Microplastics Expert Workshop Report

Trash Free Waters Dialogue Meeting

Convened June 28-29, 2017

EPA Office of Wetlands, Oceans and Watersheds

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EPA Microplastics Expert Workshop Report

Executive Summary

Recent global efforts to better understand microplastics distribution and occurrence have detailed both the ubiquity of microplastics and the uncertainties surrounding their potential impacts.

In light of this scientific uncertainty, the US Environmental Protection Agency (EPA) convened a Microplastics Expert Workshop in June 2017 to identify and prioritize the scientific information needed to understand the risks posed by microplastics (broadly defined as plastic particles <5 mm in size in any one dimension (Arthur et al. 2009)) to human and ecological health in the United States. The workshop gave priority to gaining greater understanding of these risks, while recognizing that there are many research gaps needing to be addressed and scientific uncertainties existing around microplastics risk management (e.g., waste management/recycling/ circular economy principles, green chemistry approaches to developing alternatives to current-use plastics).

The workshop participants adopted a risk assessment-based approach and addressed four major topics: 1) microplastics methods, including deficits and needs; 2) microplastics sources, transport and fate; and 3) the ecological and 4) human health risks of microplastics exposure. A framework document was developed prior to the workshop to guide discussion. During the workshop, the participants recommended adopting a conceptual model approach to illustrate the fate of microplastics from source to receptor.

This approach is helpful in describing the various scientific uncertainties associated with answering the overarching questions of the ecological and human health risks of microplastics, the degree to which information is available for each, and the interconnections among these uncertainties. Draft conceptual models were developed during the workshop, and these draft models were the basis for more detailed models developed through discussions and comments from the participants after the workshop. The resulting detailed models are introduced and explained in the main body of this report.

The participants identified the following priority scientific information needs within each of the four research topics discussed during the workshop:

- ***Methods needs*:** Establish reproducible, representative, accurate, precise methods for microplastics analysis that include appropriate quality assurance/quality control (QA/QC) for: microplastics sample collection; microplastics extraction from surface and drinking water, dust, sediment and tissue samples; microplastics characterization (size, shape and chemical composition [polymer, as well as additive chemicals]); and microplastics quantification, particularly for particles in the micron scale (≥1 µm and ≤1 mm in size) for which information is limited and which are relevant to human and ecological exposure risks.

- ***Microplastics sources, transport and fate needs*:** Conduct research on the sources, transport, fate, and distribution of microplastics in the environment to be used for exposure characterization in risk assessment of human and ecological health impacts, particularly to understand and characterize: (a) how consumer product use and wear, agricultural practices and waste management processes (including sludge land application and landfill leachate) in the US contribute to microplastics in the environment, and (b) how particle characteristics such as chemical composition (i.e., polymer type) affect microplastics behavior (transport, degradation, and distribution);

- ***Ecological assessment needs:*** Create standardized toxicity tests for microplastics in test organisms and ecologically representative organisms and systems (including field studies) to understand the ecological impacts of microplastics, considering whether standard laboratory tests and endpoints can be applied to microplastics toxicity assessments, bioavailability of microplastics and their additive chemicals (especially particle translocation and chemical bioaccumulation), and how dose-response relationships can be developed for microplastics to better understand the full range of their potential impacts; and

- ***Human health assessment needs:*** Create methods and conduct research to characterize human exposure to and impacts from microplastics in drinking water (including source water), seafood, freshwater fish and indoor/outdoor dust, in order to assess potential human health risks.

Of the needs identified above, the workshop participants echoed the conclusion of many microplastics review papers and reports that the development of reliable, reproducible and high-quality methods for microplastics quantification and characterization is fundamental and of paramount importance for understanding microplastics risks.

These priority scientific information needs are reflected in the discussion and conceptual models presented below. Graphic representations of the models are provided on pages 11, 14, 17, and 20 of this report.

Workshop Participants and Observers

Participants

Name	Agency/Affiliation
Invited Experts	
Robert Hale	Virginia Institute of Marine Science
Paul Helm	Ontario Ministry of the Environment
Jenna Jambeck	University of Georgia
Kara Lavender Law	Sea Education Association
Chelsea Rochman	University of Toronto
Environmental Protection Agency	
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Robert Burgess	Office of Research & Development, Atlantic Ecology Division
Bob Cantilli	Office of Research & Development, Office of Science Policy
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Other	
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Observers

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Alix Grabowski	World Wildlife Fund
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Introduction

Plastics pollution has raised concern worldwide, with a recent study estimating that 8 million metric tons of plastics was released into the world's oceans in 2010 (Jambeck et al. 2015). Freshwater and terrestrial systems are also affected by plastics pollution, and research over the past few decades has shown that plastic items such as derelict fishing gear and plastic grocery bags can have detrimental effects on wildlife via entanglement and ingestion (reviewed by Browne et al. 2015; Provencher et al. 2017). More recently, studies conducted around the world have shown that microplastics, plastic particles <5 mm in size in any one dimension (Arthur et al. 2009), are widespread in marine and freshwaters, and may also have negative ecological impacts (GESAMP 2015; 2016).

Since its inception in 2013, the EPA's Trash Free Waters (TFW) program has pursued a multi-pronged approach to reducing and preventing trash in US waters, including plastics. One part of this approach assesses the current state-of-the-science of understanding the ecological and human health impacts of trash in the environment. As part of this approach, TFW convened the "Expert Discussion Forum on Possible Human Health Risks from Microplastics in the Marine Environment" in April 2014 (US EPA 2015). This discussion forum brought together experts in plastics and microplastics to share their perspectives on microplastics pollution. The discussion at the forum focused on microplastics as vectors for persistent, bioaccumulative and toxic substances (PBT), and the participants determined that priority should be given to understanding the relative contribution of PBTs sorbed to or present in microplastics in the context of other PBT sources to seafood to better assess human health risks.

Although microplastics have been identified as a potential environmental concern since the 1970s, research efforts in this area have increased substantially in the last five years, and therefore TFW considered it relevant to convene another expert group to make further recommendations toward improving our understanding of the potential impacts of microplastics in the environment. The Microplastics Expert Workshop was convened on June 28th and 29th, 2017 and included three of the experts who participated in the 2014 event.

Workshop Aims and Process

The central aim of the Microplastics Expert Workshop was to identify and prioritize the scientific information needed to understand the risks posed by microplastics to human and ecological health in the United States. In order to achieve this aim, a framework document and meeting agenda were prepared by an internal EPA working group prior to the microplastics workshop as a means of guiding discussion using a risk assessment-based approach (Appendices 1 and 2). The framework document was shared with the workshop participants prior to the workshop for their comments, and their feedback was incorporated into the final version of the document.

The workshop participants adopted a risk assessment-based approach and addressed four major topics:

1. Microplastics methods, including deficits and needs;
2. Microplastics sources, transport and fate;
3. The ecological occurrence and impacts of microplastics exposure; and
4. The human health effects of microplastics exposure.

The framework document includes brief summaries of what was known for each of the four major workshop topics at the time of the workshop and associated key questions, as well as overarching considerations to be taken into account during discussion. Briefly, these considerations were:

a) Relevant microplastic size ranges for the four major topics, given that microplastics occur at sizes that may encompass 6-7 orders of magnitude;

b) Plastic particle type/geometry/polymer, given the physical diversity of plastic polymers currently on the market, and the large variation in microplastic shape, size and composition (reviewed by Andrady 2017);

c) Spatial and temporal heterogeneity, given that microplastics concentrations are known to be highly variable across space and time; and

d) Future scenarios, given that plastics production is predicted to continue to increase in the next 5-10 years.

Two approaches were adopted for the four major topics during the workshop. Topic 1 was discussed according to the framework document (Appendix 2), and a priority need was identified. In addition, the workshop participants expressed that a conceptual model approach would be useful for identifying and prioritizing scientific information needs for Topics 2-4 (microplastics sources, transport and fate; ecological exposure and human exposure), and therefore this approach was adopted.

Conceptual Model Approach

Conceptual models were constructed to help guide the identification of the overall research priority for Topics 2-4. Draft conceptual models were initially developed in the meeting room during the workshop, some of which were relatively limited in scope. These draft models served as the basis for expanded models that were developed in follow-up group conversations and communication with the workshop participants. Each of these models is explained in detail in the corresponding sections for Topics 2-4 below.

The models share some common features: in each, color-coding is used to indicate the relative amount of information currently available for that part of the model, with green, orange and red indicating most information/good confidence, some information/moderate confidence and little information/low confidence, respectively. These confidence levels were assigned by the workshop experts based on their knowledge of the scientific literature and the quality of the data available therein, and are relative statements of confidence; microplastics occurrence, exposure and effects data are generally lacking. Confidence levels were assigned by group consensus. Priority areas for research are identified in the conceptual models and explained in the *Notes* for each individual model.

Priority Information Needs Within Topic Areas

For each of the four topics, the priority need is presented first and then the flow of the discussion at the workshop is briefly summarized. As Topic 1 underpins the other three topics, some specific methods needs were also identified for Topics 2-4.

