日化協LRI研究報告会
2026年8月28日
東京証券会館

マイクロプラスチック汚染のリスク対策に資する環境負荷量・発生源解析と環境リスク評価の実践

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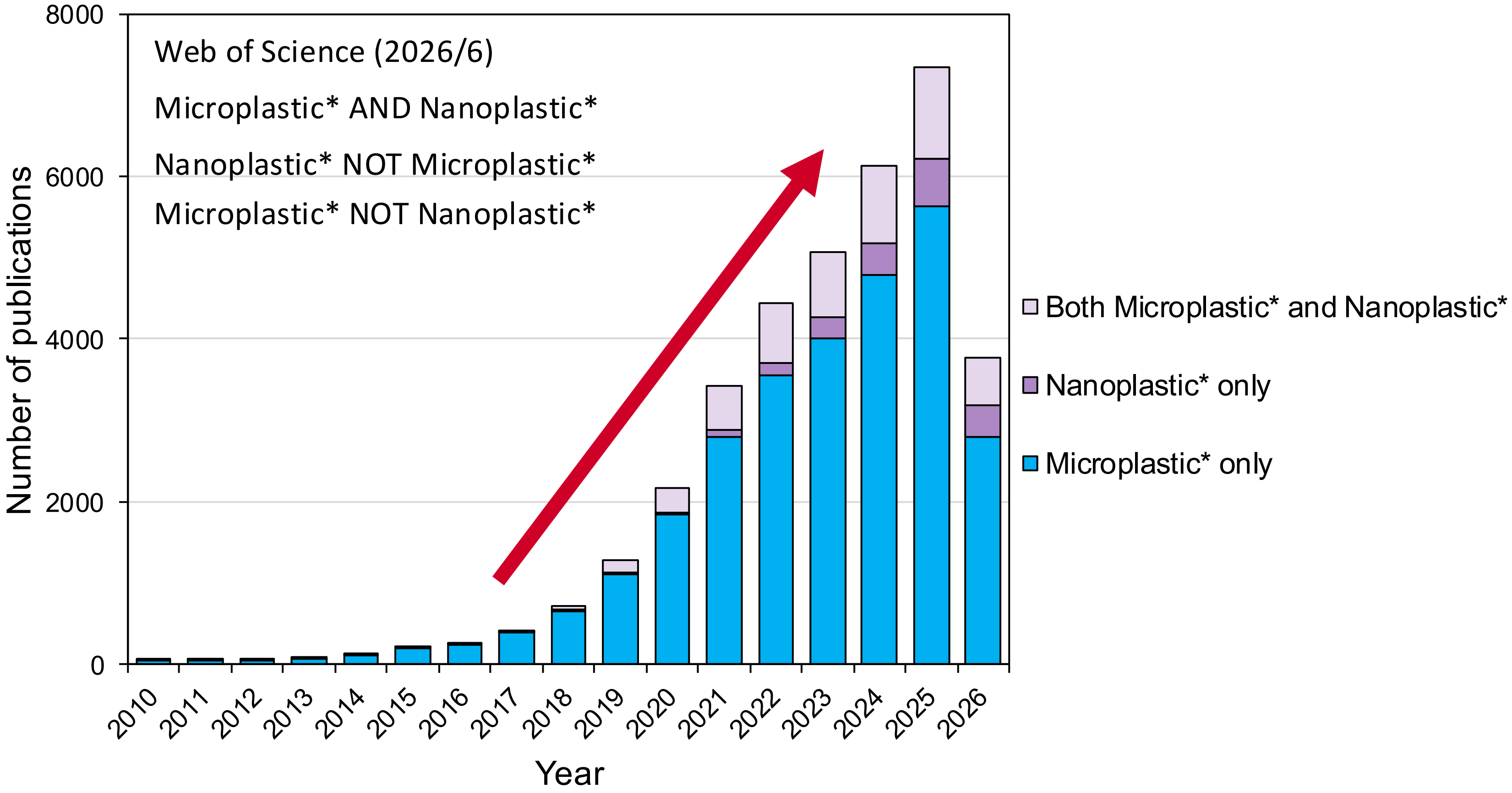
NATIONAL INSTITUTE OF ADVANCED INDUSTRIAL SCIENCE & TECHNOLOGY

配布公開用

マイクロプラスチックへの懸念の高まり

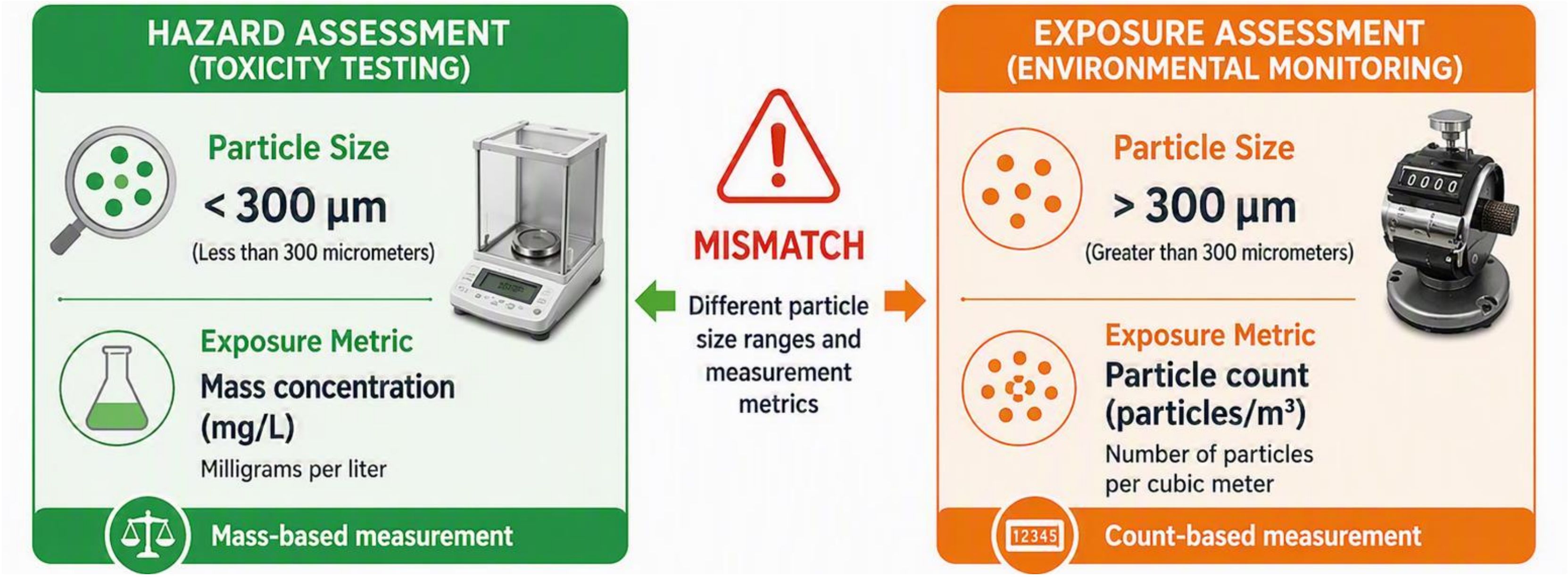
- ●マイクロプラスチック（MP）は水圏環境に広く分布
- ●モニタリング研究・生態毒性研究が急増
- ●生態系に対してどの程度リスクがあるのか

