cluster analysis. This analysis allowed clustering of contaminant concentrations into groups such that the numbers contained within a group are more like each other than any other number in a different group. Results in the low, medium and high categories did not represent measurements that have exceeded regulatory thresholds; rather, it denoted that they are significantly higher than the preceding category ($p < 0.05$; Wilcoxon). The high, medium and low categories are not associated with human health or ecosystem health endpoints. In cases where the concentration measurements could not be grouped into a category of at least 3, the measurements were labeled as outliers, and removed to perform the analysis again.

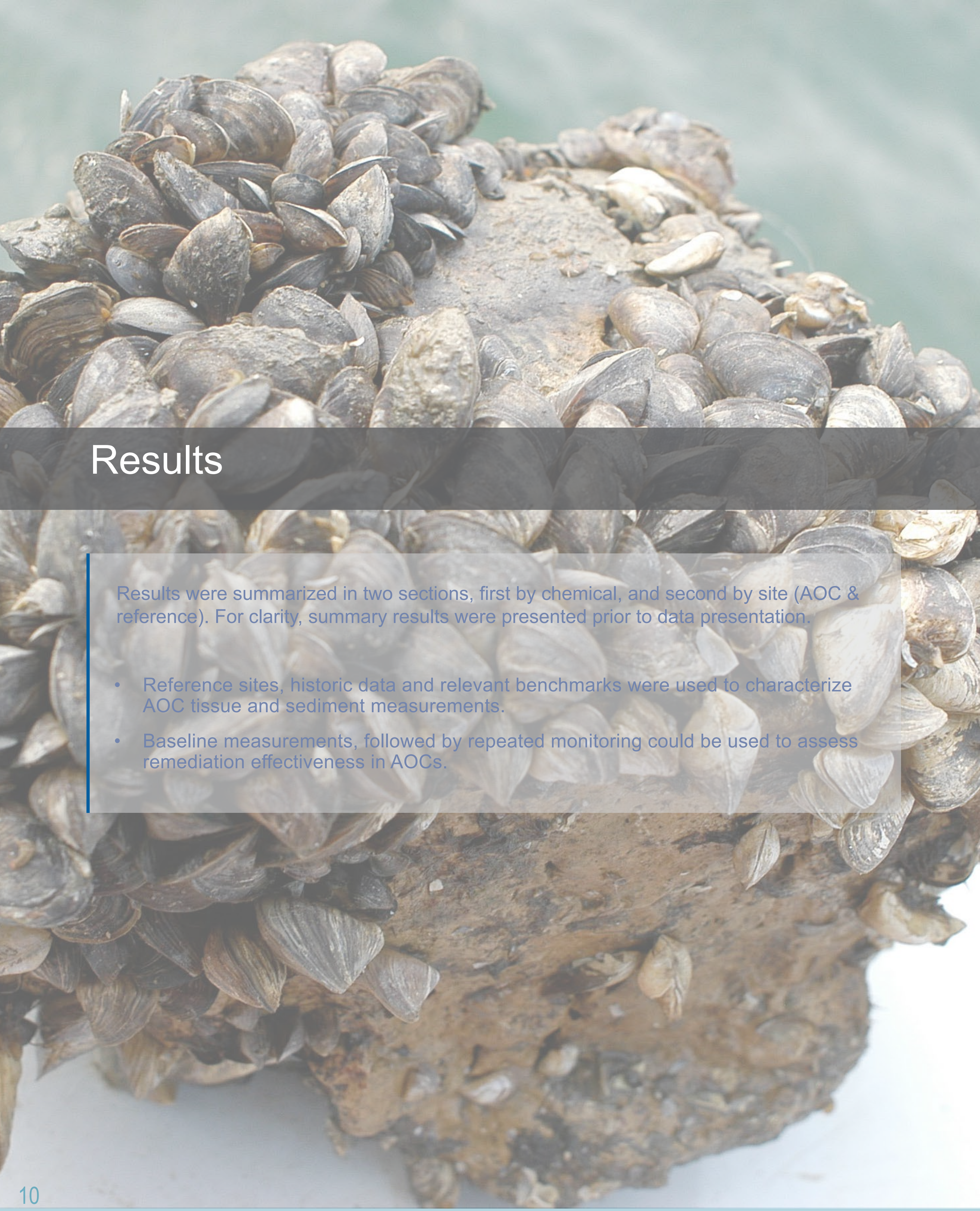
The Shapiro-Wilks test was used to test for normality. None of the analytes tested had a normal distribution so non-parametric statistics were used. The non-parametric Kruskal Wallis test was used to test for significant differences in contaminant concentrations among AOCs and reference sites, and between national and Great Lakes (inclusive of AOC and reference) sites. Data summaries (descriptive statistics) for selected chemicals measured in mussel tissue and sediment are provided categorically by chemical and by site. Descriptive statistics are organized by site type (AOC and reference site), and by matrix (mussel and sediment). Sediment results for the Great Lakes are compared to the latest national MWP survey (2006/2007). Concentration of contaminants in *dreissenid* mussel tissue from the Great Lakes were not compared to concentrations found in mussels/ bivalves from other regions because of contaminant uptake and bioaccumulation differences among species.

Benchmarks and Background

Resource managers rely on chemical-specific, numerically based benchmarks to guide their actions to ensure protection of the environment and/or human health. This report uses the term "benchmark" to describe any published chemical concentration or concentration range reported in sediment (e.g.,"criteria," "standard," guideline," value," indicator," "alert or action level," "tolerance level," "threshold level").

Sediment benchmarks commonly reported in the literature as sediment quality guidelines (SQGs) rely on empirical or theoretically based approaches that are predictive of toxicity and bioaccumulation. For this report, we used freshwater sediment quality guidelines reported by MacDonald et al., (2000), their consensus-based numbers, Probable Effects Concentration (PEC), and Threshold Effects Concentration (TEC). The PECs are SQGs for individual chemicals above which adverse effects in sediments are expected to frequently occur, whereas TECs were developed to provide an estimate of conditions where toxicity would not be expected. If no SQG was reported by MacDonald et al., (2000), NOAA SQuiRTs (Screen Quick Reference Tables) were consulted, followed by the Canadian Environmental Quality Guidelines.

Benchmarks for biota, including shellfish, are scarce. The FDA provides "action levels" and "tolerance levels" for fish and shellfish for a few chemicals but these are intended for regulating food safety and commerce. The EPA provides "screening levels" for management decisions to issue fish consumption advisories, but these are of limited value for assessing mussel contaminant levels. In this study, we have not attempted to compare dreissenid mussel tissue concentration to any existing thresholds for other bivalve tissue. Instead, the mussels tissue concentrations in U.S. AOCs were interpreted by leveraging data from reference sites.



Results

Results were summarized in two sections, first by chemical, and second by site (AOC & reference). For clarity, summary results were presented prior to data presentation.

- Reference sites, historic data and relevant benchmarks were used to characterize AOC tissue and sediment measurements.
- Baseline measurements, followed by repeated monitoring could be used to assess remediation effectiveness in AOCs.

Major results and discussion, based on statistical comparisons of AOCs, references sites, and coastal marine sites, are presented in the ensuing paragraphs. Graphical summarization of results by analyte and by site appear in the Analyte and Site Characterization sections respectively.

AOC vs. Reference Sites

Data analyses indicated that greater than 50 percent of all tissue and sediment measurements (AOC and reference sites) were categorized as low, and greater than 85 percent of all measurements were categorized as low or medium (Figure 6). Conversely, high and outlier sites together represented 5-15 percent of all sediment and tissue measurements (Figure 6). The difference between AOC and reference sites was primarily found in the percentage of each that comprise the elevated measurements found in the high and outlier categories. For trace elements and organics in sediment, and organics in tissue, a higher proportion of high and outlier measurements were found at AOC sites (Figure 6). In contrast, the percentage of outlier and high measurements were almost equal for trace elements in mussel tissue in AOC and reference sites.

For tissue, no significant difference was found between AOC and reference sites for trace elements examined except for cadmium. Cadmium concentrations in mussels from reference sites were higher than those from AOC sites (Kruskal Wallis; $p < 0.05$; Figure 7). Four of the nine organic analytes (DDT, Benzo[a] pyrene, Benzo[e]pyrene and PCB) measured in dreissenid tissue were significantly higher at AOCs when compared to reference sites (Kruskal Wallis; $p < 0.05$; Figure 7). The lack of significance among other analytes may be due to the fact that majority of sites (both AOC and reference sites) have concentrations that fall in the low and medium categories.

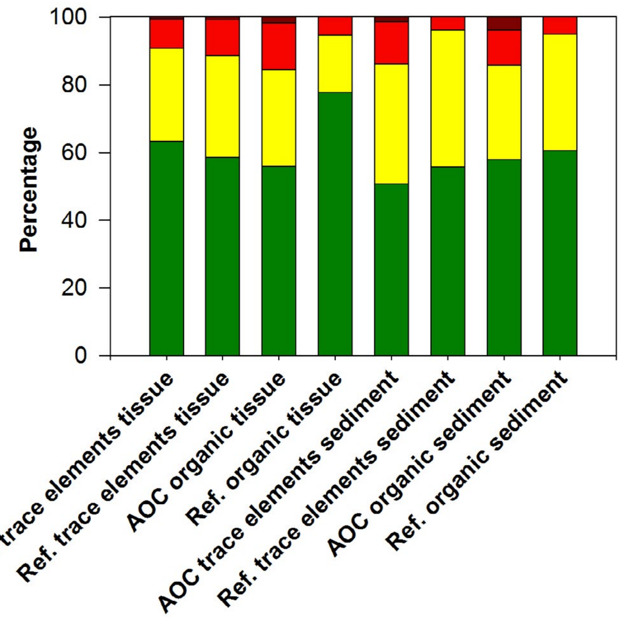


Figure 6. Percentage of low (green), medium (yellow), high (red), and outliers (maroon) categories for metals and organics in AOCs and reference sites (Ref.) for both tissue and sediment matrices.

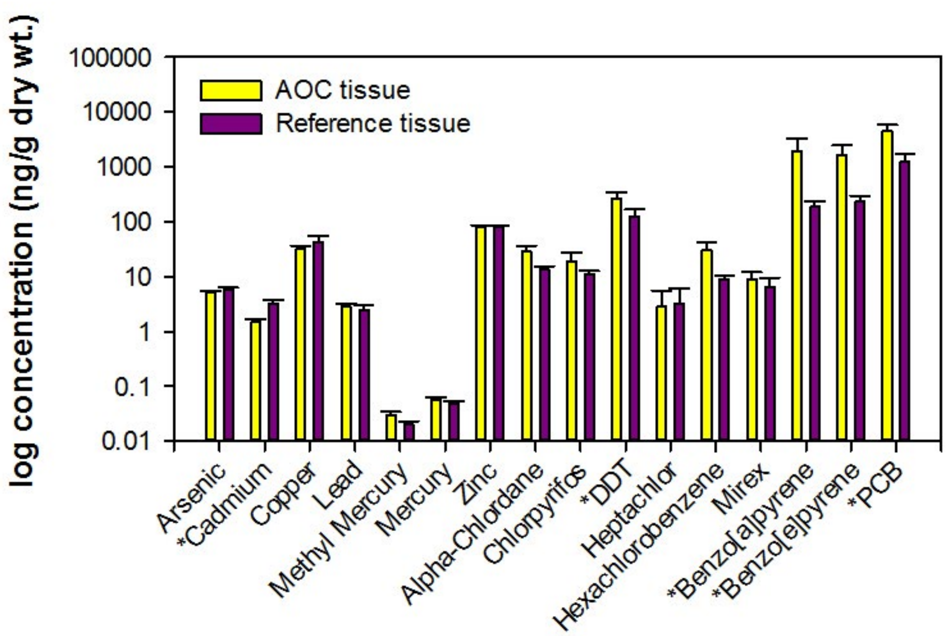


Figure 7. Comparison of AOC and reference sites tissue measurement means with standard error bars. Asterisk represent analytes with significant differences. Organic compounds are lipid normalized.

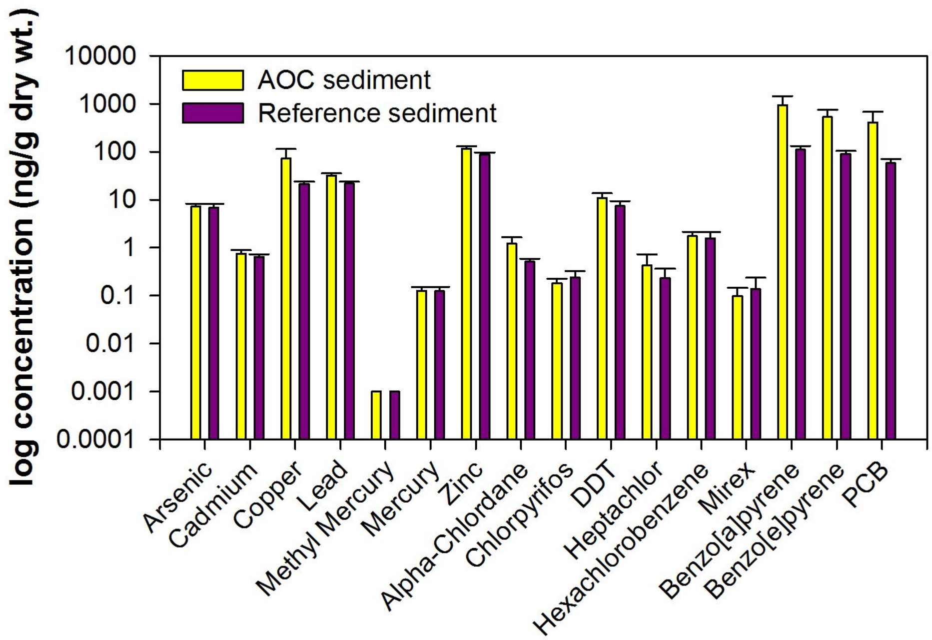


Figure 8. Comparison of AOC and reference sites concentration means with associated standard error bars.

For sediment, there were no significant differences found between AOCs and reference sites for organics or trace elements (Kruskal Wallis; $p > 0.05$; Figure 8).

Great Lakes vs. National Sediment Sites

The sediment concentrations for all analytes from Great Lakes were higher than the concentrations from the rest of the MWP sites in the nation (Kruskal Wallis; $p < 0.05$; Figure 9). All of the trace elements and organic contaminants examined were higher in the Great Lakes with respect to the nation as a whole irrespective of inclusion of AOCs in the analysis (Figure 9), that is, even Great Lakes reference sites were higher.

MWP's national sediment measurements are obtained from small embayments, estuaries, and open coast sites, many of which have higher flushing/turnover rates when compared to the Great Lakes. Conversely, the residence time of some of the persistent pollutants in the Great Lakes is higher, which may partly explain the difference between national and Great Lakes sediment measurements.

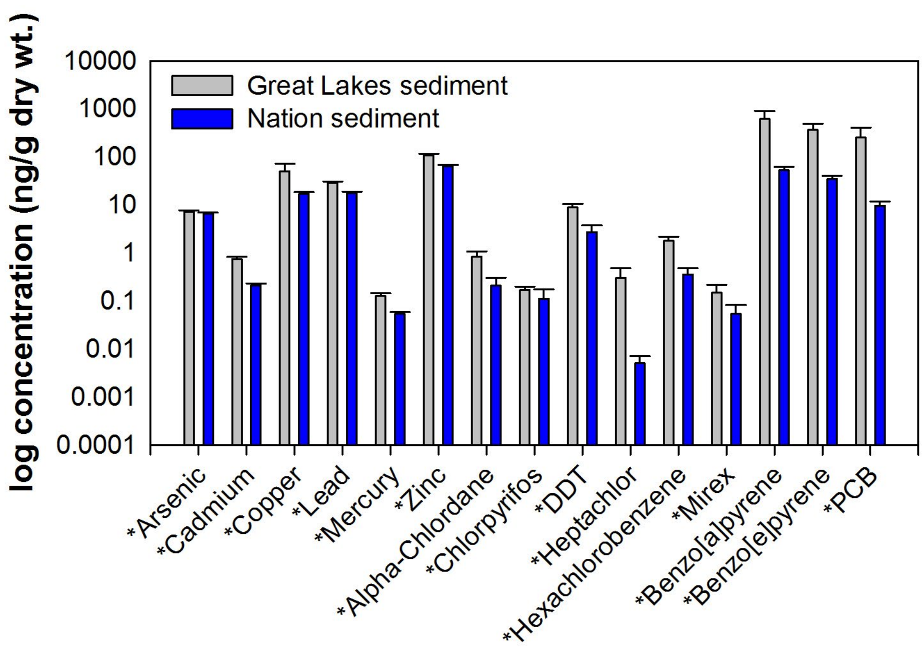


Figure 9. Comparison of Great Lakes (AOCs and reference sites) and national sediment concentration means with associated standard error bars. Asterisk represent analytes with significant differences.

Comparison Among AOCs
To identify the relative magnitude and extent of contamination in the outer harbor areas among AOCs, heat maps were generated for both tissue and sediment, which show the heirarchical Ward's cluster analysis categories (outlier, high, medium and low). These heat maps summarize the data in maps and associated figures in Section 2 & 3, and clearly show the utility of using one unique matrix for characterizing sites as well as dentifying sites with elevated concentrations that require further investigation. However, unlike abiotic measurements, mussels integrate the contaminant signal over long periods of time allowing for a time-integrated indication of environmental contamination. More importantly, contaminant tissue burden in mussels that reside at the base of the food chain reflect contaminant bioavailability and bioaccumulation potential, and thus provide information about environmental contamination and effects that cannot be defined by abiotic matrices. Therefore, having mussel tissue data from AOC sites across the basin provide biologically relevant data that can be used in making informed management decisions.

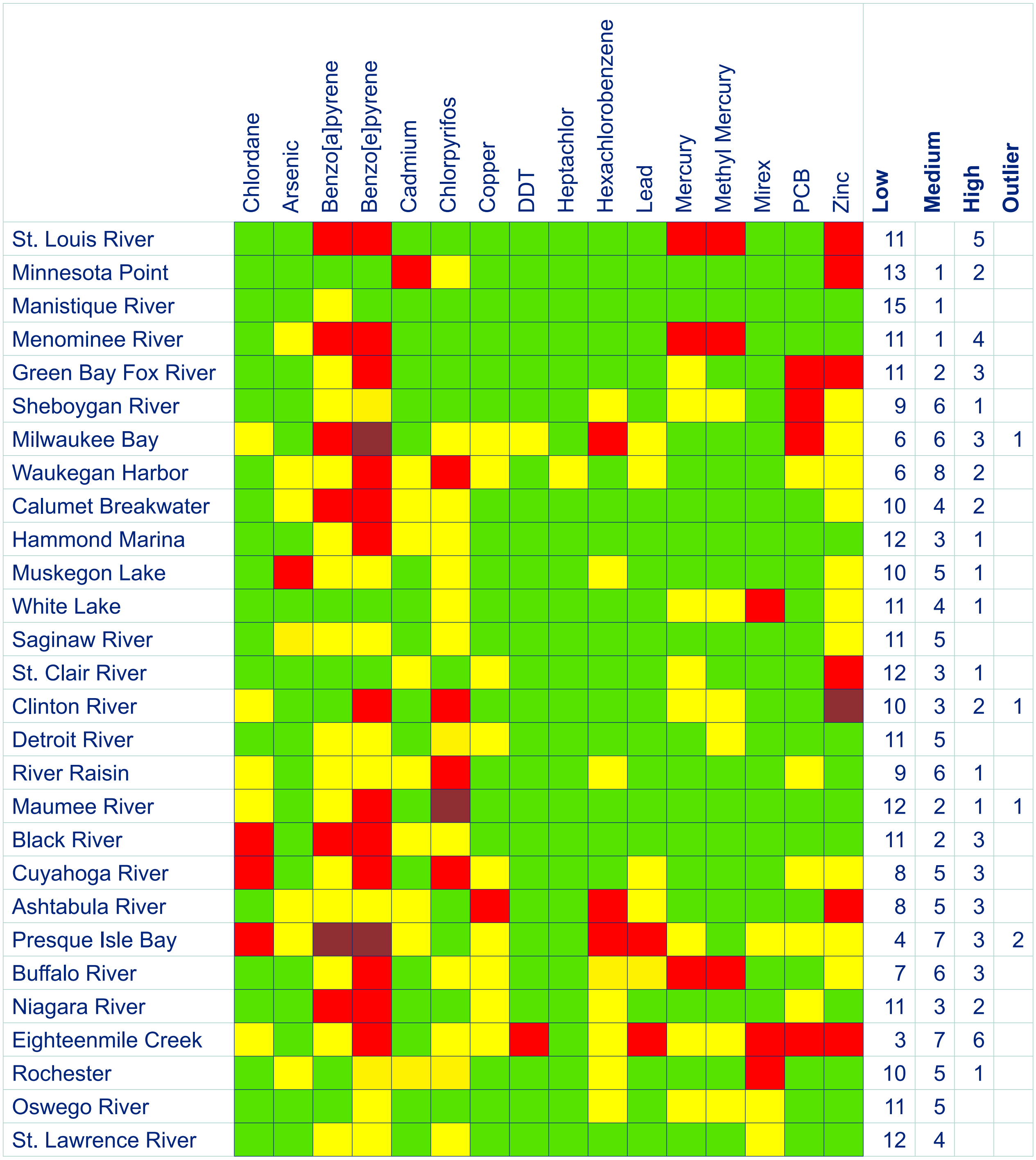
Readers should be mindful that these results are not representative of the entire AOC and that low concentrations in the harbor area (where the majority of the sites are located) do not imply that the entire AOC is free of contamination. However, this baseline assessment effort helps identify the contaminant concentration in the harbor, which can serve as a chemical reduction target goal for remediation purposes. To provide enhanced characterization of AOCs, intensive sampling is required, and has begun at some prioirity AOCs.

Benchmarks
Specific benchmarks and threshold concentrations were not found for dreissenid mussels. As such, mussel tissue concentrations from AOCs were compared to concentrations obtained from reference sites. In contrast, for sediment, consensus based TEC and PEC sediment quality guidelines (MacDonald et al., 2000) was used to compare concentrations from AOCs and reference sites. For several chemicals (DDT, PCBs, benzo(a)pyrene), the mean reference site concentration exceeded or was only slightly below the reported TEC. Other chemicals with TEC exceedances at many sites included arsenic, cadmium, copper, lead, total mercury, zinc, chlordane (as alpha chlordane), DDT, and heptachlor epoxide (as heptachlor).

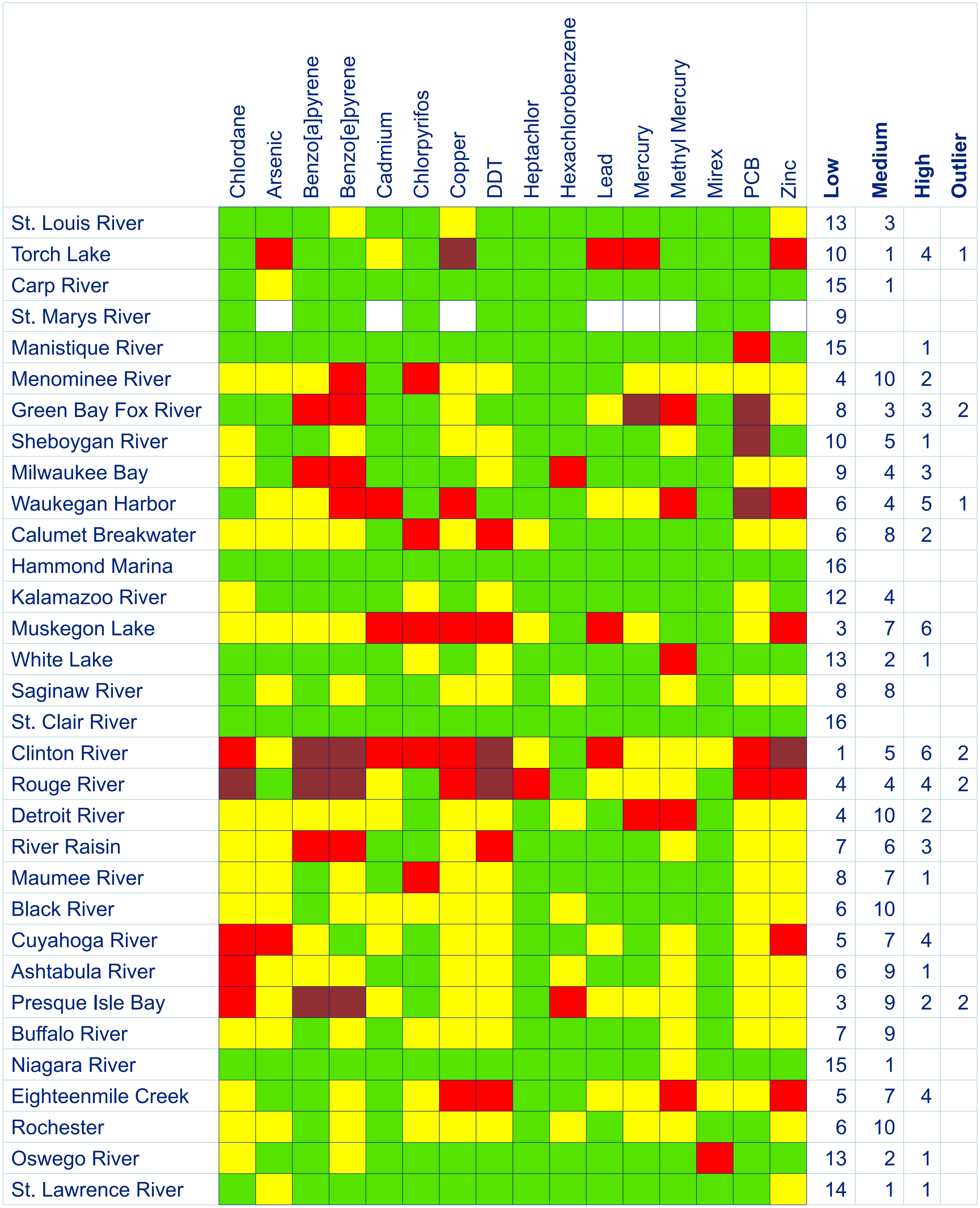
Interpretation of Chemical Data
Trace elements are naturally occurring but can have anthropogenic sources as well. Distinguishing the sources of elevated concentrations is beyond the scope of MWP, however, our monitoring data can identify sites with elevated concentrations where further investigation is required.

The organic compound results have two primary patterns of distributions. The first distribution is characterized by the majority of the sites being at or near detection limits with a few sites exhibiting measurements that are elevated, (chlordane, chlorpyrifos, heptachlor, hexachlorobenzene, Mirex); essentially a presence and absence distribution. The second group of organic compounds are more ubiquitous and thus have a "background level" arising from its chemical persistence and also have several outlier measurements that are orders of magnitude higher than the "background" measurements (Benzo [a]pyrene, Benzo[e]pyrene, DDT, and PCB). This second group of organic contaminants approaches a skewed distribution that is similar to the trace element distribution (Site Characterization Section).

Most regulatory controls of chlorinated organics went into effect in the 1970s and 1980s, prior to the initiation of mussel monitoring in the Great Lakes. The tissue trend map for reference sites (Analyte Characterization Section-Page 16) shows historic site measurements for a subset of MWP long-term data. The box and whisker plots for organic contaminants from reference sites show no significant difference between years since 2001 across the entire basin, and is supported by the bar charts in the adjacent map. These results suggest that decreasing organic contaminant trends have reached asymptotic levels and further reductions in these levels by natural means alone will likely take decades.



Tissue heat map. Figure showing outlier (★), high (●), medium (●), and low (●) AOC tissue measurements for all trace elements, and organic contaminants discussed in this report.



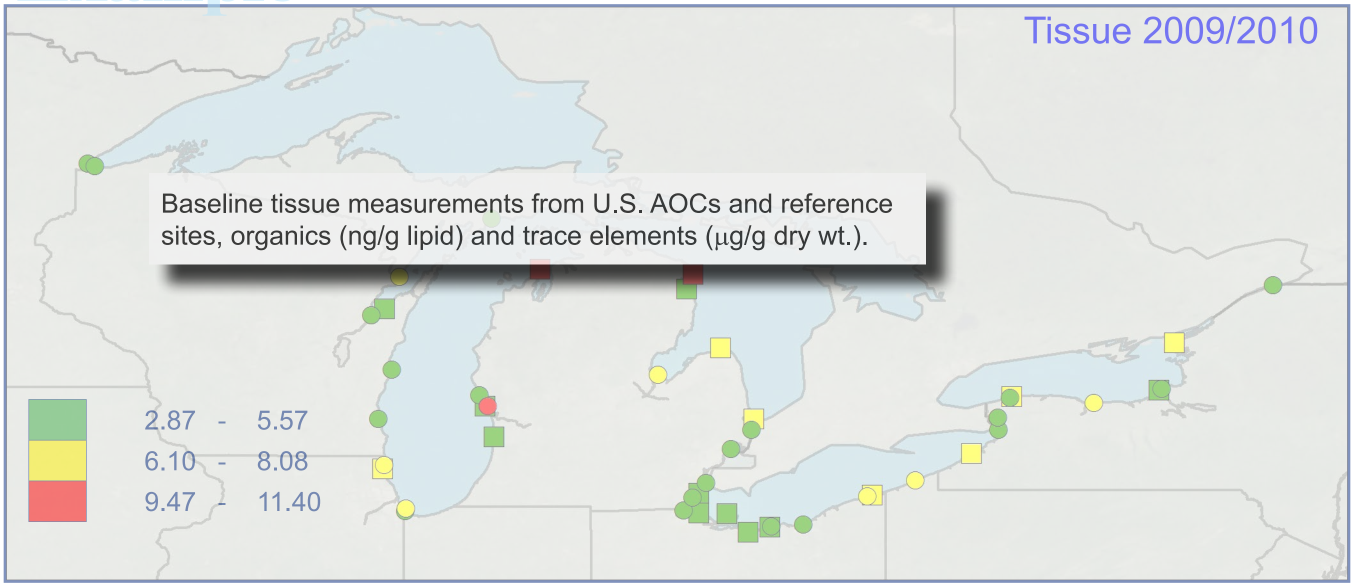
Sediment heat map. Figure showing outlier (★), high (●), medium (●), and low (●) AOC sediment measurements for all trace elements and organic contaminants discussed in this report. Boxes are white when no data is available.

Analyte Characterization

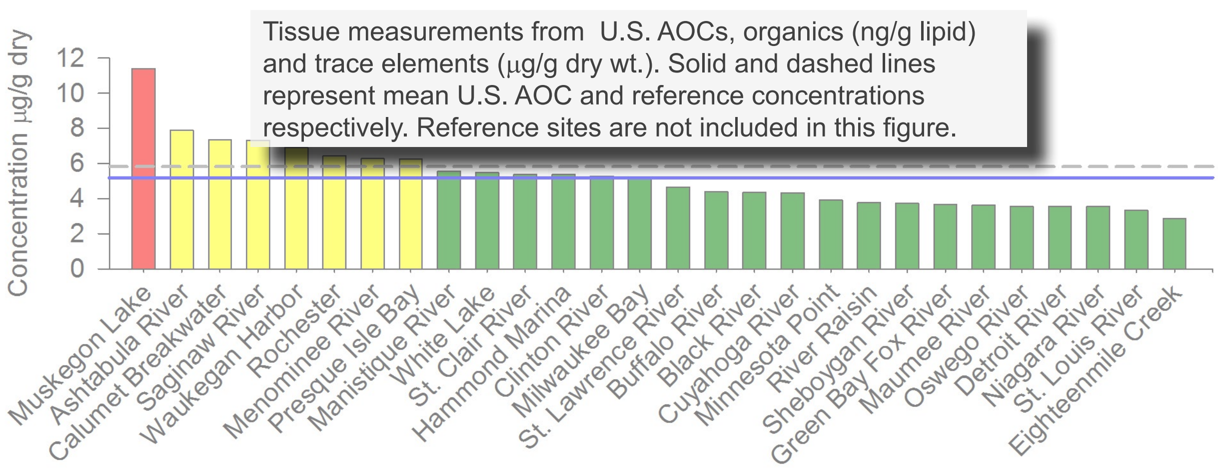
- Great Lakes sediment (U.S. AOC & reference) measurements were found to be significantly higher than national measurements.
- Significant differences between U.S. AOC and reference site tissue measurements were primarily limited to organic contaminants.
- When compared to national and reference site measurements, U.S. AOCs registered a disproportionate number of outlier and high measurements for organic contaminants but not for trace elements.
- Sediment measurements for U.S. AOCs were not significantly different from reference sites sediment measurements.


YAMAHA

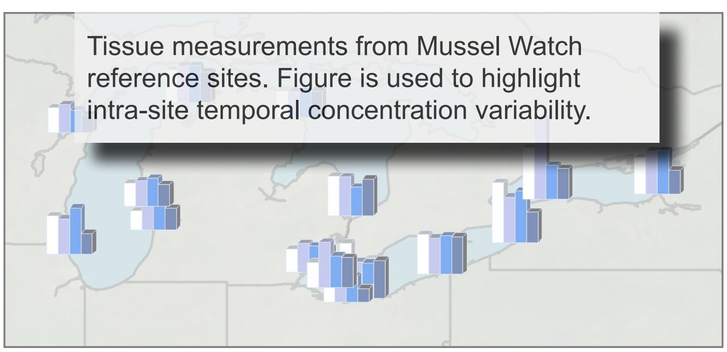
Example

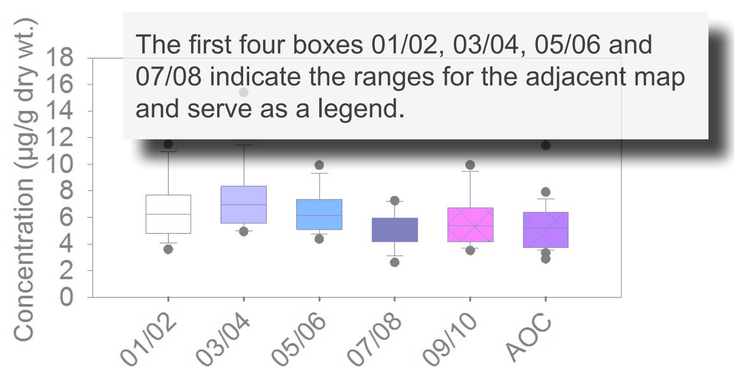


Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (µg/g dry wt.) in dressenid mussels.



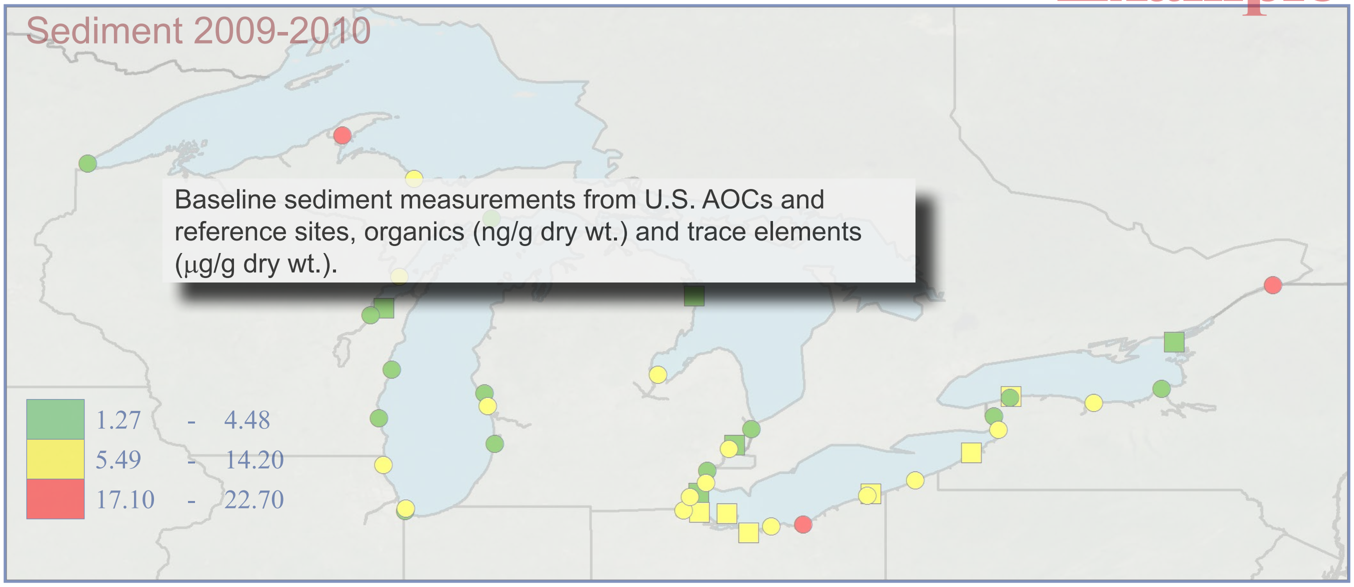
AOC barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (µg/g dry wt.). Reference lines represent mean AOC (solid line) and reference site (dotted line) concentrations.



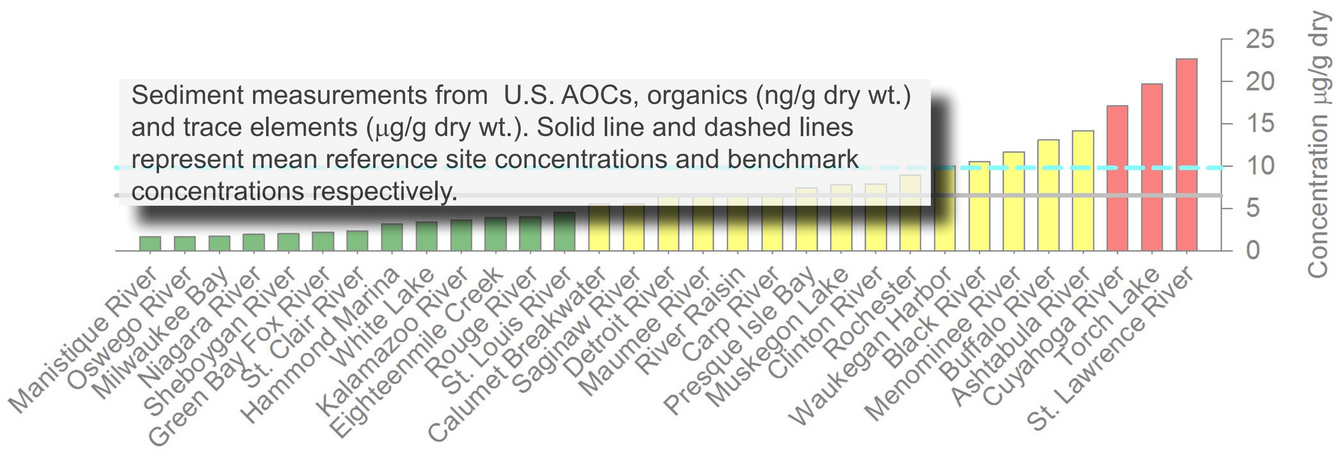


Historic data: Mussel tissue concentration (µg/g dry wt.) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and U.S. AOC sites collected in 2009/2010.

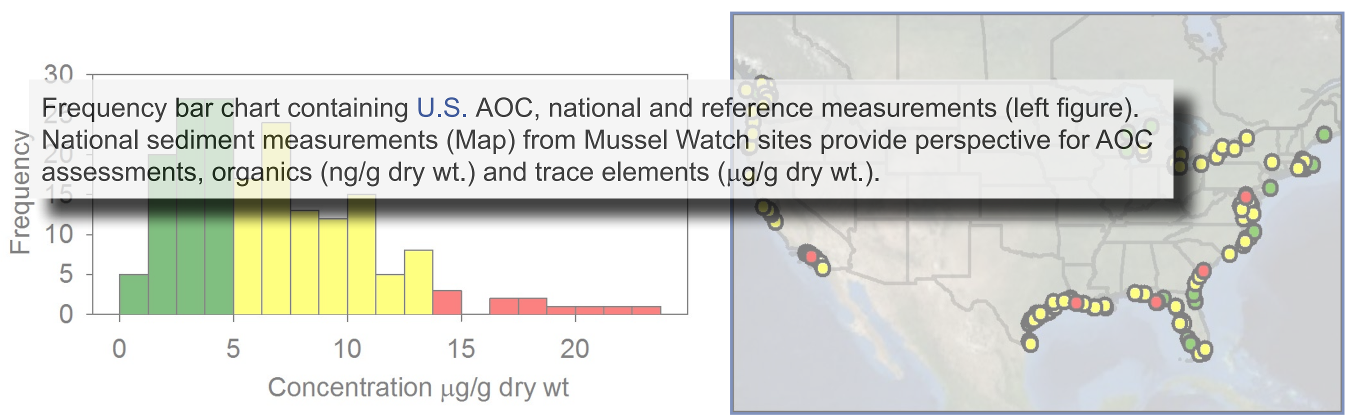
Example



Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (µg/g dry wt.).

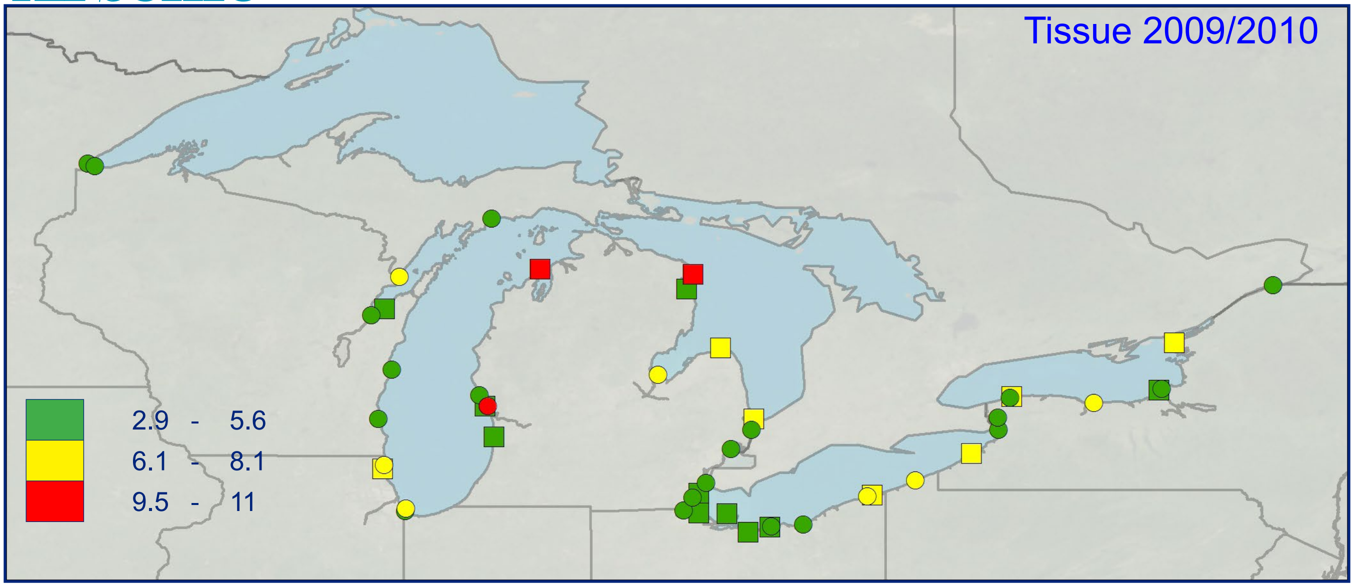


AOC barchart: Comparison of AOC contaminant concentrations in sediment (µg/g dry wt.). Where available, reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.

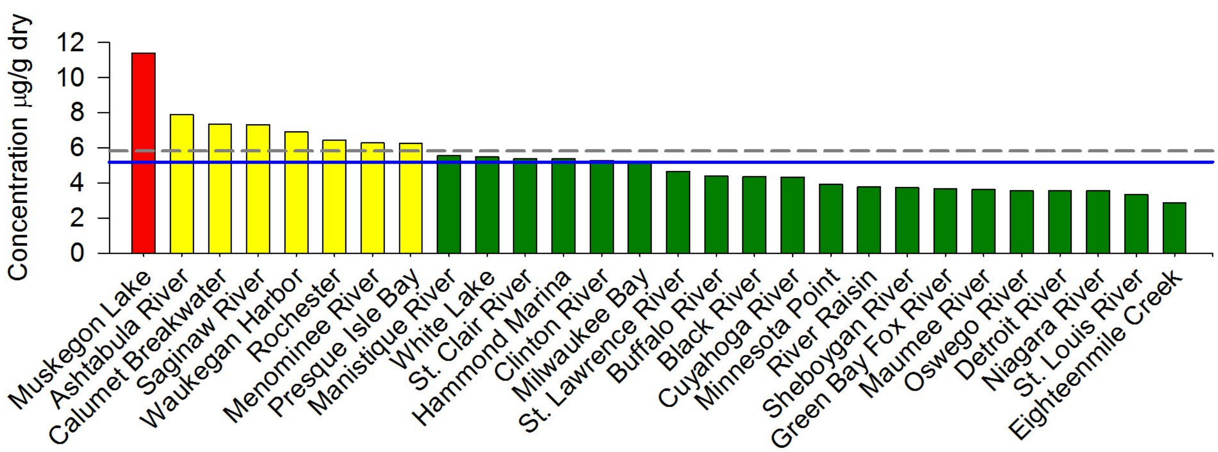


National frequency plot and sediment map: Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; µg/g dry wt.).

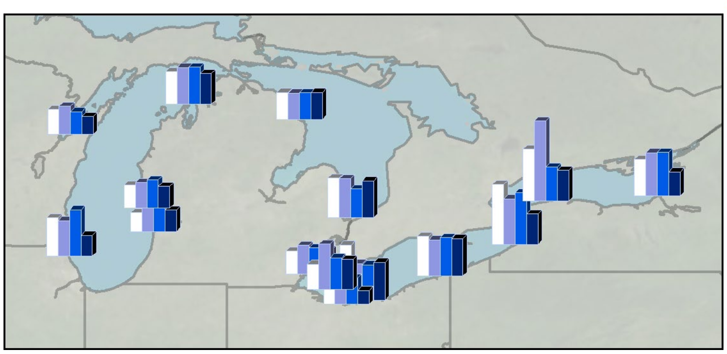
Arsenic

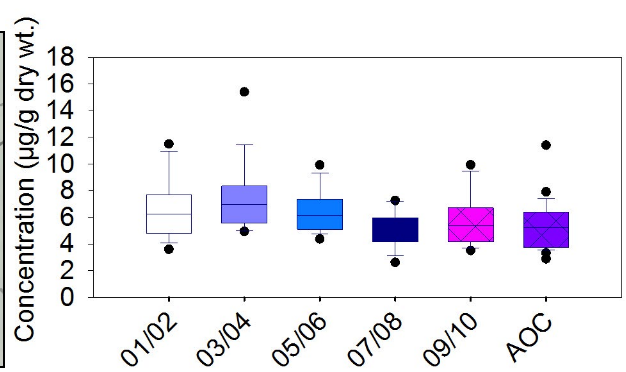


Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (µg/g dry wt.) in dressenid mussels.

