2023 ICCA MARII WORKSHOP@Alexis Royal Sonesta Hotel, Seattle, USA
12-14 June 2023

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Characterizing Composition Profiles and Environmental Risk of Microplastics in Tokyo Bay

Wataru Naito

Research Institute of Science for Safety and Sustainability (RISS)

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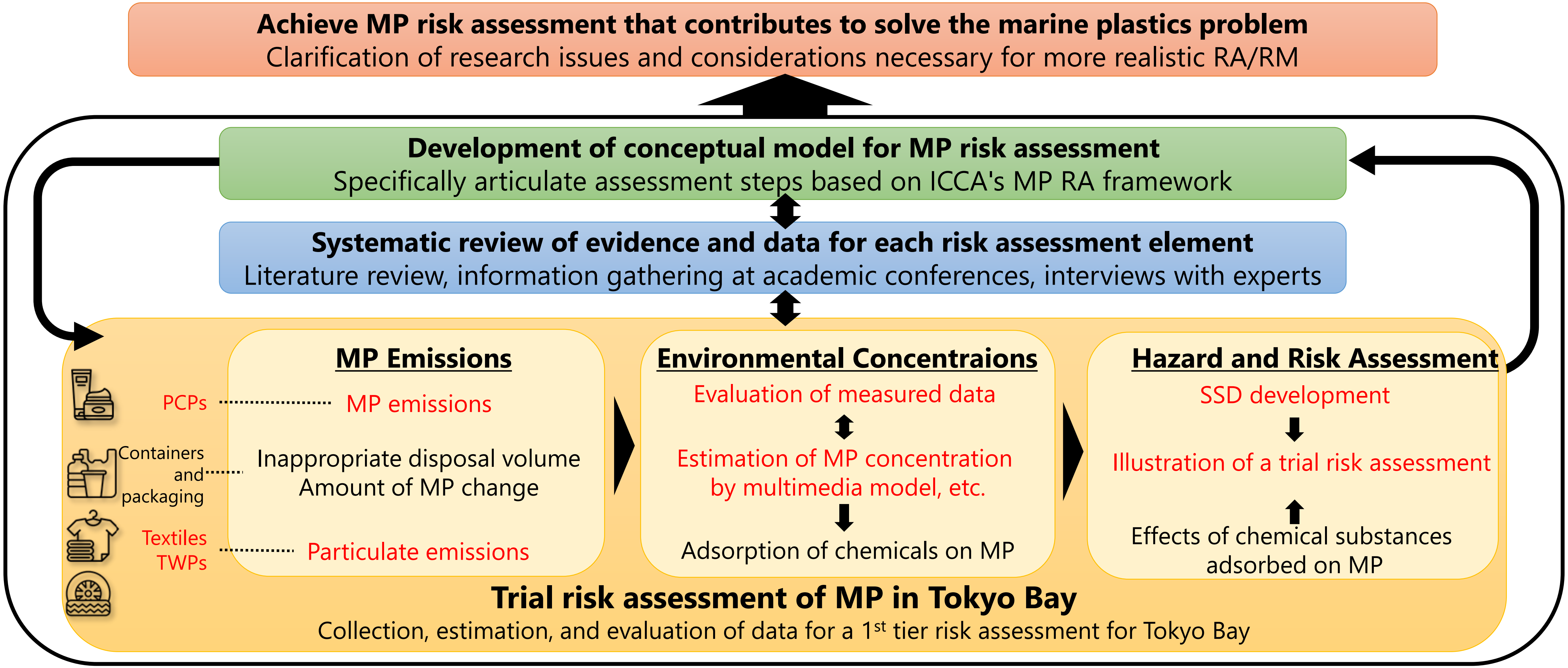
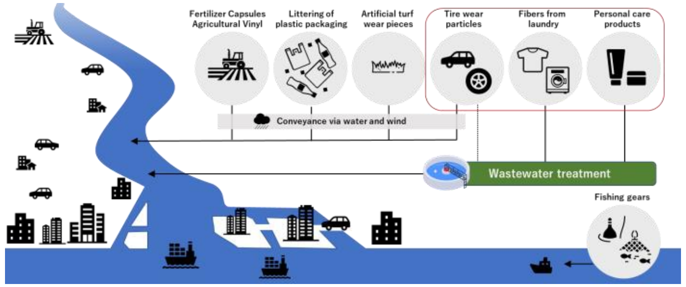
Development of a conceptual framework for environmental risk assessment of microplastics and a trial risk assessment in Tokyo Bay (FY2019-FY2022)

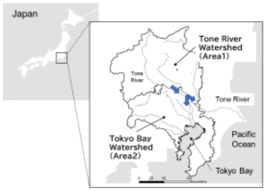


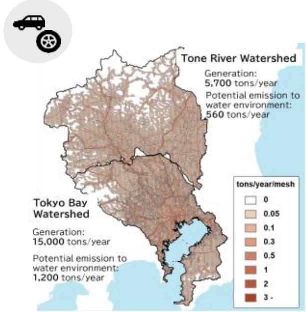
Development of a conceptual framework for environmental risk assessment of microplastics and a trial risk assessment in Tokyo Bay (FY2019-FY2022)

Estimation of MP loadings to TB



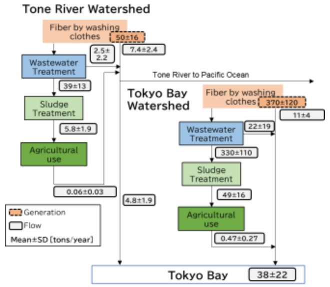
Study area



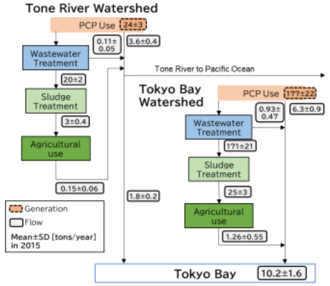


*The values are potential annual MP emissions into Tokyo Bay.

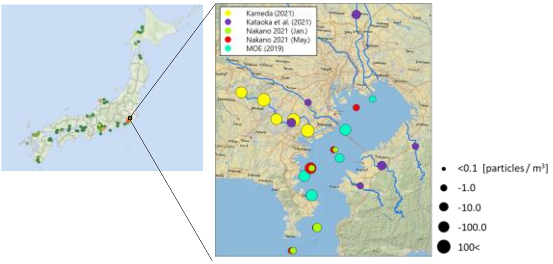
Fibers from laundry : 38 tons/year*



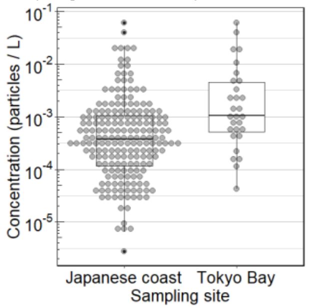
Personal care products in 2015 : 10 tons/year*



Reviewing MP monitoring data in Japan and identifying data gap and research needs

