IJC Microplastics Workshop #2 – Advancing a Risk Assessment and Management Framework for Microplastics in the Laurentian Great Lakes

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Workshop Report

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Prepared for:

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Prepared By:

Potomac-Hudson Engineering, Inc.

Rockville, MD

LimnoTech

Ann Arbor, MI

Table of Contents

Acronyms ... 3
1. Project Background ... 4
2. Workshop #2 Objectives and Proceedings ... 6
Workshop #2 Objectives and Structure ... 6
Workshop #2 Proceedings ... 8
Welcoming Remarks and Background Information on Risk Assessment Frameworks ... 8
Plenary Session #1: Risk Management Framework ... 9
1.1 How many management tiers should be included in the risk management framework? ... 9
1.2 How many risk threshold values should be included in the risk management framework? ... 10
1.3 How do we decide when the trend is unchanging, deteriorating, or improving? ... 10
1.4 What are the management responses associated with each tier? ... 11
Plenary Session #2: Risk Threshold Value Development ... 12
2.1 Should all available toxicity data be used across all taxa or only taxa relevant to the Great Lakes? ... 12
2.2 How many, and which, taxonomic groups and species should be represented in the species sensitivity distribution (SSD) curves? ... 13
2.3 Which endpoint categories/levels of biological organization should be included? ... 14
2.4 What effect concentrations should be used (e.g., LOEC, NOEC, other)? ... 15
2.5 How should the toxicity data be aggregated within species? ... 15
2.6 What hazard concentration (HC) values should be used for the risk threshold values in the risk management framework? ... 15
Plenary Session #3: Data Rescaling and Alignment ... 16
3.1 Which fitting parameters should we use to rescale the exposure data? ... 17
3.2 Which fitting parameters should we use to rescale the effects data? ... 17
Plenary Session #4: Quality assurance and quality control (QA/QC) for Exposure and Effects Data ... 17
4.1 Which QA/QC criteria should be required to include effects data in the risk assessment? ... 18
4.2 Which QA/QC criteria should be required to include exposure data in the risk assessment? ... 19
Day 2 – Review of Key Decisions, SSD Reveal, and Wrap Up ... 20
3. Post-Workshop Activities ... 25
Confidence Assessment Exercise ... 25
Conclusion ... 27
4. References ... 29
Appendix A. Workshop Agenda ... 30
Appendix B. Workshop Participants ... 34
Appendix C. Monitoring Data and SSD-Derived Risk Threshold Values ... 36

Acronyms

CCME	Canadian Council of Ministers of the Environment
CMC	Chemicals of Mutual Concern
EC	Effect Concentration
GLWQA	Great Lakes Water Quality Agreement
HC	Hazard Concentration
HONEC	Highest Observed No-Effect Concentration
IC	Inhibition Concentration
IJC	International Joint Commission
LOD	Limit of Detection
LOEC	Lowest Observed Effect Concentration
MATC	Maximum Acceptable Toxicant Concentration
NOEC	No Observed Effect Concentration
PDF	Probability Density Function
QA/QC	Quality Assurance/Quality Control
SAB	Science Advisory Board
SCCWRP	Southern California Coastal Water Research Project Authority
SOGL	State of the Great Lakes
SOP	Standard Operating Procedure
SSD	Species Sensitivity Distribution
SWRCB	State Water Resources Control Board
ToMEx	Toxicity of Microplastics Explorer

1. Project Background

Plastic debris is accumulating in aquatic and terrestrial systems worldwide, including the Laurentian Great Lakes. In 2016, the International Joint Commission (IJC) conducted a project on how to address microplastic pollution in the Great Lakes. The project included a workshop with regional subject matter experts and a report (published in 2016) summarizing its presentations and discussions as well as ten recommendations. From this, and with public input, the IJC developed four recommendations (published in 2017) for the American and Canadian governments to consider. Among these, the IJC recommended that the governments develop and/or adopt standardized sampling and analytical methods for microplastics and assess their potential ecological health impacts to advance a binational assessment of microplastic pollution in the Great Lakes and inform decision-making.

In 2022, the IJC's Great Lakes Science Advisory Board (SAB) established a Great Lakes Microplastics Monitoring and Risk Assessment Work Group to follow up on the 2016 report and advance the 2017 recommendations. The IJC SAB Work Group consists of subject matter experts working in a voluntary capacity to synthesize our understanding of microplastic pollution in the Great Lakes, including their prevalence and potential for ecological impacts, and develop recommendations on advancing regional monitoring and risk assessment and management frameworks. The SAB, in turn, will consider these recommendations when advising the IJC. The overarching objectives of this project are to:

1. Synthesize recent advances and knowledge in plastics science relevant to the Great Lakes through a literature review, database updates, and events that bring together researchers to share the latest information on plastics.
2. Develop a framework for monitoring microplastic pollution in the Great Lakes that would support its use as a Toxic Chemicals sub-indicator for the State of the Great Lakes (SOGL) reports under Annex 10 (Science) of the Great Lakes Water Quality Agreement (GLWQA).
3. Develop a coordinated risk assessment and management framework for microplastic pollution in the Great Lakes focused on ecological effects that would contextualize the results of a monitoring program.

The IJC SAB Work Group's current focus is on environmental monitoring and ecological effects in aquatic ecosystems, and it is hoped that future groups will build on this work to focus on human exposure and risk.

Activities that the IJC SAB Work Group has conducted to meet Objective 1 include (a) a synthesis of studies on the prevalence of microplastics in the Great Lakes and compilation of Great Lakes microplastics monitoring data into a publicly accessible database, (b) a synthesis of available information on the toxicity of microplastics to species of relevance to the Great Lakes, (c) the organization and facilitation of a conference session on plastic pollution in the Great Lakes with a summary of the session proceedings, and (d) an update to a publicly accessible database[1] of ecotoxicological studies on the effects of microplastics on marine and freshwater biota (available early 2025). Activities conducted to meet Objective 2 include the organization and facilitation of a workshop (Workshop #1) to elicit expert insights and feedback to support the advancement of a framework for monitoring microplastic pollution in the Great Lakes, including standard operating procedures (SOPs) for sampling microplastics in ambient water, biota, sediment, and riverine water. Building on prior activities, this workshop (Workshop #2) was organized to complete activities to meet Objective 3 and elicit expert insights and feedback to support the advancement of a coordinated risk assessment and management framework for microplastic pollution in the Great Lakes. This report summarizes Workshop #2 proceedings and key outcomes.

[1] ToMEx Is an open-source database and accompanying R Shiny web application that enables users to search and visualize microplastics toxicity data as well as model ecosystem-specific risks pertaining to aquatic organisms. ToMEx can be accessed online at https://microplastics.sccwrp.org/.

2. Workshop #2 Objectives and Proceedings

Workshop #2 Objectives and Structure

This workshop was organized to support the IJC SAB Work Group in meeting Objective 3 (*Develop a coordinated risk assessment and management framework for microplastic pollution in the Great Lakes focused on ecological effects that would contextualize the results of a monitoring program*). The specific objectives of the workshop were to:

1. Develop recommendations to inform a threshold-based ecological risk assessment framework for exposure in ambient water and sediment in the Great Lakes that would contextualize the results of a monitoring program and inform the potential inclusion of microplastics as a Toxic Chemicals sub-indicator for ecosystem health for the SOGL reports.
2. Develop recommendations for a management framework coordinated with the threshold-based ecological risk assessment framework.
3. Develop recommendations to inform decision-making about including exposure and effects data in the risk assessment and management framework.

Workshop #2 was held on January 17th and 18th, 2024, in Windsor, ON. The agenda is included in Appendix A. Twenty experts participated in the workshop (including four virtual participants), in addition to five IJC and three contractor staff. A list of participants is included in Appendix B.

Figure 1. In-Person Workshop Participants During a Break

The workshop was organized around a set of decision points that needed to be made to adapt a coordinated risk management and assessment framework, developed in the State of California by an expert work group convened and coordinated by the Southern California Coastal Water Research Project Authority (SCCWRP), for relevance to the Great Lakes region. The workshop began with presentations describing relevant background, including the frameworks developed and used by SCCWRP and earlier work done in the Great Lakes region to inform the workshop's objectives. The first session was followed by four plenary sessions covering different decision points and recommendations on adapting the tools for regional relevance. Each plenary session comprised a more detailed background presentation followed by a guided discussion to elicit insights and feedback from the workshop participants on the proposed decision points and associated recommendations to ultimately reach a consensus. All workshop presentations are available online. The decisions made by the workshop participants during each plenary session are summarized in Table 1 and described in more detail in the following sections.

Table 1. Questions discussed and decisions reached during Workshop #2.

Question	Decision/Recommendation
Plenary Session #1: Risk Management Framework	
How many tiers should be included in the risk management framework?	*The framework should include three management tiers, representing a Good, Fair, or Poor status of ecosystem health.*
How many thresholds should be included in the risk management framework?	*The framework should include two risk thresholds to differentiate the three tiers.*
How do we decide if a trend is *Unchanging*, *Deteriorating*, or *Improving*?	*To be consistent with the structure of the SOGL reporting framework, trends in ecosystem health should be based on increases or decreases in monitored concentrations relative to the previous report (published every three years).*
What are the recommended management responses associated with each tier?	*Recommended management responses should be separated from the tiers and instead associated with Status and Trend combinations.*
Plenary Session #2: Risk Threshold Value Development	
Which SSD curves should be used to derive the risk thresholds?	*One SSD curve relevant to microplastic volume should be created and used to derive risk thresholds; for animals, limit particle size to gape size or smaller, and use the full microplastic size range for plants and algae.*
Should all available toxicity data across all taxa be included in the SSD curves or only species relevant to the Great Lakes ecosystem?	*Use toxicity data for all taxa and species that are biologically relevant to the Great Lakes ecosystem, including plants and algae.*
How many and which taxonomic groups and species should be represented in the SSD curves?	*Aim to meet the minimum dataset requirements of the CCME's Canadian Environmental Quality Guidelines.*
Which endpoint categories/ levels of biological organization should be included in the SSD curves?	*Use organismal-level apical endpoints (i.e. mortality, growth, and reproduction).*

Question	Decision/Recommendation
Which effect metrics should be included in the SSD curves?	*Use NOECs (i.e., No Observed Effect Concentration) for now; however, ECs (i.e., Effect Concentration) are preferred once available.*
How should toxicity data be averaged within species?	*Use the geometric mean of toxicity data for the same species and endpoint, or for toxicity data for different endpoints within the same species, use data for the most conservative endpoint that meets the minimum data quality requirements.*
Which hazard concentration (HC) values should be used for the thresholds in the risk management framework?	*Threshold 1 (between Good and Fair; Figure 2) should represent the HC_5 value, and threshold 2 (between Fair and Poor) should represent the HC_{30} value.*
Plenary Session #3: Data Rescaling and Alignment	
Which PDFs should be used to rescale and align exposure data?	*Use PDFs for freshwater surface water and sediment from Kooi et al. (2021) to rescale and align exposure (i.e., monitoring) data until Great Lakes-specific PDFs are available.*
Which PDFs should be used to rescale and align effects data?	*Use PDFs for freshwater surface water and sediment from Kooi et al. (2021) to rescale and align exposure (i.e., monitoring) data until Great Lakes-specific PDFs are available.*
Plenary Session #4: QA/QC Criteria for Exposure and Effects Data	
Which QA/QC criteria should be required to include effects (i.e., toxicity) data in the risk assessment?	*Aim to meet the Red criteria developed by the SCCWRP Work Group in combination with the criteria from the CCME's Canadian Environmental Quality Guidelines (CCME, 2007; Table 3).*
Which QA/QC criteria should be required to include exposure (i.e., monitoring) data in the risk assessment?	*Use the approach outlined by Hataley et al. (2023). Additional recommended criteria include disclosure of study limits of detection (LOD) and whether key particle characteristics (size, color, morphology) were reported.*

Workshop #2 Proceedings

Welcoming Remarks and Background Information on a Risk Assessment and Management Framework

Day 1 of the workshop began with opening remarks from the organizers and facilitators (IJC and contractor staff and the IJC SAB Work Group Co-Chairs) outlining objectives, approaches, and deliverables. Several introductory presentations followed, describing previous exploratory work from within the region on integrating microplastic pollution into Great Lakes governance structures, as well as work from beyond the region on developing tools for microplastic risk assessment and management.