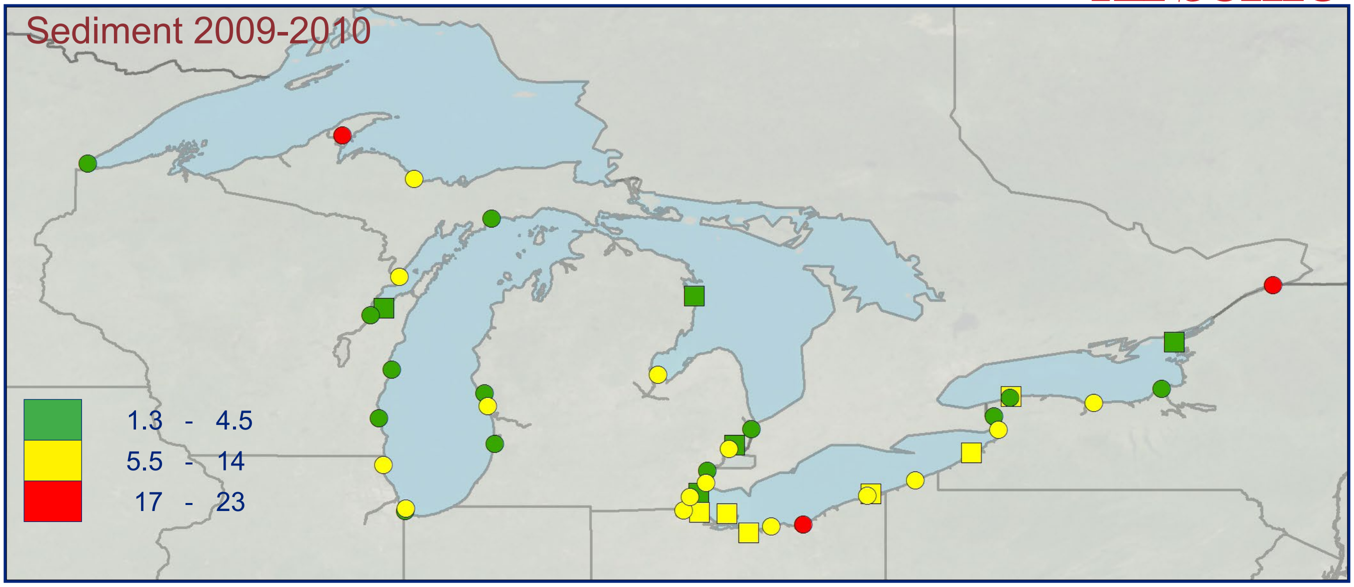


AOC barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (µg/g dry wt.). Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.

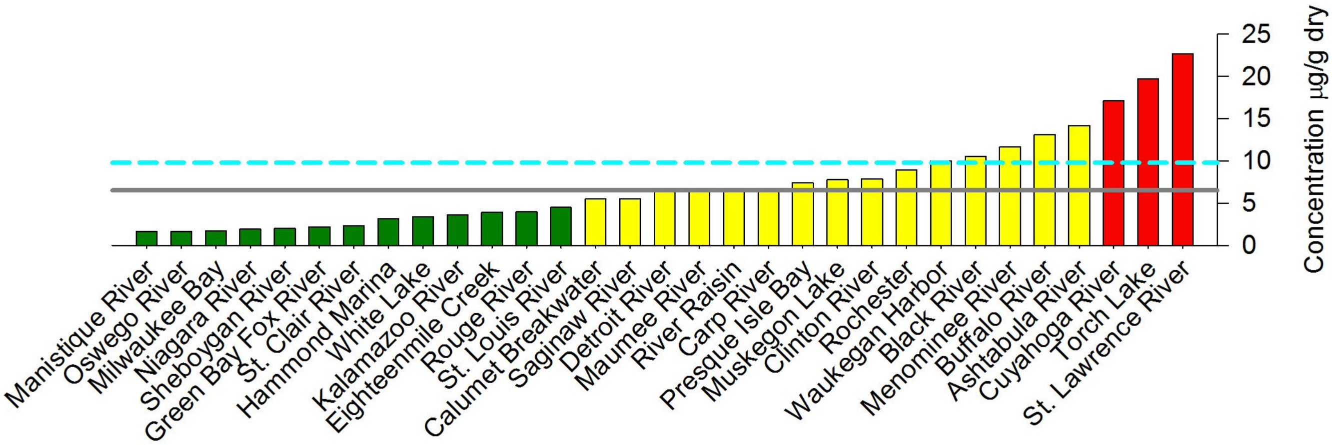




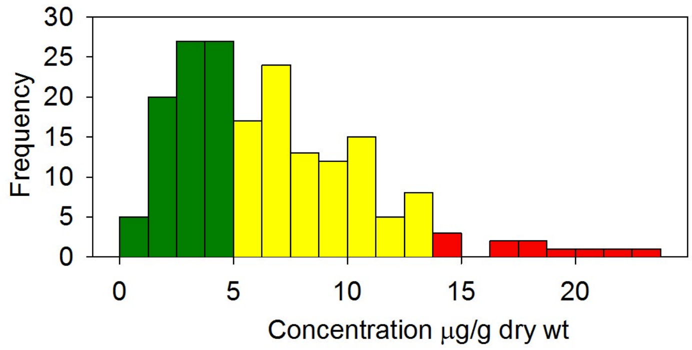
Historic data: Mussel tissue concentration (µg/g dry wt.) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

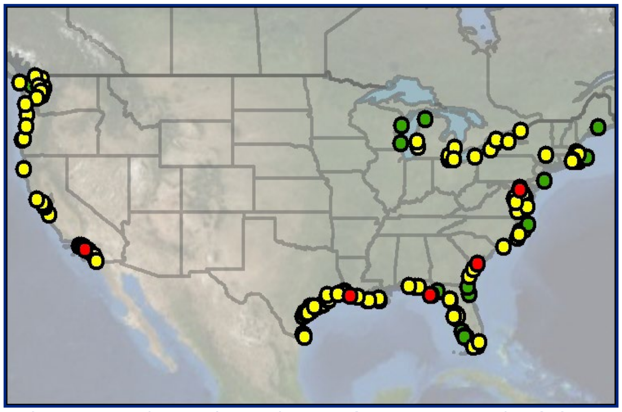


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (µg/g dry wt.).



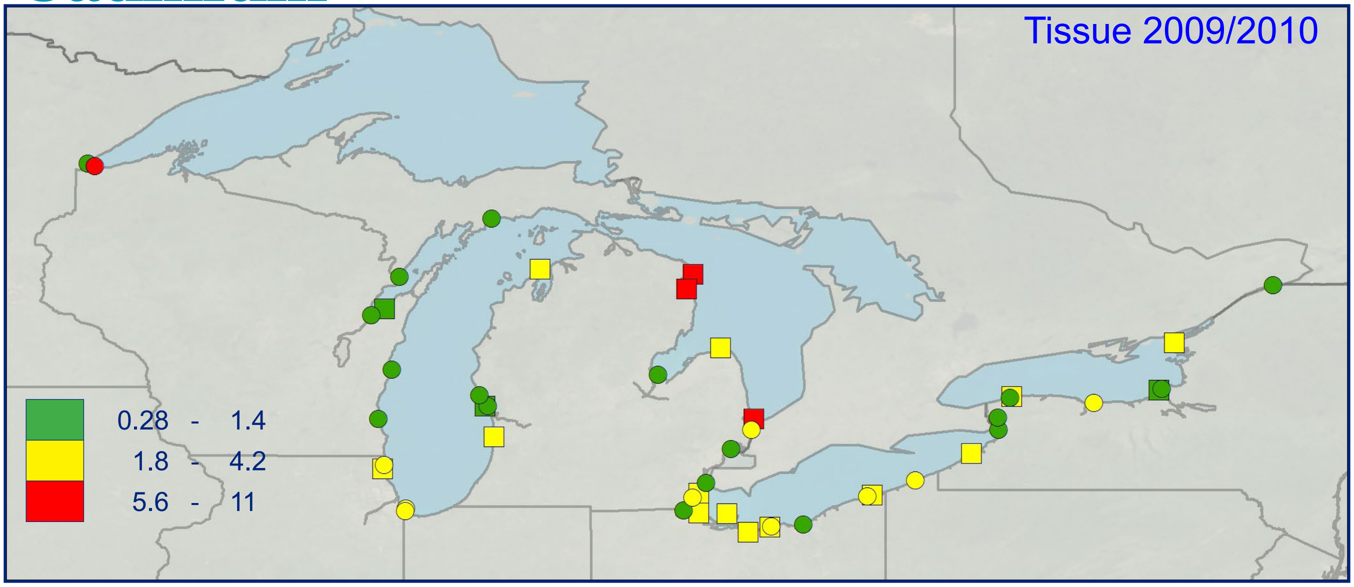
AOC barchart: Comparison of AOC contaminant concentrations in sediment (µg/g dry wt.). Where relevant, reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



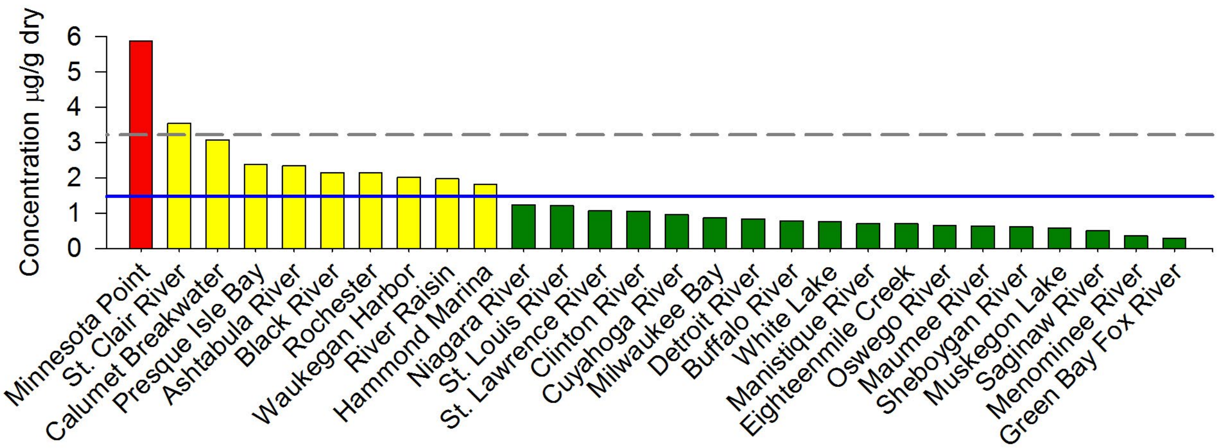


National frequency plot and sediment map: Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; µg/g dry wt.).

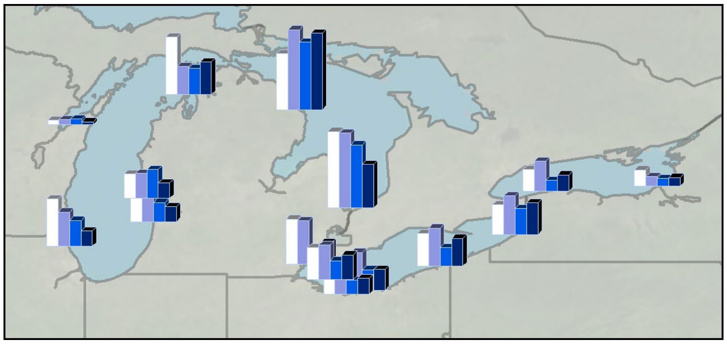
Cadmium

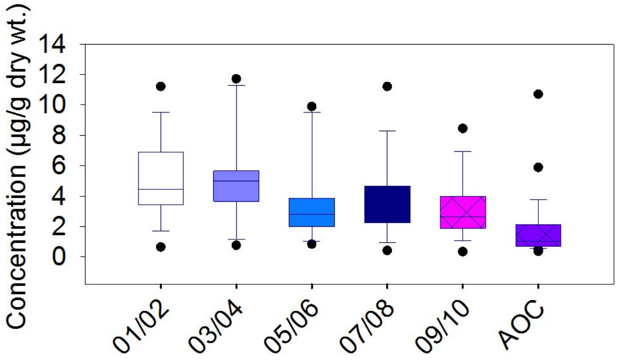


Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (µg/g dry wt.) in dressenid mussels.

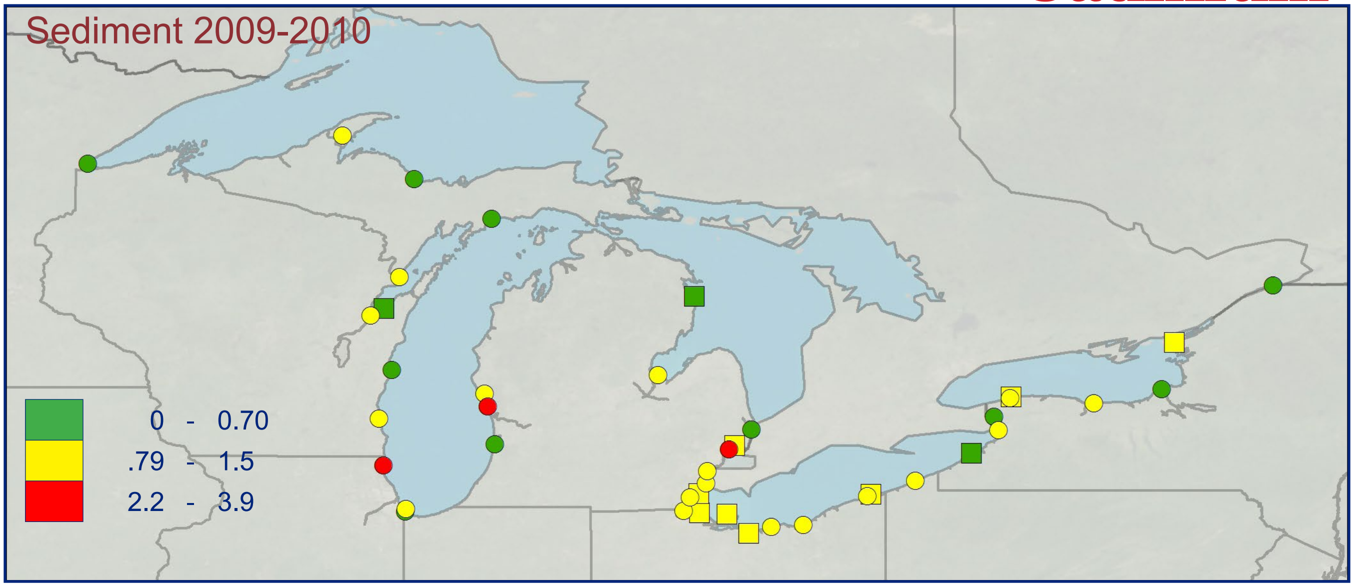


AOC barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (µg/g dry wt.). Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.

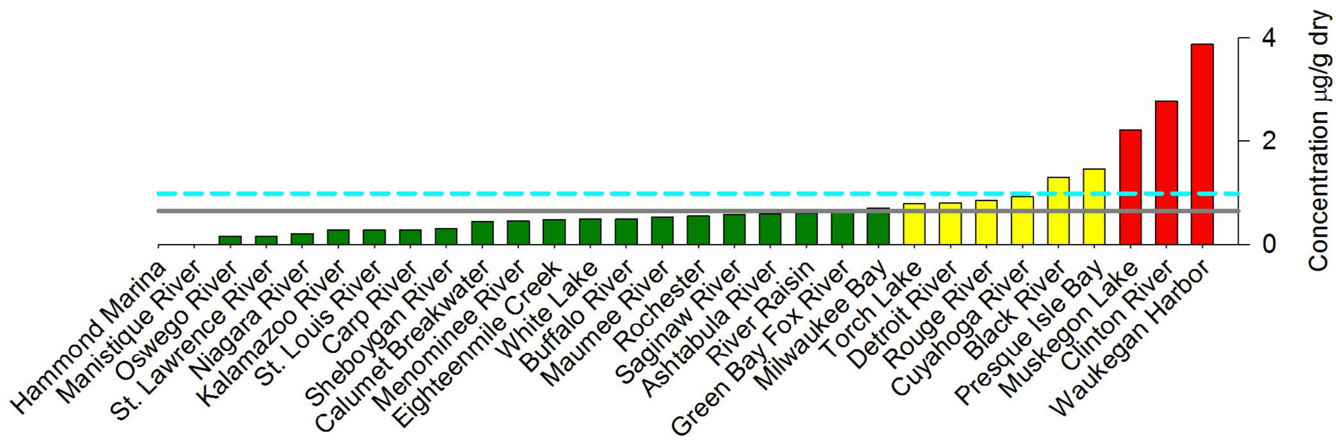




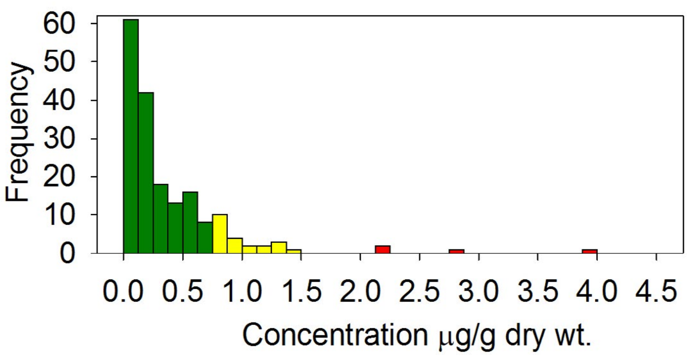
Historic data: Mussel tissue concentration (µg/g dry wt.) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

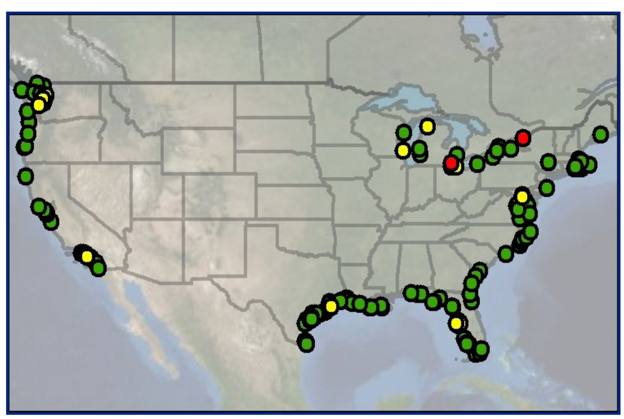


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (µg/g dry wt.).



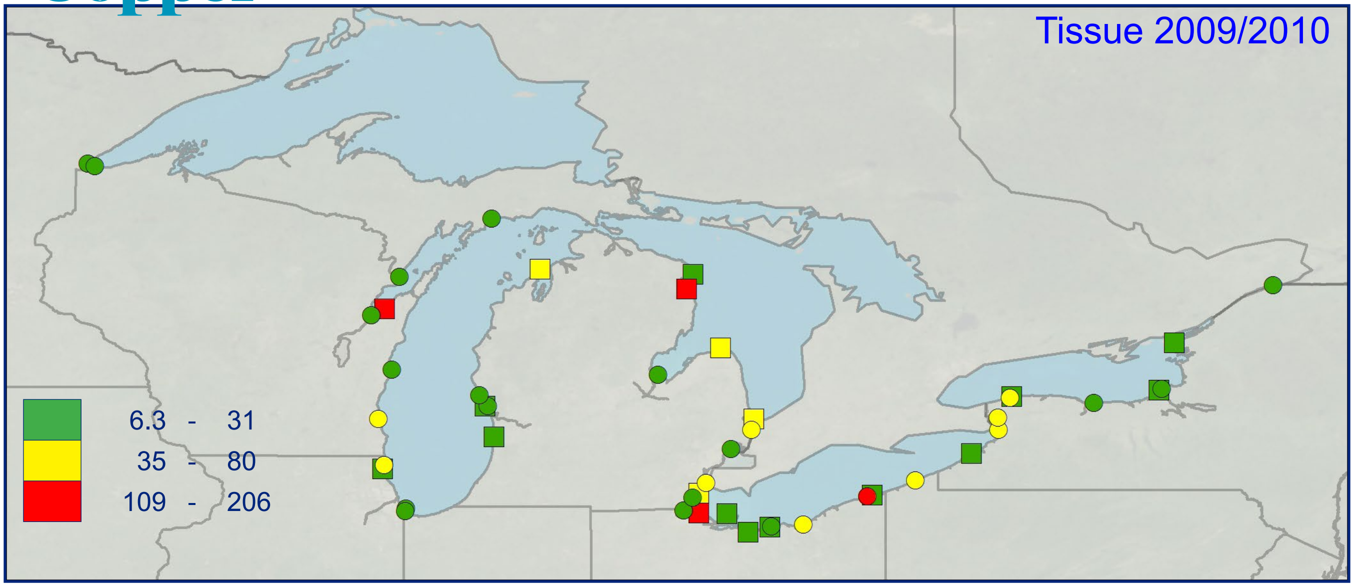
AOC barchart: Comparison of AOC contaminant concentrations in sediment (µg/g dry wt.). Where relevant, reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



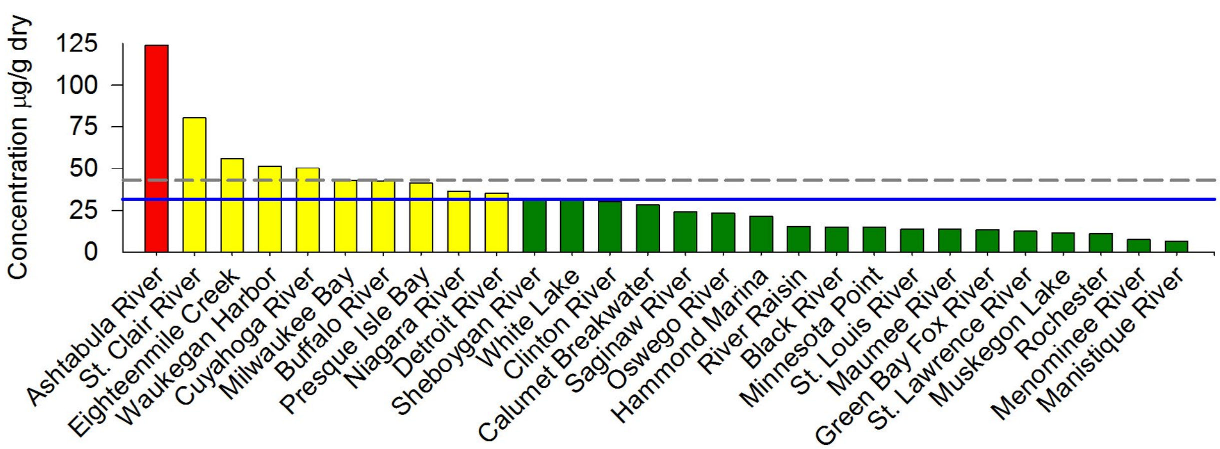


National frequency plot and sediment map: Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; µg/g dry wt.).

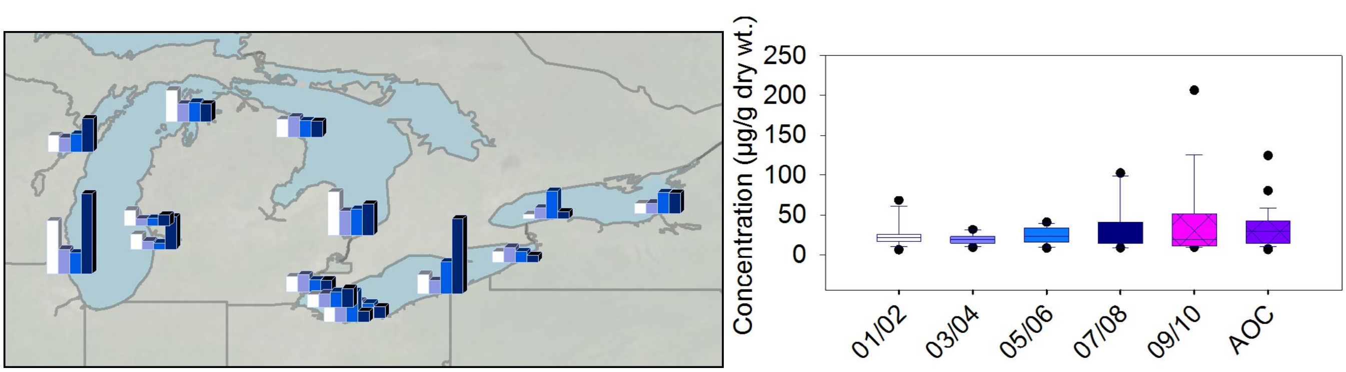
Copper



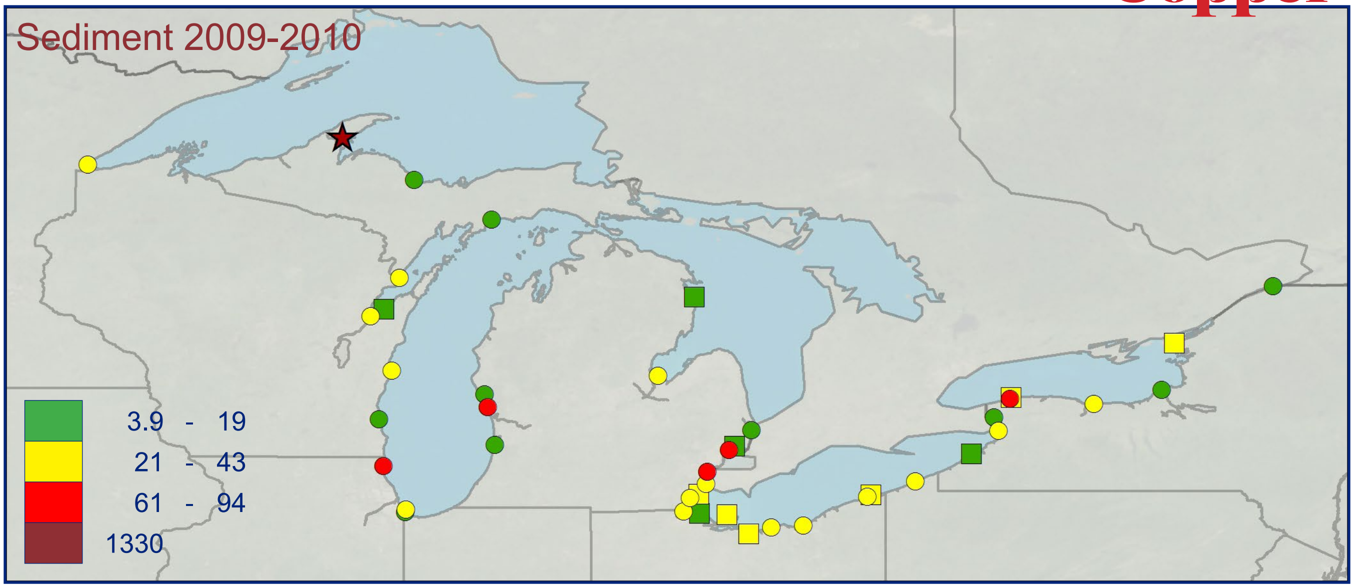
Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (ng/g lipid) in dressenid mussels.



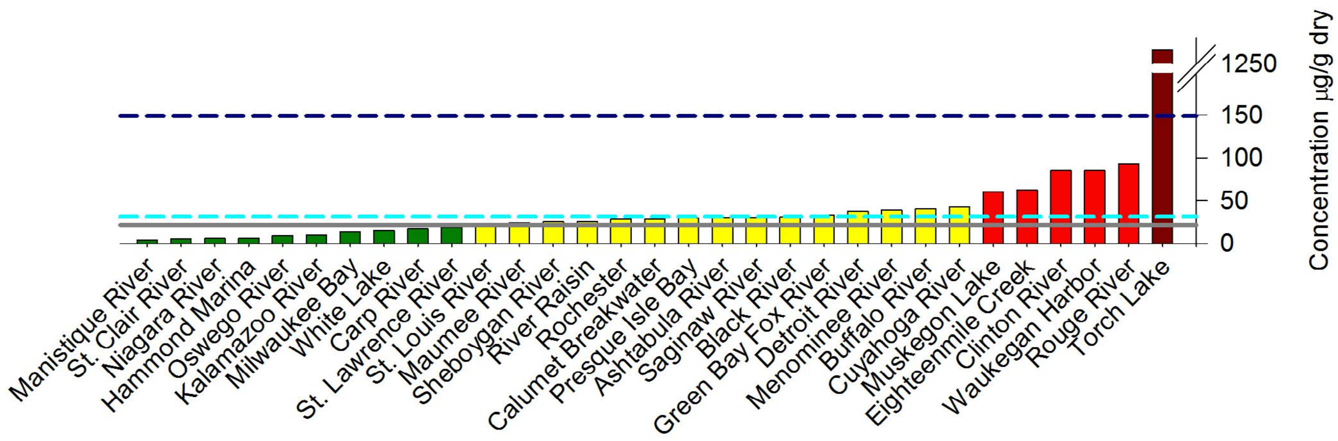
AOC Barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (ng/g lipid) among AOCs. Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.



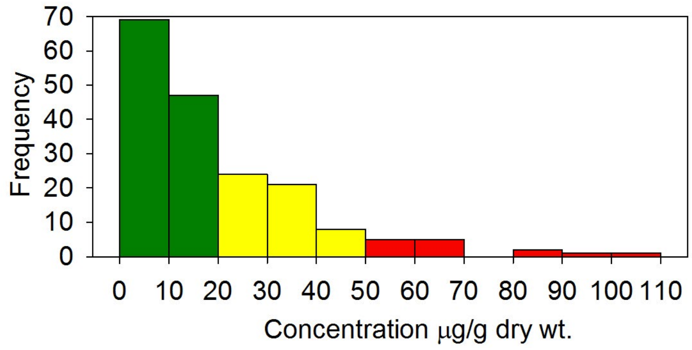
Historic data. Mussel tissue concentration (ng/g lipid) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

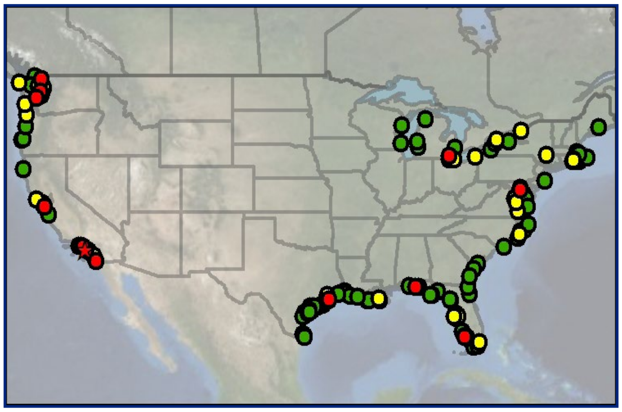


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (ng/g dry wt.).



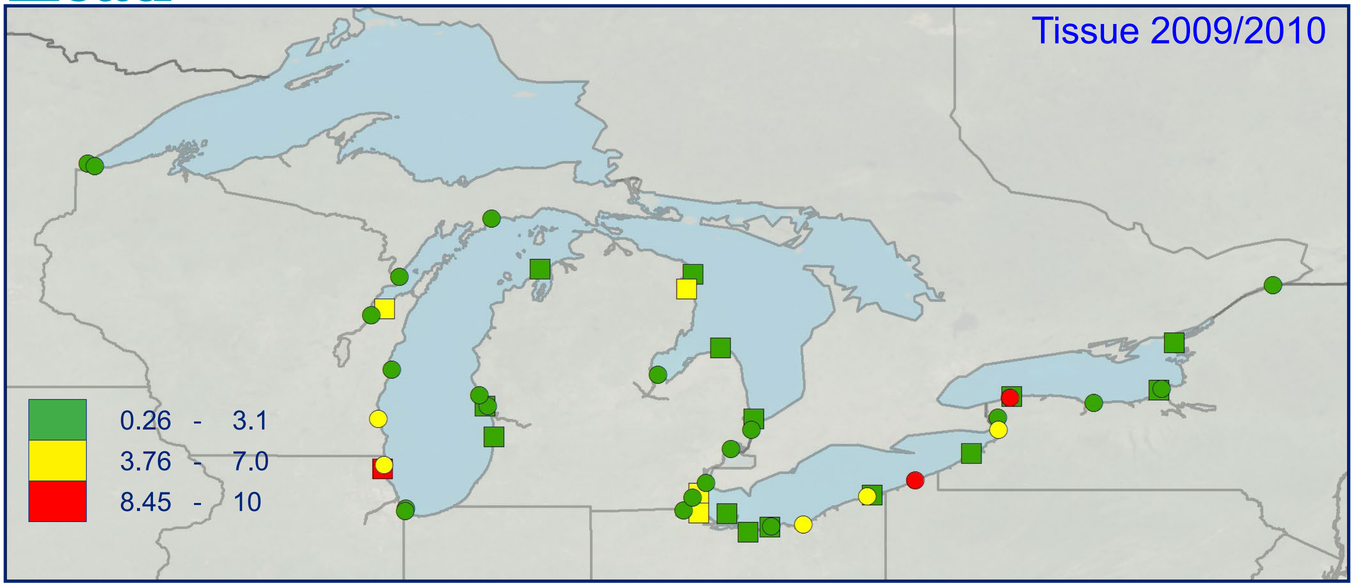
AOC barchart: Comparison of AOC contaminant concentrations in sediment (ng/g dry wt.). Where relevant reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



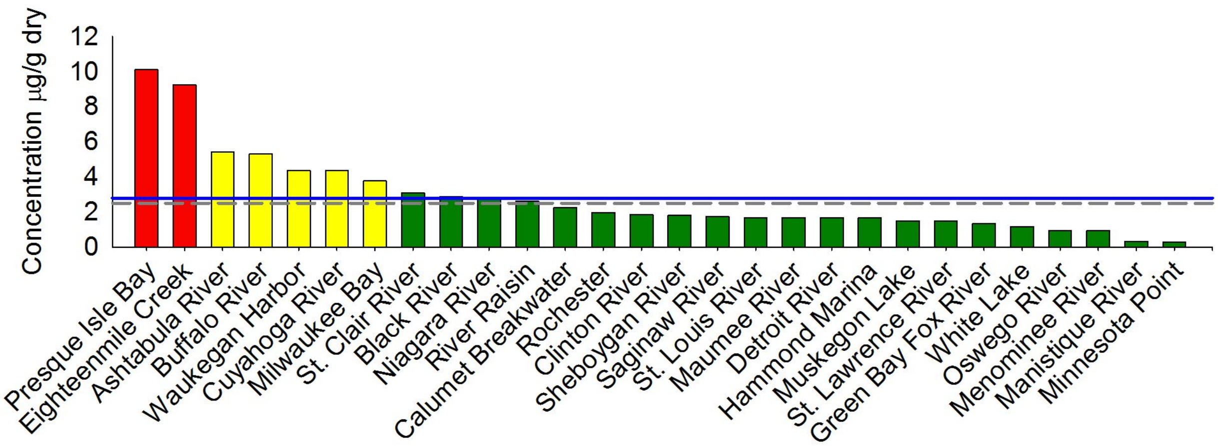


National frequency plot and sediment map. Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; ng/g dry wt.). Extreme outliers omitted.

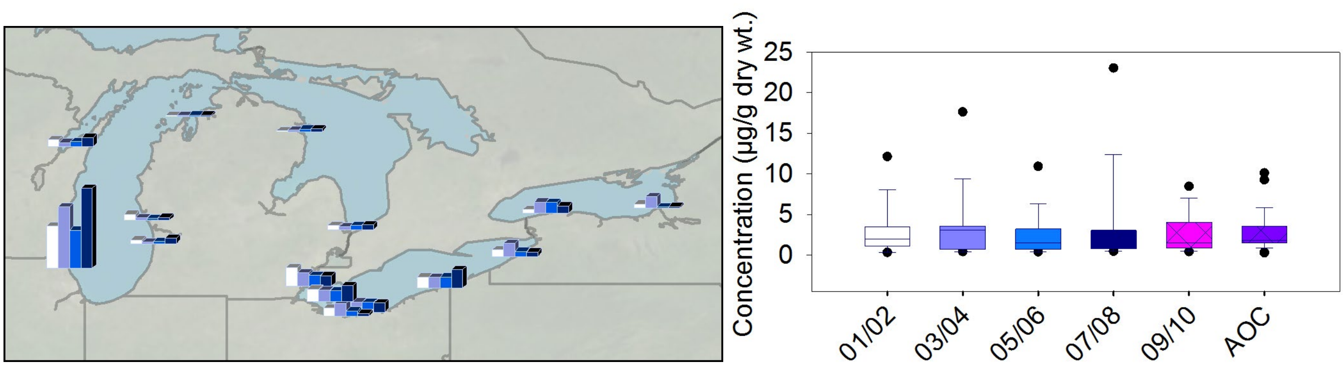
Lead



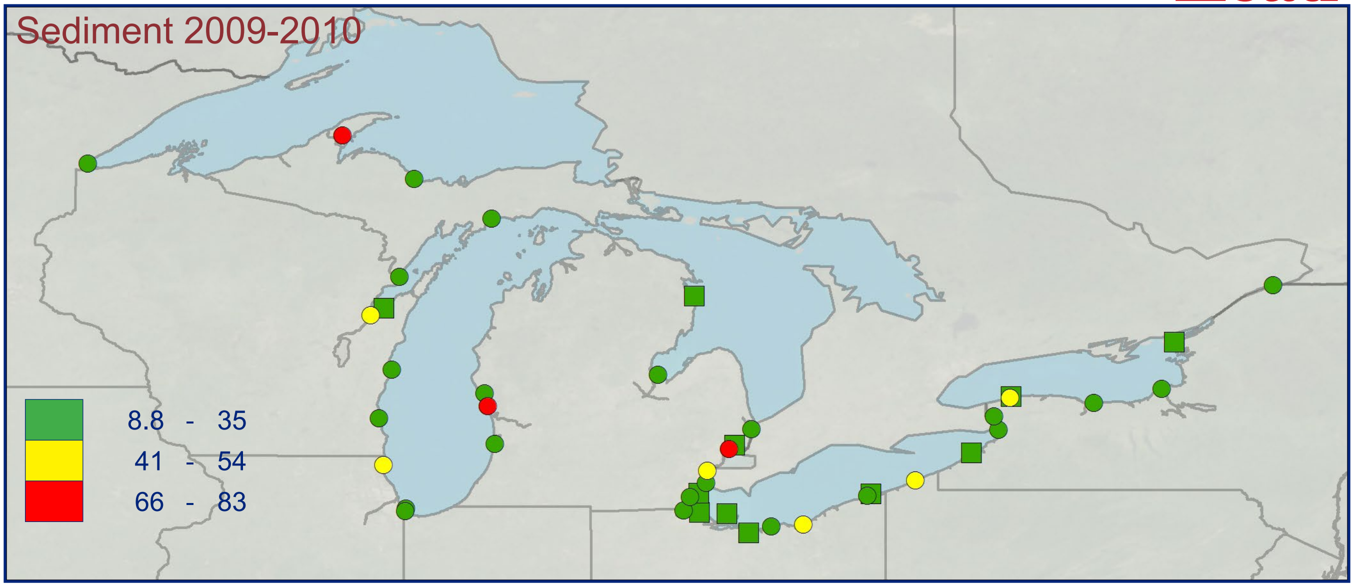
Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (µg/g dry wt.) in dressenid mussels.



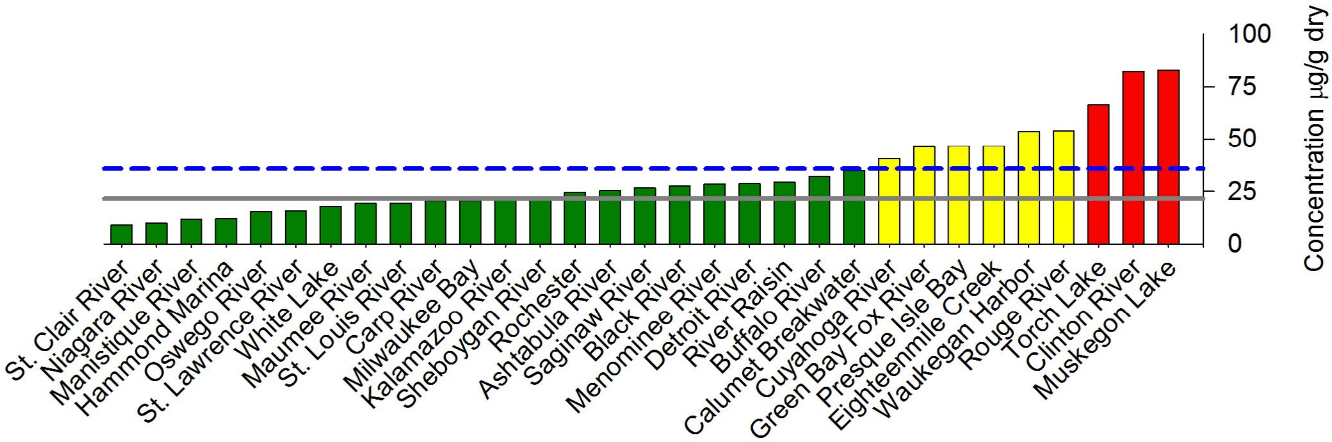
AOC barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (µg/g dry wt.). Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.



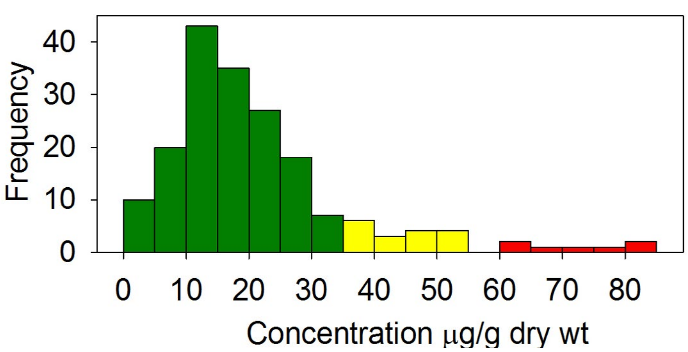
Historic data: Mussel tissue concentration (µg/g dry wt.) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

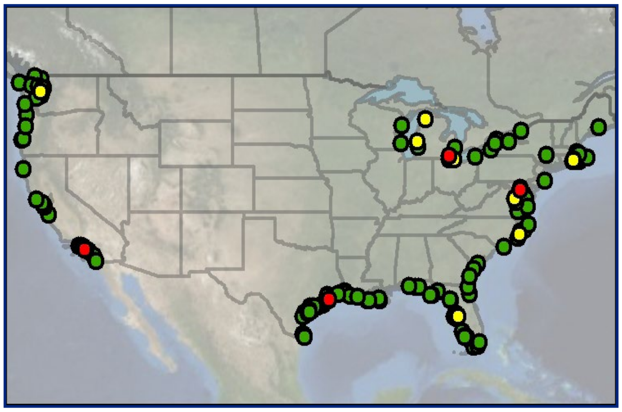


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (µg/g dry wt.).



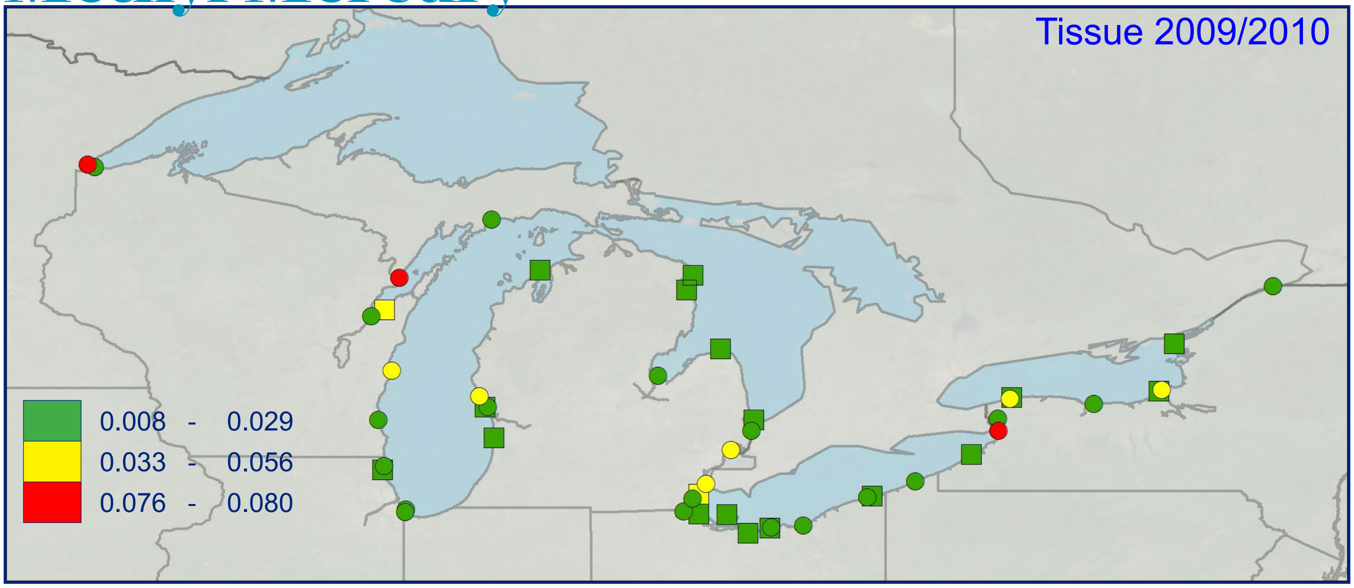
AOC barchart: Comparison of AOC contaminant concentrations in sediment (µg/g dry wt.). Where relevant, reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



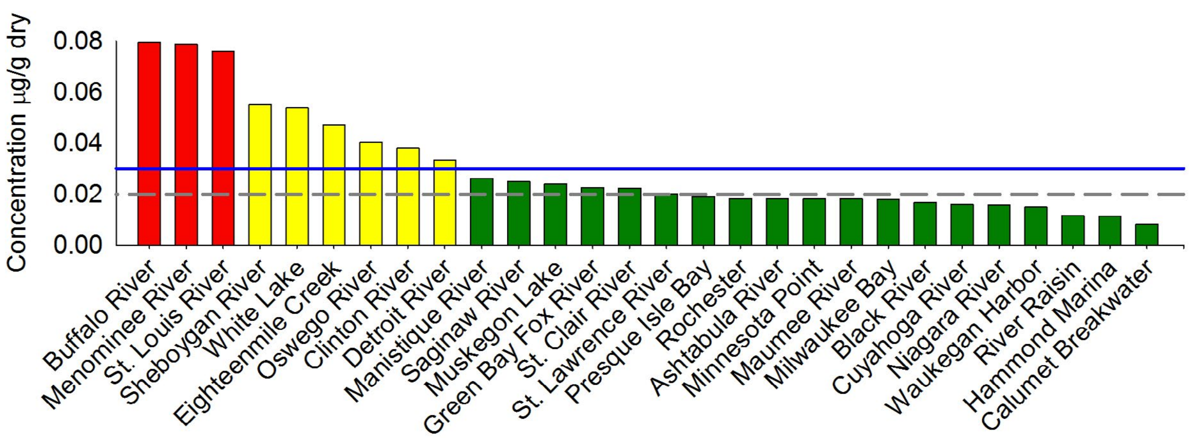


National frequency plot and sediment map: Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; µg/g dry wt.).