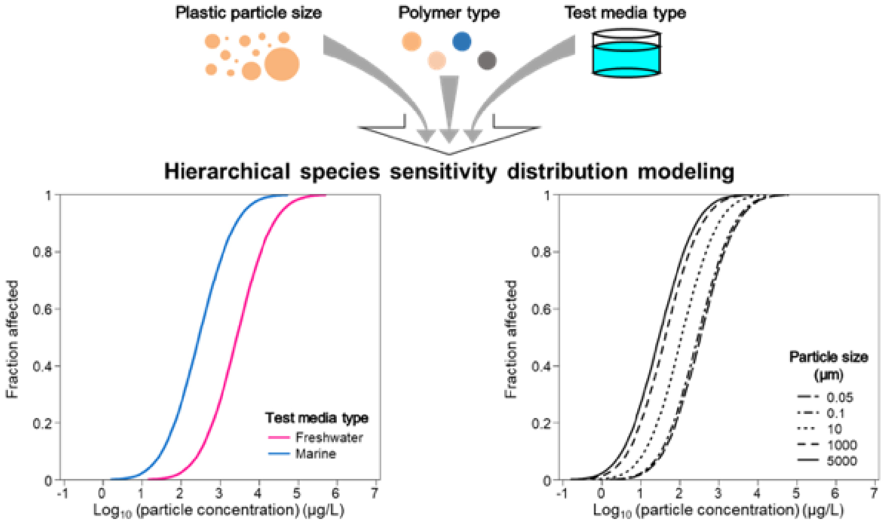


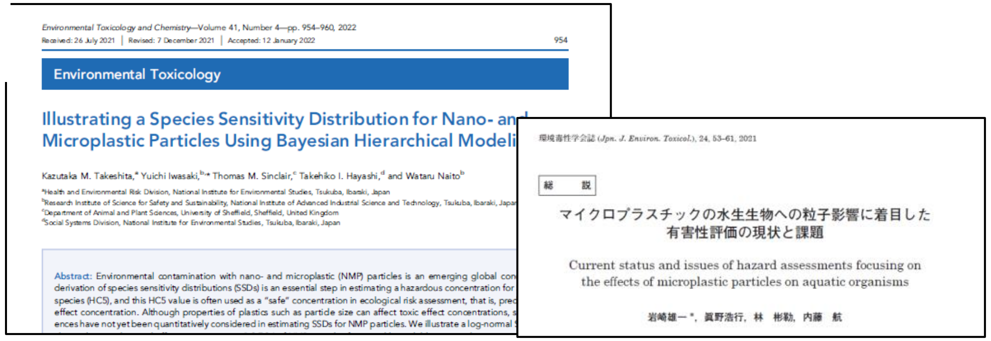
N = 200 (sampled 2015-2022)
N = 29 (2015-2022)



Microplastic concentrations (N=29, 300 µm ≦) observed in Tokyo Bay areas ranged from 0.04 (Nakano 2021) to 61.2 particles / m³ (MOE 2019).

SSD development using Bayesian Hierarchical Modeling and identifying data gap and research needs





Environmental Toxicology and Chemistry—Volume 41, Number 4—pp. 954–960, 2022

Environmental Toxicology

Illustrating a Species Sensitivity Distribution for Nano- and Microplastic Particles Using Bayesian Hierarchical Modeli...

Kazutaka M. Takeshita, Yuichi Iwasaki, Thomas M. Sinclair, Takehiko I. Hayashi, and Wataru Naito

環境毒性学会誌 (Jpn. J. Environ. Toxicol.), 24, 53-61, 2021

総 説

マイクロプラスチックの水生生物への粒子影響に着目した有害性評価の現状と課題

Current status and issues of hazard assessments focusing on the effects of microplastic particles on aquatic organisms

Assessing Sources, Emissions and Environmental Risk of Microplastics in support of Effective Risk Reduction Strategies (FY2023-FY2025)

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LRI Long-Range Research Initiative

Implementation of effective reduction measures for MP contaminations

Assessing Sources, Emissions and Environmental Risk of Microplastics in support of Effective Risk Reduction Strategies

A Case Study : environmental risk assessment of MP for Tokyo Bay — AIST

Exposure Assessment

High-precision monitoring of MP in the environment

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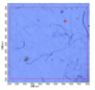
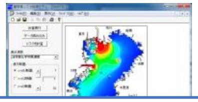


AIST **Environmental Modeling**

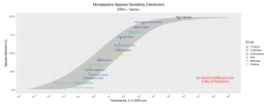


AIST **Estimation of Emissions of MPs**

Alignment of exposure and effect data

Koelmans et al. (2020); Coffin et al. (2022) Mehinto et al. (2022) etc.

Hazard Assessment



TōMEx

Kameda Laboratory
Monitoring Trace Contaminants in the Environment MP's high-precision analytical technol[ogy]

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Environmental Pollution 284 (2021) 117516

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

ELSEVIER

Source- and polymer-specific size distributions of fine microplastics in surface water in an urban river☆

Yutaka Kameda*, Naofumi Yamada, Emiko Fujita

Chiba Institute of Technology, 1-17-1 Tsudanuma, Narashino, Chiba, 275-0016, Japan

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Development of a conceptual framework for environmental risk assessment of microplastics and a trial risk assessment in Tokyo Bay
JCIA-LRI 8th -10th (FY2019-FY2022)

AIST

Achieve MP risk assessment that contributes to solve the marine plastics problem
Clarification of research issues and considerations necessary for more realistic RA/RM

Development of conceptual model for MP risk assessment
Specifically articulate assessment steps based on ICCA's MP RA framework

Systematic review of evidence and data for each risk assessment element
Literature review, information gathering at academic conferences, interviews with experts

MP Emissions	Environmental Concentraions	Hazard and Risk Assessment
MP emissions	Evaluation of measured data	SSD development
Inappropriate disposal volume Amount of MP change	Estimation of MP concentration by multimedia model, etc.	Illustration of a trial risk assessment
Particulate emissions	Adsorption of chemicals on MP	Effects of chemical substances adsorbed on MP

PCPs; Containers and packaging; Textiles TWPs

Trial risk assessment of MP in Tokyo Bay
Collection, estimation, and evaluation of data for a 1st tier risk assessment for Tokyo Bay

- ✓ Identification of research and data gaps in risk assessment of MPs (for Tokyo Bay)
- ✓ Development of SSD using hierarchical Bayesian model
- ✓ Trial env. risk assessment of MPs for Tokyo Bay using existing data
- ✓ Establishment of multiple emission estimation methods,

Assessing Sources, Emissions and Environmental Risk of Microplastics in support of Effective Risk Reduction Strategies (FY2023-FY2025)

What are the key features of the current LRI research project ?

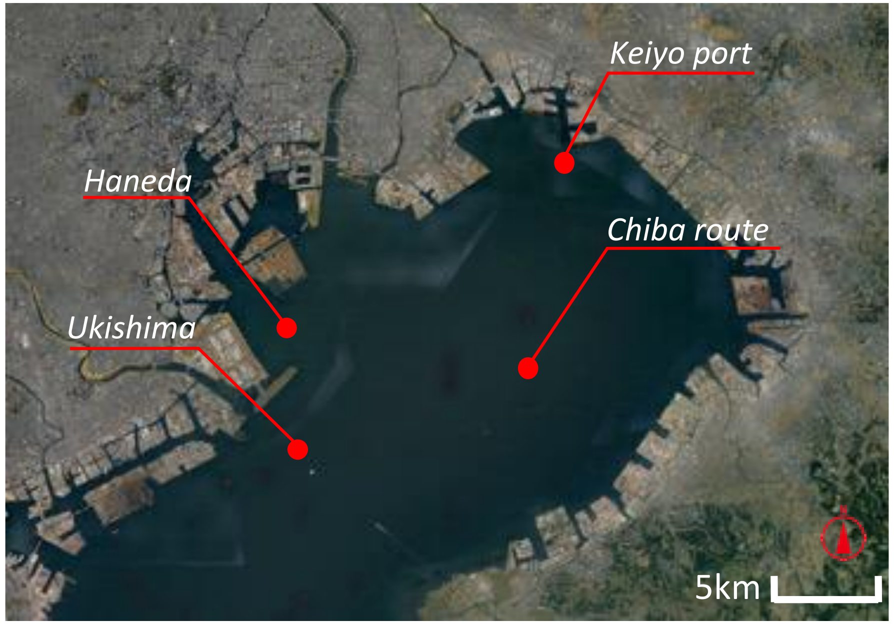
- Elucidating the environmental concentrations of small size MPs in Tokyo Bay and understanding their characteristics such as size, type, and shape
- Estimating the long-term loadings of microplastics from major sources contributing to the Tokyo Bay.
- Updating SSDs using available and reliable data set to date
- Developing environmental models (modifying the existing AIST environmental models) for microplastics for the Tokyo bay and its watershed [NEDO PJ]
- Applying those models to quantify the effectiveness of RM countermeasures including future changes