Topic 1: Microplastics Methods

Priority need: *Establish reproducible, representative, accurate, precise methods for microplastics analysis that include appropriate quality assurance/quality control (QA/QC) for: microplastics sample collection; microplastics extraction from surface and drinking water, dust, sediment and tissue samples; microplastics characterization (size, shape and chemical composition [polymer, as well as additive chemicals]), and microplastics quantification, particularly for particles in the micron scale (≥1 µm and ≤1 mm in size) for which information is limited and which are relevant to human and ecological exposure risks.*

Much of the discussion of Topic 1 focused on the need to return to first principles of experimental design when planning microplastics sampling and analysis. These first principles include considerations such as:

- What is the research question being asked? For what purpose?
- What are the impacts of the methods being used on the final results? What are the limitations of the selected methods?
- What is the acceptable uncertainty in the chosen methods, and how should this uncertainty be accounted for?
- What is the cost of the planned sampling and analysis?

The experts went into further detail by considering three broad steps of microplastics sampling and analysis: microplastics field sampling; microplastics extraction, separation and cleanup; and microplastics quantification and characterization. The relevant considerations for each of these steps as discussed by the participants are presented in **Table 1**.

Table 1. Considerations when planning microplastics sampling and analysis.

Microplastics Field Sampling	Microplastics Extraction, Separation and Cleanup	Microplastics Quantification and Characterization
▪ Which sample type/matrix is relevant? ▪ What size range is relevant? ▪ Which particle/polymer types are relevant? ▪ How many samples are needed? ▪ Will samples be kept discrete, homogenized or pooled for analysis, and what does this mean for interpretation of the results? ▪ Which sampling method is appropriate? ▪ What sample volume is needed to get a representative sample? ▪ What quality assurance/ quality control (QA/QC) methods are needed? ▪ Which units will be used for the final results and what does that mean for the comparability of data? ▪ What are the detection limits of the methods used?	▪ What QA/QC methods can be used (e.g., to determine procedural recoveries or to prevent background contamination)? ▪ What are the impacts of the chosen method on the final result? Will artifacts be introduced? ▪ How can sorbed contaminants and microbes be accounted for? ▪ Which polymers/particle types are accounted for, recognizing that some particle types such as microfibers can be challenging to extract and may be lost? ▪ What are the detection limits of the methods used?	▪ What are the limitations of the methods used? ▪ Which polymers/particle types are accounted for? ▪ What are the detection limits of the methods used?

The group emphasized the importance of carrying out complementary analytical (instrumental) identification of microplastics in addition to visual methods to help reduce the uncertainty inherent in these methods, which are prone to error and can under- or over-estimate microplastics quantities, particularly for particles <1 mm in size. The experts also expressed the need for high-throughput methods and instrumentation (including automation) to increase the efficiency of microplastics analysis.

As reflected in the priority need for Topic 1, participants strongly emphasized the importance of including appropriate QA/QC measures in microplastics sampling and analysis. In this area, they identified the needs shown in **Table 2**. It should be noted that some microplastics types can be purchased commercially for use as analytical standards; for example, polystyrene and polyethylene beads are available in a range of sizes. However, most polymers cannot be purchased at standard sizes or in standard mixtures, leaving researchers to generate their own microplastics for experimental use.

The experts shared their experience that the use of heat or corrosives (e.g., hydrogen peroxide) for sample extraction led to loss of microplastics and/or waxes in samples, as well as losses of microplastics purchased for use as analytical standards. The need for standardization also emerged repeatedly during the workshop discussion, both with respect to methodology and terminology; for example, terms such as "foam", "film", "fragment", etc. are currently commonly used to describe microplastics by shape, but there are no standard definitions of these terms.

Table 2. QA/QC needs for microplastics sampling and analysis.

Microplastics Field Sampling	Microplastics Extraction, Separation and Cleanup	Microplastics Quantification and Characterization
▪ Methods to ensure the statistical representativeness of samples ▪ Consideration of the implications of bulk sampling versus pre-filtration/screening ▪ Use of appropriate blanks (field and lab blanks) to assess background contamination ▪ Use of appropriate methods to reduce procedural contamination in samples	▪ Standard reference materials for microplastics in various environmental media ▪ Analytical standards for microplastics ▪ Use of appropriate blanks (matrix and spikes) ▪ Use of aged particles rather than pristine particles for QA/QC, taking into account relevant time scales of environmental exposure for the matrix being analyzed ▪ Use of individual versus homogenized/pooled samples	▪ Instrumental library accuracy, including pristine and weathered microplastics ▪ Identifying and accounting for analytical confounders ▪ Shape standard terms to describe microplastics types

The experts discussed which information should be reported for microplastics data, and concluded that the following parameters should be reported:

- Particle sizes, including dimensions (if possible);
- Particle shapes, taking into account the need for standardized terminology;
- Polymer types;

- Particle quantity, taking into account the choice of units (e.g., mass/volume, mass/area, particles/volume, particles/area);
- Detection limits for the sampling and analysis methods used.

The group also discussed the need for different methods across sample matrices (e.g., water, sediment, tissue) and whether different methods are needed for different plastic polymers, and noted that as researchers become more confident in identifying polymer types, polymer-specific methods might be needed. The group further discussed whether the types of plastics included in "microplastics" should be limited to the most widely produced plastic polymers, but ultimately decided that qualitative limits were not needed.

Finally, the group emphasized that rigorous peer review was important to ensure that high-quality microplastics data are available in the scientific literature.

Topic 2: Microplastic Sources, Transport and Fate

Priority need: *Conduct research on the sources, transport, fate, and distribution of microplastics in the environment, to be used for exposure characterization in risk assessment of human and ecological health impacts, particularly to understand and characterize: (a) how consumer product use and wear, agricultural practices and waste management processes (including sludge land application and landfill leachate) in the US contribute to microplastics in the environment, and (b) how particle characteristics such as chemical composition (i.e., polymer type) affect microplastics behavior (transport, degradation, and distribution).*

The discussion of Topic 2 began with consideration of some of the questions included in the framework document. The experts concluded that it was not necessary to limit the definition of microplastics to include only widely-produced plastic polymers, but that it was important to consider how much of the plastics market is currently captured by microplastics research (i.e., are all the polymers currently in use being investigated?). The participants identified microplastics sources and processes that they considered important in the United States, and these were incorporated into the conceptual model. The model was also used to determine relative levels of confidence regarding microplastics occurrence data in the United States, as well as to identify priority information needs (**Model I**).

See the graphic representation of Model I on page 11. **The following bullets provide information on how to read and interpret Model I.**

- Existing data on microplastics sources, transport and fate has been reviewed in detail by GESAMP (2015; 2016).
- Black rectangles represent abiotic environmental compartments. Each compartment is labelled in <u>UNDERLINED CAPITAL LETTERS</u>.
- Rounded boxes represent biotic compartments (receptors).
- Notched rectangles represent microplastics sources, and those outlined in bold black lines are priority areas for research.
- Parallelograms represent processes that are likely to occur in every abiotic compartment, except for biodegradation/biotransformation, which are expected to occur in biotic compartments.

- Microplastics are expected to distribute between adjacent abiotic compartments (i.e., there are double-headed arrows among all of the rectangular compartments).
- Biota living in each abiotic compartment will be exposed to microplastics occurring in that compartment at varying concentrations. “Sediment organisms” includes demersal, benthic and infaunal species.
- Biotic interactions within, between and among abiotic compartments will also affect the distribution of microplastics (e.g., predator-prey interactions, trophic transfer, inhalation of microplastics by air-breathing organisms, human consumption of food items from multiple compartments).
- “Combustion/Burning” includes industrial combustion; backyard burning of waste; fires; and catastrophic events.
- “Flow, Transport and Deposition” includes flow conditions; particle settling and dynamics; long-range transport; and dry and wet deposition.
- “Freshwater Organisms” and “Marine Organisms” include aquatic-dependent organisms such as amphibians, waterfowl and seabirds.

Table 3. Expected distribution of microplastics among the abiotic compartments in Model I.

Microplastics Source	Distribution to Abiotic Compartments
Sludge Land Application and Landfill Leachate	Primarily S, G; potential for transport to W, CW, IH; FW, MW
Combustion/Burning	All compartments
Deposition	All terrestrial and aquatic compartments except G (Includes W, CW, IH)
Product Wear	All compartments
Mismanaged Waste	All compartments
Wastewater Effluents	G, W, FW, CW, IH, MW
Human Aquatic Activities	W, FW, CW, IH, MW

S: Soils; G: Groundwater; W: Wetlands; FW: Freshwaters; CW: Coastal Wetlands; IH: Intertidal Habitats; MW: Marine Waters