Under Annex 10 (Science) of the GLWQA, Canada and the United States are required to report on the health of the Great Lakes ecosystem every three years by assessing the current status and trends over time of a suite of nine chemical, physical, and biological indicators (i.e., the SOGL reports; see https://stateofgreatlakes.net/ for a complete list of indicators). If considered for inclusion in the SOGL reports, microplastic would be most relevant as a sub-indicator for the Toxic Chemicals indicator. This idea has been explored by the Canadian federal government through the drafting of sub-indicator reports for microplastic as if it was considered a Toxic Chemicals sub-indicator. This exercise demonstrated that the region was missing two prerequisites to include microplastic as a Toxic Chemicals sub-indicator: (1) a monitoring program that provides concentrations of microplastics across environmental matrices, with high enough spatial and temporal resolution to establish a baseline and assess trends, and (2) environmental quality benchmarks for microplastics (i.e., threshold values to inform risk) to contextualize the results of monitoring efforts and assess statuses. Workshop #1 focused on advancing a monitoring program for microplastics, while Workshop #2 focused on advancing environmental quality benchmarks for microplastics.

To fill these needs in the Great Lakes region, we can look to recent work by a work group of international experts convened and coordinated by the Southern California Coastal Water Research Project Authority (SCCWRP) in California. The SCCWRP Work Group developed a multi-tiered, risk-based management framework for microplastic pollution in aquatic ecosystems and derived ecological risk threshold values for exposure to microplastic in ambient water (Mehinto et al., 2022) using a quantitative risk assessment framework created by the Microplastic Lab at Wageningen University and Research led by Dr. Albert Koelmans (Koelmans et al., 2020; 2022). The risk management framework developed by Mehinto et al. (2022) contains five management tiers, ranging from low to high regulatory concern, and four risk threshold values relevant to the concentrations at which 5% (HC_5) and 10% (HC_{10}) of the species in a community would be impacted. Each management tier contains a recommended management action, which ranges from "no action required" under the "No Concern" tier to "implement pollution control measures" under the "Highest Concern" tier. The risk assessment framework uses species sensitivity distributions (SSDs) to derive risk threshold values for effects assumed to be triggered by two of the most well-understood mechanisms of microplastic toxicity to date: ingestion resulting in food dilution (related to particle volume) and tissue translocation resulting in inflammation (related to particle surface area). In addition, the risk assessment framework requires that exposure and effects data are both screened against QA/QC criteria and rescaled and aligned before being used for assessment. To construct SSDs and derive risk threshold values, the SCCWRP Work Group also developed an open-source database and accompanying R Shiny web application that enables users to search and visualize microplastic toxicity data as well as model ecosystem-specific risks pertaining to aquatic organisms called the Toxicity of Microplastics Explorer (ToMEx; Thornton-Hampton et al., 2022).

Due to the similarities in objectives and deliverables between the IJC SAB Work Group and the SCCWRP Work Group, the novelty of the frameworks and tools both used and produced by the SCCWRP Work Group, as well as global efforts to increase harmonization in microplastics research and management, we chose to build on the frameworks and tools used and produced by the SCCWRP Work Group and adapt them for relevance to the Great Lakes region.

Plenary Session #1: Risk Management Framework

Plenary Session #1 began with a detailed background presentation by Dr. Chelsea Rochman (University of Toronto and IJC SAB Work Group Co-Chair) on the multi-tiered, risk-based management framework for microplastic pollution in aquatic ecosystems developed by the SCCWRP Work Group (i.e., Mehinto et al., 2022) as well as the SOGL reporting framework. Both frameworks are described above under *Welcoming Remarks and Background Information on Risk Assessment and Management Frameworks*. The presentation was designed to spearhead a discussion on how the risk management framework could be adapted to fit within the structure of the SOGL reporting framework. To guide this discussion, Dr. Rochman posed the following questions for consideration by workshop participants:

- How many tiers should be included in the risk management framework?
- How many thresholds should be included in the risk management framework?
- How do we decide if a trend is *Unchanging*, *Deteriorating*, or *Improving*?
- What are the recommended management responses associated with each tier?

1.1 How many tiers should be included in the risk management framework?

Decision: *The risk management framework should include three tiers, each representing a status of ecosystem health (i.e., Good, Fair, and Poor) to align with the structure of the SOGL reporting framework (Figure 2). In addition, and also aligned with the structure of the SOGL reporting framework, trends over time (i.e., Improving, Unchanging, or Deteriorating) should be considered together with the tiers. The Undetermined category indicates that there is insufficient data to clearly determine the status or trend or that the threshold value has yet to be determined.*

Discussion: The group agreed that the risk management framework should align as fully as possible with the structure of the SOGL reporting framework. There was some discussion about splitting the middle tier (*Fair*) into two sub-tiers. However, the group determined that this may be confusing because it would not align with the structure of the SOGL reporting framework.

1.2 How many thresholds should be included in the risk management framework?

Decision: *The risk management framework should include two thresholds to differentiate the three tiers (Figure 2).*

Discussion: As mentioned above, there was a discussion about including an additional threshold inside the *Fair* tier. The group thought this might be useful if the existing threshold values were far apart. However, it was decided that this would impede the framework's usability because it would deviate from the typical structure of the SOGL reporting framework. The group discussed that the thresholds should represent hazard concentration (HC) values and that these be spaced far apart to separate the three tiers clearly and to convey the message that characterizing the ecosystem health of the Great Lakes as *Poor* implies a high degree of ecological risk from microplastic pollution. Additionally, if the threshold values are spaced far apart, trends can be used to further contextualize impairments in ecosystem health, i.e., ecosystem health may be characterized as *Deteriorating*, *Improving*, or *Unchanging* within a given tier.

1.3 How do we decide if a trend is *Unchanging*, *Deteriorating*, or *Improving*?

Decision: *To be consistent with the structure of the SOGL reporting framework, trends in ecosystem health should be based on whether monitored concentrations have increased or decreased relative to the previous report (published every three years).*

Discussion: SOGL indicator trends are calculated based on ten years of data, which is not available for microplastic pollution in the Great Lakes. Therefore, the trend should be determined using available data and comparing it to the data published in the last triennial report until ten years of data are available. Most SOGL indicators use a fairly qualitative assessment of trends. SOGL reports typically do not use a rigorous, quantitative trend analysis with defined confidence intervals. The group did not recommend any specific approach to define the trend but provided some guidance and/or ideas for consideration below. In addition, it is possible to assess the status of a lake without having sufficient data to evaluate the trend in conditions, resulting in an *Undetermined* trend.

There was discussion about whether to link trends to thresholds, i.e., a trend would be defined as *Improving* if monitored concentrations cross a threshold into a "better" tier (i.e., from *Poor* to *Fair* or *Fair* to *Good*) or as *Deteriorating* if concentrations cross a threshold into a "worse" tier (i.e., from *Good* to *Fair* or *Fair* to *Poor*). The trend would be defined as *Unchanging* if the tier remains the same. However, the group felt that defining trends independently of the tiers would allow for more nuance in characterizing the ecosystem health of the lakes and potentially in recommending management actions. For example, a *Fair* and *Unchanging* lake could be subject to different management actions than a *Fair* and *Deteriorating lake*.

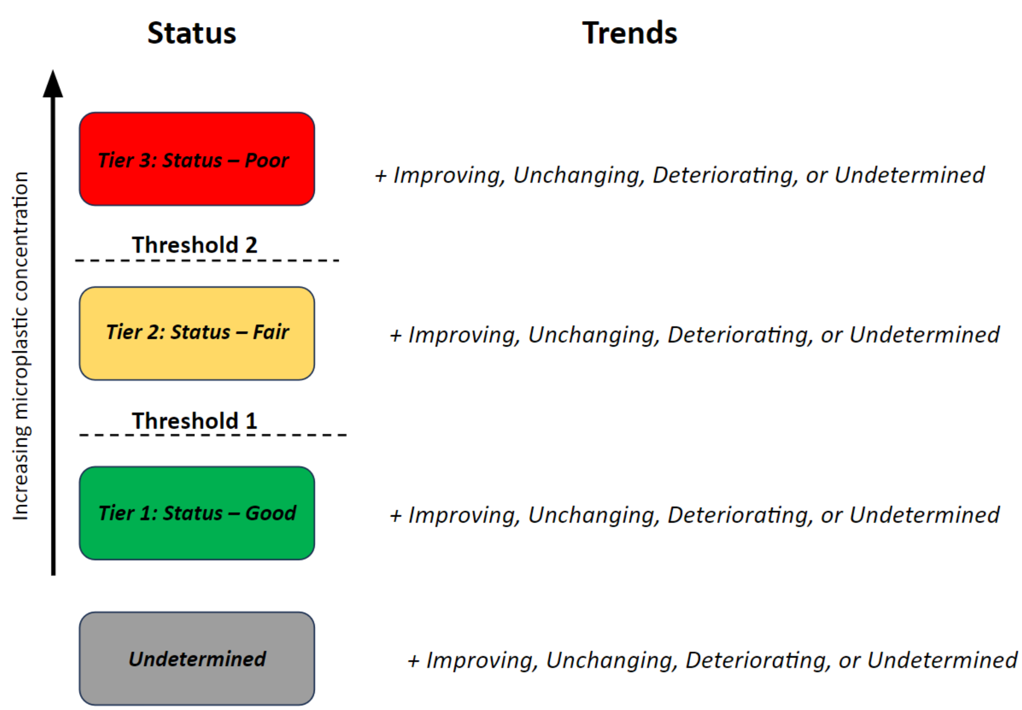

Figure 2 – Proposed Risk Management Framework for Microplastic Pollution in the Great Lakes

1.4 What are the recommended management responses associated with each tier?

Decision: *Recommended management responses should be separated from the tiers and instead associated with Status and Trend combinations.*

Discussion: Workshop participants believed that management responses included in the framework should be less prescriptive and more suggestive and also consistent with the language already used in the risk management reports for Chemicals of Mutual Concern (CMC). Recommended management responses include increased or "optimized" monitoring of both ambient concentrations and known transport pathways (e.g., wastewater and stormwater), as well as mitigation strategies and pollution control measures. The specific details of these actions would need to be determined by the GLWQA Parties. Workshop participants generally supported making bold recommendations for each action to the GLWQA Parties. As such, the group discussed management actions that could be tied to each Status and Trend combination (Figure 3) but ultimately decided not to include them as part of the risk management framework.