Characterizing MPs found in Surface water of Tokyo Bay

Applying two sampling methods to characterize MPs

Neuston net (NN) with a mesh size of 0.35 mm (Commonly used)

Filtration volume： 200～300m^3



Sampling Site (Dec. 2022)

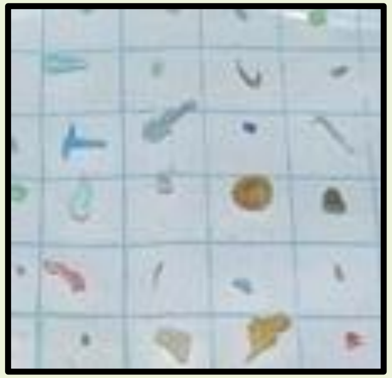
Plankton net (PN) with a mesh size of 0.01 mm

Filtration volume： 0.6 m^3

Characterizing MPs found in Surface water of Tokyo Bay

Characterizing MPs collected with two sampling methods

Neuston net (NN)



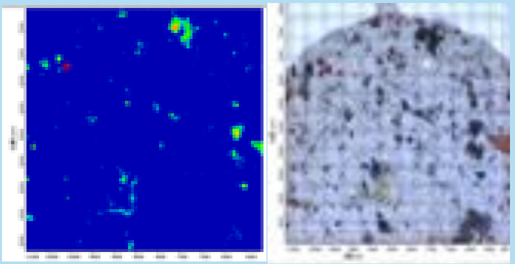
Collect particles and fibers (350 µm ≦)

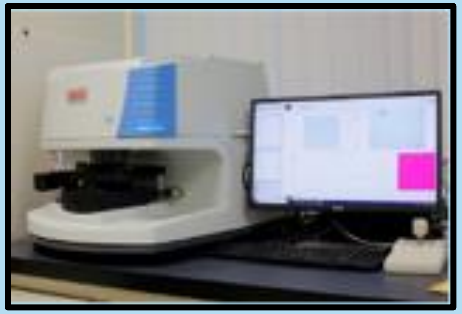
Measure long and short length using Image J

Identify types of polymers using microscopy FT-IR

Plankton net (PN)

Imaging analysis of MPs (>20 µm) by micro FT-IR





Measure long and short length using OMNIC
and
Identify types of polymers

Characterizing MPs found in Surface water of Tokyo Bay

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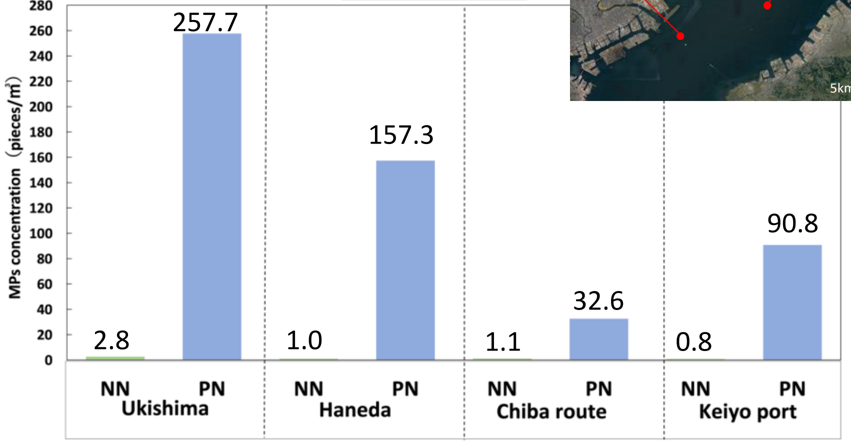
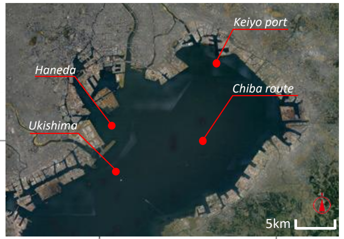
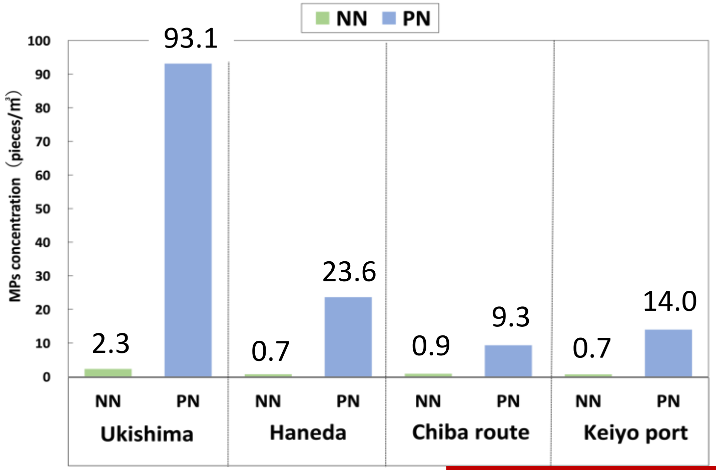
Unpublished data

MP concentrations

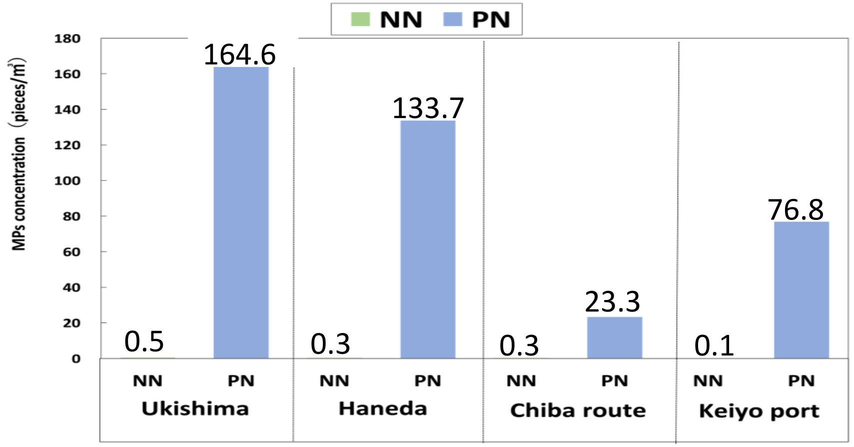




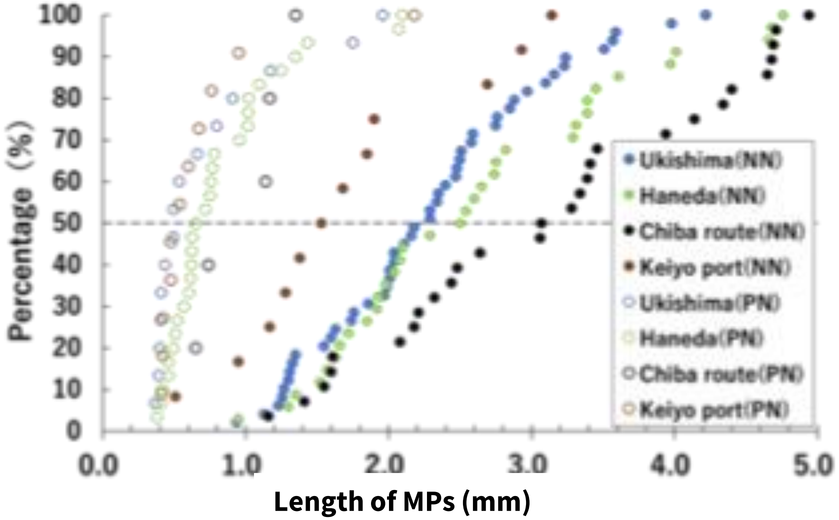
MP concentrations (Fragments)



