

ISBN 978-1-927797-66-2
ISSN 1198-273X

PICES SCIENTIFIC REPORT

No. 66, 2025



NORTH PACIFIC MARINE SCIENCE ORGANIZATION



Report of Working Group 42 on Indicators of Marine Plastic Pollution

**PICES Scientific Report No. 66
2025**

**Report of Working Group 42
on
Indicators of Marine Plastic Pollution**

edited by
Chengjun Sun and Jennifer Lynch



January 2025

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PICES Scientific Reports

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Front cover:

Plastic debris on a Hawaiian shore. (Photo credit: Sonia Batten)

This document should be cited as follows:

Sun, C. and Lynch, J. (Eds.) 2025. Report of Working Group 42 on Indicators of Marine Plastic Pollution. PICES Sci. Rep. No. 66, North Pacific Marine Science Organization, Sidney, BC, Canada, 71 pp.

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Acknowledgements

The editors would like to thank all the members of WG 42 for their contributions, especially Amy Uhrin, Connie Ng, Sarah Dudas, Jennifer Provencher and Matthew Savoca who provided much valuable input. Thanks to Dr. Won Joon Shim for his pioneering role in the Study Group on *Marine Microplastics* which made this Working Group possible. We would also like to thank our parent committee MEQ for its support and help. Special thanks to Drs. Guangshui Na, Andrew R.S. Ross, Takafumi Yoshida and Thomas Therriault for their consistent encouragement and help.

Research work related to this report was supported by the APEC Cooperation Fund of China (No. WJ1323001), Asian Cooperation Fund (No. WJ1223001, WJ0923015), Korea Institute of Ocean Science and Technology (No. EA0014), National Research Foundation of Korea (No. 2017R1E1A1A01073137), and direct support for open access publication fees from the NOAA Marine Debris Program.

Chengjun Sun and Jennifer Lynch

Executive Summary

Among the myriad challenges we face to maintain a sustainable ocean, plastic pollution comes to the fore as a global concern. It is predicted that by the year 2050 the amount of plastic is going to exceed the total amount of fish in the world ocean. Plastic pollution calls for every country's attention. Of the ten challenges listed by the UN Decade of Ocean Science for Sustainable Development, the first is to understand and map land and sea-based sources of pollutants and contaminants, of which plastic and nutrients are the two most important, and develop solutions to remove them or mitigate their potential impacts on human health and ocean ecosystems.

Microplastics (plastics less than 5 mm in size) have attracted a lot of attention as they are widely distributed around the world oceans and pose numerous potential negative effects on the ecosystem. In 2017, PICES scientists formed a Study Group on *Marine Microplastics* (SG-MMP) to begin discussions on how we could best coordinate monitoring of plastic pollution in the PICES region. Succeeding SG-MMP, PICES approved the formation of our Working Group on *Indicators of Marine Plastic Pollution* (WG 42), parented by the MEQ Committee, in September 2019.

WG 42 has brought together experienced scientists from all PICES member countries to better understand and evaluate the plastic pollution problem we are facing in the PICES region. WG 42 members actively participated in different activities to achieve the goals described in the terms of reference (ToR) (Appendices 1 and 2). The intensive and coordinated in-depth discussions, communications, information exchanges and idea sharing have helped the group to be very productive. The significant accomplishments of WG 42 include three peer-reviewed papers published in the world-renowned journal *Environmental Pollution*. WG 42 members systematically reviewed the scientific literature on plastic pollution in the seawater, biota and shoreline in the North Pacific Ocean, provided recommendations and called for a long-term monitoring program for ocean plastic pollution in the region. In addition, the Global Plastic Bioindicators Project led by Dr. Matthew Savoca and involving other WG 42 members was endorsed by the UN Decade of Ocean Science for Sustainable Development. This report outlines these major accomplishments and findings by WG 42 members and provides useful references to the current plastic and microplastic pollution status in the PICES region.

Although the term of WG 42 has come to its end, it is clear that the work conducted by the group needs to continue. With increasing plastic production and plastic waste generation globally, more plastic waste is entering the world's oceans, posing more threat to the ocean environment. There are many unknown challenges as well, such as the impacts of those microplastics generated from the plastic debris. We still need more research to better understand and evaluate the impact of plastic pollution, including microplastic pollution, on our ecosystems and find ways to combat the problem. Work conducted by WG 42 can be built upon to achieve better understanding, data generation, information sharing and global progress on marine plastic pollution. Therefore, we recommend the establishment of an Advisory Panel or Section on Plastics and Microplastic Bioindicators. With Plastic Pollution Treaty negotiations still underway there is a strong need for monitoring so that, when societal changes are enacted to improve the plastic pollution problem, we can detect the ultimate results (changed levels of plastic pollution in the ocean) and show the successes or shortcomings of those changes.

1 Introduction

The North Pacific Ocean (NPO) is home to the Great Pacific Garbage Patch, which is the largest of the five offshore plastic accumulation zones in the world's oceans. The NPO is incredibly contaminated by floating plastic waste and microplastics coming from every country bordering the Pacific Ocean. Plastic waste comes in all shapes and sizes, from megaplastics to nanoplastics. When large pieces of plastic debris enter the ocean gyres, they tend to stay within the gyre until they are further broken down into small plastic particles (microplastics and nanoplastics) under the effects of sun, waves and marine organisms. Since plastic waste in the ocean has no political boundaries, the countries that border the North Pacific must work together to understand the source, transport, fate and impact of the marine plastics on NPO ecosystems.

The goal of the Working Group on *Indicators of Marine Plastic Pollution* (WG 42) is to better understand the current plastic pollution status in the NPO and to find better ways to quantify and monitor marine plastic pollution. Together, WG 42 group members thoroughly reviewed publications on the plastic pollution in the NPO and wrote three companion review articles that focus on providing the best monitoring protocols for sample collection and processing in the lab to quantify micro- to mega- plastics in four different compartments of the NPO: seawater, shorelines, sediment, and biota. Data on the NPO were also compared with data collected elsewhere and recommendations towards a target goal that a country could use to manage its waste were also made. Three of the review articles (on seawater, shoreline and biota) have already been published in the peer-reviewed journal *Environmental Pollution* (Appendix 3).

Marine plastic and microplastic pollution is an ever-increasing problem all around the world, and many questions remain to be answered. We hope that our scientifically determined suggestions for monitoring programs in the NPO are implemented and used to best effect across political boundaries for the benefit and conservation of ecosystems in the NPO. We also hope that the review findings and suggestions serve as a model for other regions to adopt and begin region-wide plastic pollution monitoring programs.

2 WG 42 Achievements with Respect to Terms of Reference

1. To review pollution (e.g. abundance, distribution, composition, and potential impacts) across different size categories in the North Pacific and its marginal seas.

Macro- and micro-plastics are ubiquitous in the oceans worldwide. They have been found in many different compartments, including seawater, sediment, shoreline, biota and the atmosphere. Reported data show that the NPO and its surrounding marginal seas are more polluted than most, apart from the Mediterranean Sea (Cózar *et al.*, 2014; Isobe *et al.*, 2015, 2019; Shim *et al.*, 2018). To better understand the current plastic pollution status in the NPO, WG 42 conducted comprehensive literature reviews on the abundance, distribution, composition, and potential impacts and risks of plastics across sizes ranging from mega-, macro- and meso- to micro- and nano-plastics. Below are the major findings and conclusions from review papers focusing on the shoreline, seawater and biota. For detailed information, please refer to the published papers listed in Appendix 3.

2.1 Review and recommendations for plastic ingestion bioindicators in the North Pacific Ocean

WG 42 members first created a comprehensive inventory of all studies examining plastics in biota in the NPO region and reviewed plastic ingestion in all major taxonomic groups – invertebrates, fish, seabirds, marine mammals and sea turtles (Fig. 1). We then assessed the status and plastic ingestion trends in these groups and compared them with data from seven other regions, including the South Pacific, North Atlantic, South Atlantic, Arctic, Indian, and Southern Oceans and the

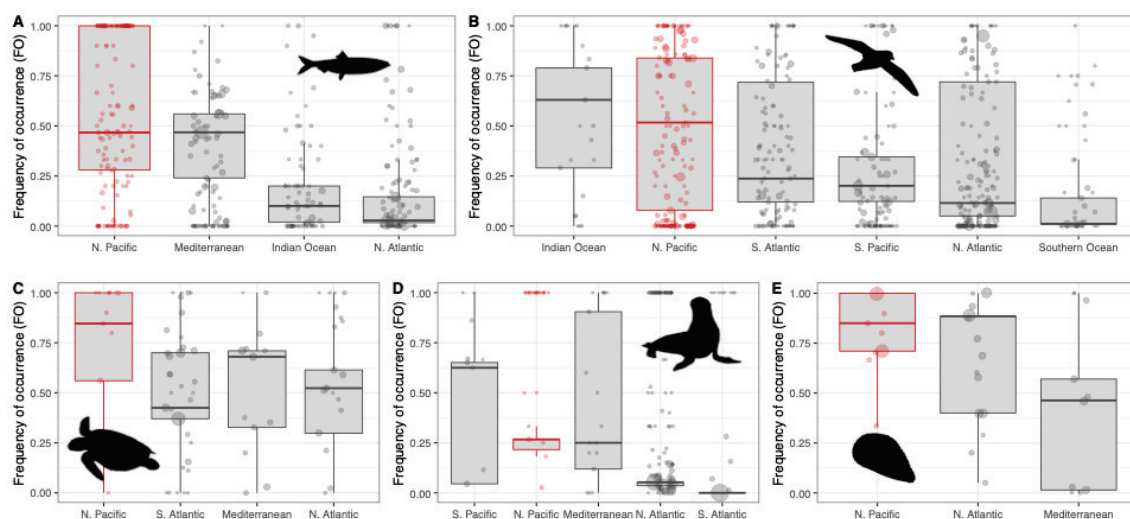


Fig. 1 Frequency of occurrence of plastic ingestion across taxa. A) fishes, B) seabirds, C) sea turtles, D) marine mammals, E) bivalves. The North Pacific is highlighted with red-outlined boxplots, all other regions are in gray. (From Savoca *et al.*, 2022, *Environmental Pollution* 310: 119861, <https://doi.org/10.1016/j.envpol.2022.119861>)

Mediterranean Sea. We found that the NPO is among the most polluted of world ocean regions, and about half of the studied fish and seabirds and over three-quarters of bivalves and sea turtles in the NPO contained plastic.

Next, we evaluated 352 species to assess their suitability as bioindicators of plastic pollution in the NP region and developed a rubric to evaluate the potential use of some species as bioindicators in the NPO (Fig. 2). The rubric takes into account seven main categories, including prior sampling, plastic occurrence frequency in the PICES region, species distribution in the PICES region, species distribution globally, threat to humans, residency in the PICES region, and whether or not the species has previously been used as a bioindicator. Scoring subcategories were listed under each category. A total of four points were allocated to each category and each species was scored according to the subcategories. Based on the outcome of the rubric scoring, we proposed a suite of 12 candidate indicator species to monitor NPO trends in plastic pollution. These species include invertebrates, fishes, sea turtles and seabirds. For invertebrates, mussel (*Mytilus edulis*), oyster (*Crassostrea gigas*) and clam (*Venerupis philippinarum*) scored high. For fishes, long-nosed lancetfish (*Alepisaurus ferox*), common dolphinfish (*Coryphaena hippurus*) and anchovy (*Engraulis* spp.) are among the top bioindicators. Sea turtles, such as loggerhead sea turtle (*Caretta caretta*) and green sea turtle (*Chelonia mydas*), and seabirds, such as the northern fulmar (*Fulmarus glacialis*), Leach's storm-petrel (*Oceanodroma leucorhoa*), and Laysan and black-footed albatross (*Phoebastria* spp.) are also good bioindicators. These species can indicate various ecosystem components and cover a wide range of plastic sizes.

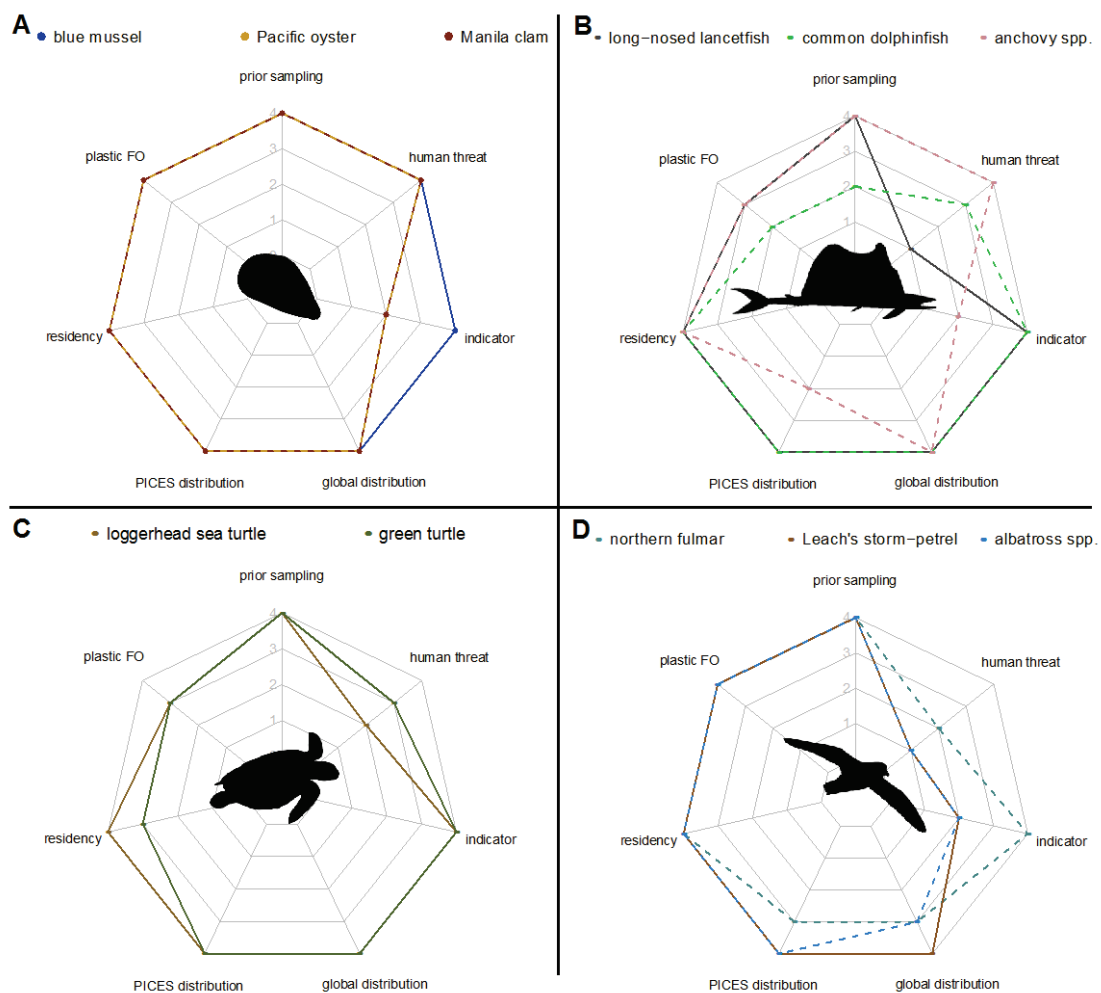


Fig. 2 Bioindicator rubric for top-scoring species by taxa. (From Savoca *et al.*, 2022, *Environmental Pollution* 310: 119861, <https://doi.org/10.1016/j.envpol.2022.119861>)

Finally, we proposed a monitoring strategy for the selected bioindicators by identifying monitoring goals, proposing harmonized sampling methods with standardized reporting format and defining ingestion targets (*i.e.*, Ecological Quality Objective threshold). Our findings and recommendations will be able to help research scientists and resource managers to further coordinate the regional and global research efforts on plastic ingestion bioindicators. For detailed information, please refer to Savoca *et al.* (2022) in Appendix 3.

2.2 Review and global comparison of seawater plastic pollution in the North Pacific Ocean

Of the 1178 peer-reviewed papers on microplastics in seawater published between 1972 and 2020, we screened 129 papers with reported mean microplastic abundance values and compiled data from these papers for analysis and comparison. We found that the NPO was the most actively monitored region for microplastics and showed comparatively high levels in the global context (Fig. 3).

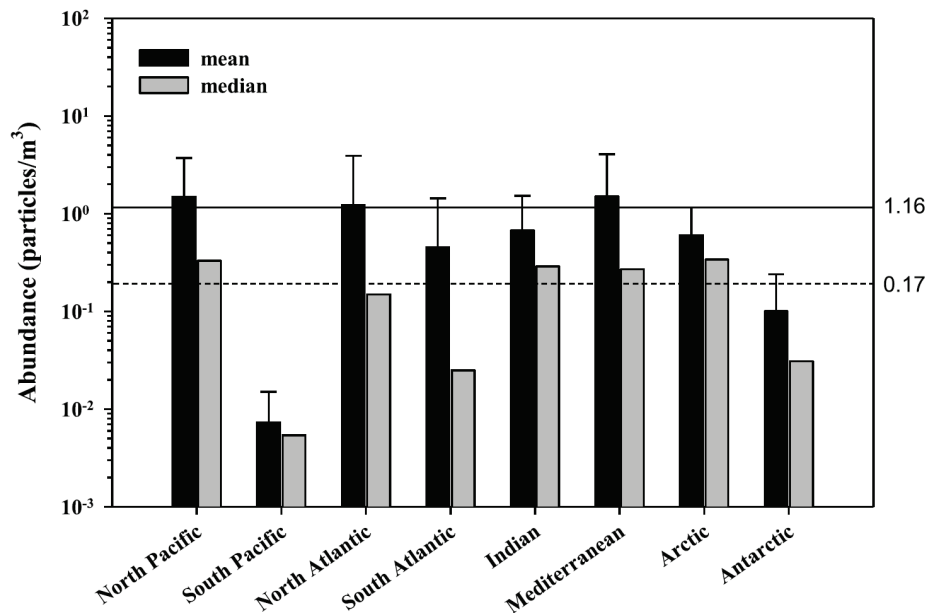


Fig. 3 Average microplastic abundances in global seawater using 300–355 μm mesh sizes. Solid line, average of mean values; dotted line, average of median values. (From Shim *et al.*, 2022, *Environmental Pollution* 311: 119911, <https://doi.org/10.1016/j.envpol.2022.119911>)

The minimum cut-off size in sampling and/or analysis of microplastics was crucial to the comparison of monitoring data. For regional and global assessments of pollution status across space and time, as well as assessment of ecological risk, we recommend two microplastic monitoring approaches. The first is the net tow method with a mesh size range of 300–355 μm (Tier I) for the long-term monitoring and inter-comparison of surface water because its large water volume ensures that large-sized microplastic particles (>1 mm) are not missed. The second is large-volume (>100 L) grab or pump sampling (Tier II), which meets the increasing need for the acquisition of small-sized (<300 μm) microplastic abundance data to fully evaluate the ecological risks.

Worth noting is that although microplastic pollution is closely linked with macroplastics, available monitoring data for floating macroplastics and mesoplastics in most oceans are still limited. With

the implementation of standardized methods and more specific framework for surveys, increased efforts on floating macroplastics and mesoplastic surveys across the world oceans will facilitate data comparison to gain a complete picture of ocean plastic pollution status. For detailed information, please refer to Shim *et al.* (2022) in Appendix 3.

2.3 Review and recommendations for shorelines plastic pollution in the North Pacific Ocean

Using Web of Science, we conducted a systematic review of literature published between 1970 and 2020 that reported shoreline debris from countries bordering the NPO (Fig. 4). We screened 81 papers that reported shoreline debris density as either a count, mass or volume of items per specified linear length or area of shoreline, or a count, mass or volume of items per specified mass of shoreline sediment, or a count, mass or volume of items per specified volume of shoreline sediment.

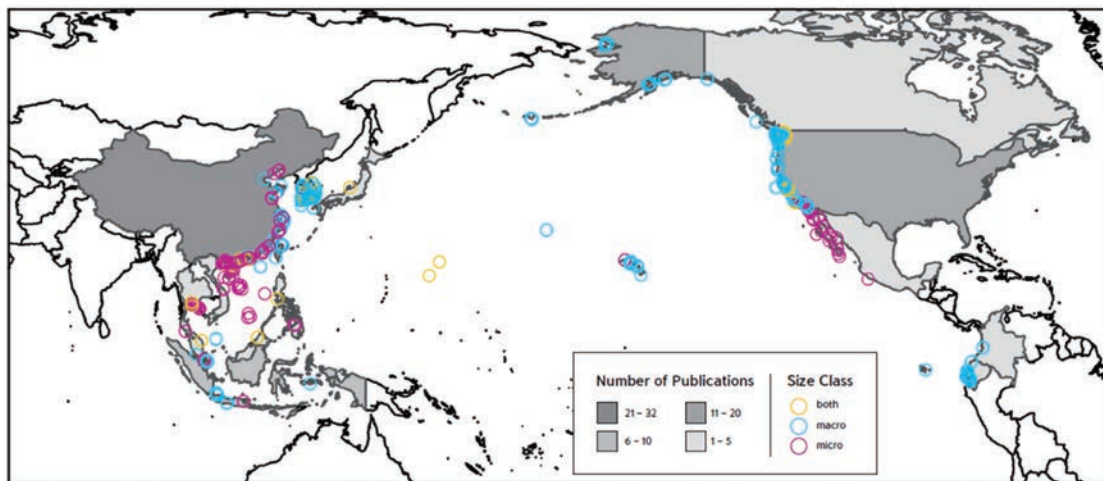


Fig. 4 Summary of 81 studies of shoreline marine debris in the North Pacific Ocean. Countries are gray-shaded (light to dark) based on the number of publications included in the review. (From Uhrin *et al.*, 2022, *Environmental Pollution* 310: 119862, <https://doi.org/10.1016/j.envpol.2022.119862>)

By extracting information from these papers and conducting statistical analysis, we were able to conduct comprehensive statistical analysis on data reporting metrics, sampling methods, sourcing and geographic distribution of macroplastics and microplastics. We found that, prior to the year 2000, most studies were focused on macroplastics, typically reporting them in terms of item counts per linear meter of shoreline (Fig 5). Around 2008, there was a shift towards more sampling of microplastics.