科学的知見は限られている、
リスク評価には不十分



マイクロプラスチックのリスク評価における大きな課題

- 一般的な化学物質：溶存濃度，単一指標（mg/L）
- マイクロプラスチック：サイズ・形状・ポリマー種が多様
- ばく露と影響で用いられる濃度単位が異なる

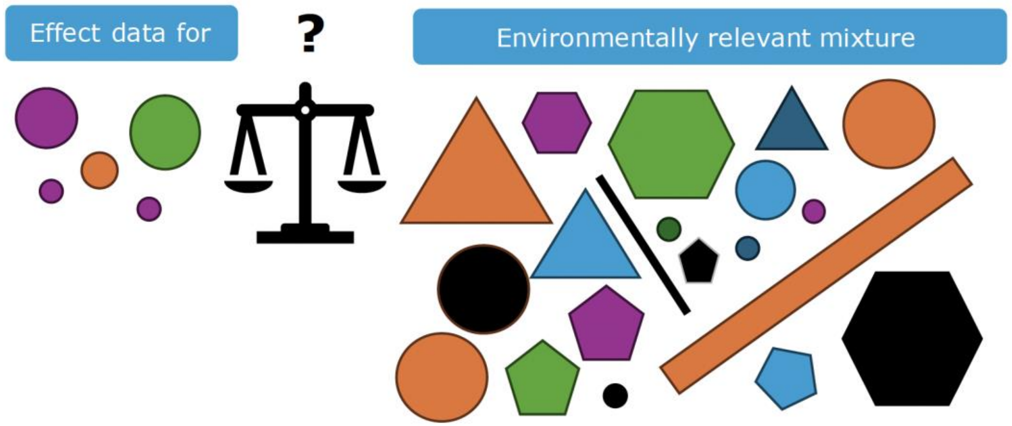


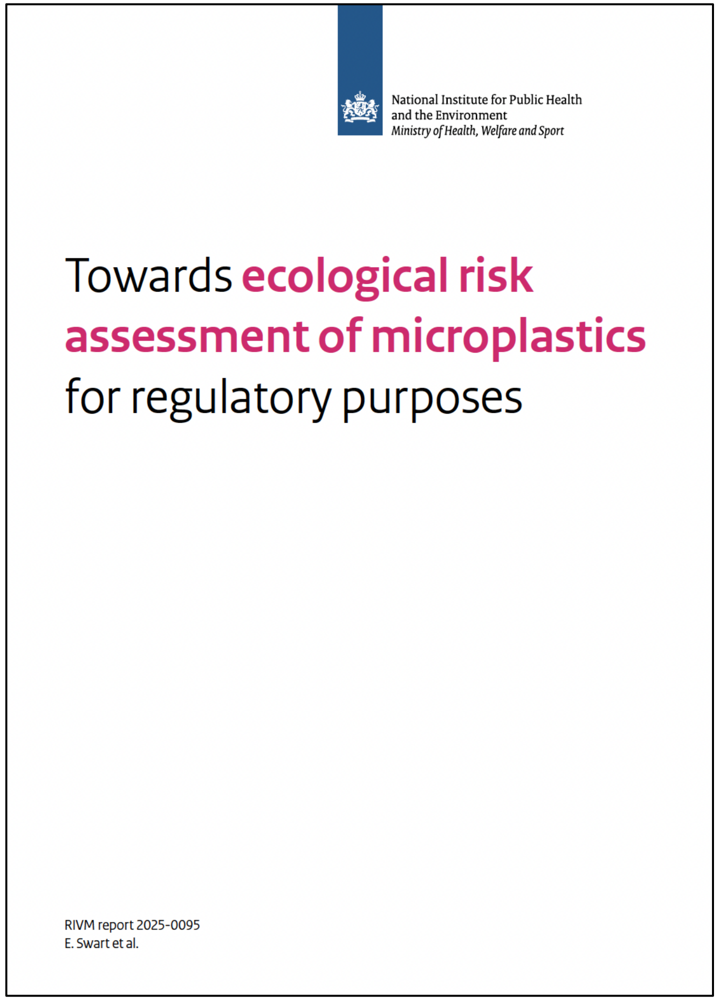
Exposure and effect data are not directly comparable

MPは化学物質と異なり、暴露データと影響データが直接比較できない

ばく露–影響データの整合化に向けて（RIVM 2025)

- 国際的にも重要な課題と認識
- Koelmans らのアプローチ：
  - ➢生態学的関連指標の選択
  - ➢未計測粒径範囲の外挿
  - ➢影響データの環境条件への補正




National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

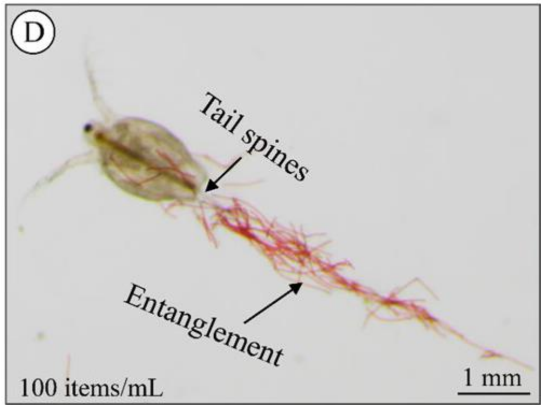
Towards ecological risk assessment of microplastics for regulatory purposes

RIVM report 2025-0095
E. Swart et al.

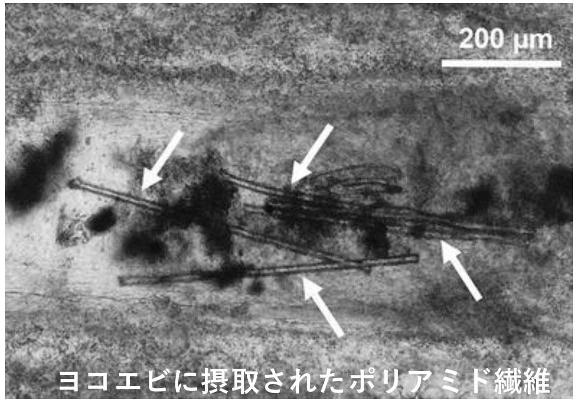
「ばく露と影響を同じ土俵に乗せること」が合理的なリスク評価・管理に不可欠

MPによる影響は何を考慮すべきか?