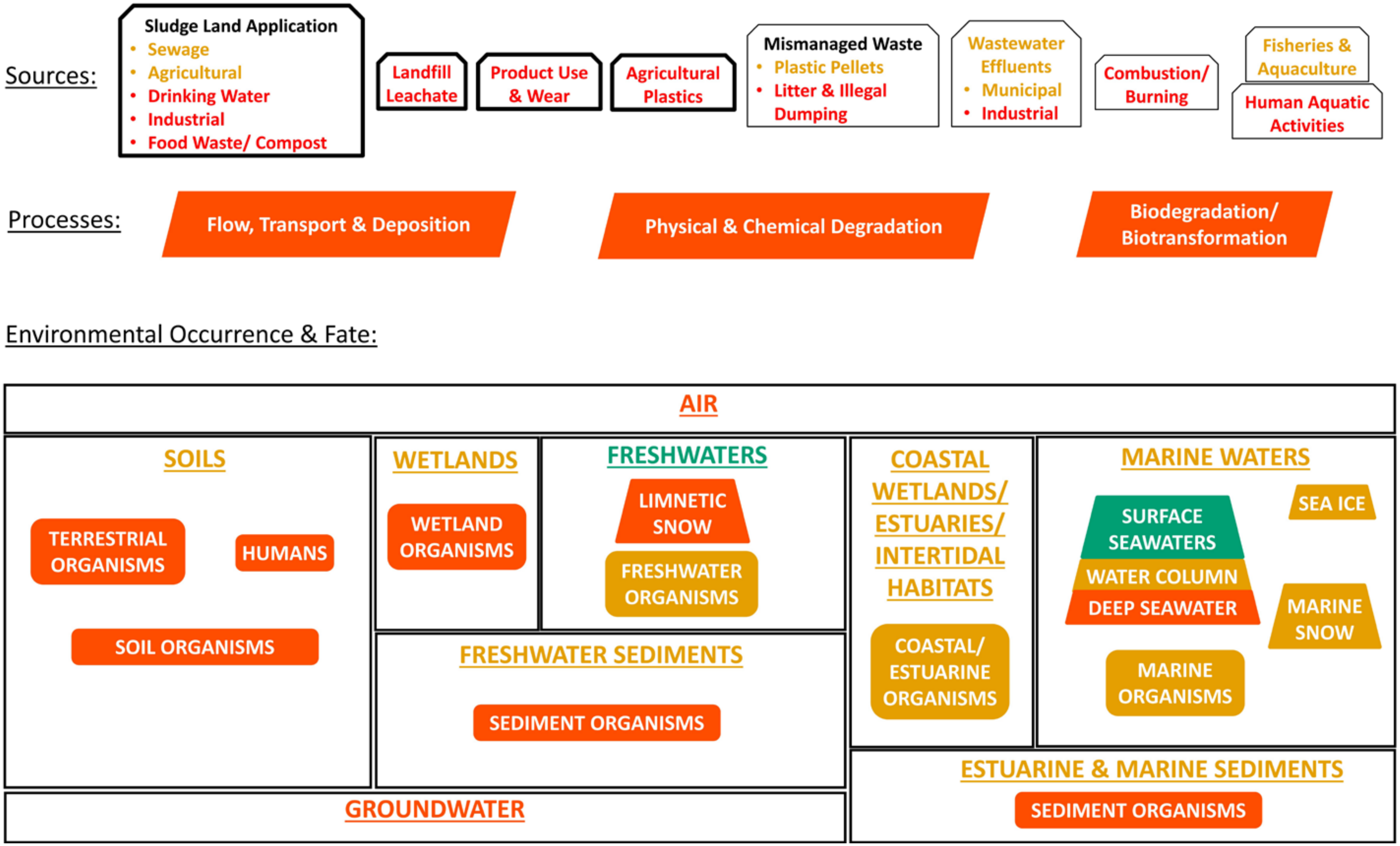
Apart from the references included in the comprehensive GESAMP reports (2015; 2016) referenced above, additional information on the some of the environmental sources, processes and compartments identified in **Model I** is arranged alphabetically below. These references are updated as of November 30, 2017.

<u>Sources and Processes:</u>

- **Agriculture:** There are limited data available for agricultural practices as a source of microplastics in the US. Two studies have examined the use of polyethylene mulches (Li et al. 2014; Brodhagen et al. 2017) in the US, while another has suggested that land application of biosolids could be a source to agricultural soils in the EU and land application of biosolids has been suggested as a potential source of microplastics to agricultural soils in the EU (Nizzetto et al. 2016).
- **Atmospheric deposition:** As noted above, one study in France has measured microplastics in atmospheric fallout (Dris et al. 2016).

Model I: Microplastics Sources, Transport & Fate in the US

- Little information; low confidence
- Some information; moderate confidence
- Most information; good confidence



- **Combustion/burning:** The fate of microplastics formed during combustion/burning likely depends upon both polymer type (Andrady 2017) and the pollution controls in place during combustion.
- **Fisheries and aquaculture:** Reviewed in a recent FAO report (Lusher et al. 2017). This source category includes both active and inactive fishing and aquaculture gear (e.g., nets, traps, buoys, fishing line, tarps, tubing and any other gear used for fishery or aquaculture purposes).
- **Human aquatic activities:** This source category is a broad one that includes both recreational activities such as boating and diving and commercial activities (e.g., shipping and transportation). It also includes sunken vessels and planes. The experts noted that ship paints may be a source of microplastics in aquatic environments. This category also includes legal ocean disposal of waste, such as of dredged sediments.
- **Product wear:** Limited information is available on how rapidly microplastics are generated from the breakdown of plastic products. Data on the degradation of several plastic types has been reviewed by Fotopoulou & Karapanagioti (2017), and tire wear has been reported to be a major source of microplastics in some European countries such as Norway (Sundt et al. 2014) and has been reviewed in a recent paper (Kole et al. 2017). The generation of plastic microfibers by the use and laundering of synthetic fabrics has also raised concern (Browne et al. 2011; Hartline et al. 2016; reviewed by Salvador Cesa et al. 2017). Wear rates are likely to be highly product- and condition-dependent.

<u>Compartments:</u>

- **Air:** There are no data available for microplastics in air in the US. The only studies worldwide have been carried out in France and Iran, and reported that microplastics were present in indoor and outdoor dust samples and atmospheric fallout (Dris et al. 2015; 2016; 2017; Dehghani et al. 2017).
- **Groundwater:** There are no data available for microplastics in groundwater in the US. Some states (e.g., Florida) discharge wastewater treatment plant effluent into subterranean aquifers (http://www.dep.state.fl.us/southeast/water/uic.htm), and one of the workshop experts noted that plastic filters are often used during the injection process.
- **Marine waters:** Reviewed in a recent publication (Law 2017).
- **Marine waters, sediments and biota:** Reviewed in a recent publication (Auta et al. 2017).
- **Sea ice:** Two studies have reported the occurrence and release of microplastics from Arctic sea ice (Obbard et al. 2014; Bergmann et al. 2017).
- **Surface freshwaters:** Most of the data for surface waters are for particles >333 µm because of the use of plankton nets for sampling (recently reviewed by Horton et al. (2017)). Among US freshwaters, the Great Lakes have been comparatively well studied (Driedger et al. 2015; IJC 2016).
- **Soils:** There are limited data available for soils in the US. The terrestrial compartment is home to the vast majority of plastics in either contained (landfills) or uncontained (litter) form. Terrestrial microplastics pollution was recently reviewed by Horton et al. (2017).

Global climate change may also affect microplastics occurrence and distribution, for example by causing large-scale release of microplastics from sea ice (Obbard et al. 2017), or through stronger storms and subsequent flooding that result in sewage overflow and micro- and macro-debris making its way to coastal and freshwaters more frequently and in larger amounts.

Topic 3: Ecological Occurrence and Impacts of Microplastics

Priority need: *Create standardized toxicity tests for microplastics in test organisms and ecologically representative organisms and systems (including field studies) to understand the ecological impacts of microplastics, considering whether standard laboratory tests and endpoints can be applied to microplastics toxicity assessments, bioavailability of microplastics and their additive chemicals* (*especially particle translocation and chemical bioaccumulation*), *and how dose-response relationships can be developed for microplastics to better understand the full range of their potential impacts.*

After initial discussion of the information presented in the framework document, the workshop participants divided into two groups to consider the potential ecological impacts of microplastics in aquatic systems and in air/soils in the US. An objective of this exercise was to prepare a corresponding conceptual model. The participants considered priority information needs, confidence levels based on the available data in the literature, and uncertainty. The products generated by both groups were merged into a single conceptual model (**Model II**) and then further expanded through conversations with the participants after the workshop.

Microplastic occurrence and toxicity data for North American species are limited, and therefore **Model II** represents a general accounting of the current state of knowledge of the ecological occurrence of microplastics around the world in various feeding guilds. Data from field studies on microplastics impacts are also very limited (e.g., Goldstein et al. 2012; Welden & Cowie 2016). For this reason, the priority need for Topic 3 focuses on toxicity testing and on obtaining the high-quality laboratory data and toxicity values that are necessary to conduct ecological risk assessments.