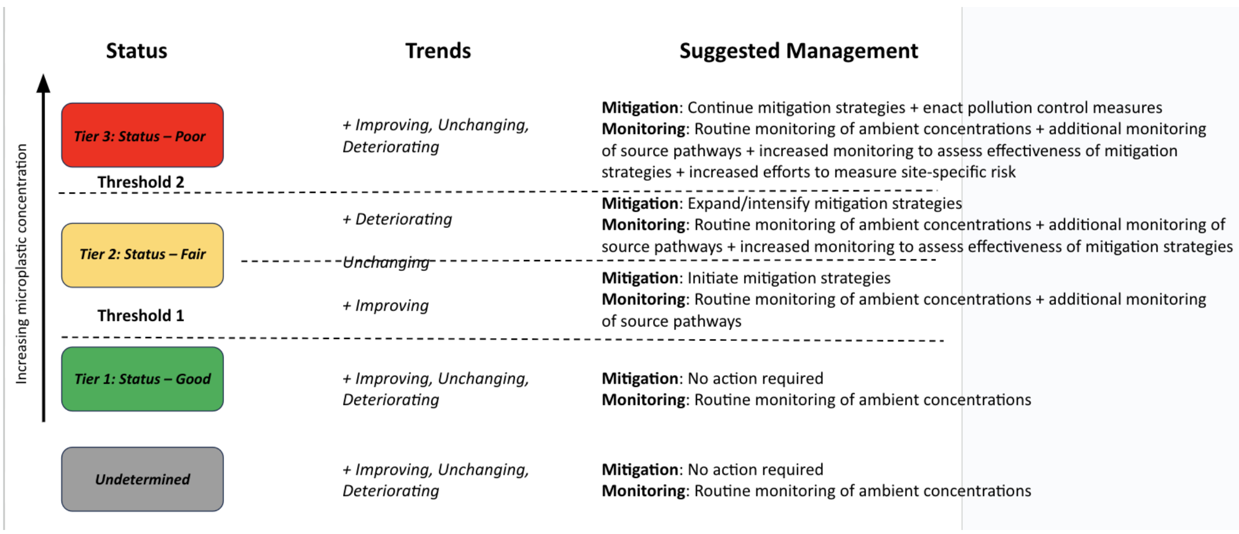

Figure 3 – Initial Management Framework Discussed by Workshop Participants, including Management Actions

Plenary Session #2: Risk Threshold Value Development

Plenary Session #2 began with a presentation by Dr. Alvina Mehinto (SCCWRP) on the approach used by the SCCWRP Work Group to derive risk threshold values for microplastic (i.e., the quantitative risk assessment framework developed by Koelmans et al. (2020) described in *Welcoming Remarks and Background Information*). The presentation was designed to spearhead a discussion on how the parameters of the SSD curves used to derive the risk threshold values could be adapted for better relevance to the Great Lakes ecosystem (i.e., a freshwater ecosystem) and jurisdictional standards (i.e., in accordance with the protocol used by the Canadian Council of Ministers of the Environment (CCME; 2007) to derive the Canadian Water Quality Guidelines for the Protection of Aquatic Life). To guide this discussion, Dr. Mehinto posed the following questions for consideration by workshop participants:

- Should all available toxicity data across all taxa be included in the SSD curves or only species relevant to the Great Lakes ecosystem?
- How many and which taxonomic groups and species should be represented in the SSD curves?
- Which endpoint categories/levels of biological organization should be included in the SSD curves?
- Which effect metrics should be included in the SSD curves?
- How should toxicity data be averaged within species?
- Which hazard concentration (HC) values should be used for the thresholds in the risk management framework?

2.1 Should all available toxicity data across all taxa be included in the SSD curves or only species relevant to the Great Lakes ecosystem?

Decision: *Use toxicity data for all taxa and species that are biologically relevant to the Great Lakes ecosystem, including plants and algae.*

Discussion: The most relevant species are those that reside in the Great Lakes. However, where there is not yet enough data available on resident species, workshop participants agreed to include species if they are biologically relevant to those in the Great Lakes (e.g., toxicity data for temperate bivalve species from freshwater and marine ecosystems could be used as a surrogate for Great Lakes bivalve species). Toxicity data for algae and plants should be included for the SSD curve relevant to effects related to particle volume (i.e., food dilution) because microplastics may block sunlight from reaching algae and plants, reducing their ability to photosynthesize. It was decided to exclude species with no Great Lakes analog, e.g., a tropical species.

The group also raised the point that Indigenous perspectives should be considered in prioritizing species for future lab studies. The field needs to ensure that the potential impacts of microplastics on culturally significant species are considered and studied.

2.2 How many and which taxonomic groups and species should be represented in the SSD curves?

Decision: *Aim to meet the minimum dataset requirements of the Canadian Council of Ministers of the Environment's (CCME) Canadian Environmental Quality Guidelines (Table 2).*

Discussion: Workshop participants found that sufficient toxicity data are available in ToMEx to construct initial SSD curves for ambient water. However, toxicity data for constructing sediment SSD curves are currently very limited. Workshop participants recommended that future work prioritize addressing these knowledge gaps by conducting more toxicity tests for exposure to microplastics in sediment. Workshop participants noted that SSD-derived sediment quality guidelines are not commonly used, at least to date. For example, the CCME's Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life uses instead the National Status and Trends Program approach and the spiked-sediment toxicity test approach (CCME, 1995). Still, the workshop participants included a provisional SSD for sediment herein.

Table 2. Minimum dataset requirements for the derivation of a long-term exposure guideline for freshwater environments (Source: CCME, 2007)

<table>
<tr><th rowspan="2">Group</th><th colspan="3">Guideline</th></tr>
<tr><th>Type A[1]</th><th>Type B1[2]</th><th>Type B2[2]</th></tr>
<tr><td>Fish</td><td colspan="2">Three species, including at least one salmonid and one non-salmonid.</td><td>Two species, including at least one salmonid and one non-salmonid.</td></tr>
<tr><td>Aquatic Invertebrates</td><td colspan="2">Three aquatic or semi-aquatic invertebrates, at least one of which must be a planktonic crustacean. For semi-aquatic invertebrates, the life stages tested must be aquatic.

It is desirable, but not necessary, that one of the aquatic invertebrate species be either a mayfly, caddisfly, or stonefly.</td><td>Two aquatic or semi-aquatic invertebrates, at least one of which must be planktonic crustacean. For semi-aquatic invertebrates, the life stages tested must be aquatic.

It is desirable, but not necessary, that one of the aquatic invertebrate species be either a mayfly, caddisfly, or stonefly.</td></tr>
<tr><td>Aquatic Plants</td><td colspan="2">At least one study on a freshwater vascular plant or freshwater algal species.

If a toxicity study indicates that a plant or algal species is among the most sensitive species in the data set, then this substance is considered to be phyto-toxic and three studies on nontarget freshwater plant or algal species are required.</td><td>Toxicity data for plants are highly desirable, but not necessary.

If a toxicity study indicates that a plant or algal species is among the most sensitive species in the data set, then this substance is considered to be phyto-toxic and two studies on nontarget freshwater plant or algal species are required.</td></tr>
<tr><td>Amphibians</td><td colspan="2">Toxicity data for amphibians are highly desirable, but not necessary. Data must represent fully aquatic stages.</td><td>Toxicity data for amphibians are highly desirable, but not necessary. Data must represent fully aquatic stages.</td></tr>
<tr><td>Preferred Endpoints</td><td>The acceptable endpoints representing the no-effects threshold and EC_{10}/IC_{10} for a species are plotted. The other, less preferred, endpoints may be added sequentially to the data set to fulfill the minimum data requirement condition and improve the result of the modelling for the guideline derivation if the more preferred endpoint for a given species is not available.

The preference ranking is done in the following order: Most appropriate EC_x/IC_x representing a no-effects threshold > EC_{10}/IC_{10} > $EC_{11\text{-}25}/IC_{11\text{-}25}$ > MATC > NOEC > LOEC > $EC_{26\text{-}49}/IC_{26\text{-}49}$ > nonlethal EC_{50}/IC_{50}.

Multiple comparable records for the same endpoint are to be combined by the geometric mean of these records to represent the averaged species effects endpoint.</td><td colspan="2">The most preferred acceptable endpoint representing a low-effects threshold for a species is used as the critical study; the next less preferred endpoint will be used sequentially only if the more preferred endpoint for a given species is not available.

The preference ranking is done in the following order: Most appropriate EC_x/IC_x representing a low-effects threshold > $EC_{15\text{-}25}/IC_{15\text{-}25}$ > LOEC > MATC > $EC_{26\text{-}49}/IC_{26\text{-}49}$ > nonlethal EC_{50}/IC_{50} > LC_{50}.</td></tr>
<tr><td>Data Quality Requirement</td><td>Primary and secondary no-effects and low-effects level data are acceptable to meet the minimum data set requirement. Both primary and secondary data will be plotted.</td><td>The minimum data requirement must be met with primary data. The value used to set the guideline must be primary.</td><td>Secondary data are acceptable. The value used to set the guideline may be secondary.</td></tr>
</table>

Group	Guideline		
	Type A[1]	Type B1[2]	Type B2[2]
	A chosen model should sufficiently and adequately describe data and pass the appropriate goodness-of-fit test.	Only low-effect data can be used to fulfill the minimum data requirement.	Only low-effect data can be used to fulfill the minimum data requirement.

[1] Under CCME protocols (CCME, 2007), Type A guidelines are derived using a species sensitivity distribution (SSD) approach when there are adequate primary and secondary toxicity data to satisfactorily fit an SSD curve.

[2] Type B guidelines are derived for substances that either have inadequate or insufficient toxicity data for the SSD approach (i.e., Type A guideline), but for which enough toxicity data from a minimum number of primary and/or secondary studies are available. Type B guidelines are divided into Type B1 and Type B2 guidelines, based on the quantity and quality of available toxicity data. At present, there is no protocol for deriving guidelines when the minimum toxicity data requirement for a Type B guideline is not met.

2.3 Which endpoint categories/levels of biological organization should be included in the SSD curves?

Decision: *Use apical endpoints (i.e., mortality, growth, and reproduction).*

Discussion: The workshop participants felt that thresholds should be based on population-relevant endpoints to make the most convincing case for the management of microplastics. Including sub-organismal endpoints may make the SSD curves more robust by increasing the number of studies and data points included, but may also be challenging to communicate and defend. There was a discussion of including sub-organismal-level endpoints with a clear link to survival and reproduction; however, the workshop participants decided not to include these endpoints. In the future, if such endpoints are considered, clear criteria should be established to guide their selection.