- MPによる主要な粒子影響:
  - ➢ Food dilution (摂餌希釈)
    （餌の希釈効果や栄養価の低下）
  - ➢ Physical damage（物理的影響）
  - ➢ Oxidative stress（酸化ストレス）

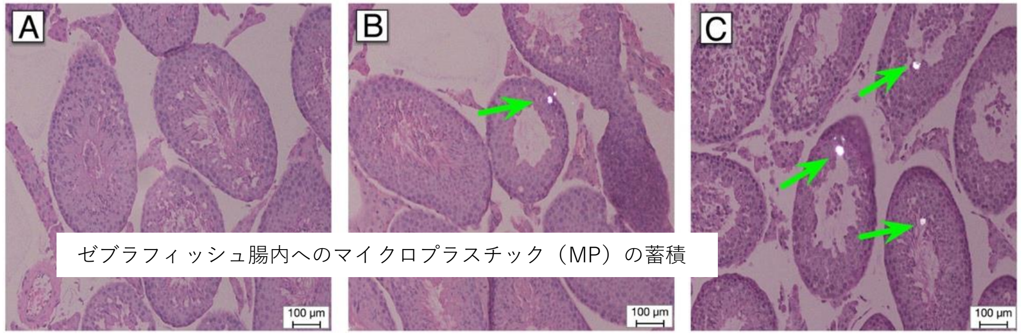


Ma et al. 2024. Environ. Sci. Technol. Lett. 11, 5, 433-437



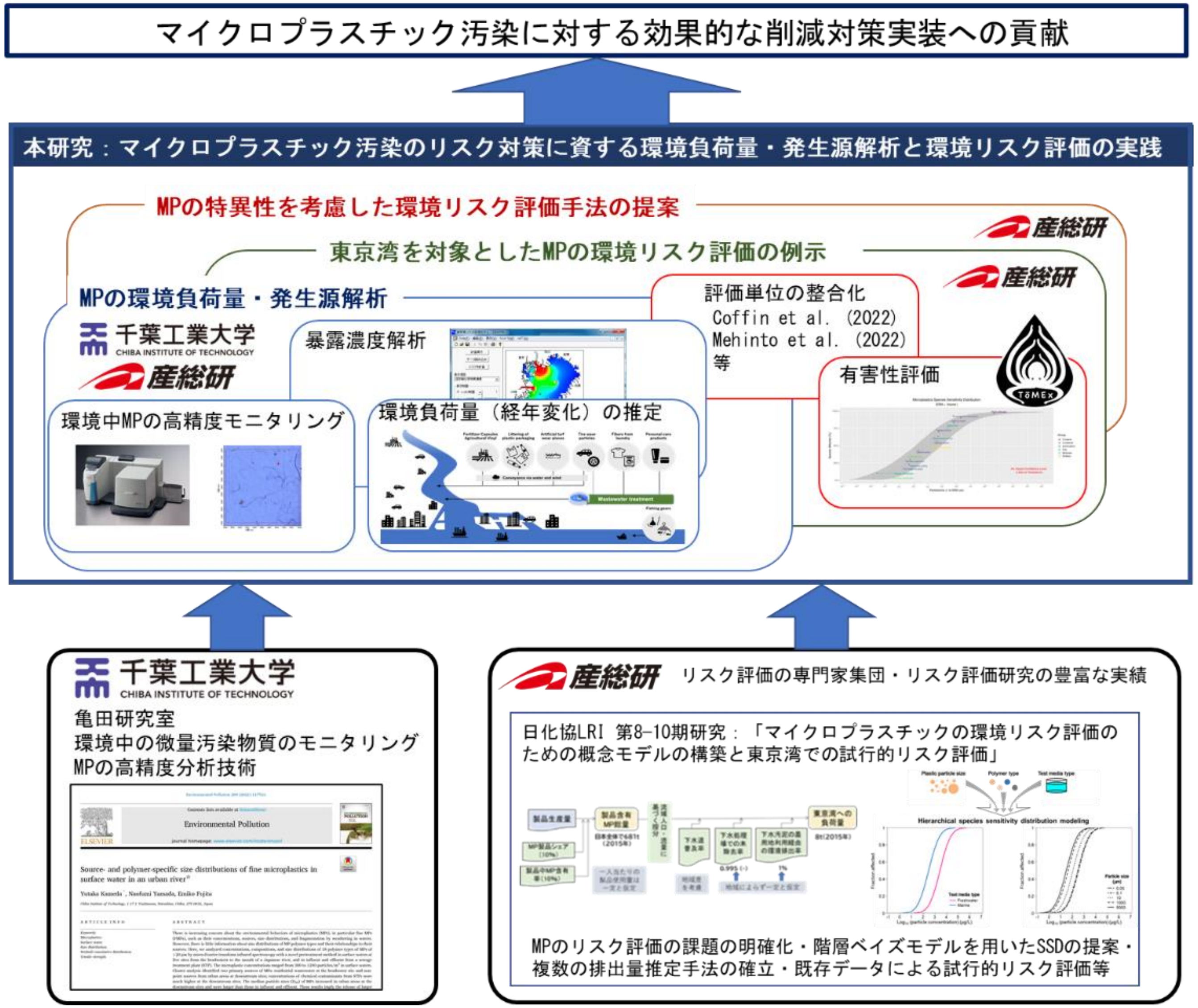
Blarer and Burkhardt-Holm.(2016) *Environ Sci Pollut Res* 23

- 本研究では:
  「摂餌希釈」に着目し
  ecologically relevant mechanism
  として想定



Qiao et al. 2019 Sci. Total Environ. 2019, 662, 246–253.

- 濃度単位:
  - **➢体積ベース濃度（Volume-based concentration）**



プラスチックを完全になくせない中で、
どの種類・用途を削減または代替できるか？

その対策によってリスクはどの程度低減できるか？

本研究のアプローチ

- 東京湾におけるMPの特性把握
- 最新データを用いたSSDの構築
- 環境リスクと対策効果の定量化

どのようなMPが、どこで、どの程度のリスクに関係するのかを定量化し、対策の優先順位づけにつなげる

どうやって多様なMP粒子の環境リスク評価を行うのか？

Understand the mechanisms driving ecological effects
どう影響するのか（メカニズム）を**明らかにし**、

Fill data gaps in unmeasured concentration ranges
見えていない濃度の範囲を科学的に**補い**、

Harmonize exposure metrics (particle number, volume, and mass)
“個数”や“体積”、“重さ”などの単位を**そろえて**、

Compare laboratory and environmental data using a common framework
実験と環境のデータを同じ基準で**比べる**

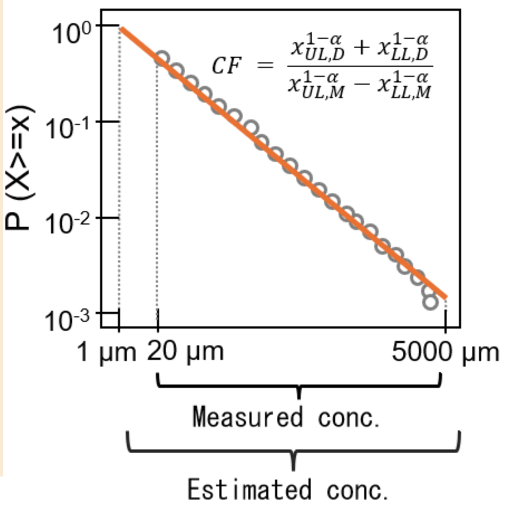
ばく露と有害性データの整合化

未計測粒径の推定）

モニタリングデータで把握できる粒径範囲は限定的
小さい粒子は測定されないことが多い

アプローチ:

観測された粒径と存在量の関係を統計分布に当てはめ対象とする粒径範囲（例：1-5000 µm）へ外挿

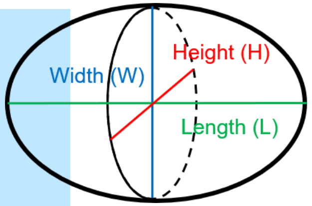


生態学的に関連の高い指標への変換

環境データは粒子数で報告されることが多い
生態影響は摂取された物質量に依存する

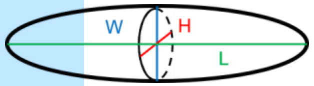
換算:

粒子数 → 体積（主要指標）
暴露量を影響指標（摂餌希釈）に結び付ける



$\frac{L}{W} < 3$

$H = \left(\frac{W}{L}\right)_{\mathrm{median}} \times W$



$\frac{L}{W} \geq 3$

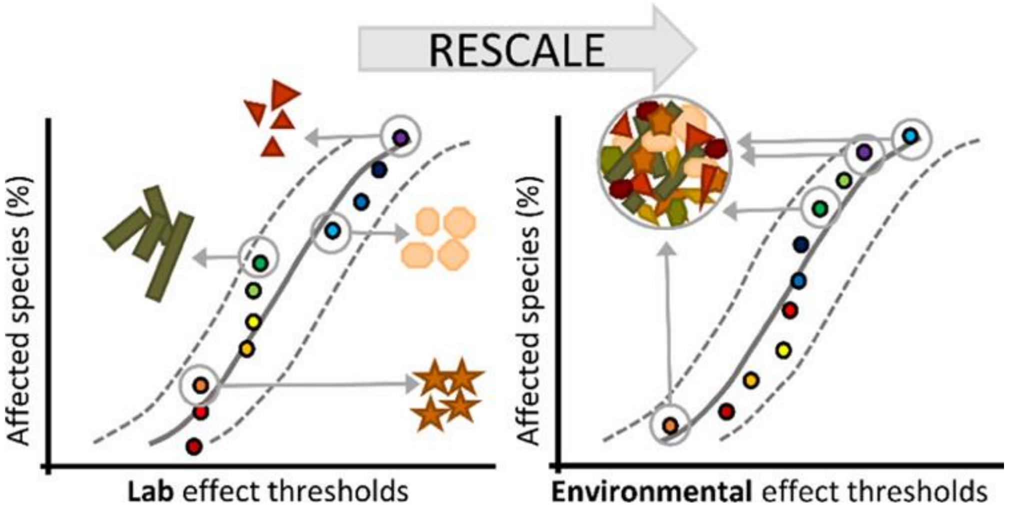
$H = 15\mu\mathrm{m}$

毒性データの環境中MPへの補正

影響試験に用いられるMP粒子は環境中MP粒子と異なる
（サイズ・形状・ポリマー種）

アプローチ：

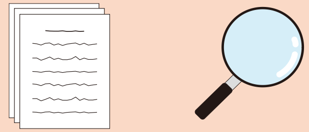
粒子特性を考慮して影響データを補正
生物利用可能な粒径範囲を考慮
環境中ばく露と比較できる形に整える



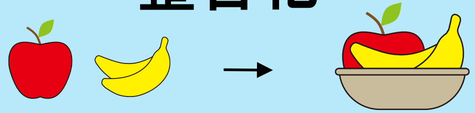
マイクロプラスチックの環境リスク評価の枠組み

Redondo-Hasselerharm et al.（2024）*Journal of Hazardous Materials, Article 133732.*

データ取得・整理・分析



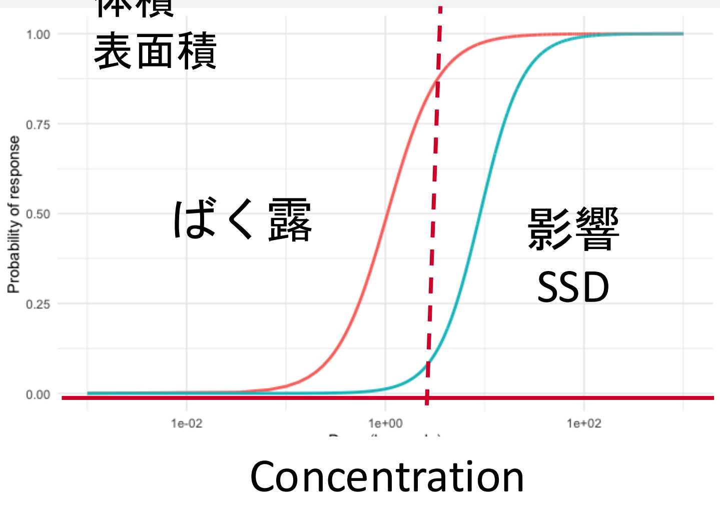
ばく露と影響の整合化



リスク評価

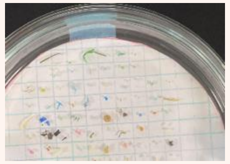
どの指標で評価するのか?

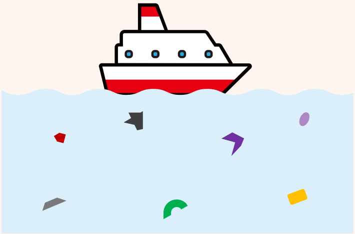
粒子数
重量
体積
表面積



参照値を超過する割合は？

ばく露





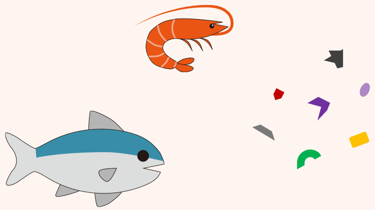
ポリマーの種類？
形状？
サイズ？

どのようなMPが環境中に存在しているのか？

QA/QC

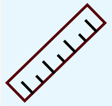
影響

Toxicity endpoints:
NOEC, LOEC, EC10, etc.



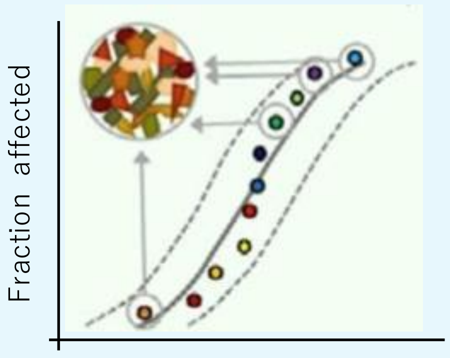
ポイント:
影響のメカニズムは?
生物に取り込まれるサイズは?