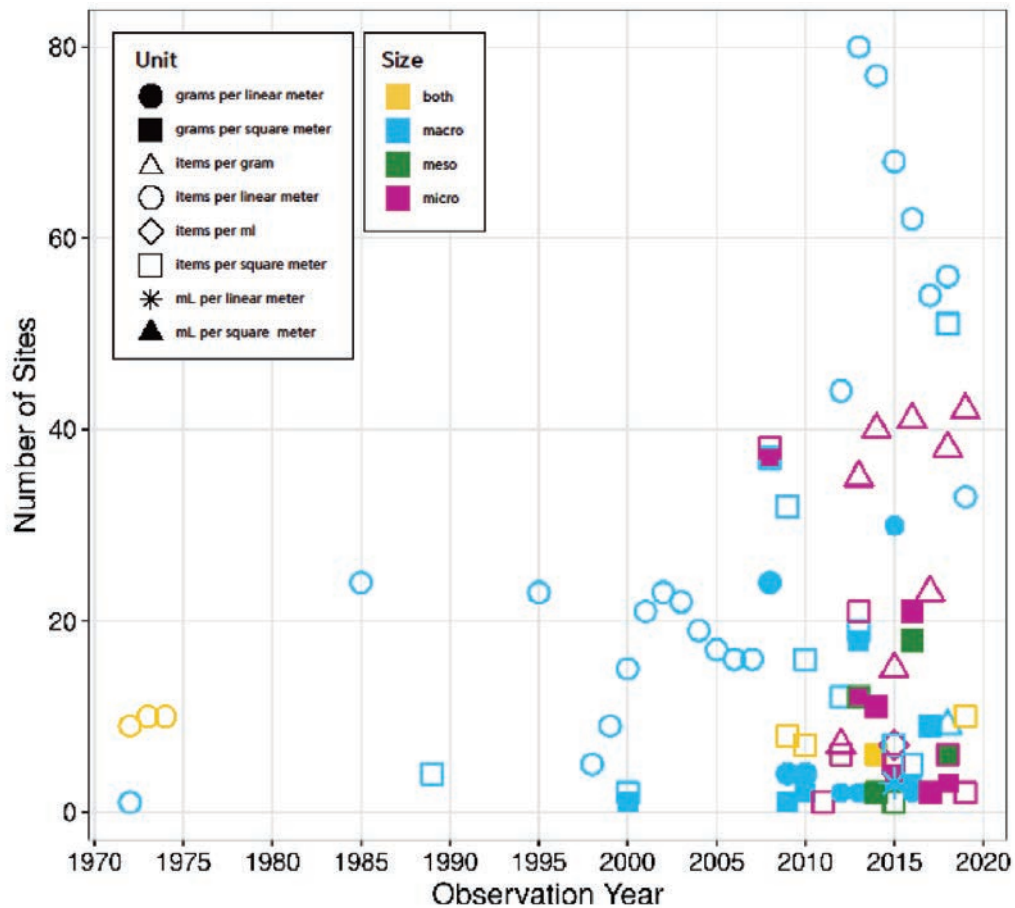


Fig. 5 Reporting of various plastic size classes and units of measurement at 903 sites across the world over time. The year is based on the survey year. (From Uhrin *et al.*, 2022, *Environmental Pollution* 310: 119862, <https://doi.org/10.1016/j.envpol.2022.119862>)

Based on our analysis, we recommend use of a standardized length of shoreline of 100 m and integrating across the width of the beach to allow for reporting debris both as item counts per linear distance (the preferred method) or per area. We also suggest that shoreline surveys focus on all macrodebris (≥ 2.5 cm). Any threshold value or reduction target for the greater NPO should be informed by basin-wide data collected using comparable methods.

We also need to bear in mind that limited geographic sampling locations, lack of spatial and temporal replication within locations, shortcomings associated with sampling position on a beach, variations in classification of target debris (size classes, material type) and difference in units of measure (counts or mass per unit area or length of shoreline) might have limited the representation of current data. For detailed information, please refer to Uhrin *et al.* (2022) in Appendix 3.

2. *To identify multiple organismal and non-organismal indicators of plastic pollution and its environmental impacts including associated chemicals in the North Pacific and its marginal seas.*

We have identified multiple organismal and non-organismal indicators of plastic pollution, as published in the peer-reviewed papers: *Towards a North Pacific Ocean long-term monitoring program for plastic pollution: A review and recommendations for plastic ingestion bioindicators*. *Environmental Pollution*, 310:119861; *Towards a long-term monitoring program for seawater plastic pollution in the north Pacific Ocean: Review and global comparison*. *Environmental Pollution*, 311:119911; and *Towards a North Pacific long-term monitoring program for ocean*

plastic pollution: A systematic review and recommendations for shorelines. Environmental Pollution, 310:119862. There was very limited information on plastic pollution associated chemicals in the North Pacific and its marginal seas. Therefore, the topic of plastic-associated chemicals was not the focus of our work but remains important for future groups to investigate.

3. *To recommend guidelines for monitoring environmental indicators and a target improvement goal for the established indicators.*

We designed a rubric to evaluate species for use as plastic pollution bioindicators, as shown in Figure 6. We consider accessibility as a top priority because no monitoring can be practically conducted without it. We also integrated plastic pollution indicator criteria from GESAMP (The Group of Experts on the Scientific Aspects of Marine Environmental Protection) into our complete rubric to make it comprehensive. Recent research on Alaska pollock shows that other parameters, such as age of the species, should be considered when selecting bioindicator species (Ding *et al.*, 2023). Further research on selecting the most appropriate bioindicator species is therefore needed.

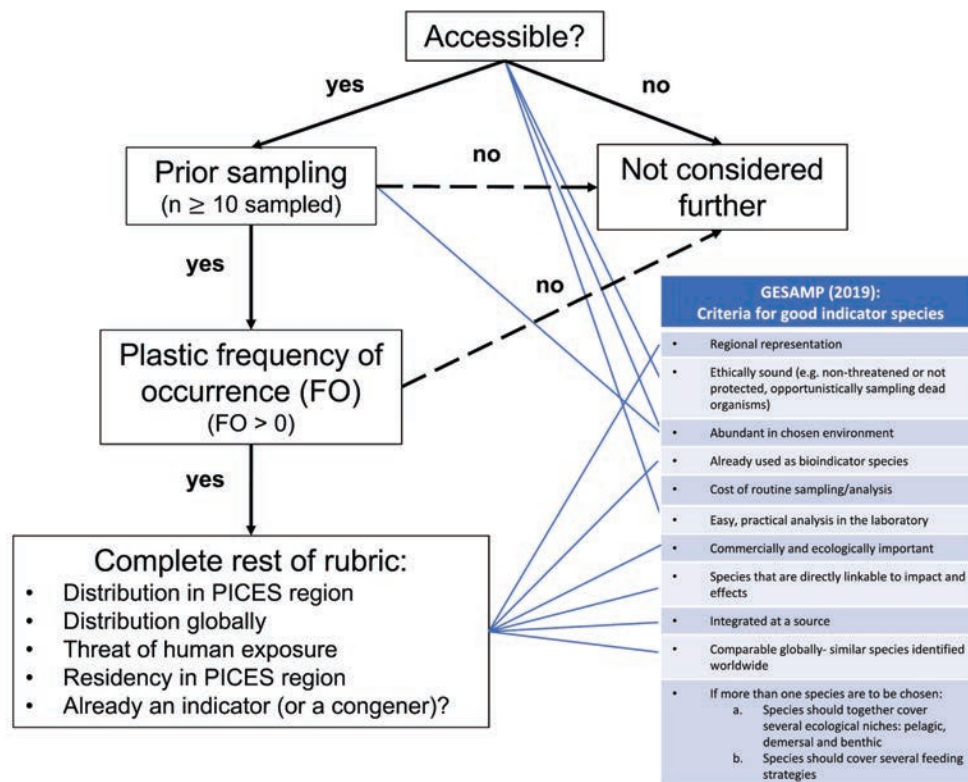


Fig. 6 Flowchart of the rubric evaluation process. (From Savoca *et al.*, 2022, *Environmental Pollution* 310: 119861, <https://doi.org/10.1016/j.envpol.2022.119861>)

We evaluated 352 species for their potential to serve as bioindicators of plastic pollution in the NPO. Based on the rubric above, our analysis revealed a suite of 12 species representing a variety of ecosystems and covering a wide range of plastic size classes, making them strong bioindicator candidates. These results will help to lay the foundations for developing a comprehensive plastic monitoring program in the NPO.

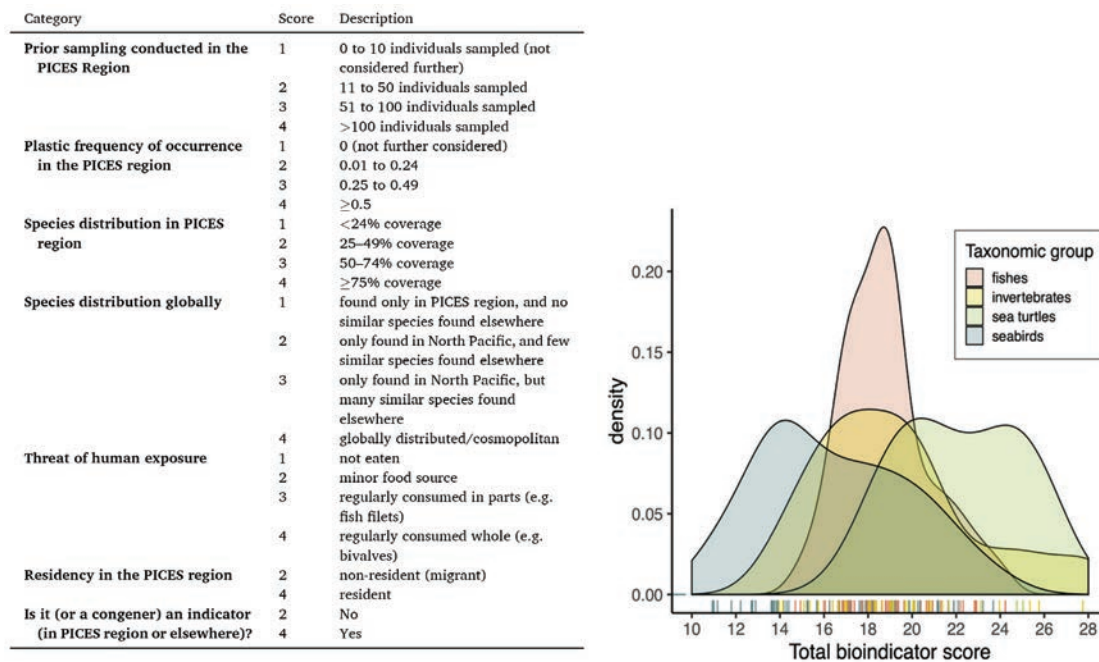


Fig. 7 Rubric for species evaluation as bioindicators and bioindicator scores for different taxonomic groups. (From Savoca *et al.*, 2022, *Environmental Pollution* 310: 119861, <https://doi.org/10.1016/j.envpol.2022.119861>)

For seawater plastic pollution monitoring, we recommend two approaches. Tier I is the net tow method with a mesh size range of 300–355 μm for long-term monitoring because it can catch large-sized microplastic particles (>1 mm). Tier II is the grab or pump sampling method which can fulfill the goal of catching small-sized (<300 μm) microplastics.

For shoreline plastic pollution monitoring, we recommend spatially-balanced survey design, a spatial resolution of 100 m length of beach, multi-year sampling over a minimum of 5 years, replicate samples and analysis of all macrodebris on all beaches, at a temporal resolution to be determined. Reported variables should include precise GPS coordinates of the sample locations, time of sampling, sampling site characteristics, depth of sampling, debris size category and the limit of detection, sampling handling, polymer identification for microplastics, *etc.*

4. *To convene a topic session and/or workshop on environmental indicators and impacts of plastic pollution and coordinate a special issue in an international peer-reviewed journal.*

WG 42 members Matthew Savoca and Chengjun Sun along with Lev Neretin from NOWPAP, convened the topic session “*Environmental indicators of plastic pollution in the North Pacific*” at PICES-2019 on October 24, 2019.

WG 42 members Chengjun Sun, Sanghee Hong and Matthew Savoca proposed a topic session for PICES-2020 called, “*Using environmental indicators to assess baselines, targets, and risk of plastic pollution in the North Pacific,*” but the meeting was postponed because of the COVID-19 pandemic. The session took place virtually on October 27, 2021 at PICES-2021.

On September 6, 2021, a jointly convened theme session on “*Advances and challenges in marine litter pollution*” between ICES and PICES was successfully held online during ICES ASC 2021. WG 42 member Chengjun Sun was the co-convenor, together with Thomas Maes, Francois Galgani, and Andy Booth.

On March 1, 2022, WG 42 members Matthew Savoca, Chengjun Sun and Wonjoon Shim co-convened a session, along with Patrick O’Hara, on “*Environmental indicators of plastic pollution in the North Pacific*”, and on March 2, WG 42 members Jennifer Lynch and Sanghee Hong co-convened a session on “*Chemical methods to understand marine plastic pollution quantities, sources, transport, fate, impacts, and solutions*”, along with Katherine Shaw, Sarah-Jeanne Royer and Samreen Siddiqui, and at the Ocean Sciences Meeting in Waco, USA.

On September 20, 2022, WG 42 members Wonjoon Shim (on-site) and Chengjun Sun (Virtual) successfully convened the session on “*Behavior and Fate of Nano- and Microplastics in the Atmosphere and Ocean*” during the 7th International Marine Debris Conference (7IMDC) held in Busan, Korea. At 7IMDC Wonjoon Shim also convened, with Carlie Herring, the session on “*Ecological Risk Assessment Frameworks for Determining the Risk to Natural Resources from Marine Debris*”; Amy Uhrin convened, with Jenna Jambeck, the session on “*Inland to the Ocean: Evaluating Sources, Pathways, Fate and Transport from Upstream to Prevent Ocean Plastic*” and, with Carlie Herring, the session on “*Debris Accumulation in Wetlands: Sinks & Physical Impacts*”; Jennifer Lynch (on-site) convened, with John Kucklick, the session “*Chemistry to understand quantities, sources, transport, fate, impacts, and solutions*”.

The intent of producing companion review papers was to create a virtual special issue. While we did not accomplish this goal, three review papers were published independently and stand together as a key resource and product from WG 42 (Appendix 3). For other products by WG 42 members, please see Appendices 4 and 5.

5. *Contribute to FUTURE by publishing a final report summarizing results of the Working*

It is our hope that this final report summarizes the results of WG 42 for FUTURE.

3 Conclusions and Future Plans

Working Group 42 was established to identify bioindicators for different size scales of marine plastic and to advance our understanding of plastic pollution in the NPO. We evaluated 352 species for their potential to serve as bioindicators of plastic pollution in the NPO using a framework developed by us, and identified 12 bioindicator species candidates which represent different ecosystem components and cover a wide plastic size range. Tracking plastic ingestion by these bioindicators will help to assess the plastic pollution status and changing trends in the region.

Other results coming out of WG 42's work has demonstrated that the NPO has unusually high marine plastic abundance and diversity both in the ocean and on shorelines. However, the lack of standardization with regard to marine plastic and microplastic sampling metrics, indicator species, sample handling protocol and analytical methods, and target goals have made cross comparison very difficult. Therefore, in our published papers, we proposed a series of guidelines for temporal and spatial monitoring of plastic pollution status and assessment of ecological risks. These standardized methods and more real time monitoring data will significantly increase our understanding of marine plastic pollution.

COVID-19 greatly hindered more effective collaboration among PICES member countries and with other countries. The requirement of virtual meetings only limited on-site investigation and hands-on training. In spite of this difficulty, we have convened joint topic sessions with ICES and the Arctic Monitoring and Assessment Program (AMAP). Members have actively participated in International Marine Debris Conference research and PICES Annual Meetings. We are hopeful that more collaboration can be carried out from now on.

We recommend that future work should include studies on implementing a long-term marine plastic and microplastic monitoring program in the NPO by implementing the guidelines we have put forward. Therefore, as a follow-up, we recommend the establishment of an Advisory Panel or Section on Plastic and Microplastic Bioindicators. Continuous research on relevant topics will greatly help to improve ocean health and benefit the United Nations Sustainable Development Goals of the world ocean. Close collaboration with the newly adopted Ocean Decade Global Plastic Bioindicators Project is also recommended to further improve our understanding of marine plastic pollution and employ countermeasures to mitigate the problem.

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Appendix 1

WG 42 Terms of Reference

WG 42 term: 2018–2022

Extended 1 year to 2023

Parent Committee: MEQ

1. To review pollution (*e.g.*, abundance, distribution, composition, and potential impacts) across different size categories in the North Pacific and its marginal seas;
2. To identify multiple organismal and non-organismal indicators of plastic pollution and its environmental impacts including associated chemicals in the North Pacific and its marginal seas;
3. To recommend guidelines for monitoring environmental indicators and a target improvement goal for the established indicators;
4. To convene a topic session and/or workshop on environmental indicators and impacts of plastic pollution and coordinate a special issue in an international peer-reviewed journal;
5. Contribute to FUTURE by publishing a final report summarizing results of the Working Group deliberations.

Appendix 2

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Appendix 3

Peer-Reviewed Publications by WG 42



Environmental Pollution

Supports open access

Volume 310, 1 October 2022, <https://doi.org/10.1016/j.envpol.2022.119861>

Savoca, M.S., Kühn, S., Sun, C., Avery-Gomm, S., Choy, C.A., **Dudas, S., Hong, S.H.,** Hyrenbach, K.D., Li, T.-H., **Ng, C. K., Provencher, J.F., Lynch, J.M.**

Towards a North Pacific Ocean long-term monitoring program for plastic pollution: A review and recommendations for plastic ingestion bioindicators

Highlights

- North Pacific marine biota are among the most polluted by plastic ingestion globally.
- Generated rubric and evaluated 352 species' potential to serve as bioindicators of plastic.
- Twelve species highlighted as having highest bioindicator potential.
- Developed monitoring plans for these species to track plastic in North Pacific Ocean.

Volume 310, 1 October 2022, <https://doi.org/10.1016/j.envpol.2022.119862>

Uhrin, A.V., Hong, S., Burgess, H.K., Lim, S., Dettloff, K.

Towards a North Pacific long-term monitoring program for ocean plastic pollution: A systematic review and recommendations for shorelines

Highlights

- We reviewed 81 papers documenting shoreline debris in the North Pacific Ocean (NPO).
- Debris data is inadequate for assessing status and trends for most NPO countries.
- Most studies took place for less than one year (76.5%).
- Most sites were sampled only once (57.3%).
- To compare shorelines across the NPO, data collection and reporting must be improved.

Volume 311, 15 October 2022, <https://doi.org/10.1016/j.envpol.2022.119911>

Shim, W.J., Kim, S.-K., Lee, J., Eo, S., Kim, J.-S., **Sun, C.**

Toward a long-term monitoring program for seawater plastic pollution in the north Pacific Ocean:
Review and global comparison

Highlights

- Sampling methods and abundance levels of plastics in seawater were reviewed.
- Microplastic abundances decreased according to increasing minimum cutoff size.
- Marginal seas including coasts were more polluted with microplastics than open ocean.
- Macroplastic data were limited and geographically biased in the North Pacific.
- The future microplastics in seawater of the North Pacific will well exceed the predicted no-effect concentration.

Appendix 4

Session Summaries and Meeting Reports from Past Annual and Inter-sessional Meetings Related to WG 42

International Workshop on The Science of Microplastics in the World Ocean Woods Hole Oceanographic Institution, Woods Hole, USA, 2019.....	20
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PICES-2021, Virtual MEQ Topic Session on “ <i>Using environmental indicators to assess baselines, targets, and risk of plastic pollution in the North Pacific</i> ”	40
2021 Meeting Report	42
Ocean Sciences Meeting 2022 February 28–March 4, 2022, Waco, USA Scientific Session on “ <i>Environmental indicators of plastic pollution in the North Pacific</i> ”	48
Scientific Session on “ <i>Chemical methods to understand marine plastic pollution quantities, sources, transport, fate, impacts, and solutions</i> ”	49
The 7 th International Marine Debris Conference Busan, Korea, 2022 Topic Session on “ <i>Ecological Risk Assessment Frameworks for Determining the Risk to Natural Resources from Marine Debris</i> ”	51
Topic Session on “ <i>Inland to the Ocean: Evaluating Sources, Pathways, Fate and Transport from Upstream to Prevent Ocean Plastic</i> ”	53
Topic Session on “ <i>Behavior and Fate of Nano- and Microplastics in the Atmosphere and Ocean</i> ”	54

Topic Session on “ <i>Debris Accumulation in Wetlands: Sinks & Physical Impacts</i> ”	56
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International Workshop on The Science of Microplastics in the World Ocean

October 15–18, 2019, Woods Hole Oceanographic Institution, USA

Assessing the Fate of Plastics - Mechanisms of Fragmentation and Colonization

Moderator: Collin Ward, WHOI

Anthony Andrady (North Carolina State University)
Degradation and Fragmentation of LDPE in Sea Water

Collin Ward (Woods Hole Oceanographic Institution)
How long does plastic last in the environment?