2.4 Which effect metrics should be included in the SSD curves?

Decision: *Use NOECs (i.e., No Observed Effect Concentration) for now; however, ECs (i.e., Effect Concentration) are preferred once available.*

Discussion: Effect metrics available in ToMEx 2.0 include NOEC, HONEC (Highest Observed No Effect Concentration), LOEC (Lowest Observed Effect Concentration), and EC, LC (Lethal Concentration), and IC (Inhibition Concentration). Assessment factors can be used to convert effect metrics to NOECs. The SCCWRP Work Group excluded HONECs, also known as unbounded NOECs, due to their limited reliability. HONECs are generated in studies that failed to observe an effect across the range of concentrations tested and, as a result, may overestimate toxicity responses. Workshop participants also chose not to include HONECs and noted that relying solely on NOECs may lead to very conservative threshold values. ECs are the preferred effect metric for constructing SSD curves but are only available for a very limited number of species that are biologically relevant to the Great Lakes ecosystem. SSD curves should also be constructed using chronic exposure results. Acute data can be converted to chronic data using assessment factors, but this requires assumptions about acute-to-chronic ratios. Acute exposure studies account for approximately half of the data in ToMEx 2.0.

2.5 How should toxicity data be averaged within species?

Decision: *Use the geometric mean of toxicity data for the same species and endpoint, or for toxicity data for different endpoints within the same species, use data for the most conservative endpoint that meets the minimum data quality requirements.*

Discussion: CCME (2007) minimum dataset requirements (Table 2) use the geometric mean to average toxicity data for the same species and endpoint. The geometric mean is preferred because it is less susceptible to the influence of outliers. The median or 1st quartile could also be used to average toxicity data; however, using the 1st quartile would lead to a more conservative SSD.

2.6 Which hazard concentration (HC) values should be used for the thresholds in the risk management framework?

Decision: *Threshold 1 (between Good and Fair; Figure 2) should represent the HC_5 value, and threshold 2 (between Fair and Poor) should represent the HC_{30} value.*

Discussion: The workshop participants spent some time discussing which HC values the thresholds should represent, recognizing the importance of this decision. Since NOECs, a more conservative effect metric, are being used to build the SSDs curves, there was some discussion of assigning a higher HC value toThreshold 1 (e.g., HC_{10}); however, HC_5 was agreed upon as more protective. HC_{20} and HC_{50} were both proposed for Threshold 2; however, the workshop participants agreed upon HC_{30} because they felt that a status of *Poor* should be acknowledged before 50% of the species in the community are affected.

The workshop participants also recommended constructing only one SSD curve relevant to the food dilution effect mechanism (i.e., a particle volume-based effect) for each matrix (i.e., ambient water and sediment). This differs from the SCCWRP Work Group, which constructed two SSD curves relevant to food dilution and tissue translocation. The SSD curves for food dilution and tissue translocation integrate much of the same toxicity data because the toxicity data used is not directly relevant to each effect mechanism but, instead, is differentiated by the particle sizes and characteristics considered. Therefore, the workshop participants agreed that constructing an SSD curve and deriving threshold values for a volume-based effect was sufficient. Workshop participants agreed to limit the particle size ranges to the gape size and smaller for animals and to use the full microplastic size range for plants and algae.

Plenary Session #3: Data Rescaling and Alignment

Plenary Session #3 began with a detailed background presentation by Dr. Scott Coffin from the California State Water Resources Control Board (SWRCB) on the need for data rescaling and alignment in microplastic research and management and methods developed by the Microplastic Lab at Wageningen University and Research, led by Dr. Albert Koelmans. Microplastics comprise a diverse range of particle sizes, shapes, and polymer types, among other physical and chemical properties (Rochman et al., 2019). However, depending on the sampling and analytical methods, environmental monitoring typically captures only a limited range of particle sizes, shapes, and polymer types. Additionally, effect studies typically test particles of a single shape, size, and polymer type to measure toxicity, which does not reflect the complex mixture of particles that organisms are exposed to in the environment. Rescaling and alignment methods allow us to adjust monitoring and toxicity data to account for these limitations. For example, monitoring data can be rescaled to a standard size range (e.g., 1 – 5,000 µm), allowing for sampling results from studies using different methods to be compared directly, and toxicity data can be realigned to better reflect real-world microplastics based on particle characteristics such as volume or surface area. This session aimed to determine if workshop participants agreed with the need for rescaling and alignment and to try and get a consensus on the methods to be used.

Probability distribution functions (PDFs) have been created for particle characteristics of microplastics, including size, shape, polymer, volume, and mass, sampled across different aquatic environments (Kooi and Koelmans, 2019; Kooi et al., 2021). However, it is not yet known if and how these PDFs differ between locations, and therefore, it is important to validate these for the Great Lakes region.

3.1 Which PDFs should we use to rescale and align exposure data?

Decision: *Use PDFs for freshwater surface water and sediment from Kooi et al. (2021) to rescale and align exposure (i.e., monitoring) data until Great Lakes-specific PDFs are available.*

Discussion: The most preferred PDFs for rescaling and alignment are location- and matrix-specific. However, recognizing that it would take time to create Great Lakes-specific PDFs, workshop participants agreed to recommend using freshwater PDFs developed by Kooi et al. (2021). Developing Great Lakes-specific PDFs should be a future goal.

3.2 Which PDFs should we use to rescale and align effects data?

Decision: *Use PDFs for freshwater surface water and sediment from Kooi et al. (2021) to rescale and align effects (i.e., toxicity) data until Great Lakes-specific PDFs are available.*

Discussion: The most preferred PDFs for rescaling and alignment are location- and matrix-specific. However, recognizing that it would take time to create Great Lakes-specific PDFs, workshop participants agreed to recommend using freshwater PDFs developed by Kooi et al. (2021). Developing Great Lakes-specific PDFs should be a future goal.

Plenary Session #4: Quality assurance and quality control (QA/QC) for Exposure and Effects Data

Plenary Session #4 began with detailed background presentations from Dr. Leah Thornton Hampton (SCCWRP) on screening data for risk threshold development and by Eden Hataley (University of Toronto and IJC SAB Work Group member) on data quality requirements for exposure (i.e., monitoring) data. The presentation was designed to spearhead a discussion on which QA/QC criteria should be required for the selection of exposure and effects data in a risk assessment for microplastic pollution in the Great Lakes. Dr. Thornton-Hampton described the QA/QC criteria for ecotoxicological studies programmed into ToMEx (Thornton Hampton et al., 2022) and used by the SCCWRP Work Group to construct SSD curves and derive risk threshold values. Ms. Hataley described QA/QC criteria for environmental monitoring studies proposed in the peer-reviewed literature (Koelmans et al., 2019; Redondo-Hasselerharm et al., 2023) for comparison to threshold values to characterize risk. To guide this discussion, Dr. Thornton Hampton and Ms. Hataley posed the following questions for consideration by workshop participants:

- Which QA/QC criteria should be required to include effects (i.e., toxicity) data in the risk assessment?
- Which QA/QC criteria should be required to include exposure (i.e., monitoring) data in the risk assessment?

4.1 Which QA/QC criteria should be required to include effects (i.e., toxicity) data in the risk assessment?

Decision: *Aim to meet the Red criteria developed by the SCCWRP Work Group in combination with the criteria from the CCME's Canadian Environmental Quality Guidelines (CCME, 2007; Table 3).*

Table 3 - QA/QC Criteria for Microplastics Effects Studies

Evaluation Category	Primary Data (CCME)	Secondary Data (CCME)	Red Criteria (Cal)
Validation of Test Concentrations	Test concentrations must be validated at start and end	Test concentrations may be validated via stock solutions	Not required
Measurement of Abiotic Variables (e.g., temperature)	Should be reported	Should be reported	Not required
Preferred Test Endpoints	Embryonic development, hatching, growth, reproduction, survival	Primary Data endpoints + pathological, behavioral, and physiological effects	Organismal endpoints and/or sub-organismal endpoints with relationship to organismal/population level effects
Control Reporting	Must be reported and with acceptability criteria (if applicable)	Must be reported	Must be reported, and a control group should be used
Dose Response	"A clear dose-response relationship should be demonstrated."	Not required	At least 3 concentrations required, ideally 5 so a dose-response relationship can be assessed.
Replication	Required	Pseudo-replication acceptable	Not specified, but sample size should be reported
Statistics	Must be reported and deemed appropriate	Must be reported and deemed appropriate	Not specified
Particle size, morphology, polymer type, particles source reported	Not specified	Not specified	Must be reported
Concentrations reported as mass or count	Not specified	Not specified	Must be reported
Test medium vehicle, Administration route, Test species, and Exposure duration reported	Not specified	Not specified	Must be reported

Discussion: It was noted that while CCME and SCCWRP Red Criteria generally align well, the Red Criteria are binary compared to the CCME's more granular requirements. One advantage of SSDs is that a large data set is used, which allows many different studies to be included, all of which do not need to meet all quality criteria. It was noted that the CCME protocol for deriving water quality guidelines is very similar to USEPA guidance for ecological risk assessments. CCME typically does not use unbounded NOECs (HONECs). ToMEx data does include HONECs, but they can be removed from subsequent analyses. Using HONECs in an SSD can lead to an over-estimation of risk, while using LOECs may lead to under-estimating risk. Participants noted that using both CCME protocol and Red Criteria may be overly restrictive, but when used together they could help identify primary (high-quality) and secondary data. DeRuijter et al. (2020) have also developed an extensive list of QA/QC criteria for microplastics effects studies that were reviewed during the workshop, although participants noted that using the full set of criteria herein may be overly restrictive.