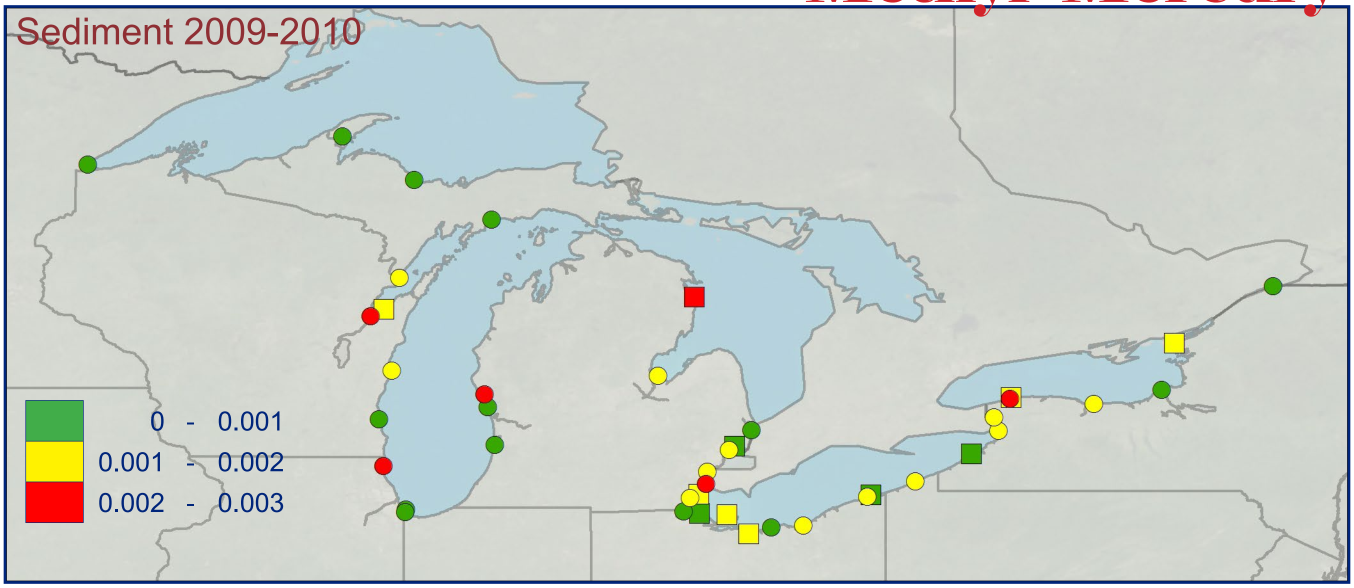
Methyl Mercury



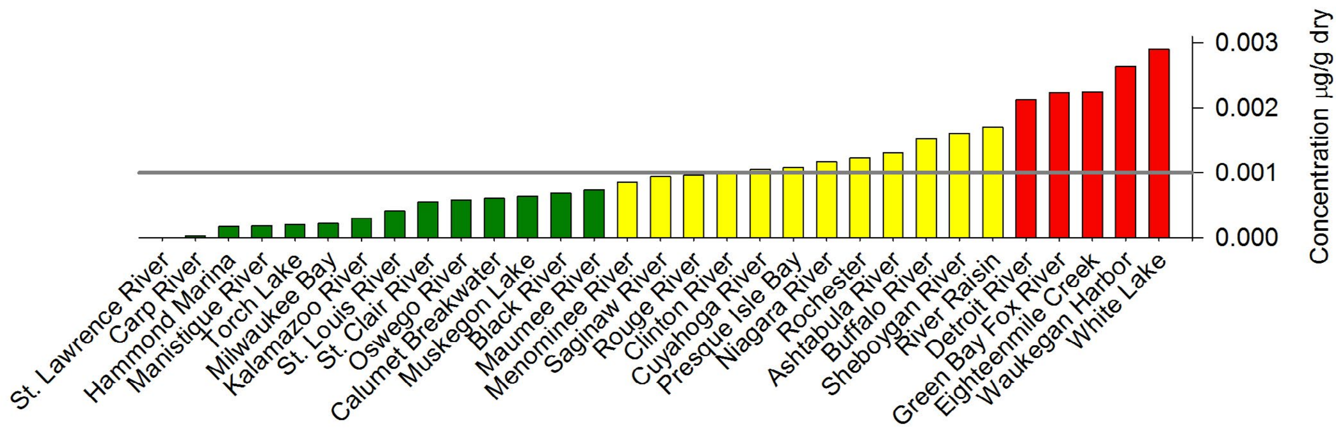
Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (µg/g dry wt.) in dressenid mussels.



AOC barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (µg/g dry wt.). Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.



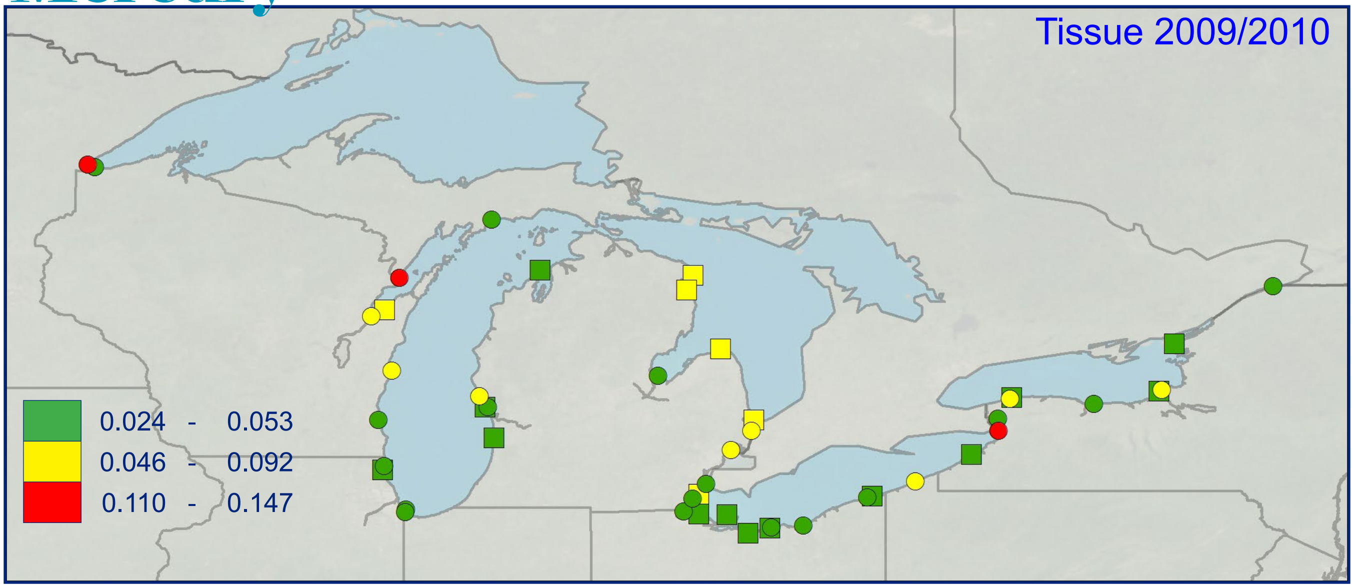
Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (µg/g dry wt.).



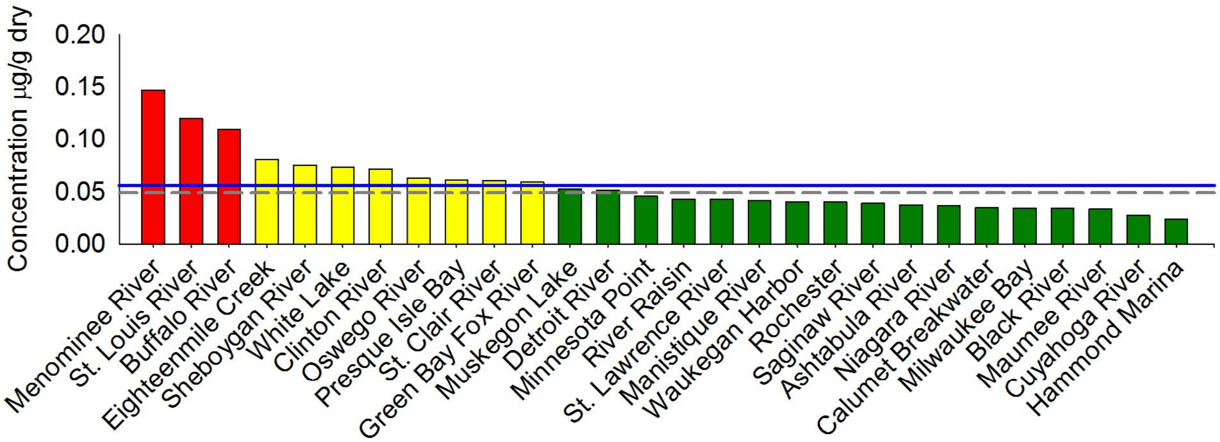
AOC barchart: Comparison of AOC contaminant concentrations in sediment (µg/g dry wt.). Where relevant, reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.

and

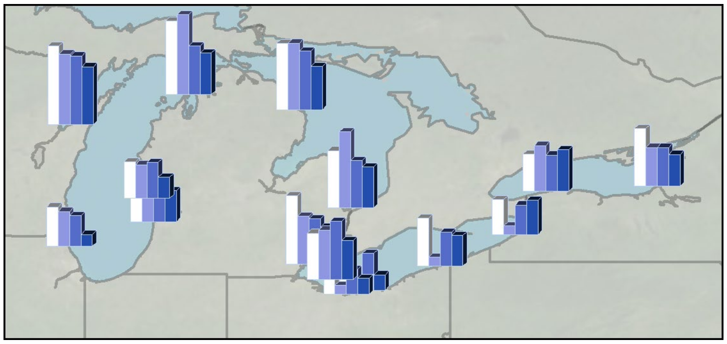
Mercury

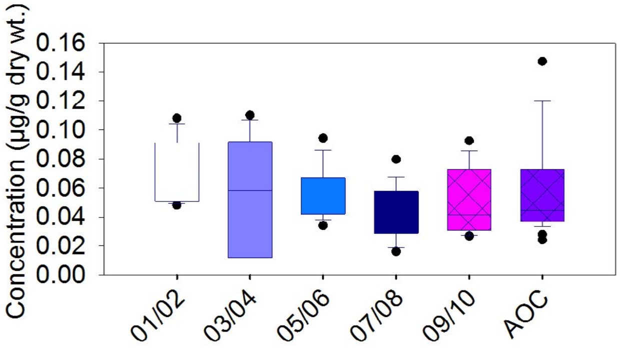


Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (µg/g dry wt.) in dressenid mussels.

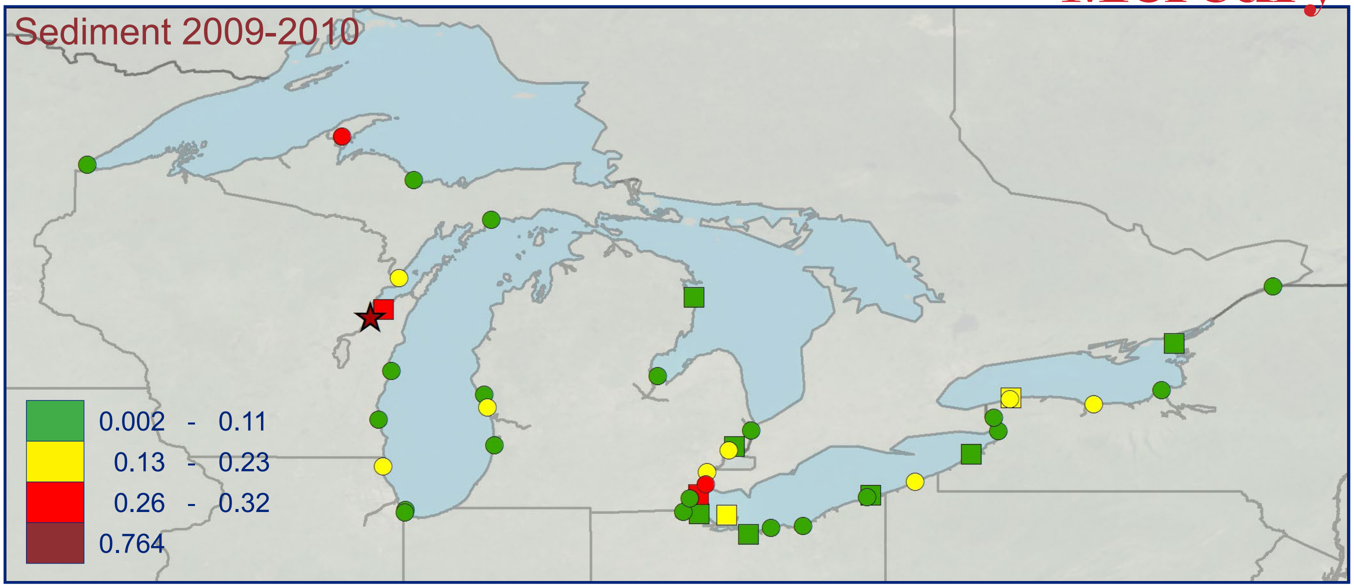


AOC barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (µg/g dry wt.). Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.

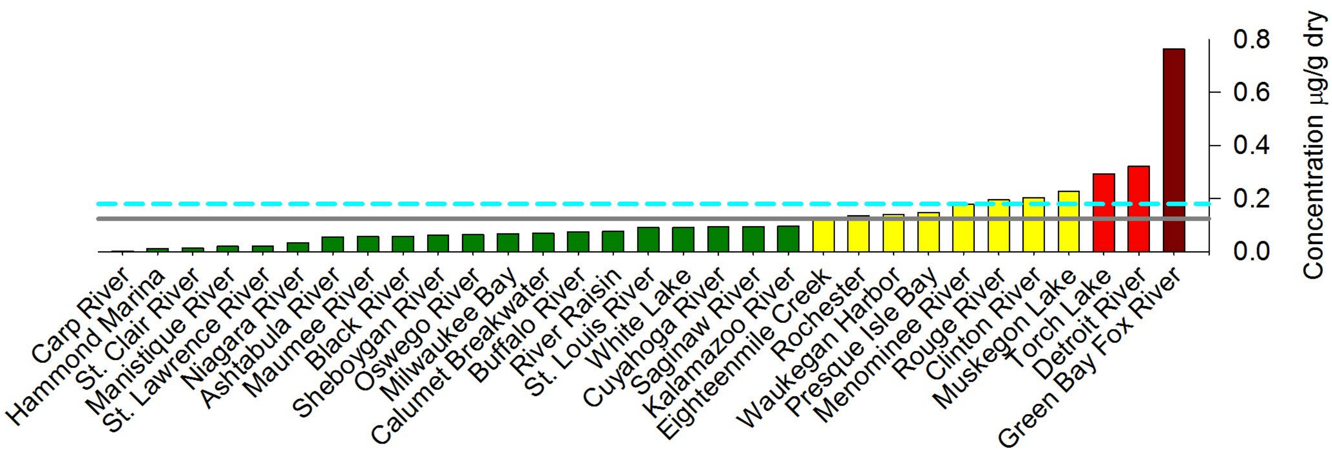




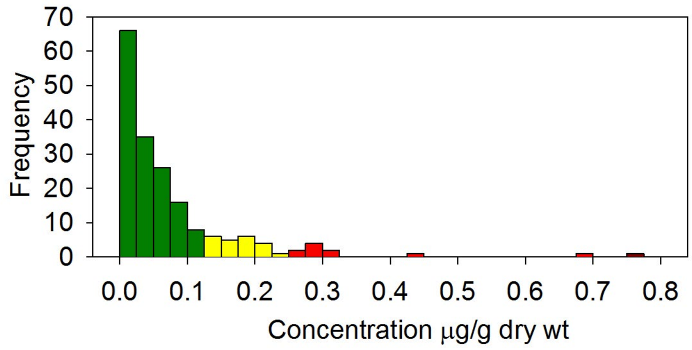
Historic data: Mussel tissue concentration (µg/g dry wt.) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

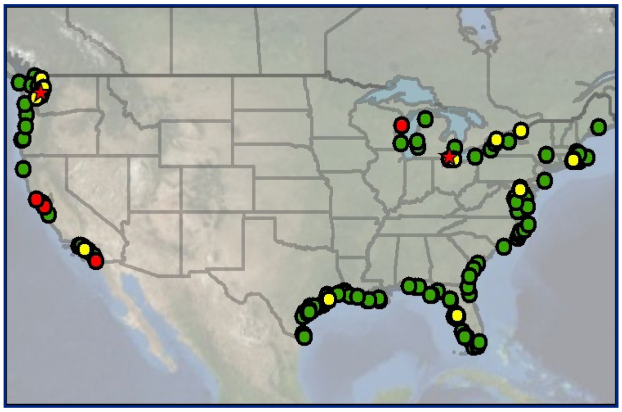


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (µg/g dry wt.).



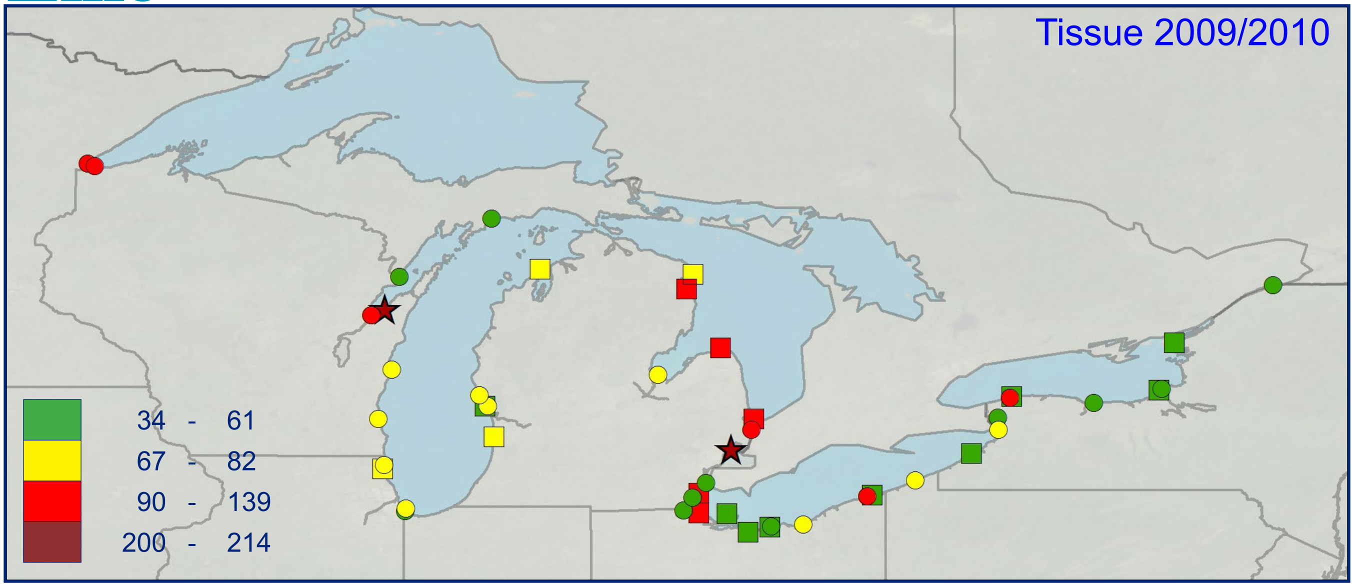
AOC barchart: Comparison of AOC contaminant concentrations in sediment (µg/g dry wt.). Where relevant, reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



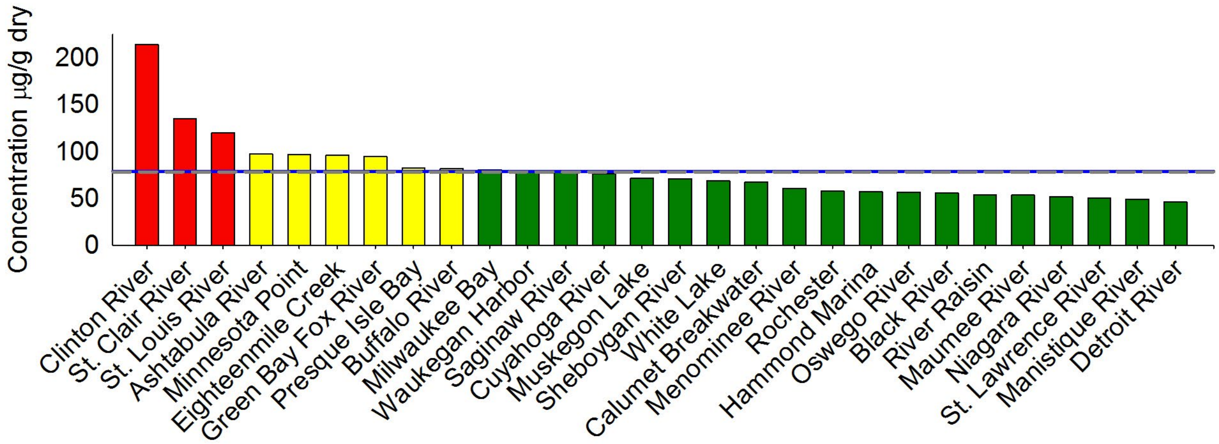


National frequency plot and sediment map: Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; µg/g dry wt.).

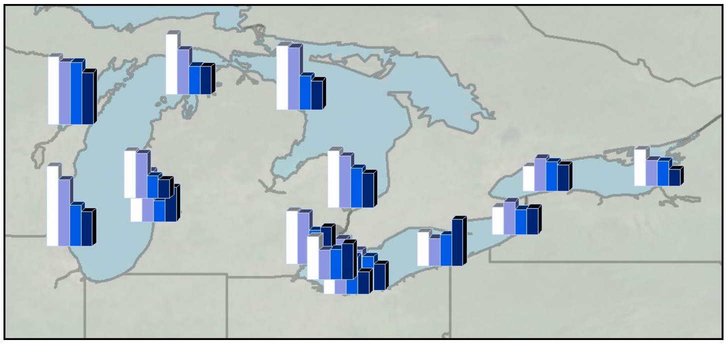
Zinc

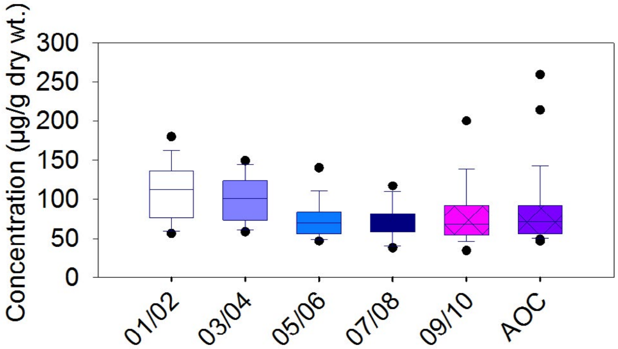


Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (µg/g dry wt.) in dressenid mussels.

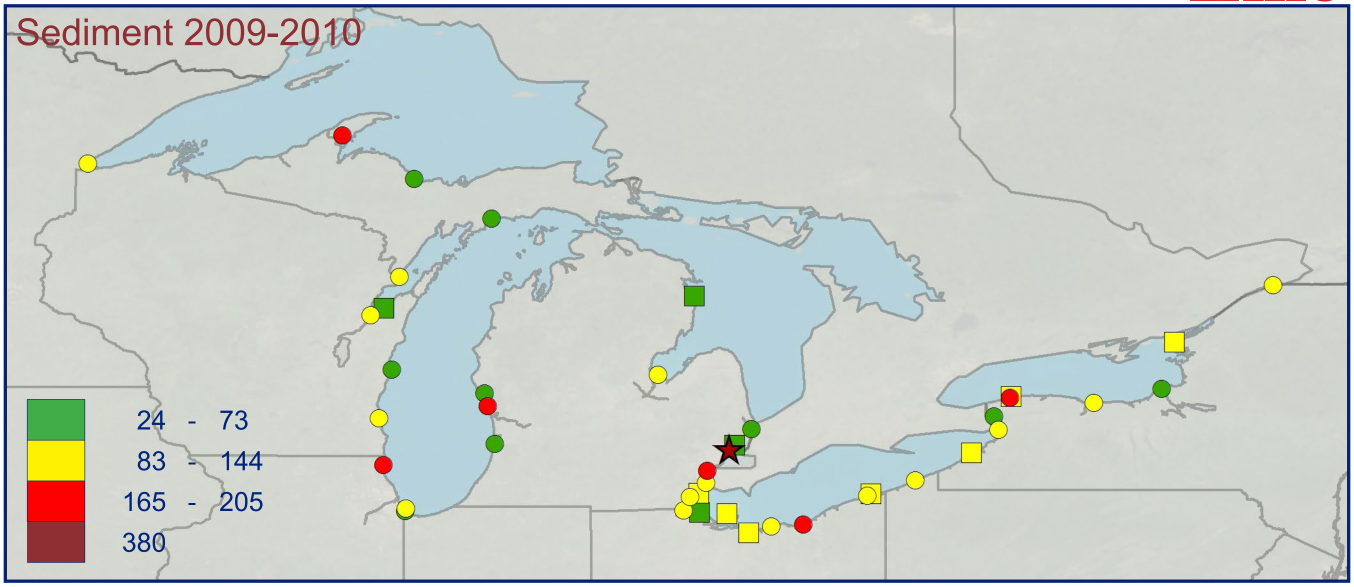


AOC barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (µg/g dry wt.). Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.

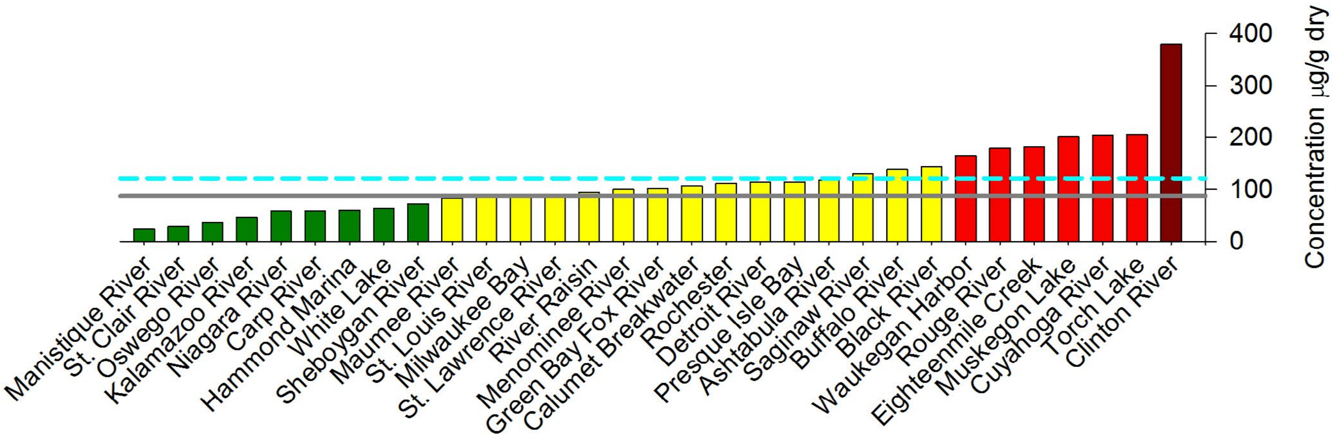




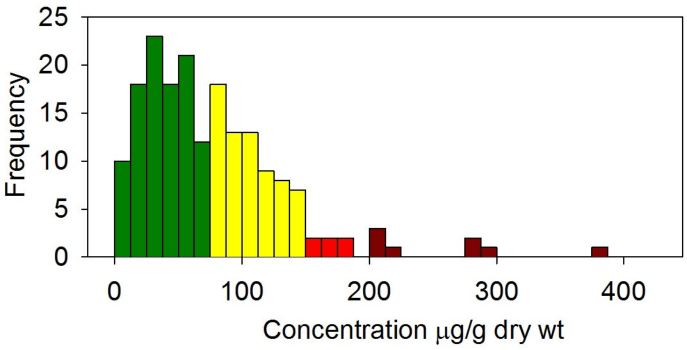
Historic data: Mussel tissue concentration (µg/g dry wt.) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

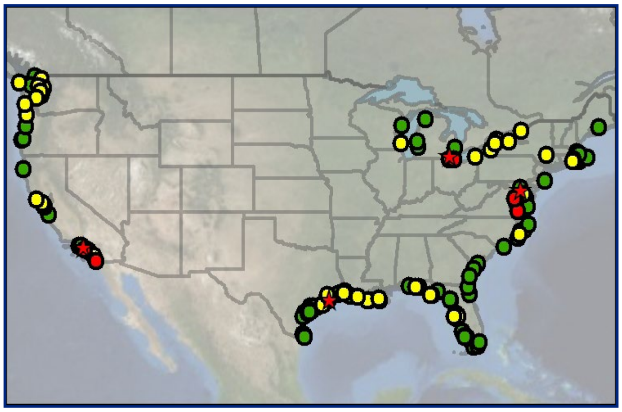


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (µg/g dry wt.).



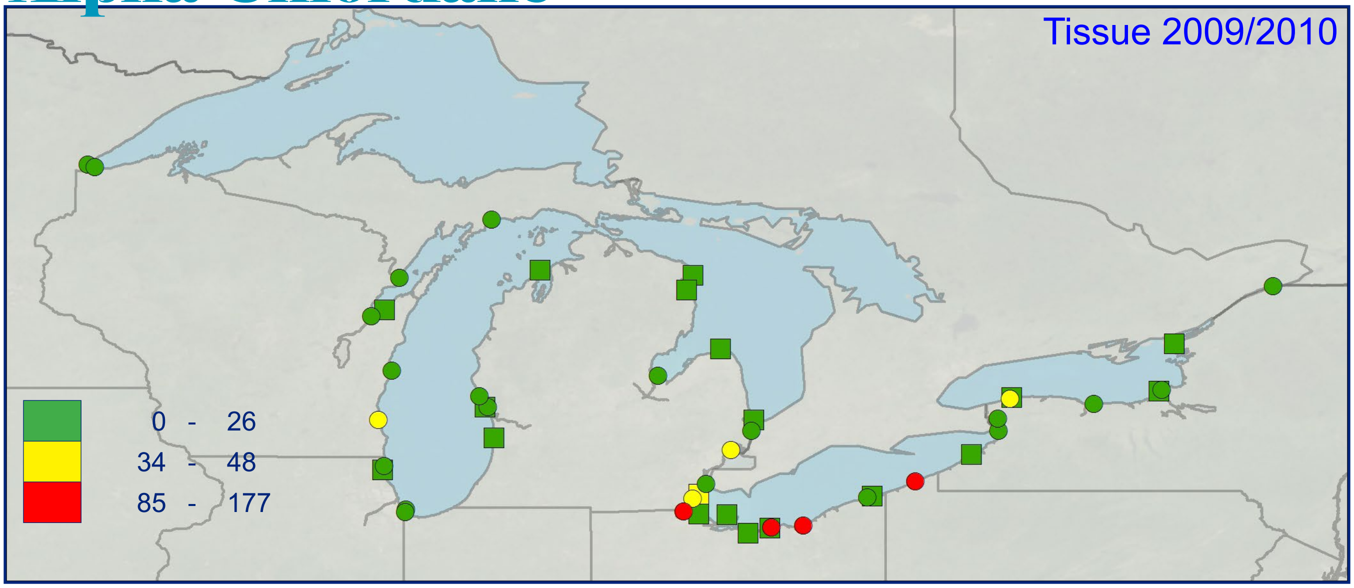
AOC barchart: Comparison of AOC contaminant concentrations in sediment (µg/g dry wt.). Where relevant, reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



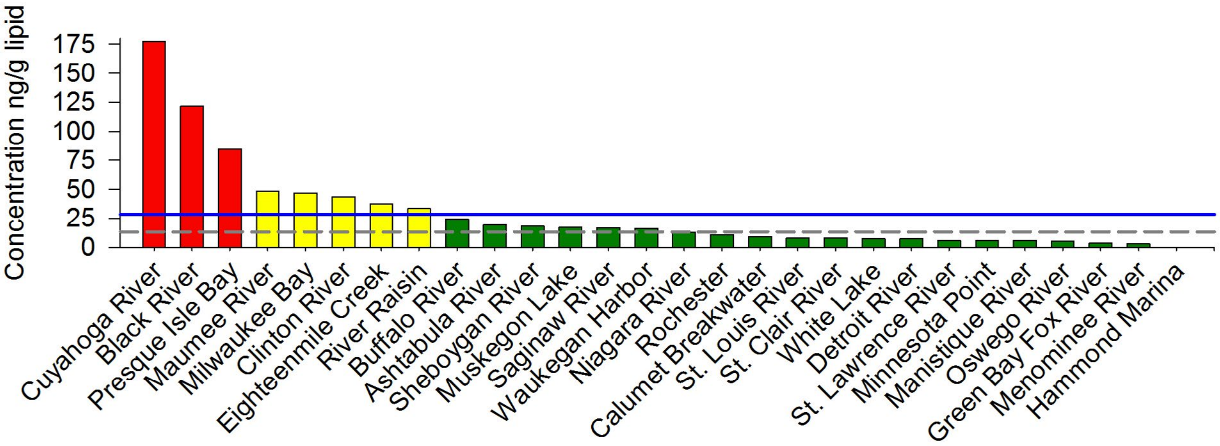


National frequency plot and sediment map: Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; µg/g dry wt.).

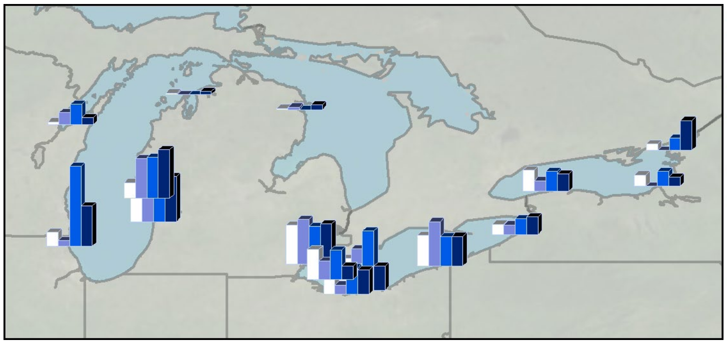
Alpha-Chlordane

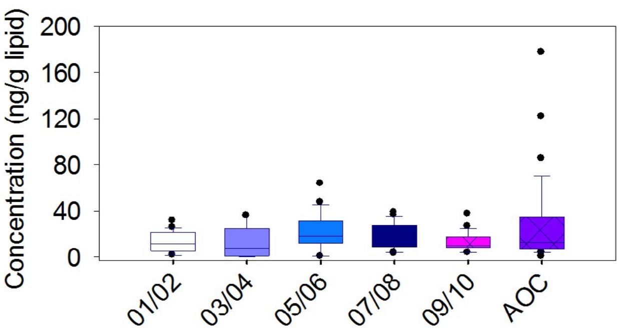


Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (ng/g lipid) in dressenid mussels.

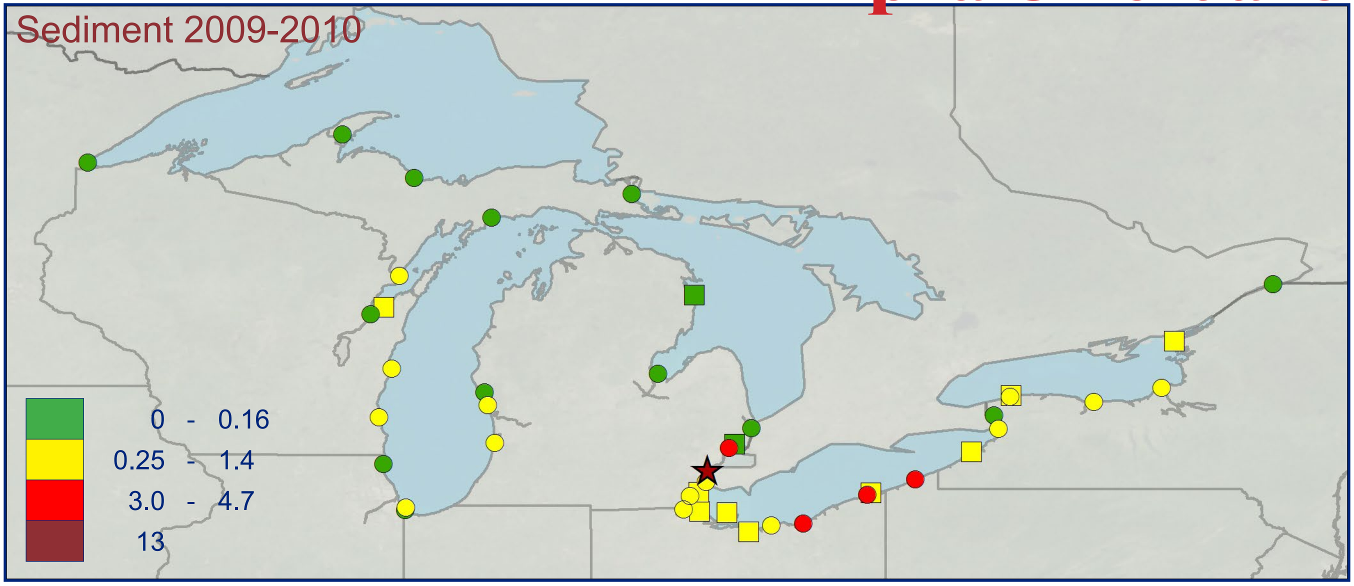


AOC Barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (ng/g lipid) among AOCs. Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.

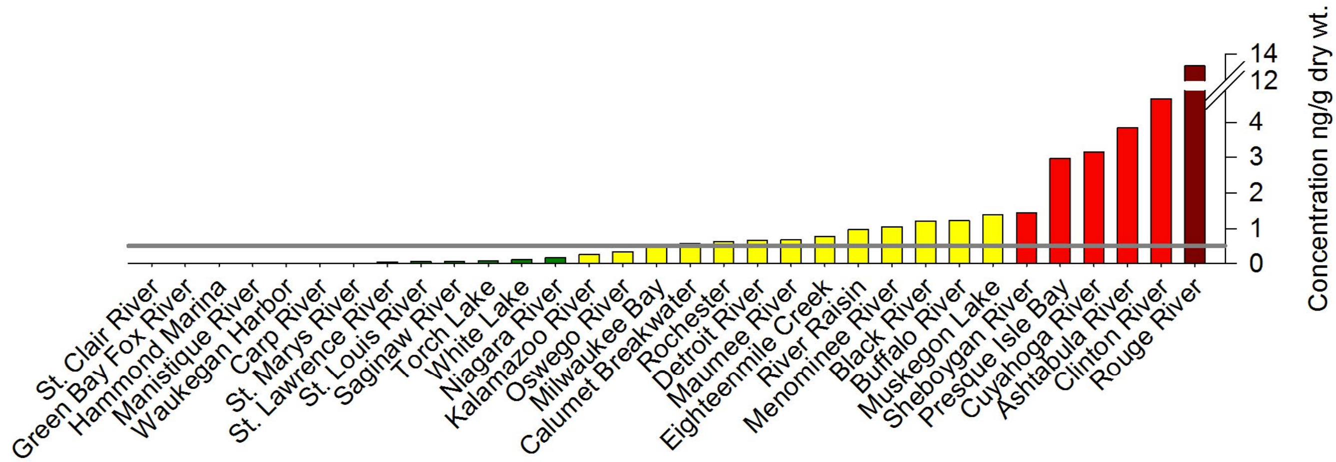




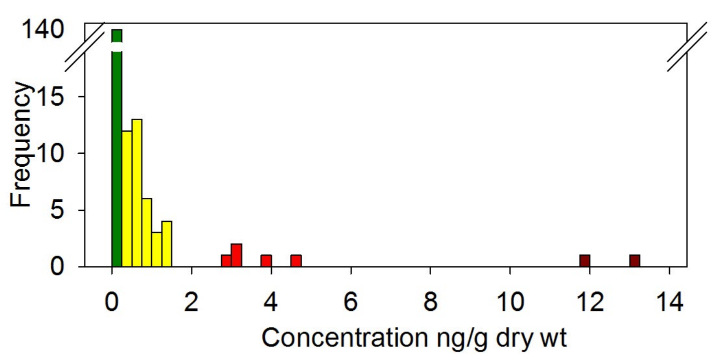
Historic data. Mussel tissue concentration (ng/g lipid) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

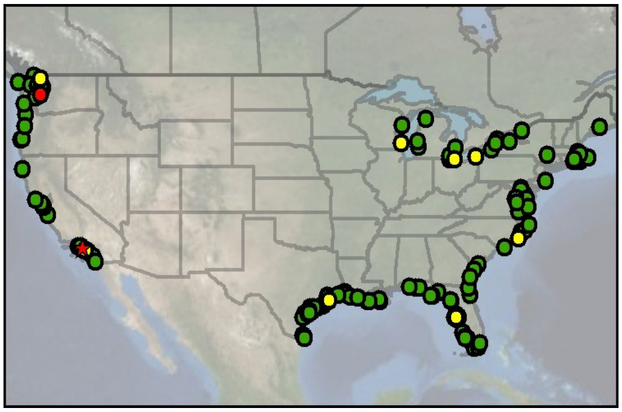


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (ng/g dry wt.).



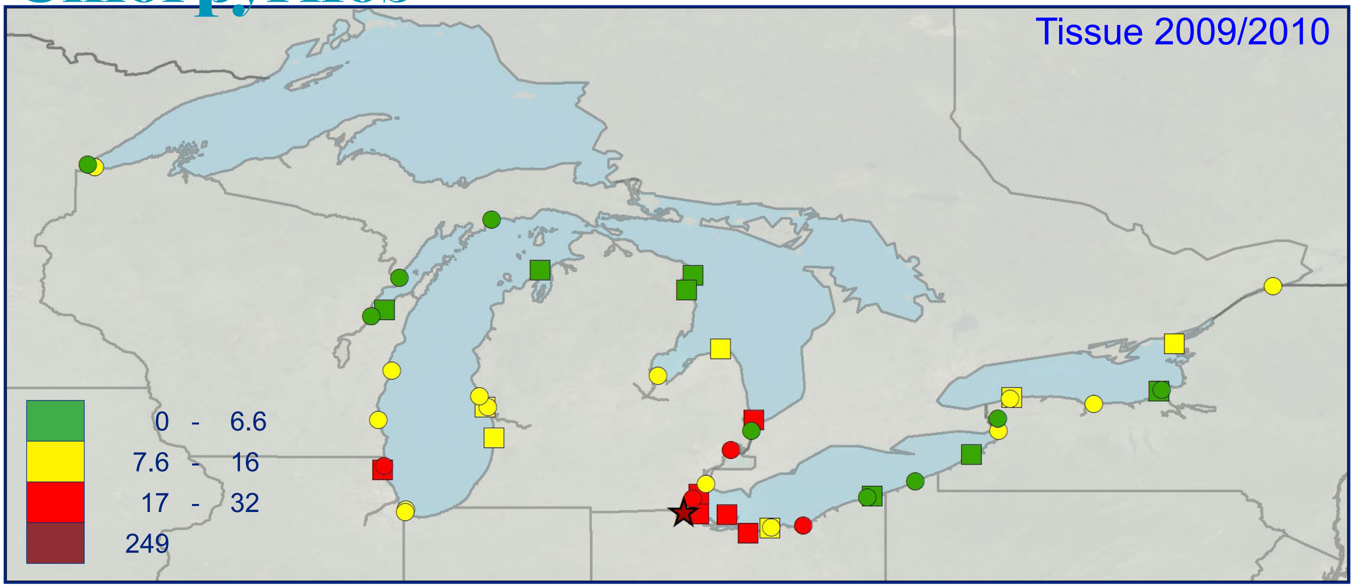
AOC barchart: Comparison of AOC contaminant concentrations in sediment (ng/g dry wt.). Where relevant reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



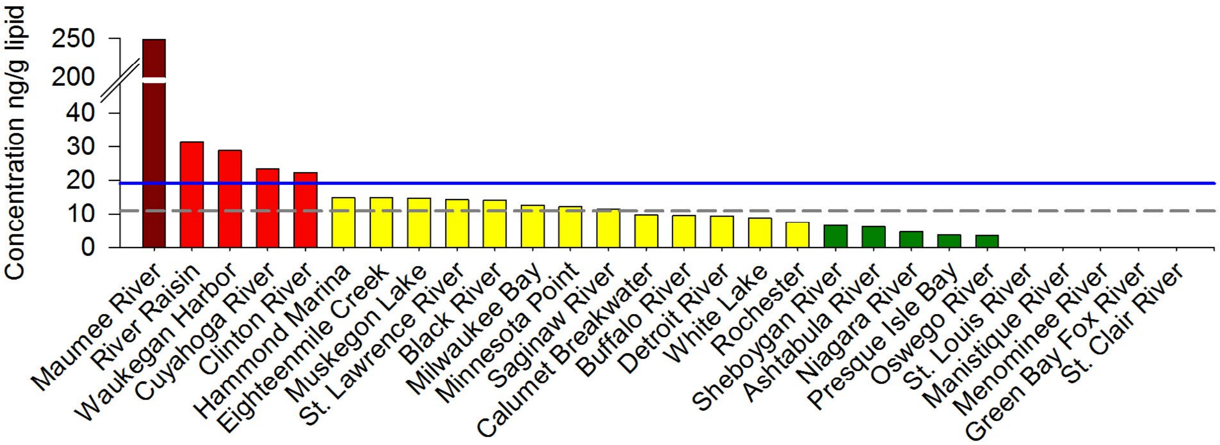


National frequency plot and sediment map. Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; ng/g dry wt.).