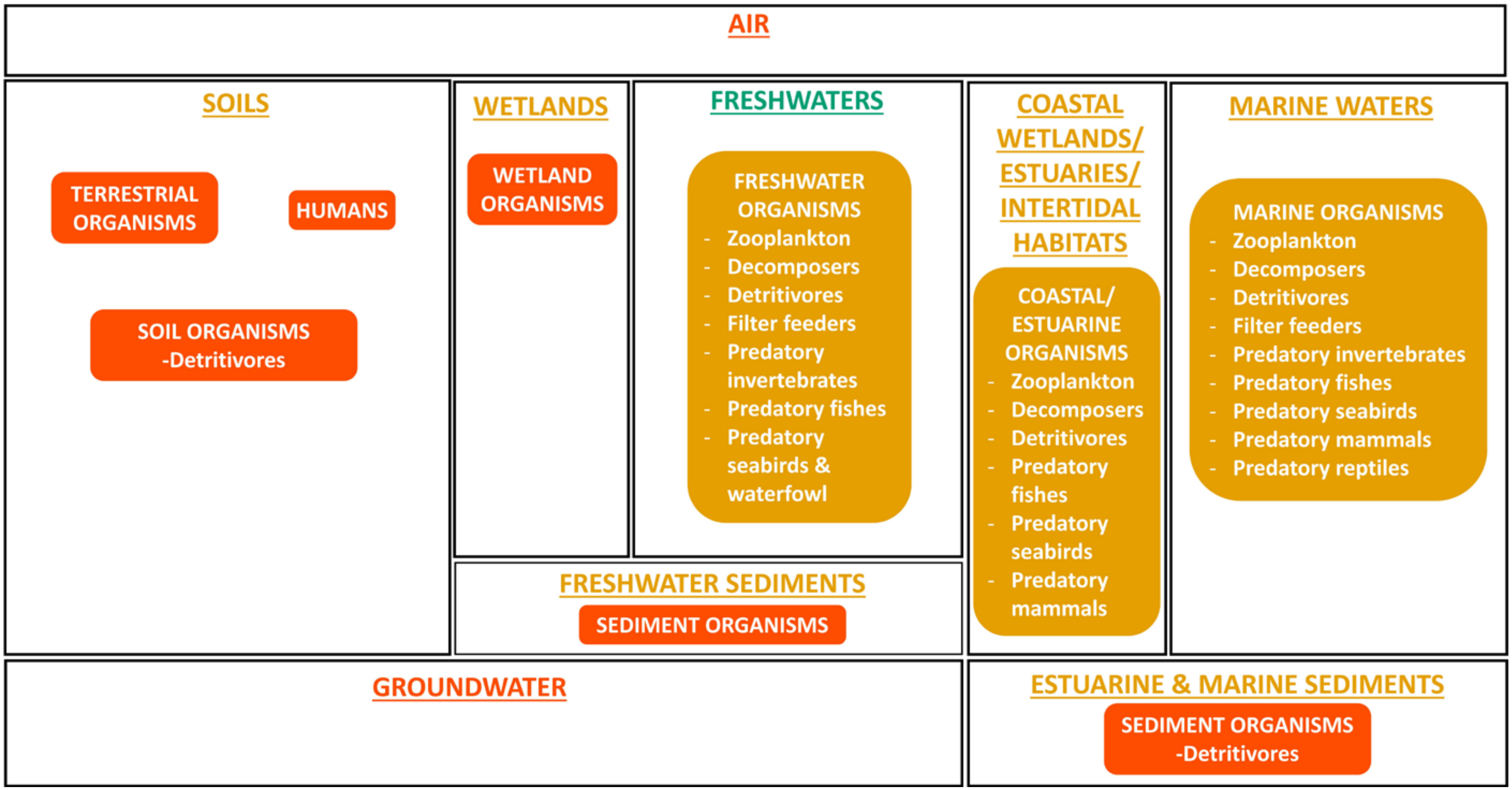
Because risk assessments also rely upon high-quality concentration data, both in the environment and for confirmation of exposure levels in toxicity testing, the paramount importance of the Topic 1 priority need (i.e., reproducible, representative, accurate, precise methods for microplastics analysis) is clear. Understanding microplastics sources, distribution and fate is also key to understanding ecological exposure and potential impacts.

See the graphic representation of Model II on page 14. **The following notes provide information on how to read and interpret Model II.**

- The model structure, shapes and labels are the same as in Model I. Sources and Processes have been removed for the sake of simplicity.
- Existing data on ecological exposure to microplastics have been reviewed in detail by GESAMP (2016).
- Feeding guilds are used to indicate broad categories of organisms for which microplastics data are available within each biotic compartment based on field studies.
- Most of the available data address microplastics occurrence in species belonging to the listed guilds, and is for non-North American species. Field data on the effects of microplastics exposure in organisms are extremely limited.
- The model does not include information for organisms which are known to ingest macroplastic (e.g., seabirds, marine mammals, terrestrial consumers, among others).

Model II: Ecological Occurrence & Impacts of Microplastics

Little information; low confidence
Some information; moderate confidence
Most information; good confidence



The workshop participants then considered whether existing toxicity testing methods and dose-response relationship approaches were relevant to microplastics, and how these could be tied into higher-level biological effects, such as using the Adverse Outcome Pathway (AOP) approach (Ankley et al. 2010). The group referred to a review by Connors et al. (2017) ("Needed improvements in microplastic research").

The participants noted that the use of lethality as a toxicity endpoint was likely not sensitive enough to account for the majority of microplastics effects, and suggested that sub-lethal endpoints or biomarkers such as changes to tissue structure that capture the potential physical effects of plastic particles, or changes in developmental patterns or reproductive success should also be investigated. One participant suggested that existing toxicity tests should be reviewed for their appropriateness for microplastics research and recommendations made as to which tests are most relevant.

The toxicokinetics/toxicodynamics of microplastics in a representative organism are detailed in **Model III.** This model was constructed after the workshop to identify potential uncertainties and concerns related to the toxicokinetics and toxicodynamics of microplastics, and to determine relative levels of confidence regarding toxicological data for microplastics.

The priority information needs for **Model III** are for data on (1) particle translocation within organisms (e.g., from the digestive tract to other organ systems) and (2) exposure to and bioaccumulation of additive chemicals (i.e., chemicals added to the plastic polymer during the manufacturing process) in tissues (reviewed by US EPA 2016; Hahladakis et al. 2017; Hermabessiere et al. 2017). To date, only one field study has reported translocation of microplastics from the digestive tract to other tissues (in European anchovies; Collard et al. 2017).

See the graphic representation of Model III on page 17. ***The information contained in Model III applies to both <u>Topic 3</u> (Ecological Occurrence and Impacts) and <u>Topic 4</u> (Human Exposure and Health Impacts), below.*** **The following bullets provide information on how to read and interpret Model III.**

- The rounded box at the top of the model represents the relevant receptor, hexagons represent exposure pathways, rectangles represent toxicokinetic/dynamic processes and trapezoids represent additional relevant considerations.
- Boxes outlined in bold black lines are priority areas for research.
- Microplastics exposure potentially includes a particle effect (physical), a chemical effect, and the combined effect of particle + chemical.
- Additive chemicals in microplastics are likely to be present at much higher concentrations than environmental contaminants (e.g., persistent organic pollutants (POPs)) sorbed to microplastics surfaces (reviewed by Hahladakis et al. 2017; Hermabessiere et al. 2017).
- Research on engineered nanomaterials may be informative in understanding the toxicokinetics and toxicodynamics of microplastics, especially at smaller size ranges.
- Particle retention time may be influenced by physiology (e.g., ability to egest particles, digestive tract structure).

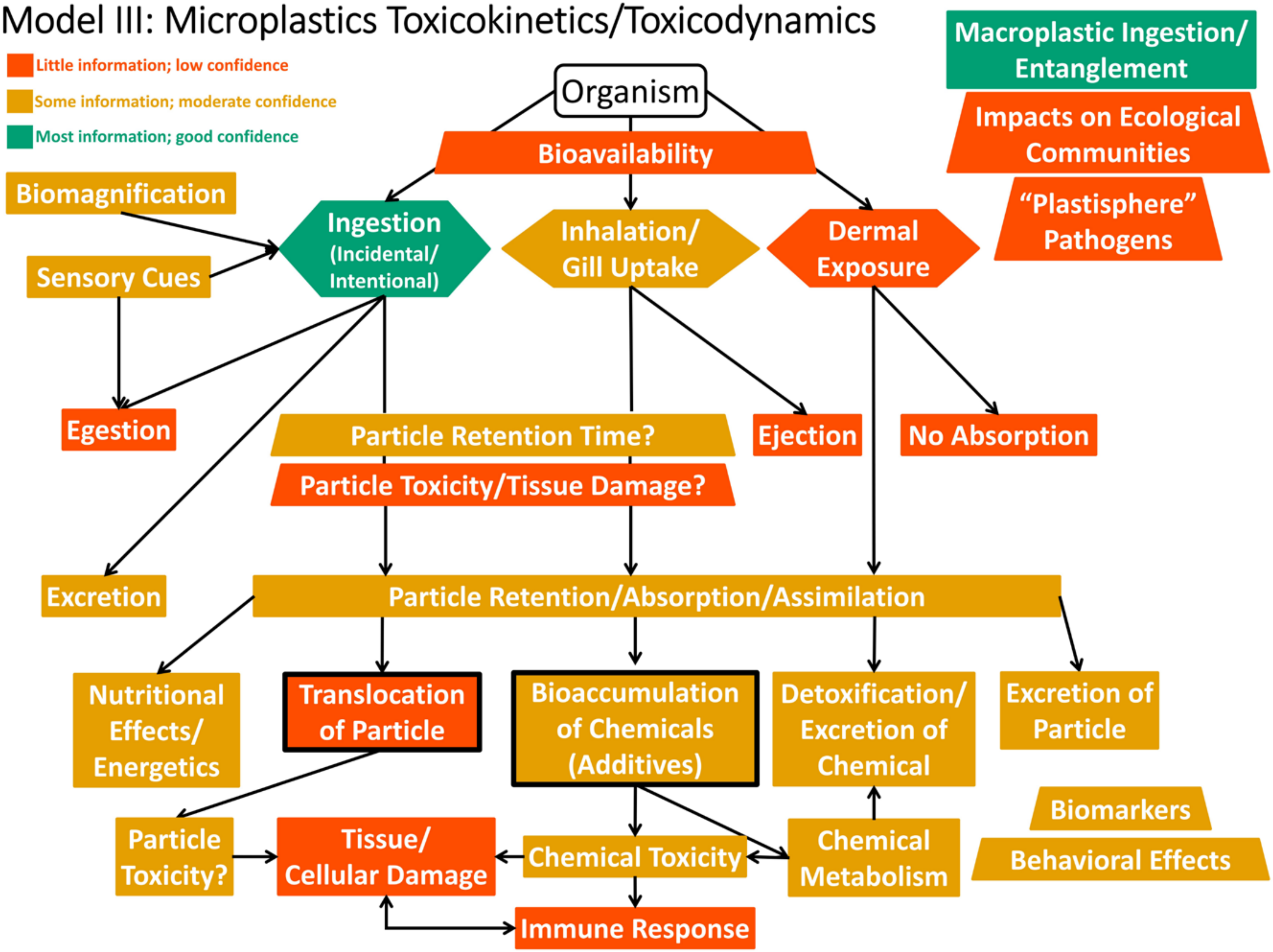
- Biomarkers may be relevant to all toxicokinetic/toxicodynamic processes shown in the model.
- Pathogens present in biofilms on microplastics (the “plastisphere”) may be relevant to microplastics effects (reviewed by Keswani et al. 2006; Harrison et al. 2018).