4.2 Which QA/QC criteria should be required to include exposure (i.e., monitoring) data in the risk assessment?

Decision: *Exposure data should be assessed using the approach outlined by Hataley et al. (2023). Additional recommended criteria include disclosure of study limits of detection (LOD) and whether key particle characteristics (size, color, morphology) were reported. These guidelines are summarized below and in Figure 4:*

- *Provide a full assessment of each study according to the criteria outlined in Koelmans et al. (2019) for surface water and Redondo-Hasselerharm et al. (2023) for sediment*
    - *See Figure 4 for a summary of criteria*
    - *See paper SIs for scoring instructions*
- *For studies that measure and report particles smaller than 300 µm, remove those that do not include negative controls and polymer identification in their study design due to the increased risk of contamination and false positives for these smaller particles.*
- *Recommend researchers determine and report their method Limit of Detection for particle size and provide size, morphology, and color distributions for particles reported.*

QA/QC criteria for water, developed by Koelmans et al., 2019
Water Res. 10.1016/j.watres.2019.02.054

Category		Criteria
Sampling	1	Sampling methods
	2	Sample size
	3	Sample processing and storage
Contamination mitigation	4	Laboratory preparation
	5	Clean air conditions
	6	Negative control
Sample handling and purification	7	Positive control
	8	Sample treatment
Polymer analysis	9	Polymer identification

See paper SI for scoring instructions

QA/QC criteria for sediment, developed by Redondo-Hasselerharm et al., 2023
J. Hazard. Mater. 10.1016/j.jhazmat.2022.129814

Category		Criteria
Sampling	1	Sampling reporting
	2	Sample size
	3	In-site variability representation
	4	Sample processing and storage
Contamination mitigation	5	Laboratory preparation
	6	Clean air conditions
	7	Negative control
Sample handling and purification	8	Positive control
	9	Sample treatment
Polymer analysis	10	Polymer identification

See paper SI for scoring instructions

Figure 4 - QA/QC Criteria for Water (Left) and Sediment (Right) Exposure Studies

Discussion: For water sampling, Koelmans et al. (2019) require a minimum of 500L of sampling, but workshop participants noted that this is not always practical (participants shared that a minimum volume around 50L may be more realistic, especially for grab or pump-and-filter samples) and depending on the particle size of interest and environmental concentrations, a lower volume may be sufficient. The QA/QC criteria for exposure studies should be divided into primary and secondary to match the criteria for effects studies. Hataley et al. (2023) used negative controls and polymer identification below a certain particle size. Other recommendations include reporting particle size distribution above a minimum size. Positive controls are important (i.e., matrix spiked with different types of particles) and should be included (see, for example, Cui et al., 2022).

Day 2 – Review of Key Decisions, SSD Reveal, and Wrap Up

Day 2 of the workshop began with a recap of Day 1 activities and discussions. All of the decisions documented in Table 1 were discussed and reviewed with workshop participants. Following this, several SSDs were presented for different compartments (ambient water, sediment) and effect mechanisms (food dilution, tissue translocation), effect metric (NOEC only, NOEC + HONEC, ECx only), effect endpoints (organism and above, organism and above + histological/behavioral), and taxa/species (freshwater only, freshwater + relevant marine species, freshwater + marine species without algae/macrophyte). These SSDs were created and shared to help solidify key decisions. Workshop participants reviewed each SSD (and the risk thresholds derived from it) and discussed the effect of Day 1 decisions. These discussions are reflected in Table 1 and Figure 2, and the respective Day 1 topics summarized earlier.

Following these discussions, revised SSDs for water and sediment were presented. Participants once reviewed and discussed these revised SSDs and agreed to proceed with one SSD based on volume (for animals, limit microplastic sizes to the gape size or smaller, and for plants/algae use full size range) each for water and sediment. These final SSDs reflect the workshop decisions summarized in Table 1 and Figure 2 and under the respective Day 1 plenary session topic summaries above. These final SSDs and the associated risk thresholds are shown below in Figures 5 through 8.

Further, Figures 9 and 10 compare the SSD-derived thresholds to observed microplastics concentrations in the Great Lakes, for water and sediment respectively. The y-axes (Cumulative Frequency) represent the total percentage of observations that are equal to or less than a given observed particle concentration (shown on the x-axes). Particle concentration data were extracted from peer-review and published Great Lakes microplastic monitoring studies.

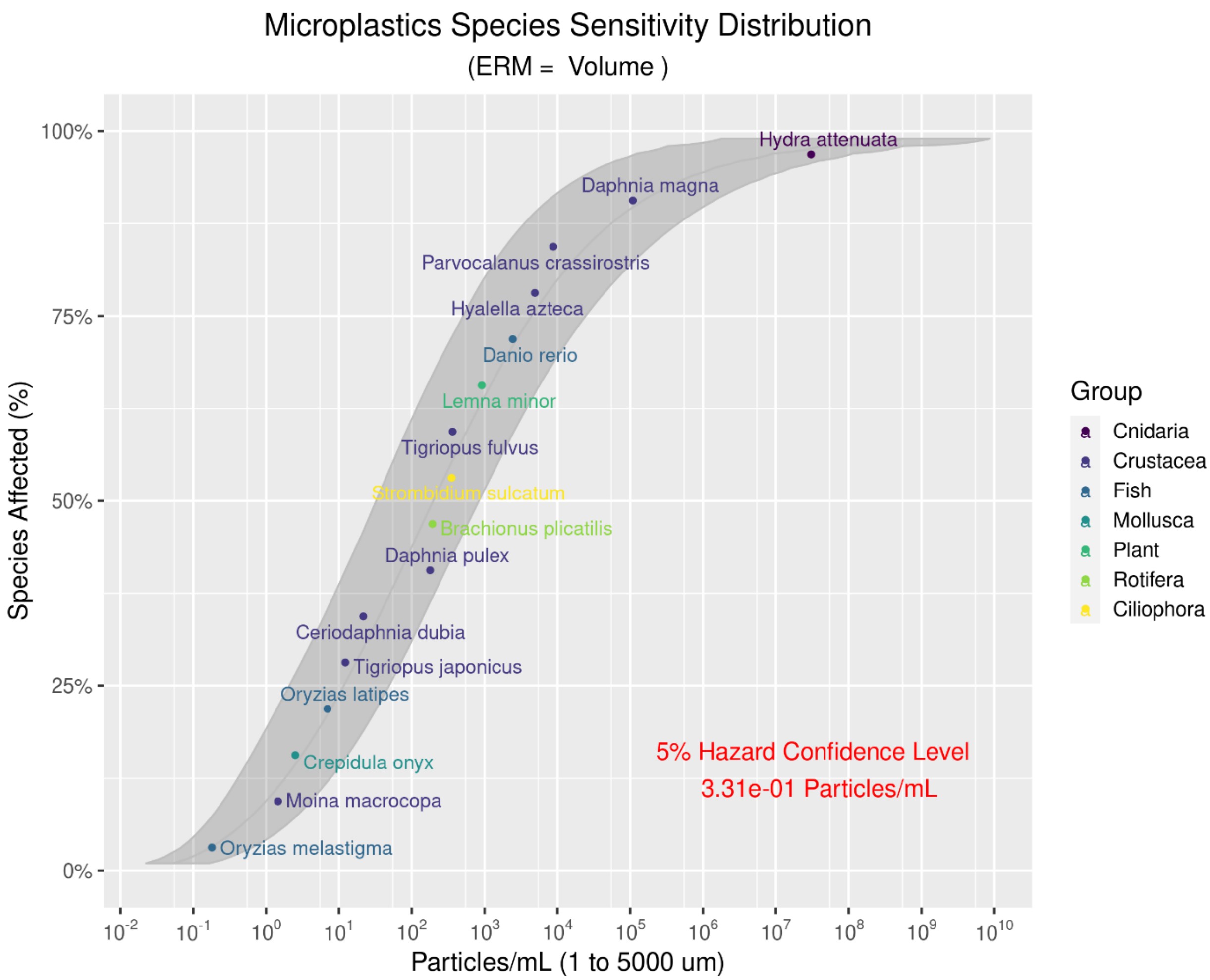

Figure 5[2] – Microplastic SSD for Ambient Water; Volume-based Effect; no HONEC; Apical Endpoints only

	HC	Data aggregation	Point estimate	Value (particle/L)
Threshold 1	HC_5	Geometric mean	Estimated mean	**331** (112-1,340)
Threshold 2	HC_{30}	Geometric mean	Estimated mean	**21,400** (3,800 – 88,400)

Total number of species: 16

- cnidaria: 1
- crustacea: 8
- fish: 3 (no salmonid)
- mollusca: 1
- plant: 1
- rotifera: 1
- ciliophora: 1

No amphibians, only one plant (no algae), and no salmonid.

Figure 6 - SSD-derived Microplastic Exposure Thresholds for Ambient Water; Number of Species Included

[2] Between Workshop #2 and the drafting of the Final Report, minor adjustments to the ambient water SSD were made after the final vetting of the data in ToMEx 2.0. As a result, the Final Report shows slightly higher HC values than those in the Workshop #2 Report.

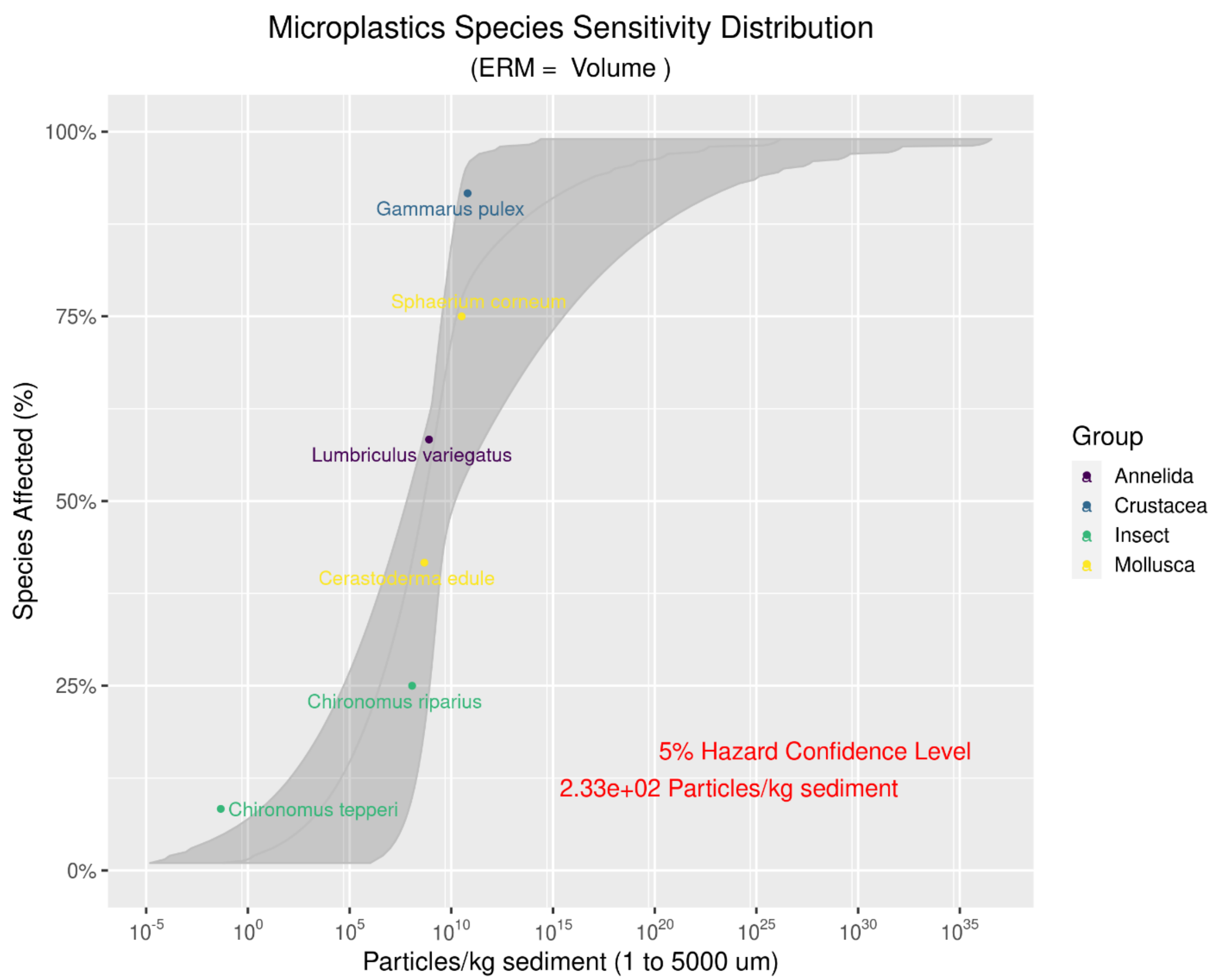

Figure 7. Microplastic SSD for Sediment; Volume-based Effect; no HONEC; Apical Endpoints only.