Matthew MacLeod (Stockholm University)
Chemical and toxicological characterization of chemicals released from plastic polymers under ultraviolet light

Won Joon Shim¹ (Korea Institute of Ocean Science and Technology)
Producing secondary nano- and microplastics by photooxidation and (or) mechanical abrasion

Erik Zettler (Royal Netherlands Institute for Sea Research)
Assessing the Fate of Plastics: Colonization and density changes

Evan Ward (University of Connecticut)
Examining the use of marine bivalves as indicators of microplastic pollution in the environment

Chelsea Rochman (University of Toronto)
What is known and unknown about the effects of plastic pollution on wildlife

Bart Koelmans (Wageningen University)
Thought experiments to understand the impacts of microplastic on the (marine) environment

Tracy Mincer (Florida Atlantic University)
Microplastics in the Ocean's Interior

Dror Angel (University of Haifa, Israel)
Microplastics in the Levant – a snapshot from an ocean desert

Hideshige Takada (Tokyo University of Agriculture and Technology)
Hazardous chemicals in marine plastics and their threat to marine organisms

The Need for Standards and Best-Practices in Sampling and Reporting Methods

Moderator: Scott Gallager

Jennifer Lynch (National Institute of Standards and Technology, Hawaii Pacific University, Center for Marine Debris Research)
Standards for Measurement Science of Microplastic Pollution

Brett Howard (American Chemistry Council)
Microplastics Standards – Status and Future Needs

Linda Amaral-Zettler (NIOZ Royal Netherlands Institute for Sea Research)
Next-Generation Science for Microbial Biodegradation Standards for Biobased Plastics

¹ Presenters in bold face denote WG 42 members.

PICES-2019

October 16–27, 2019, Victoria, Canada

Excerpted from:

Summary of Scientific Sessions and Workshops at PICES-2019

MEQ Topic Session (S7)

Environmental indicators of plastic pollution in the North Pacific

Co-sponsor: *NOWPAP*

Convenors: *Matthew Savoca (USA), Chengjun Sun (China), Lev Neretin (NOWPAP)*

Invited Speakers:

Stephanie Avery-Gomm (University of Queensland, Australia)

Daoji Li (Plastics Marine Debris Research Center, East China Normal University, China)

Background

Small fragments of plastic debris – known as meso- and microplastics – are pervasive in marine systems. These synthetic particles may transfer contaminants and pathogens to organisms that consume them; as such, meso and microplastics are now considered hazardous, persistent marine pollutants. Sampling an entire system for debris is challenging; therefore, having environmental indicators of plastic debris is critical to assess the status and trends of plastic pollution in addition to predicting ecosystem risk and quantifying potential impacts. The intent of this session was to identify and discuss potential organismal and non-organismal (*e.g.*, sediments) indicators of small synthetic material in the marine environment, including the potential sources and input pathways of small plastic debris (*e.g.*, wastewater effluent) to the North Pacific and its marginal seas with a focus on indirect indicators of plastic pollution, such as plastic additives leading to chemical contamination in organismal tissues. A deeper understanding of these marine debris sentinels will help us elucidate the status and trends of small plastic pollution and their environmental impacts in the North Pacific and globally, thus allowing us to make informed decisions for plastic usage and litter management policies.

Summary of presentations

Session S7 was introduced by a well-received and attended plenary by Dr. Stephanie Avery-Gomm titled “Past progress and future opportunities: Seabirds as biological monitors of microplastic pollution in the Pacific”. Dr. Avery-Gomm’s talk was a fantastic introduction to our session in that she discussed the work that had been done establishing Northern Fulmar (*Fulmarus glacialis*) as a bioindicator of plastic in the marine environment in the North Atlantic. These birds are often found stranded on beaches and bycaught as an unintended side effect of fisheries operations. As such, there is a steady stream of fulmars available to be sampled for plastic ingestion. In the ICES region they have determined a target of < 10% of samples fulmars with 0.1g of ingested plastic. Dr. Avery-Gomm provided a compelling argument that we should use the Northern Fulmar to monitor plastic pollution in the North Pacific as well. While the plastic ingestion targets may have to be adjusted for the PICES region, there is value in using the same species as a bioindicator of plastic pollution in both the North Atlantic and North Pacific.

Our main topic session began with an invited talk from Professor Daoji Li from East China Normal University with his talk titled “Main advances in marine microplastics research in China”. This presentation was an excellent overview of microplastic research coming out of Professor Li’s group, and out of the Western North Pacific region more broadly. Several of the projects that he spoke about included the abiotic fate of microplastics, a reassessment of the role of major Chinese rivers (e.g., the Yangtze) to ocean plastic pollution, as well as microplastic in marine food webs. It was interesting to learn that a paper came out of their group (Liu *et al.*, 2019, *Marine Pollution Bulletin*) that described a method for sampling plastic *in situ* throughout the water column, similar to the study presented by Kyle Van Houtan later in the session.

Professor Wonjoon Shim (Korea Institute of Ocean Science and Technology) then presented a talk titled “Fast fragmentation rate of secondary nano- and microplastics from foamed polystyrene by sunlight exposure”. In their study the researchers experimentally exposed expanded polystyrene (EPS) to seawater and sunlight over the course of 2–8 months and quantified the release of micro- and nanoplastics. They found more micro- and nanoplastics released over time with higher release rates with higher levels of irradiance. In some cases, they report the release of billions of micro- and nanoplastics from their experimental EPS. Next steps would be to try a similar experiment in a more natural (*i.e.*, non-laboratory) setting.

Nicholas Vanderzyl (University of Hawai’i) presented his undergraduate research on “Microplastic accumulation patterns in sand at three Hawaiian beaches”. He collected surface sand samples from three different beaches on the big island of Hawaii, from the high berm down to the low tide line. More plastic was found higher up on the beach, likely to plastic getting washed away and recirculated in the intertidal lower on the beach near the water. One of his beaches was newly created by the recent volcanic event at Kilauea, where he found the fewest microplastics. He is still waiting on FTIR to confirm the identity of putative microplastics.

For the last talk before lunch, we had Dr. Peter Ross from Ocean Wise give a talk titled “Microplastic pathways into the ocean: Lessons learned from Vancouver, Canada”. This was an overview of a large body of research being spearheaded by Dr. Ross in the Vancouver area, in an effort to create a microplastic budget from land to sea. He discussed the rigorous determination of microplastic saying that every particle and fiber that has not been confirmed to be synthetic in nature by spectroscopy should be called a “suspected microplastic”. In addition to talking about standardization and QA/QC methods his research group was advocating, he also provided information on the public-facing campaign that Ocean Wise and the Vancouver Aquarium are coordinating to raise awareness about this issue locally.

After lunch we heard from Dorothy Horn on her doctoral research on “Impacts of environmentally-relevant concentrations of polypropylene rope on Pacific mole crab (*Emerita analoga*) development and lifespan” at Portland State University. Her thorough talk correlated the concentration of microplastics found in beach sand to microplastics found in mole crabs. She then reported results of a lab experiment demonstrating that the ingestion of microplastics by mole crabs had negative effects on crab behavior and physiology.

Chief Scientist at the Monterey Bay Aquarium, Dr. Kyle Van Houtan, presented on “The vertical distribution and biological transport of marine microplastics across the epipelagic and mesopelagic water column,” based on a study published earlier this year in *Scientific Reports*, and led by Dr. Anela Choy (now an assistant professor at UC San Diego) who reported the vertical distribution of microplastic from 5–1000 m depth in Monterey Bay, California. Surprisingly, plastic concentrations were highest in the midwater column, from 200–600 m depth. In addition, they found more plastics at their offshore, as compared to their nearshore, site. Using Raman Spectroscopy, they determined that PET, likely originating from single-use items such as disposable water bottles, was the most common plastic type found in their samples.

Graduate student Rhiannon Moore (Simon Fraser University) presented on her research “Microplastics in pelagic food webs: initial insights from a study on microplastic contamination in the Beaufort Sea beluga whales and its prey”. Working with Ocean Wise, she collected samples of fish and beluga whale gastrointestinal material from the Canadian Arctic to examine for microplastics. Microplastics were found in every beluga whale sampled ($n = 7$) with an average of 102 plastic particles per whale. Fiber was the dominant microplastic type in fish, but particles were more common in whales.

Dr. Jennifer Lynch (Center for Marine Debris Research at Hawaii Pacific University) spoke about sea turtles as indicators of plastic marine debris quantities and types in the Central Pacific, giving an overview of plastic ingestion patterns in this taxon. Dr. Lynch mentioned the importance of standardizing methods to make studies comparable across regions and over time. In addition, zeros are valuable data points that we need to be recording and reporting. One overall trend in turtles she noted was that pelagic post-hatching turtles have more plastic ingested on average than older pelagic juvenile turtles and neritic adult turtles.

Dr. David Hyrenbach (Center for Marine Debris Research at Hawaii Pacific University) gave a talk titled “BIOPs: Towards seabird bioindicators of North Pacific plastic pollution”. He gave us an overview on the plastic ingestion research his group has been conducting on the seabirds of the central North Pacific. Certain seabird species, like the Tristram’s Storm-Petrel (*Oceanodroma tristrami*) and the Bonin Petrel (*Pterodroma hypoleuca*) are, despite being less charismatic than the North Pacific Albatrosses, still heavily affected by the ingestion of plastic debris. Certain species, like the Bonin Petrel, may be especially useful because they breed in the winter season, unlike other Hawaiian seabirds, and can help us track marine plastic during that time of the year when other commonly sampled shorebirds (*e.g.*, albatrosses) are not available to be sampled.

Professor Taewon Kim of Inha University reported on his research titled “The feeding preference for the color of plastic debris in the hawksbill turtle, *Eretmochelys imbricata*”. He performed behavioral experiments on the turtles and found that they prefer yellow plastic over white or black plastic. Now he is working on a project to explicitly test the “jellyfish hypothesis,” where he will present captive turtles with jellyfish and plastic bags to see which they prefer to feed on. This experiment will use olfactory, in addition to visual, cues.

Dr. Sang Hee Hong (Korea Institute of Ocean Science and Technology and University of Science and Technology) looked at quantities and characteristics of plastic debris ingested by sea turtles in the Korean coastal waters. She reported results on 35 turtles of 4 species collected in Korean waters and reported that plastic ingestion trends differ by species, age of turtle, and region of Korea where the turtle was collected. These studies can be compared to turtles sampled in other regions of the North Pacific.

Dr. Miran Kim (Korea National Park Research Institute) reported on microplastic ingestion by seabirds in South Korea. She sampled 11 species of seabirds around the Korean Peninsula and found 5 of them to have ingested microplastic debris; however, only 5% of the 192 individuals sampled contained microplastic. Birds from the Yellow Sea region ingested microplastics most commonly.

Dr. Yutaka Watanuki from Hokkaido University discussed ingestion of plastics by seabirds and its potential effects. This ambitious study experimentally fed plastics to shearwaters in Japan and found higher concentrations of flame retardants and UV stabilizers in the bird’s liver tissues if the individuals had been experimentally fed plastics. These causative studies are needed to provide direct evidence of harm from plastics to marine wildlife.

The talks in session S7 were concluded by NOAA's Peter Murphy who introduced "AMAP's Microplastics and Marine Litter Expert Group". The efforts being led by the nations bordering the Arctic Ocean were discussed as was the general structure of the Arctic Monitoring Action Plan. He concluded with a brief discussion of how PICES could be plugged into these efforts, as several of the PICES countries – Russia, Canada, United States – border the Arctic.

In summary, our session was well attended throughout, with no fewer than 30 people in attendance at all times. There was a lot of engagement with the speakers with questions and discussions during lunch and coffee breaks. We had excellent representation of the PICES member countries in our session (though the only presentation from a Russian scientist was withdrawn in the days leading up to the meeting). We plan to continue the momentum from this session at the next PICES meeting in Qingdao, China, with a topic session titled "Using environmental indicators to assess baselines, targets, and risk of plastic pollution in the North Pacific".

List of papers

Oral presentations

Past progress and future opportunities: Seabirds as biological monitors of microplastic pollution in the Pacific (Plenary)

Stephanie Avery-Gomm

Main advances in marine microplastics research in China (Invited)

Daoji Li

Fast fragmentation rate of secondary nano- and microplastics from foamed polystyrene by sunlight exposure

Young Kyoung Song, Won Joon Shim, Sang Hee Hong, Soeun Eo

Microplastic accumulation patterns in sand at three Hawaiian beaches

Nicolas Vanderzyl, Steven Colbert and Tracy Wiegner

Microplastic pathways into the ocean: Lessons learned from Vancouver, Canada

Peter S. Ross, Katerina Vassilenko, Mathew Watkins, Stephanie Wang and Anna Posacka

Impacts of environmentally-relevant concentrations of polypropylene rope on Pacific mole crab (*Emerita analoga*) development and lifespan

Dorothy Horn, Elise Granek and Clare Steele

The vertical distribution and biological transport of marine microplastics across the epipelagic and mesopelagic water column

C. Anela Choy, Bruce H. Robison, Tyler O. Gagne, Benjamin Erwin, Evan Firl, Rolf U. Halden, J. Andrew Hamilton, Kakani Katija, Susan E. Lisin, Charles Rolsky, and Kyle S. Van Houtan

Microplastics in pelagic food webs: initial insights from a study on microplastic contamination in the Beaufort Sea beluga whales and its prey

Rhiannon Moore, Peter Ross, Leah Bendell, and Lisa Loseto

Sea turtles as indicators of plastic marine debris quantities and types in the Central Pacific

Jennifer M. Lynch, Melissa R. Jung, George H. Balazs, Thierry M. Work, Shandell Brunson, Alexander Gaos, and T. Todd Jones

BIOPs: Towards seabird bioindicators of North Pacific plastic pollution

K. David Hyrenbach, Lauren Chamberlain, Michelle Hester, Paula Hartzell, Meg Duhr, Jenn Lynch

The feeding preference for the color of plastic debris in the hawksbill turtle, *Eretmochelys imbricata*

Taewon Kim, Seonmyeong Choo, Jibin Im, Soojin Jang

Quantities and characteristics of plastic debris ingested by sea turtles in the Korean coastal waters

Yelim Moon, Sang Hee Hong, Gi Myung Han, Won Joon Shim, Youna Cho, Mi Jang, Il-Hun Kim and Min-Seop Kim

Microplastic ingestion by seabirds in South Korea

Miran Kim, Mijin Hong, Hee Young Kim, Sang-moon Cho, Ki-Baek Nam, Ha-na Yoo, A-hyeon Lim and Youngsoo Kwon

Ingestion of plastics by seabirds and its potential effects

Yutaka Watanuki, Naya Sena, Kosuke Tanaka, Rei Yamashita, Mami Kazama, Ken Yoda, Hideshige Takada

AMAP's Microplastics and Marine Litter Expert Group

Peter Murphy

*Poster presentations***Introduction of convergence cluster for human and environmental safety research of (nano)microplastics in Korea**Yunwi Heo and June-Woo Park**Review of microplastic pollutions in captured and cultured seafood in China**Zuhao Zhu, Haibo Huang, Qiufeng Zhang and Jie Chen**Microplastic pollution in the Vancouver urban watershed: the role of Combined Sewer Overflows (CSOs)**Amir H. Parizi, Ryan Ziels, Stephanie Wang, Farida Bishay, Peter S. Ross, and Anna Posacka**Tackling microfiber pollution at source: an evaluation of washing-machine lint filters**Mathew J. Watkins, Katerina Vasilenko, José Gutiérrez-García, Farida Bishay, Peter Ross and Anna Posacka

Report of Working Group on *Indicators of Marine Plastic Pollution*

The Working Group on *Indicators of Marine Plastic Pollution* (WG 42) held its first meeting on October 20, 2019, from 900 to 1700 h in Victoria, Canada. Nine members and 6 observers (including one by videoconferencing) were in attendance (*WG 42 Endnote 1*). The meeting was co-chaired by Drs. Jennifer Lynch and Chengjun Sun who welcomed the participants. After calling the meeting to order, Drs. Lynch and Sun reviewed the meeting agenda. Three items, the addition of members, frequent scheduled meetings of the WG, and review of the PICES Data Inventory and Policy, were added to the agenda, which was then adopted (*WG 42 Endnote 2*).



WG 42 meeting participants at PICES-2019, Victoria, Canada. From left: Guangshui Na, Wonjoon Shim, Miran Kim, Sang Hee Hong, Chengjun Sun, Jennifer Lynch, Amy Uhrin, Matthew Savoca, Shuhei Tanaka, Kazuhiko Mochida, Yumi Okochi.

AGENDA ITEM 3

Presentations

1. Report of the *Study Group on Marine Microplastics*

Dr. Wonjoon Shim presented an overview of the Study Group on *Marine Microplastics* (SG-MMP) whose one-year term ended in 2018. He briefly discussed the SG's final report which included its findings on MMP hotspots and recommendation for the establishment of a new Working Group on *Indicators of Marine Plastic Pollution*.

2. Overview of WG 42 by MEQ

Dr. Guangshui Na, Chair of the Marine Environmental Quality Committee (MEQ) discussed the role of MEQ, as parent of WG 42, and responsibilities of the WG in its reporting to MEQ.

3. European Union Marine Strategy Framework Directive

Dr. François Galgani, Chair of the MSFD technical group on marine litter, and Co-Chair of the ICES Working Group on Marine Litter, attended the meeting by videoconference. He talked about plastic pollution studies coordinated and funded by European Union countries and target goals for reduction of marine litter in the European region.

4. Topic Session (S7) on “*Environmental indicators of plastic pollution in the North Pacific*”

Dr. Matthew Savoca reminded participants about the 1-day MEQ-sponsored Topic Session (S7) and co-sponsored by NOWPAP that was going to take place on Wednesday, October 24.

5. Overview of FUTURE

Dr. Toyomitsu Horii, FUTURE liaison to WG 42, discussed the objectives and activities of FUTURE, WG 42’s linkage to the program, and the purpose the FUTURE-WG 42 liaison.

AGENDA ITEM 4

Mission and terms of reference

WG members reviewed the mission statement and agreed to change it from:

“1. Identify multiple abiotic and biotic environmental indicators of plastic pollution, including meso and microplastics, and additive chemicals in North Pacific, which may contribute towards establishing monitoring guidelines and environmental quality objectives for policy options in the North Pacific and globally.

2. Strengthen partnerships and collaboration with other professional organizations (e.g. Working Group Marine Litter (WGML) of ICES, GESAMP WG40 for microplastic global assessment, NOWPAP MARLITA program, IOC/WESTPAC Asian microplastic capacity building and monitoring program, and Global Interest Group on microplastics of Society of Environmental Toxicology and Chemistry) to address marine plastic pollution related issues.”

to:

“1. Identify multiple abiotic and biotic environmental indicators of plastic pollution, across different size categories, and additive chemicals in North Pacific, which may contribute towards establishing monitoring guidelines and environmental quality objectives for policy options in the North Pacific and globally.

2. Strengthen partnerships and collaboration with other professional organizations (e.g. Working Group Marine Litter (WGML) of ICES, GESAMP WG40 for microplastic global assessment, UNEP Regional Seas Action Plan: NOWPAP MARLITA program, IOC/WESTPAC Asian microplastic capacity building and monitoring program, and Global Interest Group on microplastics of Society of Environmental Toxicology and Chemistry, U.S. State Department, Monterey Bay Seafood Watch, MARPOL, UNEP G7/G20 Sustainable Development Goals, Protection of Arctic Marine Environment (PAME), Partnerships in Environmental Management for the Seas of East Asia (PEMSEA), JPI Oceans, AMAP, OceanObs, International Marine Debris Conference, UNESCO Decade of Ocean Science for Sustainable Development, OSPAR) to address marine plastic pollution related issues.”

WG members reviewed the terms of reference and agreed to change ToR 1 from:

“To review micro- and mesoplastic pollution (e.g., abundance, distribution, composition, and potential impacts) in North Pacific and its marginal seas”

to: “To review pollution (e.g., abundance, distribution, composition, and potential impacts) across different size categories in the North Pacific and its marginal seas”

ToR 1 – *To review pollution (e.g., abundance, distribution, composition, and potential impacts) across different size categories in the North Pacific and its marginal seas.*

The WG will ask *Environmental Pollution* if they would consider a special issue of 3 to 4 review papers on plastic pollution in the North Pacific based on the mini review prepared by SG-MMP.

- Sea surface and water column – Wonjoon Shim?

- Shoreline, sediment, sea floor – Amy Uhrin and Shuhei Tanaka
- Biota ingestion – Chengjun Sun, Matthew Savoca, Sanghee Hong, Jennifer Lynch
- Biota entanglement – Jennifer Lynch?