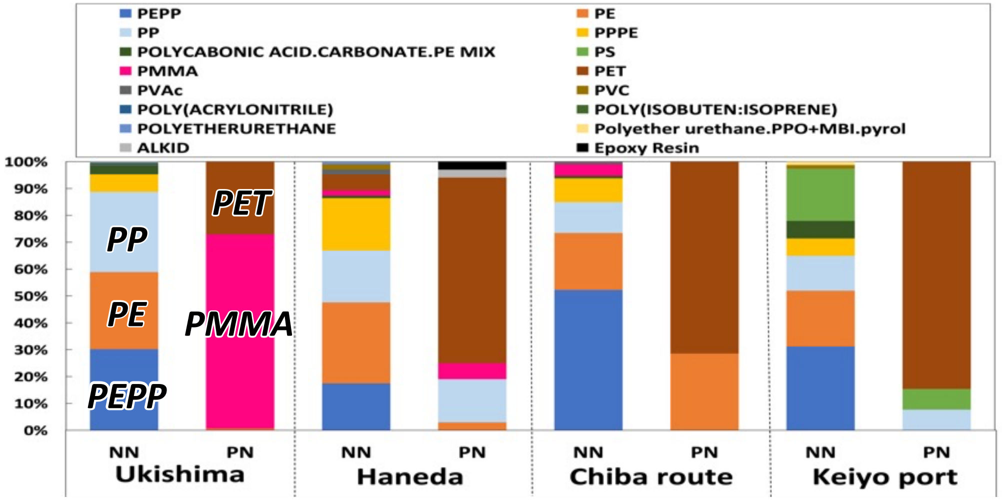
MP concentrations (Fibers)



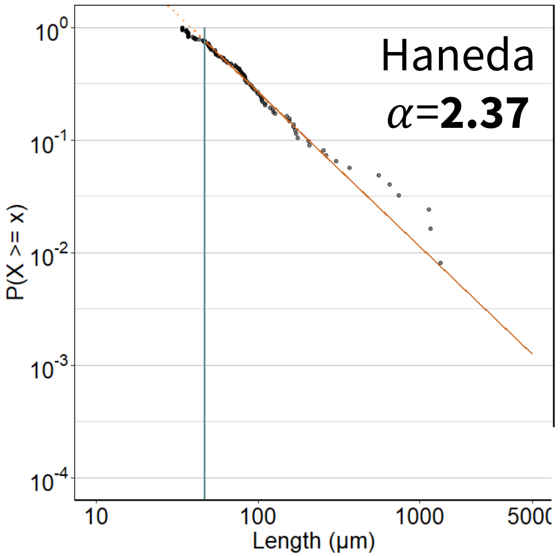
Distribution of long length of MP fibers

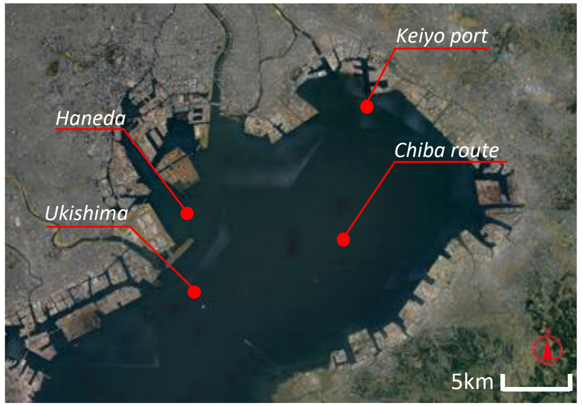


Comparison of polymer compositions

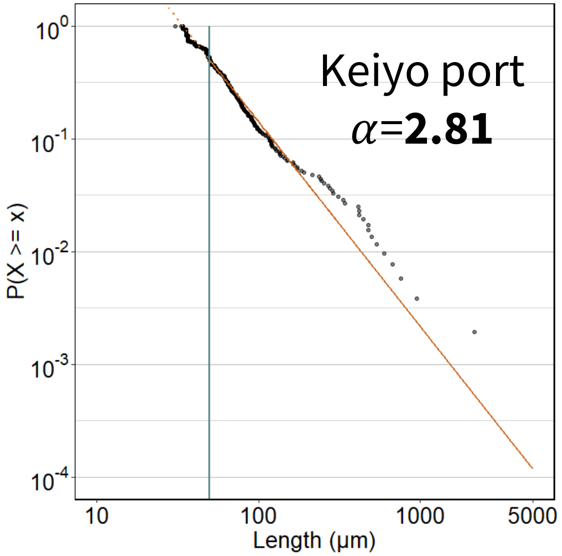


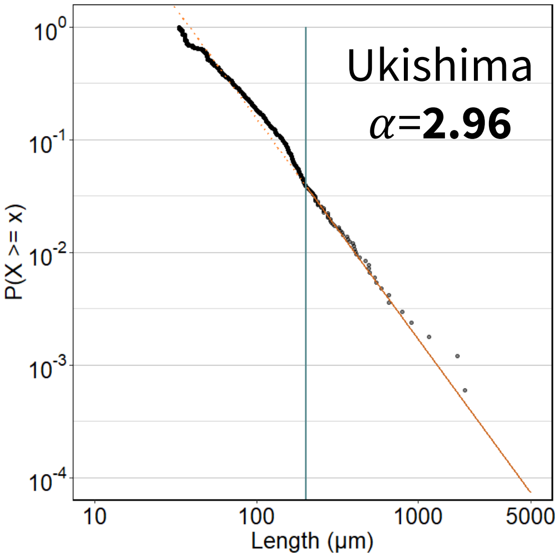
Estimating α for rescaling MP concentrations for Tokyo bay