Study 1
Study 2
Study 3



1 µm 5000

比較可能な単位指標へ変換

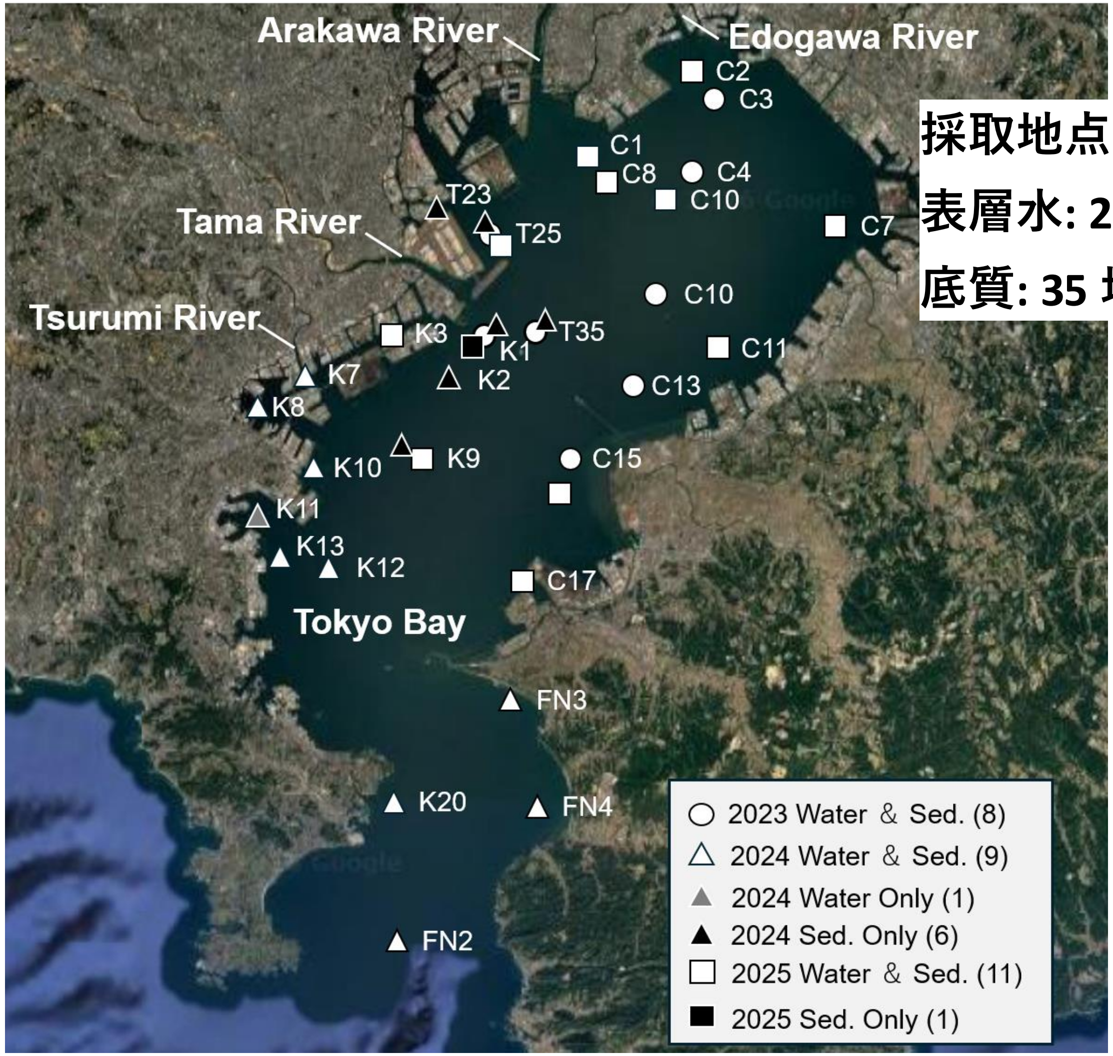


東京湾を対象としたMPのリスク評価の例示

東京湾におけるMP粒子濃度（20 µm超）の特性把握

千葉工業大学
CHIBA INSTITUTE OF TECHNOLOGY

千葉工業大学・亀田研究室と連携

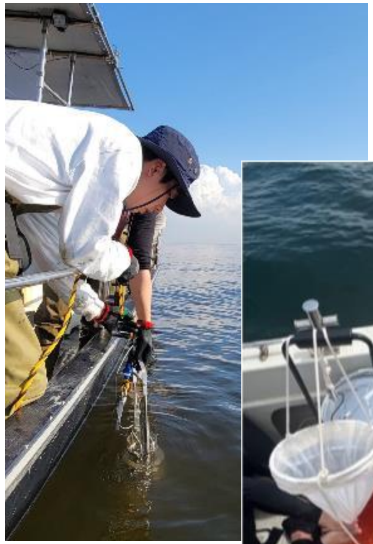


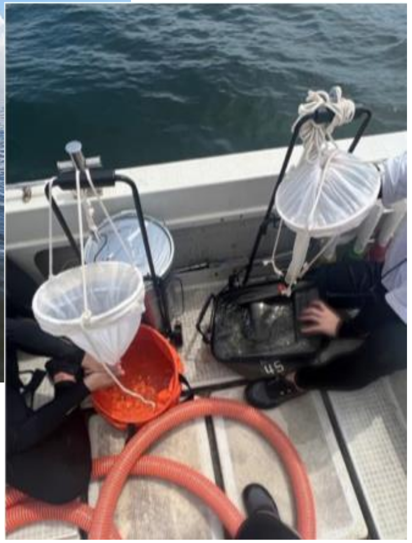
採取地点数

表層水: 29 地点

底質: 35 地点

ポリマーの種類、サイズ、形状を把握





Ueda et al. Microplastics and Nanoplastics (2025) 5:47
https://doi.org/10.1186/s43591-025-00168-z
Microplastics and Nanoplastics

RESEARCH Open Access

Size-specific distribution, morphology, and polymer composition of microplastic particles in surface water and sediments of Tokyo Bay

Koji Ueda[1*], Yutaka Kameda[2], Emiko Fujita[2], Gakushi Fujimura[2], Eiji Fukazawa[2], Yutaro Numazawa[2], Yuichi Iwasaki[1] and Wataru Naito[1*]

Abstract
Microplastic particles (MPs) are ubiquitous in marine environments; however, comprehensive studies comparing their characteristics across environmental matrices and size ranges remain limited. This study investigated MPs in surface water and sediment samples collected from eight stations in Tokyo Bay during October–November 2023. The samples were analyzed for MP concentration, size distribution, morphology, and polymer composition. The results showed that small MPs (20–100 µm) numerically dominated in both surface water and sediment, accounting for more than 70% of total MP concentration. However, medium and large MPs (100–350 µm and ≥350 µm), although less abundant, contributed substantially to total estimated MP mass in both matrices. Morphologically, fragmentary MPs were dominant in most samples, particularly among small and medium MPs, whereas fibrous MPs became more prevalent with increasing particle size in both matrices. In terms of polymer types, PMMA, PE, and PP were abundant in surface water, while PE and PP predominated in sediments, with PMMA occurring at a smaller proportion. In the large-size fraction (≥350 µm) of both matrices, PET was the most abundant polymer in both number- and mass-based compositions. By targeting a broad size range of MPs (20–5000 µm), this study demonstrates that key MP characteristics, particularly morphology and polymer composition, vary systematically across size classes and environmental matrices. These findings suggest that both particle size and the selected quantification metric (number- or mass-based) play an important role in the assessment of MP pollution. The dataset provides valuable size-resolved baseline information for long-term monitoring and supports future ecological risk assessments in urbanized coastal environments.

Keywords Fiber, Fragment, Mass, Semi-enclosed bay, Volume

Regional Studies in Marine Science 84 (2025) 104108
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ELSEVIER
Regional Studies in Marine Science
journal homepage: www.elsevier.com/locate/rsma

Concentrations and characteristics of microplastic particles collected by neuston net or pump system in the surface layer of Tokyo Bay

Koji Ueda[a,*], Yutaka Kameda[b], Emiko Fujita[b], Shingo Rachi[b], Yuichi Iwasaki[a], Rie Tai[a], Wataru Naito[a,*]