The participants also noted the various challenges of conducting toxicity tests with microplastics. Like engineered nanomaterials, microplastics do not dissolve in solution and may instead aggregate and/or sink, and therefore traditional aquatic exposure methods might not be appropriate.

In addition, interactions with natural organic material affect the bioavailability of microplastics in the laboratory and the field. Testing single polymer types is not representative of environmental exposure, and does not capture the diversity of biofilms that may form on different polymers (reviewed by Rummel et al. 2017), or the additive chemicals that may be present in polymers. Also, testing pristine microplastics may give different results than weathered microplastics.

The experts suggested the use of complex microplastics mixtures and experimental setups such as mesocosms that allow for multi-species and community-level assessments would generate better and more realistic data for understanding microplastic impacts. The participants also emphasized the importance of selecting ecologically relevant species for testing. For example, microplastics in shellfish (e.g., bivalves) may be of concern for both human and ecological health, and there is also an economic component in testing commercially-important species. Marine species are generally under-represented in toxicity testing.

Model III: Microplastics Toxicokinetics/Toxicodynamics



Topic 4: Human Exposure and Health Impacts of Microplastics

Priority need: *Create methods and conduct research to characterize human exposure to and impacts from microplastics in drinking water (including source water), seafood, freshwater fish and indoor/outdoor dust, in order to assess potential human health risks.*

A conceptual model was used to identify the exposure pathways relevant to potential human health impacts of microplastics in the US, to determine relative levels of confidence regarding available microplastics data relevant to human health in the US, and to identify priority information needs (**Model IV**). The priority research needs identified to better understand human exposure and health impacts of microplastics are based on other priorities identified in this report: the availability of *reliable and reproducible methods* for microplastics analysis, an understanding of *microplastics sources,* and *toxicokinetic/toxicodynamic* information for microplastics.

See the graphic representation of Model IV on page 20. **The following bullets provide information on how to read and interpret Model IV.**

- Existing data on human exposure to microplastics have been reviewed in detail by GESAMP (2016). Study results released in August 2017 reported the widespread occurrence of microplastics in drinking water from various countries (Orb Media, 2017), but these results have not yet been peer-reviewed. One additional study of microplastics in sea salt in Spain was recently published (Iñiguez et al. 2017).

- Ovals represent exposure modes, rectangles represent microplastics sources, hexagons represent exposure pathways, and the rounded box represents the relevant receptor. Boxes outlined in bold black lines are priority areas for research.
- In the “Intentional/Incidental” category:
  - Pharmaceuticals (including toothpaste) may be intentionally ingested, inhaled or dermally applied, but exposure may also be incidental via these pathways;
  - Glitter may be a cosmetic ingredient or have household applications and may be applied intentionally, or inhaled or ingested incidentally;
  - Cosmetics are intentionally applied dermally, but may be incidentally inhaled or ingested during application or use; and
  - Dust exposure occurs incidentally via ingestion, inhalation and dermal contact.
- Food preparation methods may affect exposure (e.g., consumption of raw shellfish versus cooked seafood).
- Food sources may also be an important factor (e.g., potential differences in microplastics exposure due to consumption of wild-caught versus aquacultured seafood).
- It is important to consider which human susceptible populations and life stages are relevant to exposure considerations; for example, workers who may be occupationally exposed; infants and children; women of childbearing age and the fetus; and subsistence fishers. The relevance of economic strata to exposure should also be considered.

- Soot may originate from wildfires, house/domestic fires, backyard burning and/or catastrophic events.
- Microplastics impacts in humans have been studied in relation to occupational exposure and the use of plastic medical devices (reviewed by Wright & Kelly 2017).

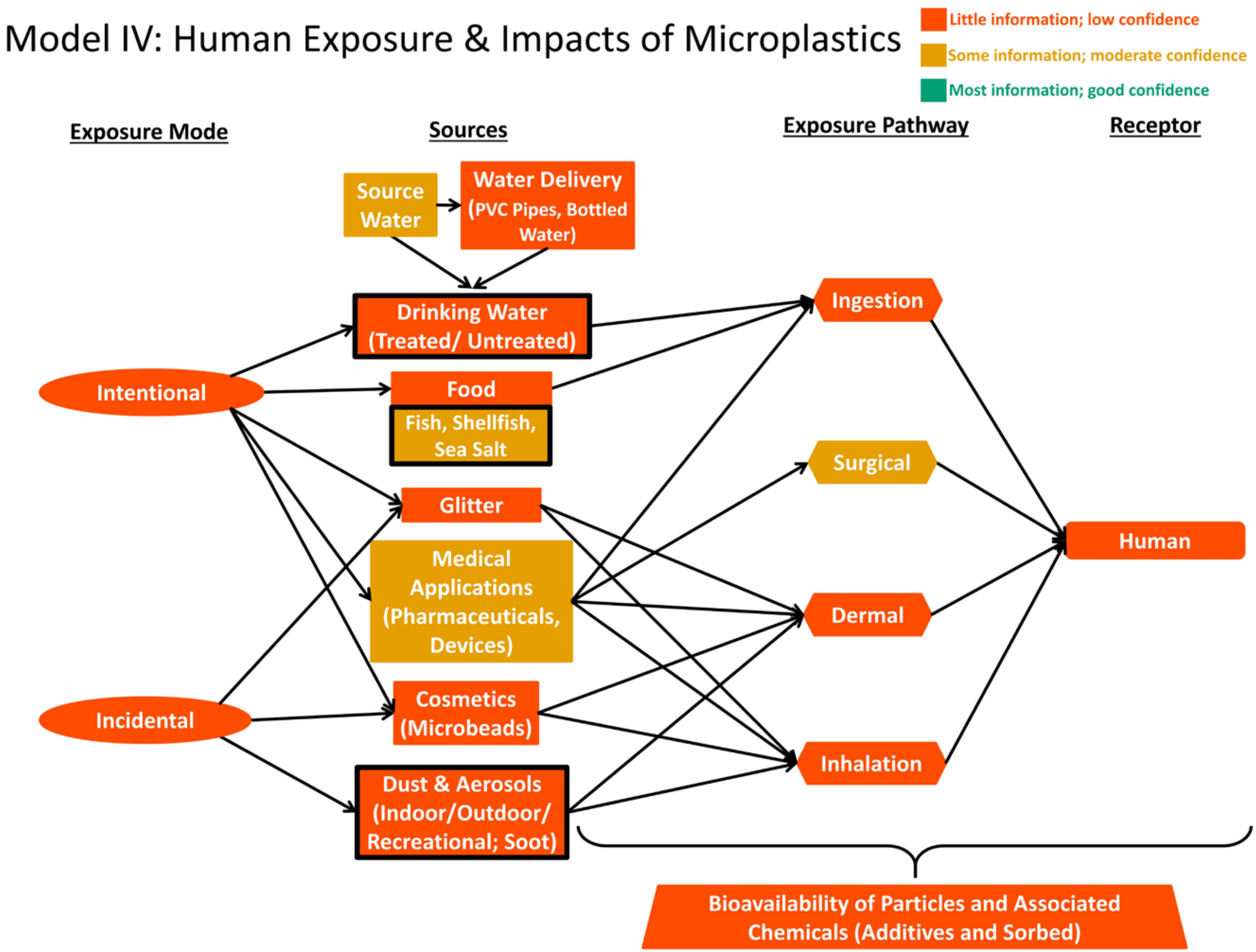
The existing exposure and toxicity data on microplastics in humans comes from the medical literature, where plastic devices have been in use for decades, and from occupational exposure (reviewed by Wright & Kelly 2017). In contrast to the ecological context, human physiological responses to particulate matter are relatively well-known, particularly for the inhalation exposure pathway, and air quality criteria based on particle sizes are used worldwide (US EPA 2009). However, information on the amounts and types of microplastics present in particulate matter is not known apart from the few air studies cited above.