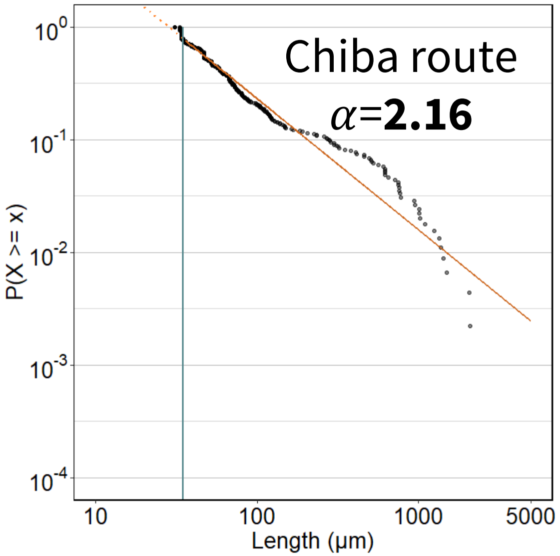




Ueda (2023) Unpublished



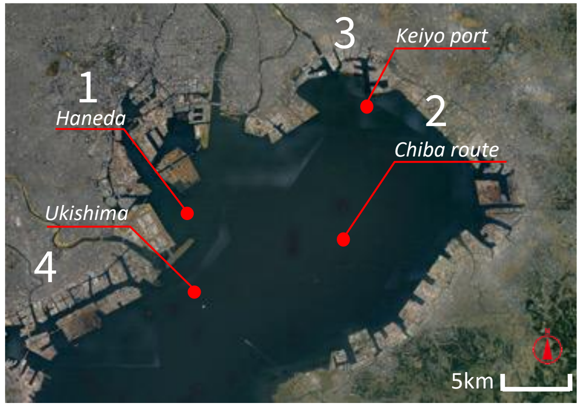


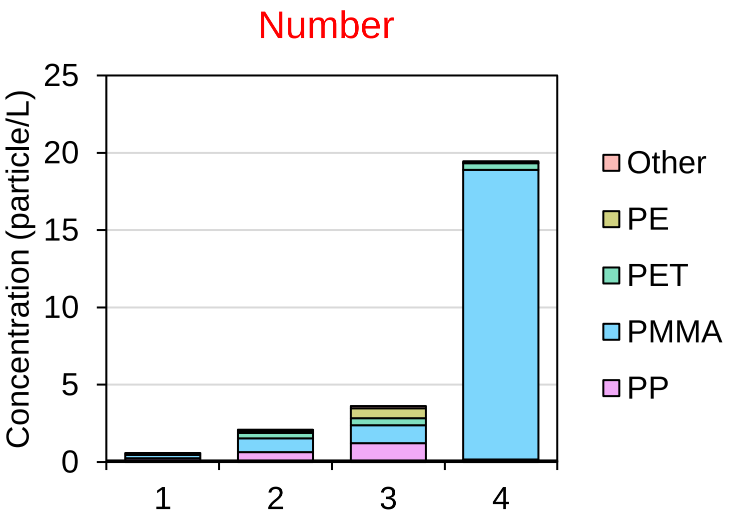


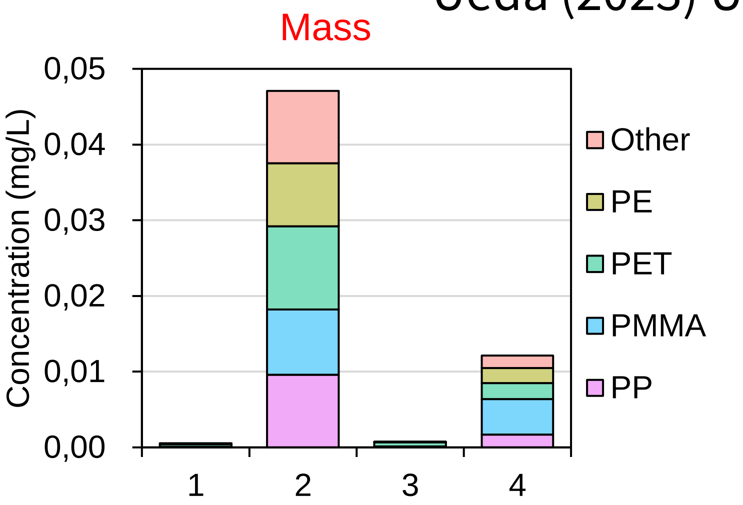
Care should be taken when rescaling MP concentration obtained with the NN using α estimated by MP concentration obtained with the PN

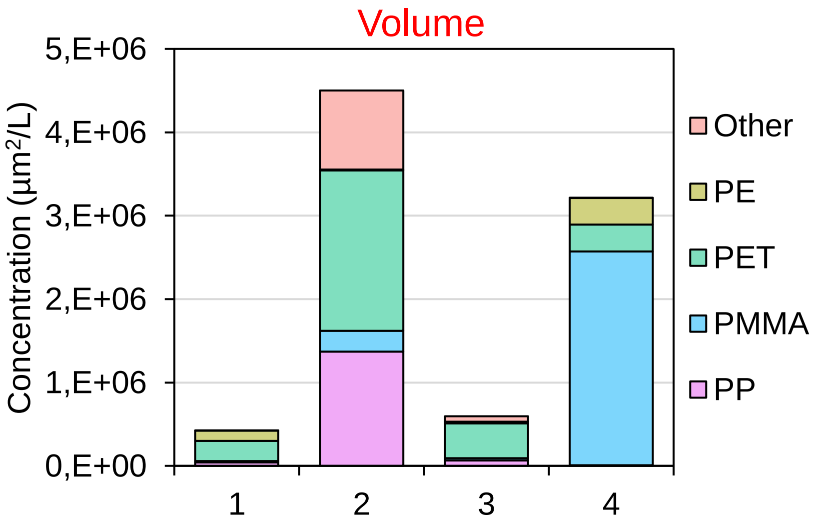
Converting MP number concentration to other dose metrics