Timeline: October 2020 marginally polished draft
June 2021 submit to journal

Format template to be taken from ToR 2 and 3; deadlines to be recommended by Dr. Lynch

- Review abundance, distributions and impacts with a comparison to other ocean basins – North Pacific is the most plastic polluted,
- Recommend indicators of plastic pollution,
- Think about recommending a target goal.

ToR 2 – *To identify multiple organismal and non-organismal indicators of plastic pollution and its environmental impacts including associated chemicals in the North Pacific and its marginal seas.*

- WG 42 will create a list of indicators and discuss how these could be incorporated into the 3–4 review articles.

ToR 3 – *To recommend guidelines for monitoring environmental indicators and a target improvement goal for the established indicators.*

- François Galgani gave an overview of the European Union’s work towards this task;
- Plan to invite someone from the OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic) Commission to define how they came up with Good Environmental Status for northern fulmars in 2021, keep in mind North Pacific has 1-3 orders of magnitude higher levels of plastic pollution than the North Atlantic;
- We will conclude the 3–4 review articles with recommended indicators and consider providing target goals to NOWPAP and UN Sustainable Development Goals

ToR 4 – *To convene a topic session and/or workshop on environmental indicators and impacts of plastic pollution and coordinate a special issue in an international peer-reviewed journal.*

- WG 42 submitted a proposal for a Topic Session on “*Using environmental indicators to assess baselines, targets, and risk of plastic pollution in the North Pacific*” at PICES-2020 (**WG 42 Endnote 3**)

ToR 4 – *Contribute to FUTURE by publishing a final report summarizing results of the Working Group deliberations.*

- To be completed in 2021.

At the request of MEQ, WG 42 will add a sixth ToR: *Review the PICES Data Inventory, and identify data and/or data products developed under the direction of WG 42 not currently recorded in the Data Inventory and inform MEQ, the TCODE Chair and the Secretariat.*

AGENDA ITEM 5

WG 42 achievements

Drs. Lynch and Sun noted that although the WG got a late start (June 2019) due to the slowness of filling membership, it has been very active since that time.

- WG 42/MEQ sponsored a 1-day Topic Session (S7) on “*Environmental indicators of plastic pollution in the North Pacific*” at PICES-2019;
- Prof. Juying Wang participated in a marine litter management workshop in September 2019 in Dalian, China;

- Drs. Shim and Lynch participated in an international Workshop on “*The science of microplastics in the World Ocean*”, October 15–18, 2019, Woods Hole, Massachusetts.

Request: MEQ to recommend to Science Board that Governing Council members act quicker and completely to fill membership positions. WG 42 requests 2 additional members from Canada, and 3 members from Russia.

AGENDA ITEM 6

Other business

- WG 42 requests MEQ to recommend to Science Board that Governing Council members act quicker and completely to fill membership positions. WG 42 requests 2 additional members from Canada, and 3 members from Russia.
- The WG agreed that quarterly meetings (via Skype) to review progress would be worthwhile. Dr. Lynch will coordinate the first one in mid-January.
- As requested by MEQ, WG 42 reviewed the PICES Data Inventory Management Policy and will identify and submit any data/data products as they become available to TCODE, MEQ and the Secretariat.
- Upcoming meetings: see *WG 42 Endnote 4*.

WG 42 Endnote 1

WG 42 participation list

Members

Jennifer M. Lynch (USA, Co-Chair)
 Chengjun Sun (China, Co-Chair)
 Sang Hee Hong (Korea)
 Miran Kim (Korea)
 Kazuhiko Mochida (Japan)
 Matthew Savoca (USA)
 Wonjoon Shim (Korea)
 Shuhei Tanaka (Japan)
 Amy Uhrin (USA)

Members unable to attend

Canada: Peter S. Ross
 China: Daoji Li, Connie Ka-yan Ng, Juying Wang
 Japan: Hideshige Takada
 Korea: Seung-Kyu Kim

Observers

François Galgani (ICES) (remote conferencing)
 Toyomitsu Horii (Japan)
 Guangshui Na (MEQ Chair, China)
 Yumi Okochi (Japan NUS Co., Ltd.)
 Hyoung Chul Shin (Korea)
 Taleafumi Toshida (Japan)

WG 42 Endnote 2**WG 42 meeting agenda**

1. Welcome and introductions
2. Review and adoption of meeting agenda
3. Presentations to WG 42
4. WG 42 mission and terms of reference
5. WG 42 achievements
6. Other business

WG 42 Endnote 3

Proposal for a Topic Session on
“Using environmental indicators to assess baselines, targets,
and risk of plastic pollution in the North Pacific”
at PICES-2020

Duration: 1 day

Convenors: Chengjun Sun (China), Matthew Savoca (USA), Sanghee Hong (Korea)

Potential Invited Speakers: Jennifer Provencher (Canada; jennifer.provencher@canada.ca) Anela Choy (USA; anela@ucsd.edu) Sarah-Jeanne Royer (USA; sroyer@ucsd.edu)

The North Pacific and its marginal seas are heavily polluted with plastics. It is important to develop environmental indicators of plastic pollution to determine baselines, set targets, and project risk to species and ecosystems. The goal of this session is to continue to identify indicators – both biotic and abiotic – of plastic pollution, and to move beyond the development of indicators to determine how we can use indicators to determine baselines in the North Pacific. Environmental indicators will also prove important to project risk from plastics to the ecosystem. Risk may be assessed by the quantity or abundance of plastic particles, or as the concentration of plastic associated pollutants in organismal tissues. Research presented in this topic session will help us elucidate the status and trends of plastic pollution and their environmental impacts in the North Pacific to better allow comparisons to other regions globally. This science-informed approach will allow us to make informed decisions for plastic usage and litter management policies.

WG 42 Endnote 4**Upcoming meetings of interest**

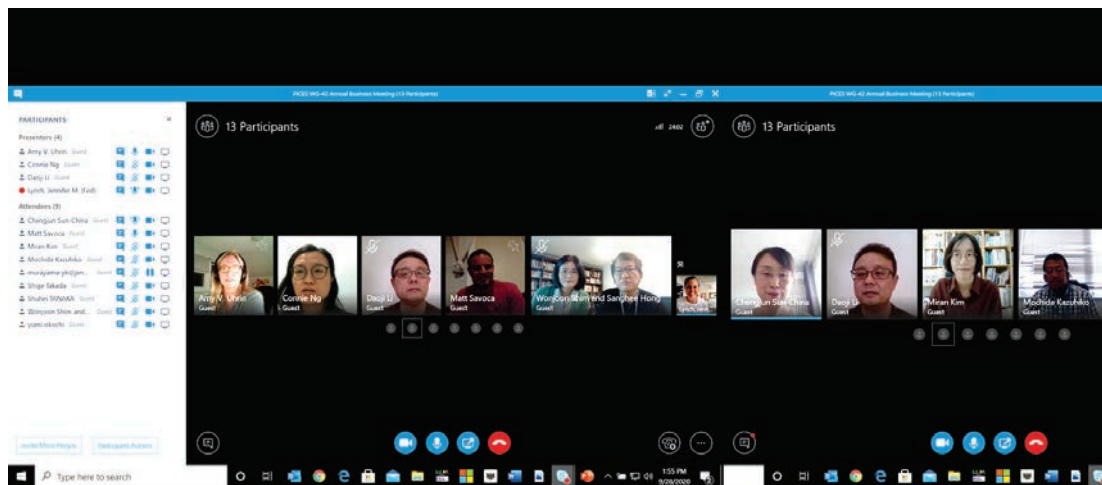
- November 6–8, 2019 – 3rd WESTPAC Workshop on “*Distribution, source, fate and impacts of marine microplastics in Asia and the Pacific*”, Shanghai, China (Chengjun Sun presenting);
- January 27–28, 2020 – National Academies of Sciences, Engineering, and Medicine Workshop on “*Emerging technologies to advance research and decisions on the environmental health effects of microplastics*”, Washington, DC, USA (Jennifer M. Lynch presenting);
- April 21–23, 2020 – International Symposium on “*Plastics in the Arctic and Sub-Arctic region*”, Reykjavik, Iceland (co-sponsored by PAME, UNEP, ICES, PICES, OSPAR Commission, IASC and others);
- June 4-6, 2020 – China National Conference on (marine) Microplastics Pollution and Control
- ~summer 2020 – Polymer kit with FTIR spectra and DSC melt curves for sale by Hawaii Pacific University.

PICES-2020

October 13–15, 2020, Virtual Annual Meeting

Report of Working Group on *Indicators of Marine Plastic Pollution*

The Working Group on *Indicators of Marine Plastic Pollution* (WG 42) held its meeting on September 28 to 30, 2020, virtually during PICES-2020. Thirteen members and four observers were in attendance over the 3 days (*WG 42 Endnote 1*). The meeting was co-chaired by Drs. Jennifer Lynch and Chengjun Sun who welcomed the participants. After calling the meeting to order, Drs. Lynch and Sun reviewed the meeting agenda. The agenda was adopted (*WG 42 Endnote 2*).



WG 42 meeting participants on one day of its virtual meeting during PICES-2020.

AGENDA ITEMS 3 AND 9

Achievements

Dr. Jennifer Lynch reviewed the presentation given to MEQ on September 22, 2020. The Working Group met via Skype on February 25 and June 2 in 2020. Sarah Dudas (Canada) was added as a new member in July 2020. Working Group members presented at least three conferences in 2020. We are working towards five companion review articles regarding plastic pollution indicators in the North Pacific. We postponed our approved (at PICES-2019) Topic Session on “*Using environmental indicators to assess baselines, targets, and risk of plastic pollution in the North Pacific*” to the in-person PICES-2021 meeting. We requested open access publication fees from PICES; fees for only one of the five will be considered. We discussed extending our term, but it is still too early to tell if we need this or it will be approved.

AGENDA ITEMS 4 AND 5

Paper progress presentations

1. Sea surface and water column - Dr. Wonjoon Shim presented progress with data entered from 86 papers from a literature search and graphs made. Suggested indicator: $300 \mu\text{m}$ manta/neuston surface tow quantifying # of particles/ km^2 or particles/ m^3 .

2. Shoreline - Dr. Amy Uhrin presented progress with a literature search with approximately 89 papers to review. We discussed spatial scales. Suggested indicator: NOAA standing stock by area method quantifying # of pieces/m², mass of plastic/m², # of pieces/linear m, or mass of plastic/linear m.
3. Sediment and seafloor – Dr. Shuhei Tanaka presented progress with a literature search with approximately 171 papers collected for sediments globally including freshwater and other ocean basins. Suggested indicator: whichever is the dominant method from the review quantifying items/kg, items/m³, items/L, or mass/kg. We discussed how important it is to provide all raw metadata so that conversions among units are possible.
4. Biota ingestion – Dr. Matthew Savoca presented progress with a literature search resulting in <100 papers. We discussed other published reviews on this topic and existing programs that could be leveraged. Next steps are to create a rubric to score indicators. Suggested indicators: albatross, fulmar (missing W Pacific seabirds), loggerhead/green, mahi, lancet fish, anchovy, marine mammal feces, bivalve quantifying # items/individual, frequency of occurrence, mass/individual, mass/body mass, mass/GI tract mass.
5. Biota entanglement – Dr. Jennifer Lynch presented limited progress. A systematic literature search has not been done, but approximately 60 papers have been obtained. We discussed other published reviews on this topic and existing programs that could be leveraged. Suggested indicators: drone photography of marine mammal scars, leverage existing program in sea turtle strandings, bird monitoring quantifying frequency of occurrence.

AGENDA ITEMS 6 and 8

Review article timeline and journal selection

The following timeline was agreed upon. Each paper will have a breakout group meeting by end of November 2020. The next WG 42 meeting would be in January 2021 where we will discuss paper progress, indicator selections, and target reduction recommendations. Literature beyond January 2021 will not necessarily be included. Co-author review will begin May 2021, WG 42 review will start June 2021, agency internal reviews will start in August 2021, and journal submission is targeted for October 2021.

Environmental Pollution journal is interested in our companion review articles. There is no fee for regular submission, but the fee for open access is \$3550 per paper. Dr. Takada requested we look at submitting to *Environmental Monitoring and Contaminants Research* (EMCR), a new journal.

AGENDA ITEM 7

NOWPAP and other regions activities

Dr. Lynch shared communication as requested from NOWPAP activities. Dr. Ning Liu is Programme officer of NOWPAP, and he coordinates NOWPAP's marine litter activities. Dr. Takafumi Yoshida stated that one of the Regional Activity Centres of NOWPAP, POMRAC, is developing Ecological Quality Objectives (EcoQO) for the NOWPAP region. In the EcoQOs, marine pollution, including marine litter and microplastics, are future targeted Objectives. If WG 42 recommended a target/goal for plastic pollution from scientific knowledge, the information would be used for establishing NOWPAP's target. Dr. Yegor Volovik requested that Dr. Lynch share this email, "*Despite quite a difference between PICES with its strong scientific focus and NOWPAP with more engagement with ministries and governmental employees, we do find many dots we can connect for the benefits of both organisations. Let me reciprocate on some ideas you came up with in your message below:*"

1. Marine Litter/Plastics EQOs and targets. *NOWPAP strongly supports your proposal to strengthen our collaboration in this field. You are right that PICES' recommendations for EQOs and targets are expected earlier than those in the NOWPAP region. However, our Regional Activity Centres and experts have expressed their interest in testing those in the NOWPAP region. One of our experts also proposed to extend those to the river runoff to ensure source-to-sea approach. Certainly, more technical discussions are required to shape up the cooperation to both organisations' benefit, but we are happy to move this way.*
2. Experts and Sharing of Experiences. *We have a Regional Action Plan on Marine Litter (RAP MALI) for the NOWPAP region. Each member state has nominated a Focal Point (FP). However, these people are not scientists but mostly government employees, so if the need for stronger cooperation between PICES WG 42 and NOWPAP is supported, NOWPAP can ask the existing FPs to nominate experts to support the cooperation with PICES. This will allow us to strengthen the capacity of FPs and ensure a solid scientific approach. Similarly, PICES could assign a contact point(s) to keep the communication channel between PICES WG 42 and NOWPAP team operational. **WG 42 assigned Drs. Lynch and Sun as points of contact with NOWPAP.***
3. *NOWPAP is implementing a Special Project and has a Working Group on Microplastics. The 3rd Overview of Marine Litter is currently being finalised. NOWPAP will be happy to find some entry points for cooperation as well.*
4. *In terms of points of contact from NOWPAP's POMRAC (Russia), which could provide more information and insight on what POMRAC is doing, are Dr. Yana Blinovskaya (blinovskaya@hotmail.com) and Mr. Nikolay Kozlovsky (geo@tigdvo.ru). **This resulted in Russia approving Dr. Blinovskaya to join us as a member to WG 42.***
5. *And lastly, regarding a presentation of NOWPAP at the WG 42 Business Meeting starting tomorrow. As the notice is so short, I have requested our team to re-jiggle their schedules if possible, but the time difference is an issue. Maybe we can use another chance when we have more clarity on where we can move from here. Meanwhile, if you could present these points in general to the meeting, this will be sufficient for now, I think."*

Dr. Savoca reported that the Arctic Monitoring and Assessment Programme (AMAP) is working on indicators for plastic pollution, and point of contact is Dr. Jennifer Provencher. **This resulted in Drs. Savoca and Lynch meeting with Dr. Provencher, and AMAP draft documents will be shared with WG 42 to help guide our review articles.**

Dr. Sun described WestPAC's activities. WESTPAC has done three training workshops over the past three years on the Distribution, Source, Fate and Impacts of Marine Microplastics in Asia and the Pacific. Workshop in 2020 was not held due to COVID-19. We will keep our connection with WESTPAC for information exchange if needed.

AGENDA ITEM 10

Term extension

WG 42 will wait to request an extension after seeing our progress through mid-2021.

AGENDA ITEM 11

Other business

- PacifiChem has been rescheduled for December 16 – 21, 2021 in Honolulu, Hawaii;
- The *Microplastics and Nanoplastics* journal is now open at :
<https://microplastics.springeropen.com/submission-guidelines/aims-and-scope>;

- Hawaii Pacific University is selling a polymer standards kit;
- Hawaii Pacific University is sourcing derelict fishing gear washing ashore in Hawaii, and could use help with translation, survey participants, fisheries contacts.

WG 42 Endnote 1

WG 42 participation list

Members

Jennifer M. Lynch (USA, Co-Chair)
 Chengjun Sun (China, Co-Chair)
 Sang Hee Hong (Korea)
 Mochida Kazuhiko (Japan)
 Miran Kim (Korea)
 Daoji Li (Korea)
 Kazuhiko Mochida (Japan)
 Connie Ka-yan Ng (China)
 Matthew Savoca (USA)
 Wonjoon Shim (Korea)
 Hideshige Takada (Japan)
 Shuhei Tanaka (Japan)
 Amy Uhrin (USA)

Members unable to attend

Canada: Sarah Dudas, Peter S. Ross
 China: Juying Wang
 Korea: Seung-Kyu Kim

Observers

Murayama Yuka (Japan)
 Yumi Okochi (Japan NUS Co., Ltd.)
 Lixin Zhu (China)
 Jiaya Yu (China)

WG 42 Endnote 2

WG 42 meeting agenda

1. Welcome and adoption of agenda
2. Review of WG 42 mission and Terms of Reference
3. Achievements of WG 42
4. Revisit the template for review articles and Google Share Drive structure and function
5. Reports from each review article lead
6. Discuss timeline and journal selection for review article submission
7. Share NOWPAP announcement; plans to set an EcoQO
8. Schedule future online meetings and activities before PICES-2021
9. Discuss 2021 topic session
10. Discuss proposal to extend the term of WG 42
11. Other business

International Symposium on Plastics in the Arctic and Sub-Arctic Region

March 2–4, 2021, Reykjavik, Iceland

SYMPOSIUM PARTNERS



PANELISTS:

Jennifer Provencher,
Research Scientist for Environment and Climate Change Canada),

Alvise Vianello,
PhD.

Dr. Maria Gavrilov,
Association Maritime Heritage and BirdsRussia

Dr. Amy Lusher,

Jórun Pólsdóttir,
Bachelor of Science in Biological Ecology,
working at the Faroe Marine Research Institute

Douglas Causey,
PhD. Professor, University of Alaska Anchorage;
Arctic Initiative Associate, Harvard Kennedy
School, Belfast Center for Science and
International Affairs

Ásta Margrét Ásmundsdóttir,
Chemist and adjunct at the University of Akureyri

PRE-RECORDED SPEECHES (15 min.)

Keynote by Jennifer Provencher (30 min.)

First quantification of microplastic > 10 µm in Western Greenland using a novel filtration device,
Alvise Vianello

Plastic in the Russian high-Arctic: initial survey of marine litter,
Maria Gavrilov

Large-scale study of microplastics in five bivalve species from the Nordic marine environment: A validated approach to monitoring,
Amy Lusher

Diet and micro plastic ingestion in pelagic fish in the North Atlantic Ocean,
Jórun Pólsdóttir

Monitoring the Presence, Abundance, and Identity of Micro- and Nano-plastics of Arctic and Beringian Foodwebs,
Douglas Causey

First record of the occurrence and composition of microplastics in sediments in Eyjafjordur, Iceland,
Ásta Margrét Ásmundsdóttir

15:30-16:30 IMPACT OF PLASTIC (TOXICOLOGY AND ECOTOX)

Moderator: Björn Einar Grösvik

15:15-15:30 Poster session: Impact of plastic (eco-tox) (pre-recorded)

- Crumb rubber toxicity in coastal marine systems, *Dr. Claudia Halsband*
- Using seabirds to examine patterns of contaminants related to the ingestion of plastic pollution, *Jennifer Provencher, Research Scientist for Environment and Climate Change Canada*
- Variation in phthalate concentrations in ten seabird species from the Aleutian Archipelago, *Veronica M. Padula, Academic Program Director, Bering Sea Campus and Research Center, Aleut Community of St. Paul Island Tribal Government*
- The container incident with the MSC Zoe: assessing damage and compensation under the EU environmental liability directive, *Prof. Dr. Ir. Katja Philippart and Prof. Mr. Edward Brans*

Global Microplastics Symposium, Virtual April 13–15, 2021

Overview of microplastics in different geo-environments

Opening remarks & General overview of microplastic pollution: issues and perspectives	Rui Chen, Ph. D. Thermo Fisher Scientific Chelsea Rochman, Ph. D., University of Toronto, Canada
Microplastics in Hawaiian marine environments: where and how do we find them	Jennifer Lynch, Ph. D.² Hawaii Pacific University
Microplastics in the North Pacific Gyre	Charles and Shelly Moore The Moore Institute for Plastic Pollution Research
The effects of micro and nanoplastics on biota in the aquatic environment: what we know about hazard and risk	Susanne Brander, Ph. D. Oregon State University
Atmospheric plastic deposition	Janice Brahney, Ph. D. Utah State University

Analysis of microplastics in different sample matrices

Session	
Review Day 1 and California's path towards assessing risks and developing regulations for microplastics in drinking water	Suja Sukumaran, Ph.D., Thermo Fisher Scientific Scott Coffin, Ph. D., California State Water Resources Control Board
Microplastics measurement interlaboratory calibration for drinking water	Charles Wong, Ph. D. Southern California Coastal Water Research Project
Great Shearwater: the microplastics within – A study on Great Shearwater microplastic ingestion in the Gulf of Maine	Ms. Christy Hudak Center for Coastal Studies
Distribution and bioavailability of anthropogenic microparticles in California's coastal ecosystems	Clare Steele, Ph. D. California State University Channel Islands
The 2020 Bianca nurdle spill in New Orleans and the use of FT-IR to identify putative nurdles from the incident	Mark C. Benfield, Ph. D. Louisiana State University

Challenges and solutions in microplastic research: from sample prep to library

Session	
Comparison of microplastic identification methods using FTIR-ATR, FTIR-transmission with mapping, and Raman spectroscopy for beach sediment samples	Wonjoon Shim, Ph. D. Korea Institute of Ocean Science and Technology, South Korea
FTIR and SEM analyses of microplastic chemistry, size, shape, and surfaces in various sample matrices	Jeff Wagner, Ph. D. California Department of Public Health
Microplastics in the Sierra Nevada: from peak to pipe	Monica Arienzo, Ph. D. Desert Research Institute
Open source Raman and IR spectroscopy, paving the future for artificial intelligence spectral analysis	Mr. Win Cowger University of California Riverside
Method standardization and technique development for FTIR and ATR-FTIR analyses in Belgian Research	Maaïke Vercauteren, Ph. D. Ghent University
Closing and live panel discussion	Moderator – Rui Chen Panelists: Suja Sukumaran, Chelsea Rochman, Clare Steele, Maaïke Vercauteren, Monica Arienzo, Janice Brahney, Scott Coffin, Charles Wong, Win Cowger, Susanne Brander

² Presenters in bold face denote WG 42 members.