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ARTICLE INFO

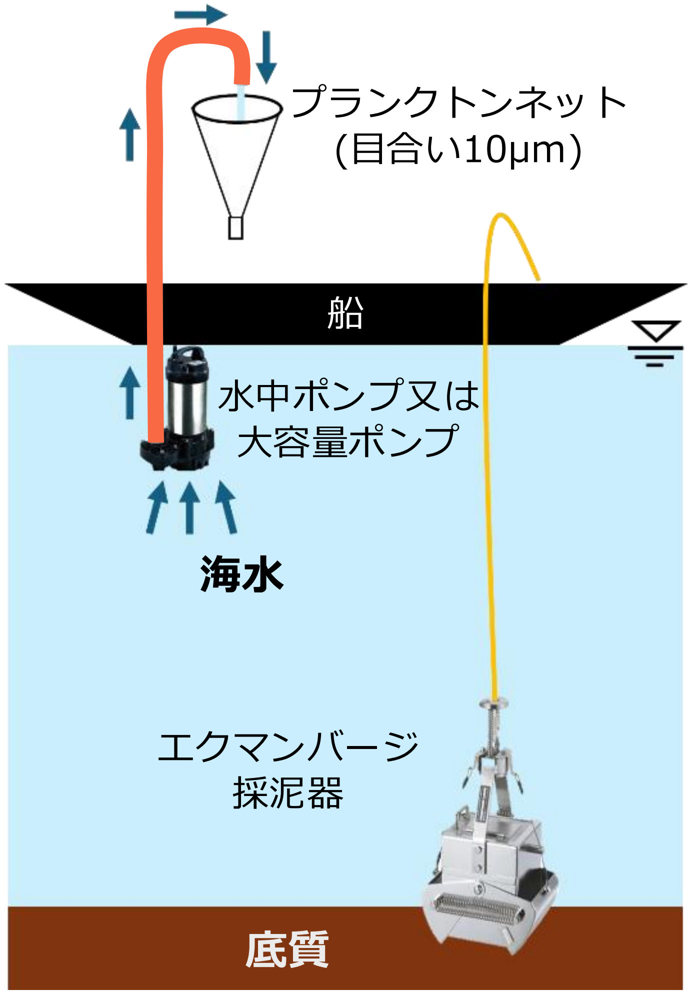
Keywords:
Fiber
Sampling method
Polymer type
Particle size distribution
Poly(methyl methacrylate)
Small microplastic

ABSTRACT

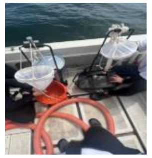
This study examined the number concentrations, size distributions, shapes, and polymer compositions of microplastic particles (MPs) in Tokyo Bay surface waters with a neuston net (350 µm mesh) and a pump system (10 µm mesh). The results demonstrated that the pump system collected a broader range of MPs, particularly smaller and fibrous particles, leading to higher concentrations than the neuston net. In contrast, the neuston net was less effective at capturing MPs < 1000 µm, especially fibrous MPs. Principal component analysis revealed that the polymer composition differed between the two methods, with poly(ethylene terephthalate) (PET) and poly(methyl methacrylate) (PMMA) being dominant in pump system samples, while polyethylene (PE) and polypropylene (PP) were predominant in neuston net samples. These differences were influenced by multiple factors, including mesh size, sampling depth, and the volume of water filtered. The findings highlight the limitations of single-method sampling and suggest that integrating multiple sampling approaches is essential for a more comprehensive understanding of MP distribution and characteristics in surface waters. Future research should refine sampling strategies to improve the accuracy of MP pollution assessments and better inform ecological risk evaluations.

サンプリングと定量分析

サンプル採取



海水



水中ポンプ（2023年）又は大容量ポンプ（2024年以降）で表層水を採取し、10 μm

プランクトンネットでろ過

5 μmPTFEメンブレン（2023年）又はシリコンベースメンブレン（2024年以降）で吸引ろ過

30%H_2O_2で有機物を分解（55℃で72時間以上）

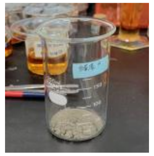
ヨウ化ナトリウム水溶液（1.7 g/cm^3）で密度分離し、上澄み液を5 μmメンブレンで吸引ろ過

顕微FTIRで透過法を用いたイメージング分析

底質

エクマンバージ採泥器で表層10 cm底質を採取

湿泥試料を55℃で72時間以上乾燥



乾泥試料を30%H_2O_2と0.5M $FeSO_4$を加えて、フェントン反応で有機物を分解（55℃で72時間以上）

ヨウ化ナトリウム水溶液（1.7 g/cm^3）で密度分離し、上澄み液を5 μmメンブレンで吸引ろ過

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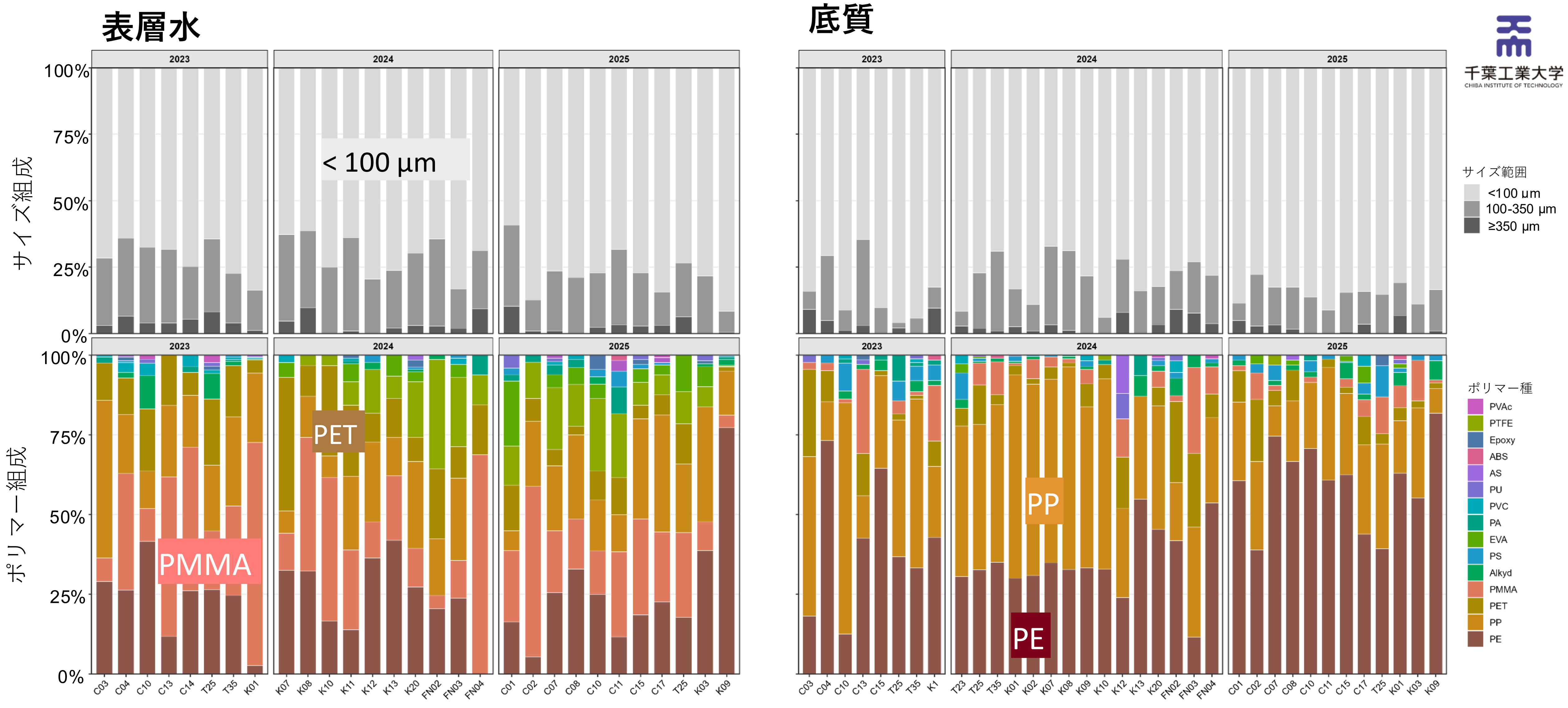
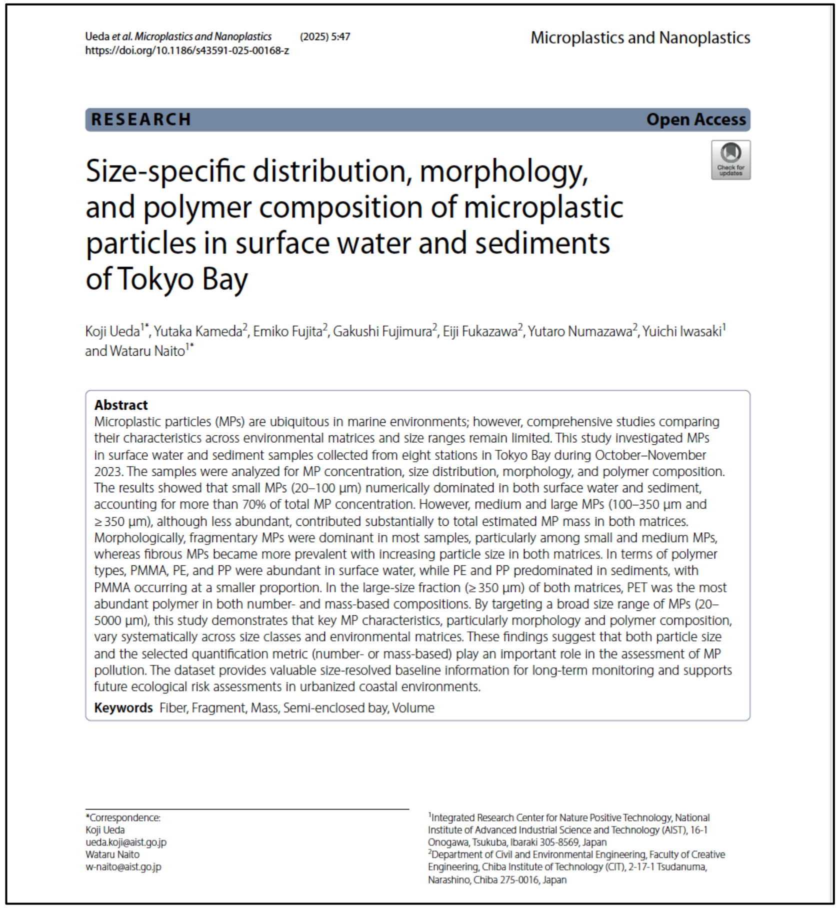
東京湾で観測されたMP粒子の粒径分布とポリマー組成