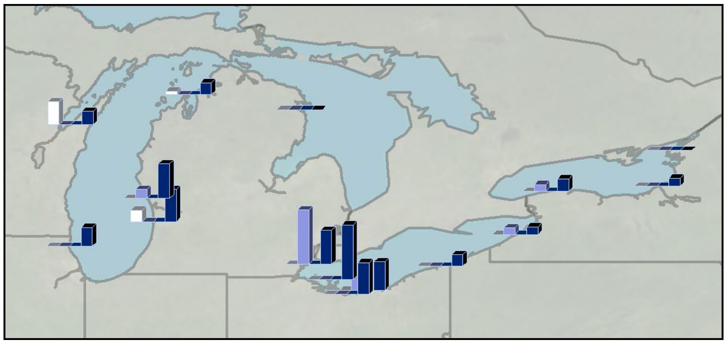
Chlorpyrifos

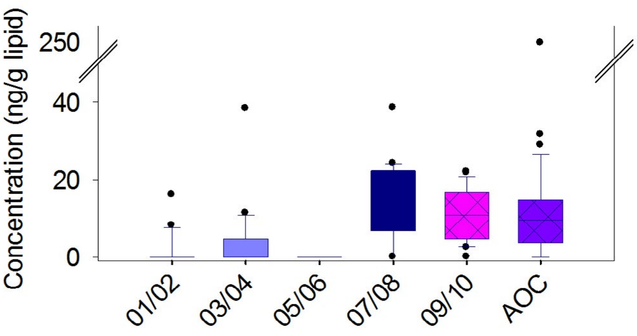


Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (ng/g lipid) in dressenid mussels.

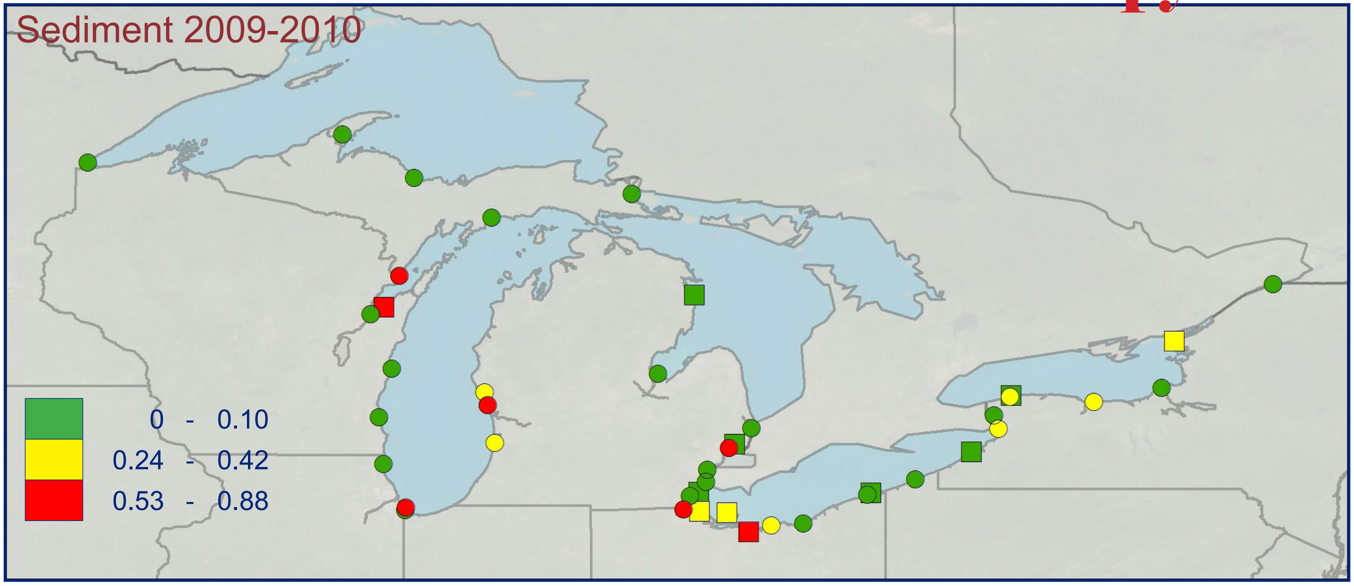


AOC Barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (ng/g lipid) among AOCs. Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.

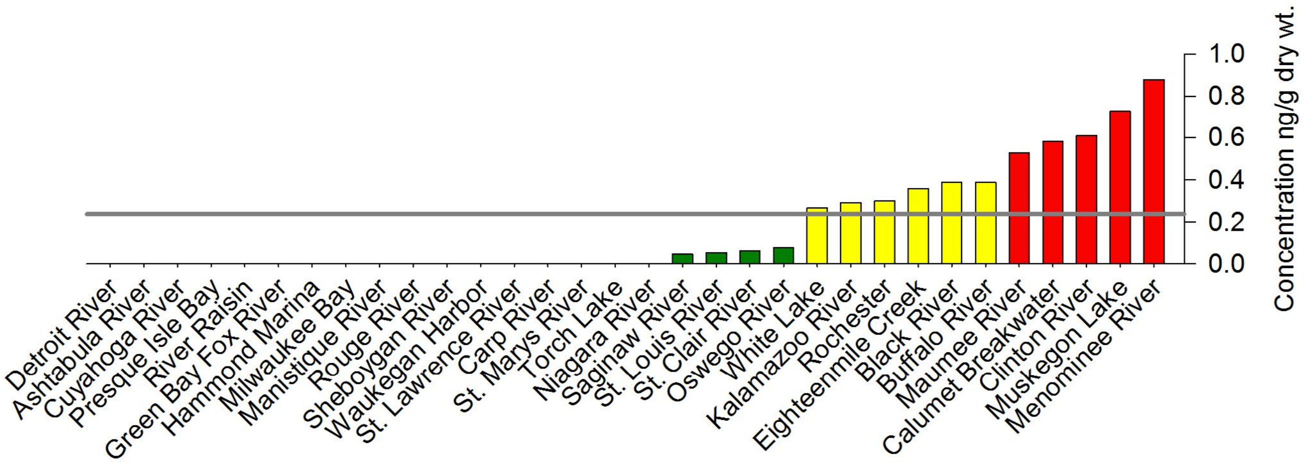




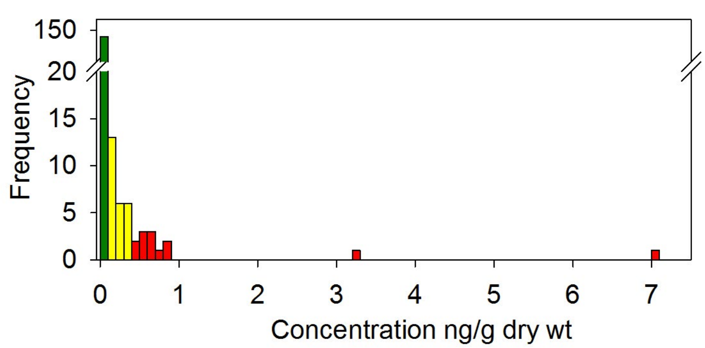
Historic data. Mussel tissue concentration (ng/g lipid) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

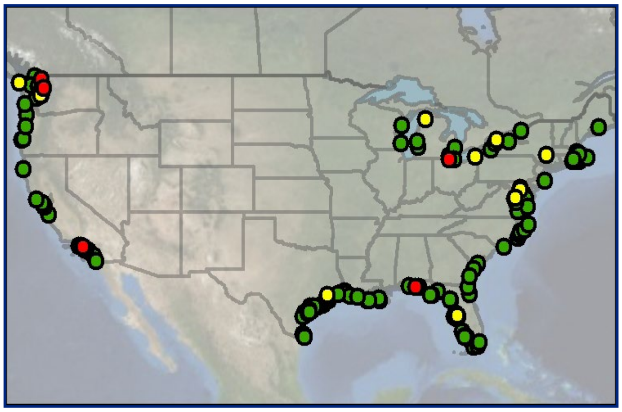


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (ng/g dry wt.).



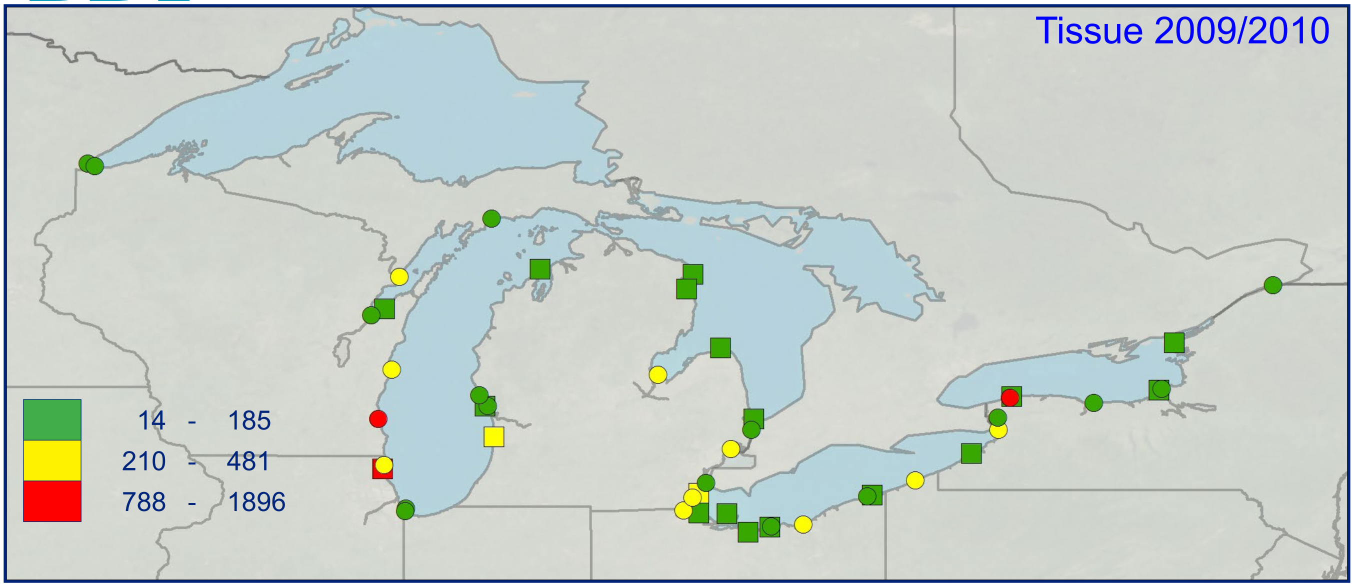
AOC barchart: Comparison of AOC contaminant concentrations in sediment (ng/g dry wt.). Where relevant reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



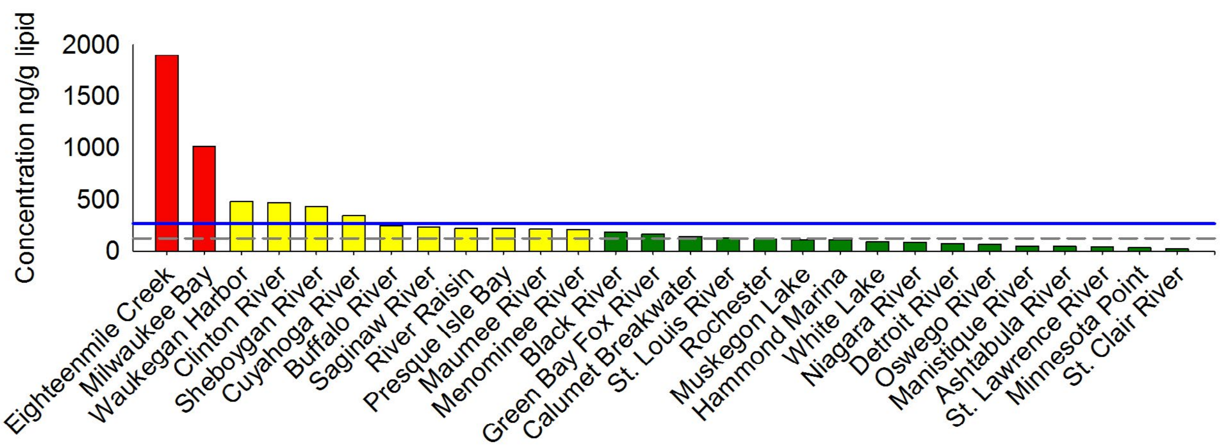


National frequency plot and sediment map. Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; ng/g dry wt.).

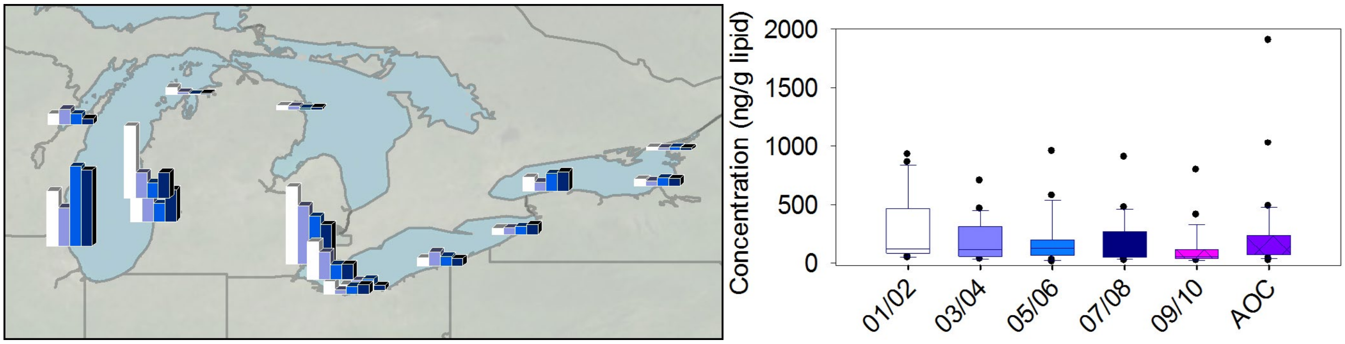
DDT



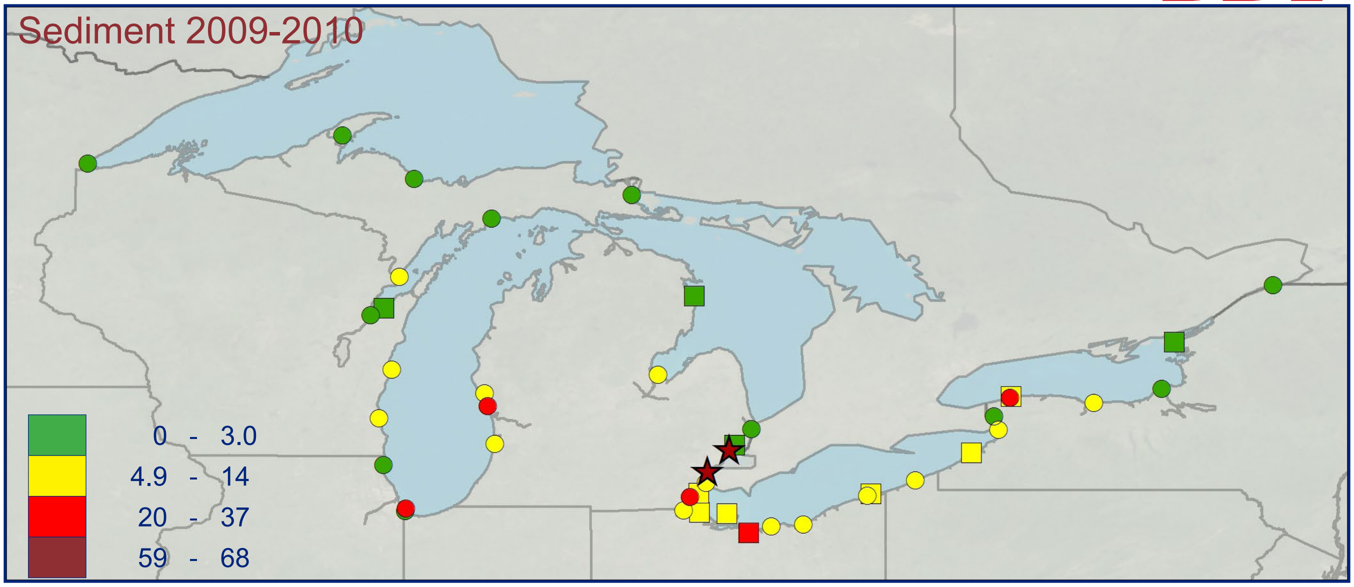
Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (ng/g lipid) in dressenid mussels.



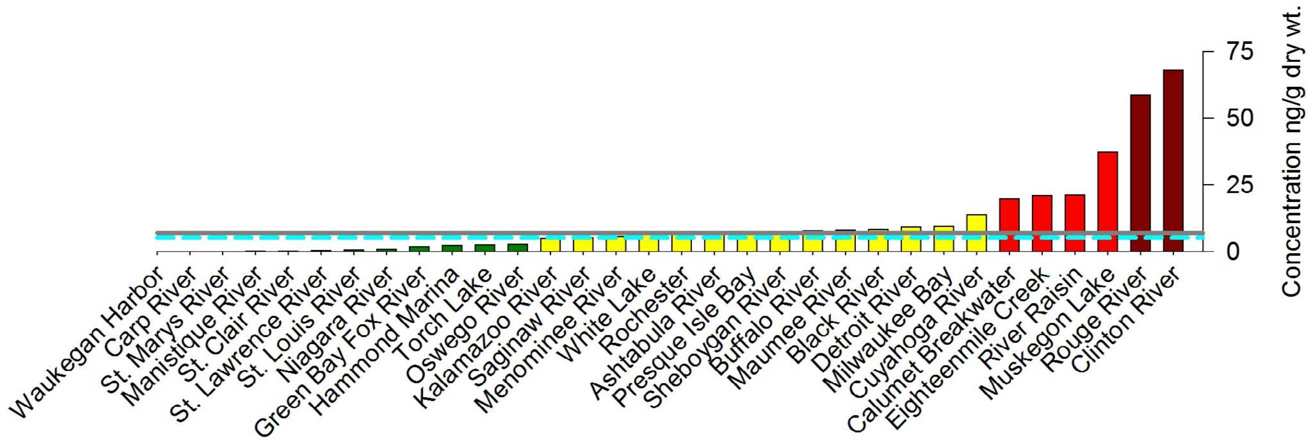
AOC Barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (ng/g lipid) among AOCs. Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.



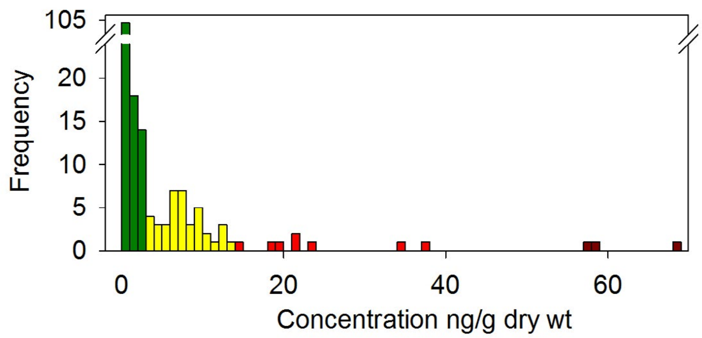
Historic data. Mussel tissue concentration (ng/g lipid) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

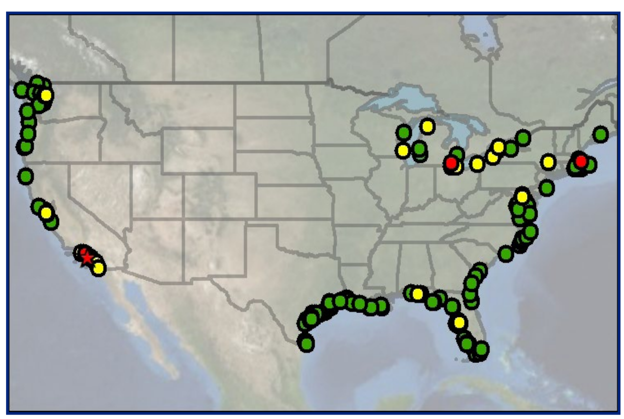


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (ng/g dry wt.).



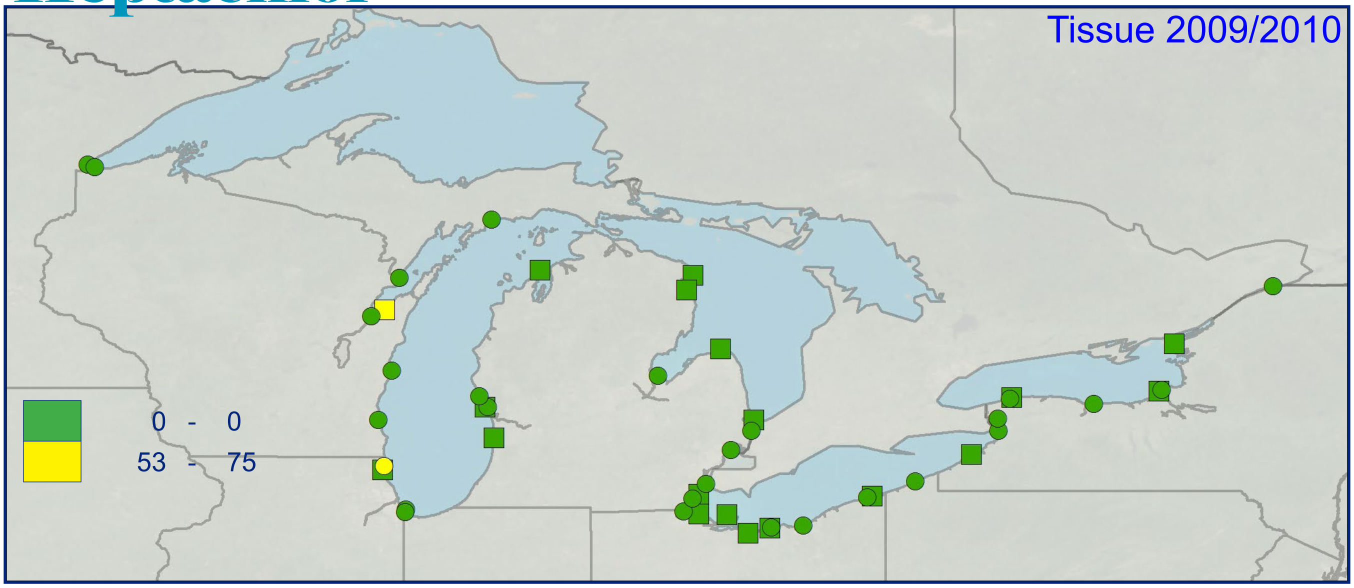
AOC barchart: Comparison of AOC contaminant concentrations in sediment (ng/g dry wt.). Where relevant reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



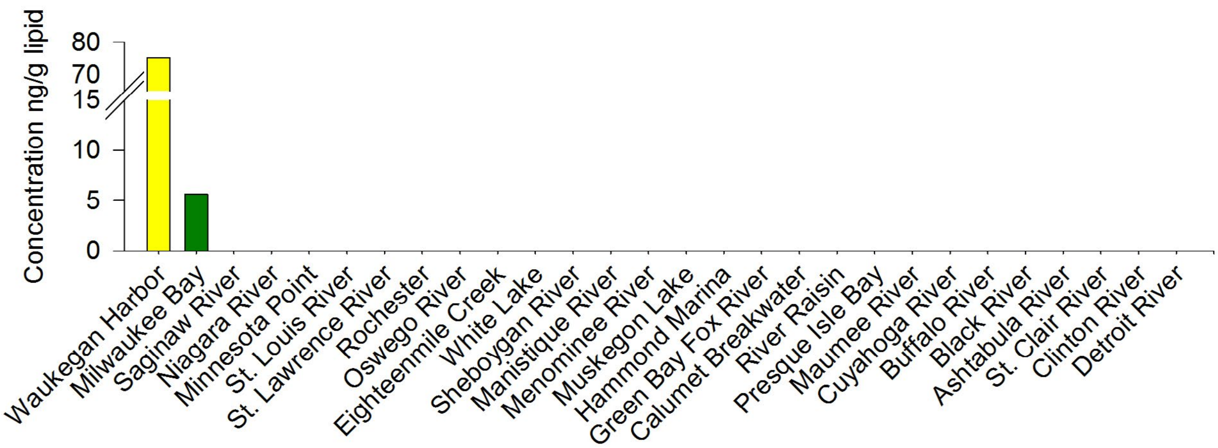


National frequency plot and sediment map. Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; ng/g dry wt.).

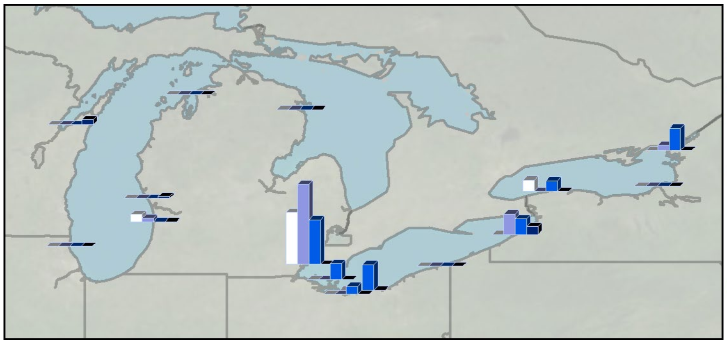
Heptachlor

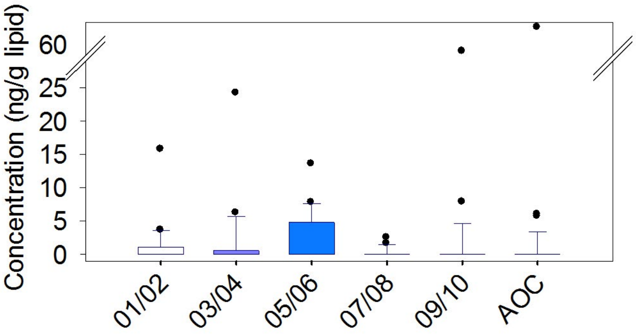


Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (ng/g lipid) in dressenid mussels.



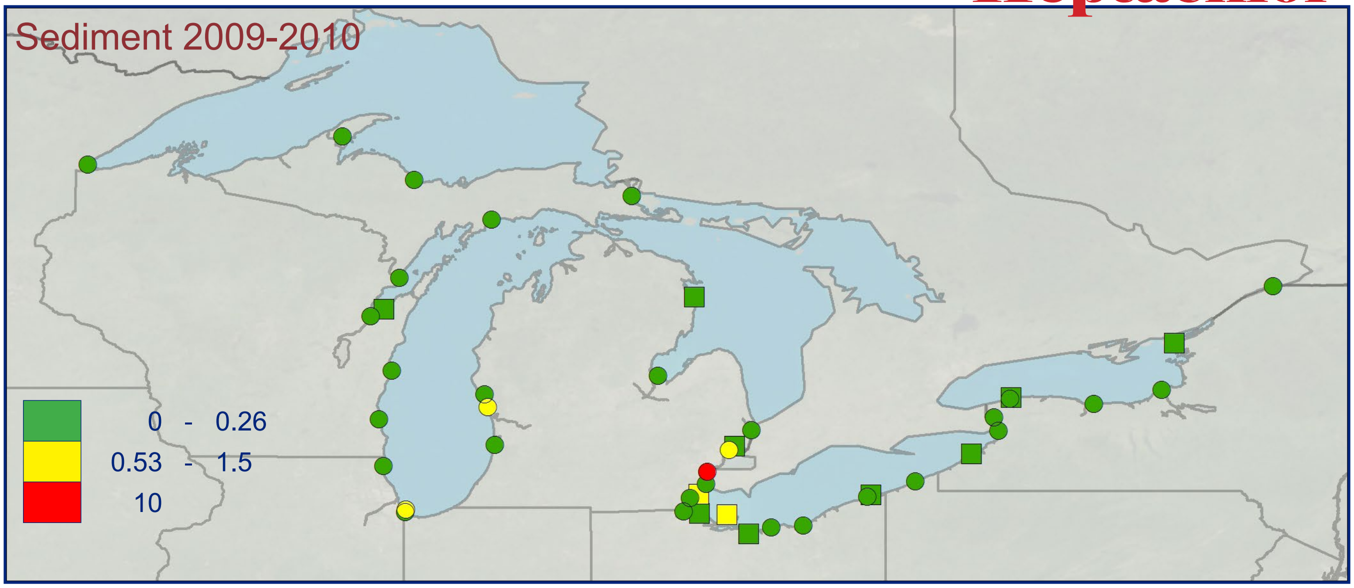
AOC Barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (ng/g lipid) among AOCs. Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.



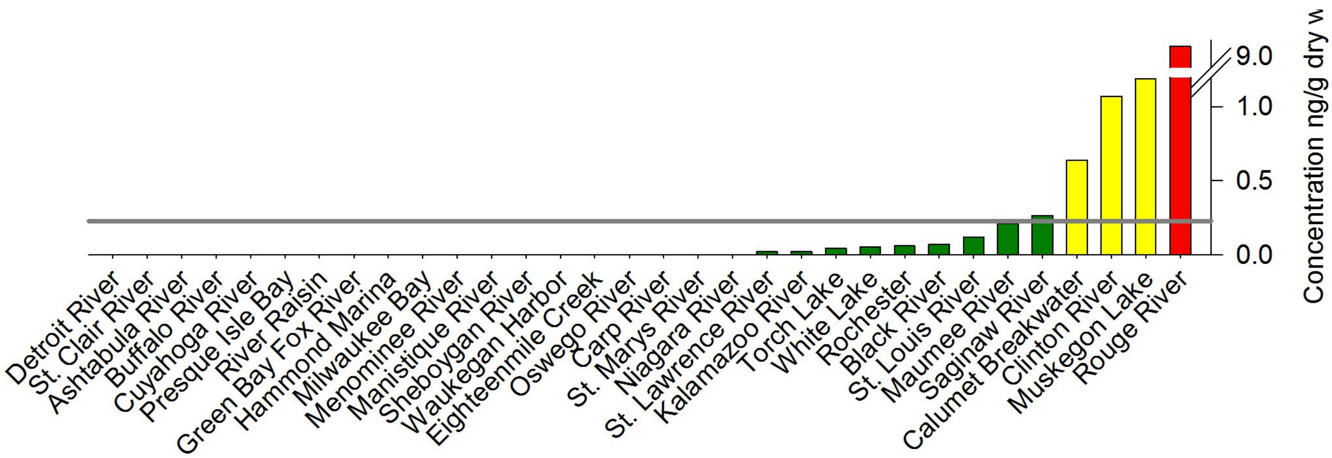


Historic data. Mussel tissue concentration (ng/g lipid) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

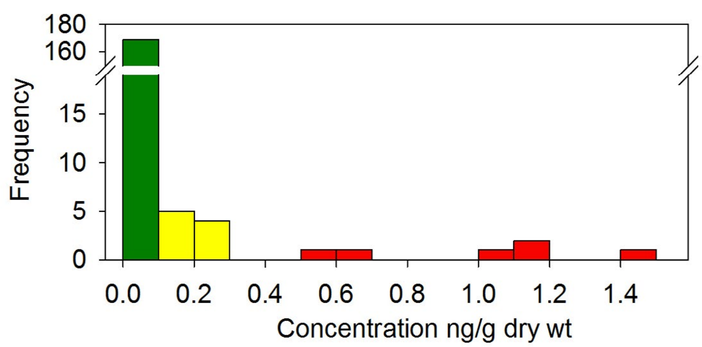
Heptachlor

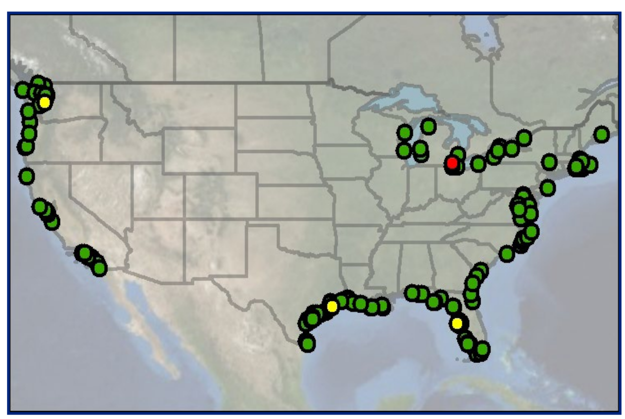


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (ng/g dry wt.).



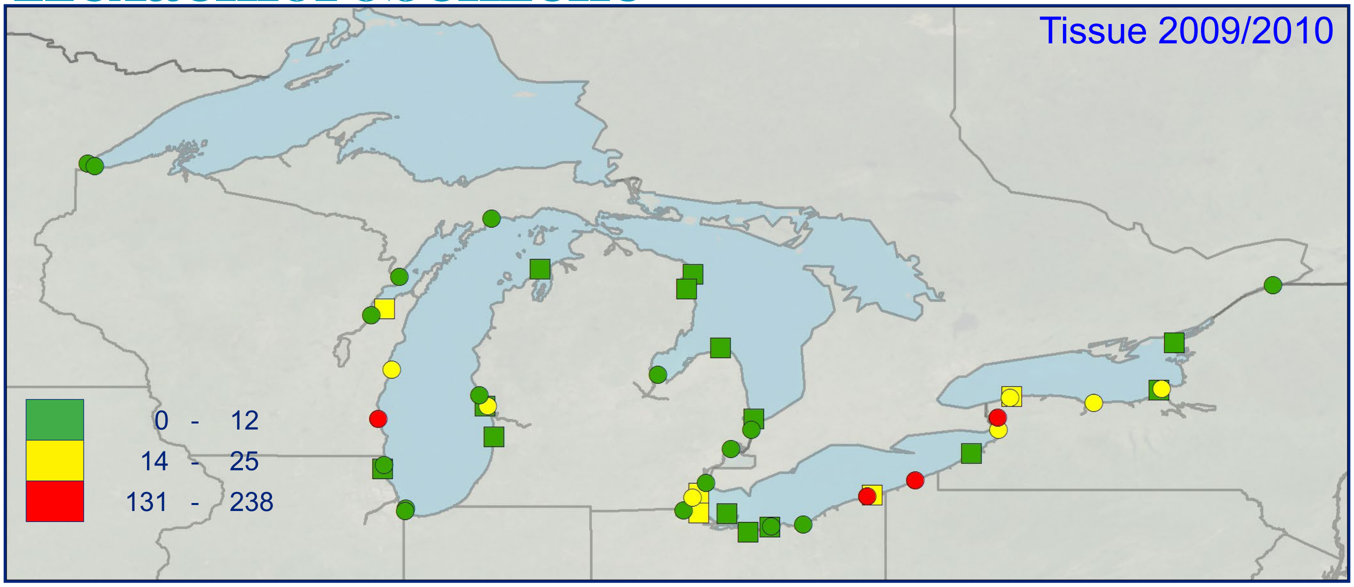
AOC barchart: Comparison of AOC contaminant concentrations in sediment (ng/g dry wt.). Where relevant reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



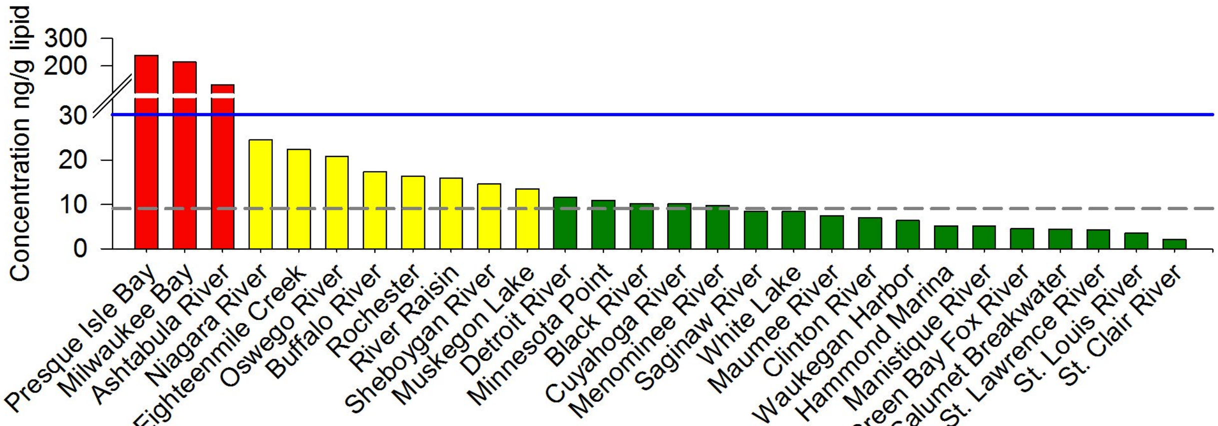


National frequency plot and sediment map. Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; ng/g dry wt.). Extreme outliers omitted.

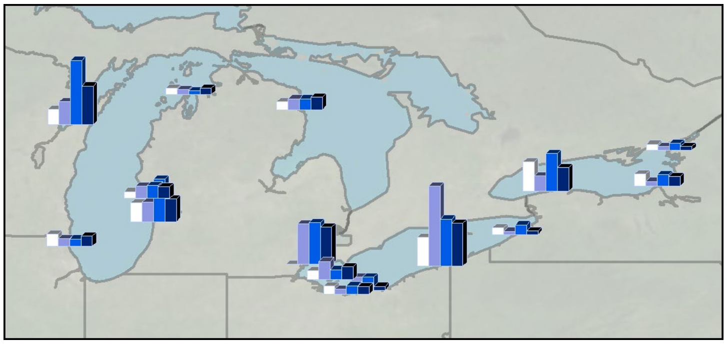
Hexachlorobenzene

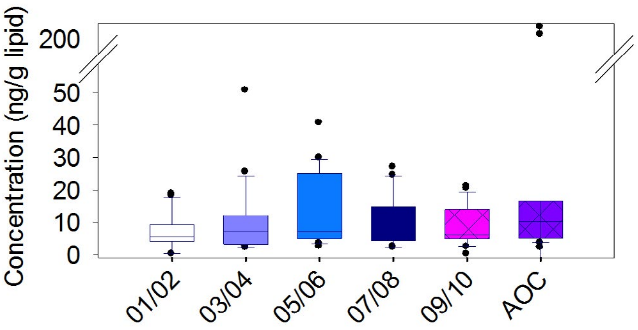


Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (ng/g lipid) in dressenid mussels.



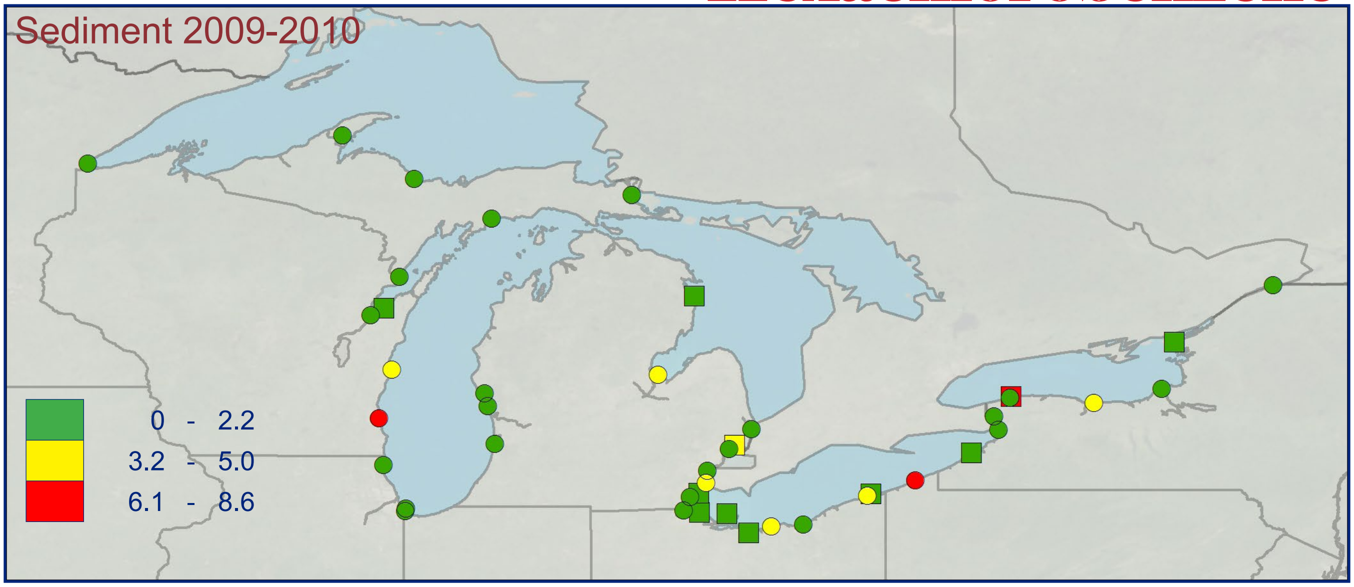
AOC Barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (ng/g lipid) among AOCs. Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.



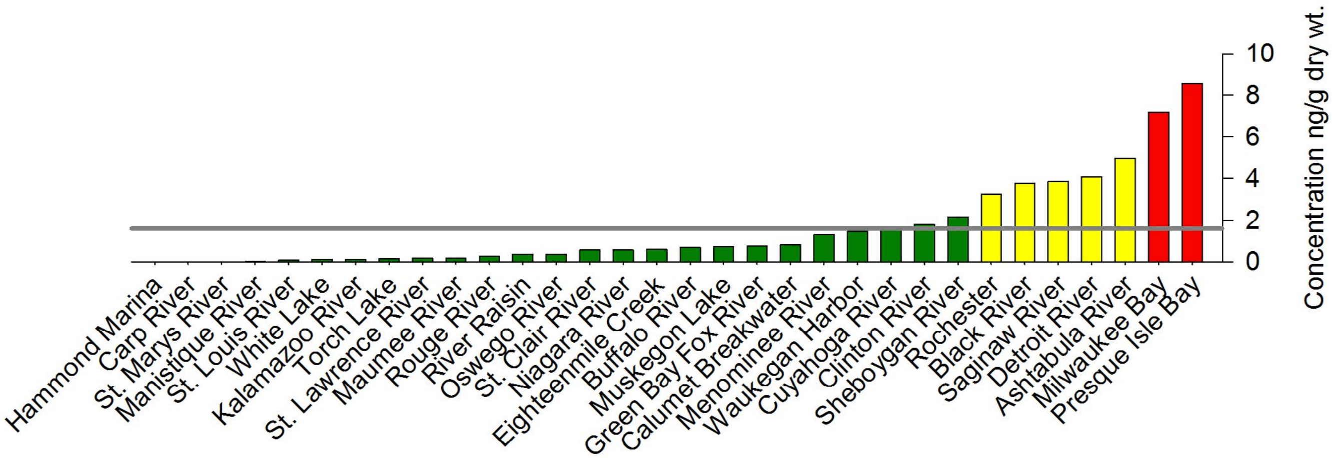


Historic data. Mussel tissue concentration (ng/g lipid) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

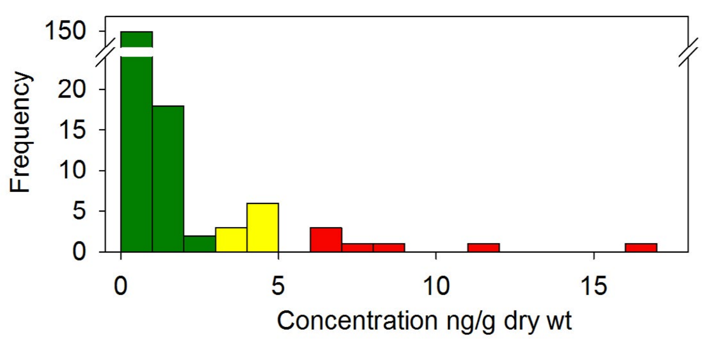
Hexachlorobenzene

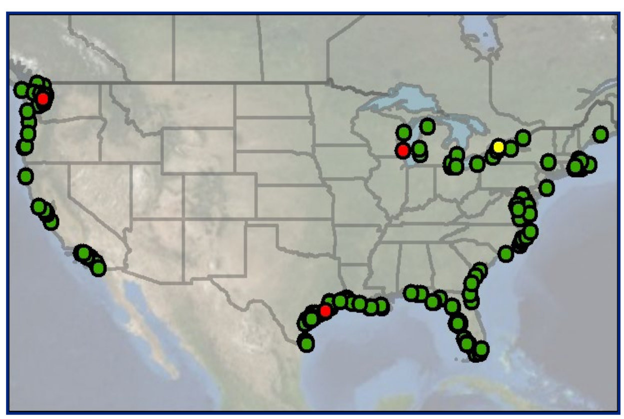


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (ng/g dry wt.).



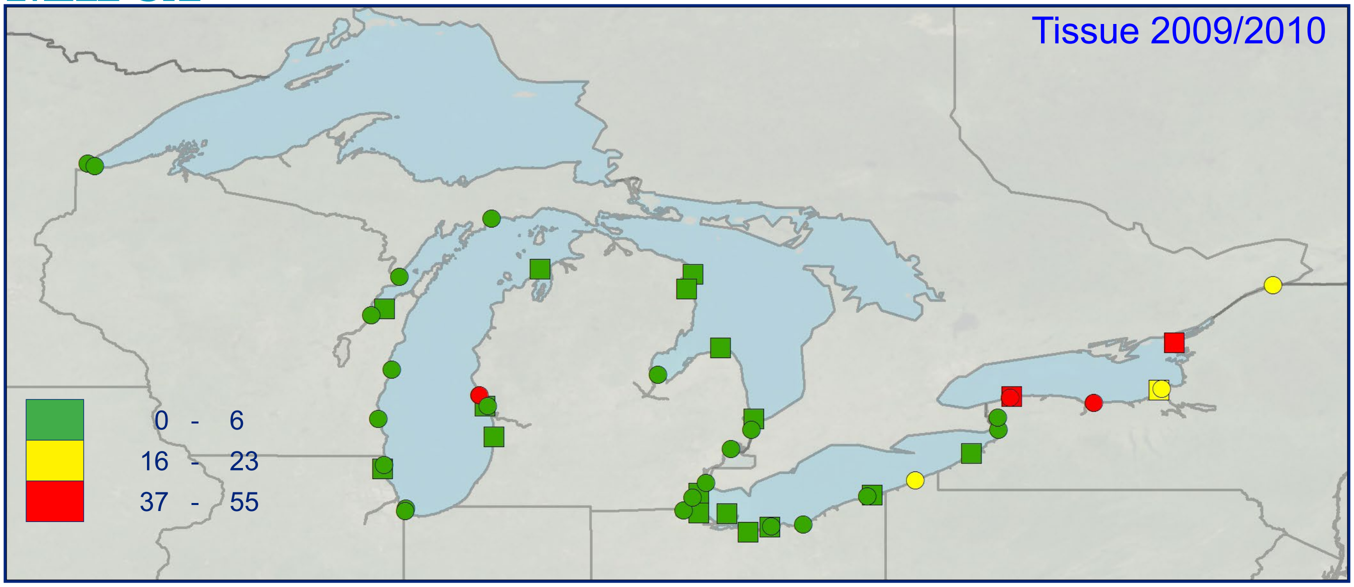
AOC barchart: Comparison of AOC contaminant concentrations in sediment (ng/g dry wt.). Where relevant reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



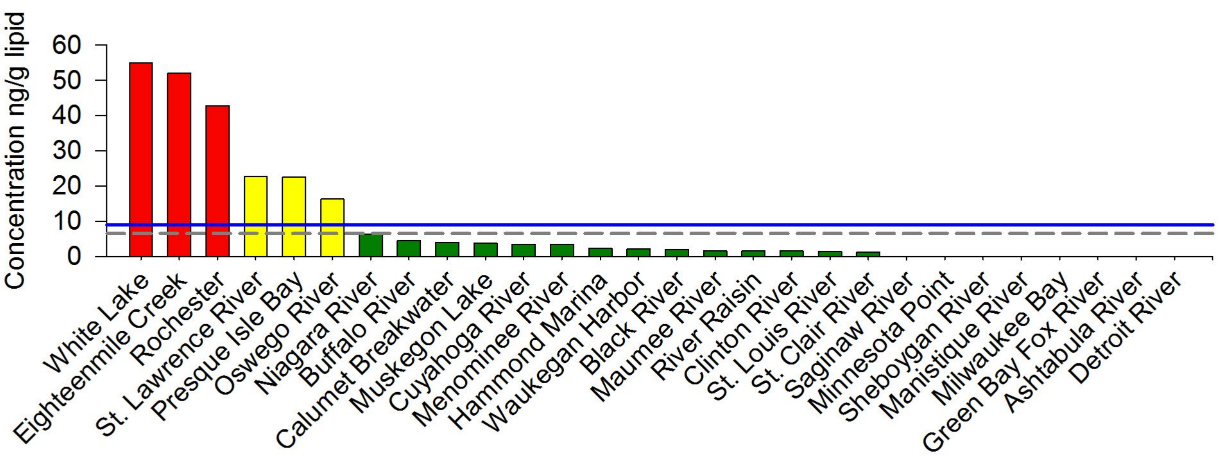


National frequency plot and sediment map. Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; ng/g dry wt.).