Treatment of source water for drinking is expected to filter out large particles, leaving behind particles in the low micron-to-nanometer range (Abbott Chalew et al. 2013), though uncertainties remain as to whether or how drinking water delivery systems (e.g., plastic piping) contribute microplastics to finished water. It should also be noted that approximately 15 million Americans obtain their drinking water from private wells that are unregulated (US EPA 2017). The need for more information about the bioavailability of microplastics and their additive chemicals also applies to human health concerns.

Although the impacts of particulate exposure to human health are relatively well-studied, much less is known about the composition of complex particulate mixtures such as house dust, which is known to be highly relevant to human exposure to PBT chemicals (e.g., polybrominated diphenyl ethers (PBDEs)) that are used in furnishings, electronics and other household products, including plastic products (reviewed by Stubbings & Harad 2014). Humans are estimated to spend up to 90% of their time indoors in their homes, work places, schools and vehicles (reviewed by Cincinelli & Martellini 2017), and therefore data on the types of particles that comprise house dust and dust from other sources will be informative to human health risk assessment and may also provide information on product wear.

The use of technology to remove pollutants based on size for protection of human health means that nanoplastics are expected to be highly relevant to human exposure (reviewed by Galloway 2015; Koelmans et al. 2015; da Costa et al. 2016). Only a few studies have been published measuring nanoplastics in the laboratory; quantifying nanoplastics is challenging due to the potential for high background contamination, and very few methods are available. There is also on only one study that has quantified nanoplastics in the environment (Ter Halle et al. in press). Knowledge of the properties of engineered nanomaterials may be informative in understanding the potential risks of nanoplastics (reviewed by Rist & Hartmann 2018).

Biofilms may also be relevant to human exposure, as pathogenic organisms may grow on microplastic particles that are taken up by commercial species such as shellfish (reviewed by Keswani et al. 2016; Harrison et al. 2018). There are currently no data on the occurrence of microplastics in humans due to food or drinking water consumption, and no studies on human exposure to chemicals via microplastics ingestion. Finally, the risks posed by PBTs sorbed to or present in microplastics may be relevant to humans via exposure pathways such as seafood consumption.


Model IV: Human Exposure & Impacts of Microplastics
Little information; low confidence
Some information; moderate confidence
Most information; good confidence
Exposure Mode
Sources
Exposure Pathway
Receptor
Source Water
Water Delivery (PVC Pipes, Bottled Water)
Drinking Water (Treated/ Untreated)
Intentional
Food
Fish, Shellfish, Sea Salt
Glitter
Medical Applications (Pharmaceuticals, Devices)
Incidental
Cosmetics (Microbeads)
Dust & Aerosols (Indoor/Outdoor/ Recreational; Soot)
Ingestion
Surgical
Dermal
Inhalation
Human
Bioavailability of Particles and Associated Chemicals (Additives and Sorbed)

Conclusions

Microplastics pollution is complex and ubiquitous, and microplastics research is in its infancy. Microplastics have been found in surface waters worldwide and, as indicated in recent studies, are present in various foodstuffs including seafood. Studies of other sample types for which data are limited, such as air and soil, also indicate that microplastics pollution is widespread.

However, the potential risks associated with microplastics exposure are unknown for both humans and wildlife, largely critical information needed to conduct risk assessments—exposure and effects data—are lacking. The uncertainties associated with understanding the potential impacts of microplastics to ecological and human health therefore warrant urgent attention to minimize these uncertainties.

This workshop report aims to identify and summarize the scientific information needed to inform Agency regulatory and research objectives relative to assessing human and ecological health impacts of microplastics. Among other things, the document presents a set of linked conceptual models that address the fate of microplastics from their sources to the environment through various human and ecological exposure pathways, including consideration of the amount of information currently available and a list of suggested priority information areas.

In summary, the workshop participants find that the following are priority needs within the four research topic areas discussed:

- **Establish reliable and reproducible methods** for microplastics quantification and characterization;
- **Conduct research on the sources, transport, fate, degradation, and distribution of microplastics in the environment** to be used in risk assessment of human and ecological health impacts, particularly to understand and characterize: (a) how consumer product use and wear, agricultural practices and waste management processes in the US contribute to microplastics in the environment, and (b) in which ways particle characteristics such as chemical composition (i.e., polymer type) affect microplastics behavior (transport, fate, degradation, and distribution);
- **Create standardized toxicity tests for microplastics in test organisms and ecologically representative organisms and systems** (including field studies) to understand the ecological impacts of microplastics, considering whether standard laboratory tests and endpoints can be applied to microplastics toxicity assessments, bioavailability of microplastics and their additive chemicals (especially particle translocation and chemical bioaccumulation) and how dose-response relationships can be developed for microplastics; and
- **Create methods and conduct research to characterize human exposure to microplastics in drinking water (including source water), seafood, freshwater fish and indoor/outdoor dust** to assess potential human health risks.

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Appendix 1: Workshop Agenda

EPA Microplastics Expert Workshop
Crystal City Marriott at Reagan National Airport, Salon F (Mezzanine floor)
June 28-29, 2017

Agenda

Workshop Facilitator: Lee-Ann Tracy, CSRA

Wednesday, June 28th

8:00 am	Registration Begins
8:30 am	Welcoming remarks by Benita Best-Wong Acting Deputy Assistant Administrator, EPA Office of Water
8:40 am	Introductions (Participants/facilitator)
8:50 am	Meeting overview - Meeting purpose and expectations - Major discussion topics - Agenda and framework documents - Guidelines/housekeeping matters - Outcomes and "what next"
9:00 am	**Focused presentation: Microplastics methods**
9:10 am	Discussion begins - Validate framework questions and modify as needed - Identify scientific information needs/next steps for these questions
10:35 am	Break
10:50 am	Continue discussion - Prioritize scientific information needs/next steps - Wrap-up topic
12:20 pm	Lunch
1:20 pm	**Focused presentation: Sources and fate of microplastics in the environment**
1:30 pm	Discussion begins - Validate framework questions and modify as needed - Identify scientific information needs/next steps for these questions
3:00 pm	Break
3:15 pm	Continue discussion - Prioritize scientific information needs/next steps - Wrap-up topic

5:00 pm	**Wrap-up**
5:15 pm	**End of Day 1**

Thursday, June 29th

8:00 am	Arrive at workshop venue
8:15 am	F**ocused presentation: Ecological impacts of microplastics**
8:25 am	Discussion begins - Validate framework questions and modify as needed - Identify scientific information needs/next steps for these questions
10:00 am	Break
10:15 am	Continue discussion - Prioritize scientific information needs/next steps - Wrap-up topic
11:45 am	Lunch
12:45 pm	F**ocused presentation: Human health impacts of microplastics**
12:55 pm	Discussion begins - Validate framework questions and modify as needed - Identify scientific information needs/next steps for these questions - Prioritize scientific information needs/next steps - Wrap-up topic
2:30 pm	Break
2:45 pm	**Review priority needs from each session and develop overall priorities**
4:15 pm	**Wrap up/Summary and next steps**
4:30 pm	**End of workshop**

Appendix 2: Workshop Framing Document (6/28/17)

EPA Microplastics Expert Workshop

Framing Document to Facilitate Discussion

Workshop Purpose: To identify and prioritize the scientific information needed to inform science-based policies on the ecological and human health risks associated with exposures to microplastics in the United States.

Purpose of the Framing Document: To briefly summarize the state-of-the-science on four discussion topics and outline the key questions to be addressed at the workshop. The workshop agenda will follow this Framing Document. Participants are invited to expand the scope of the discussions beyond what is included in this Framing Document, but the key questions included in it will be addressed, at minimum. Following the workshop, the Framing Document may serve as an outline for the participants to produce the workshop report and a short summary document for policymakers. <u>This framework is not intended to comprise either a research strategy/program for any one entity.</u>

Basis of the Framing Document: The Framing Document uses a risk assessment approach: problem identification, exposure assessment, effects assessment and risk characterization. This framework and workshop will not address specific information needs for risk management options, e.g., recycling, green (or "sustainable") chemistry, etc. The workshop may identify categories for such needs, however, and may allude to them in discussion of the uncertainties associated with a better understanding of microplastics impacts on ecological and human health.

<u>"Microplastics" size definition.</u> For the purposes of this workshop, the participants will adhere to the generally accepted definition of microplastics found in much of the literature: 5 mm in any one dimension and below.