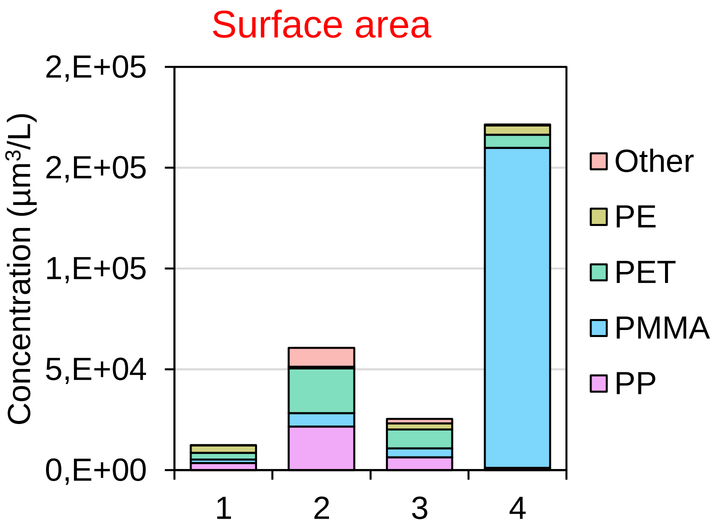
Ueda (2023) Unpublished



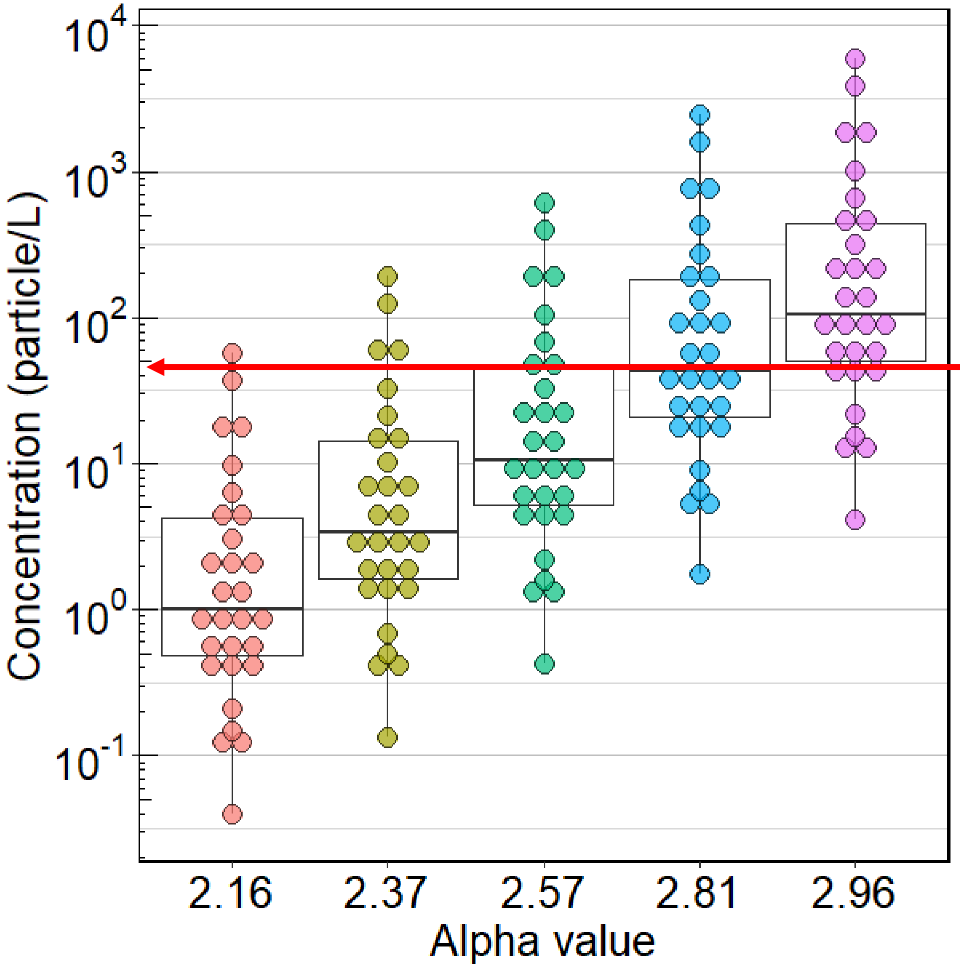




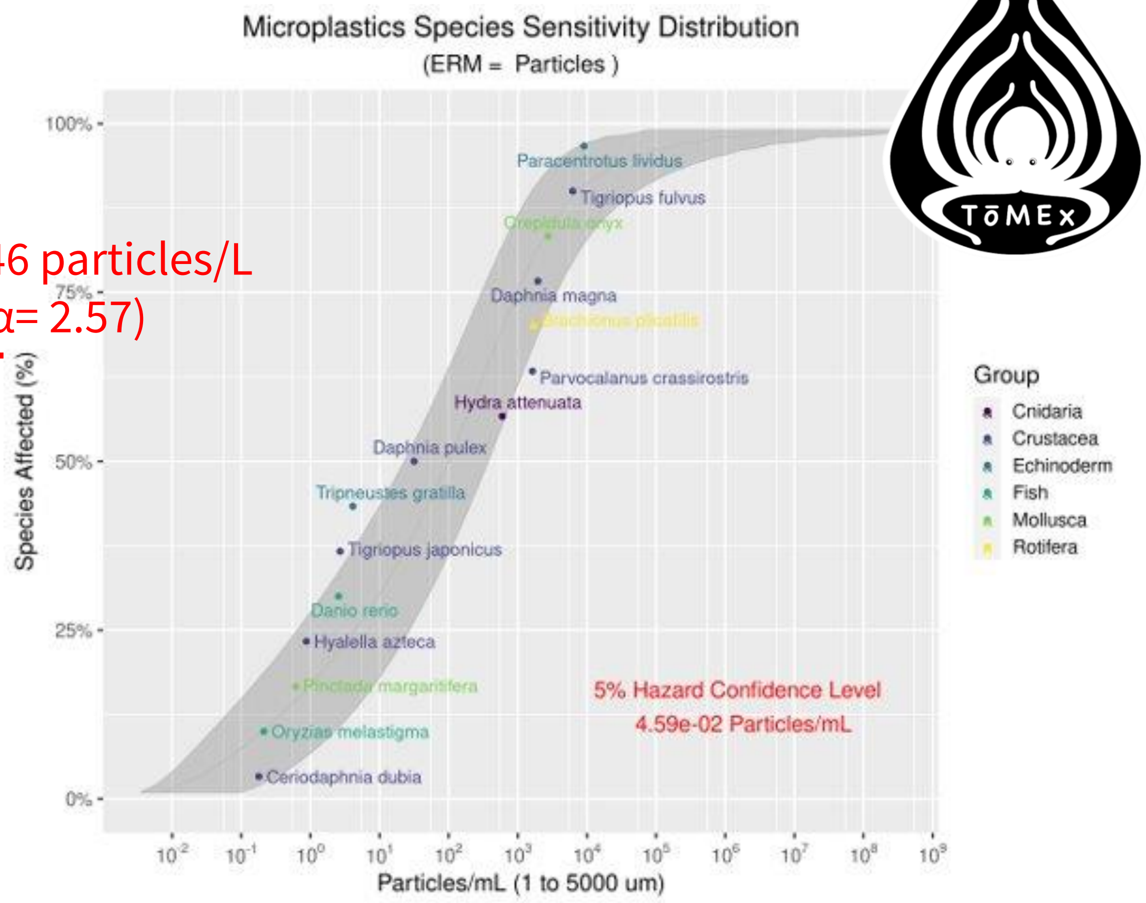




A trial ERA of MPs for Tokyo bay

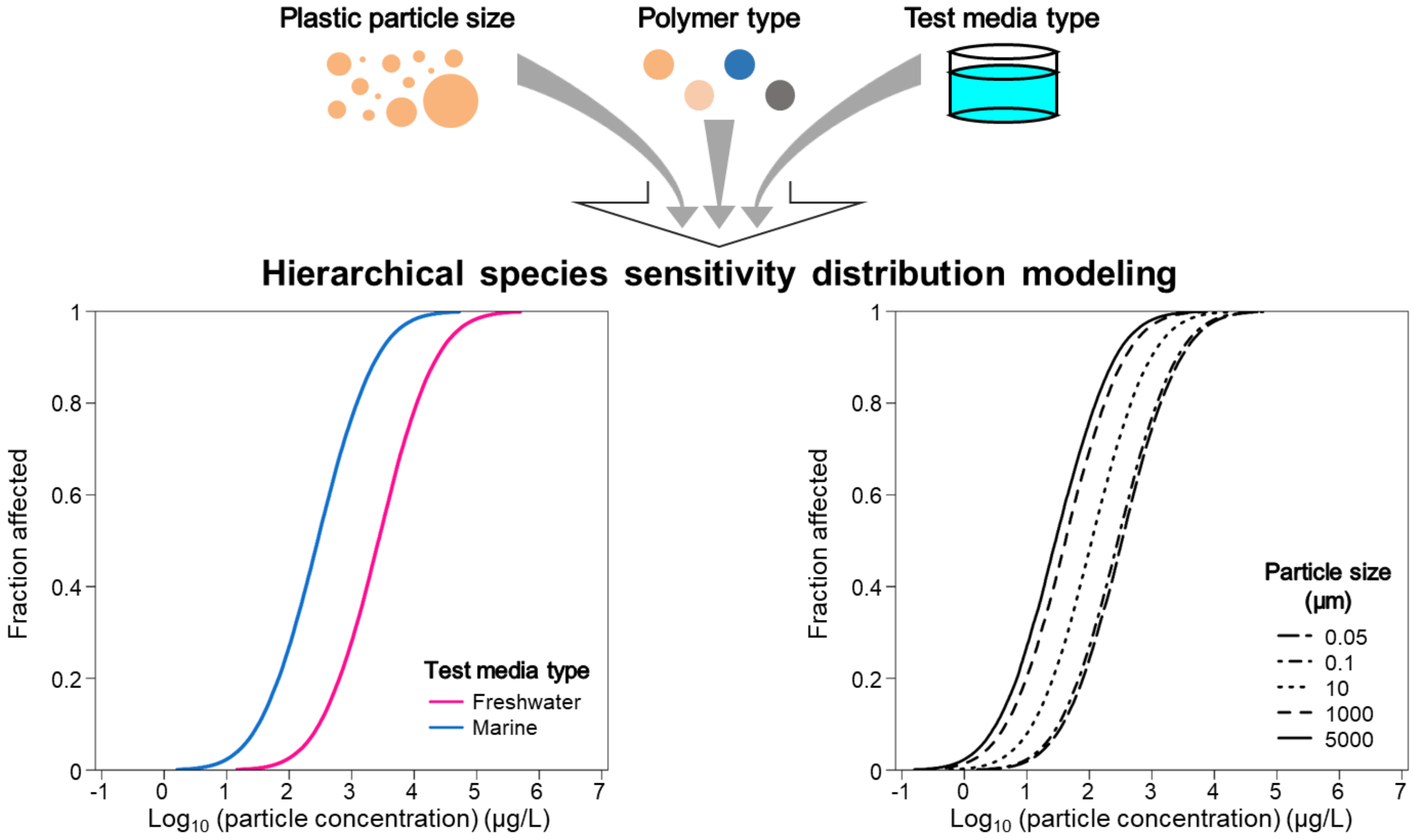


HC5 : 46 particles/L
(α= 2.57)



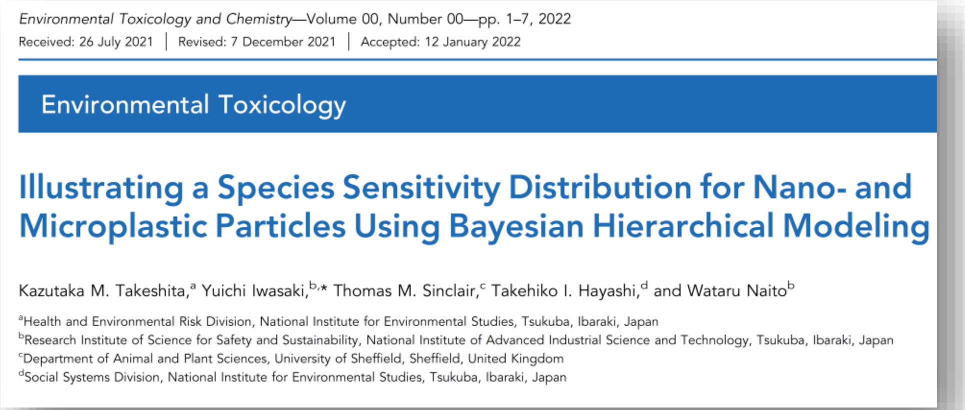
Hierarchical SSD modeling for MPs

Estimating species sensitivity distribution by considering characteristics of MP such as particle length