	HC	Data aggregation	Point estimate	Value (particle/kg dw)
Threshold 1	HC_5	Geometric mean	Estimated mean	**62.6** (0.0136 – 1.78 x 10^7)
Threshold 2	HC_{30}	Geometric mean	Estimated mean	**6.09 x 10^6** (1.23x 10^5 – 1.14 x 10^9)

Total number of species: 6

- annelida: 1
- crustacea: 1
- insect: 2
- mollusca: 2

Figure 8. SSD-derived Microplastic Exposure Thresholds for Sediment; Number of Species Included

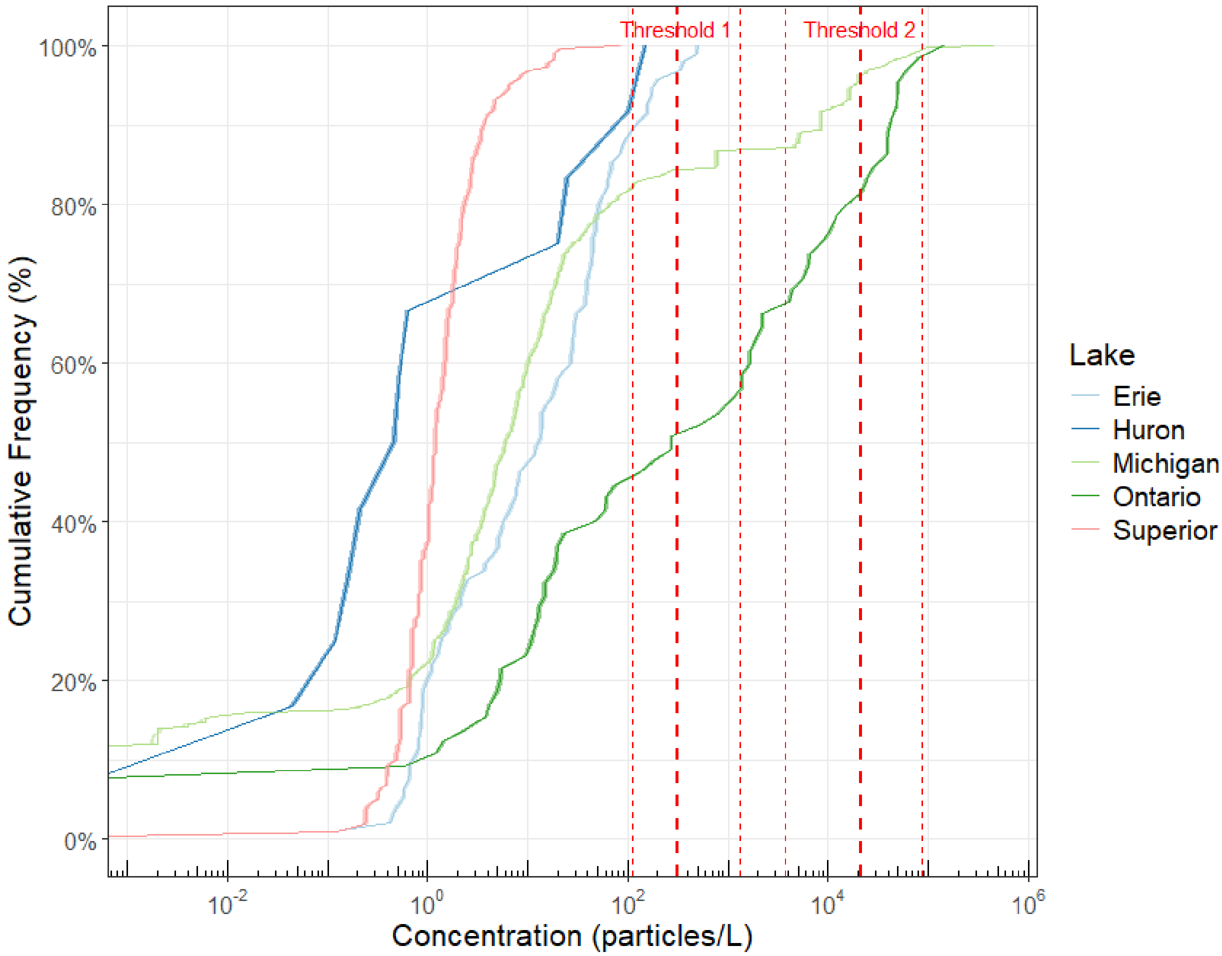

Figure 9 - Comparing Great Lakes Microplastic Concentrations (including Tributary Data) to SSD-Derived Thresholds for Ambient Water. The uncertainty in the estimates is calculated using the standard deviation of the freshwater surface water power law exponent value for particle length derived by Kooi et al. (2021; 2.64 ± 0.01). Uncertainty shading is not visible here because the variability around the mean is small.

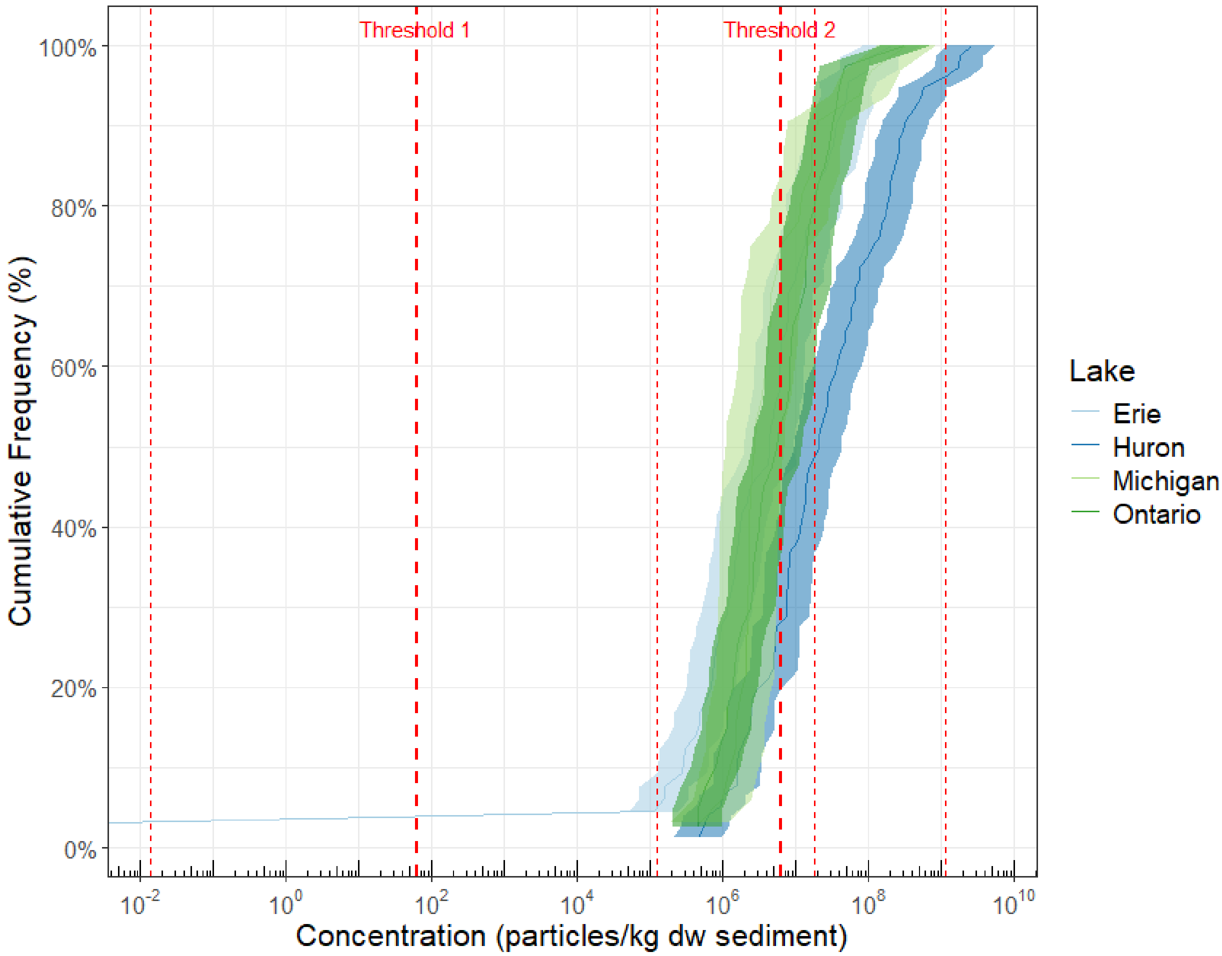

Figure 10 - Comparing Great Lakes Microplastic Concentrations (including Tributary Data) to SSD-Derived Thresholds for Sediment. The uncertainty in the estimates is calculated using the standard deviation of the freshwater sediment power law exponent value for particle length derived by Kooi et al. (2021; 3.25 ± 0.19).

3. Post-Workshop Activities

Following the conclusion of the workshop, the IJC SAB Work Group leads prepared a final workshop summary and circulated it to all participants. The summary included an outline of the key decisions that were made (see Table 1 and Figure 2), SSDs for water (Figures 5 and 6) and sediment (Figures 7 and 8), and a comparison of Great Lakes monitored concentrations to the proposed SSD-derived thresholds (Figures 9 and 10). In addition, we surveyed the workshop participants to assess their post-hoc confidence in the assessment and framework (Figures 11 through 13).

Confidence Assessment Exercise

As a final step, workshop participants were asked to complete a survey and express their confidence in the decisions and framework developed during the workshop. The results of this exercise are summarized below. Of the 20 individuals who attended the workshop, 14 completed the confidence assessment exercise. Overall, participants expressed a medium-high degree of confidence in the framework, medium confidence in the threshold values for water, and medium-low confidence in the threshold values for sediment.