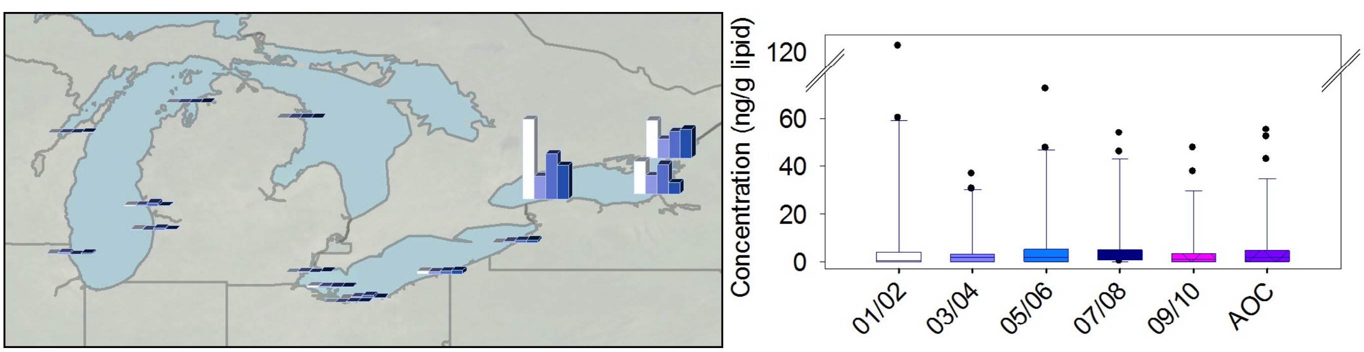
Mirex



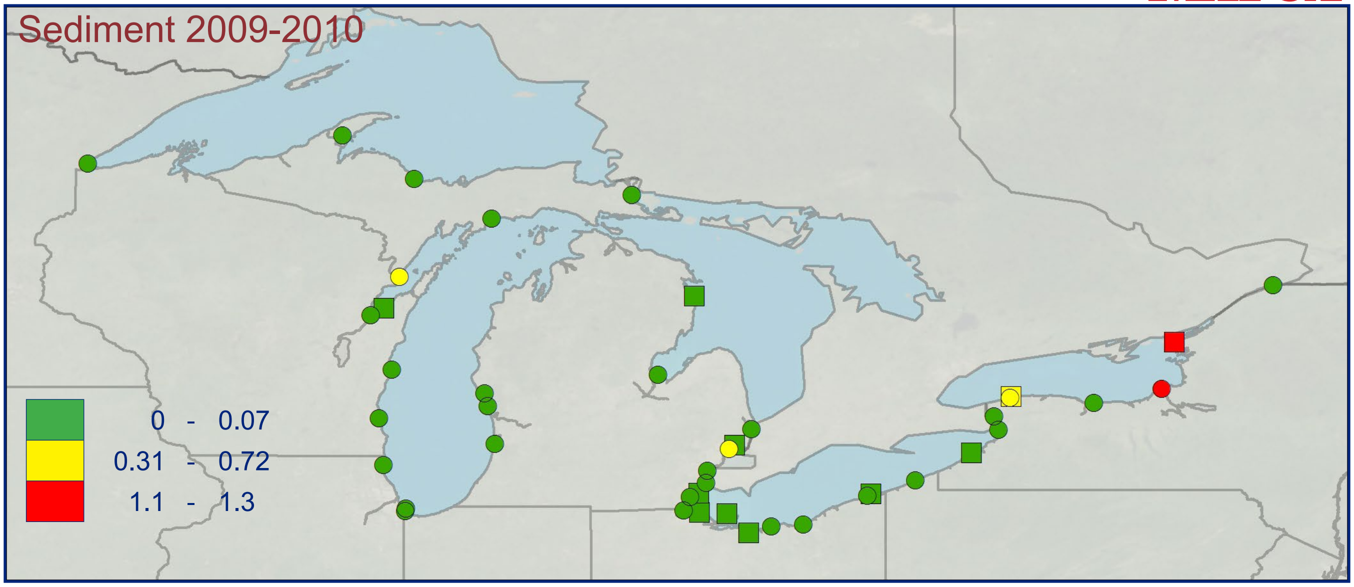
Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (ng/g lipid) in dressenid mussels.



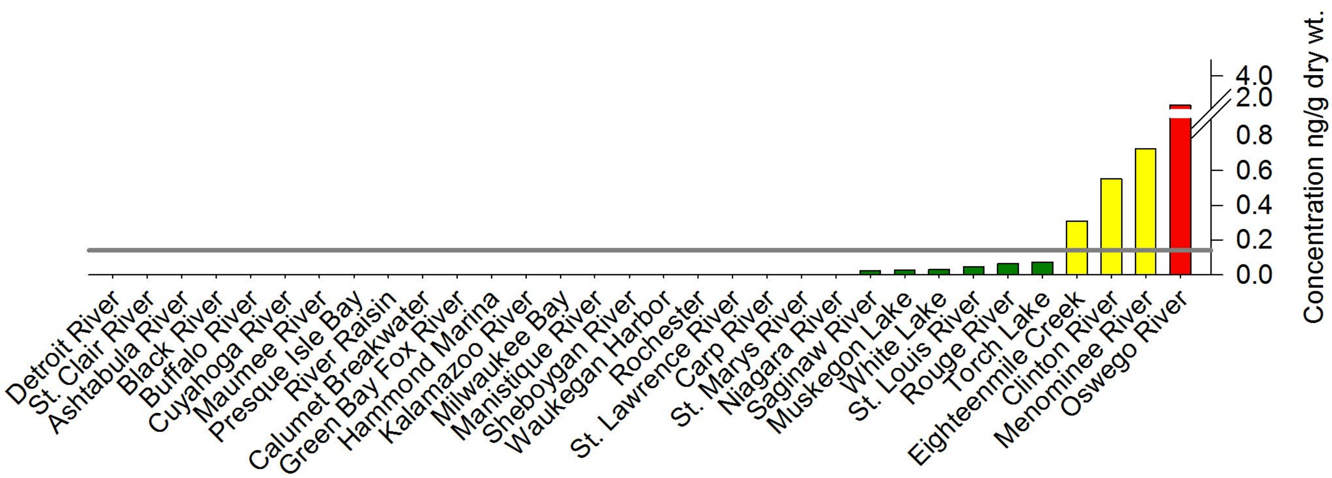
AOC Barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (ng/g lipid) among AOCs. Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.



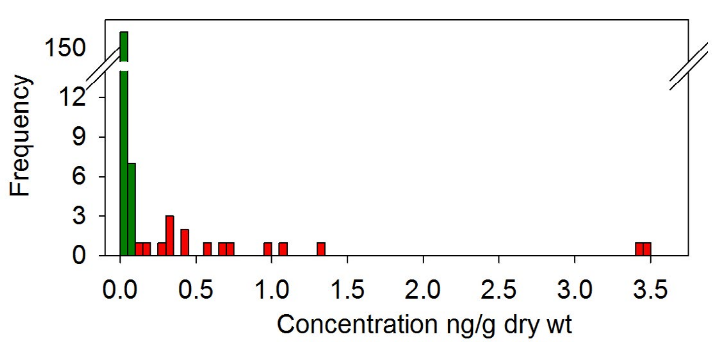
Historic data. Mussel tissue concentration (ng/g lipid) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

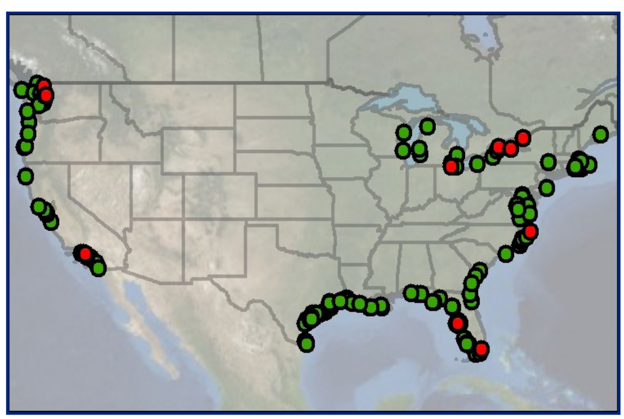


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (ng/g dry wt.).



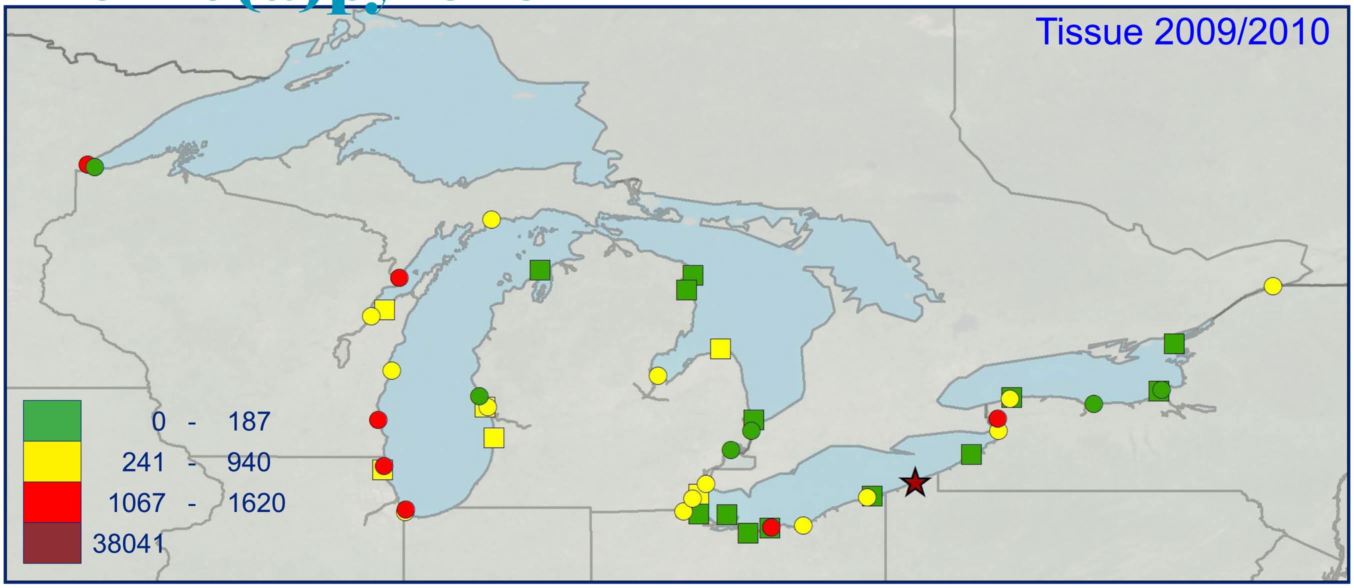
AOC barchart: Comparison of AOC contaminant concentrations in sediment (ng/g dry wt.). Where relevant reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



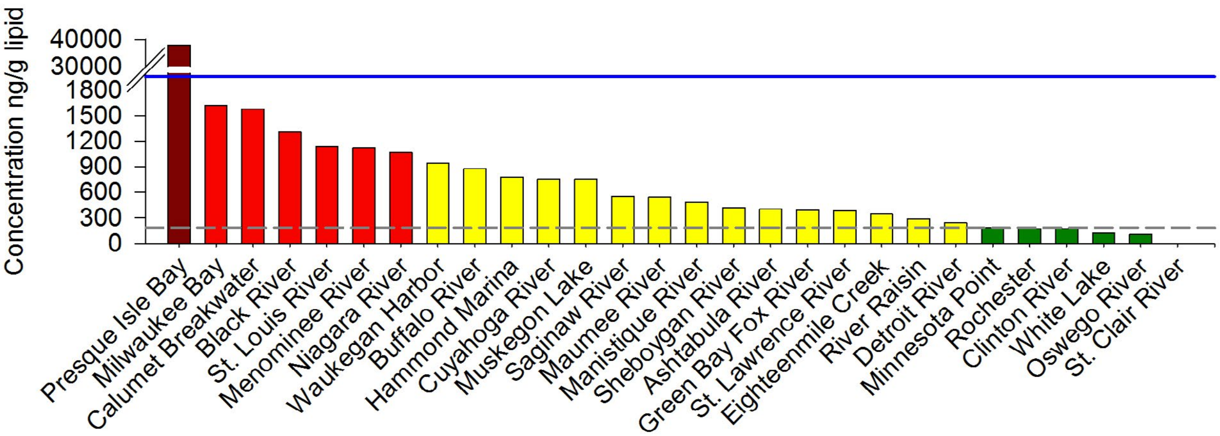


National frequency plot and sediment map. Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; ng/g dry wt.).

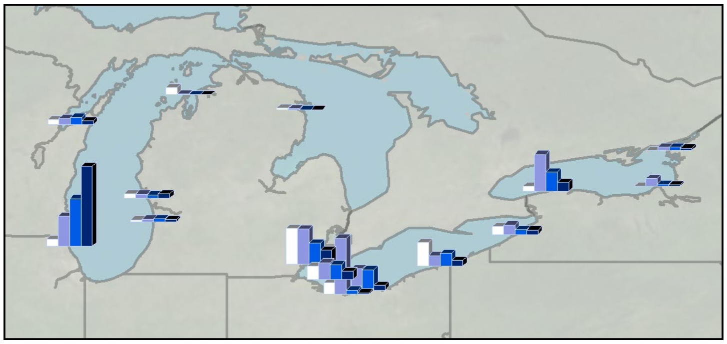
Benzo(a)pyrene

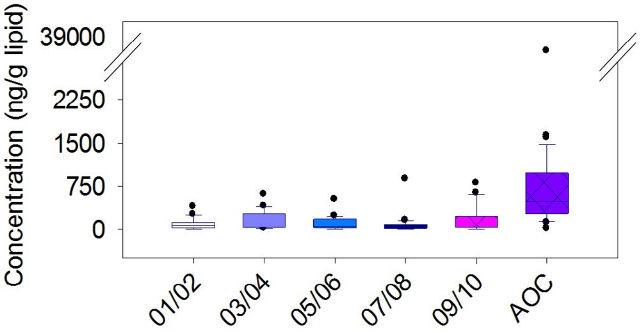


Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (ng/g lipid) in dressenid mussels.



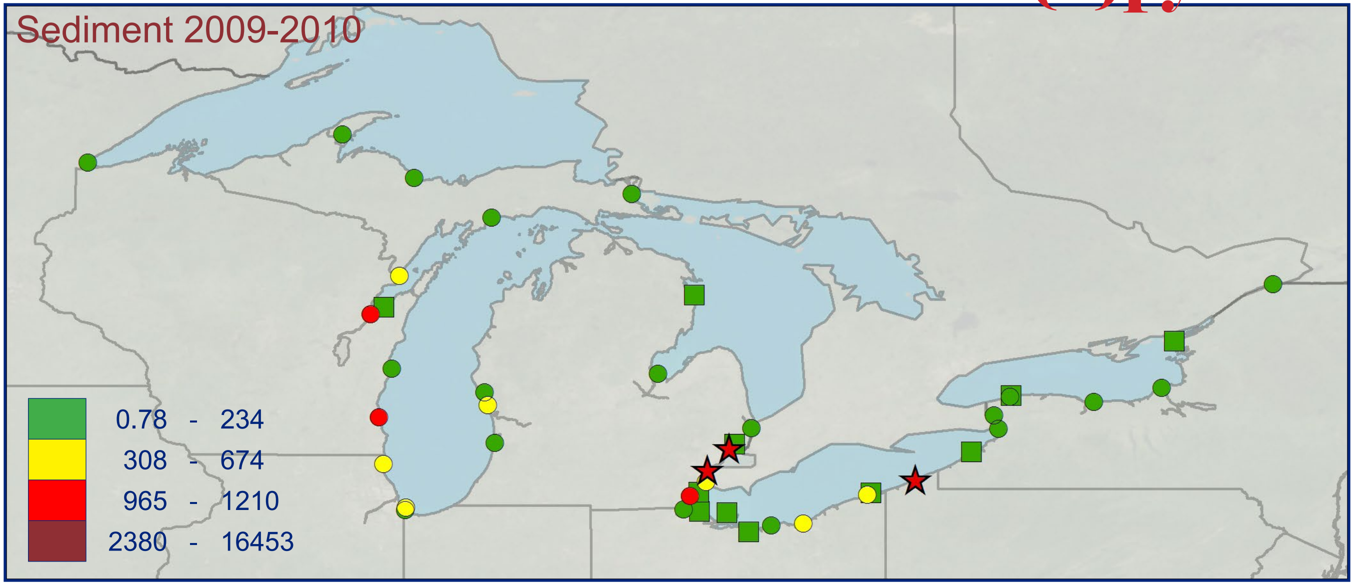
AOC Barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (ng/g lipid) among AOCs. Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.



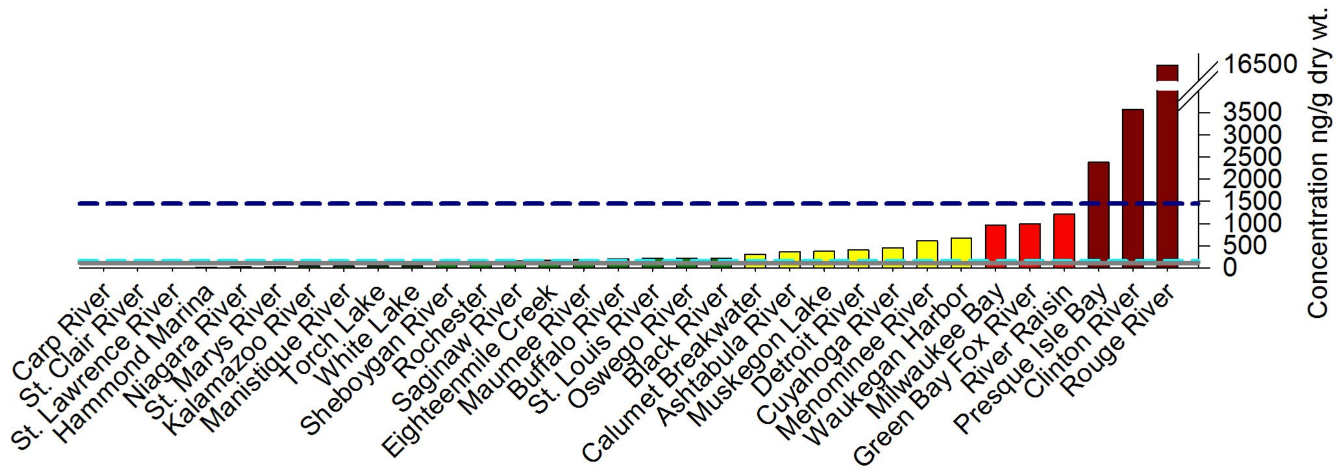


Historic data. Mussel tissue concentration (ng/g lipid) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

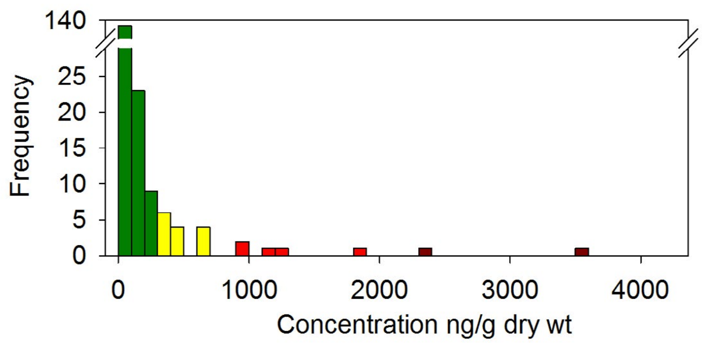
Benzo(a)pyrene

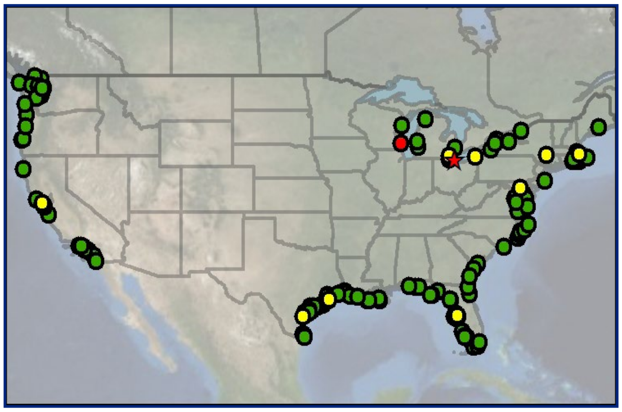


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (ng/g dry wt.).



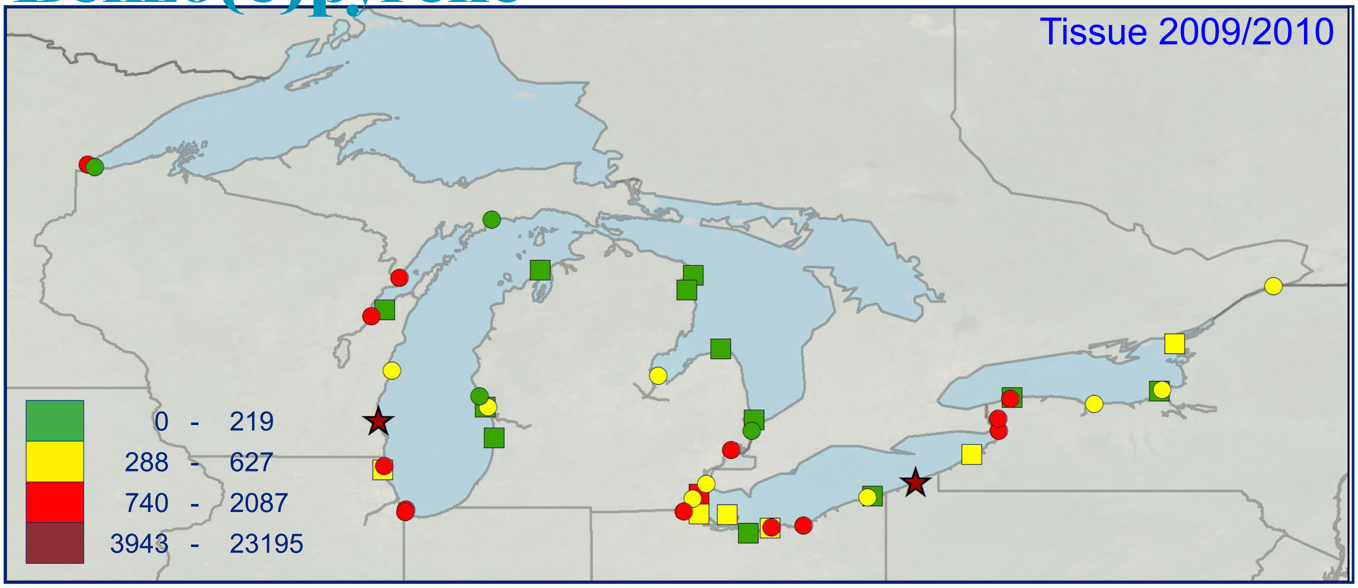
AOC barchart: Comparison of AOC contaminant concentrations in sediment (ng/g dry wt.). Where relevant reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.



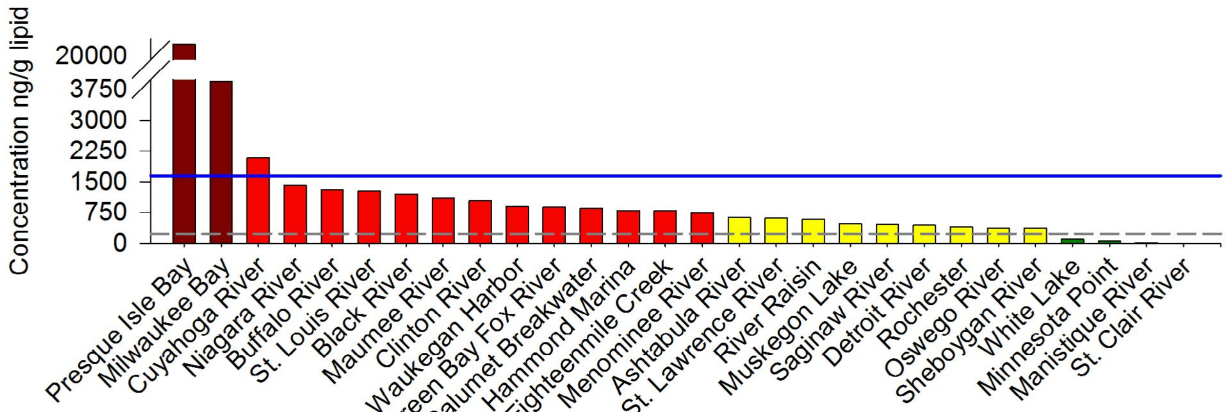


National frequency plot and sediment map. Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; ng/g dry wt.). Extreme outliers omitted.

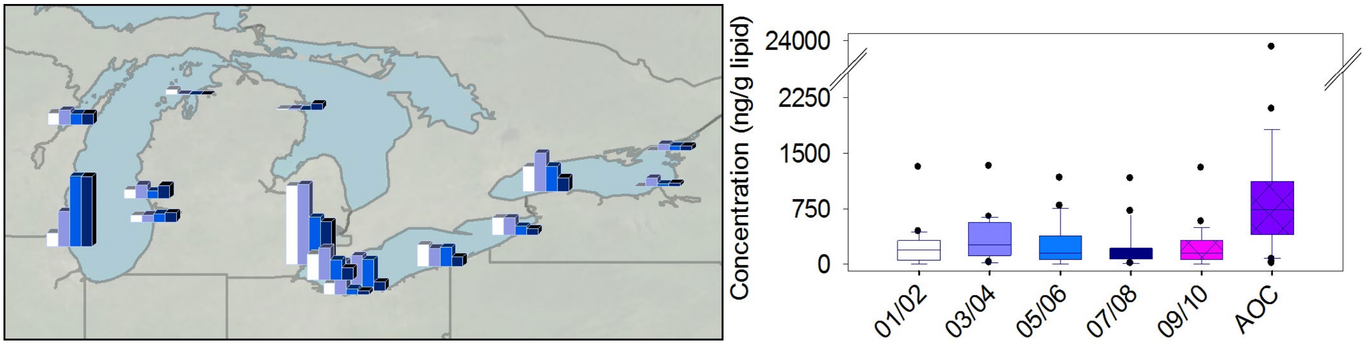
Benzo(e)pyrene



Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (ng/g lipid) in dressenid mussels.

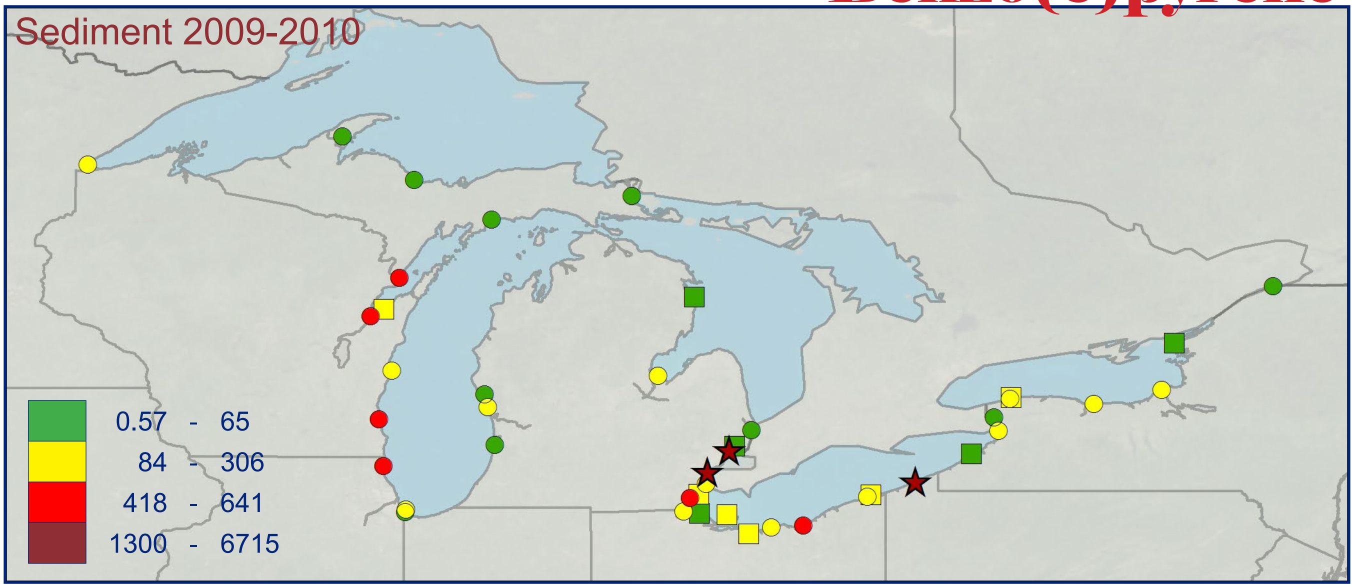


AOC Barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (ng/g lipid) among AOCs. Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.

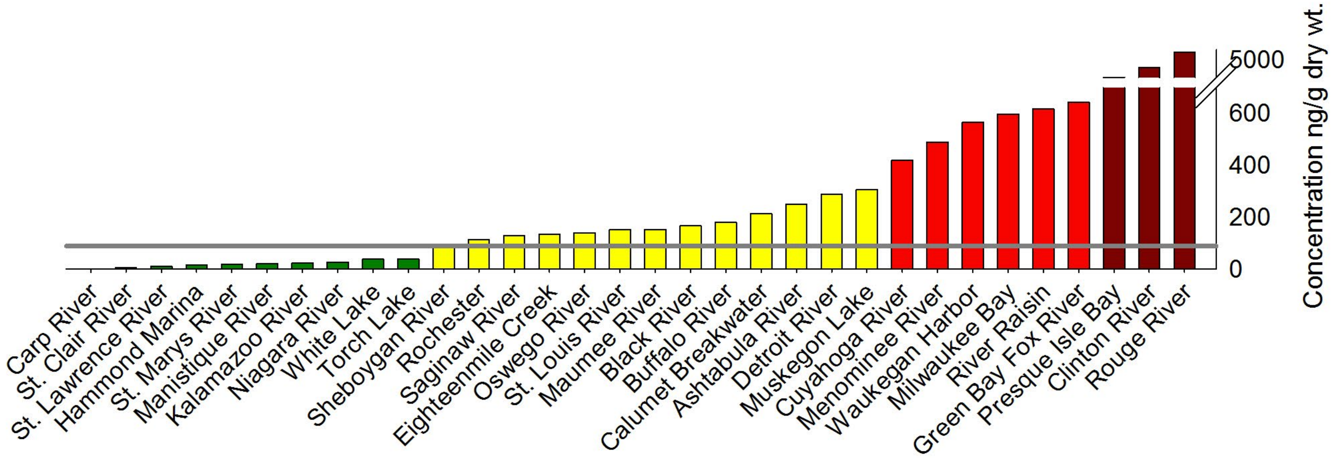


Historic data. Mussel tissue concentration (ng/g lipid) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

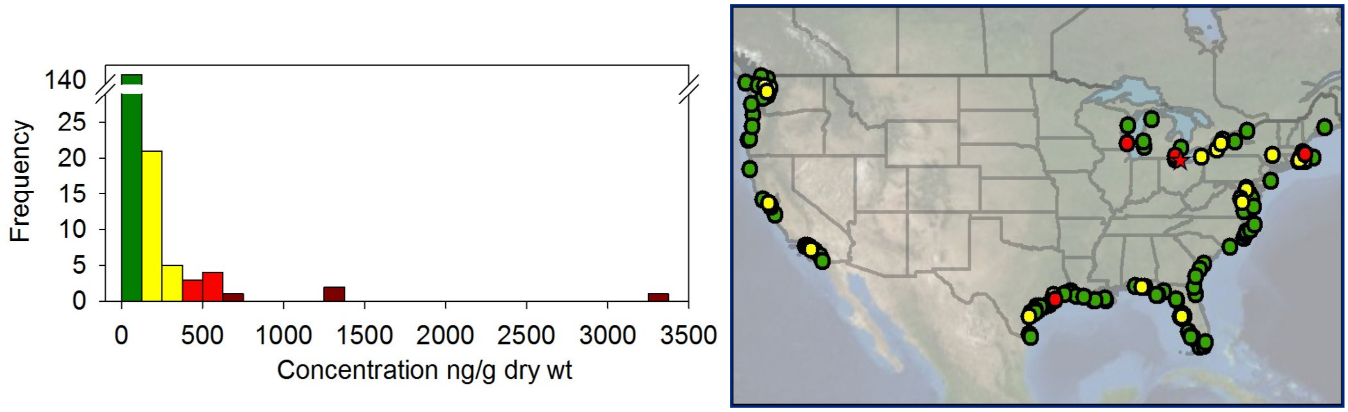
Benzo(e)pyrene



Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (ng/g dry wt.).

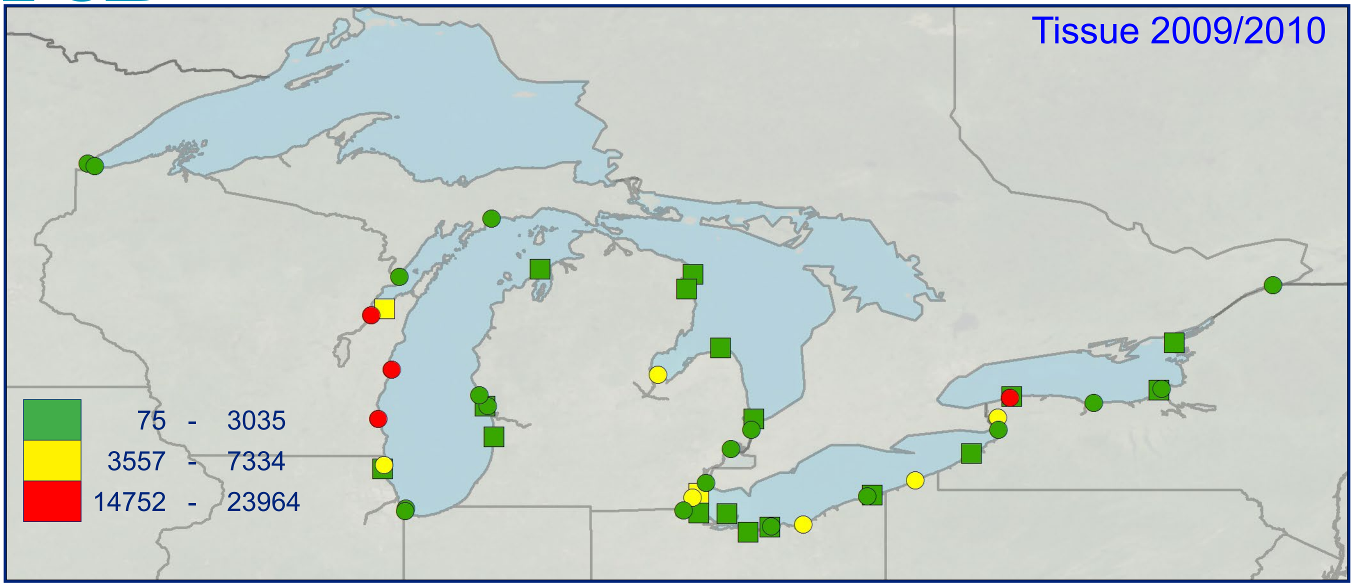


AOC barchart: Comparison of AOC contaminant concentrations in sediment (ng/g dry wt.). Where relevant reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.

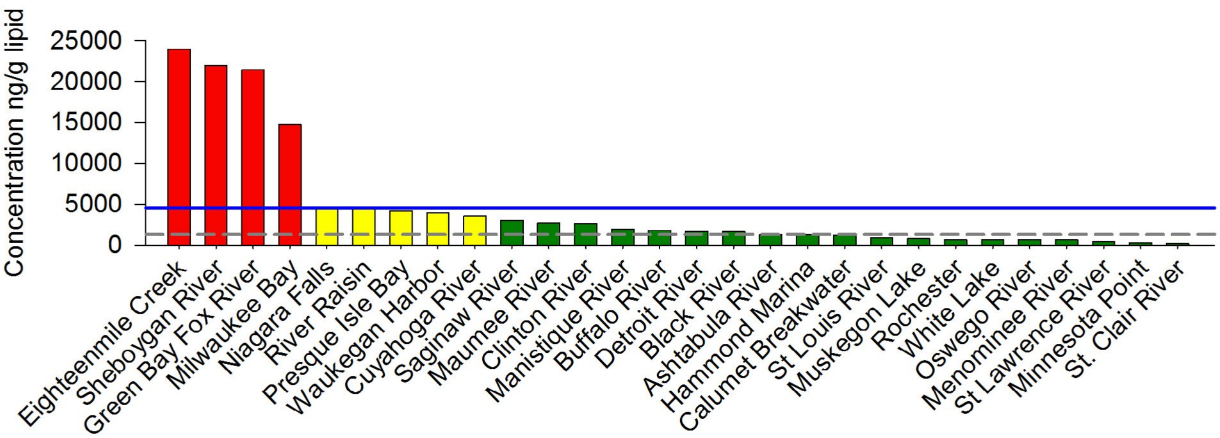


National frequency plot and sediment map. Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; ng/g dry wt.). Extreme outliers omitted.

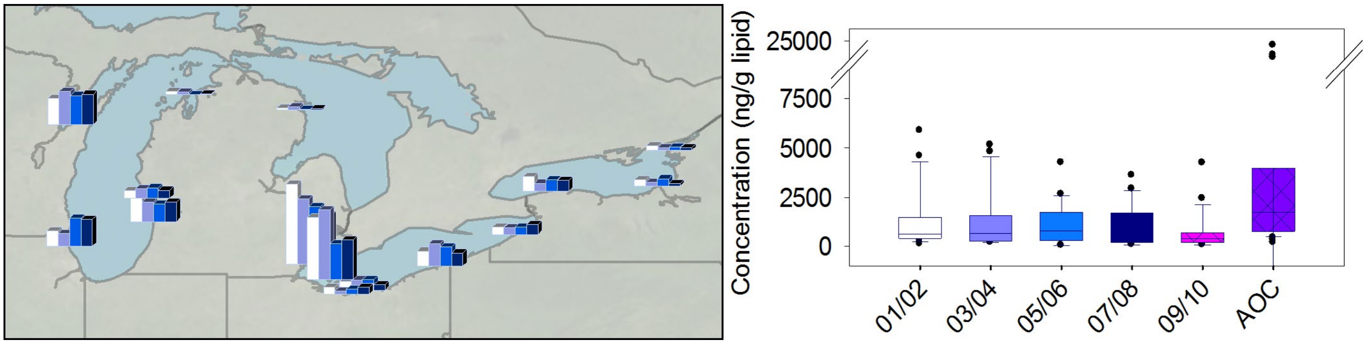
PCB



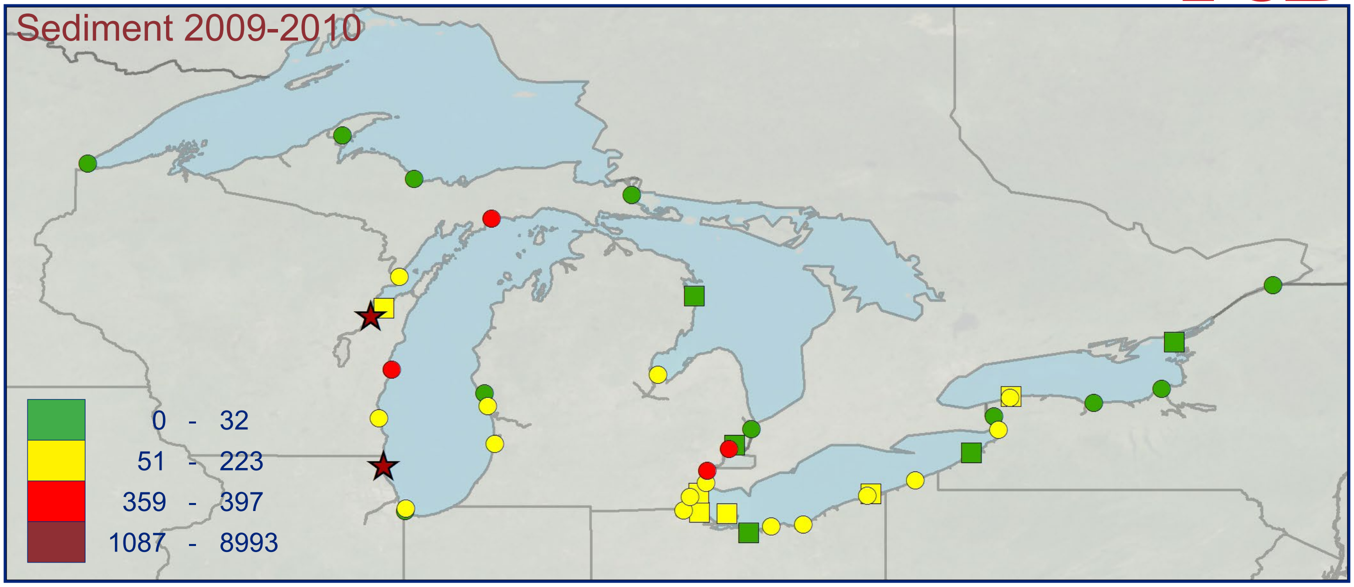
Tissue map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site contaminant concentrations (ng/g lipid) in dressenid mussels.



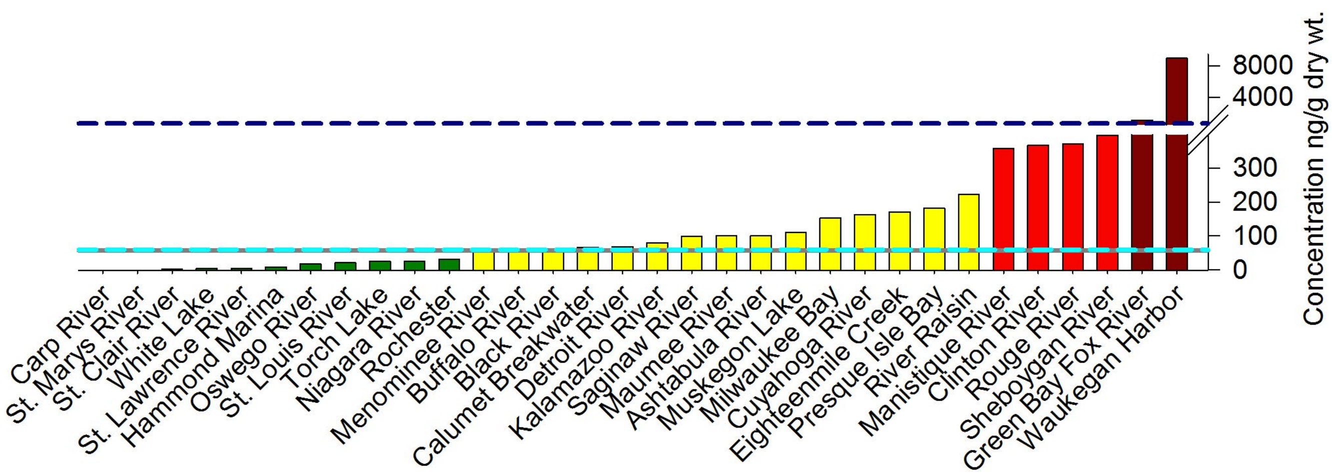
AOC Barchart: Comparison of AOC contaminant concentrations in dreissenid mussels (ng/g lipid) among AOCs. Reference lines represent mean AOC (solid line) and reference site (dashed line) concentrations.



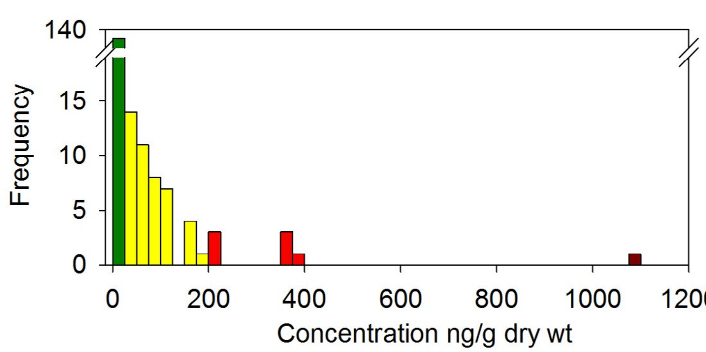
Historic data. Mussel tissue concentration (ng/g lipid) from reference sites collected from 2001- 2008 (map), and whisker plot of the mapped data in addition to reference and AOC sites collected in 2009/2010.