東京湾で観測されたMP粒子の粒径分布とポリマー組成

- 表層水でも底質でも微小粒子が大半（20–100 µmの粒子が70%以上を占めた）
- 粒子数と質量では寄与する粒径サイズが違う（粒子数ベースでは小粒径MPが卓越、質量ベースでは100 µm より大きいサイズの寄与が大）
- 形状はサイズによって異なる（小粒径では破片が支配的、一方大粒径では繊維が増加）
- 表層水と底質では主要ポリマーが異なる
  - 表層水：PMMA, PE, PP, PET（PETは大きい粒子で優占）
  - 底質：PE,PP


Ueda *et al. Microplastics and Nanoplastics* (2025) 5:47
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Microplastics and Nanoplastics

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Keywords Fiber, Fragment, Mass, Semi-enclosed bay, Volume

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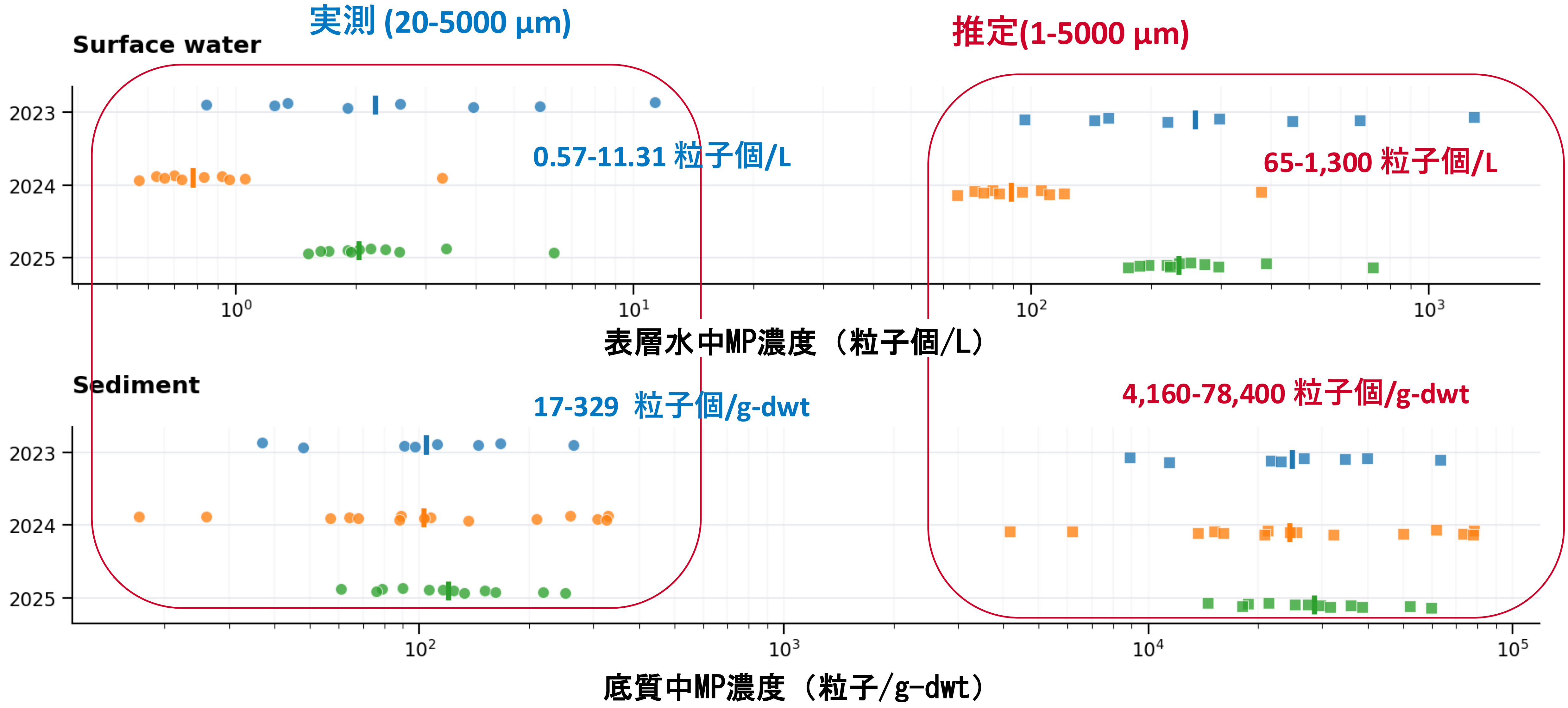
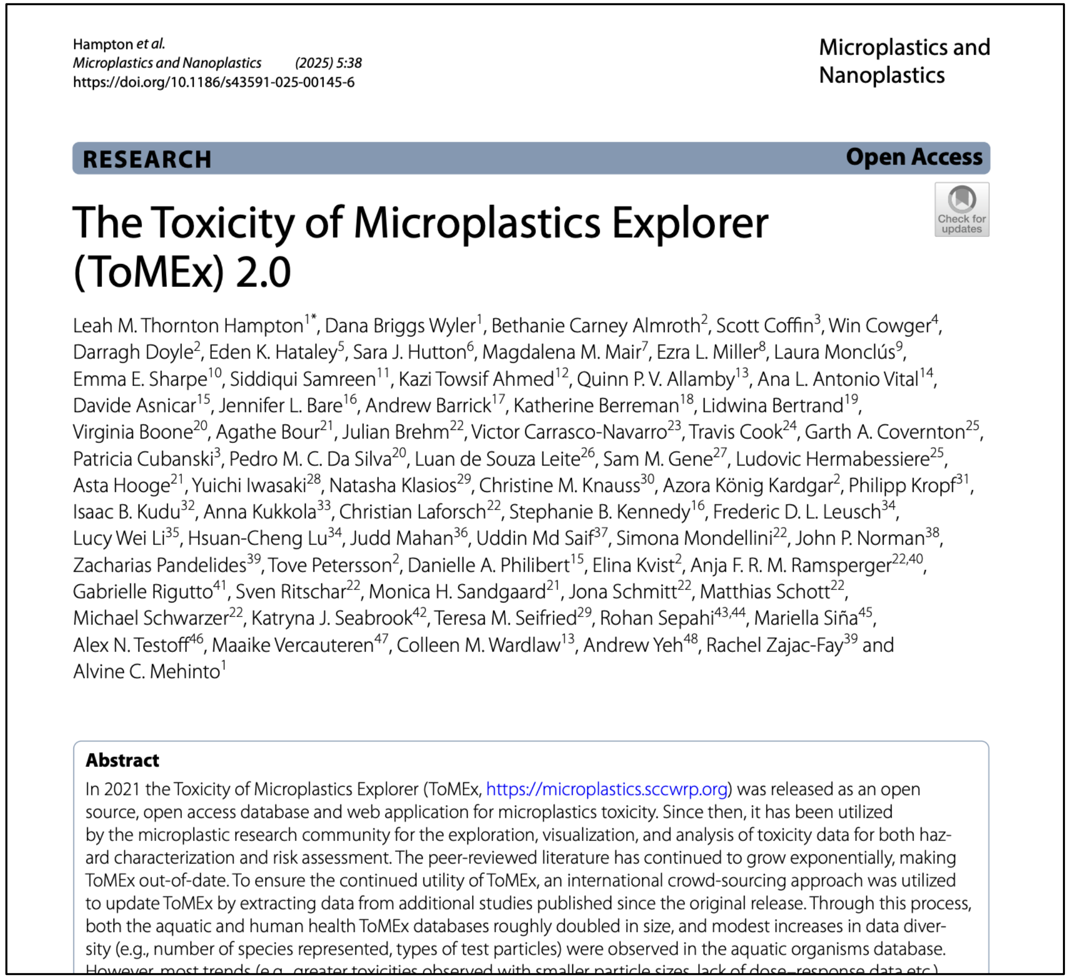
何をモニタリングするかで結果が変わる
（環境中におけるMPの多様さを実証）→ 世界的に貴重なデータ