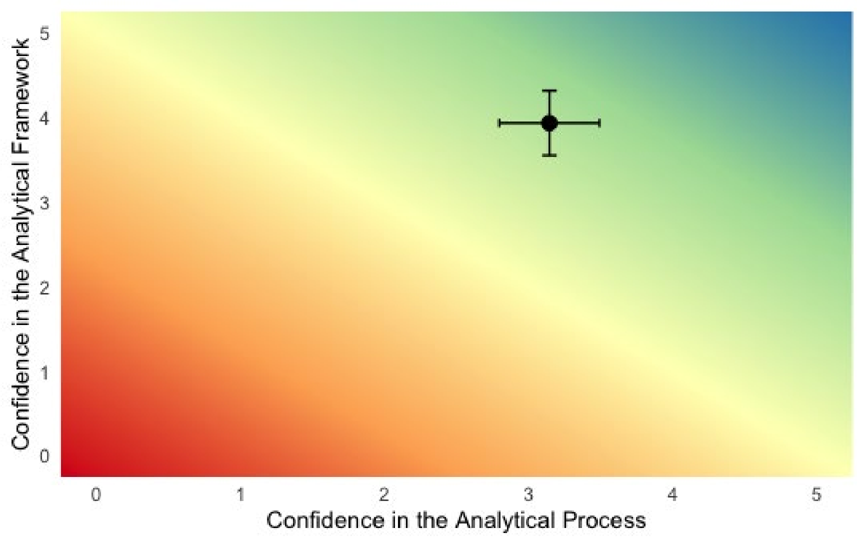

Figure 11 - Participant Confidence in the Overall Management Framework. The x-axis represents confidence in the analytical process (i.e., the assumptions and data transformations made for calculations), and the y-axis represents the confidence in the analytical framework (i.e., the calculations and models themselves).

Participants noted benefits as well as weaknesses of the framework. In general, participants liked the three status options (good, fair, poor) and two thresholds because of their consistency and simplicity. Participants also found it useful that the framework is similar to other, existing frameworks. Some participants questioned the selection of HC30 over HC50 or ECx. It was noted that while data are not yet available for effects concentrations (ECx), when that data becomes available, it would strengthen the framework to base HC thresholds on ECx data.

Participants expressed less confidence in the analytical process used to derive the threshold values, citing the uncertainties that are likely to result from the process of fitting many studies into a single threshold, and stating that at present there is limited understanding of the error potentially propagated during these calculations. It was acknowledged that some uncertainty is inevitable at this time, in part due to a lack of Great Lakes-specific data/studies. Some participants expressed that they did not fully understand the data realignment process and the methods behind it, calling the process highly technical and not accessible to non-experts.

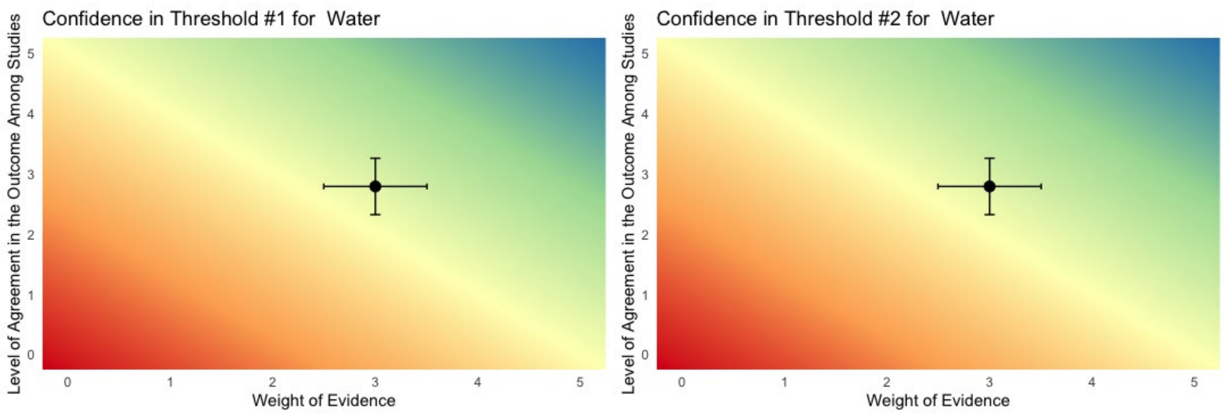

Figure 12 - Participant confidence in thresholds for water. The x-axis represents the weight of evidence, which is the data used to calculate the SSDs. The y-axis is relevant to the agreement in the outcome among studies (i.e, the variability among studies looking at similar taxa and endpoints).

Among participants, there was variation in the confidence level in the weight of evidence available to populate the SSD. Some participants felt that there was not enough data, with others expressing concern that the existing data are limited or imperfect, while acknowledging that this limitation is, at present, unavoidable due to the current lack of studies and data available. Many of the studies focus on the same or similar species, and there is a lack of differently authored studies available for each species.

Regarding confidence in the level of agreement among outcomes for studies available to populate the SSD, participants found it difficult to assess overall outcomes because many of the studies examined had different endpoints, polymer types, species, and toxicity effects. It was expressed that there are not enough replicate studies to assess similarities between tests of the same species and endpoints.

Regarding confidence in the weight of evidence available to populate the SSD, participants expressed similar concerns for Threshold #1 as they did for Threshold #2, citing a lack of available studies for many species, a lack of differently authored studies for each species, and differences in the amount and type of data collected. One participant stated that use of HC30 does not provide enough differentiation between green (good) and red (bad).

Regarding Threshold #2, concerns regarding the level of agreement among outcomes for ambient water studies were again similar to those discussed for Threshold #1. While a majority of participants supported the use of HC30 during the workshop, other participants seemed uncertain about the use of HC30 versus HC50, and noted in their survey responses that HC30 could be too conservative a threshold to indicate a change from Fair to Poor status.

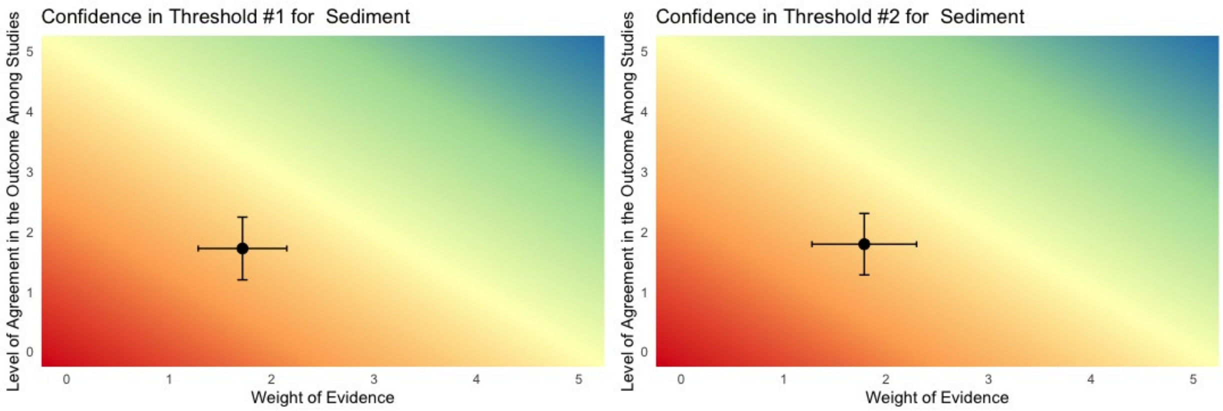

Figure 13 - Participant Confidence in Thresholds for Sediment

Regarding Threshold #1 for sediment, participants reported having low confidence in the weight of evidence available to populate the SSD, stating that there is not enough studies/data available and that not enough species are represented by the available data. Participants suggested that more data should be collected for a larger number of species before using this threshold in a regulatory context or to make risk management recommendations. In addition to the limited quantity of data, participants were concerned that the studies available differed in terms of the amount and type of data collected.

Similar concerns were expressed regarding confidence in the level of agreement among outcomes for studies available to populate the SSD. Participants stated that there are not enough studies yet available, and those that are available differ in terms of examined endpoints, polymer types, species, and toxicity effects. Additionally, results varied among the studies available (the range of impacts is very large).

Regarding Threshold #2 for sediment, participants reported having low confidence in the weight of evidence available to populate the SSD, citing the lack of available data/studies and concerns that the two thresholds (HC_5 and HC_{30}) vary by five orders of magnitude but have overlapping confidence intervals. It was additionally noted that the HC5 threshold appears to be below any sediment measurements made in the Great Lakes. Participants suggested that more data should be collected for a larger number of species before using this threshold in a regulatory context or to make risk management recommendations.

Similar concerns were expressed regarding confidence in the level of agreement among outcomes for studies available to populate the SSD. Participants stated that there are not enough studies yet available, and those that are available differ in terms of examined endpoints, polymer types, species, and toxicity effects. One participant noted that the study by Lu et al. (2023) reported effects at significantly lower concentrations than the other studies included in the SSD, likely pulling down the threshold value (i.e., one study may be having a disproportionate influence).

Conclusion

Overall, the deliverables from this workshop include a risk assessment and management framework relevant for the Great Lakes that was based on work done by SCCWRP and that can be adopted today to include microplastics as part of SOGL reporting. The framework aligns with existing reports on other sub-indicators and experts at the workshop were confident about using it to inform the GLWQA. Moreover, the risk assessment tools can be adopted now, and iteratively updated and adapted as more toxicity data are available and/or more Great Lakes-relevant particle metrics are measures. We now have a risk assessment tool for microplastics that can be used in parallel with monitoring data to measure patterns and trends, and to report the status of this contaminant within the Great Lakes.

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Appendix A. Workshop Agenda

International Joint Commission mixte internationale
Canada and United States Canada et États-Unis

Towards a Risk-Management Framework for Microplastics in the Laurentian Great Lakes
Workshop Agenda
January 17th and 18th, 2024
Ontario Room, DoubleTree by Hilton Windsor Hotel & Suites
333 Riverside Drive W, Windsor, Ontario

Day 1 virtual link and phone:
https://teams.microsoft.com/l/meetup-join/19%3ameeting_NWQ3ZmE1ODltZDcyNy00NWE5LWFiMWUtMDFhZjE1YjYxMGIx%40thread.v2/0?context=%7b%22Tid%22%3a%22ac2eafbc-d7ac-4576-973d-356d672122bb%22%2c%22Oid%22%3a%22c0799dda-2940-41b9-a8f0-bb6d924d2433%22%7d
Meeting ID: 269 189 166 596, Passcode: 2YehoK
+1 646-979-9737, 813576402# United States, New York City
(844) 634-3201, 813576402# Canada (Toll-free)

Day 2 virtual link and phone:
https://teams.microsoft.com/l/meetup-join/19%3ameeting_YTY4NzRlYWYtMWEzZS00MTNkLTllZmItNTI2YTFlOWZmNzly%40thread.v2/0?context=%7b%22Tid%22%3a%22ac2eafbc-d7ac-4576-973d-356d672122bb%22%2c%22Oid%22%3a%22c0799dda-2940-41b9-a8f0-bb6d924d2433%22%7d
Meeting ID: 270 424 118 28, Passcode: SjZByk
+1 646-979-9737, 276671314# United States, New York City
(844) 634-3201, 276671314# Canada (Toll-free)

This workshop is being held as an activity of the International Joint Commission (IJC) Microplastics Monitoring and Risk Assessment Working Group (WG). The group consists of subject matter experts, working in a voluntary capacity, helping to develop recommendations on microplastics management for the IJC's Science Advisory Board.