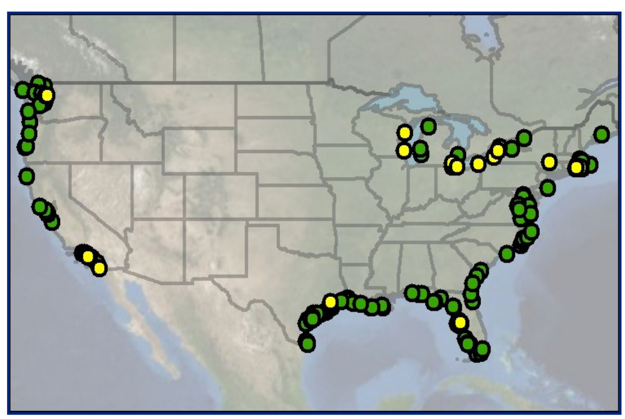


Sediment map: Categories low (●), medium (●) and high (●), and where applicable outlier (★), are used to characterize U.S. AOC (●) and reference (■) site sediment concentrations (ng/g dry wt.).



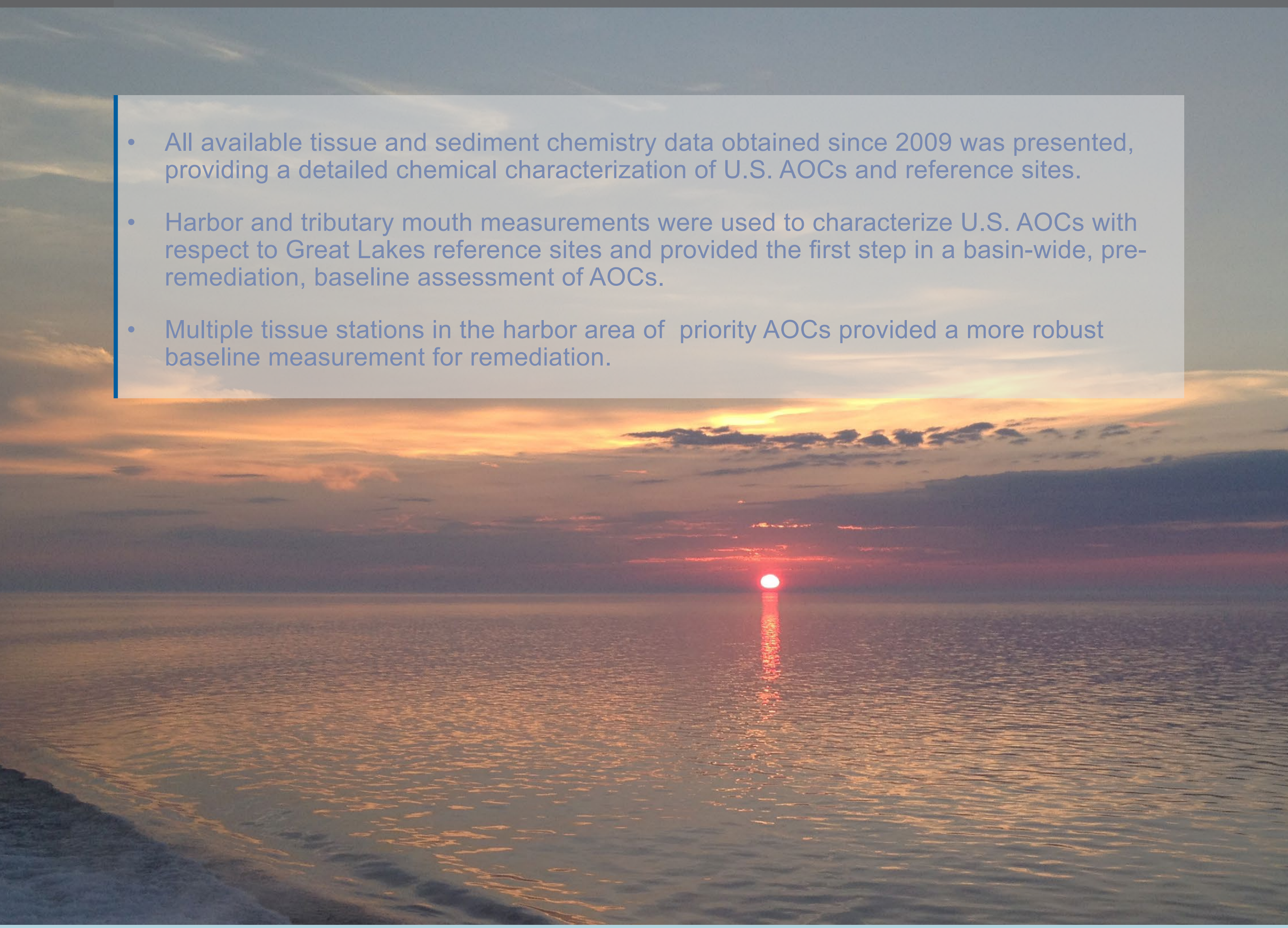
AOC barchart: Comparison of AOC contaminant concentrations in sediment (ng/g dry wt.). Where relevant reference lines representing PEC (black dashed line), TEC (blue dashed line), and reference site mean (gray solid line) are given.





National frequency plot and sediment map. Frequency plot of national (2006/2007) and Great Lakes (AOC and reference; 2009/2010) sediment data, and map of national sediment concentrations (2006/2007; ng/g dry wt.). Extreme outliers omitted.

Section 3: Site characterization



- All available tissue and sediment chemistry data obtained since 2009 was presented, providing a detailed chemical characterization of U.S. AOCs and reference sites.
- Harbor and tributary mouth measurements were used to characterize U.S. AOCs with respect to Great Lakes reference sites and provided the first step in a basin-wide, pre-remediation, baseline assessment of AOCs.
- Multiple tissue stations in the harbor area of priority AOCs provided a more robust baseline measurement for remediation.

Site Example

Basin location map: Depicts the location of a U.S. AOC with respect to the Great Lakes basin.

Legend

Low 🟢 Medium 🟡 High 🔴 Outlier ★

Analyte (µg/g dry)	Baseline Tissue		Baseline Sediment		Sediment 1	Sediment 2	Tissue 1	Tissue 2	Tissue 3
Arsenic	5.57	Low	1.65	Low	0.73	1.09	7.47	7.6	
Cadmium	0.70	Low	0.00	Low	0.00	0.00	1.7	1.72	
Copper	6.32	Low	3.88	Low	1.66	2.82	26.2	108	
Lead	0.34	Low	11.70	Low	6.41	10.20	3.05	4.24	
Methyl Mercury	0.03	Low	0.00	Low	0.00	0.00			
Mercury	0.04	Low	0.02	Low	0.01	0.01	0.0729	0.0768	
Silver	0.06		0.22	Medium	0.00	0.33	0.0234	0.0515	
Zinc	49.20		24.20	Low	9.48	19.50	70.3	80.2	

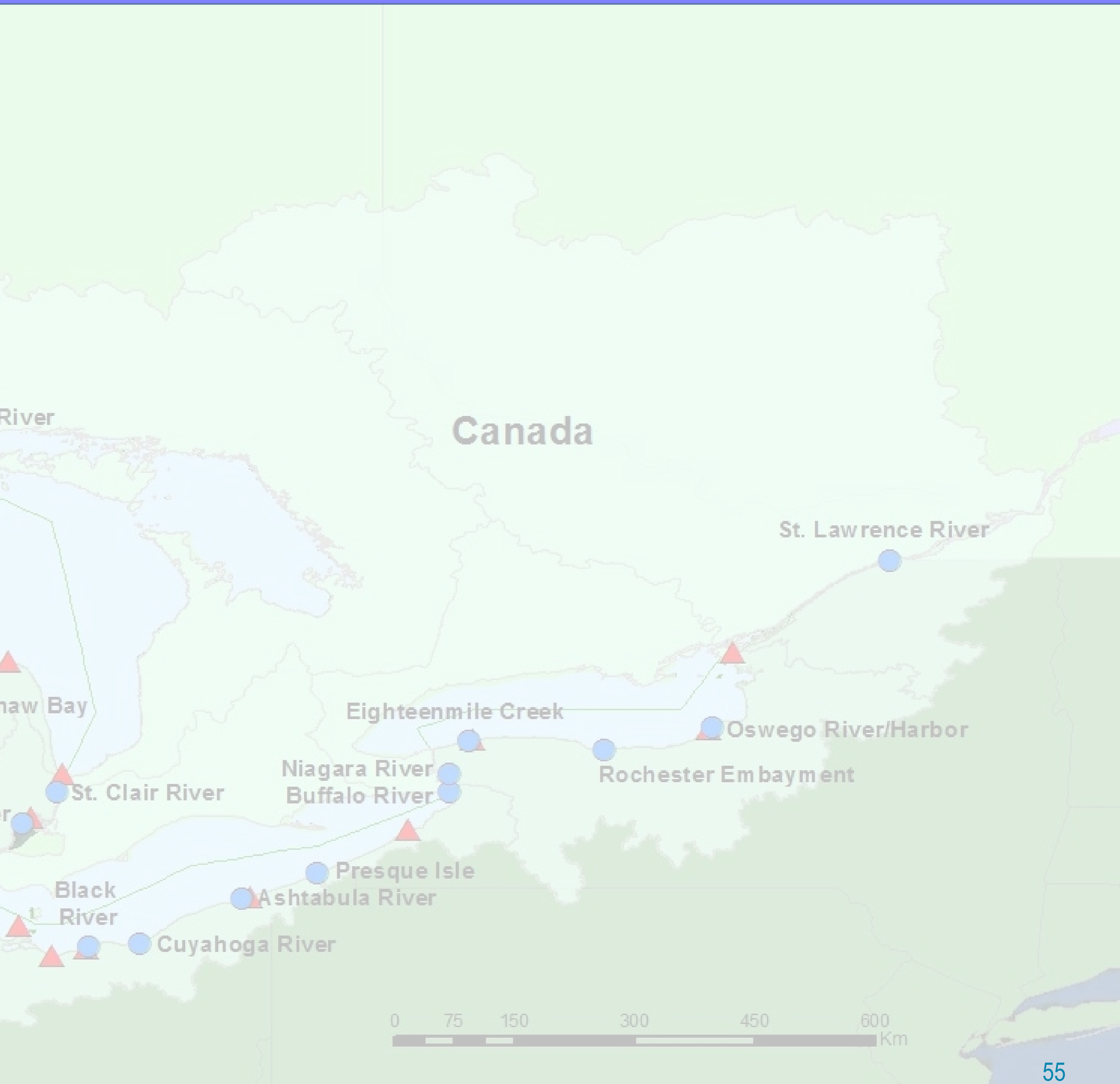
Each tissue station represents data from a composite of 50 - 100 mussels.

Analyte tables: Concentrations and associated ranking from the previous section for baseline tissue and sediment sites are presented along with all additional measurements from 2010 (2 sediment stations for some U.S. AOCs in western Great Lakes) and from 2011 (additional tissue stations in priority U.S. AOCs).

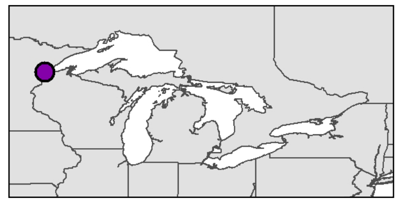
Analyte (ng/g dry)	Baseline Tissue		Baseline Sediment		Sediment 1	Sediment 2	Tissue 1	Tissue 2	Tissue 3
Alpha-Chlordane	5.86	Low	0.00	Low	0.00	0.00	0.49	0.66	
Chlorpyrifos	0.00	Low	0.00	Low	0.00	0.00	0	0	
DDT	47.73	Low	0.30	Low	0.07	0.04	3.43	4.54	
Heptachlor	0.00	Low	0.00	Low	0.02	0.00	1.35	2.15	
Hexachlorobenzene	5.08	Low	0.03	Low	0.00	0.00	0.44	0.52	
Mirex	0.00	Low	0.00	Low	0.02	0.00	0	0	
Benzo[a]pyrene	487.29	Medium	33.26	Low	6.71	6.91	5.9	8.7	
Benzo[e]pyrene	16.57	Low	21.72	Low	4.64	5.71	7.1	10.2	
PCB	1976.91	Low	359.00	High	5.05	13.80	116.4	147.02	

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

U.S. Areas of Concern


Canada
St. Lawrence River
Eighteenmile Creek
Oswego River/Harbor
Rochester Embayment
Niagara River
Buffalo River
St. Clair River
Presque Isle
Ashtabula River
Black River
Cuyahoga River
0 75 150 300 450 600
Km

St. Louis River



Legend

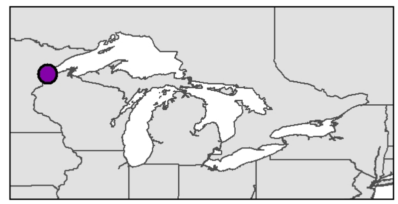
Low | Medium | High | Outlier

Metals (µg/g dry wt.)	Baseline - 2009/10** Tissue	Baseline - 2009/10** Sediment	Sediment - 2010	Sediment - 2010	Tissue - 2011	Tissue - 2011	Tissue - 2011
Arsenic	3.3	4.5	5.9	6.7			
Cadmium	1.21	0.29	0.55	0.52			
Copper	14	21	30	34			
Lead	1.7	19	27	32			
Methyl Mercury	0.08	0.000	0.000	0.000			
Mercury	0.12	0.090	0.176	0.210			
Zinc	120	87	141	165			

Organics (ng/g dry wt.)*	Baseline - 2009/10** Tissue	Baseline - 2009/10** Sediment	Sediment - 2010	Sediment - 2010	Tissue - 2011	Tissue - 2011	Tissue - 2011
Alpha-Chlordane	8.2	0.05	0.25	0.36			
Chlorpyrifos	0.00	0.05	0.51	0.29			
DDT	130	0.8	3.4	4.7			
Heptachlor	0	0.12	0.10	0.06			
Hexachlorobenzene	4	0.09	0.08	0.14			
Mirex	1.4	0.045	0.038	0.024			
Benzo[a]pyrene	1141	208	741	435			
Benzo[e]pyrene	1276	152	446	287			
PCB	894	21	19	29			

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Minnesota Point



Legend

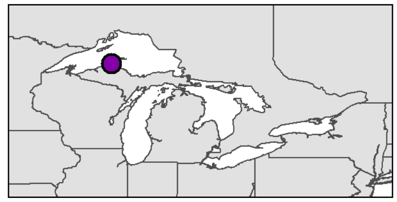
Low ● Medium ● High ● Outlier ★

Arsenic	3.9	Low
Cadmium	5.88	High
Copper	15	Low
Lead	0.3	Low
Methyl Mercury	0.02	Low
Mercury	0.05	Low
Zinc	97	High

Alpha-Chlordane	5.9	Low
Chlorpyrifos	12	Medium
DDT	33	Low
Heptachlor	0	Low
Hexachlorobenzene	11	Low
Mirex	0.0	Low
Benzo[a]pyrene	185	Low
Benzo[e]pyrene	57	Low
PCB	305	Low

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Torch Lake



Legend

Low | Medium | High | Outlier

Metals (µg/g dry wt.)	**Baseline - 2009/10**** Tissue	**Baseline - 2009/10**** Sediment	**Sediment - 2010**		**Tissue - 2011**		
Arsenic		19.7	3.5	24.8			
Cadmium		0.79	0.21	0.91			
Copper		1330	337	1950			
Lead		66	15	133			
Methyl Mercury		0.000	0.000	0.000			
Mercury		0.294	0.075	0.476			
Zinc		205	52	232			

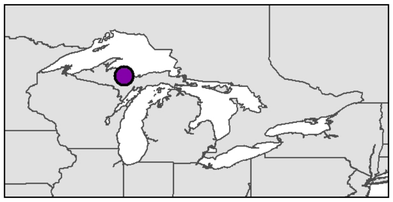
Organics (ng/g dry wt.)*	**Baseline - 2009/10**** Tissue	**Baseline - 2009/10**** Sediment	**Sediment - 2010**		**Tissue - 2011**		
Alpha-Chlordane		0.08	0.02	0.32			
Chlorpyrifos		0.00	0.03	0.11			
DDT		2.4	0.3	5.2			
Heptachlor		0.04	0.03	0.27			
Hexachlorobenzene		0.15	0.55	0.68			
Mirex		0.071	0.000	0.069			
Benzo[a]pyrene		42	7	173			
Benzo[e]pyrene		39	7	122			
PCB		25	3	43			

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Carp River

Legend

Low · Medium · High · Outlier

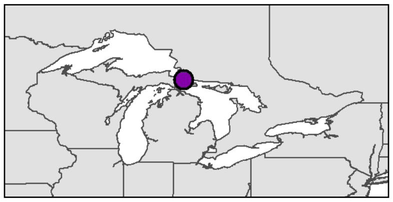


Arsenic	6.8	12.4
Cadmium	0.29	0.00
Copper	17	10
Lead	21	11
Methyl Mercury	0.000	0.000
Mercury	0.002	0.049
Zinc	58	40

Alpha-Chlordane	0.00	0.00
Chlorpyrifos	0.00	0.00
DDT	0.0	0.2
Heptachlor	0.00	0.00
Hexachlorobenzene	0.00	0.04
Mirex	0.000	0.017
Benzo[a]pyrene	1	66
Benzo[e]pyrene	1	39
PCB	0	0

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

St. Marys River



Legend

Low (green circle) | Medium (yellow circle) | High (red circle) | Outlier (star)

Metals (µg/g dry wt.)	Baseline - 2009/10** Tissue	Baseline - 2009/10** Sediment	Sediment - 2010		Tissue - 2011		
Arsenic							
Cadmium							
Copper							
Lead							
Methyl Mercury							
Mercury							
Zinc							

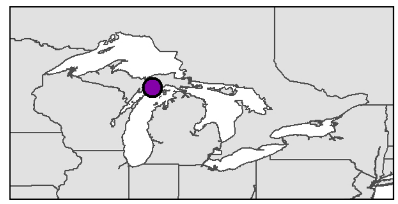
Organics (ng/g dry wt.)*	Baseline - 2009/10** Tissue	Baseline - 2009/10** Sediment	Sediment - 2010		Tissue - 2011		
Alpha-Chlordane		0.00					
Chlorpyrifos		0.00					
DDT		0.0					
Heptachlor		0.00					
Hexachlorobenzene		0.01					
Mirex		0.000					
Benzo[a]pyrene		29					
Benzo[e]pyrene		19					
PCB		1					

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Manistique River

Legend

Low ● Medium ● High ● Outlier ★

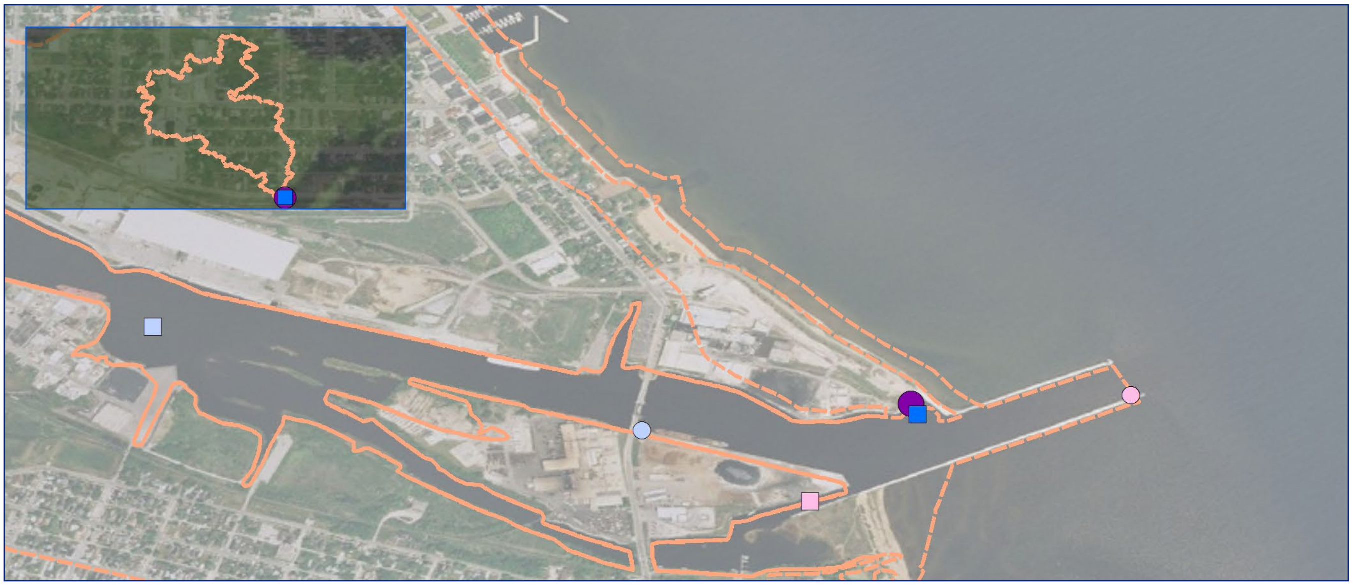


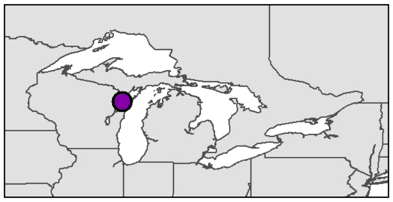
Arsenic	5.6	Low	1.7	Low	0.7	1.1	7.5	7.6
Cadmium	0.70	Low	0.00	Low	0.00	0.00	1.70	1.72
Copper	6	Low	4	Low	2	3	26	108
Lead	0.3	Low	12	Low	6	10	3	4
Methyl Mercury	0.03	Low	0.000	Low	0.000	0.000		
Mercury	0.04	Low	0.020	Low	0.009	0.012	0.073	0.077
Zinc	49	Low	24	Low	9	20	70	80

Alpha-Chlordane	5.9	Low	0.00	Low	0.00	0.00	6.3	8.7
Chlorpyrifos	0	Low	0.00	Low	0.00	0.00	0	0
DDT	48	Low	0.3	Low	0.1	0.0	44	60
Heptachlor	0	Low	0.00	Low	0.02	0.00	17	28
Hexachlorobenzene	5	Low	0.03	Low	0.00	0.00	6	7
Mirex	0.0	Low	0.000	Low	0.015	0.000	0.0	0.0
Benzo[a]pyrene	487	Medium	33	Low	7	7	76	114
Benzo[e]pyrene	17	Low	22	Low	5	6	91	134
PCB	1977	Low	359	High	5	14	1492	1934

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Menominee River





Legend

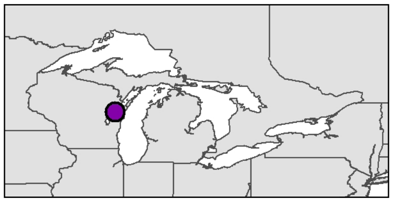
Low (green) | Medium (yellow) | High (red) | Outlier (star)

Metals (µg/g dry wt.)	**Baseline - 2009/10** Tissue		**Baseline - 2009/10** Sediment		**Sediment - 2010** (pink square)	**Sediment - 2010** (blue square)	**Tissue - 2011** (pink circle)	**Tissue - 2011** (blue circle)	**Tissue - 2011** (green circle)
Arsenic	6.3	Medium	11.7	Medium	4.0	16.7	6.8	6.1	
Cadmium	0.35	Low	0.45	Low	0.24	0.67	0.38	0.39	
Copper	7	Low	39	Medium	11	22	11	13	
Lead	0.9	Low	28	Low	14	23	1	1	
Methyl Mercury	0.08	High	0.001	Medium	0.001	0.002			
Mercury	0.15	High	0.180	Medium	0.087	0.251	0.088	0.103	
Zinc	61	Low	100	Medium	52	94	58	60	

Organics (ng/g dry wt.)*	**Baseline - 2009/10** Tissue		**Baseline - 2009/10** Sediment		**Sediment - 2010** (pink square)	**Sediment - 2010** (blue square)	**Tissue - 2011** (pink circle)	**Tissue - 2011** (blue circle)	**Tissue - 2011** (green circle)
Alpha-Chlordane	3.0	Low	1.04	Medium	0.66	0.71	5.1	3.1	
Chlorpyrifos	0	Low	0.88	High	0.56	0.53	0	0	
DDT	210	Low	5.8	Medium	3.7	3.9	31	39	
Heptachlor	0	Low	0.00	Low	0.02	0.05	0	0	
Hexachlorobenzene	10	Low	1.31	Low	0.29	0.64	16	15	
Mirex	3.4	Low	0.724	Medium	0.468	0.211	0.0	0.0	
Benzo[a]pyrene	1126	High	608	Medium	485	296	170	761	
Benzo[e]pyrene	740	High	489	High	305	214	256	309	
PCB	644	Low	53	Medium	29	95	549	447	

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Green Bay Fox River



Legend

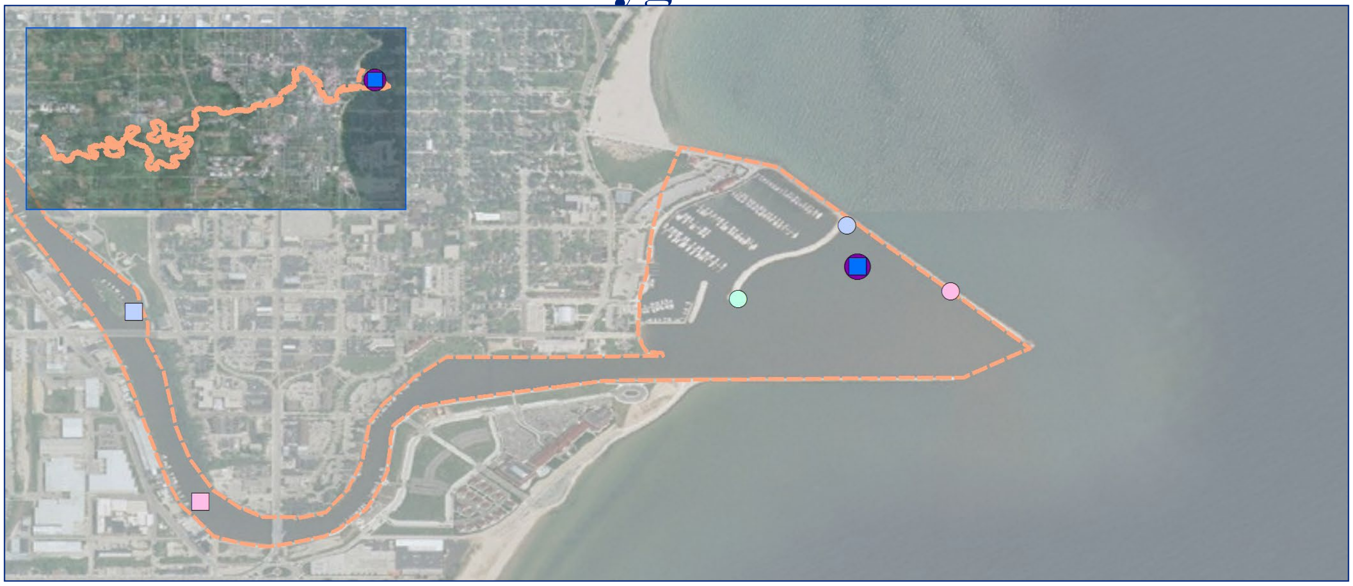
Low — Medium — High — Outlier

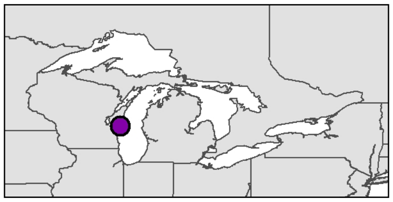
Arsenic	3.7	2.2	0.0	2.5
Cadmium	0.28	0.64	0.19	1.06
Copper	13	34	14	62
Lead	1.3	46	18	67
Methyl Mercury	0.02	0.002	0.001	0.004
Mercury	0.06	0.764	0.219	1.050
Zinc	95	102	46	183

Alpha-Chlordane	3.7	0.00	0.00	1.12
Chlorpyrifos	0	0.00	0.00	0.00
DDT	170	1.8	6.5	2.3
Heptachlor	0	0.00	0.00	0.00
Hexachlorobenzene	4	0.77	0.00	0.00
Mirex	0.0	0.000	0.000	0.000
Benzo[a]pyrene	391	992	1090	1109
Benzo[e]pyrene	893	641	536	696
PCB	21439	1088	276	1507

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Sheboygan River





Legend

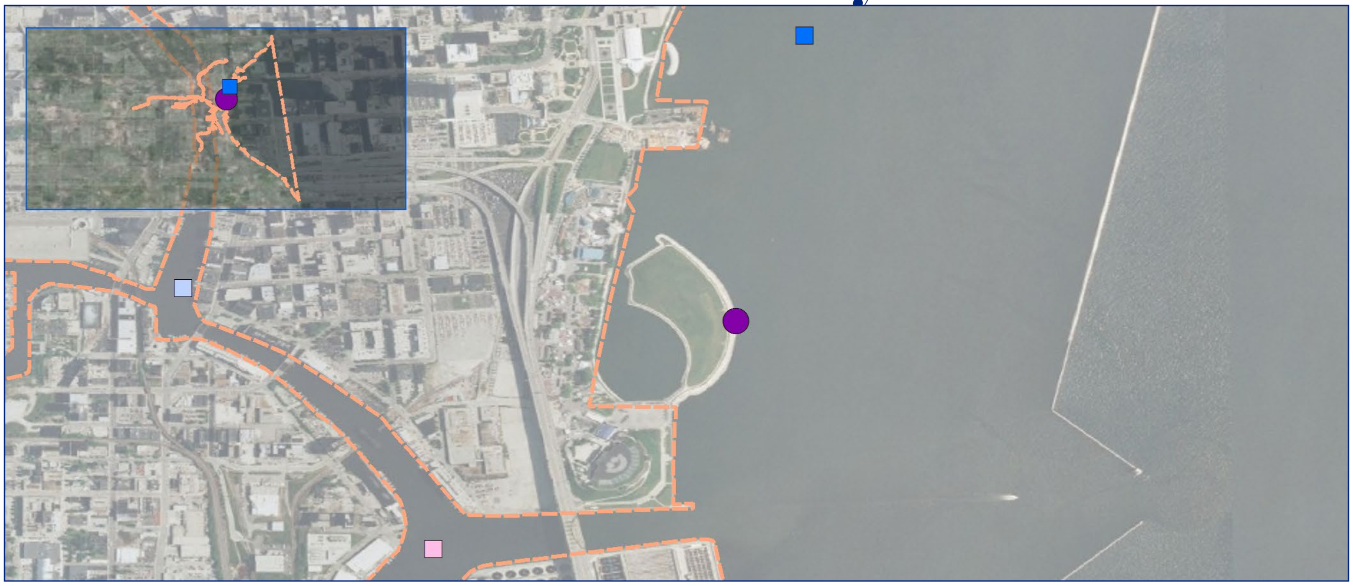
Low (green) | Medium (yellow) | High (red) | Outlier (star)

Metals (µg/g dry wt.)	**Baseline - 2009/10** Tissue (purple circle)		**Baseline - 2009/10** Sediment (blue square)		**Sediment - 2010** (pink square)	**Sediment - 2010** (blue square)	**Tissue - 2011** (pink circle)	**Tissue - 2011** (blue circle)	**Tissue - 2011** (green circle)
Arsenic	3.7	Low	2.0	Low	1.4	2.1	4.2	3.7	4.3
Cadmium	0.62	Low	0.31	Low	0.29	0.25	0.41	0.37	0.36
Copper	31	Low	25	Medium	27	31	15	9	11
Lead	1.8	Low	22	Low	46	35	1	1	1
Methyl Mercury	0.06	Medium	0.002	Medium	0.001	0.001			
Mercury	0.08	Medium	0.062	Low	0.057	0.153	0.051	0.059	0.053
Zinc	71	Medium	73	Low	78	93	57	46	54

Organics (ng/g dry wt.)*	**Baseline - 2009/10** Tissue (purple circle)		**Baseline - 2009/10** Sediment (blue square)		**Sediment - 2010** (pink square)	**Sediment - 2010** (blue square)	**Tissue - 2011** (pink circle)	**Tissue - 2011** (blue circle)	**Tissue - 2011** (green circle)
Alpha-Chlordane	18.2	Low	1.45	Medium	0.00	0.00	27.5	33.4	29.1
Chlorpyrifos	7	Low	0.00	Low	0.00	0.00	0	0	0
DDT	438	Low	7.6	Medium	21.5	24.4	680	745	919
Heptachlor	0	Low	0.00	Low	0.00	0.00	0	39	0
Hexachlorobenzene	15	Medium	2.17	Low	0.24	0.21	32	121	18
Mirex	0.0	Low	0.000	Low	0.000	0.000	0.0	0.0	0.0
Benzo[a]pyrene	419	Medium	99	Low	384	413	919	217	1355
Benzo[e]pyrene	378	Medium	84	Medium	300	287	534	392	911
PCB	21969	High	397	High	786	786	30310	22273	38261

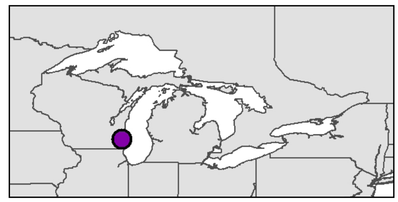
***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Milwaukee Bay



Legend

Low 🟢 Medium 🟡 High 🔴 Outlier ★

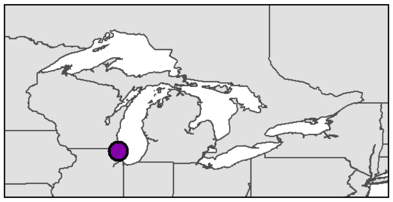


Arsenic	5.2	🟢	1.7	🟩	3.2	1.7
Cadmium	0.87	🟢	0.70	🟩	1.44	0.68
Copper	43	🟡	13	🟩	60	26
Lead	3.8	🟡	21	🟩	77	112
Methyl Mercury	0.02	🟢	0.000	🟩	0.001	0.000
Mercury	0.03	🟢	0.068	🟩	0.174	0.094
Zinc	81	🟡	90	🟨	278	146

Alpha-Chlordane	46.8	🟡	0.47	🟨	3.55	1.62
Chlorpyrifos	13	🟡	0.00	🟩	0.00	0.00
DDT	1018	🟡	9.6	🟨	78.0	44.6
Heptachlor	6	🟢	0.00	🟩	6.08	0.00
Hexachlorobenzene	213	🔴	7.17	🟥	0.557	0.319
Mirex	0.0	🟢	0.000	🟩	0.000	0.000
Benzo[a]pyrene	1620	🔴	965	🟥	961	1021
Benzo[e]pyrene	3943	★	597	🟥	743	607
PCB	14752	🔴	152	🟨	661	602

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Waukegan Harbor



Legend

Low (green circle) | Medium (yellow circle) | High (red circle) | Outlier (star)

Metals (µg/g dry wt.)	**Baseline - 2009/10**** Tissue (purple circle)		Sediment (blue square)		**Sediment - 2010** (pink square)	(light blue square)	**Tissue - 2011** (pink circle)	(light blue circle)	(light green circle)
Arsenic	6.9	Medium	10.0	Medium			7.6	2.6	2.5
Cadmium	2.01	Medium	3.88	High			2.35	0.52	0.49
Copper	52	Medium	85	High			24	19	51
Lead	4.4	Medium	54	Medium			2	1	1
Methyl Mercury	0.01	Low	0.003	High					
Mercury	0.04	Low	0.141	Medium			0.033	0.036	0.034
Zinc	80	Medium	165	High			68	51	57

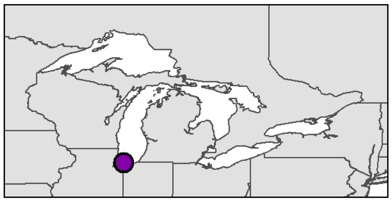
Organics (ng/g dry wt.)*	**Baseline - 2009/10**** Tissue (purple circle)		Sediment (blue square)		**Sediment - 2010** (pink square)	(light blue square)	**Tissue - 2011** (pink circle)	(light blue circle)	(light green circle)
Alpha-Chlordane	16.2	Low	0.00	Low			18.6	23.6	24.4
Chlorpyrifos	29	High	0.00	Low			0	0	0
DDT	481	Low	0.0	Low			515	395	697
Heptachlor	75	Medium	0.00	Low			0	0	
Hexachlorobenzene	6	Low	1.45	Low			9	13	9
Mirex	2.1	Low	0.000	Low			1.7	1.0	1.2
Benzo[a]pyrene	940	Medium	674	Medium			1614	975	1209
Benzo[e]pyrene	899	High	565	High			1007	1143	1506
PCB	3924	Medium	8993	Outlier			9247	6154	5315

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Calumet Breakwater

Legend

Low ● Medium ● High ● Outlier ★

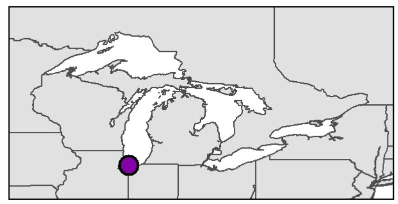


Arsenic	7.3	Medium	5.5	Medium
Cadmium	3.08	Medium	0.45	Low
Copper	28	Low	28	Medium
Lead	2.2	Low	35	Low
Methyl Mercury	0.01	Low	0.001	Low
Mercury	0.04	Low	0.069	Low
Zinc	67	Medium	106	Medium

Alpha-Chlordane	9.2	Low	0.57	Medium
Chlorpyrifos	10	Medium	0.58	High
DDT	144	Low	19.8	High
Heptachlor	0	Low	0.64	Medium
Hexachlorobenzene	4	Low	0.81	Low
Mirex	4.0	Low	0.000	Low
Benzo[a]pyrene	1580	High	308	Medium
Benzo[e]pyrene	853	High	214	Medium
PCB	1167	Low	66	Medium

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Hammond Marina



Legend

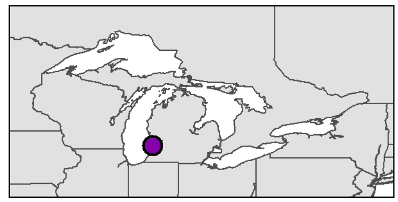
Low ● Medium ● High ● Outlier ★

Metals (µg/g dry wt.)	Baseline - 2009/10** Tissue		Sediment		Sediment - 2010		Tissue - 2011		
Arsenic	5.4	Low	3.2	Low					
Cadmium	1.81	Medium	0.00	Low					
Copper	22	Low	6	Low					
Lead	1.7	Low	12	Low					
Methyl Mercury	0.01	Low	0.000	Low					
Mercury	0.02	Low	0.012	Low					
Zinc	57	Low	59	Low					

Organics (ng/g dry wt.)*	Baseline - 2009/10** Tissue		Sediment		Sediment - 2010		Tissue - 2011		
Alpha-Chlordane	0.0	Low	0.00	Low					
Chlorpyrifos	15	Medium	0.00	Low					
DDT	109	Low	2.2	Low					
Heptachlor	0	Low	0.00	Low					
Hexachlorobenzene	5	Low	0.00	Low					
Mirex	2.4	Low	0.000	Low					
Benzo[a]pyrene	779	Medium	16	Low					
Benzo[e]pyrene	805	High	15	Low					
PCB	1270	Low	8	Low					

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Kalamazoo River



Legend

Low ● Medium ● High ● Outlier ★

Arsenic	3.7	■	5.3
Cadmium	0.28	■	0.34
Copper	10	■	11
Lead	21	■	27
Methyl Mercury	0.000	■	0.001
Mercury	0.097	■	0.191
Zinc	46	■	54

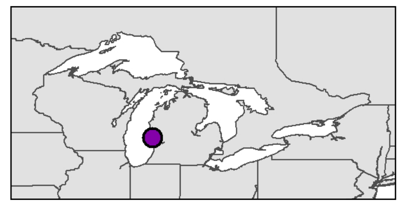
Alpha-Chlordane	0.25	■	0.42
Chlorpyrifos	0.29	■	0.11
DDT	4.9	■	9.7
Heptachlor	0.02	■	0.09
Hexachlorobenzene	0.13	■	0.062
Mirex	0.000	■	0.000
Benzo[a]pyrene	32	■	28
Benzo[e]pyrene	23	■	24
PCB	80	■	173

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Muskegon Lake

Legend

Low (green) Medium (yellow) High (red) Outlier (star)

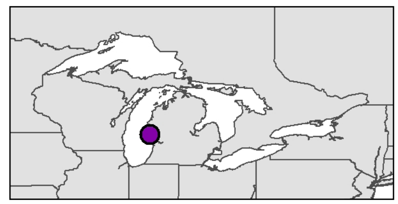


Metals (µg/g dry wt.)	Baseline - 2009/10** Tissue		Baseline - 2009/10** Sediment		Sediment - 2010		Tissue - 2011		
Arsenic	11.4	High	7.8	Medium					
Cadmium	0.57	Low	2.22	High					
Copper	11	Low	61	High					
Lead	1.5	Low	83	High					
Methyl Mercury	0.02	Low	0.001	Low					
Mercury	0.05	Low	0.227	Medium					
Zinc	71	Medium	201	High					

Organics (ng/g dry wt.)*	Baseline - 2009/10** Tissue		Baseline - 2009/10** Sediment		Sediment - 2010		Tissue - 2011		
Alpha-Chlordane	17.1	Low	1.39	Medium					
Chlorpyrifos	15	Medium	0.73	High					
DDT	110	Low	37.3	High					
Heptachlor	0	Low	1.19	Medium					
Hexachlorobenzene	14	Medium	0.72	Low					
Mirex	3.8	Low	0.026	Low					
Benzo[a]pyrene	753	Medium	371	Medium					
Benzo[e]pyrene	475	Medium	306	Medium					
PCB	773	Low	110	Medium					

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

White Lake



Legend

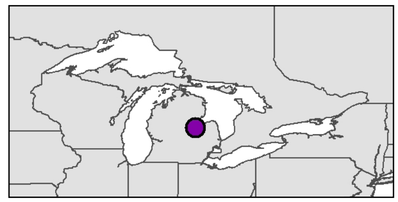
Low ● Medium ● High ● Outlier ★

Arsenic	5.5	● (green)	3.4	■ (green)	2.1
Cadmium	0.76	● (green)	0.49	■ (green)	0.00
Copper	31	● (green)	15	■ (green)	2
Lead	1.2	● (green)	18	■ (green)	11
Methyl Mercury	0.05	● (yellow)	0.003	■ (red)	0.000
Mercury	0.07	● (yellow)	0.091	■ (green)	0.015
Zinc	68	● (yellow)	64	■ (green)	36

Alpha-Chlordane	7.5	● (green)	0.12	■ (green)	0.03
Chlorpyrifos	9	● (yellow)	0.27	■ (yellow)	0.05
DDT	89	● (green)	6.8	■ (yellow)	0.2
Heptachlor	0	● (green)	0.05	■ (green)	0.00
Hexachlorobenzene	8	● (green)	0.12	■ (green)	0.127
Mirex	55.0	● (red)	0.032	■ (green)	0.017
Benzo[a]pyrene	119	● (green)	46	■ (green)	1
Benzo[e]pyrene	107	● (green)	38	■ (green)	1
PCB	677	● (green)	4	■ (green)	3

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Saginaw River



Legend

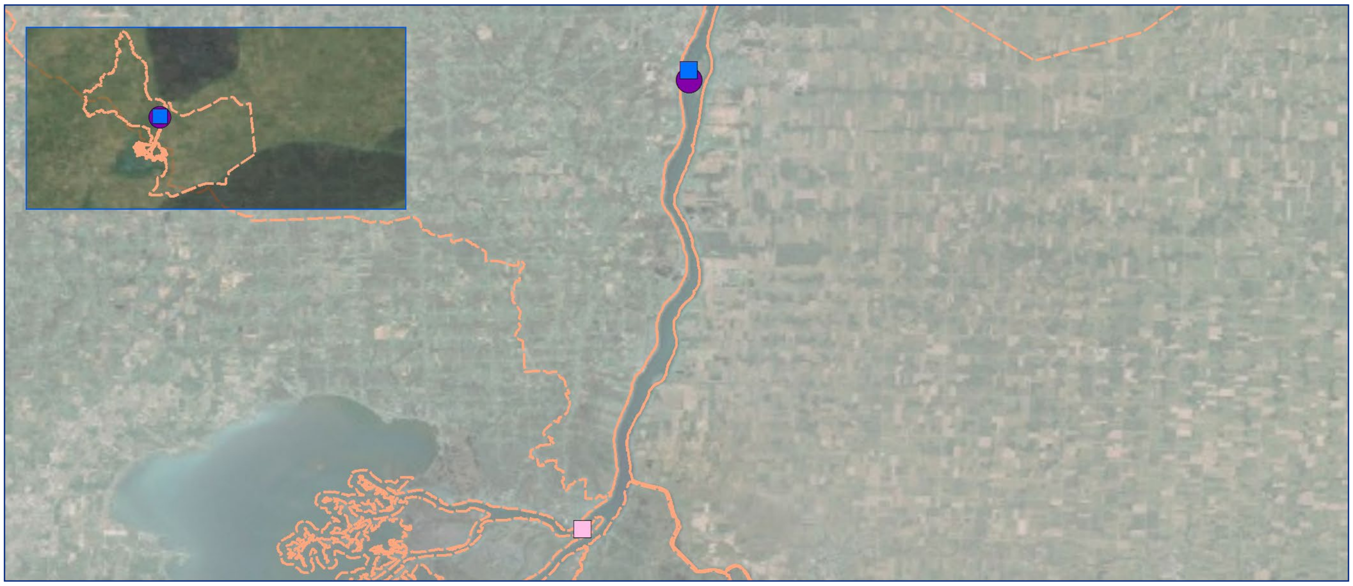
Low | Medium | High | Outlier

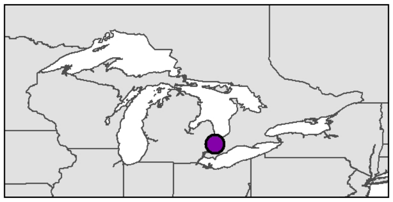
Metals (µg/g dry wt.)	Baseline - 2009/10** Tissue	Baseline - 2009/10** Sediment	Sediment - 2010		Tissue - 2011		
Arsenic	7.3	5.5	6.5				
Cadmium	0.50	0.58	0.66				
Copper	24	30	31				
Lead	1.7	27	29				
Methyl Mercury	0.02	0.001	0.001				
Mercury	0.04	0.095	0.094				
Zinc	80	130	144				

Organics (ng/g dry wt.)*	Baseline - 2009/10** Tissue	Baseline - 2009/10** Sediment	Sediment - 2010		Tissue - 2011		
Alpha-Chlordane	16.7	0.05	0.18				
Chlorpyrifos	11	0.05	0.31				
DDT	238	5.3	11.4				
Heptachlor	0	0.26	0.30				
Hexachlorobenzene	8	3.86	6.394				
Mirex	0.0	0.024	0.031				
Benzo[a]pyrene	552	162	238				
Benzo[e]pyrene	462	128	205				
PCB	3035	98	90				