Europe SETAC 2021 Annual Meeting

Virtual

May 3–6, 2021

Presentations

2.11.08 - Plastic Pollution in Antarctic Terrestrial Ecosystems: An Underestimated Contamination With Manifold Implications for Fragile Polar Soil Communities

Elisa Bergami, Emilia Rota, Tancredi Caruso, **Won Joon Shim**³, **Sang Hee Hong**, Giovanni Birarda, Lisa Vaccari, Andrews Krupinski Emerenciano, Leticia Palmeira Pinto, Willian Reina Joviano, Valentina Venuti, Vincenza Crupi, Jose Roberto Silva, Marcelo González-Aravena and Ilaria Corsi

3.08.19 - Practical Comparison of Microplastic Identification Methods: Manual, Semi-Auto and Automated FTIR and Raman Spectroscopy

Youngkyoung Song, Soeun Eo, **Sang Hee Hong** and **Won Joon Shim**

3.11.04 - Atmospheric Deposition As a Pathway for Microplastic to Marine Environment

Youna Cho, **Sang Hee Hong**, Mi Jang, Gi Myung Han and **Won Joon Shim**

3.11.05 - Different Characteristics of Microplastics in Stormwater Runoff by Urban Land Use Patterns

Mi Jang, **Sang Hee Hong**, Sung Yong Ha, Gi Myung Han, **Won Joon Shim**, Youna Cho and Jongwook Jeong

3.11.12 - Prevalence of High-Density Microplastics in Continental Shelf and Deep Sea Waters of East Asia

Soeun Eo, **Sang Hee Hong**, Young Kyoung Song, Gi Myung Han, Seongbong Seo and **Won Joon Shim**

3.12.11 - Potential Toxic Effects of Environmental Plastic Litters on Wharf Roach (*Ligia exotica*): Two Omics Approaches

Youmi Choi, Dongju Shin, Chang Pyo Hong, Sung-Hee Cho, **Sang Hee Hong**, Mi Jang, Youna Cho, Gi Myung Han, **Won Joon Shim** and Jee hyun Jung

3.12.25 - Plastic Debris Ingested by Sea Turtles From the Korean Waters: Quantity, Shape, Origins, and Polymer Composition

Yelim Moon, **Sang Hee Hong**, Gi Myung Han, **Won Joon Shim**, Youna Cho, Mi Jang, Il-Hun Kim and Min Seop Kim

3.12.30 - One-Year Monitoring of Microplastics in Mussels (*Mytilus edulis*) From an Industrialized Bay of South Korea

Jongwook Jeong, **Sang Hee Hong**, Youna Cho, Gi Myung Han, Mi Jang and **Won Joon Shim**

3.13.21 - Perfluoroalkyl Acids (PFAAs) in Eggs of Black-Tailed Gull From Its Breeding Sites Along the Korean Coast

Gi Myung Han, **Sang Hee Hong**, Mi Jang, Yelim Moon and **Won Joon Shim**

³ Authors in bold face denote members of WG 42

ICES ASC 2021

Virtual Annual Science Conference

September 6–10, 2021

ICES/PICES Theme session J

Advances and challenges in marine litter pollution

Conveners:

Thomas Maes – GRID-Arendal (Norway), Andy Booth –Sintef Ocean (Norway), Francois Galgani –Ifremer (France), **Chengjun Sun –First Institute of Oceanography (China/PICES)**

Marine litter covers an extremely wide variety of materials and sizes, originating from many unspecified sources. It is one of the most serious, rapidly developing, and worsening global environmental problems. The annual global production of waste has reached 4 billion tonnes and this figure is expected to double by 2025. About half of this amount concerns non-biodegradable material (i.e. plastics and metals).

Periodic assessments of the state of the marine environment, monitoring, and the formulation of environmental targets are perceived as part of the adaptive management process within Regional Sea Convention Action Plans (OSPAR in the Northeast Atlantic or HELCOM in the Baltic Sea) and within the MSFD for EU members states.

In the Northeast Atlantic and the Baltic Sea, a better understanding of marine litter pollution and the implementation of monitoring to support reduction measures are the main objectives, with a focus on some specific aspects of marine litter pollution such as the evaluation of sources, distribution, fate and impact of marine litter.

With some indicators already in place and new development to come, to cover all aspects of marine litter pollution, the aim of the session is to present the most recent and updated information on this issue with consideration to all compartments of the marine environment.

Evaluation of sources, distribution, fate and impact of marine litter, and specific issues such as interactions with the fishery sector will be addressed. New concepts and insights, shared and harmonized methodologies, coordinated environmental monitoring will be also considered to support dedicated guidelines and reduction measures.

The session has taken into account both science and management to

- provide new insights, methods and concepts
- develop shared and harmonized methodologies
- coordinated environmental monitoring, mapping and data management
- translate information in guidelines

Interactions with the fishery sector were also be considered as an important aspect of marine litter pollution, and results from ongoing research projects in the North east Atlantic and Baltic sea were analyzed and discussed.

The presentations received could be grouped into the following main topics:

- Microplastics
- Seafloor trawling
- Ingestion (macro or micro)
- Ghost gear

There were 10 presentations and 3 posters, covering a broad range of sub-topics, including improvement of our understanding of plastic pollution in different sectors (e.g. aquaculture as a source of plastic, a review on additives), management tools to support policy or solutions (e.g. an app to collect data on fishing gear stranded onshore, stronger links between research with SDG 14) and the current suitability and directions for monitoring guidelines (relevant to WGML activities). We especially want to highlight the following three presentations:

- The first one “Marine litter in the water column of the North Sea – composition, distribution, abundance and potential sources” from Bastian Huwer (DTU Aqua, Denmark) in relation to mid-water trawling, using existing trawling efforts in the North Sea, provided novel data on litter in the water column. The results indicated that this compartment is important to investigate further, in addition to existing schemes covering other compartments.
- The second presentation “All that glitters is not plastic: the case of openocean textile fibres” from Giuseppe Suaria (CNR-ISMAR, Italy) on the relative importance of synthetic fibers in relation to microplastic pollution and the need to distinguish between both types.
- The third presentation “Towards a Long-Term Monitoring Program of Plastic Ingestion by Marine Organisms in the North Pacific” from Matthew Savoca (PICES WG 42) on how to use marine organisms to monitor marine litter and its harmful effects.

In the discussions, we allowed the session presenters to select and respond to two pre-defined questions (see list in ANNEX) across two main topics MACRO and MICRO litter. They were given approx. 5 min to reply and discuss with the chairs within the context of their own presentations. The following four questions were those chosen most frequently by the session presenters:

- Which type of macro plastic is most prevalent in the marine environment?
- Which marine animals are most severely impacted in your opinion?
- Are microplastic fibres adequately sampled and accurately identified and quantified using existing sampling and analysis techniques?
- What are your experiences and identified limitations in comparing MP occurrence data from different studies?

Conclusions:

According to the session presenters, the most prevalent macroplastic items they observed were single use plastics. This is in line with a recent review, which highlights that up to 45% of all marine litter reported across 36 studies worldwide were single use plastic bags (Morales-Caselles et al., 2021), closely followed by fishing gear. Our session presenters indicated that several types of organisms were affected by marine litter, and that this was highly dependent on the region and seasons according to their findings. In relation to microfibrils, the session presenters thought that microplastic fibres are currently not adequately sampled or accurately identified and quantified using existing sampling and analysis techniques. There is a need to separate microfibrils from other types of microplastics, not just in terms of analysis, but also in relation to reporting. The session presenters all confirmed that there is a need for harmonisation across regions in the long term, while we should start with standardisation of techniques to allow for some comparability in the short term. These issues are recommended as focus areas for ICES WGML in the coming years.

PICES-2021

October 18–2021, Virtual Annual Meeting

Excerpted from:

Summary of Scientific Sessions and Workshops at PICES-2021

Session 8: MEQ Topic Session

Using environmental indicators to assess baselines, targets, and risk of plastic pollution in the North Pacific

Convenors:

Chengjun Sun (China), Sanghee Hong (Korea), Matthew Savoca (USA)

Background

The North Pacific and its marginal seas are heavily polluted with plastics. It is important to develop environmental indicators of plastic pollution to determine baselines, set targets, and project risk to species and ecosystems. The goal of this session is to continue to identify indicators – both biotic and abiotic – of plastic pollution, and to move beyond the development of indicators to determine how we can use indicators to determine baselines in the North Pacific. Environmental indicators will also prove important to project risk from plastics to the ecosystem. Risk may be assessed by the quantity or abundance of plastic particles, or as the concentration of plastic associated pollutants in organismal tissues. Research presented in this topic session will help us elucidate the status and trends of plastic pollution and their environmental impacts in the North Pacific to better allow comparisons to other regions globally. This science-informed approach will allow us to make informed decisions for plastic usage and litter management policies.

List of papers

Oral presentation

1. **Evaluating species as bioindicators for plastic pollution in North Pacific food webs.** Matthew S. Savoca, Susanne Kühn, ChengJun Sun, Stephanie Avery-Gomm, Anela Choy, Sarah Dudas
2. **Assessing impacts of plastic accumulation in Laysan Albatross (*Phoebastria immutabilis*) chick growth and body condition.** K. David Hyrenbach, Dan Rapp, Sarah Youngren, and Paula Hartzell
3. **Field measurements reveal the risk of microplastic ingestion by filter-feeding megafauna.** Shirel R. Kahane-Rapport, Max F. Czapanskiy, James A. Fahlbusch, Ari S. Friedlaender, John Calambokidis, Jeremy A. Goldbogen, and Matthew S. Savoca
4. **Occurrence and risk assessment of microplastics in various shellfish from the two major coastal cities of China.** Jinfeng Ding, Jingxi Li, Chengjun Sun, Fenghua Jiang and Peng Ju
5. **(Invited) Widespread plastic ingestion in an abundant pelagic fish species, *Alepisaurus ferox*, across the subtropical North Pacific.** Anela Choy, Sierra M. Byrne, Jennifer A.T.K. Wong-Ala, Elan J. Portner, and Phoebe A. Woodworth-Jefcoats
6. **Ecological risk assessment of waterborne microplastic particles in the marine environments of Korea.** Won Joon Shim, Jae-Woong Jung, June-Woo Park, Soeun Eo, Jinsoo Choi, Young Kyoung Song, Youna Cho, and Sang Hee Hong
7. **First estimates on the amount of water-borne microplastics entering the ocean from the Korean Peninsula.** Seung-Kyu Kim, Hee-Jee Lee, and Ji-Su Kim
8. **Prevalence of small high-density microplastics in continental shelf and deep-sea waters of East Asia.** Soeun Eo, Sang Hee Hong, Young Kyoung Song, Gi Myung Han, Seongbong Seo and Won Joon Shim,
9. **(Invited) Polyolefins and the effect of biofouling on their sinking behaviours in the oceanic water column.** Sarah-Jeanne Royer, Kayla C. Brignac, and Laurent Lebreton
10. **(Invited) Litter and microplastics monitoring in the Arctic under the Arctic Council's Arctic Monitoring and Assessment Programme (AMAP).** Jennifer F. Provencher, Eivind Farmen and Jan Rene Larsen

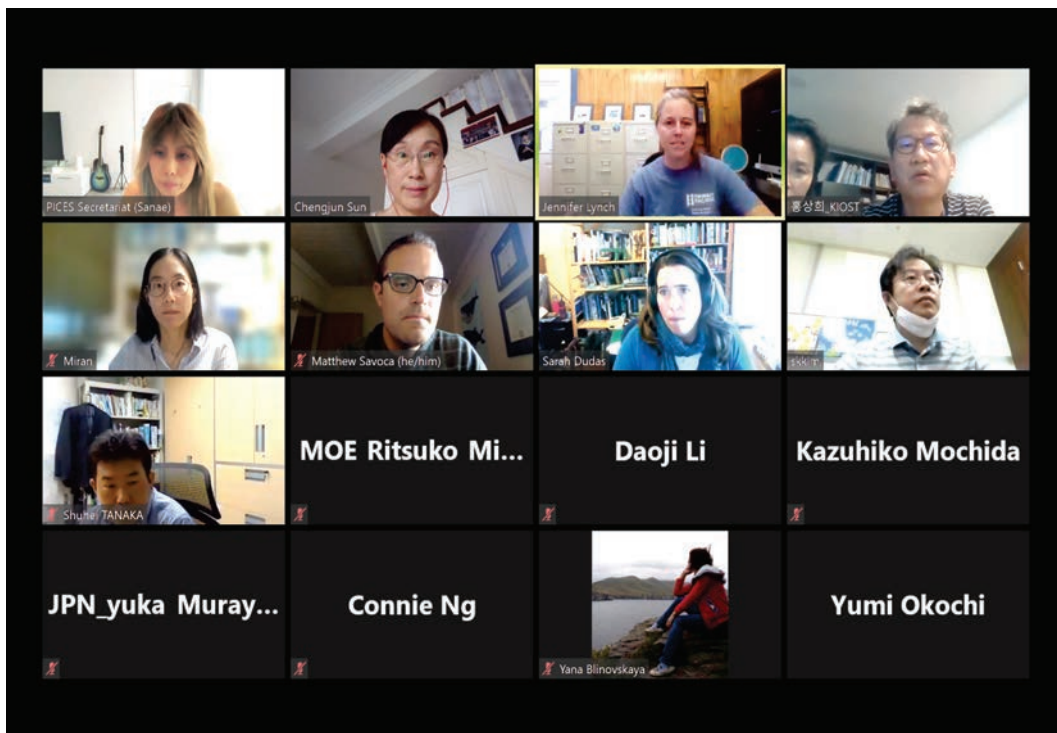
11. **Using shellfish as potential microplastic pollution indicator.** Chengjun Sun, Jinfeng Ding, Jingxi Li, Peng Ju, and Fenghua Jiang

E-Poster presentation

1. **A close relationship between microplastic contamination and coastal area use pattern.** Mi Jang, Won Joon Shim, Youna Cho, Gi Myung Han, Young Kyoung Song and Sang Hee Hong
2. **Microplastics and microfibers in surface waters of Monterey Bay National Marine Sanctuary, California.** Lauren M. Kashiwabara, Shirel R. Kahane-Rapport, Chad King, Marissa De Vogelaere, Jeremy A. Goldbogen, and Matthew S. Savoca
3. **Importance of seasonal sea ice in the western Arctic Ocean to the Arctic and global microplastic budgets.** Seung-Kyu Kim, Hee-Jee Lee, Ji-Su Kim, Sung-Ho Kang, Eun-Jin Yang, Kyoung-Ho Cho, Zhexi Tian, and Anthony Andrady
4. **Importance of point source to microplastic accumulation in Antarctic environment.** Ji-Su Kim, Seung-Kyu Kim, and In-Young Ahn

2021 Report of Working Group on *Indicators of Marine Plastic Pollution*

The Working Group on *Indicators of Marine Plastic Pollution* (WG 42) held its annual meeting virtually on September 23, 2021. Fourteen members and four observers were in attendance over the 3-hr zoom meeting hosted by PICES and monitored by Dr. Sanae Chiba (*WG 42 Endnote 1*). The meeting was co-chaired by Drs. Jennifer Lynch and Chengjun Sun who welcomed the participants. After calling the meeting to order, Dr. Lynch reviewed the meeting agenda. The agenda was adopted (*WG 42 Endnote 2*).



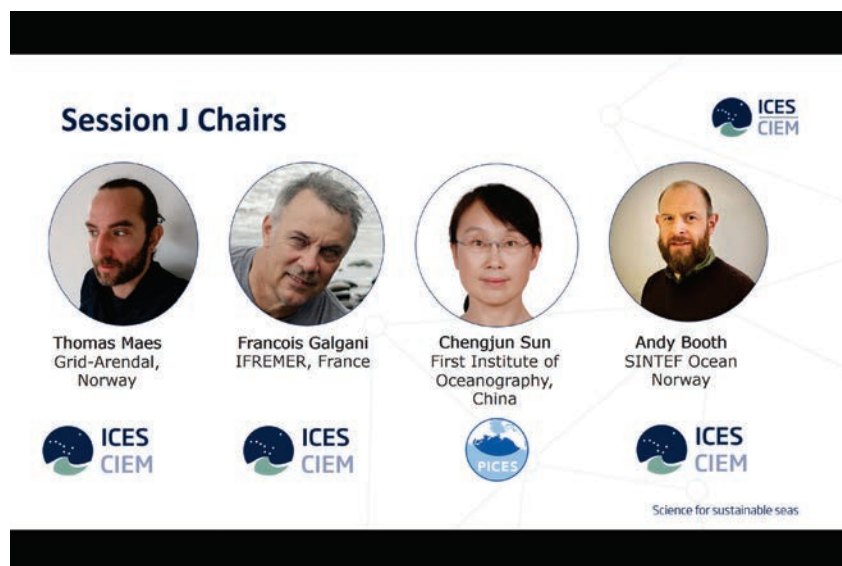
WG 42 virtual meeting participants during PICES-2021.

AGENDA ITEM 2

Achievements

Dr. Lynch reviewed the presentation prepared by Dr. Sun and herself to be submitted to parent committee MEQ. WG 42 is on track for 4 out of the 5 planned companion review articles for submission to *Environmental Pollution*. Working Group members participated in many international conferences (see table below for just a select few), including the International Symposium on “Plastics in the Arctic and Sub-Arctic Region. Members also hosted, co-hosted or chaired multiple workshops and conference sessions. Two Ocean Sciences Meeting 2022 sessions will be organized by WG 42 members: OS07 “Environmental indicators of plastic pollution in the North Pacific” by Savoca et al. and CT04 “Chemical methods to understand marine plastic pollution quantities, sources, transport, fate, impacts, and solutions” by Lynch et al. have been accepted. Dr. Sun participated in ICES Annual Science Conference 2021 representing PICES and co-hosted session J on “*Advances and challenges in marine litter pollution*”.

No.	Conference	Time	Place	Participants	Role
1	International Symposium on “Plastics in the Arctic and Sub-Arctic Region”	March 2–4, 8–9, 2021	Reykjavik, Iceland	Matt Savoca, Seung-Kyu Kim	Attendees
2	Global Microplastic Symposium	April 13–15, 2021	Virtual	Wonjoon Shim	Presenter
3	Europe SETAC 2021 (Society of Environmental Toxicology and Chemistry) Annual Meeting	May 3–6, 2021	Virtual	Wonjoon Shim	Presenter
4	3 rd National Microplastic Conference of China	June 7–9, 2021	Qingdao, China	Chengjun Sun	Organizer and Presenter
5	ICES ASC 2021	Sept. 6–10, 2021	Virtual	Chengjun Sun	Theme Session co-chair
6	PICES-2021	Oct. 25–29, 2021	Virtual	Chengjun Sun, Sanghee Hong, Matthew Savoca	Topic Session co-chairs



AGENDA ITEM 3

Review of TOR and Review article timeline

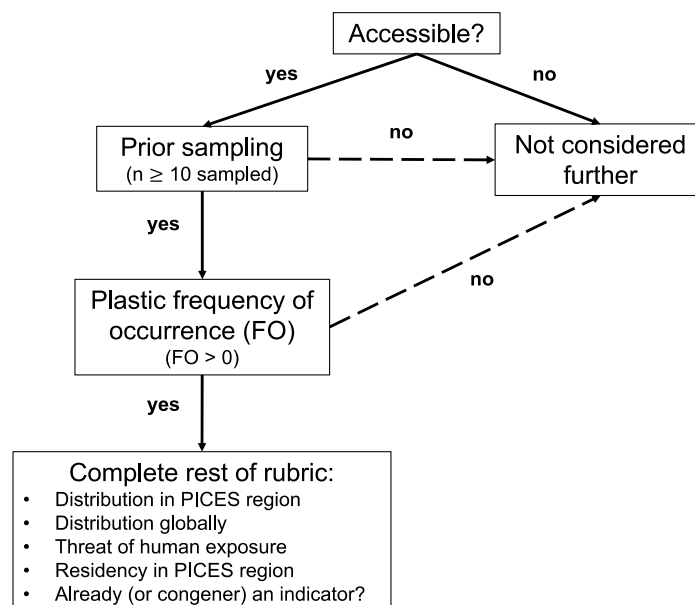
Jennifer Lynch reviewed the WG TOR. We are on track of our TORs. For the TOR on the review papers, we have made significant progress on four review articles for plastic pollution in seawater, shoreline, sediment and biota ingestion, and one overview summary paper. For the TOR on identifying indicators, methods for seawater, shoreline, sediment and biota ingestion have been proposed in each review. For the TOR on recommending monitor guidelines and target, we have begun to discuss target improvement goals, but may not make much progress on this in the review articles. For the TOR on convening meetings or special issues, we have convened 2019 and 2021 PICES topic sessions and are preparing 5 review articles for a Virtual Special Issue in *Environmental Pollution*.