Overarching objectives of the IJC WG are to:

1. Synthesize recent advances and knowledge in plastics science relevant to the Great Lakes through events that bring together researchers to share the latest information on plastics.
2. Develop a framework for monitoring microplastic pollution in the Great Lakes that would support its use as a *Toxic Chemicals* sub-indicator for *State of the Great Lakes* reporting under GLWQA.
3. ****Develop a risk assessment framework for microplastic pollution in the Great Lakes focused on ecological effects that would contextualize the results of a monitoring program.**

This workshop will support the IJC WG in meeting Objective 3. The objectives of this workshop are to:

PHE LimnoTech Water Environment Scientists Engineers

1. Develop recommendations to inform a threshold-based ecological risk assessment framework for ambient water and sediment in the Great Lakes that would contextualize the results of a monitoring program and inform the potential inclusion of microplastics as a *Toxic Chemicals* sub-indicator for ecosystem health under the *State of the Great Lakes* reporting.
2. Develop recommendations for a management framework linked to the threshold-based ecological risk framework.
3. Develop recommendations to inform decision-making about the inclusion of exposure and effects data as part of the risk assessment and management frameworks.

Pre-reading material and other helpful resources:

- Mehinto et al., 2022 *Microplast. Nanoplast.* https://doi.org/10.1186/s43591-022-00033-3
- Redondo-Hasselerharm et al., 2023 *J. Hazard. Mater.* https://doi.org/10.1016/j.jhazmat.2022.129814
- Hataley et al., 2023 *Can. J. Fish. Aquat. Sci.* http://dx.doi.org/10.1139/cjfas-2023-0023
- Koelmans et al., 2023 *Environ. Pollut.* https://doi.org/10.1016/j.envpol.2023.121445
- ToMEX - https://sccwrp.shinyapps.io/tomex_20_aquatic_organisms/; username: tomex-im@sccwrp.org PW:MPtox2023
- de Ruijter et al., 2020 https://dx.doi.org/10.1021/acs.est.0c03057?ref=pdf
- Koelmans et al., 2019 https://doi.org/10.1016/j.watres.2019.02.054

Great Lakes Microplastics Risk Workshop Agenda:

DAY 1 (WED., JAN. 17): RISK ASSESSMENT AND MANAGEMENT FRAMEWORK

Time	Workshop Element	Speaker/Facilitator
8:15am	Coffee available in meeting room Pick up nametags and handouts	
9:00-10:00am	Welcoming remarks and background information • Meeting facility orientation • IJC welcome and overview • IJC WG overview, objectives, deliverables • Microplastics as ecosystem subindicators • California risk assessment & mgmt. framework • Tools for regional microplastics hazard assessment • Applying California framework to Great Lakes	Lizhu Wang, IJC Heather Stirratt, IJC Rebecca Rooney, WG Chelsea Rochman, WG Alvina Mehinto, SCCWRP (remote) Leah Thornton-Hampton, SCCWRP Eden Hataley, WG
10:00-11:00am	Plenary Session #1: Management Framework • Background presentation • Discussion about decisions relevant to creating a management framework in the Great Lakes	Chelsea Rochman
11:00-11:15am	Coffee and pastries break	
11:15-12:45pm	Plenary Session #2: Threshold Development • Background presentation	Alvina Mehinto (remote) Leah Thornton-Hampton

	• Discussion about the SSD parameters that will be used to derive thresholds for the risk assessment framework	
12:45-2:00pm	Lunch (ordered in advance), River Room (2nd floor of hotel)	
2:00-3:00pm	Plenary Session #3: Data Rescaling and Realignment • Background presentation • Discussion about how to rescale and realign effects and exposure data to be used in the risk assessment framework	Scott Coffin, California State Water Resources Control Board (remote) Eden Hataley
3:00-4:00pm	Plenary Session #4: QA/QC for exposure (i.e., monitoring) and toxicity test data • Background presentation • Discussion about the QA/QC we want to see in effects and exposure studies informing our assessment	Leah Thornton-Hampton Eden Hataley
4:00-4:15pm	Break	
4:15-5:00pm	Review of major decision points, discussion, capturing lingering decisions/ideas (reviewing flow chart)	WG Co-chairs
5:00pm	End of Day 1	
5:00-6:00pm	Break	
6:00pm	Dinner – Loose Goose RestoPub and Lounge (order and pay separately) 126 Ouellette Ave, Unit #102 – a 5-minute walk upriver from the hotel	

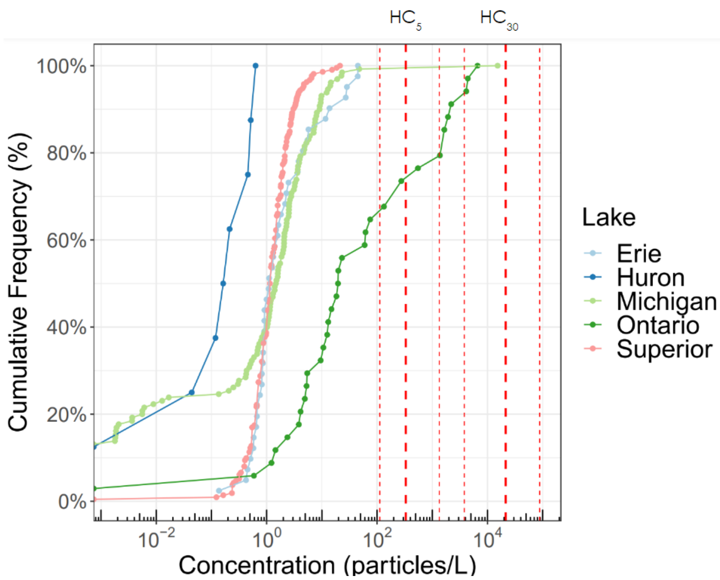
DAY 2 (THURS., JAN. 18): RISK ASSESSMENT AND MANAGEMENT FRAMEWORK

Time	Workshop Element	Speaker/Facilitator
8:15am	Coffee and pastries available in meeting room	
9:00-9:30am	Welcome back; review of Day 1 decisions and discussion	WG Co-chairs
9:30-11:30am	Threshold Reveal: ToMex and Great Lakes Data	WG Co-chairs
11:30-1:00pm	Lunch at Bistro on the River, 78 Riverside Dr. West (pre-ordered; 5-minute walk upriver)	
1:00-2:00pm	Expert Elicitation Exercise to Gauge Confidence in the Framework and Thresholds • Background presentation • Exercise to assess confidence in the work done over the last 2 days	Chelsea Rochman
2:00-3:00pm	Final Thoughts, Next Steps, Thanks!	WG Co-chairs
3:00pm	End of workshop	

Appendix B. Workshop Participants

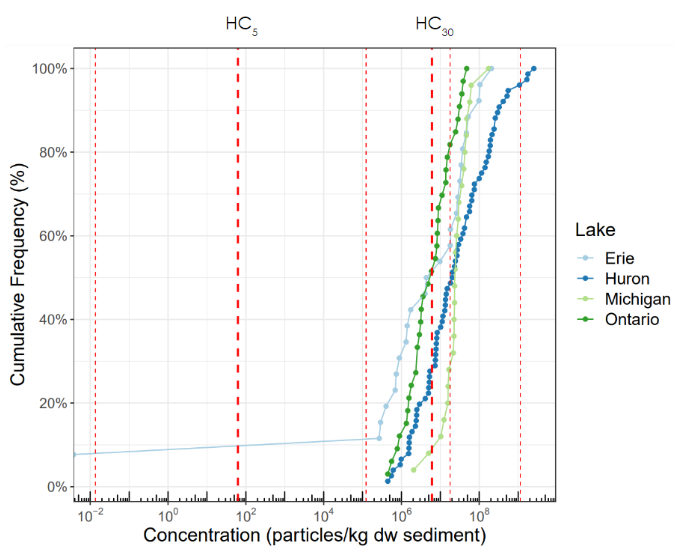
Attendee	Affiliation	Email
Alvina Mehinto	Southern California Coastal Water Research Project (SCCWRP)	alvinam@sccwrp.org
Andrew McQueen	U.S. Army Corps of Engineers	andrew.d.mcqueen@usace.army.mil
Austin Baldwin	US Geological Survey	akbaldwi@usgs.gov
Bob Murphy	Tetra Tech	bob.murphy@tetratech.com
Carl Platz	U.S. Army Corps of Engineers	carl.a.platz@usace.army.mil
Carlie Herring	NOAA Marine Debris Program	carlie.herring@noaa.gov
Chelsea Rochman	University of Toronto, Department of Ecology and Evolutionary Biology	chelsea.rochman@utoronto.ca
Colleen Wardlaw	McMaster University	wardlac@mcmaster.ca
Donna Kashian	Wayne State University, Environmental Science and Geology	dkashian@wayne.edu
Eden Hataley	University of Toronto Scarborough, Department of Physical and Environmental Sciences	eden.hataley@mail.utoronto.ca
Haley Dalian	NOAA Marine Debris Program	haley.dalian@noaa.gov
Karen Keil	U.S. Army Corps of Engineers	karen.g.keil@usace.army.mil
Karen Kidd	McMaster University	karenkidd@mcmaster.ca
Kelly Somers	US EPA Region 3 Mid-Atlantic	somers.kelly@epa.gov
Leah Thornton Hampton	Southern California Coastal Water Research Project (SCCWRP), Toxicology	leahth@sccwrp.org
Quinn Allemby	McMaster University	allambyq@mcmaster.ca
Rebecca Rooney	University of Waterloo	rebecca.rooney@uwaterloo.ca
Ryan Prosser	University of Guelph	prosserr@uoguelph.ca
Scott Coffin	California State Water Resources Control Board	Scott.Coffin@Waterboards.ca.gov
Tim Fletcher	Ontario Ministry of Environment, Conservation and Parks	tim.fletcher@ontario.ca
Heather Stirratt	*IJC*	*heather.stirratt@ijc.org*
Matthew Child	*IJC*	*matthew.child@ijc.org*
Lizhu Wang	*IJC*	*lizhu.wang@ijc.org*
Raj Bejankiwar	*IJC*	*Rajesh.bejankiwar@ijc.org*
Antonette Arvai	*IJC*	*matthew.child@ijc.org*
Samir Qadir	*Potomac-Hudson Engineering, Inc. (Contractor team)*	*samir.qadir@phe.com*
John Bratton	*LimnoTech (Contractor team)*	*jbratton@limno.com*
Ken Gibbons	*LimnoTech (Contractor team)*	*kgibbons@limno.com*

Appendix C. Monitoring Data and SSD-Derived Thresholds



	HC	Value (particle/L)
Threshold 1	HC5	**331** (112 - 1,340)
Threshold 2	HC30	**21,400** (3,800 - 88,400)

Figure C-1 – Ambient Water, Volume-Based Effect, without Tributary Data



	HC	Value (particle/kg dw)
Threshold 1	HC5	**62.6** (0.0136 - 1.78×10^{7})
Threshold 2	HC30	**6.09×10^{6}** (1.23×10^{5} - 1.14×10^{9})

Figure C-2 – Sediment, Volume-Based Effect, without Tributary Data