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

St. Clair River





Legend

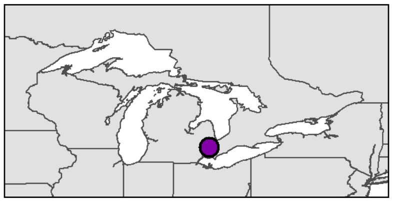
Low (green) Medium (yellow) High (red) Outlier (star)

Arsenic	5.4	Low	2.3	■	3.5
Cadmium	3.55	Medium	0.00	■	0.49
Copper	80	Medium	5	■	21
Lead	3.1	Low	9	■	15
Methyl Mercury	0.02	Low	0.001	■	0.002
Mercury	0.06	Medium	0.012	■	0.138
Zinc	135	High	28	■	62

Alpha-Chlordane	8.0	Low	0.00	■	0.02
Chlorpyrifos	0	Low	0.06	■	0.12
DDT	24	Low	0.3	■	1.7
Heptachlor	0	Low	0.00	■	0.10
Hexachlorobenzene	2	Low	0.57	■	10.857
Mirex	1.2	Low	0.000	■	0.094
Benzo[a]pyrene	0	Low	6	■	33
Benzo[e]pyrene	0	Low	5	■	25
PCB	173	Low	2	■	24

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Clinton River



Legend

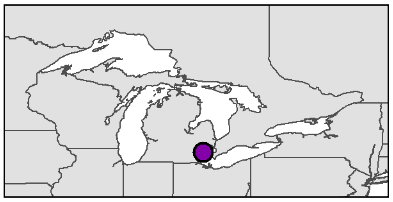
Low (green) — Medium (yellow) — High (red) — Outlier (star)

Metals (µg/g dry wt.)	**Baseline - 2009/10** Tissue (purple circle)		Sediment (blue square)		**Sediment - 2010** (pink square)	(light blue square)	**Tissue - 2011** (pink circle)	(light blue circle)	(light green circle)
Arsenic	5.3	Low	7.9	Medium	7.2				
Cadmium	1.05	Low	2.78	High	2.54				
Copper	30	Low	85	High	75				
Lead	1.9	Low	82	High	75				
Methyl Mercury	0.04	Medium	0.001	Medium	0.001				
Mercury	0.07	Medium	0.204	Medium	0.182				
Zinc	214	Outlier	380	Outlier	330				

Organics (ng/g dry wt.)*	**Baseline - 2009/10** Tissue (purple circle)		Sediment (blue square)		**Sediment - 2010** (pink square)	(light blue square)	**Tissue - 2011** (pink circle)	(light blue circle)	(light green circle)
Alpha-Chlordane	43.8	Medium	4.66	High	0.46				
Chlorpyrifos	22	High	0.61	High	0.55				
DDT	474	Low	68.1	Outlier	66.9				
Heptachlor	0	Low	1.07	Medium	1.54				
Hexachlorobenzene	7	Low	1.77	Low	1.257				
Mirex	1.5	Low	0.552	Medium	0.422				
Benzo[a]pyrene	169	Low	3569	Outlier	2594				
Benzo[e]pyrene	1038	High	3369	Outlier	1988				
PCB	2636	Low	367	High	378				

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Rouge River



Legend

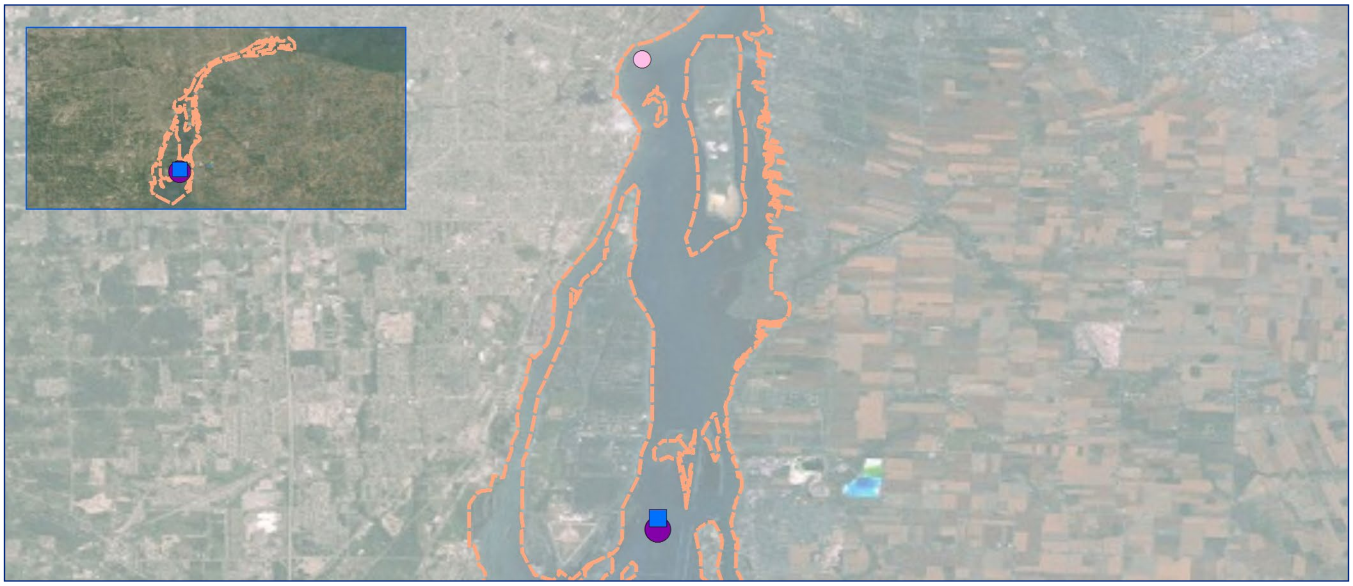
Low 🟢 Medium 🟡 High 🔴 Outlier ★

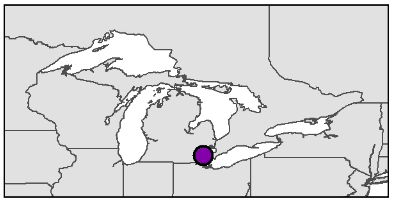
Arsenic	4.0	🟩
Cadmium	0.86	🟨
Copper	94	🟥
Lead	54	🟨
Methyl Mercury	0.001	🟨
Mercury	0.195	🟨
Zinc	180	🟥

Alpha-Chlordane	13.10	★
Chlorpyrifos	0.00	🟩
DDT	58.6	★
Heptachlor	9.96	🟥
Hexachlorobenzene	0.27	🟩
Mirex	0.062	🟩
Benzo[a]pyrene	16454	★
Benzo[e]pyrene	6715	★
PCB	372	🟥

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Detroit River





Legend

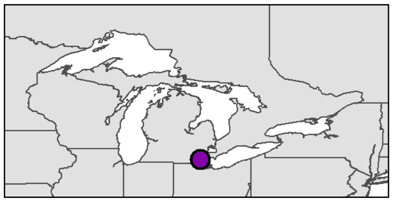
Low | Medium | High | Outlier

Metals (µg/g dry wt.)	**Baseline - 2009/10** Tissue	Sediment	**Sediment - 2010**		**Tissue - 2011**		
Arsenic	3.6	6.4			3.7		
Cadmium	0.83	0.80			0.87		
Copper	35	37			60		
Lead	1.7	29			4		
Methyl Mercury	0.03	0.002					
Mercury	0.05	0.323			0.046		
Zinc	46	114			86		

Organics (ng/g dry wt.)*	**Baseline - 2009/10** Tissue	Sediment	**Sediment - 2010**		**Tissue - 2011**		
Alpha-Chlordane	7.4	0.67			0.0		
Chlorpyrifos	9	0.00			0		
DDT	73	9.2			454		
Heptachlor	0	0.00			0		
Hexachlorobenzene	12	4.08			16		
Mirex	0.0	0.000			0.0		
Benzo[a]pyrene	246	401			1852		
Benzo[e]pyrene	441	288			2602		
PCB	1652	68			5126		

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

River Raisin



Legend

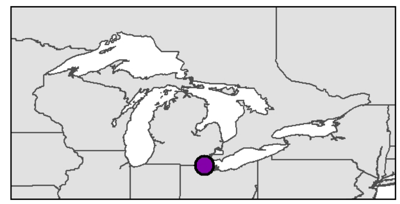
Low ● Medium ● High ● Outlier ★

Arsenic	3.8	Low	6.6	Medium
Cadmium	1.97	Medium	0.60	Low
Copper	16	Low	26	Medium
Lead	2.6	Low	29	Low
Methyl Mercury	0.01	Low	0.002	Medium
Mercury	0.04	Low	0.077	Low
Zinc	54	Low	94	Medium

Alpha-Chlordane	33.5	Medium	0.97	Medium
Chlorpyrifos	32	High	0.00	Low
DDT	225	Low	21.2	High
Heptachlor	0	Low	0.00	Low
Hexachlorobenzene	16	Medium	0.38	Low
Mirex	1.5	Low	0.000	Low
Benzo[a]pyrene	288	Medium	1210	High
Benzo[e]pyrene	578	Medium	616	High
PCB	4562	Medium	223	Medium

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Maumee River



Legend

Low (green circle) · Medium (yellow circle) · High (red circle) · Outlier (star)

Metals (µg/g dry wt.)	**Baseline - 2009/10**** Tissue		Sediment		**Sediment - 2010**		**Tissue - 2011**		
Arsenic	3.6	Low	6.6	Medium					
Cadmium	0.64	Low	0.53	Low					
Copper	14	Low	24	Medium					
Lead	1.7	Low	19	Low					
Methyl Mercury	0.02	Low	0.001	Low					
Mercury	0.03	Low	0.058	Low					
Zinc	53	Low	83	Medium					

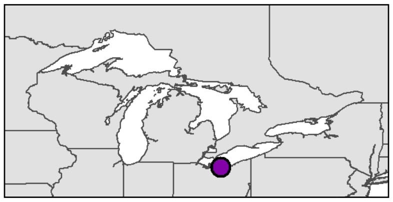
Organics (ng/g dry wt.)*	**Baseline - 2009/10**** Tissue		Sediment		**Sediment - 2010**		**Tissue - 2011**		
Alpha-Chlordane	48.2	Medium	0.69	Medium					
Chlorpyrifos	249	Outlier	0.53	High					
DDT	216	Low	7.9	Medium					
Heptachlor	0	Low	0.21	Low					
Hexachlorobenzene	7	Low	0.19	Low					
Mirex	1.6	Low	0.000	Low					
Benzo[a]pyrene	543	Medium	190	Low					
Benzo[e]pyrene	1095	High	153	Medium					
PCB	2726	Low	101	Medium					

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Black River

Legend

Low | Medium | High | Outlier

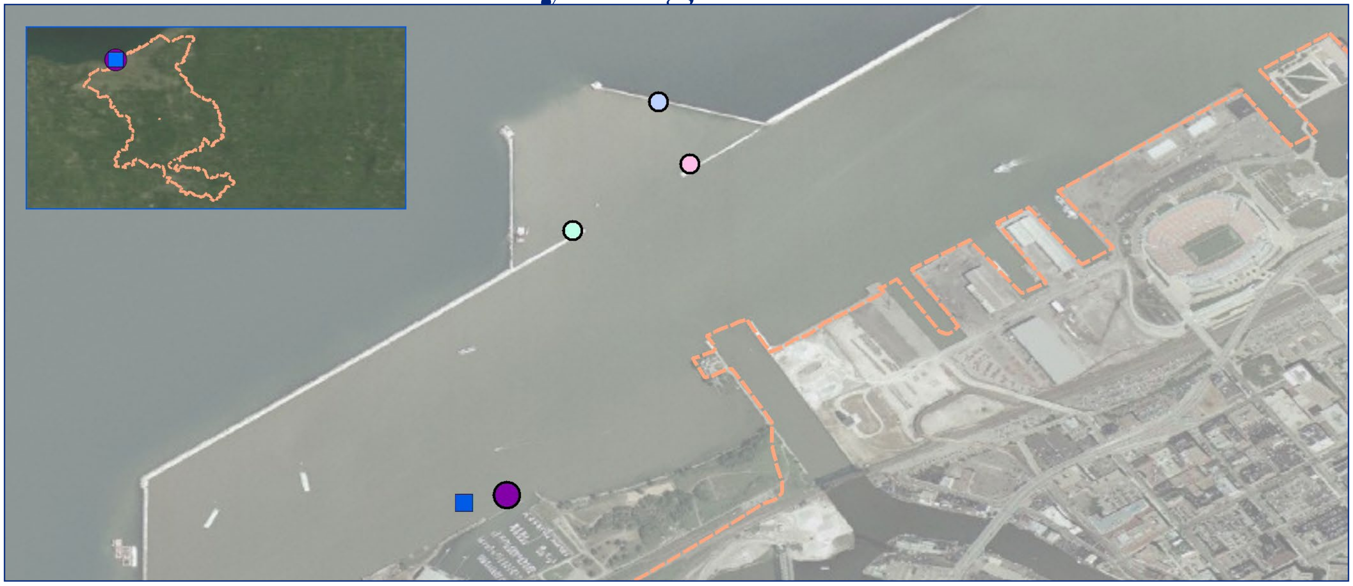


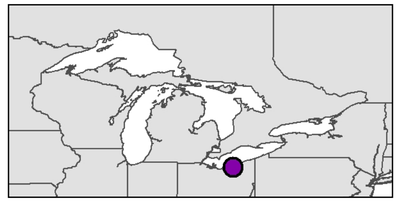
Arsenic	4.4	10.5	5.0	4.8	5.1
Cadmium	2.15	1.30	2.43	2.98	2.57
Copper	15	31	18	48	17
Lead	2.9	27	2	3	2
Methyl Mercury	0.02	0.001			
Mercury	0.03	0.058	0.051	0.055	0.050
Zinc	56	144	64	70	54

Alpha-Chlordane	121.5	1.21	93.8	61.5	74.1
Chlorpyrifos	14	0.39	0	0	0
DDT	185	8.2	171	213	244
Heptachlor	0	0.07	0	0	275
Hexachlorobenzene	10	3.77	0	0	0
Mirex	2.0	0.000	0.0	0.0	0.0
Benzo[a]pyrene	1308	219	300	322	174
Benzo[e]pyrene	1196	167	711	581	428
PCB	1624	62	1327	1511	1343

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Cuyahoga River





Legend

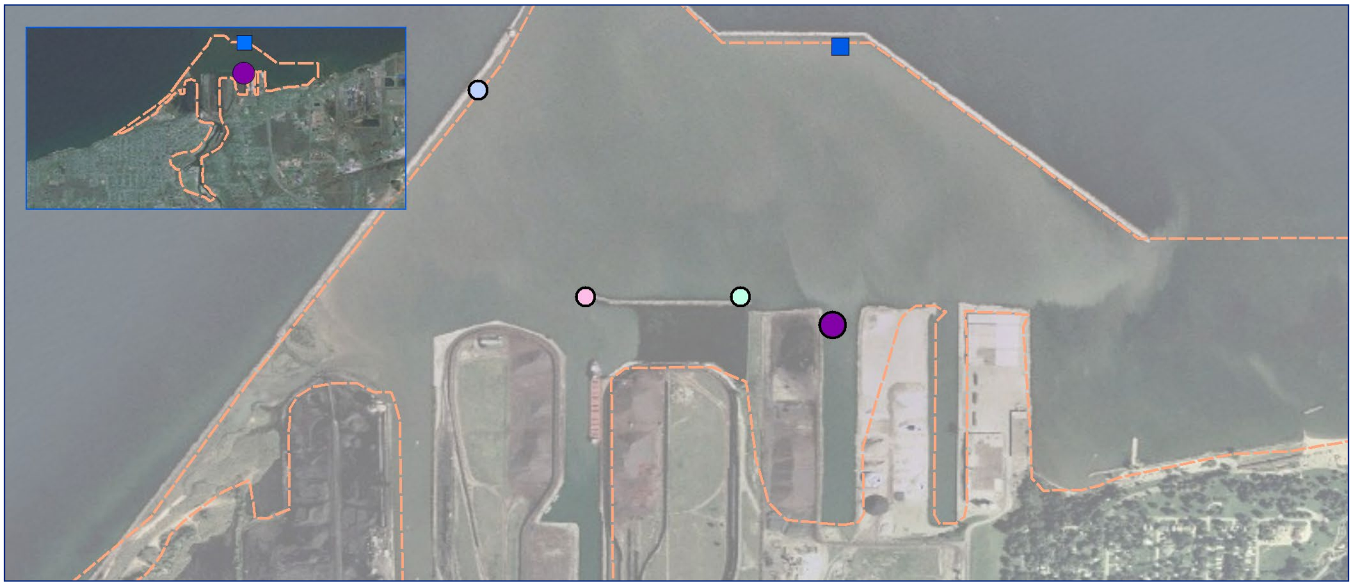
Low ● Medium ● High ● Outlier ★

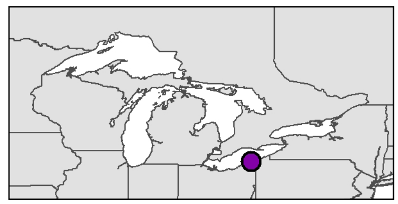
Metals (µg/g dry wt.)	Baseline - 2009/10** Tissue ●		Baseline - 2009/10** Sediment ■		Sediment - 2010 □ (pink)	Sediment - 2010 □ (blue)	Tissue - 2011 ○ (pink)	Tissue - 2011 ○ (blue)	Tissue - 2011 ○ (green)
Arsenic	4.3	Low	17.1	High			5.7	5.8	5.2
Cadmium	0.95	Low	0.93	Medium			1.60	1.55	1.31
Copper	50	Medium	43	Medium			20	54	38
Lead	4.4	Medium	41	Medium			3	5	4
Methyl Mercury	0.02	Low	0.001	Medium					
Mercury	0.03	Low	0.095	Low			0.044	0.048	0.050
Zinc	76	Medium	203	High			69	90	79

Organics (ng/g dry wt.)*	Baseline - 2009/10** Tissue ●		Baseline - 2009/10** Sediment ■		Sediment - 2010 □ (pink)	Sediment - 2010 □ (blue)	Tissue - 2011 ○ (pink)	Tissue - 2011 ○ (blue)	Tissue - 2011 ○ (green)
Alpha-Chlordane	177.3	High	3.14	High			195.9	225.0	218.3
Chlorpyrifos	23	High	0.00	Low			0	0	0
DDT	344	Low	13.9	Medium			516	596	602
Heptachlor	0	Low	0.00	Low			0	0	0
Hexachlorobenzene	10	Low	1.51	Low			0	0	0
Mirex	3.5	Low	0.000	Low			0.0	0.0	0.0
Benzo[a]pyrene	756	Medium	454	Medium			1080	1245	540
Benzo[e]pyrene	2087	High	418	High			2980	3286	1660
PCB	3557	Medium	163	Medium			3903	4664	4161

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Ashtabula River





Legend

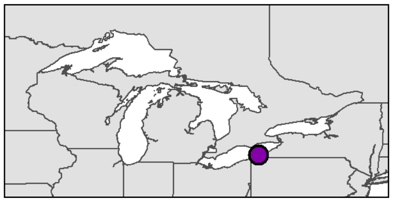
Low · Medium · High · Outlier

Metals (µg/g dry wt.)	Baseline - 2009/10** Tissue	Baseline - 2009/10** Sediment	Sediment - 2010		Tissue - 2011		
Arsenic	7.9	14.2			5.1	6.6	6.3
Cadmium	2.34	0.59			2.74	2.71	1.77
Copper	124	30			14	15	15
Lead	5.4	25			1	1	2
Methyl Mercury	0.02	0.001					
Mercury	0.04	0.055			0.038	0.045	0.045
Zinc	97	117			50	60	59

Organics (ng/g dry wt.)*	Baseline - 2009/10** Tissue	Baseline - 2009/10** Sediment	Sediment - 2010		Tissue - 2011		
Alpha-Chlordane	19.2	3.83			9.2	23.4	10.7
Chlorpyrifos	6	0.00			0	0	0
DDT	46	7.1			62	99	50
Heptachlor	0	0.00			0	0	0
Hexachlorobenzene	131	4.99			58	137	130
Mirex	0.0	0.000			0.0	8.3	0.0
Benzo[a]pyrene	403	361			94	145	323
Benzo[e]pyrene	627	250			208	360	640
PCB	1289	102			1067	1979	1292

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Presque Isle Bay



Legend

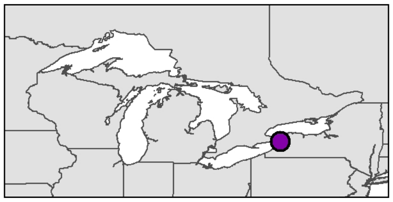
Low | Medium | High | Outlier

Metals (µg/g dry wt.)	**Baseline - 2009/10**** Tissue		Sediment		**Sediment - 2010**		**Tissue - 2011**		
Arsenic	6.3	Medium	7.4	Medium					
Cadmium	2.38	Medium	1.47	Medium					
Copper	41	Medium	30	Medium					
Lead	10.1	High	47	Medium					
Methyl Mercury	0.02	Low	0.001	Medium					
Mercury	0.06	Medium	0.147	Medium					
Zinc	82	Medium	114	Medium					

Organics (ng/g dry wt.)*	**Baseline - 2009/10**** Tissue		Sediment		**Sediment - 2010**		**Tissue - 2011**		
Alpha-Chlordane	84.7	High	2.96	High					
Chlorpyrifos	4	Low	0.00	Low					
DDT	224	Low	7.2	Medium					
Heptachlor	0	Low	0.00	Low					
Hexachlorobenzene	238	High	8.56	High					
Mirex	22.6	Medium	0.000	Low					
Benzo[a]pyrene	38041	Outlier	2380	Outlier					
Benzo[e]pyrene	23196	Outlier	1300	Outlier					
PCB	4138	Medium	182	Medium					

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Buffalo River



Legend

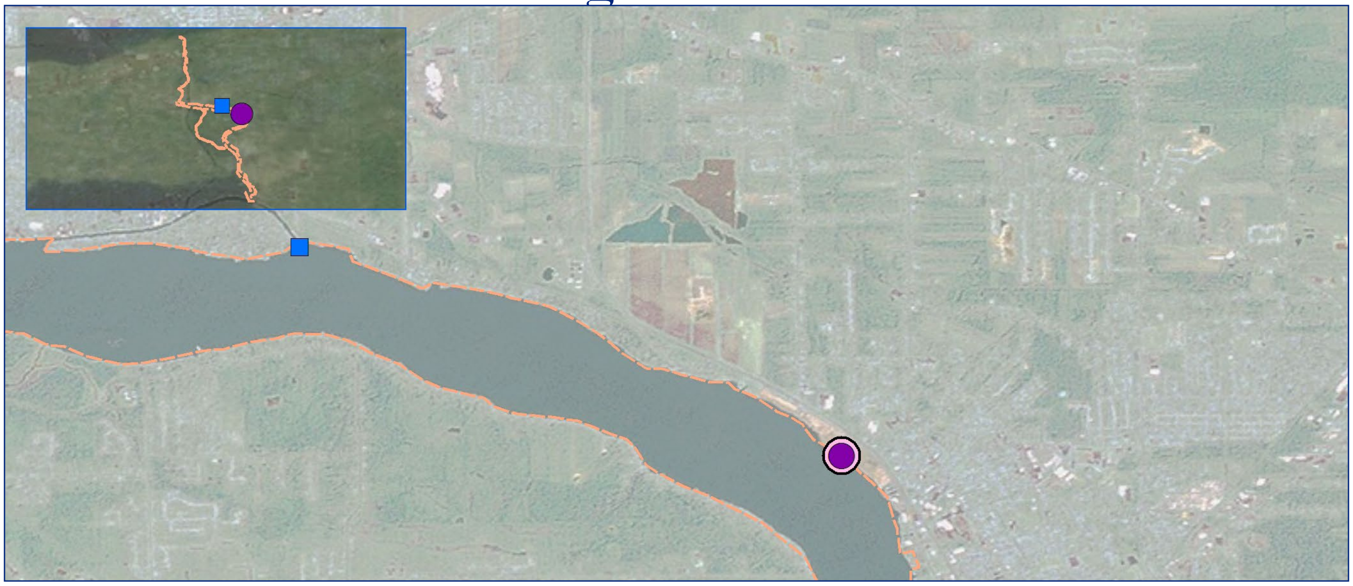
Low ● (green) Medium ● (yellow) High ● (red) Outlier ★

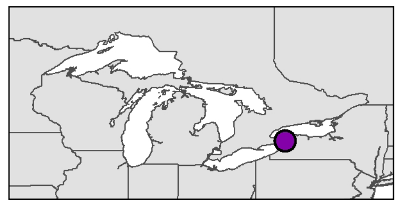
Arsenic	4.4	● (green)	13.1	■ (yellow)
Cadmium	0.78	● (green)	0.50	■ (green)
Copper	43	● (yellow)	41	■ (yellow)
Lead	5.3	● (yellow)	32	■ (green)
Methyl Mercury	0.08	● (red)	0.002	■ (yellow)
Mercury	0.11	● (red)	0.076	■ (green)
Zinc	82	● (yellow)	139	■ (yellow)

Alpha-Chlordane	24.4	● (green)	1.22	■ (yellow)
Chlorpyrifos	10	● (yellow)	0.39	■ (yellow)
DDT	249	● (green)	7.8	■ (yellow)
Heptachlor	0	● (green)	0.00	■ (green)
Hexachlorobenzene	17	● (yellow)	0.69	■ (green)
Mirex	4.5	● (green)	0.000	■ (green)
Benzo[a]pyrene	879	● (yellow)	201	■ (green)
Benzo[e]pyrene	1313	● (red)	179	■ (yellow)
PCB	1789	● (green)	53	■ (yellow)

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Niagara River





Legend

Low	Medium	High	Outlier
green circle	yellow circle	red circle	star

Metals (µg/g dry wt.)	**Baseline - 2009/10**** Tissue (purple circle)		Sediment (blue square)		**Sediment - 2010** (pink square)	(blue square)	**Tissue - 2011** (pink circle)	(blue circle)	(green circle)
Arsenic	3.6	Low	2.0	Low			7.1		
Cadmium	1.23	Low	0.21	Low			1.23		
Copper	36	Medium	6	Low			53		
Lead	2.8	Low	10	Low			4		
Methyl Mercury	0.02	Low	0.001	Medium					
Mercury	0.04	Low	0.034	Low			0.067		
Zinc	51	Low	57	Low			89		

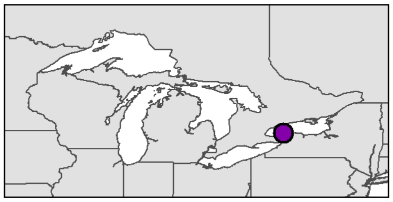
Organics (ng/g dry wt.)*	**Baseline - 2009/10**** Tissue (purple circle)		Sediment (blue square)		**Sediment - 2010** (pink square)	(blue square)	**Tissue - 2011** (pink circle)	(blue circle)	(green circle)
Alpha-Chlordane	12.9	Low	0.16	Low			9.3		
Chlorpyrifos	5	Low	0.00	Low			0		
DDT	84	Low	1.0	Low			101		
Heptachlor	0	Low	0.00	Low			0		
Hexachlorobenzene	25	Medium	0.58	Low			0		
Mirex	6.3	Low	0.000	Low			0.0		
Benzo[a]pyrene	1067	High	26	Low			2443		
Benzo[e]pyrene	1416	High	28	Low			4029		
PCB	4715	Medium	25	Low			5064		

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Eighteenmile Creek

Legend

Low ● Medium ● High ● Outlier ★

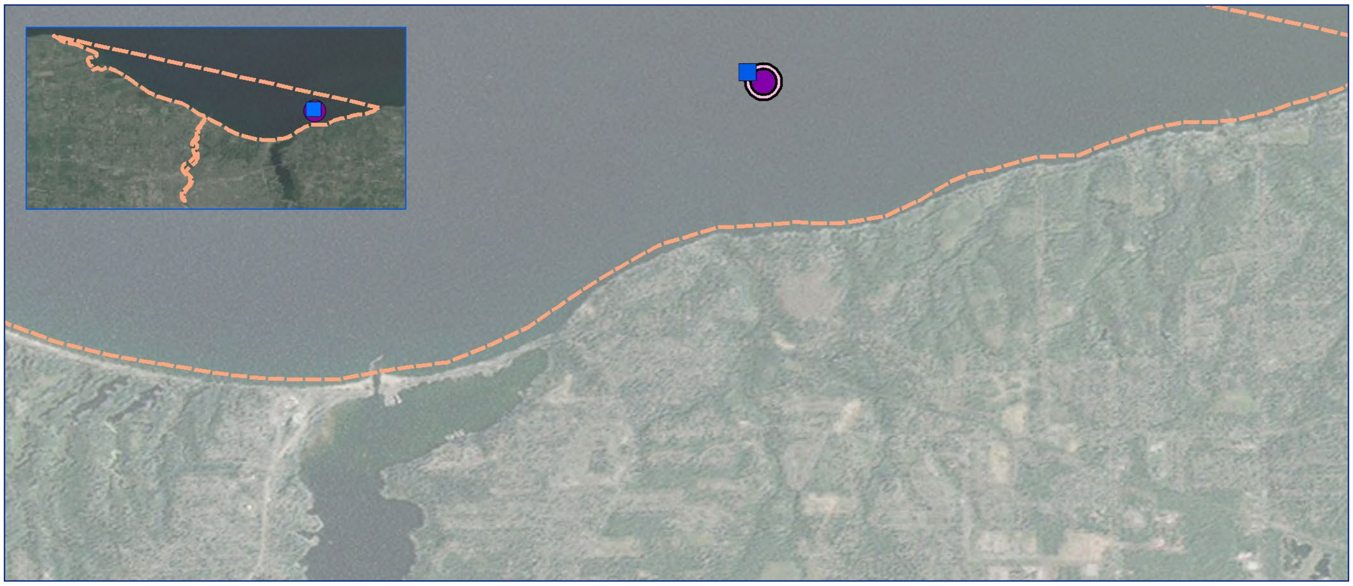


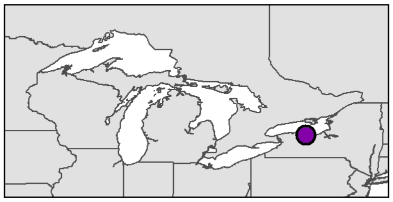
Arsenic	2.9	Low	4.0	Low
Cadmium	0.70	Low	0.48	Low
Copper	56	Medium	63	High
Lead	9.3	High	47	Medium
Methyl Mercury	0.05	Medium	0.002	High
Mercury	0.08	Medium	0.127	Medium
Zinc	96	High	182	High

Alpha-Chlordane	37.7	Medium	0.77	Medium
Chlorpyrifos	15	Medium	0.36	Medium
DDT	1896	High	21.1	High
Heptachlor	0	Low	0.00	Low
Hexachlorobenzene	22	Medium	0.60	Low
Mirex	52.0	High	0.310	Medium
Benzo[a]pyrene	344	Medium	170	Low
Benzo[e]pyrene	791	High	135	Medium
PCB	23964	High	170	Medium

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Rochester





Legend

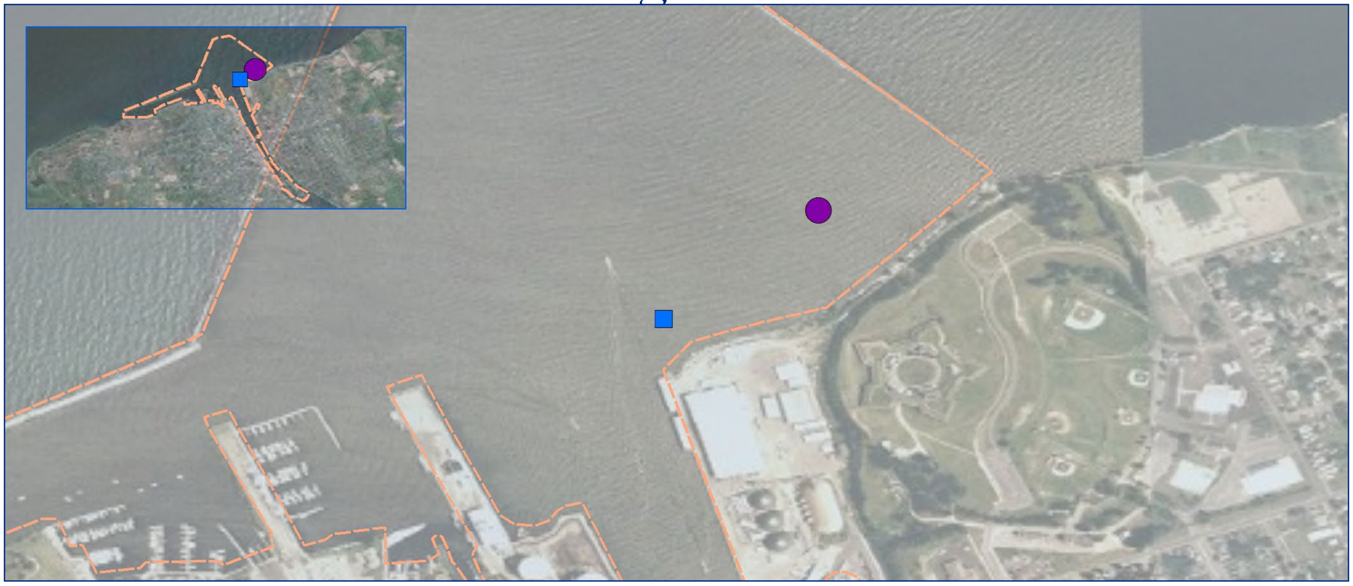
Low (green) | Medium (yellow) | High (red) | Outlier (star)

Metals (µg/g dry wt.)	Baseline - 2009/10** Tissue		Baseline - 2009/10** Sediment		Sediment - 2010		Tissue - 2011		
Arsenic	6.4	Medium	8.9	Medium			6.5		
Cadmium	2.14	Medium	0.55	Low			2.10		
Copper	11	Low	28	Medium			26		
Lead	2.0	Low	24	Low			1		
Methyl Mercury	0.02	Low	0.001	Medium					
Mercury	0.04	Low	0.136	Medium			0.033		
Zinc	58	Low	111	Medium			66		

Organics (ng/g dry wt.)*	Baseline - 2009/10** Tissue		Baseline - 2009/10** Sediment		Sediment - 2010		Tissue - 2011		
Alpha-Chlordane	10.9	Low	0.64	Medium			10.0		
Chlorpyrifos	8	Medium	0.30	Medium			0		
DDT	119	Low	6.9	Medium			216		
Heptachlor	0	Low	0.06	Low			0		
Hexachlorobenzene	16	Medium	3.23	Medium			0		
Mirex	42.8	High	0.000	Low			0.0		
Benzo[a]pyrene	173	Low	147	Low			197		
Benzo[e]pyrene	395	Medium	113	Medium			332		
PCB	681	Low	32	Low			434		

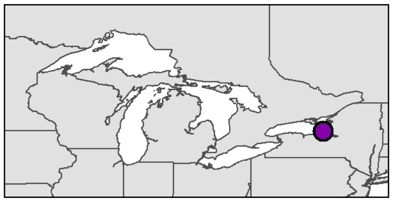
***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Oswego River



Legend

Low ● Medium ● High ● Outlier ★



Arsenic	3.6	Low	1.7	Low
Cadmium	0.65	Low	0.16	Low
Copper	23	Low	9	Low
Lead	0.9	Low	15	Low
Methyl Mercury	0.04	Medium	0.001	Low
Mercury	0.06	Medium	0.065	Low
Zinc	57	Low	36	Low

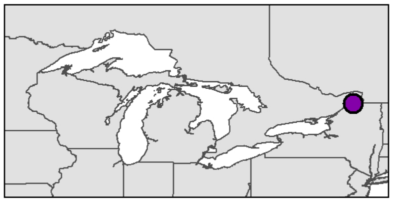
Alpha-Chlordane	5.2	Low	0.33	Medium
Chlorpyrifos	4	Low	0.08	Low
DDT	64	Low	2.9	Low
Heptachlor	0	Low	0.00	Low
Hexachlorobenzene	21	Medium	0.38	Low
Mirex	16.3	Medium	1.310	High
Benzo[a]pyrene	106	Low	213	Low
Benzo[e]pyrene	380	Medium	140	Medium
PCB	667	Low	17	Low

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

St. Lawrence River

Legend

Low · Medium · High · Outlier

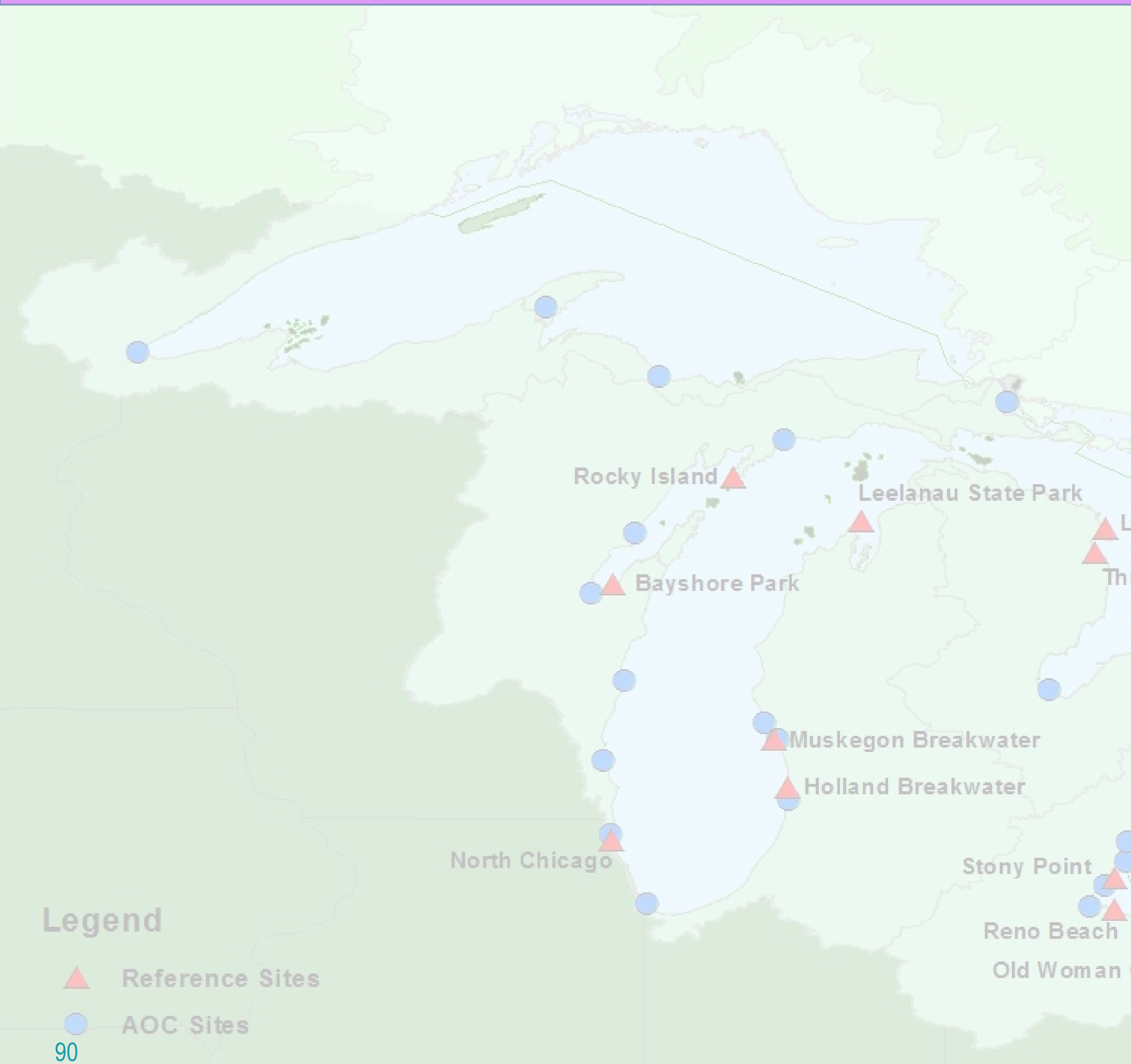


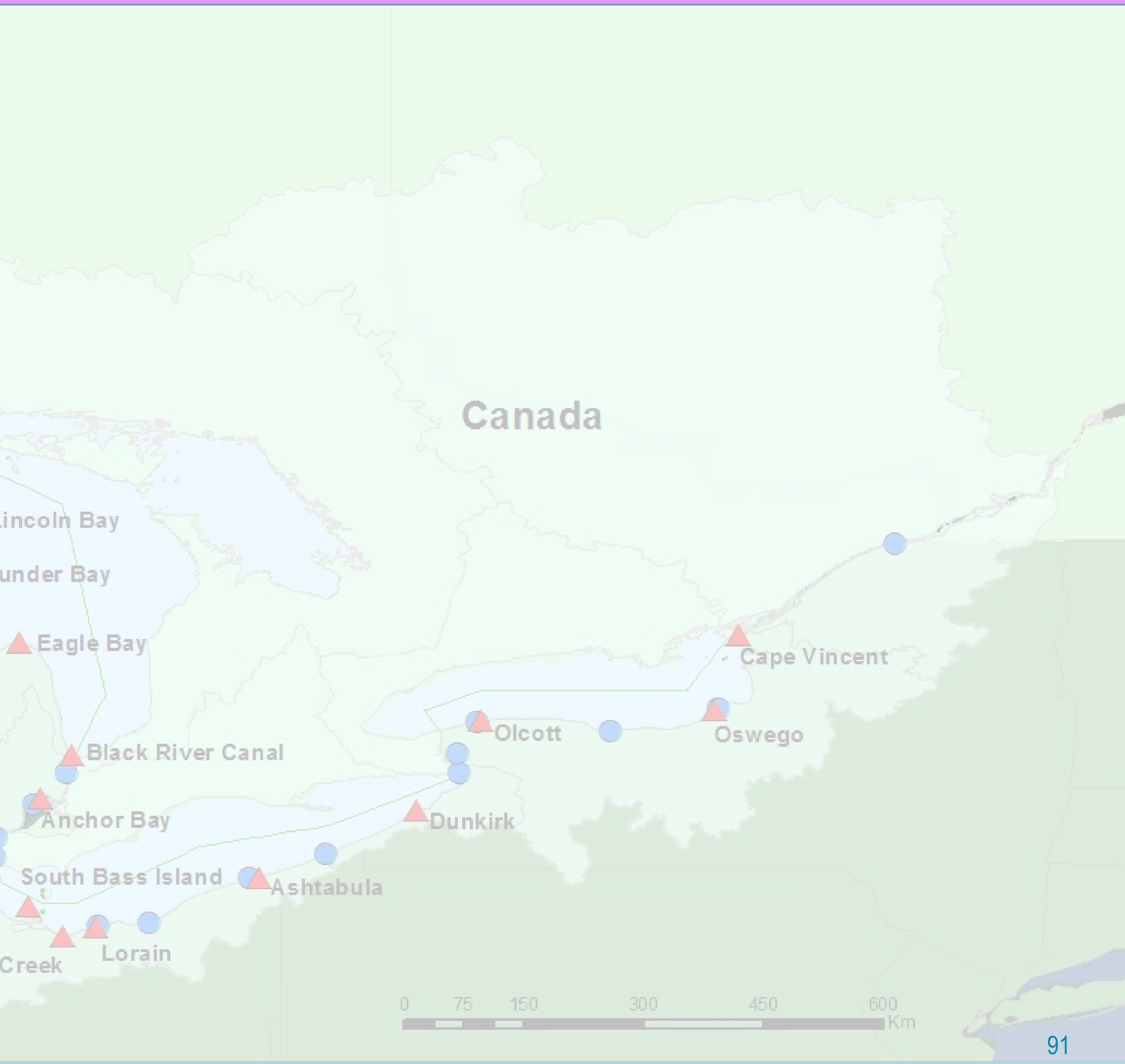
Metals (µg/g dry wt.)	Baseline - 2009/10** Tissue	Baseline - 2009/10** Sediment	Sediment - 2010		Tissue - 2011		
Arsenic	4.7	22.7					
Cadmium	1.06	0.16					
Copper	12	19					
Lead	1.5	16					
Methyl Mercury	0.02	0.000					
Mercury	0.04	0.020					
Zinc	50	91					

Organics (ng/g dry wt.)*	Baseline - 2009/10** Tissue	Baseline - 2009/10** Sediment	Sediment - 2010		Tissue - 2011		
Alpha-Chlordane	6.0	0.04					
Chlorpyrifos	14	0.00					
DDT	40	0.5					
Heptachlor	0	0.02					
Hexachlorobenzene	4	0.17					
Mirex	22.7	0.000					
Benzo[a]pyrene	386	12					
Benzo[e]pyrene	621	12					
PCB	399	5					

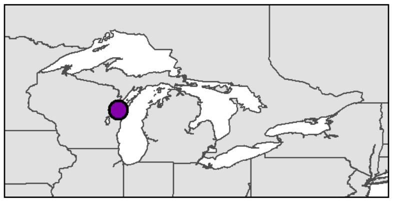
*Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).