We have set our timeline for the review articles. We are about two to three months behind schedule. Now we plan to finish the first draft of the papers by September 30, 2021 and then go through necessary internal review process before submitting before June 30, 2022.

AGENDA ITEM 4

Review article updates

1. Sea surface and water column – Dr. Wonjoon Shim presented progress on the review paper about marine plastics in the sea surface and water column. A total of 175 papers with 204 data sets on microplastics, 60 papers on meso- and macroplastics were reviewed. Review results show that the North Pacific is the most polluted ocean, but existing data are still limited to allow for analyzing the spatial trends and pollution trend in the region. We discussed the best way to present data. We also discussed sampling technique for long-term monitoring and the impact of proposing one. The presentation will be uploaded to Google docs for sharing among the group.
2. Shoreline – Dr. Amy Uhrin was not able to attend. Dr. Wonjoon Shim and Dr. Jennifer Lynch filled in on the progress of the paper. This group is trying to get raw data from the authors and it is taking longer than expected.
3. Sediment and seafloor – Dr. Shuhei Tanaka presented progress on the review paper on microplastics in sediment and seafloor globally, including freshwater and other ocean basins. The paper is about 80% finished. He presented a raw data sheet and all the comparisons that have been conducted. We also discussed microplastic extraction from the sediment. No target goal has been set yet. We also discussed how to assess the risk of microplastics. Dr. Lynch mentioned two papers on meta-analysis and risk assessment of microplastics in the ocean. The presentation will be uploaded to Google docs for sharing among the group.
4. Biota ingestion – Dr. Matthew Savoca introduced in detail the progress on the biota paper. The first draft of the paper has been sent to all the co-authors for review. Following suggestions from previous online discussion and last year's meeting, a rubric was created to score indicators, based on the following chart. Suggested indicators included invertebrates (*Mytilus edulis*, *Crassostrea gigas*, *Venerupis philippinarum*), sea turtles (*Caretta caretta*, *Chelonia mydas*), fish (*Alepisaurus ferox*, *Coryphaena hippurus*, *Engraulis* spp.) and seabirds (*Fulmarus glacialis*, *Oceanodroma leucorhoa*, *Phoebastria immutabilis*, *Phoebastria nigripes*). A draft of the paper is almost ready for agency internal review.



We discussed the FO (frequency of occurrence) data presented in the slides and also the rubric number assignment. We also looked into the paper format requirements from *Environmental Pollution*.

5. Biota entanglement – Dr. Lynch updated on the progress of this paper. It is falling a little behind. A new report on terrestrial migration animals provided by Jennifer Provencher was introduced. This report might be used for future reference in this paper. We discussed whether we really need to commit to this paper due to the complicated nature of entanglement. However, this paper will not hold up publishing of the other papers. As an alternative approach, we might consider a summary paper that summarizes the other four papers. This paper might use the OA fee requested from PICES.

AGENDA ITEM 5

Recommend indicators and target improvement goals

Covered in Agenda Item 4.

AGENDA ITEM 6

Plan for review article submission to *Environmental Pollution*

Each of the above papers will be submitted when they are ready. All of the papers will run as a virtual special issue which means each manuscript can be submitted individually when it is ready. After all the papers are in, we will ask the journal to bundle all the papers together in a virtual special issue and an announcement will be posted on the journal's website. More communications with the journal will be conducted.

The following timeline was agreed upon.

- Each paper will have a breakout group meeting by end of November 2022.
- The next WG 42 meeting will be in January 2022 where we will discuss paper progress, indicator selections, and target reduction recommendations. Literature beyond Jan 2022 will not necessarily be included.
- Co-author review will begin May 2022.
- WG 42 review will start June 2022.
- Agency internal reviews will start in August 2022.
- Journal submission will be targeted for October 2022.

Environmental Pollution journal is interested in our companion review articles. There is no fee for regular submission, but the fee for open access is \$3550 per paper. Dr. Takada requested we look at submitting to *Environmental Monitoring and Contaminants Research* (EMCR), a new journal.

AGENDA ITEM 7

2021 topic session

Drs. Sun, Songhee Hong and Matthew Savoca are the convenors of this year's topic session S8 on *Using environmental indicators to assess baselines, targets, and risk of plastic pollution in the North Pacific* at PICES-2021. The session starts on October 27, Pacific Standard Time. We received 16 oral presentation requests. Since our session is only open for two hours, we tried to accommodate as many orals as possible. In the end, we fit 11 talks and 4 e-posters into the session. (It turned out to be a great success.)

AGENDA ITEM 8

Report of WG 42

Drs. Lynch and Sun have finished the report to the WG's parent committee MEQ. We prepared both .doc and .ppt formats of the report. Final report to PICES will wait for the outcome of how the WG go forward, either being extended or changed to an Advisory Panel or Section. We briefly talked about presenting our review papers as a main part of the WG report at the end of our term.

AGENDA ITEM 9

Define future of WG 42

Dr. Lynch presented options as an Advisory Panel or a Section if we would like the WG to go forward. Dr. Sanae Chiba, PICES Deputy Executive Secretary, provided information on how PICES works and explained the options. With her help, the WG made the decision to ask Science Board for a one-year extension, through our parent Committee. We also discussed the focus on microplastics, whichever way we move. Dr. Lynch nominated Dr. Jennifer Provencher to take over the leadership of the proposed group, if it is accepted by Science Board and Governing Council.

AGENDA ITEM 10

PICES financial request

WG 42 will publish the group's papers in *Environmental Pollution*. There is no fee for regular submission, but the fee for open access is \$3550 per paper. The WG will request one open access fee to be covered by PICES. We have not decided on which paper will go with open access.

Dr. Savoca requested financial support to cover the registration fee for attending the Ocean Science Meeting 2022.

AGENDA ITEM 11

Other business

WG 42 will discuss PICES-2022 session proposals offline.

WG 42 Endnote 1**WG 42 participation list**Members

Jennifer M. Lynch (USA, Co-Chair)
 Chengjun Sun (China, Co-Chair)
 Sarah Dudas (Canada)
 Jennifer Provencher (Canada)
 Connie Ka-yan Ng (China)
 Sang Hee Hong (Korea)
 Wonjoon Shim (Korea)
 Mochida Kazuhiko (Japan)
 Kazuhiko Mochida (Japan)
 Shuhei Tanaka (Japan)
 Miran Kim (Korea)
 Daoji Li (Korea)
 Iana Blinovskaia (Russia)
 Matthew Savoca (USA)

Members unable to attend

Canada: Peter S. Ross
 China: Juying Wang
 Korea: Seung-Kyu Kim
 Russia: Nikolai Kozlovskii
 Japan: Hideshige Takada
 USA: Amy Uhrin

Observers

Sanae Chiba (PICES Deputy Executive Secretary)
 Murayama Yuka (Japan)
 Yumi Okochi (Japan NUS Co., Ltd.)
 Ritsuko Minaekishi (Japan, MOE)

WG 42 Endnote 2**WG 42 meeting agenda**

1. Welcome and adoption of agenda (chairs)
2. Achievements of WG 42 (chairs)
3. Review of WG 42 Terms of Reference and Review article timeline (chairs)
4. Review article updates (leads)
 - a) Sea surface and water column – Wonjoon Shim
 - b) Shoreline – Amy Uhrin
 - c) Sediment and seafloor – Shuhei Tanaka
 - d) Biota ingestion – Matthew Savoca
 - e) Biota entanglement – Jennifer Lynch
5. Discuss recommended indicators and target improvement goals
6. Discuss plan for review article submission to Environmental Pollution
7. Announce 2021 topic session
8. Final report of WG 42 is due to PICES
9. Define future of WG 42
 - a) Advisory Panels or Section?
 - b) Term of Reference
 - c) Chair(s)
10. PICES financial request
 - a) Open access fees for one paper – which one?
 - b) Conference travel/registrations
 - i. PacifiChem
 - ii. Ocean Sciences Meeting
 - iii. Others
11. Other business (All)

Ocean Sciences Meeting 2022

February 28–March 4, 2022, Waco, USA

OS07 Environmental indicators of plastic pollution in the North Pacific

Organizers:

Matthew Savoca,⁴ msavoca13@gmail.com

ChengJun Sun, csun@fio.org.cn

Won Joon Shim, wjshim@kiost.ac.kr

Patrick O'Hara, patrick.ohara@canada.ca

Small fragments of plastic debris – known as meso- and microplastics – are pervasive in marine systems. The North Pacific is among the most polluted oceanic regions worldwide in regard to synthetic debris. Sampling a vast and varied system for debris is challenging; therefore, having environmental indicators of plastic debris is critical to assess the status and trends of plastic pollution in addition to predicting ecosystem risk and quantifying potential impacts. This session will identify and discuss potential organismal and non-organismal (e.g., sediments) indicators of small synthetic material in the North Pacific and its marginal seas. Presenters may also focus on indirect indicators of plastic pollution, such as plastic additives leading to chemical contamination in organismal tissues. A deeper understanding of these marine debris sentinels will help us elucidate the status and trends of small plastic pollution and associated environmental impacts in the North Pacific, thus allowing us to make informed decisions for plastic usage and litter management policies in the region and elsewhere. This information will be vital to achieve the clean ocean called for under the UN Decade of Ocean Science for Sustainable Development (2021-2030).

Co-sponsors: PICES

Relative abundance of derelict fishing gear intercepted by pelagic longlines as a potential marine debris indicator in the North Pacific Ocean

Amy Uhrin, William Walsh, Jon Brodziak

Quantities and characteristics of plastic debris ingested by sea turtles from East Asian waters

Ye Lim Moon, Gi Myung Han, **Won Joon Shim**, Jongwook Jeong, Youna Cho, Il-Hoon Kim, Hae-Rim Lee, **Sang Hee Hong**

Proposing bioindicators to monitor plastic pollution in the North Pacific

Matthew Savoca, Susanne Kühn, **Chengjun Sun**, Stephanie Avery-Gomm, Anela Choy, **Sarah Dudas**, **Sanghee Hong**, David Hyrenbach, Tsung-Hsien Li, **Connie Ng**, **Jennifer Provencher**, **Jennifer Lynch**

Review and metadata analysis of floating plastics in the North Pacific Ocean: Global comparison and recommendation for a pollution indicator

Wonjoon Shim, **Seung-Kyu Kim**, Jongsu Lee, Soeun Eo, Ji-Su Kim

An ideal biomonitoring program for plastic pollution in the Pacific Ocean: Sea turtles from the Hawaiian and American Samoan longline observer programs

Jennifer Lynch, Katherine Shaw, Thierry Work, Shandell Brunson, George Balazs, Jamie Marchetti, Rebecca Pugh, Summer Martin, T. Todd Jones

Developing ecosystem metrics of plastic ingestion by Hawaiian seabirds

K. David Hyrenbach, Jessie Beck, Daniel Rapp, Sarah Youngren, Megan Duhr, Cynthia Vanderlip

⁴ Organizers and authors in bold face denote WG 42 members.

CT04 Chemical methods to understand marine plastic pollution quantities, sources, transport, fate, impacts, and solutions

Organizers:

Jennifer Lynch, jennifer.lynch@nist.gov

Katherine Shaw, katherine.shaw@nist.gov

Sarah-Jeanne Royer, sroyer@hpu.edu

Sanghee Hong, shhong@kiost.ac.kr

Samreen Siddiqui, samreen_siddiqui@outlook.com

Plastic marine debris is a global problem and increasing every year. Synthetic polymers have diverse molecular structures, additives, environmental transport and fates, contaminant affinities, and degradation rates, thus having different impacts on exposed organisms. Chemical techniques are needed to answer fundamental questions related to plastic pollution and this session aims to highlight studies that encompass diverse topics. Topics may include: 1) production of nano- and microplastic standards, 2) development of optimal or harmonized methods to detect, identify, and quantify polymers (nano to mega sized) in complex environmental samples, 3) measurements of weathering rates and processes, 4) investigations into the fate of additive chemicals and other contaminants sorbed onto plastic debris, and 5) assessments of toxicological effects and ecological risk of polymers and associated chemicals. The marine debris problem affects every facet of ocean science, and chemical methods are direly needed to address the quantities, types, source, movement, fate, and impacts of the plastic found in every zone of the ocean.

Co-sponsors: PICES

Drifting Polystyrene as Source of New Global Contamination in the Ocean

Koshiro Koizumi, Hideki Kimukai, Hideto Sato, Akifumi Okabe, Seon-Yong Chung, Masahiko Nishimura, Katsuhiko Saido

Chemical pollution and toxicity due to drifting plastic degradation

Katsuhiko Side, Hideki Kimukai, Koshiro Koizumi, Akifumi Okabe, Keug Tae Kim, Sarah-Jeanne Royer, Nobuo Suzuki, Takashi Kusui, Katsuhiko Saido

Searching for microplastics in the “plasticene”: microplastic accumulation rate in the marine sediments of the Ebro Prodelta (NW Mediterranean)

Laura Simon-Sánchez, Michaël Grelaud, Claudia Lorenz, Jordi Garcia-Orellana, Alvis Vianello, Fan Liu, Jes Vollertsen, Patrizia Ziveri

Plastic pellet consumption in sea anemones

Zoie Diana, Megan Swanson, Nelson Rivera Jr., Heileen Hsu-Kim, Daniel Rittschof

Three stage screening process finds no ingested plastics in Marshall Islands reef fish

Katherine Shaw, Jonathan Whitney, Madeline Schmidbauer, Eileen Nalley, Megan Donahue, Jesse Black, Raquel Corniuk, Kellie Teague, Rachel Sandquist, **Jennifer Lynch**

Comparison of levels of microplastics in raw salts from salterns and table salt used for human consumption in Sri Lanka

Rupika Rajakaruna, R.W.M.G.K. Kapukotuwa, Nilmini Jayasena, Krishni Weerakoon, Charmalie Abayasekara, Rupika Rajakaruna

EPA trash free waters: Directions in microplastics research

Courtney Arthur, Romell Nandi, Nizanna Bathersfield, Meagan Currie, Eric Ruder

Methods for controlled preparation and dosing of microplastic fragments in bioassays

Hayden Boettcher, Jonathan Cohen, Tobias Kukulka

Tracking the weathering patterns of different types of plastics under long-term UV exposure

Xiangtao Jiang, Scott Gallager, Rut Pedrosa Pàmies, Emil Ruff, Zhanfei Liu

Utilizing chemometrics to differentiate polymers comprising floating derelict fishing gear on O'ahu, Hawai'i

Raquel Corniuk, Kayla Brignac, Andrew McWhirter, Granya Boyd, Hank Lynch, Sarah-Jeanne Royer, Katherine Shaw, **Jennifer Lynch**

From nano to megaplastics: An overview of chemical methods for plastic pollution

Kellie Teague, Katherine Shaw, Meredith Seeley, Raquel Corniuk, Kayla Brignac, Rachel Sandquist, Sarah-Jeanne Royer, Andrew McWhirter, Cara Megill, Ray Aivazian III, K. David Hyrenbach, John Kucklick, **Jennifer Lynch**

Potential high throughput, low-cost method combining polarized light microscopy and Nile red staining to detect microplastics

Christine Knauss, Jacob Goodwin, Elizabeth North

The 7th International Marine Debris Conference September 18–23, 2022, Busan, Korea

TS-2.1 Ecological Risk Assessment Frameworks for Determining the Risk to Natural Resources from Marine Debris

Chaired by

Ms. Carlie E. Herring (NOAA)

Dr. Wonjoon Shim⁵ (Korea Institute of Ocean Science and Technology)

The overall goal of this session is to gain a better understanding of the types and utility of various ecological risk assessment frameworks and how these may be adapted to assess risk to marine and freshwater resources from marine debris. We welcome presentations that have applied or modified ecological risk assessment (ERA) frameworks currently employed to address risk assessment approaches for marine debris. Presentations will also address the importance of the following ERA processes: problem formulation (including, identifying research and management questions, defining your study region, and identifying assessment endpoints), constructing conceptual frameworks, identifying and characterizing exposure (environmental exposure levels) and effects (from dose-response data to derive 'safe' concentrations/doses for ecosystem), and finally calculating risk and evaluating uncertainty and sensitivity of the risk calculations. Presenters will also discuss data considerations (how to utilize different types of datasets, assigning causality, dealing with gaps/uncertainty, etc.), risk assessment and risk management applications, and the importance of scale (temporal, spatial, biological).

Through this session we hope to answer the following questions: What are the different types of ERA and the benefits and limitations of each? Why is it important to construct conceptual frameworks prior to conducting a risk assessment? What types of tools can and should be incorporated into marine debris research to facilitate risk assessment (lessons learned from other fields)? How to incorporate different types of environmental data into risk assessments? An additional outcome of this session is to connect researchers in both fields and encourage collaboration on future studies.

- **Hidden treasures amongst the trash: a socio-ecological risk assessment of marine debris in the Florida Keys**
Ms. Tokea Payton, Dr. Michael Childress
- **First steps towards an Assessment of plastic Risk to the Environment (FARE)**
Dr. Andy Booth, Dr. Amy Lusher, Dr. Martin Wagner, Dr. Lisbet Sørensen, Dr. Thomas Maes
- **A risk management framework for the State of California and its application to the Laurentian Great Lakes**
Dr. Chelsea Rochman, Ms. Eden Hataley, Ms. Dimple Roy, Dr. Alvine C., Dr. Scott Coffin, Dr. Albert Koelmans, Dr. Susanne Brander, Dr. Martin Wagner, Dr. Leah M. Thornton Hampton, Dr. G. Allen, Dr. Ezra, Dr. Todd Gouin, Dr. Steve Weisberg
- **Ecological risk assessment of marine microplastic particles in Korean waters**
Dr. Wonjoon Shim, Dr. Jae-Woong Jung, Dr. June-Woo Park, Ms. Soeun Eo (Korea), Ms. Jin Soo Choi, Dr. Young Kyoung Song, Ms. Youna Cho, Dr. Sanghee Hong

⁵ Chair or author in bold face denotes a WG 42 member.

- **Understanding plastic litter impacts on wildlife in data poor aquatic systems: Demonstrating a novel risk matrix framework using a case study of the Mekong and Ganges River Basins**
Dr. Lauren Roman, Dr. Qamar Schuyler, Dr. Britta Denise Hardesty
- **Risk assessment of marine debris to seabird using InVEST Habitat Risk Assessment model**
Mr. Gang Sun Kim, Ms. Sujung Heo, Dr. Choong Ki Kim, Mr. Junsung, Dr. Hyun-Jung Hong, Dr. Hyun-woo Lee, Dr. Lee SeungHyun

TS-2.2 Inland to the Ocean: Evaluating Sources, Pathways, Fate and Transport from Upstream to Prevent Ocean Plastic

Chaired by

Dr. Jenna Jambeck (University of Georgia)

Dr. Amy V. Uhrin (NOAA Marine Debris Program)

While the movement of marine debris has been relatively well studied in oceanic surface waters, the fate and transport of debris in rivers and other upstream sources is less studied. Rivers and estuaries are known transporters of marine debris to coastal waters. However the processes involved in the transport of marine debris in riverine systems, estuaries, and bays are not as well understood, though research on this topic is emerging. These systems have many complexities that may affect the ultimate fate and transport of debris, including physical factors, such as wind, waves, tidal influences, currents, and frontal zones between estuarine and coastal ecosystems; biological factors, such as biofilms, or even submerged aquatic vegetation that may result in the settling of debris to sediments; as well as the shape, size and profile of a specific river/estuary/bay.

In this session we invite presentations that delve into the fate and transport of marine debris focusing on upstream to downstream sources and pathways. Presentations in this session will investigate and identify the critical input pathways for marine debris introduction into the coastal zone (e.g., surface runoff, stormwater discharge, wind-driven transport, etc.), evaluate factors that may influence riverine transport downstream, as well as any sinks or transformation processes (e.g., degradation and fragmentation of debris) that may occur during transport.

Preventing plastic and other anthropogenic litter from entering rivers protects the entire watershed and people living in it. Ultimately, to prevent and mitigate marine debris from entering the ocean, we need to understand the sources, evaluate pathways in which debris may enter the aquatic environment, and any sinks that remove debris from these pathways. Research on the fate and transport of debris from upstream sources and pathways to downstream coastal waters will also improve our understanding and estimation of how much debris is transported to coastal waters from inland sources, informing mass balance equations of debris inputs and sinks in the environment. Data from these projects can also inform policy- and decision-making for reducing plastic inputs upstream.