Overarching Considerations for Workshop Discussion:

1. <u>Relevant microplastic size ranges.</u> Discussions of scientific information needs and determinations of scientific priorities during the workshop will include a definition of the particle size range that is relevant to the question under discussion. This range may include nanoplastics, recognizing that there are substantial scientific uncertainties associated with nanoplastics compared to microplastics, and that these needs comprise an entire body of research needing further consideration.
2. <u>Plastic particle type/geometry:</u> Discussions of scientific information needs and determinations of scientific priorities during the workshop will include a definition of the plastic particle type(s) (including polymer types) or geometry (e.g., fragment, pellet, fiber, film) that is/are relevant to the question under discussion.
3. <u>Heterogeneity:</u> Microplastics are highly heterogeneous in their geometry, polymer composition, and environmental distribution. This variation in microplastics characteristics, concentration and composition can make it difficult to take representative environmental samples. The documented heterogeneity in microplastics distribution in the environment should be taken into account during discussions of scientific information needs and determinations of scientific priorities.
4. <u>Future scenarios:</u> Plastics production is projected to continue to increase. The potential impacts of this increasing production should be taken into account during the workshop discussions.

Proposed Workshop Discussion Topics:

A. Methods for the separation, quantification and characterization of microplastics (Workshop Day 1, AM)

What we know:

- There are no standardized or validated methods currently available for microplastics quantification or characterization, including QA/QC practices. Microplastics methods and data are reported inconsistently. This lack of methods is hindering the understanding of microplastics occurrence and potential effects.
- Existing characterization methods rely on time-consuming instrumental methods (Raman/FTIR spectroscopy), often with visual identification of microplastics as the first step. There is currently no validated high-throughput method for microplastics.
- Organic material can confound microplastics signatures (including biofilms) and impede microplastics separation in sediments or biological samples.
- Toxic chemicals present in microplastics (additive chemicals) or sorbed to microplastics surfaces have raised concern. Methods are available in the literature for examining the sorption/desorption of conventional contaminants (e.g., POPs) to and/or from various plastics. Plastics additives are measured less commonly, though methods are also available.

Key questions for discussion:

1. Which, if any, of the published methods is most appropriate for quantification of microplastics of a given size/type and in a given matrix (e.g. water, sediment, tissue)? Why?
2. What are the advantages/disadvantages of the different methods?
3. What information/technology is needed to achieve low-cost, high-throughput microplastics analysis (i.e., isolation, extraction, characterization)?
4. What are the barriers to development of standardization and validation of microplastics methods?
5. What are the barriers to development of better microplastics methods, including QA/QC methods?
6. What are the short-term scientific information needs in this area for the next 5 years?

B. Microplastics sources, distribution and fate in the US (Exposure assessment; Workshop Day 1, PM)

What we know:

- Microplastics have been found in virtually every environmental medium across a diversity of freshwater and marine habitats. That is, in water, wildlife, sediments and air samples. Microplastics have also been found in the terrestrial environment.
- Microplastics in the environment are highly heterogeneous (in amount, polymer type, geometry, etc.).
- Plastic polymer properties and particle properties—density, specific gravity, susceptibility to UV radiation, geometry, etc.—can to some extent be used to predict microplastics distribution.
- Microplastics are present in wastewater treatment plant (WWTP) effluent and sewage sludge at various concentrations. POTWs show varying efficacy in removing microplastics, with some studies reporting >95% removal and other showing much less. Studies reporting >95% removal caution that WWTPs are still likely significant sources of microplastics.
- Sewage sludge may be a source of microplastics to the environment depending on how it is used, e.g. land application of biosolids may introduce microplastics into the terrestrial environment.

Key questions for discussion:

7. Which plastic polymers are included in “microplastics”? Are e.g., synthetic waxes also microplastics?
8. What are the timescales and mechanisms of polymer/product degradation to form secondary microplastics under environmental conditions?
9. What are the major land-based sources and fluxes of macro- and microplastics in the U.S.?
10. How does derelict fishing gear contribute to microplastics loadings?
11. Does the current understanding of microplastics types and composition capture the major sectors of the U.S. plastic industry/market? Are any of these sectors un- or under-represented in plastics/microplastics inventories? (Agriculture? Tires re: microfibers?)
12. How are microplastics distributed within the water column and in sediments in aquatic systems? What is the fate of microplastics in aquatic systems?
13. What are the loadings of macro- and microplastics from major river systems into U.S. coastal waters?
14. What are the concentrations of microplastics in wastewater and sludge/biosolids?
15. What are the concentrations of microplastics in drinking water?
16. What are microplastics sources in the terrestrial environment? What are their sources in air? What are their concentrations in air under various scenarios?
17. How can models or model systems be used to understand microplastics sources, transport and fate?
18. What are the short-term scientific information needs in this area for the next 5 years?

C. Ecological impacts of microplastics in the US (Exposure & effects assessment; Workshop Day 2, AM)

What we know:

- Microplastics ingestion has been documented for many aquatic species across a wide range of body sizes and trophic positions. Ingestion is incidental in some species and intentional in others.
- The amount of microplastic ingested can range from a few particles to tens or hundreds per individual.
- Microplastics may be transferred across trophic levels.
- Microplastics contain known toxicants in the form of plastic additives or due to sorption of environmental contaminants to microplastics surfaces.
- Microplastics exposure effects can be physical (e.g., anatomical tissue damage) or chemical (toxicity), or both.
- Biofilms form rapidly on microplastics in the environment. These biofilms may contain pathogenic, invasive or opportunistic species.
- There is less information available on other routes of exposure apart from ingestion (uptake through gills or inhalation).
- Some organisms, such as microorganisms, fungi and caterpillars, are known to degrade some plastic polymers.
- Microplastics are one stressor to organisms living in a multi-stressor environment.
- Most laboratory toxicity studies test microplastics concentrations that are well above environmental levels and with sizes of microplastics that are smaller than those generally quantified.
- Risk assessment of engineered nanomaterials may be informative to understanding the potential ecological impacts of nanoplastics.

Key questions for discussion:

19. What are the gut residence times of ingested microplastics, and how are these influenced by particle size/shape?
20. Are microplastics absorbed into bodily fluids during digestion?
21. What are the impacts of microplastics in exposed organisms?
22. Are existing ecotoxicity tests and endpoints sufficient to capture microplastics effects? Are new endpoints/biomarkers needed? Are new standard toxicity tests needed?
23. What are the population-level and food web effects of microplastics exposure (Darwinian fitness parameters)?
24. Are there transgenerational effects of microplastics exposure?
25. What are the impacts of microplastics to microbial communities? What impacts do microplastics biofilms have on ecosystems?
26. Are traditional toxicological reference values (e.g., NOECs, TRVs) appropriate for microplastics? If so, what information is needed to determine these values?
27. What information do we need to conduct risk assessments for microplastics?
28. What are the short-term scientific information needs in this area for the next 5 years?

D. Human health impacts of microplastics in the US (Exposure & effects assessment; Workshop Day 2, PM)

What we know:

- The major pathways for human exposure to microplastics are likely ingestion and inhalation.
- Microplastics have been found in dust, shellfish and finfish and in sea salt.
- There are no microplastics exposure data for humans.
- There are few mammalian toxicity studies of microplastics, and limited toxicology data for humans. Medical/surgical use of plastic devices may provide information relevant to both exposure and effects.
- Risk assessment of engineered nanomaterials may be informative to understanding the potential human health impacts of nanoplastics.

Key questions for discussion:

29. What is the exposure dose to humans from the consumption of shellfish, especially when consumed after minimal cleaning and/or preparation?
30. What is the residence time of ingested microplastics in humans?
31. Are human health risks associated with ingestion of microplastics?
32. Are microplastics a meaningful source of fishery-relevant pathogens, e.g. *Vibrio spp.*?
33. Are microplastics present in drinking water? If so, how can they be quantified and characterized?
34. What are airborne microplastics concentrations in indoor/outdoor settings?
35. What is the uptake rate into the lungs due to inhalation exposure?
36. What are the human health risks associated with inhalation exposure to microplastics?
37. Are data on occupational exposure to plastics/microplastics available and informative?
38. Are reference doses needed for microplastics? If so, what information is needed to determine reference doses?
39. What are the short-term scientific information needs in this area for the next 5 years?

Useful References:

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Appendix 3: Workshop Attendee Biographies

Participants – Invited Experts

Rob Hale, Virginia Institute of Marine Science

Rob Hale is a Professor in the Dept. of Aquatic Health Sciences, Virginia Institute of Marine Science, College of William & Mary. His research over the last 30 years has focused on the sources, bioavailability/accumulation, environmental fate (transport, weathering and degradation) and impacts of organic pollutants; including polymer additives (e.g. flame retardants), emerging and legacy pollutants. Multi-media problems are a special interest, including aquatic, terrestrial and engineered environments (e.g. plastic products, indoor dust and wastewater treatment).

Paul Helm, Ontario Ministry of the Environment

Dr. Paul Helm is a Senior Research Scientist with the Ontario Ministry of the Environment and Climate Change (MOECC) in Toronto, Canada, and an Adjunct Faculty member of the School for the Environment at the University of Toronto. Paul's background is in the fate and transport of organic contaminants in the environment. His research interests include legacy and emerging contaminants in aquatic and urban environments; using passive sampling approaches for contaminant monitoring; and Great Lakes contaminant issues in general. Paul has been leading MOECC's work on microplastics since 2014 with a focus on characterizing the abundance in and sources to waters and sediments of nearshore areas of the Great Lakes and their uptake into fish in the region. Ultimately, the work is aimed at providing advice and support for management considerations to reduce microplastics to the lakes.