Graphical Abstract from Takeshita et al. (2022)

Method used by Takeshita et al. (2022)



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Environmental Toxicology

Illustrating a Species Sensitivity Distribution for Nano- and Microplastic Particles Using Bayesian Hierarchical Modeling

Kazutaka M. Takeshita,[a] Yuichi Iwasaki,[b,*] Thomas M. Sinclair,[c] Takehiko I. Hayashi,[d] and Wataru Naito[b]

[a]Health and Environmental Risk Division, National Institute for Environmental Studies, Tsukuba, Ibaraki, Japan
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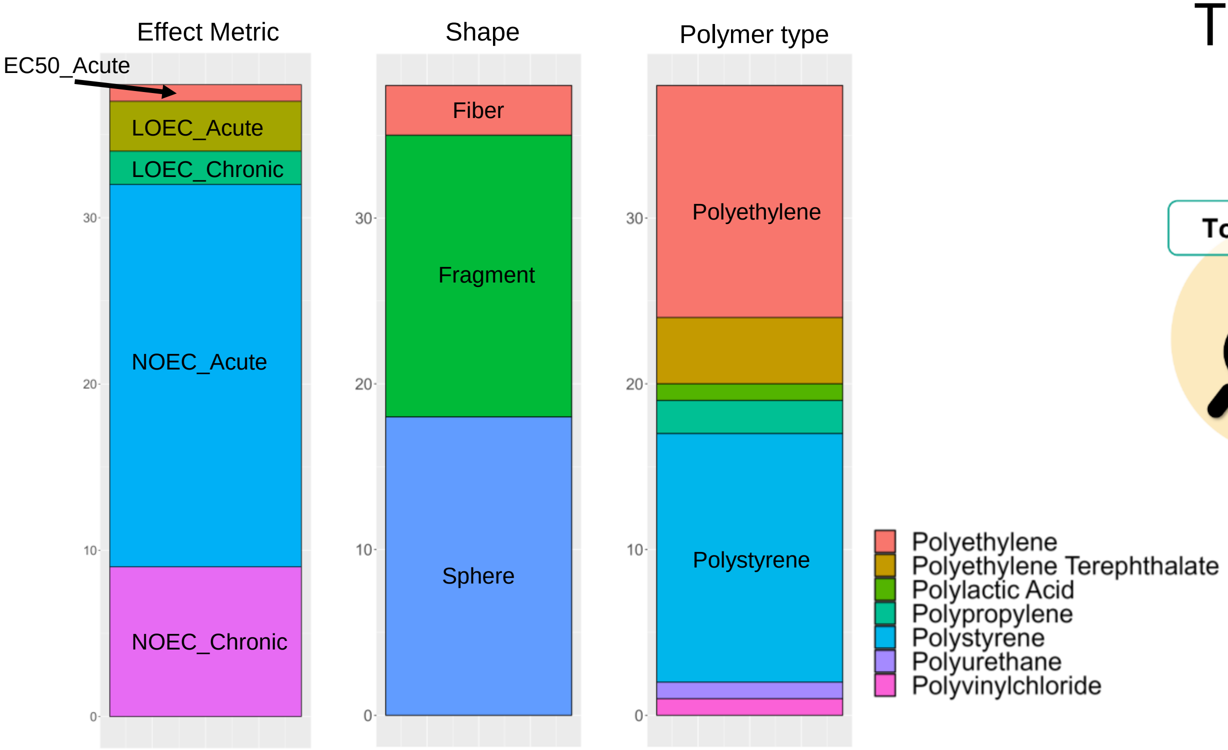
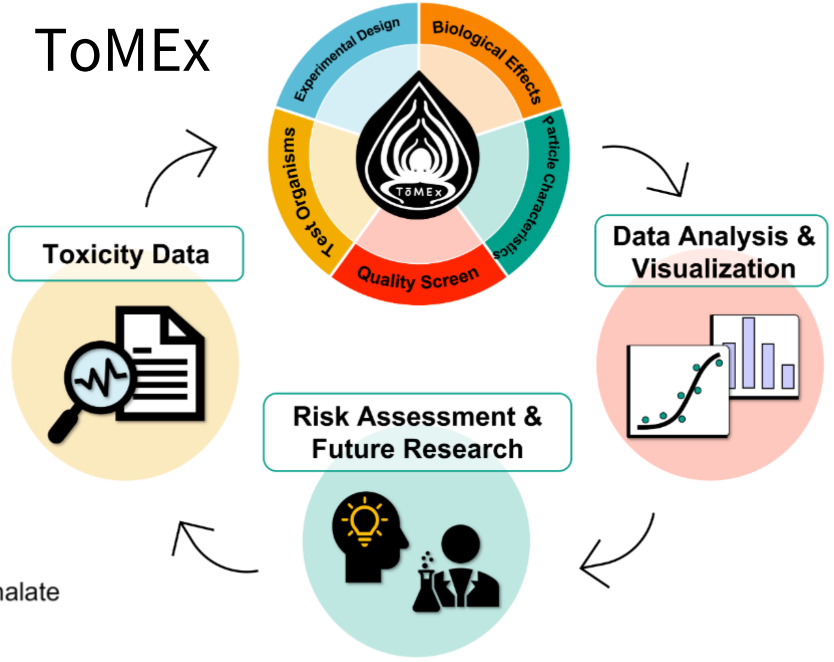
DOI: 10.1002/etc.5295

Toxicity data: Toxicity of Microplastics Explorer (ToMEx)

38 chronic NOECs obtained from ToMEx 1.0 (excluding HONEC)

- 29 chronic NOECs were derived using assessment factors of 2–100
- Excluded algae data by assuming food dilution (Mehinto et al. 2022). Mass concs were used.
- 18 biological species; 38% of NOEC from marine species, particle length of 0.05–280 µm





https://microplastics.sccwrp.org/

Thornton Hampton et al. 2022

https://doi.org/10.1186/s43591-022-00032-4

SSD modeling

- Log-normal species sensitivity distribution (SSD)