- **Confronting previous estimates of plastic losses to the ocean with empirical evidence**
Dr. Britta Denise Hardesty, Dr. Qamar Schuyler, Mr. TJ Lawson, Dr. Chris Wilcox)
- **Improving subnational estimates of litter leakage to the ocean: a case study in Brazil**
Ms. Melanie Alencar, Dr. Carla Elliff, Ms. Bianca Gimenez, Ms. Vitória Scrich, Ms. Letícia Rodrigues, Ms. Camila Sasahara, Prof. Sylmara Dias, Dr. Tiago Cetrulo, Prof. Luis Conti, Prof. Alexander Turra
- **Riverine input is more important contributor to microplastics in coastal region: Plastic budget estimation**
Prof. Seung-Kyu Kim, Ms. Ji-Su Kim, Ms. Nan-Seon Song, Ms. Hee-Jee Lee
- **Spatial and temporal heterogeneity in microplastic fate and impact in the Lake Ontario watershed**
Prof. Christy Tyler, Ms. Carmella Bangkong, Ms. Kristina Chomiak, Ms. Mechelle Cureaux, Dr. Juliette Daily, Prof. Steven Day, Prof. Nathan Eddingsaas, Dr. Matthew Hoffman, Dr. Andre Hudson, Ms. Olivia Martin
- **Seasonal variations of fate and transport of plastic debris in global scale**
Dr. Tadanobu Nakayama, Dr. Masahiro Osako
- **Experiment: Plastic Debris Transport on Land Driven by Wind and Rain**
Ms. Yvette Mellink, Dr. Tim van Emmerik, Dr. Thomas Mani

TS-2.4 Behavior and Fate of Nano- and Microplastics in the Atmosphere and Ocean

Chaired by

Dr. Wonjoon Shim (Korea Institute of Ocean Science and Technology)

Dr. Chengjun Sun (First Institute of Oceanography, Ministry of Natural Resources, China)

The overall goal of this session is to gain a better understanding of the behavior and fate of nano- and microplastics introduced to the atmosphere and ocean. Nano- and microplastics are emitted from various sources to atmosphere and ocean or produced by weathering in the ocean from large plastic particles. It is expected that nano- and microplastic will experience very complex processes in these two different media, but there has still been a big scientific knowledge gap in this research field.

This session welcomes presentations that reveal environmental processes influencing the behavioral aspects and fate of nano- and microplastics in atmosphere and ocean. Presentations may address the importance of the following environmental processes and relative contribution of environmental factors with relation to physicochemical properties of plastic particles. In the atmosphere, these processes and factors include lifting/ejection mechanisms from land and ocean, horizontal and vertical movement, photochemical reaction and weathering, and wet/dry deposition mechanisms. In the ocean, these processes and factors include biological interaction (aggregation, biofouling, ingestion and feces ejection, and ingestion and vertical migration) related to sinking, sinking flux, fragmentation by natural weathering, and resuspension and burial in seafloor sediment. Development and running practice of environmental fate model of nano- and microplastics is also welcomed.

Through this session we hope to answer the following questions: What are the major environmental process governing the fate of nano- and microplastics in the atmosphere and ocean? What are unknown and important fate so far? What type of environmental process should be incorporated and parameterized in a nano- and microplastic environment fate model? Answers to these questions will provide comprehensive knowledge and foster more in-depth research on the behavior and fate of nano- and microplastics in the atmosphere and ocean.

- **How fast nano- and microplastic particles can be fragmented from thermoplastics by accelerated sun-light simulated photooxidation**
Dr. Young Kyoung Song, Ms. Soeun Eo, Dr. Sanghee Hong, **Dr. Wonjoon Shim**
- **Deciphering the role of atmospheric transport in marine microplastic pollution**
Dr. Kai Liu, Dr. Daoji Li
- **Microplastic as a long-range transporter of chemical additives to the Canadian Arctic**
Ms. Bonnie Hamilton, Dr. Alison Criscitiello, Dr. Amila De Silva, Dr. Cora Young, Ms. Christine Spencer, Dr. Chelsea Rochman
- **Ingestion of microplastics by mesozooplankton in the East Sea, Korea: possible vertical movement of microplastics by mesozooplankton**
Dr. Jung-Hoon KANG, , Mrs. Minju Kim, **Dr. Sanghee Hong**, **Dr. Wonjoon Shim**

TS-8.14 Untangling: Innovative Solutions for Lost Fishing Gear Management

Chaired by

Ms. Joan Drinkwin (Natural Resources Consultants)

Ms. Ingrid Giskes (Global Ghost Gear Initiative)

Abandoned, lost, and discarded fishing gear (ALDFG) can wreak havoc in the marine environment, causing damage to sensitive nearshore habitats, compromising fishing harvests, and entangling non-target species such as mammals and birds. Managing abandoned, lost, and discarded fishing gear (ALDFG) requires management actions, behavior changes, and accurate data collection at different scales. This session will explore several complementary approaches to managing ALDFG. The importance of effective and accurate data collection is critical to understand both the effects of ALDFG as well and the effectiveness of management measures. This session will showcase an ongoing program documenting entanglement of a population of seals and will explore the value of pre- and post-monitoring to evaluate the effectiveness of ALDFG retrieval as compensation for natural resources damages. Also featured in this session will be a presentation of a large-scale modelling project designed to identify areas where drifting fish aggregation devices may beach in the Pacific and an innovative fishing gear position tracking technology designed to reduce gear loss. Finally, the session will include an overview of Canada's national program aimed at managing and preventing abandoned, lost, and discarded fishing and aquaculture gear as part of the countries efforts to reduce plastics in the environment. These varied approaches to managing and preventing ALDFG highlight the many different types of strategies necessary to address ALDFG in different fisheries and different geographies.

- **Entangled Seals: Impact of lost fishing gear on grey seals in the SW UK – welfare issue and mortality**

Mrs. Sue Sayer

- **Marine Debris Removal as Compensatory Restoration in Natural Resource Damage Assessment**

Dr. Amy V. Uhrin, Dr. Caitlin Wessel, Ms. Marla Steinhoff

- **Modelling drifting fad trajectories arriving at essential habitats for sea turtles**

Dr. Lauriane Escalle, Dr. Joe Scutt Phillips, Dr. Alexandre Aires-da-Silva, Ms. Raquel Corniuk, Dr. John Hampton, Dr. Jon Lopez, **Dr. Jennifer M. Lynch**, Mr. Andrew McWhirter, Dr. Hilario Murua, Dr. Victor Restrepo, Dr. Sarah-Jeanne Royer, Dr. Yonat Swimmer, Dr. Gala Moreno

- **Canada's Approach to Ghost Gear Reduction**

Mrs. Marilyn Sweet

- **Smart Buoy Tracking of Fixed Fishing Gear to Prevent Loss**

Dr. Kortney Opshaug

TS-2.17 Debris Accumulation in Wetlands: Sinks & Physical Impacts

Chaired by

Dr. Amy V. Uhrin (NOAA Marine Debris Program)

Ms. Carlie E. Herring (NOAA)

A growing body of research is documenting the accumulation of marine debris in coastal wetlands (e.g., seagrass, mangroves, salt marsh) indicating that they may serve as possible sinks for marine debris, and should be considered in any mass balance assessment. However, there is a lack of data in this regard. Additionally, the accumulation of marine debris in wetlands can alter and degrade these critical habitats through physical damage caused by abrasion, shearing, or smothering, and through alteration of the physical and chemical composition of sediments which can impair critical nursery, refuge, and forage habitat for many marine fauna. Changes in marine and coastal habitats can alter complex ecosystems and ultimately affect provision of ecosystem services afforded by these habitat elements (i.e., carbon sequestration). Damage to many habitat-forming foundation species by marine debris has not yet been fully characterized.

In this session we welcome presentations that quantify the accumulation of marine debris in wetlands as a means to improve mass balance assessments. Presentations will also quantify the extent of damage to habitat (i.e., area impacted, number of individuals impacted, mortality of individuals) from marine debris, estimate ecosystem service impairment as a result of the damage, monitor recovery of habitat upon removal of debris, and assign value to ecosystem services gained through recovery.

Knowledge of the amount of debris potentially stored in wetlands as well as the impacts of marine debris and the benefit to the environment following removal can help inform resource managers in directing limited restoration funds to projects that produce the greatest gains in ecosystem services.

- **Microplastic pollution in surface waters and sediments matrices of the Sundarbans - the largest single block of tidal halophytic mangrove forest in the world**
Prof. Harunur Rashid, Ms. Kaniz Fatema, Ms. Mansura Akter, Ms. Sabiha Masnoon, Mr. M. A. Mamun Siddiquee, Mr. Md. Helal, Dr. Kizar Ahmed Sumon, Mr. Zahid Sukhan
- **Vegetation does not necessarily affect the vertical or horizontal distribution of microplastics in seagrass beds**
Dr. Janine Ledet, Ms. Clara Yong, Ms. Lynette Ying, Dr. Peter Todd
- **Assessing the extent of macro- and microplastic pollution in the coastal environments around Singapore**
Dr. Jenny Fong, Mr. Jonas Koh, Mr. Yuchen Sun, Ms. Jolin Yean Ai Tan, Mr. Yi Hong Tan, Mr. Samuel Lee Hsien, Ms. Zhen Yu Choy, Ms. Cheng Ling Lim, Dr. Mei Lin Neo
- **Monitoring the effects of plastic marine debris on the growth and health of mangroves within the Kingston Harbour, Jamaica**
Ms. Ajani Bissick, Dr. Ava Maxam, Ms. Damoi, Mr. Romario Anderson

TS-2.12 Plastic transport monitoring from source to the marine environment

Chaired by

Ms. Rose Boahemaa Pinto (Wageningen University)

Currently about 80% of marine plastic debris comes from land-based sources due to inadequate waste management which are transported through riverine systems and eventually into the ocean. This suggests that land-based sources are major contributors for plastic leakage into aquatic systems. Understanding the leakage and transport of plastic waste from source to sea involves various monitoring or modelling methodologies cutting across different areas of expertise, and also require reliable data on waste management. In order to correctly monitor the plastic waste transport from source to sea, a harmonized approach based on standardized methodologies for data collection is much needed.

Therefore, in this session, we focus on two specific aspects that form the chain of plastic leakage from source to the marine environment, i.e., the leakage of Municipal Solid Waste (MSW) from urban areas and waste management systems, and the transport of plastics through urban water systems (e.g., coastal and riverine cities).

We expect contributions from scientists and stakeholders involved in the monitoring of the SDG indicator 11.6.1 (Proportion of MSW collected and managed in controlled facilities out of total MSW generated). Particularly, we expect results related to the use of the monitoring methods such as the Waste Wise Cities Tool for the assessment of MSW management, launched by UN-Habitat in 2021; and the Waste Flow Diagram to estimate plastic leakage and hotspots from MSW management systems, launched by GIZ. Both tools have been applied widely and can contribute to fill relevant data gaps by providing quality primary data in line with the SDG monitoring framework provided by United Nations.

In addition, we encourage researchers to submit their works on macroplastic transport in urban water systems. Since urban water systems provide the link between leakage of MSW and plastic input into freshwater and marine ecosystems, e.g., via transport through rivers and estuaries, it is necessary for the quantification on the distribution of plastics through such systems, especially in low- and middle-income countries, where data availability is low. Data on the macroplastic transport through these water systems helps to estimate the plastic mass transport and identify sources and (temporary) sinks.

- **Solid Waste Pollution Status in the Surmene River Basin**
Dr. Coşkun Erüz, Mrs. Neira Purwenty Ismail
- **Quantities and characteristics of plastic pollution found in communities and shorelines along the Ganges River**
Dr. Amy Brooks, Ms. Surshti Patel, Dr. Imogen Napper, Ms. Emily Barber, Ms. Sunanda Bhola, Mr. Navin Kumar Das, Dr. Emily Duncan, Ms. Ellen Jones, Mr. Avinash Kumar, Dr. Sarah Nelms, Mr. Gaurav Verma, Ms. Kathryn Youngblood, Dr. Brajesh Dubey, Dr. Jenna Jambeck, Prof. Heather Koldewey
- **Catchment-wide rapid assessment of macroplastic pollution in the Odaw river, Ghana**
Ms. Rose Boahemaa, Dr. Tim van Emmerik, Ms. Linda Bogerd, Dr. Martine van der Ploeg, Prof. Remko Uijlenhoet
- **Seabin™ technology to monitor plastic transport from source to the marine environment: parking tickets as a case study**
Mr. Solomon Wadani, Mr. Peter Ceglinski, Mrs. Mahi Paquette, Mr. Jack Vitnell
- **Using GPS Trackers to Investigate Longitudinal and Cross-Sectional Macroplastics Transport at Urban Estuaries**
Dr. Thomas Mani, Dr. Yotwadee Hawangchu, Dr. Pummarin, Dr. Jenyuk Lohwacharin, Dr. Doungkamon Phihusut, Dr. Ratchanon Piemjaiswang

- **Monitoring marine litter and microplastics in a South Atlantic estuarine environment: from sediments to penguins**
Dr. Andres Arias, Dr. Ana Ronda, Mrs. Tatiana Recabarren-Villalon, Ms. Guadalupe Alvarez
- **First monitoring of marine litter accumulated on Madagascar coastline : type, size and origin**
Ms. Aina Faneva Ramanampamonjy, Mrs. Margot Thibault
- **Harmonized Protocols and Indicator Selection towards Future Microplastic Monitoring**
Dr. Chengjun Sun, Ms. Yifan Zheng, Dr. Jingxi Li, Ms. Jinfeng Ding, Mr. Wei Cao

TS-2.13 Chemistry to understand quantities, sources, transport, fate, impacts, and solutions

Chaired by

Dr. John Kucklick (National Institute of Standards and Technology)

Dr. Jennifer Lynch (National Institute of Standards and Technology & Hawai'i)

Plastic pollution, of all sizes from nano to mega, is a global problem and increasing every year. Synthetic polymers have diverse molecular structures, additives, environmental transport and fates, contaminant affinities, degradation rates, impacts on exposed organisms, and waste streams. Chemical techniques are developing to answer fundamental questions related to plastic pollution and to prevent it through circular recycling solutions.

This session aims to highlight chemical technologies and innovations that encompass these diverse topics. Topics may include: 1) improved methods to quantify nano- and microplastics in complex environmental samples and in exposure assessments for toxicity testing, 2) development of chemical documentary or material standards, 3) investigations into the fate of additive chemicals and other contaminants sorbed onto plastic debris, 4) measurements of weathering rates and processes, 5) innovations for recycling post-consumer plastic or pollution removed from the environment. Because chemistry is the basis for all of these plastic pollution research and solution research, this session will share new developments, exchange lessons learned, encourage coordination and co-development of solutions.

- **Microplastic Metrology: Creation and testing of microplastic standard reference materials**
Dr. Katherine Shaw, Mr. Raleigh Aiden Johnson, Mrs. Debra Ellisor, Ms. Rachel Sandquist, Ms. Marquesa Calderon, Ms. Rebecca Pugh, Dr. John Kucklick, **Dr. Jennifer Lynch**
- **Previous successes of and future opportunities for the analysis of environmental plastics with pyrolysis - GC/MS**
Dr. Meredith Seeley, **Dr. Jennifer Lynch**
- **Diffusion-controlled Oxidation in Photodegradation of LDPE in Seawater**
Dr. Anthony Andradý, Dr. Kara Lavender Law, Ms. Jessica Donohue, Ms. Bimali Koongolla
- **Chemical degradation of polyolefins in a seawater tank exposed to natural conditions in Hawai'i**
Mrs. Kellie Teague, Ms. Kayla Brignac, Dr. Ferenc, Ms. Marquesa Calderon, Ms. Elizabeth Walker, Ms. Cara McGill, Mr. Laurent Lebreton, **Dr. Jennifer Lynch**, Dr. Sarah-Jeanne Royer
- **Environmental distribution of styrene oligomers (SOs) coupled with their source Characteristics: tracing the origin of SOs in the environment**
Mr. Zhexi Tian, **Prof. Seung-Kyu Kim**
- **Additive chemicals in plastic marine debris and their new products**
Dr. Mi Jang, **Dr. Sanghee Hong**, **Dr. Wonjoon Shim**, Ms. Youna Cho, Mr. Gi Han, Mr. SungYong Ha

TS-2.16 Mass and Material Balance Approach to Quantifying Plastic Flows

Chaired by

Dr. Thomas Maes (GRID-Arendal)

Dr. Jenna Jambeck (University of Georgia)

Plastic pollution is a global transboundary issue. Analysis of available field studies have identified a significant lack of data needed to construct a simple mass balance box model for plastic pollution. Plastics produced or plastic waste generated in one part of the world have been documented across the globe, even in uninhabited areas. Fundamental information on plastic mass input, transfer and sink terms are simply not available. Also unknown are the rates of accumulation in different environments, the dispersal pathways of plastic particles of different density, the residence times of plastic in the water column and the rate at which macroplastics are transformed into microplastics in different environments.

The risk of plastic pollution on various regions and areas are interdependent with all regions of the world, so a global understanding of the mass flow of plastics, from production – to use – to waste – to environmental contamination, is important when considering solutions to the issue. Filling these information gaps is critical for states to determine adequate response measures, including developing and tracking impact of policies to deal with the problem of plastic pollution.

- **Dynamic Material Flow Analysis to track the mass of plastic waste from Norwegian commercial fishing (2016-2021)**
Dr. Paritosh, Ms. Ragnhild Bjerkvik Alnes
- **Quantifying the stocks and flows of microplastics across Canada**
Ms. Cassandra Sherlock, Dr. Komal Habib
- **Challenges and emerging intervention strategies for plastic waste management in Latin America and the Caribbean**
Dr. Amy Brooks, Dr. Jenna Jambeck, Dr. Eliana Mozo-Reyes
- **Plastic Waste Flow Analysis in Three Select Ports of the Philippines**
Mr. Ezra Osorio, Dr. Maria Antonia Tanchuling, Mrs. Brianna Cueco-Inocencio, Mr. Benedict Requejo, Mr. Philip Andrew Lu, Mr. Sinford Anthony Ty, Mr. Leocer John Bularan, Mrs. Czarina Constantino - Panopio
- **Macroplastics transport in the coastal mangrove areas around Cebu Island: Looking at the mangrove retention parameter as an indicator for dominant transport rates**
Dr. Ian Dominic Tabañag, Ms. Anna Lorraine Espiloy, Ms. Fraulein Angela Francisco, Ms. Shaira Kyle Tagalog, Dr. Maria Kristina Paler, Dr. Francis Dave Siacor, Dr. Paul John Geraldino, Dr. Evelyn Taboada, Dr. Mark Edward Walton, Dr. Christian Dunn, Dr. Martin Skov, Dr. Jan
- **Can the Arctic Ocean sediment be an important sink of missing plastics in global budget?**
Prof. Seung-Kyu Kim, Ms. Ji-Su Kim, Dr. So-Young Kim, Ms. Nan-Seon, Dr. Hyeong-Sul Ra, Dr. Eun-Jin Yang, Mr. Byeongyong Park
- **Taking a mass-balance approach to assess marine plastics in the South China Sea**
Dr. Thomas Maes, Dr. Peter Harris
- **Quantification of plastic pollution on global coastlines**
Ms. Xia (Alice) Zhu, Dr. Chelsea Rochman, Dr. Britta Denise Hardesty, Dr. Chris Wilcox

TS-1.2 The future of the science of monitoring

Chaired by

Dr. Sunwook Hong (Our Sea of East Asia Network)

Dr. Francois Galgani (IFREMER)

Marine litter and microplastics are a priority for collaborative action under many national, regional and global initiatives. There are a wide range of potential and comparable concepts, tools and methods to support the synthesis of existing data, as well as development of new approaches and indicators for refined spatial or temporal assessments. The global marine debris community collects an abundance of data on the presence of marine debris in our environment. Considering more local efforts, microplastics, other compartments besides shorelines, the uptake of monitoring efforts to track UN sustainable development goals and a possible international treaty, in addition to emerging technologies that may be coupled with existing efforts, the volume of data is vast, varied, and fast-growing.

Approaches across different litter size ranges and environmental compartments need to be integrated in order to account for the multi-compartment and transboundary nature of marine litter. How do we ensure that these data and resulting analyses are fit-for-purpose? When should harmonization and interoperability be prioritized? What questions can be answered with existing datasets, and what are the limitations? What will be marine litter data in the future? And what is the future of monitoring?

This session will explore considerations for designing, implementing, upscaling monitoring programs, and analyzing the resultant data. The session will explore new indicators for monitoring, including life cycle indicators for plastic litter and linkages with other monitoring initiatives, consider data harmonization, interoperability and synergies between existing platforms, ensuring and measuring data quality. More generally, it will provide insights into inspirational and future developments, aiming at recommendations for scientists, policymakers, and environmental managers to optimize and update their monitoring plans and data collection schemes.