Jenna Jambeck, University of Georgia

Dr. Jenna Jambeck is an Associate Professor in the College of Engineering at the University of Georgia (UGA) and Director of the Center for Circular Materials Management in the UGA New Materials Institute. She has been conducting research on solid waste issues for 20 years with related projects on marine debris since 2001. She also specializes in global waste management issues and plastic contamination currently working through the US State Department International Speaker Program and United Nations Environment Programme (UNEP) Marine Litter Network.

Kara Law, Sea Education Association

Dr. Kara Lavender Law is a Research Professor at Sea Education Association (SEA; Woods Hole, MA), studying the sources, distribution, behavior and fate of plastic debris in the ocean. Trained as a physical oceanographer, Dr. Law has more than 12 months of sea time on oceanographic and sailing research vessels, including in the eastern North Pacific and western North Atlantic Oceans where plastic debris accumulates in regions dubbed "garbage patches". Dr. Law's current research interests focus on the sources of plastic to the marine environment, understanding how ocean physics determines the distribution of plastic and other marine debris, and the degradation and ultimate fate of different plastic materials in the ocean. She serves as the co-principal investigator of the Marine Debris Working Group at the National Center for Ecological Analysis and Synthesis (NCEAS), and holds a Ph.D. in physical oceanography from Scripps Institution of Oceanography and a B.S. in mathematics from Duke University.

Chelsea Rochman, University of Toronto

Chelsea Rochman is an Assistant Professor at the University of Toronto. She received her Ph.D. in ecology from the University of California, Davis and was a recipient of the Society for Conservation Biology's David H. Smith Postdoctoral Fellowship. Chelsea has been researching the sources, sinks and ecological implications of plastic debris in marine and freshwater habitats for the past decade, and has published dozens of scientific papers in in the field and has led international working groups about plastic pollution. In addition to her academic research, Chelsea works hard to translate her science beyond academia by interacting with the public, the news media and policy-makers.

Participants – Environmental Protection Agency

Christine Bergeron, Office of Science and Technology, Headquarters

Christine Bergeron is a biologist in Office of Water/Office of Science and Technology's Ecological Risk Assessment Branch. She was first introduced to plastics pollution issues as a co-lead on the Office of Water's recent white paper, "A Summary of the Literature on the Chemical Toxicity of Plastics Pollution on Aquatic Life and Aquatic-Dependent Wildlife". Christine's previous research experience focused on maternal transfer of mercury in amphibians and the impacts of contaminants on freshwater mussels.

Rob Burgess, Office of Research and Development, Atlantic Ecology Division

Dr. Robert M. Burgess is a Research Physical Scientist employed by the United States Environmental Protection Agency (U.S. EPA) Office of Research and Development (ORD) Atlantic Ecology Division in Narragansett, Rhode Island, USA. His current research focuses on better understanding the partitioning and bioavailability of organic and metal contaminants in the environment; specifically, this research emphasizes the use of passive samplers for measuring the bioavailability of legacy and emerging contaminants, including nanomaterials, in the marine environment. He has contributed to the authorship of approximately 100 peer-reviewed papers and book chapters, most of which are related to geochemistry, sediment contamination and aspects of ecological risk assessment. Dr. Burgess received a master's degree in biological oceanography and Ph.D. in chemical oceanography from the University of Rhode Island's Graduate School of Oceanography.

Bob Cantilli, Office of Research and Development, Headquarters

Bob Cantilli is a Senior Biologist for EPA ORD's Office of Science Policy. In his role, he works to ensure that EPA water regulations and guidance use the best science available in making scientific decisions. Prior to working in ORD, Bob worked in EPA's Office of Water, Office of Science and Technology, where he developed ecoregional nutrient criteria, contributed to the National Water Strategy on climate change, and worked on the Great Lakes Water Quality Initiative. He has a M.S. in biology from NYU and a B.S. in biology from Adelphi University.

Anna-Marie Cook, Office of Research and Development, Region 9

Anna-Marie Cook is the EPA Region 9 Superfund and Technology Liaison with EPA ORD's Regional Science Program and has previously served over the last 26 years in a number of environmental engineering roles at Region 9. As a member of the Superfund Division's Emergency Response Branch, Anna-Marie was the Region's Marine Debris Program Coordinator, establishing a cross-media team which applies a multi-statute approach to source reduction, waste management, prevention and research. In this capacity she has also been overseeing the cleanup of Tern Island, a contaminated site in French Frigate Shoals, part of the Northwestern Hawaiian Island chain. Among Anna-Marie's recent responsibilities has been research into microplastic toxicity and risk assessment, which has included the oversight of method development for the extraction and identification of microplastics in water, sediment and tissue.

Stan Durkee, Office of Research and Development, Headquarters

Stan Durkee is an environmental specialist in EPA's Office of Science Policy located within the Office of Research and Development headquarters, Washington, D.C. He works on a spectrum of air and multimedia science issues, including those associated with source characterization and risk assessments, arising at the interface of policy (e.g., regulatory actions) and research results. He holds a bachelor's degree from Amherst College and a master's degree in public administration from George Washington University. A focus for many years has included issues involving mercury. Recently, he has assisted the Office of Water/Trash Free Waters in its efforts to gain more scientific information on plastics/microplastics.

Kay Ho, Office of Research and Development, Atlantic Ecology Division

Dr. Kay Ho has worked at U.S. EPA for over 20 years. She has 90 peer- reviewed journal articles and book chapters, and has authored or co-authored over 120 presentations. Her research interests include marine toxicology, marine benthic and community ecology, method development for assessing marine systems and emerging contaminants in marine systems.

Greg Miller, Office of Science and Technology, Headquarters

Greg Miller is an Environmental Health Scientist and recently joined the Office of Water's Office of Science and Technology from the Office of Children's Health Protection. His work there focused on children's regulatory and health risk issues. Greg has participated in the review of the recent Toxic Substances Control Act (TSCA) Work Plan chemical risk assessments as well as the development of new regulations implementing the Frank R. Lautenberg Chemical Safety for the 21st Century Act. Greg began his EPA career in 2000 in the Office of Policy's National Center for Environmental Economics, where he worked on the America's Children and the Environment indicators reports. He is a graduate of the University of Michigan School of Public Health.

Margaret Murphy, AAAS S&TP Fellow, Office of Water, Headquarters (not an EPA employee)

Margaret Murphy is an AAAS Science & Technology Policy Fellow hosted by the Office of Wetlands, Oceans and Watersheds in the Office of Water at EPA. She earned her Ph.D. in zoology/toxicology from Michigan State University, and then was a postdoctoral fellow, assistant professor and associate professor in the Department of Biology & Chemistry at City University of Hong Kong until 2016. Her research focuses on ecological and human health risk assessment of legacy and emerging contaminants such as persistent organic pollutants and pharmaceuticals and personal care products, and on the development and use of bioassays for toxicity testing.

Participants – Federal Agencies

Kathy Conn, US Geological Survey

Kathy Conn is the Water-Quality Specialist for the United States Geological Survey (USGS) Washington Water Science Center in Tacoma, WA. Her recent interests include river suspended sediment-bound contaminants and pathways of contaminants into Puget Sound food webs. The USGS is developing a Microplastics Lab in the Tacoma office with the primary goals of: 1) providing water and sediment analytical services to the USGS community and cooperators through a modified National Oceanic and Atmospheric Administration (NOAA) method, and 2) developing a quality assurance/quality control protocol for microplastics analysis.

Carlie Herring, National Oceanic and Atmospheric Administration

Carlie Herring received her M.S. in environmental sciences in the Marine and Estuarine Science Program at Western Washington University with a thesis in ecological risk assessments. She completed a B.S. in marine sciences at the University of Maine, Orono. For her B.S., she conducted marine debris research, dealing specifically with plastics in the ocean. As the Research Coordinator, Carlie is responsible for overseeing research projects funded by the Marine Debris Program (MDP), staying up-to-date on new marine debris research and literature, and is involved in the MDP's Marine Debris Monitoring and Assessment Project.

Emanuel Hignutt, Food and Drug Administration

Emanuel Hignutt, Jr., MPH is currently a Subject Matter Expert in Chemistry for the U.S. FDA Division of Seafood Safety, Center for Food Safety and Applied Nutrition. Prior to joining the FDA, Mr. Hignutt served as Chemistry Section Supervisor with the Alaska State Environmental Health Laboratory. Mr. Hignutt's research interests include analysis of Marine Biotoxins by Liquid Chromatography/Tandem Mass Spectrometry. Mr. Hignutt earned his bachelor's degree in chemistry from the University of California, Davis, and a Master of Public Health degree from the University of North Carolina at Chapel Hill.

Amy Uhrin, National Oceanic and Atmospheric Administration

Amy V. Uhrin is the Chief Scientist for NOAA's MDP where she oversees the Program's research portfolio. Prior to joining the MDP in June 2015, Amy spent 15 years with NOAA as a seagrass ecologist in Beaufort, NC. Her interest in marine debris started in 2007 when she received MDP funding to estimate the abundance and distribution of derelict spiny lobster traps across various benthic habitats in the Florida Keys using divers towed behind a boat. She holds a Master of Marine Science degree from the University of Puerto Rico and will defend her Ph.D. dissertation at the University of Wisconsin Madison in Spring 2018.

Observers

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