R 3.6.3
package “rstan” ver. 2.21.2
Bayesian hierarchical modeling

A normal distribution of mean μ and standard deviation σ

$$\log_{10} \mathrm{NOEC} \sim \mathrm{Normal}(\mu, \sigma)$$

$$\mu = \alpha + \sum \beta_i (X_i)$$

SSD mean

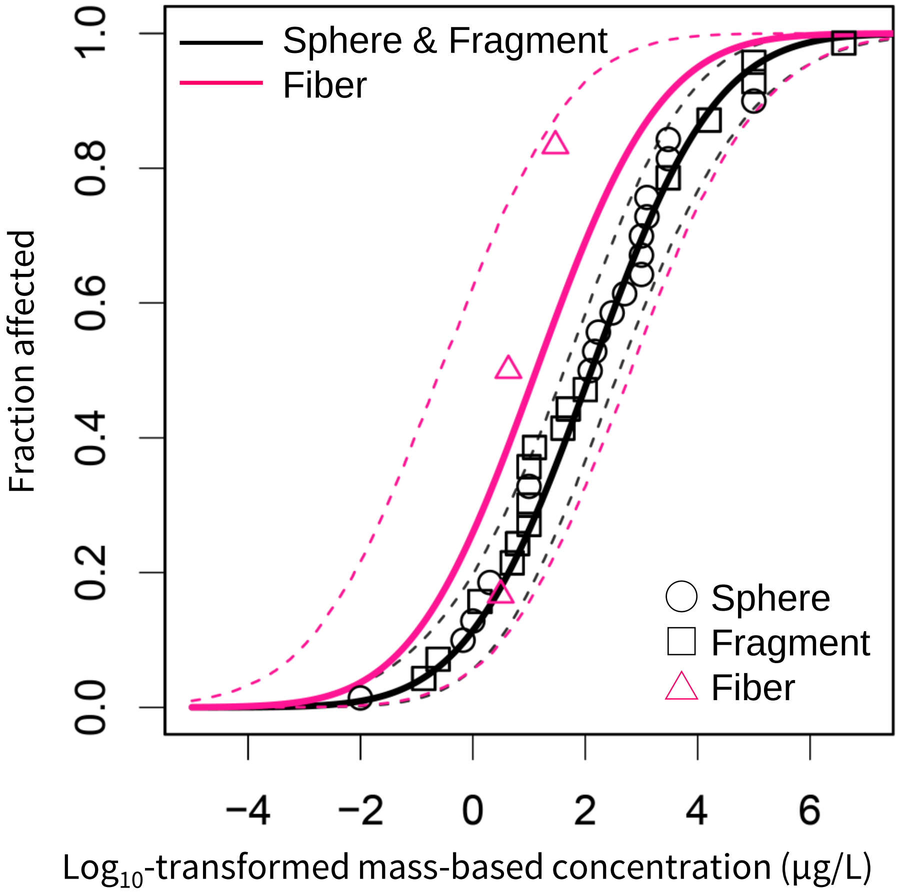
Factors (X_i) considered
- Particle length (log-transformed)
- Shape
- Polymer type
- Habitat of test species (Marine or Freshwater)

- SSD mean is assumed to be affected by MP characteristics and habitat
- Influences of shape (Fragment or not, Fiber or not), polymer type (PS or not, PE or not) , habitat (Freshwater or not) were modeled as binary variables (0, 1).
- Model selection based on WAIC (widely applicable information criterion)
  - Relative model raking is possible.
  - Absolute evaluation based on differences in WAIC is difficult.

Conclusions: Hierarchical SSD modeling for MPs

- Using hierarchical Bayesian modeling, SSDs considering MP characteristics such as particle length were estimated
  - The best SSD model suggest smaller particle size and fiber shape lead to lower NOEC/HC5 values (but see the large uncertainty →).
- Hierarchical SSD modeling enables the evaluation of MP characteristics on <u>multiple</u> species.
- There is still limited data available for each individual species.
  - Most species have only 1 to 3 data points.
  - More data are required.

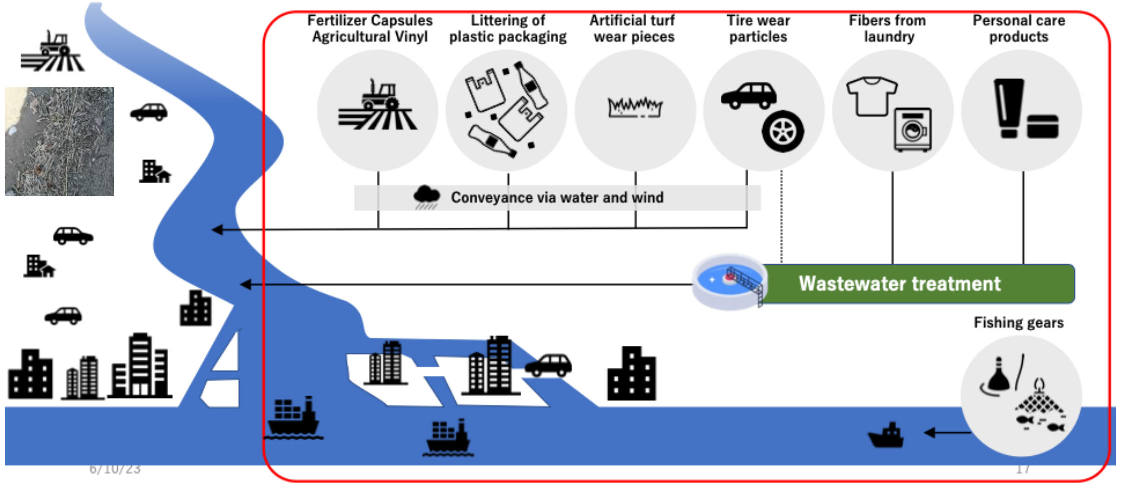
Submitted, under review



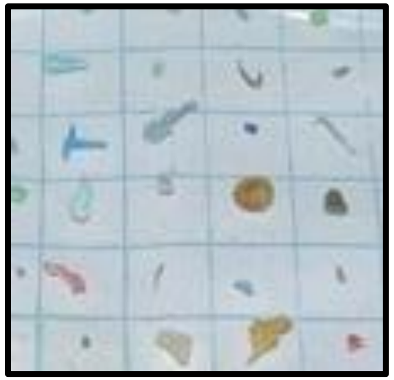
SSD curves were illustrated using median particle length (spherical/fragment: 3.5 μm, fiber: 47.5 μm).

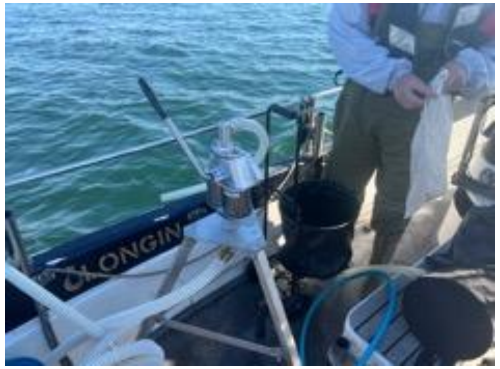
Next Steps

MP Emission Estimations (including future trends)

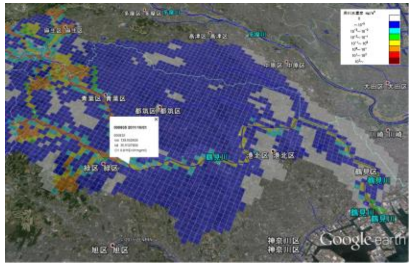


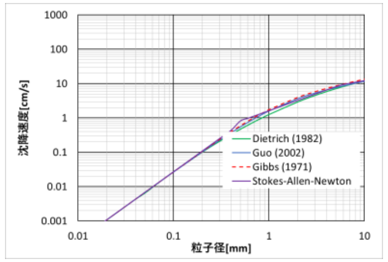
Accumulation of MP monitoring data (surface water and sediment) and characterization of MPs in Tokyo Bay using FTIR and Raman spectroscopy

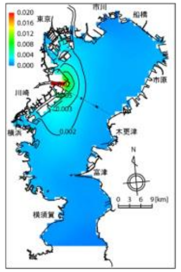




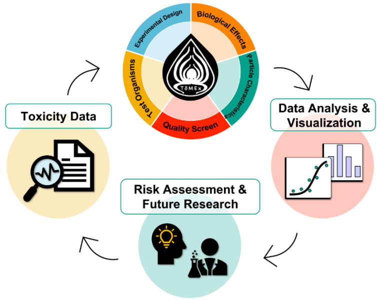
Environmental Modeling for Tokyo Bay

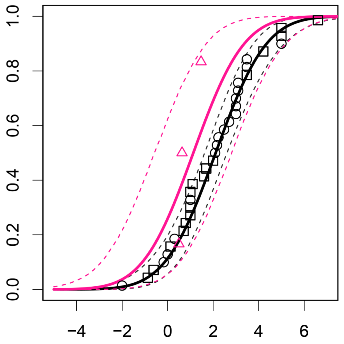






Fit –for-purpose SSD development





https://microplastics.sccwrp.org/

- To what extent does source reduction of plastic materials lead to reduce or prevent microplastic pollution?
- Which sources could be the most effective to reduce and prevent MP pollution?

Acknowledgement

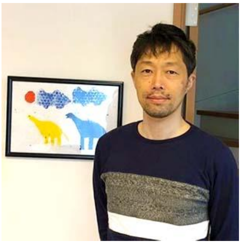
This work was supported by JCIA LRI

AIST members










Members of Kameda group from Chiba Institute of Technology

Thank you for your attention