- **Opportunities and challenges for technology advances and existing approaches in the future of plastics monitoring**
Dr. Britta Denise Hardesty
- **Identification of possible beach litter indicators in Norway based on a mixture of data collection methods**
Dr. Marthe Larsen Haarr, Mr. Carl Højman, Dr. Kjersti Eline Tønnessen Busch
- **The Power of Multi-Matrix Monitoring in the Pan-Arctic Region: Plastics in Water and Sediment**
Mr. Jake Martin, Dr. Maria Granberg, **Dr. Jennifer Provencher**, Dr. Max Liboiron, Dr. Liz Pijogge (Nunatsiavut government), Dr. Kerstin Magnusson, Dr. Ingeborg Hallanger, Dr. Melanie Bergmann, Dr. Stefano Aliani, Dr. Alessio Gomiero, Dr. Bjørn Grøsvik, Dr. Jesse Vermaire, Dr. Sebastian Primpke, Dr. Amy Lusher
- **How to decide shoreline monitoring of marine debris according to the needs, capabilities, and resources?**
Dr. Sunwook Hong, Dr. Jongmyoung Lee, Ms. Christine Rhee, Ms. Yoonjung Jang, Ms. Jongsu Lee
- **Guidelines to monitor plastic pollution and set science-based reduction goals in the North Pacific Ocean**
Dr. Jennifer Lynch, **Dr. Chengjun Sun**, **Dr. Wonjoon Shim**, **Dr. Amy V. Uhrin**, **Dr. Shuhei Tanaka**, **Dr. Matthew Savoca**

- **Life cycle impact assessment perspectives for integration of impacts caused by microplastic in the marine ecosystem**
Ms. Naiara Casagrande, Dr. Francesca Verones, Prof. Paula Sobral, Prof. Graça Martinho
- **Progress toward meaningful monitoring: Confronting the challenges of survey design and reporting**
Dr. Amy V. Uhrin, Dr. Sunwook Hong, Ms. Hillary K. Burgess, Dr. Sehan Lim, Mr. Kyle Dettloff
- **Emerging technologies for the monitoring of marine litter**
Dr. Georg Hanke, Dr. Francois Galgani

PICES-2022

September 23–October 2, 2022, Busan, Korea

2022 Report of Working Group 42 on *Indicators of Marine Plastic Pollution*

The Working Group on *Indicators of Marine Plastic Pollution* (WG 42) held its meeting on September 12, 2022, prior to PICES-2022 in Busan, Korea. The meeting was chaired by Dr. Jennifer Lynch who welcomed four members online (*WG 42 Endnote 1*). The meeting agenda was reviewed by Dr. Lynch., and adopted (*WG 42 Endnote 2*).

AGENDA ITEM 2

Achievements of WG 42

Three review papers led by Wonjoon Shim, Amy Uhrin, and Matthew Savoca on microplastics in the sea surface and water column, on the shoreline and in biota in the NPO, respectively, have recently been accepted by peer-reviewed journal *Environmental Pollution*.

AGENDA ITEM 3

Article updates

An update on the status of the fourth review paper on Sediment and seafloor microplastics led by Dr. Shuhei Tanaka was presented. This is the last review paper we planned to submit. Discussion on the status of the summary paper on the four review papers was led by Dr. Lynch.

AGENDA ITEM 4

Virtual special issue proposal to *Environmental Pollution*

WG members reviewed the status of the format of the virtual special issue in *Environmental Pollution*.

AGENDA ITEM 5

Future of WG 42

The next phase of WG 42's work was discussed. The group's term is coming to its end. Members debated on whether to proceed as a Section or Advisory Panel in the next term to continue our work. In addition, Matthew Savoca submitted a project proposal to UN Ocean Decade.

AGENDA ITEM 6

Financial request

WG members discussed obtaining PICES funding support for the open access of the review papers.

AGENDA ITEM 7

Other business

Dr. Uhrin informed the group that the ICES Working Group on Marine Litter requests that WG 42 submit a proposal for joint PICES/ICES session at PICES-2023 in Seattle.

WG 42 Endnote 1**WG 42 participation list**Members

Jennifer M. Lynch (USA, Co-Chair)
 Chengjun Sun (China, Co-Chair)
 Sarah Dudas (Canada)
 Jennifer Provencher (Canada)
 Connie Ka-yan Ng (China)
 Kazuhiko Mochida (Japan)
 Sang Hee Hong Kim (Korea)
 Miran Kim (Korea)
 Seung-Kyu Kim (Korea)
 Wonjoon Shim (Korea)
 Matthew Savoca (USA)
 Amy Uhrin (USA)

Members unable to attend

Canada: Peter S. Ross
 China: Daoji Li, Juying Wang
 Japan: Hideshige Takada, Shuhei Tanaka
 Russia: Iana Blinovskaia, Nikolai Kozlovskii

WG 42 Endnote 2**WG 42 meeting agenda**

1. Welcome and adoption of agenda (chairs)
2. Achievements of WG 42 (chairs)
 - a) Sea surface and water column – Wonjoon Shim
 - b) Shoreline – Amy Uhrin
 - c) Biota ingestion – Matthew Savoca
 - d) 7IMDC presentations
 - e) Submitted annual report
 - f) Others?
3. Review article updates and discussion (leads)
 - a) Sediment and seafloor – Shuhei Tanaka
 - b) Overview of all 4, Final report to PICES – Jennifer Lynch
4. Discuss plan for Virtual special issue proposal to Environmental Pollution
5. Discuss the imminent expiration and potential future of WG 42
6. PICES financial request
 - a) Open access fees for overview paper
7. Other business (All)
 - a) PICES MEQ Business Meeting which is due to take place on Sunday, September 25th (Day 1) and Wednesday, September 28th (Day 2) in Busan, Korea
 - b) Postponed: ICES-PICES Joint Science Conference Seattle Oct 23-27, 2023 - ICES Working Group on Marine Litter requests that PICES WG42 submits a joint session at the hybrid event (Amy Uhrin)

PICES-2023

October 23–27, 2023, Seattle, USA

2023 Report of Working Group 42 on *Indicators of Marine Plastic Pollution*

The Working Group on *Indicators of Marine Plastic Pollution* (WG 42) held a final, virtual, meeting on August 22, 2023, prior to PICES-2023 in Seattle, USA. The meeting was chaired by Dr. Jennifer Lynch who welcomed four members online (*WG 42 Endnote 1*). The meeting agenda was reviewed by Dr. Lynch., and adopted. (*WG 42 Endnote 2*).



Virtual meeting participants during WG 42's final meeting. Top, left to right: Wonjoon Shim, Connie Ng. Bottom, left to right: Amy Uhrin, Matthew Savoca, Miran Kim, Jennifer Lynch (inset).

AGENDA ITEM 2

Review of achievements

- Sediment paper update was not available.
- Summary paper update – there are benefits to writing it, but it is not necessary. Perhaps the next group could take this up. Dr. Lynch does not have the time to finish it.
- Presentations were given at the 7th International Marine Debris Conference in Busan, Korea, in September 2022, from the ToR of this working group:

Technical Session 1.2 - The Future of the Science of Monitoring

- Uhrin AV, Hong S, Burgess H, Lim S, Dettloff K. *Progress toward meaningful monitoring: Confronting the challenges of survey design and reporting*
- Lynch J, Sun C, Shim W, Uhrin A, Tanaka S, Savoca M. *Guidelines to monitor plastic pollution and set science-based reduction goals in the North Pacific Ocean*

AGENDA ITEM 3

New expert group

Members discussed a request to MEQ for a new Expert Group. Drs. Matt Savoca and Amy Uhrin will ask Dr. Andrew Ross, the Vice-Chair of MEQ (and cc Dr. Sanae Chiba, PICES Deputy Executive Secretary) about the process to formalize an Expert Group on plastic pollution. They types of groups include:

- Sections (longer term 5+ years, but more difficult to create)
- Advisory Panels (easier to create because not all PICES countries need to be members)
- Joint working group with ICES

Dr. Matt Savoca is willing to chair the group. Dr. Uhrin may consider co-chairing if the group is joint with ICES. Dr. Savoca will need help, and the two chairs from PICES can come from the US.

AGENDA ITEM 4

Topic Session/workshop for PICES-2024

Members discussed proposing a session or workshop for PICES-2024. The submission deadline is September 22. Without knowing the location and dates of the Meeting at this time, and without an official Expert Group formed, members felt it was too early to make a decision on a topic session or workshop.

AGENDA ITEM 5

Open discussion

- Dr. Savoca received a marine debris grant from California Sea Grant and California Ocean Protection Council (OPC) - Watershed to Whales, in Monterey
- Dr. Savoca announced that the UN bioindicators group was approved and is undertaking a review of monitoring programs globally for bioindicators of plastic pollution.
- Dr. Lynch received a NOAA Sea Grant grant to scale up removal and recycling of marine debris across the Hawaiian Archipelago.
- Dr. Uhrin announced that the NOAA Marine Debris Program is sponsoring a working group through the National Center for Environmental Synthesis to tackle the social costs of plastic pollution in the US. The working group will lay the groundwork for determining a robust and scientifically-grounded approach for estimating the dollar value of avoided plastic pollution emissions that would allow agencies to understand the benefits of reducing plastic pollution emissions or the social cost of increasing such emissions. The project will also support a post-doc. In addition, the NOAA Marine Debris Program, in collaboration with Western EcoSystems Technology, Inc., is finalizing a spatially-balanced survey design for conducting shoreline monitoring across 10 US regions using the Program's established on-site protocol (MDMAP). The goal is to contract out the field surveys to begin in 2024, budget pending.
- Dr. Shim reported that funding for microplastic research has been cut due to a new Korean President coming into office.
- Dr. Ng reported that environmental organizations such as the World Wildlife Fund has run programs on marine debris removal in Hong Kong.

WG 42 Endnote 1**WG 42 participation list**Members

Jennifer M. Lynch (USA, Co-Chair)
Connie Ka-yan Ng
Miran Kim (Korea)
Matthew Savoca (USA)
Wonjoon Shim (Korea)
Amy Uhrin (USA)

Members unable to attend

Canada: Peter S. Ross, Jennifer Provencher
China: Daoji Li, Chengjun Sun, Juying Wang
Japan: Kazuhiko Mochida, Hideshige Takada,
Shuhei Tanaka
Korea: Sang Hee Hong, Seung-Kyu Kim
Russia: Iana Blinovskaia, Nikolai Kozlovskii

WG 42 Endnote 2**WG 42 meeting agenda**

1. Welcome and adoption of agenda
2. Review of achievements
3. New expert group
4. Topic Session/workshop for PICES-2024
5. Open discussion

Appendix 5

PICES Press Article Related to WG 42

The (Virtual) International Symposium on Plastics in the Arctic and Sub-Arctic Regions

by *Matthew Savoca and Seung-Kyu Kim*

PICES Press Vol. 29, No. 2, Summer 202169

The (Virtual) International Symposium on Plastics in the Arctic and Sub-Arctic Regions

Matthew Savoca and Seung-Kyu Kim



At the start of the UN Decade of Ocean Science for Sustainable Development, marine researchers are excited to contribute time, energy, and most importantly, international coordination, to the myriad challenges that face the ocean. In the preceding decade (2011-2020), ocean pollution – specifically ocean plastic pollution – has come to the fore as an emergent issue of global concern. In 2017, PICES scientists formed a study group to begin discussions how we can best coordinate monitoring of plastic pollution in the PICES region. One year later, our study group became a working group (WG-42), which has catalyzed our conversation about the plastic pollution trends and research within and outside the PICES region.

In March 2021, we attended the virtual Symposium on Plastic Pollution in the Arctic and sub-Arctic Region. The symposium was originally scheduled to take place in Reykjavik, Iceland in April 2020. However, due to the coronavirus pandemic, it was postponed and held fully virtually. The symposium was hosted by the government of Iceland (the Ministry for Foreign Affairs, the Ministry for the Environment and Natural Resources, and the Ministry of Industries and Innovation). It was further sponsored by the International Council for the Exploration of the Sea

(ICES), PICES, the United Nations Environment Programme (UNEP), the OSPAR Commission, the Intergovernmental Oceanographic Commission of UNESCO (IOC), the Marine and Freshwater Research Institute of Iceland, the Harvard Kennedy School and the International Arctic Science Committee. Iceland holds the Chairmanship of the Arctic Council from May 2019 to May 2021 and has led discussions on the understanding and mitigation of plastics in the Arctic Marine Environment. This symposium helped advance that goal.

The symposium was especially relevant to PICES WG-42 in our efforts to assess the extent and impact of plastic pollution in the PICES region, and to suggest biotic and abiotic components of the ecosystem for continued monitoring. It is, therefore, prudent to engage with other regional groups with similar goals. This is particularly true for the Arctic, a region which borders the northern fringe of the PICES domain. As a result, we share common species (e.g., northern fulmar, a well-established bioindicator of plastic debris in the ICES region), and common abiotic reservoirs of plastic pollution (e.g., the Bering/Chukchi/East Siberian/Beaufort Sea).

Nearly 100 scientists, diplomats, and NGO leaders spoke or made presentations during the five-day online symposium. Each day the symposium first hosted keynote talks followed by a live panel discussion with that day's presenters. The presentations included 55 primary science talks from researchers working in the Arctic ecosystem. Recordings of all panel discussions, as well as the presentation talks and poster sessions, are available on the [Arctic Council's website](#)¹. These scientific presentations and discussions centered around several main themes including:

- Sources and transport of plastics in the Arctic and sub-Arctic including shipping, tourism, fishing, and terrestrial sources
- Setting a baseline for Arctic plastic pollution
- Arctic challenges in waste management strategies
- Methodology for isolating and quantifying on macro-, micro- and nanoplastics: instrumental technology and guidelines for harmonization of monitoring
- Arctic monitoring of macro-, micro-, and nanoplastics
- Impact of plastic pollution in the Arctic: Ecotoxicology, toxicology, and socioeconomics
- Solving the plastic challenge: Best mitigation practices from around the world (ocean-based and land-based efforts including clean-up, biodegradable alternatives, social communication)
- Developing a regional action plan for the Arctic. Taking coordinated actions between sectors and developing joint initiatives for different industries.

One way in which plastic pollution in the Arctic region differs from the PICES region – and many other large marine regions – is that a majority of the plastic in the region may not originate from land bordering the basin itself. Dr. Melanie Bergman of the Alfred Wegener Institute spearheaded the discussion of the origin of plastic pollution in the Arctic with a keynote lecture on the first day of the Symposium. In the Arctic, marine debris has grown sevenfold since the turn of the 21st century, and it appears the situation will get worse before it improves. Less than 40% of debris in the Arctic comes from local sources and ~10% of debris originates from distant locations including Asia and the continental United States. The majority of plastic in the Arctic is from Europe and North America and enters the region from the Atlantic Ocean. As a result, the global community is responsible for marine litter found in the Arctic. Both sea ice and seafloor sediment are the primary sinks of debris in the region; detailed analyses of both compartments has revealed microplastic and

¹<https://arctic-council.org/en/explore/topics/ocean/plastics/>

microfiber concentrations in the millions per cubic meter. When compared to the west coast of North America this is approximately two orders of magnitude higher than seafloor sediment and six orders of magnitude higher than in surface seawater. The mechanisms behind these extremely high concentrations of small plastics in the Arctic are believed to be the results of large-scale ocean currents and atmospheric deposition. By comparison, macro debris is more likely to originate from local sources.

A parallel between several presentations at this symposium and PICES WG-42 was the discussion of how best to track plastic pollution via indicators. In addition to monitoring abiotic components – including seawater, sediment, and the cryosphere – bioindicators to measure plastic debris in the food web were also discussed. Several researchers referenced studies on seabirds as bioindicators of plastic in Arctic marine food webs. Dr. Jennifer Provencher gave a presentation on Arctic Monitoring and Assessment Programme's (AMAP) use of the northern fulmar (*Fulmarus glacialis*) as a biomonitor of plastic. This species is also used as an indicator in the ICES region and is under discussion by PICES WG-42 as to whether it should be used as a bioindicator in our region as well. Encouragingly, new research from the Arctic and North Atlantic suggests that plastic ingestion by fulmars is decreasing over time. If these trends continue, fulmars may be below OSPAR-EcoQO guidelines of <10% of individuals having >0.1 g plastic particles in the stomach by mid-century. Julie Baak also presented on plastic ingestion by Arctic seabirds and found that, even with these declining trends, fulmars still ingested the most plastic of any of the four species her team studied. Scott Fleming reported on a high degree of plastic ingestion by breeding shorebirds in the region as well. The cocktail of chemicals that plastic debris harbors has also been monitored in Arctic seabirds. Several researchers including Dr. Provencher and Veronica Padula reported on their ecotoxicological findings. Veronica is a Ph.D. student at the University of Alaska and her findings that 10 seabird species nesting in the Aleutian Islands had detectable concentrations of phthalate plasticizers in their tissues should raise alarm for PICES scientists as all these species use the PICES region as well as the Arctic.

While seabirds can be used as a bioindicator for large-sized microplastics (LMPs), zooplankton can be used as a bioindicator for small-sized microplastics (SMPs <100 µm) in Arctic marine food webs. Dr. Fabiana Corami suggested amphipods that ingested various polymeric SMP particles could be used as a biomonitoring indicator of SMP pollution. Dr. Zara Botterell also found SMPs in all species analyzed, with much higher SMP abundance in amphipods than copepods. However, two presenters including Dr. Rist and Rocío R. Torres did not find any significant adverse effects in copepods caused by SMP exposure. The Institute of Oceanology Polish Academy

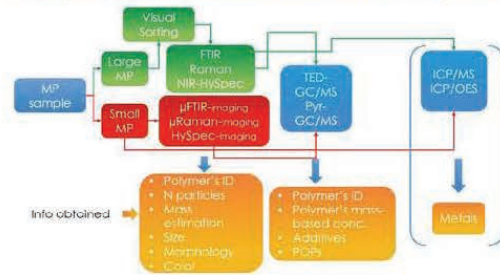
of Sciences team has a research scheme to elucidate the transfer of microplastics from seawater via plankton to seabirds. These studies show there are implications for the selection of bioindicators, a main issue for PICES WG-42.

Transport of microplastics across the Arctic basins and compartments is also an important theme of interest, considering the increasing number of findings on the importance of air and sea ice as moving vectors of microplastics. This is of importance due to their strong association with climate change. Dr. Chris Wilson of the National Oceanography Centre, UK predicted that cross-basin and cross-shelf slope fluxes would be affected by the change of ocean circulation (variability of surface drift and dense water cascading) driven by sea ice decline and enhanced atmospheric forcing. He presented “Pacific-to-Atlantic travel time reduction by ~30% in second half of the century, increased flow through Canadian Archipelago, and the disappearance of the Siberian route for Pacific water” as a future change to transport pathways. Dr. Seung-Kyu Kim, a professor of Incheon National University, South Korea, stressed the importance of the entry and accumulation of microplastics in the western Arctic Ocean (WAO; Bering/Chukchi/East Siberian/Beaufort Sea) from two years of monitoring that was conducted using a Korean Ice Breaker vessel (Araon) in a collaboration with Korea Polar Research Institute (KOPRI). Recently, his research team published a paper regarding the importance of seasonal sea ice in WAO to the Arctic and global microplastic budgets. This can be a strong driving force for collaboration between ICES and PICES on future changes.

Interesting discussions at this symposium also concerned action plans to mitigate plastic pollution and the consensus on harmonizing monitoring and measurement methods. While experts expressed support for a global agreement or treaty to address growing amounts of plastic in the oceans, some, cautioned against letting progress on a treaty distract from other efforts to prevent plastic pollution, since the treaty would take many years to come into force despite its benefits. There was emphasis on the necessity of other actions now—for example, moving forward to develop plastics made from organic materials and holding an annual coastal clean-up day in all eight Arctic countries. Arctic clean-up activities have advantages of immediately removing plastic debris, preventing their break-down into small pieces that are consumed by marine life, as well as drawing local and international attention to plastic pollution. However, due to different geographical features, the Alaska regional coordinator for the NOAA Marine Debris Program suggested that researchers in the Arctic cannot simply adopt methods developed in other regions for beach clean-up. Even worse, the different methods of analyzing microplastics make it impossible to compare each other.

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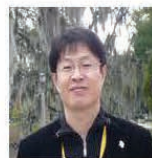
Analytical methods have diversified and improved



Jes Vollertsen, a professor of Environmental Engineering at Denmark's Aalborg University, gave a sense of how diverse methods are applied to microplastic analysis (above). Despite expectations for method standardization, it is not easy to obtain the 'silver bullet' since the method depends on the aims of researchers. Nevertheless, efforts to standardize methods that make it possible to compare measurement data, through cross-validation of methods need to continue.



Dr. Matthew Savoca is a National Science Foundation Postdoctoral Research Fellow at the Hopkins Marine Station of Stanford University. He studies the foraging behavior and ecology of marine top predators, from seabirds to marine mammals. He also works on applied conservation problems including marine plastic pollution and legacy pollutants. Within PICES, Matt serves on Working Group 42 and the Study Group on Early Career Ocean Professionals. He lives in Monterey, California with his wife Rachel and dog Marley.



Dr. Seung-Kyu Kim is a professor at the Incheon National University. He studies the monitoring, fate and transport of legacy and emerging pollutants including persistent organic pollutants and microplastics. Over the past few years his research has focused on the distribution of microplastics and plastic-additives in multiple compartments (air, freshwater, seawater, soil, sediment, seafood and wildlife) covering inland, coastal region, open ocean and polar region (Arctic and Antarctic). His final goal is to elucidate the mass flow of plastics among compartments and among basins/oceans. He participates as a member of PICES WG-42.