Reference sites




Canada
Eagle Bay
Black River Canal
Anchor Bay
South Bass Island
Lorain
Ashtabula
Dunkirk
Olcott
Oswego
Cape Vincent
0 75 150 300 450 600
Km

Bayshore Park



Legend

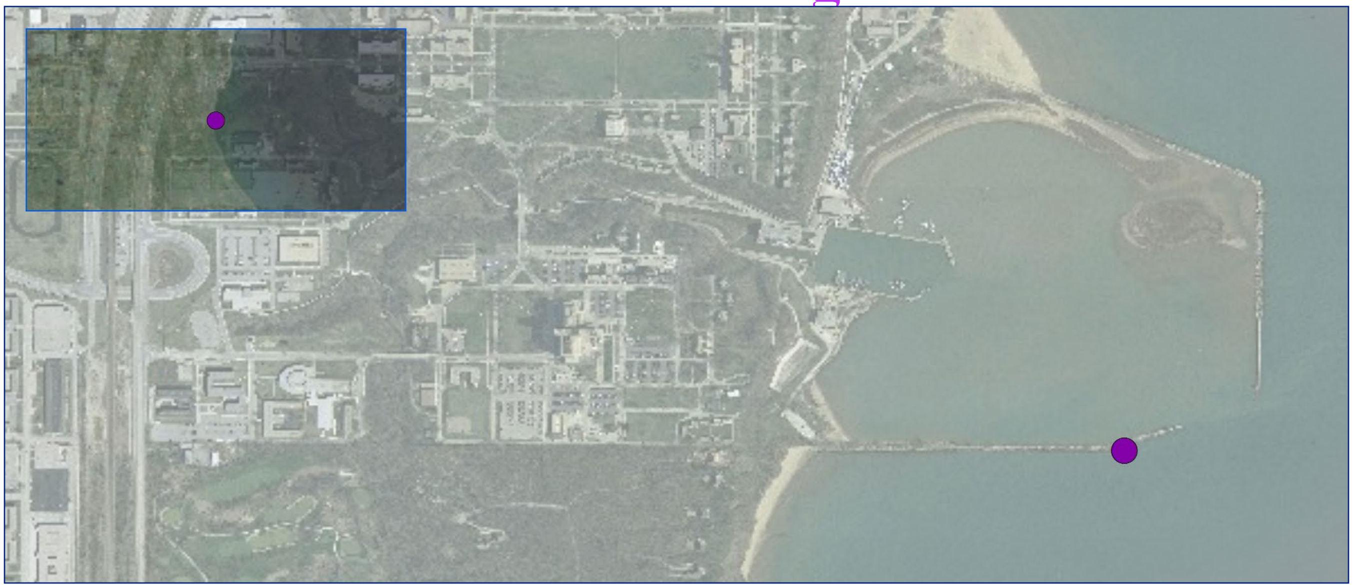
Low ● Medium ● High ● Outlier ★

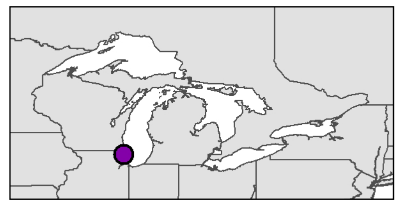
Metals (µg/g dry wt.)	**Tissue** ●		**Baseline**** **Sediment** ■	
Arsenic	3.7	Low	1.6	Low
Cadmium	0.35	Low	0.39	Low
Copper	206	High	13	Low
Lead	7.0	Medium	21	Low
Methyl Mercury	0.06	Medium	0.001	Medium
Mercury	0.08	Medium	0.261	High
Zinc	200	Outlier ★	53	Low

Organics (ng/g dry wt.)*	**Tissue** ●		**Baseline**** **Sediment** ■	
Alpha-Chlordane	3.3	Low	0.28	Medium
Chlorpyrifos	2	Low	0.65	High
DDT	109	Low	1.3	Low
Heptachlor	53	Medium	0.04	Low
Hexachlorobenzene	18	Medium	0.26	Low
Mirex	0.9	Low	0.000	Low
Benzo[a]pyrene	241	Medium	189	Low
Benzo[e]pyrene	151	Low	115	Medium
PCB	4741	Medium	100	Medium

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

North Chicago





Legend

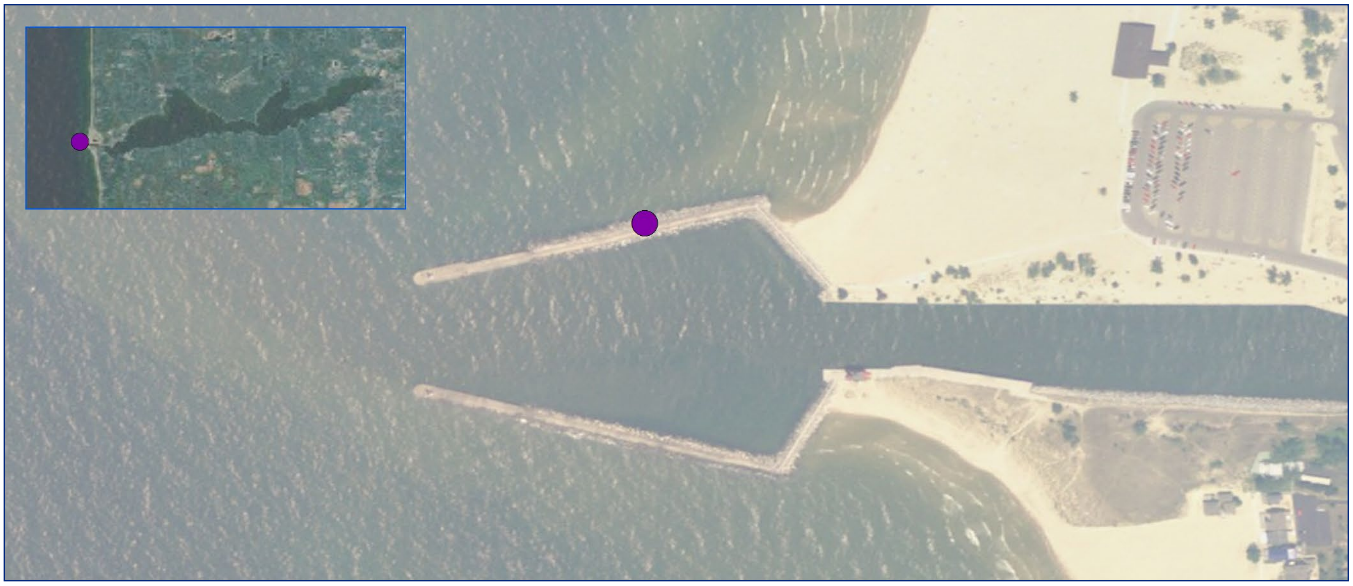
Low (green) | Medium (yellow) | High (red) | Outlier (star)

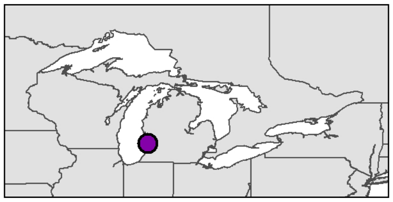
Metals (µg/g dry wt.)	Tissue	Baseline**	Sediment
Arsenic	6.2	Medium	
Cadmium	3.01	Medium	
Copper	28	Low	
Lead	8.5	High	
Methyl Mercury	0.01	Low	
Mercury	0.03	Low	
Zinc	74	Medium	

Organics (ng/g dry wt.)*	Tissue	Baseline**	Sediment
Alpha-Chlordane	26.0	Low	
Chlorpyrifos	22	High	
DDT	788	Medium	
Heptachlor	0	Low	
Hexachlorobenzene	6	Low	
Mirex	4.1	Low	
Benzo[a]pyrene	794	Medium	
Benzo[e]pyrene	562	Medium	
PCB	1851	Low	

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Holland Breakwater





Legend

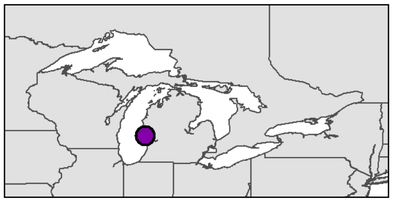
Low 🟢 Medium 🟡 High 🔴 Outlier ★

Metals (µg/g dry wt.)	**Tissue**	**Baseline** **	**Sediment**
Arsenic	5.0	🟢	
Cadmium	1.92	🟡	
Copper	28	🟢	
Lead	1.2	🟢	
Methyl Mercury	0.03	🟢	
Mercury	0.05	🟢	
Zinc	75	🟡	

Organics (ng/g dry wt.)*	**Tissue**	**Baseline** **	**Sediment**
Alpha-Chlordane	19.3	🟢	
Chlorpyrifos	10	🟡	
DDT	211	🟢	
Heptachlor	0	🟢	
Hexachlorobenzene	9	🟢	
Mirex	0.0	🟢	
Benzo[a]pyrene	187	🟢	
Benzo[e]pyrene	142	🟢	
PCB	1192	🟢	

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Muskegon



Legend

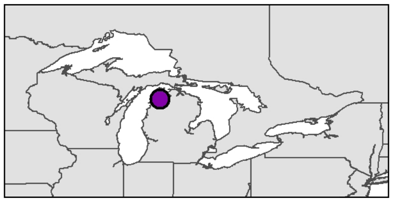
Low (green circle) · Medium (yellow circle) · High (red circle) · Outlier (star)

Metals (µg/g dry wt.)	Tissue	Baseline**	Sediment
Arsenic	4.3	Low	
Cadmium	1.39	Low	
Copper	13	Low	
Lead	1.2	Low	
Methyl Mercury	0.02	Low	
Mercury	0.04	Low	
Zinc	53	Low	

Organics (ng/g dry wt.)*	Tissue	Baseline**	Sediment
Alpha-Chlordane	18.9	Low	
Chlorpyrifos	14	Medium	
DDT	145	Low	
Heptachlor	0	Low	
Hexachlorobenzene	6	Low	
Mirex	3.5	Low	
Benzo[a]pyrene	275	Medium	
Benzo[e]pyrene	114	Low	
PCB	665	Low	

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Leelanau State Park



Legend

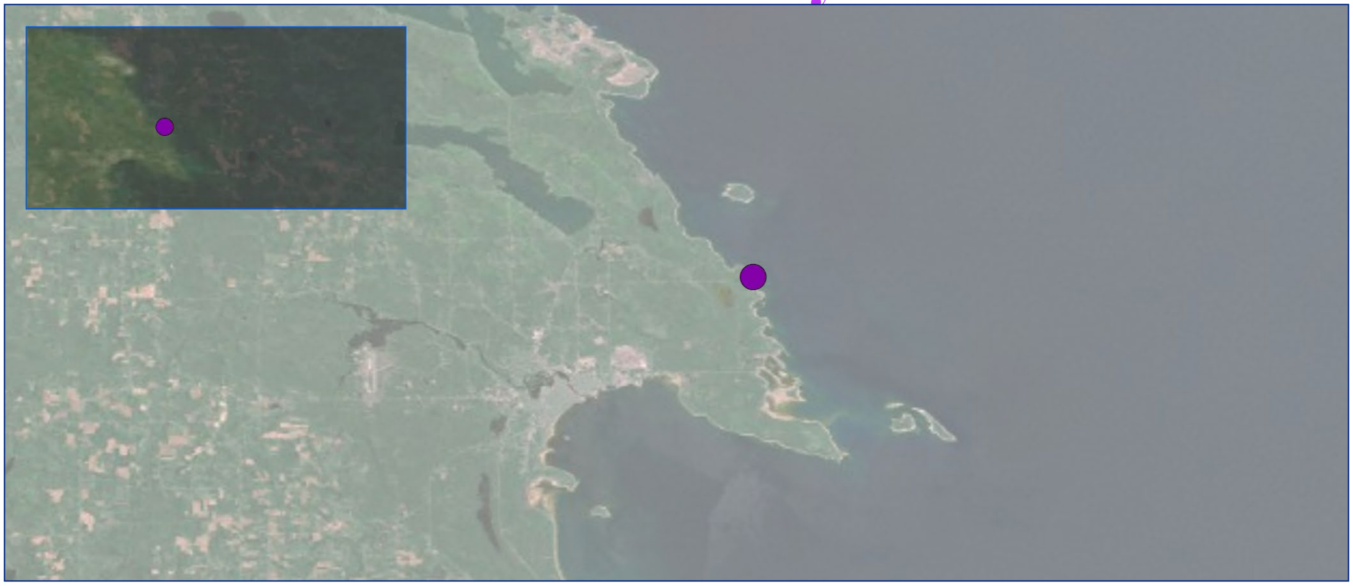
Low (green circle) | Medium (yellow circle) | High (red circle) | Outlier (star)

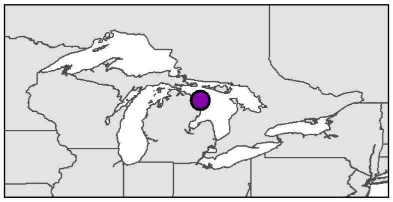
Metals (µg/g dry wt.)	**Baseline** Tissue**		**Sediment**
Arsenic	9.9	High	
Cadmium	4.24	Medium	
Copper	44	Medium	
Lead	1.6	Low	
Methyl Mercury	0.02	Low	
Mercury	0.05	Low	
Zinc	69	Medium	

Organics (ng/g dry wt.)*	**Baseline** Tissue**		**Sediment**
Alpha-Chlordane	5.3	Low	
Chlorpyrifos	6	Low	
DDT	15	Low	
Heptachlor	0	Low	
Hexachlorobenzene	0	Low	
Mirex	0.6	Low	
Benzo[a]pyrene	0	Low	
Benzo[e]pyrene	33	Low	
PCB	103	Low	

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Lincoln Bay





Legend

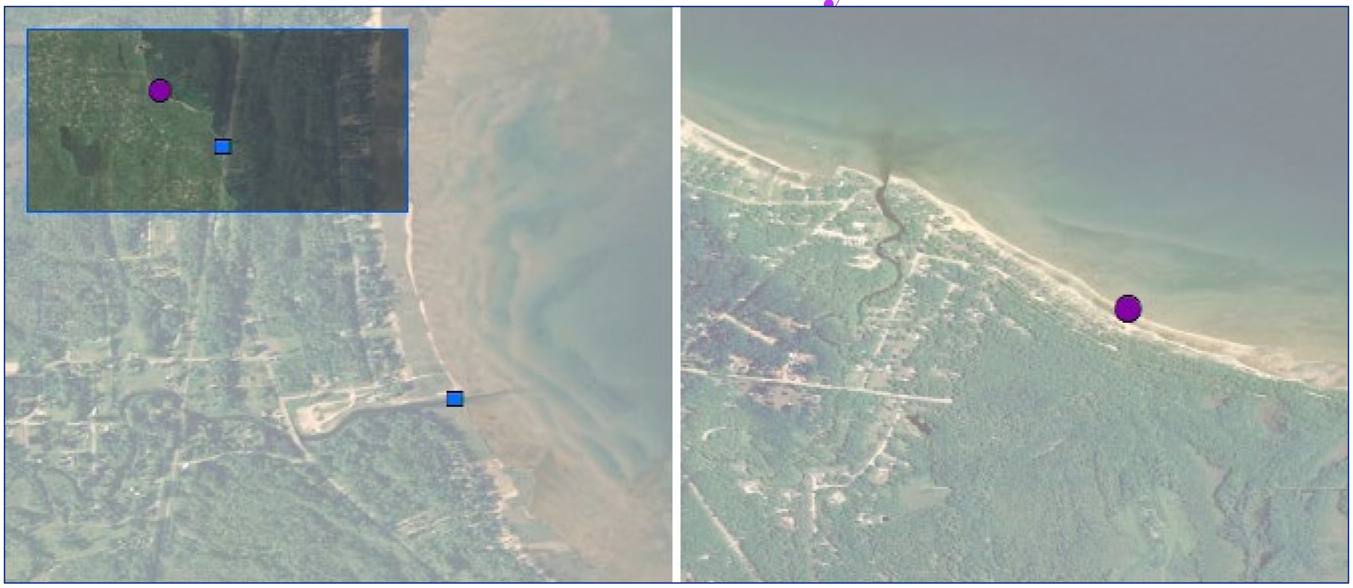
Low 🟢 Medium 🟡 High 🔴 Outlier ★

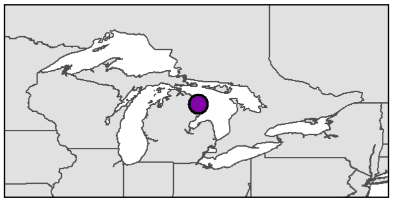
Metals (µg/g dry wt.)	**Tissue**	**Baseline****	**Sediment**
Arsenic	9.5	High	
Cadmium	6.93	High	
Copper	19	Low	
Lead	0.4	Low	
Methyl Mercury	0.03	Low	
Mercury	0.09	Medium	
Zinc	68	Medium	

Organics (ng/g dry wt.)*	**Tissue**	**Baseline****	**Sediment**
Alpha-Chlordane	3.4	Low	
Chlorpyrifos	0	Low	
DDT	14	Low	
Heptachlor	0	Low	
Hexachlorobenzene	3	Low	
Mirex	0.9	Low	
Benzo[a]pyrene	0	Low	
Benzo[e]pyrene	0	Low	
PCB	75	Low	

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Thunder Bay





Legend

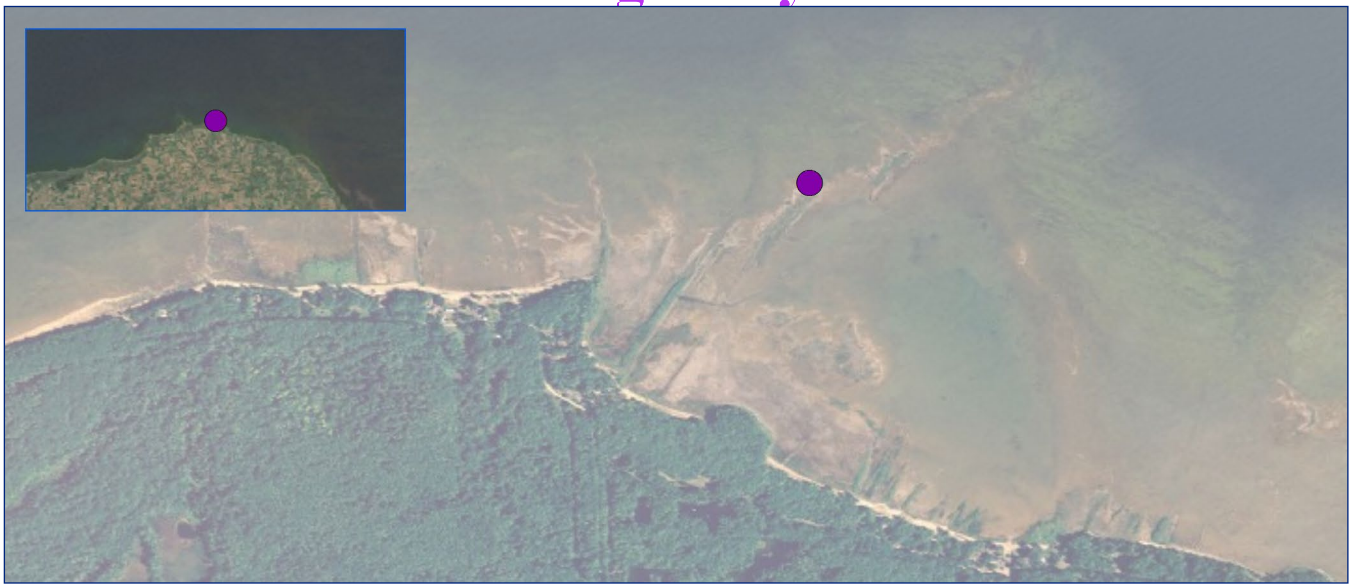
Low (green) | Medium (yellow) | High (red) | Outlier (star)

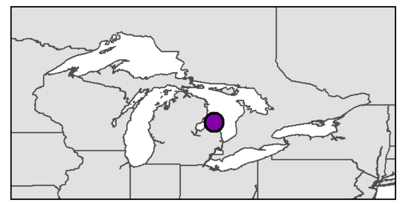
Metals (µg/g dry wt.)	**Baseline**** Tissue		Sediment	
Arsenic	5.4	Low	1.3	Low
Cadmium	8.44	High	0.24	Low
Copper	125	High	9	Low
Lead	4.9	Medium	10	Low
Methyl Mercury	0.02	Low	0.002	High
Mercury	0.07	Medium	0.040	Low
Zinc	139	High	34	Low

Organics (ng/g dry wt.)*	**Baseline**** Tissue		Sediment	
Alpha-Chlordane	9.5	Low	0.07	Low
Chlorpyrifos	3	Low	0.00	Low
DDT	30	Low	0.6	Low
Heptachlor	0	Low	0.00	Low
Hexachlorobenzene	5	Low	0.098	Low
Mirex	0.0	Low	0.011	Low
Benzo[a]pyrene	0	Low	85	Low
Benzo[e]pyrene	0	Low	46	Low
PCB	75	Low	2	Low

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Eagle Bay





Legend

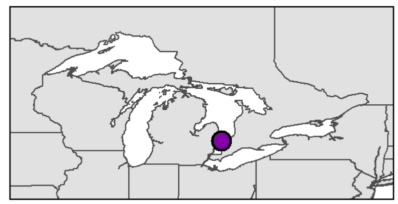
Low (green) · Medium (yellow) · High (red) · Outlier (star)

Metals (µg/g dry wt.)	**Baseline**** Tissue		Sediment
Arsenic	6.7	Medium	
Cadmium	3.94	Medium	
Copper	51	Medium	
Lead	0.9	Low	
Methyl Mercury	0.02	Low	
Mercury	0.06	Medium	
Zinc	109	High	

Organics (ng/g dry wt.)*	**Baseline**** Tissue		Sediment
Alpha-Chlordane	8.3	Low	
Chlorpyrifos	12	Medium	
DDT	38	Low	
Heptachlor	8	Low	
Hexachlorobenzene	4	Low	
Mirex	0.0	Low	
Benzo[a]pyrene	625	Medium	
Benzo[e]pyrene	54	Low	
PCB	245	Low	

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Black River Canal



Legend

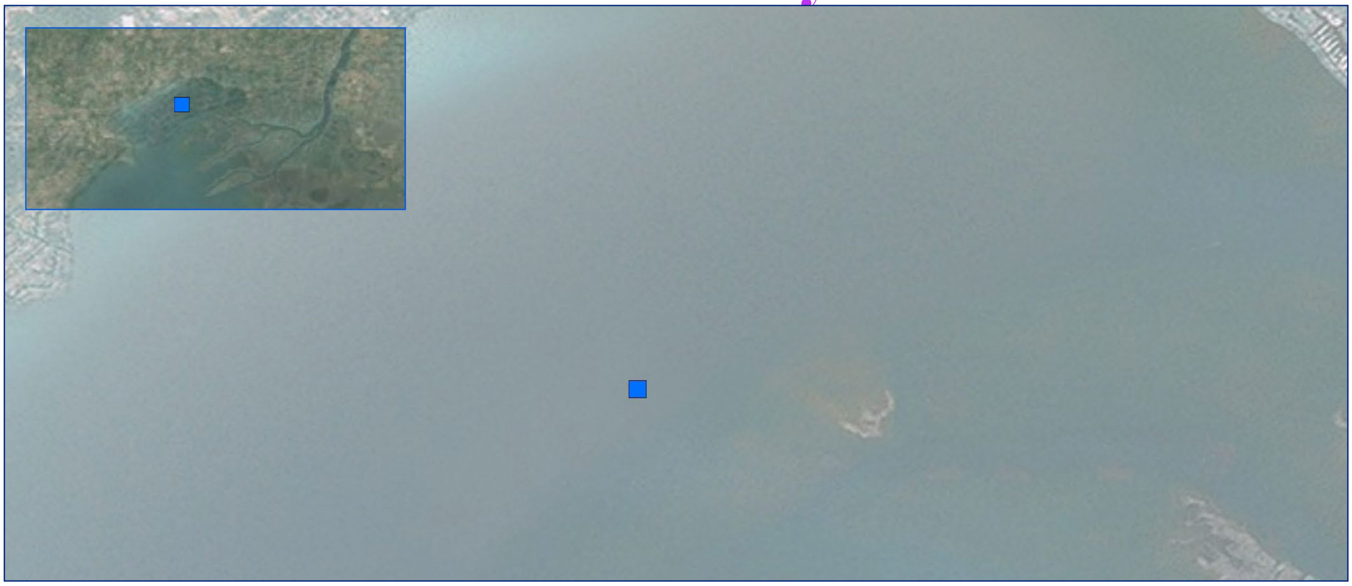
Low (green) | Medium (yellow) | High (red) | Outlier (star)

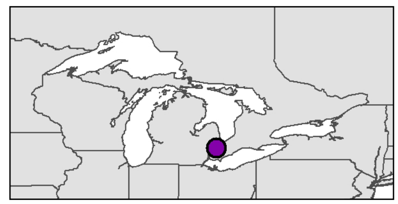
Metals (µg/g dry wt.)	**Baseline** Tissue		**Baseline** Sediment
Arsenic	8.1	Medium	
Cadmium	5.57	High	
Copper	38	Medium	
Lead	1.5	Low	
Methyl Mercury	0.02	Low	
Mercury	0.08	Medium	
Zinc	102	High	

Organics (ng/g dry wt.)*	**Baseline** Tissue		**Baseline** Sediment
Alpha-Chlordane	8.7	Low	
Chlorpyrifos	22	High	
DDT	48	Low	
Heptachlor	0	Low	
Hexachlorobenzene	2	Low	
Mirex	1.3	Low	
Benzo[a]pyrene	0	Low	
Benzo[e]pyrene	0	Low	
PCB	161	Low	

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Anchor Bay





Legend

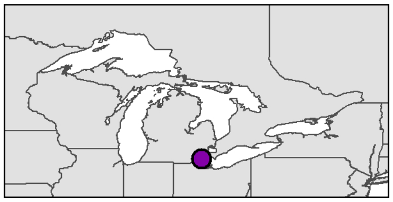
Low ● Medium ● High ● Outlier ★

Metals (μg/g dry wt.)	**Tissue** ●	**Baseline**** **Sediment** ■
Arsenic		3.3
Cadmium		0.68
Copper		17
Lead		12
Methyl Mercury		0.001
Mercury		0.072
Zinc		62

Organics (ng/g dry wt.)*	**Tissue** ●	**Baseline**** **Sediment** ■
Alpha-Chlordane		0.02
Chlorpyrifos		0.00
DDT		0.8
Heptachlor		0.04
Hexachlorobenzene		4.069
Mirex		0.000
Benzo[a]pyrene		25
Benzo[e]pyrene		18
PCB		10

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Stony Point



Legend

Low — Medium — High — Outlier

Metals (µg/g dry wt.)	**Tissue**		**Sediment**	
Arsenic	3.9	Low	4.1	Low
Cadmium	2.11	Medium	0.98	Medium
Copper	69	Medium	23	Medium
Lead	5.3	Medium	26	Low
Methyl Mercury	0.04	Medium	0.001	Medium
Mercury	0.09	Medium	0.306	High
Zinc	90	High	100	Medium

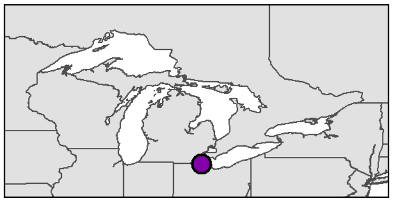
Baseline**

Organics (ng/g dry wt.)*	**Tissue**		**Sediment**	
Alpha-Chlordane	37.1	Medium	0.54	Medium
Chlorpyrifos	18	High	0.00	Low
DDT	408	Low	9.8	Medium
Heptachlor	0	Low	1.49	Medium
Hexachlorobenzene	20	Medium	1.08	Low
Mirex	3.5	Low	0.000	Low
Benzo[a]pyrene	577	Medium	174	Low
Benzo[e]pyrene	1293	High	139	Medium
PCB	7334	Medium	95	Medium

Baseline**

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Reno Beach



Legend

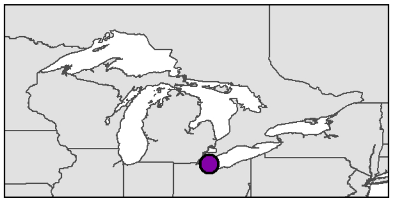
Low ● Medium ● High ● Outlier ★

Metals (µg/g dry wt.)	**Baseline** Tissue		Sediment**	
Arsenic	5.0	Low	9.0	Medium
Cadmium	1.79	Medium	0.55	Low
Copper	109	High	16	Low
Lead	4.0	Medium	15	Low
Methyl Mercury	0.02	Low	0.001	Low
Mercury	0.03	Low	0.057	Low
Zinc	92	High	53	Low

Organics (ng/g dry wt.)*	**Baseline** Tissue		Sediment**	
Alpha-Chlordane	10.1	Low	0.50	Medium
Chlorpyrifos	17	High	0.42	Medium
DDT	43	Low	7.6	Medium
Heptachlor	0	Low	0.16	Low
Hexachlorobenzene	15	Medium	0.64	Low
Mirex	0.0	Low	0.000	Low
Benzo[a]pyrene	156	Low	35	Low
Benzo[e]pyrene	335	Medium	47	Low
PCB	749	Low	51	Medium

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Peach Orchard Pt.



Legend

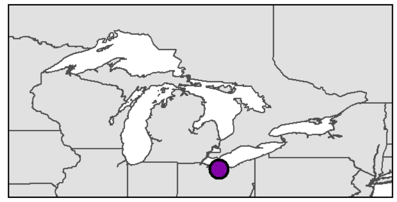
Low (green circle) | Medium (yellow circle) | High (red circle) | Outlier (star)

Metals (µg/g dry wt.)	**Tissue**		**Baseline** Sediment**	
Arsenic	5.1	Low	6.5	Medium
Cadmium	2.61	Medium	0.96	Medium
Copper	12	Low	30	Medium
Lead	2.7	Low	35	Low
Methyl Mercury	0.01	Low	0.001	Medium
Mercury	0.04	Low	0.179	Medium
Zinc	54	Low	133	Medium

Organics (ng/g dry wt.)*	**Tissue**		**Baseline** Sediment**	
Alpha-Chlordane	15.0	Low	0.73	Medium
Chlorpyrifos	20	High	0.24	Medium
DDT	109	Low	8.9	Medium
Heptachlor	0	Low	0.53	Medium
Hexachlorobenzene	9	Low	0.84	Low
Mirex	1.9	Low	0.000	Low
Benzo[a]pyrene	130	Low	82	Low
Benzo[e]pyrene	391	Medium	95	Medium
PCB	2857	Low	90	Medium

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Old Woman Creek



Legend

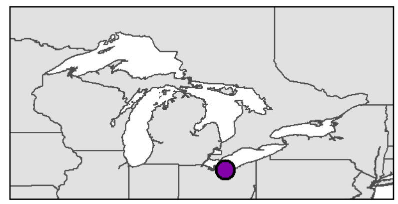
Low (green) | Medium (yellow) | High (red) | Outlier (star)

Metals (µg/g dry wt.)	**Tissue**		**Baseline** Sediment**	
Arsenic	4.2	Low	11.8	Medium
Cadmium	2.11	Medium	0.86	Medium
Copper	12	Low	31	Medium
Lead	1.2	Low	26	Low
Methyl Mercury	0.01	Low	0.001	Medium
Mercury	0.03	Low	0.075	Low
Zinc	56	Low	91	Medium

Organics (ng/g dry wt.)*	**Tissue**		**Baseline** Sediment**	
Alpha-Chlordane	14.9	Low	0.79	Medium
Chlorpyrifos	16	Medium	0.82	High
DDT	50	Low	23.9	High
Heptachlor	0	Low	0.06	Low
Hexachlorobenzene	5	Low	0.34	Low
Mirex	0.0	Low	0.020	Low
Benzo[a]pyrene	40	Low	234	Low
Benzo[e]pyrene	77	Low	164	Medium
PCB	373	Low	30	Low

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Lorain



Legend

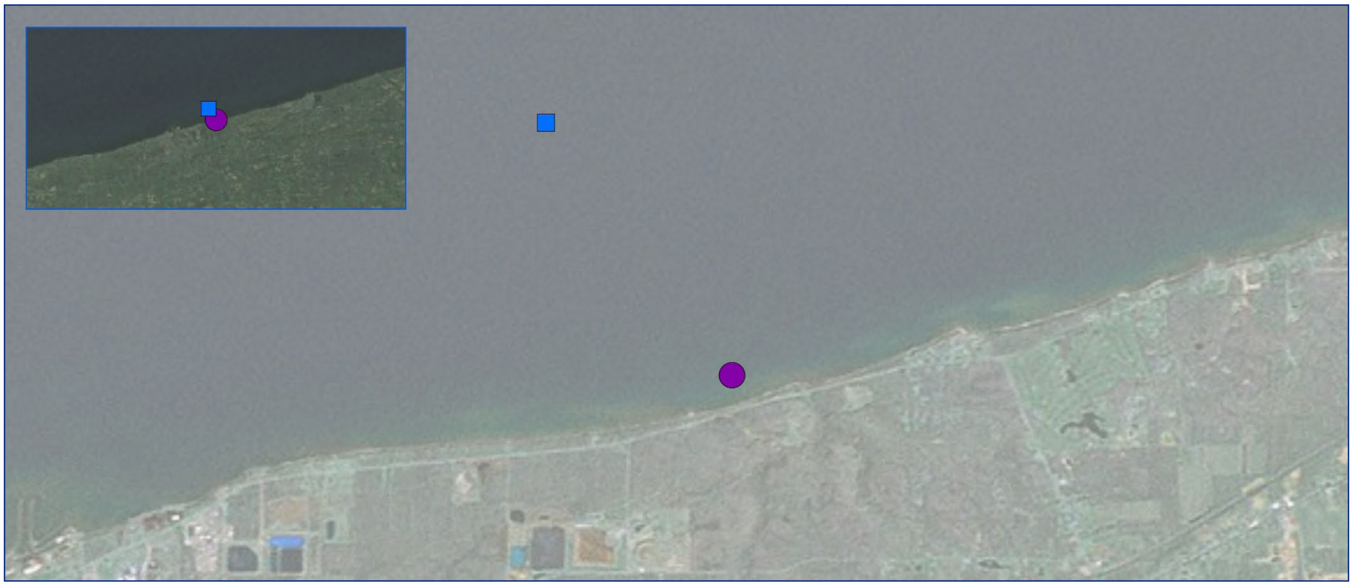
Low 🟢 Medium 🟡 High 🔴 Outlier ★

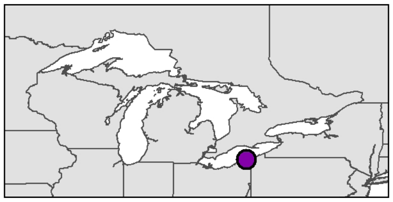
Metals (µg/g dry wt.)	Tissue	Baseline** Tissue	Baseline** Sediment
Arsenic	3.9	🟢	
Cadmium	2.66	🟡	
Copper	10	🟢	
Lead	1.6	🟢	
Methyl Mercury	0.02	🟢	
Mercury	0.03	🟢	
Zinc	47	🟢	

Organics (ng/g dry wt.)*	Tissue	Baseline** Tissue	Baseline** Sediment
Alpha-Chlordane	23.2	🟢	
Chlorpyrifos	11	🟡	
DDT	58	🟢	
Heptachlor	0	🟢	
Hexachlorobenzene	6	🟢	
Mirex	0.9	🟢	
Benzo[a]pyrene	96	🟢	
Benzo[e]pyrene	320	🟡	
PCB	604	🟢	

 ***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Ashtabula





Legend

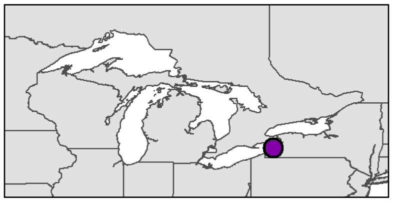
Low (green circle) | Medium (yellow circle) | High (red circle) | Outlier (star)

Metals (µg/g dry wt.)	Tissue		Baseline** Sediment	
Arsenic	6.1	Medium	10.6	Medium
Cadmium	3.52	Medium	0.54	Low
Copper	10	Low	22	Medium
Lead	1.4	Low	23	Low
Methyl Mercury	0.01	Low	0.000	Low
Mercury	0.03	Low	0.058	Low
Zinc	58	Low	106	Medium

Organics (ng/g dry wt.)*	Tissue		Baseline** Sediment	
Alpha-Chlordane	15.1	Low	0.72	Medium
Chlorpyrifos	4	Low	0.05	Low
DDT	49	Low	9.0	Medium
Heptachlor	0	Low	0.18	Low
Hexachlorobenzene	21	Medium	1.46	Low
Mirex	2.6	Low	0.000	Low
Benzo[a]pyrene	63	Low	128	Low
Benzo[e]pyrene	135	Low	118	Medium
PCB	1120	Low	109	Medium

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Dunkirk



Legend

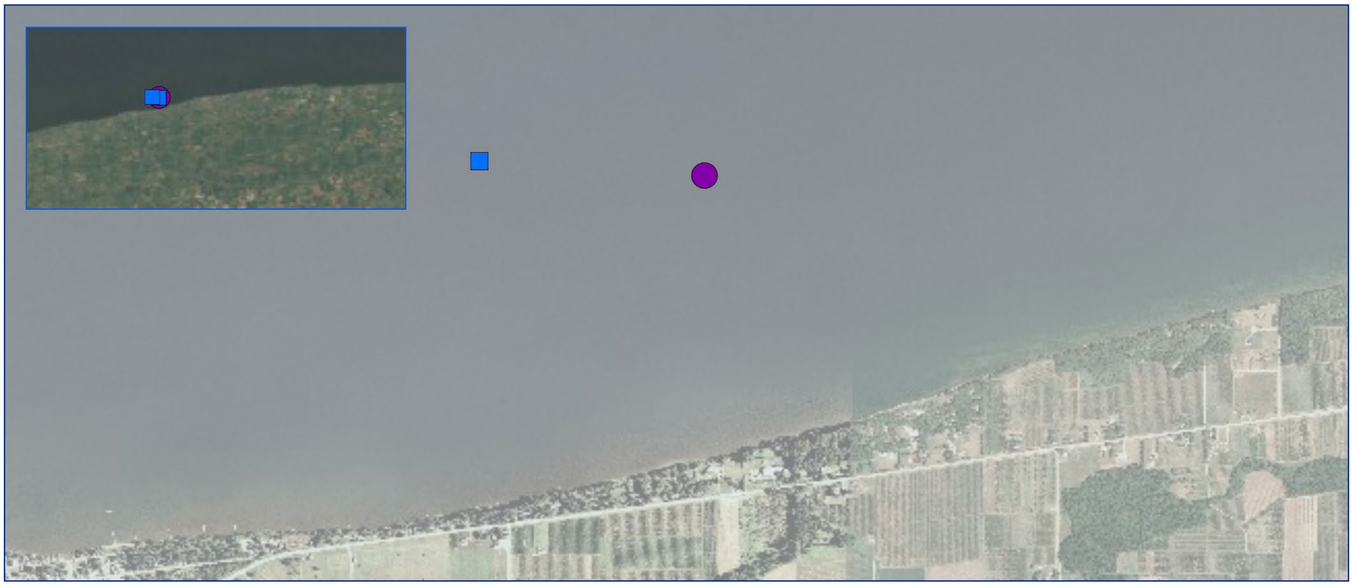
Low	Medium	High	Outlier
green circle	yellow circle	red circle	star

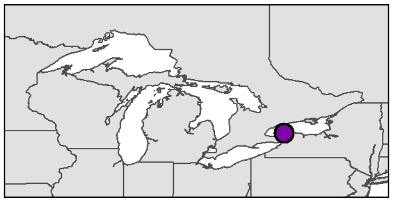
Metals (µg/g dry wt.)	**Tissue**		**Baseline** Sediment**	
Arsenic	6.6	Medium	12.3	Medium
Cadmium	3.99	Medium	0.36	Low
Copper	11	Low	15	Low
Lead	2.0	Low	22	Low
Methyl Mercury	0.01	Low	0.000	Low
Mercury	0.03	Low	0.033	Low
Zinc	56	Low	109	Medium

Organics (ng/g dry wt.)*	**Tissue**		**Baseline** Sediment**	
Alpha-Chlordane	7.5	Low	0.53	Medium
Chlorpyrifos	4	Low	0.07	Low
DDT	53	Low	8.2	Medium
Heptachlor	0	Low	0.00	Low
Hexachlorobenzene	10	Low	1.26	Low
Mirex	0.0	Low	0.000	Low
Benzo[a]pyrene	139	Low	57	Low
Benzo[e]pyrene	219	Low	65	Low
PCB	599	Low	31	Low

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Olcott





Legend

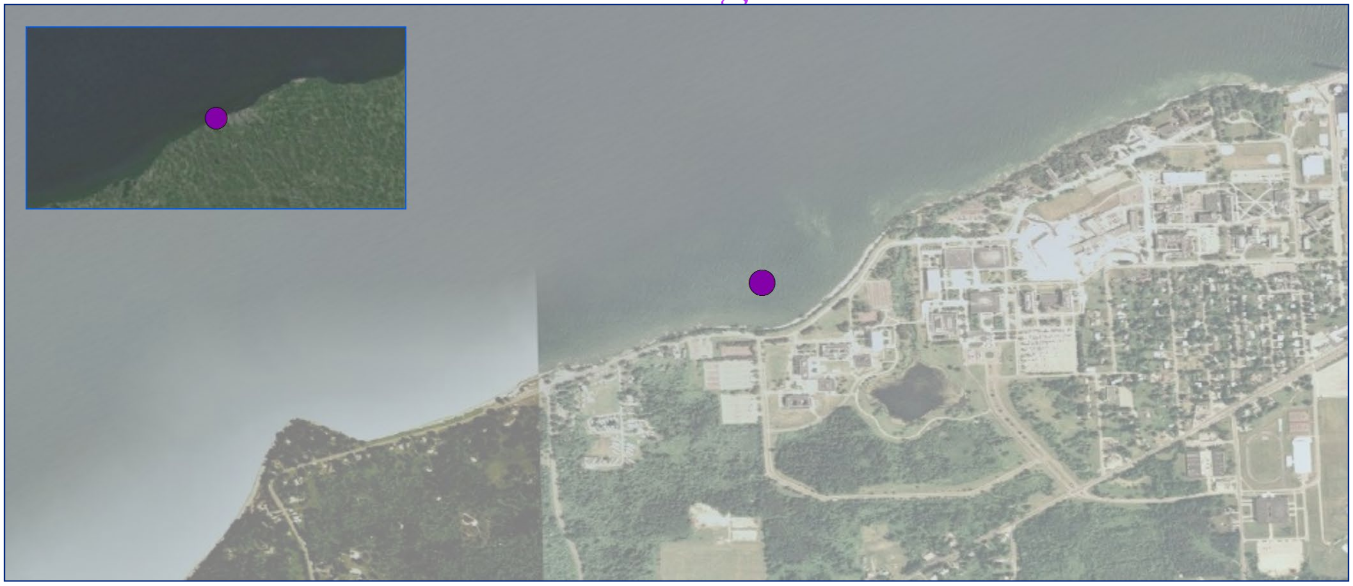
Low (green) | Medium (yellow) | High (red) | Outlier (star)

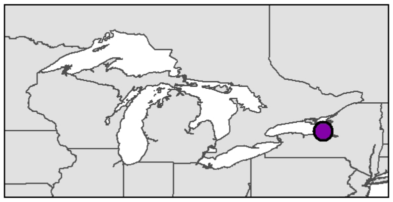
Metals (µg/g dry wt.)	**Tissue**		**Sediment** (Baseline**)	
Arsenic	6.2	Medium	10.6	Medium
Cadmium	3.59	Medium	0.54	Low
Copper	9	Low	28	Medium
Lead	0.9	Low	25	Low
Methyl Mercury	0.02	Low	0.002	Medium
Mercury	0.04	Low	0.176	Medium
Zinc	57	Low	122	Medium

Organics (ng/g dry wt.)*	**Tissue**		**Sediment** (Baseline**)	
Alpha-Chlordane	9.9	Low	0.81	Medium
Chlorpyrifos	8	Medium	0.10	Low
DDT	117	Low	7.7	Medium
Heptachlor	0	Low	0.00	Low
Hexachlorobenzene	17	Medium	6.1	High
Mirex	47.4	High	0.400	Medium
Benzo[a]pyrene	77	Low	149	Low
Benzo[e]pyrene	207	Low	129	Medium
PCB	866	Low	99	Medium

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

Oswego





Legend

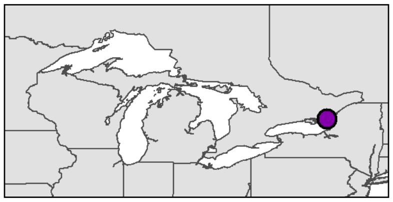
Low (green circle) | Medium (yellow circle) | High (red circle) | Outlier (star)

Metals (µg/g dry wt.)	Tissue	Baseline** Tissue	Baseline** Sediment
Arsenic	3.5	Low	
Cadmium	1.08	Low	
Copper	12	Low	
Lead	0.5	Low	
Methyl Mercury	0.01	Low	
Mercury	0.03	Low	
Zinc	34	Low	

Organics (ng/g dry wt.)*	Tissue	Baseline** Tissue	Baseline** Sediment
Alpha-Chlordane	9.7	Low	
Chlorpyrifos	5	Low	
DDT	62	Low	
Heptachlor	0	Low	
Hexachlorobenzene	9	Low	
Mirex	18.7	Medium	
Benzo[a]pyrene	100	Low	
Benzo[e]pyrene	61	Low	
PCB	281	Low	

*Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).

Cape Vincent



Legend

Low (green) | Medium (yellow) | High (red) | Outlier (star)

Metals (µg/g dry wt.)	Tissue		Baseline** Sediment	
Arsenic	7.5	Medium	4.1	Low
Cadmium	1.90	Medium	1.00	Medium
Copper	10	Low	31	Medium
Lead	0.73	Low	22	Low
Methyl Mercury	0.01	Low	0.002	Medium
Mercury	0.04	Low	0.105	Low
Zinc	54	Low	95	Medium

Organics (ng/g dry wt.)*	Tissue		Baseline** Sediment	
Alpha-Chlordane	8.5	Low	0.58	Medium
Chlorpyrifos	14	Medium	0.27	Medium
DDT	29	Low	3.0	Low
Heptachlor	0	Low	0.00	Low
Hexachlorobenzene	6	Low	1.01	Low
Mirex	37.4	High	1.060	High
Benzo[a]pyrene	34	Low	51	Low
Benzo[e]pyrene	288	Medium	45	Low
PCB	293	Low	18	Low

***Tissue data is lipid normalized. **Core basin-wide measurements (AOC and reference sites).**

References

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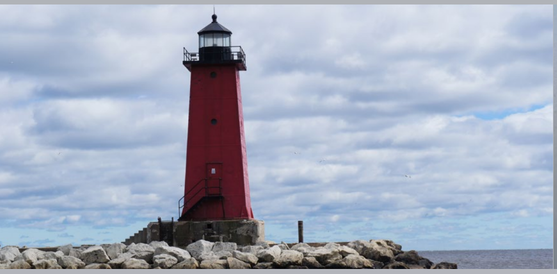

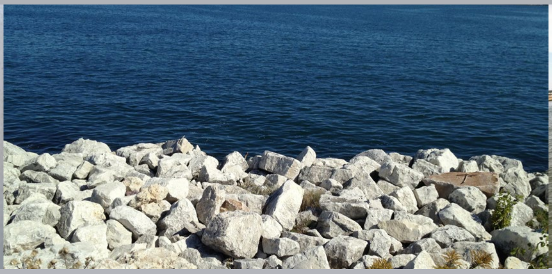

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