東京湾の表層水・底質におけるMP濃度



影響の閾値の導出



Hampton *et al.*
Microplastics and Nanoplastics (2025) 5:38
https://doi.org/10.1186/s43591-025-00145-6

Microplastics and Nanoplastics

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The Toxicity of Microplastics Explorer (ToMEx) 2.0

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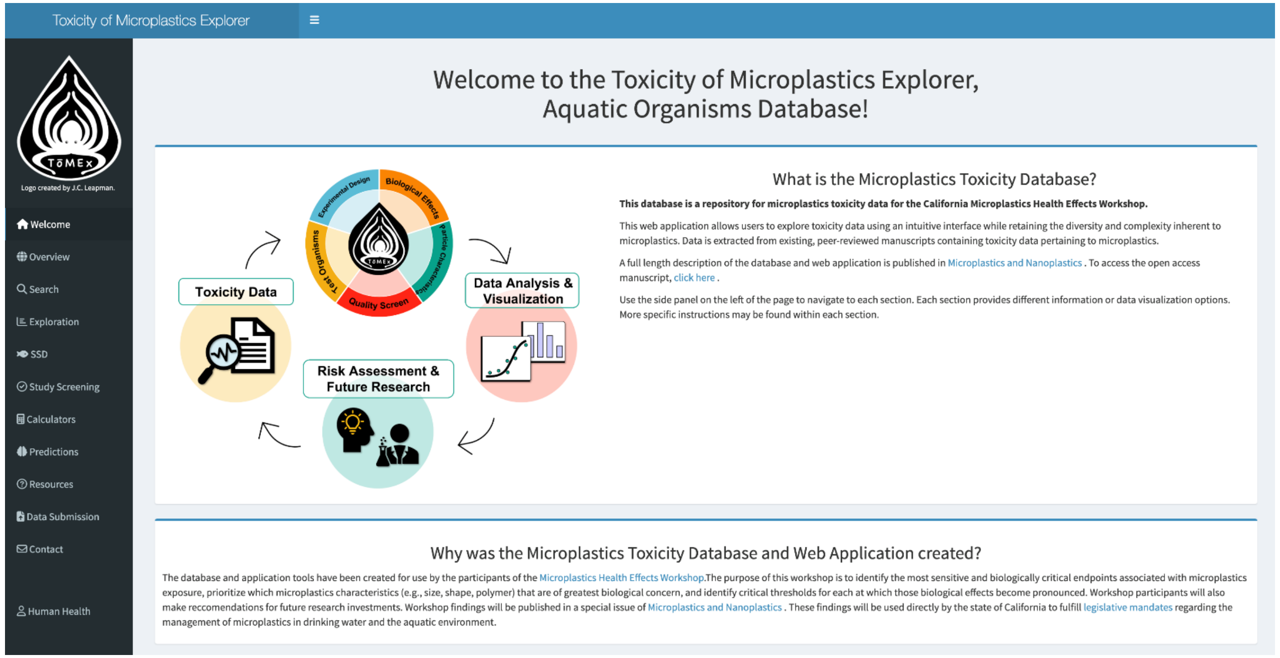
Abstract

In 2021 the Toxicity of Microplastics Explorer (ToMEx, https://microplastics.sccwrp.org) was released as an open source, open access database and web application for microplastics toxicity. Since then, it has been utilized by the microplastic research community for the exploration, visualization, and analysis of toxicity data for both hazard characterization and risk assessment. The peer-reviewed literature has continued to grow exponentially, making ToMEx out-of-date. To ensure the continued utility of ToMEx, an international crowd-sourcing approach was utilized to update ToMEx by extracting data from additional studies published since the original release. Through this process, both the aquatic and human health ToMEx databases roughly doubled in size, and modest increases in data diversity (e.g., number of species represented, types of test particles) were observed in the aquatic organisms database.

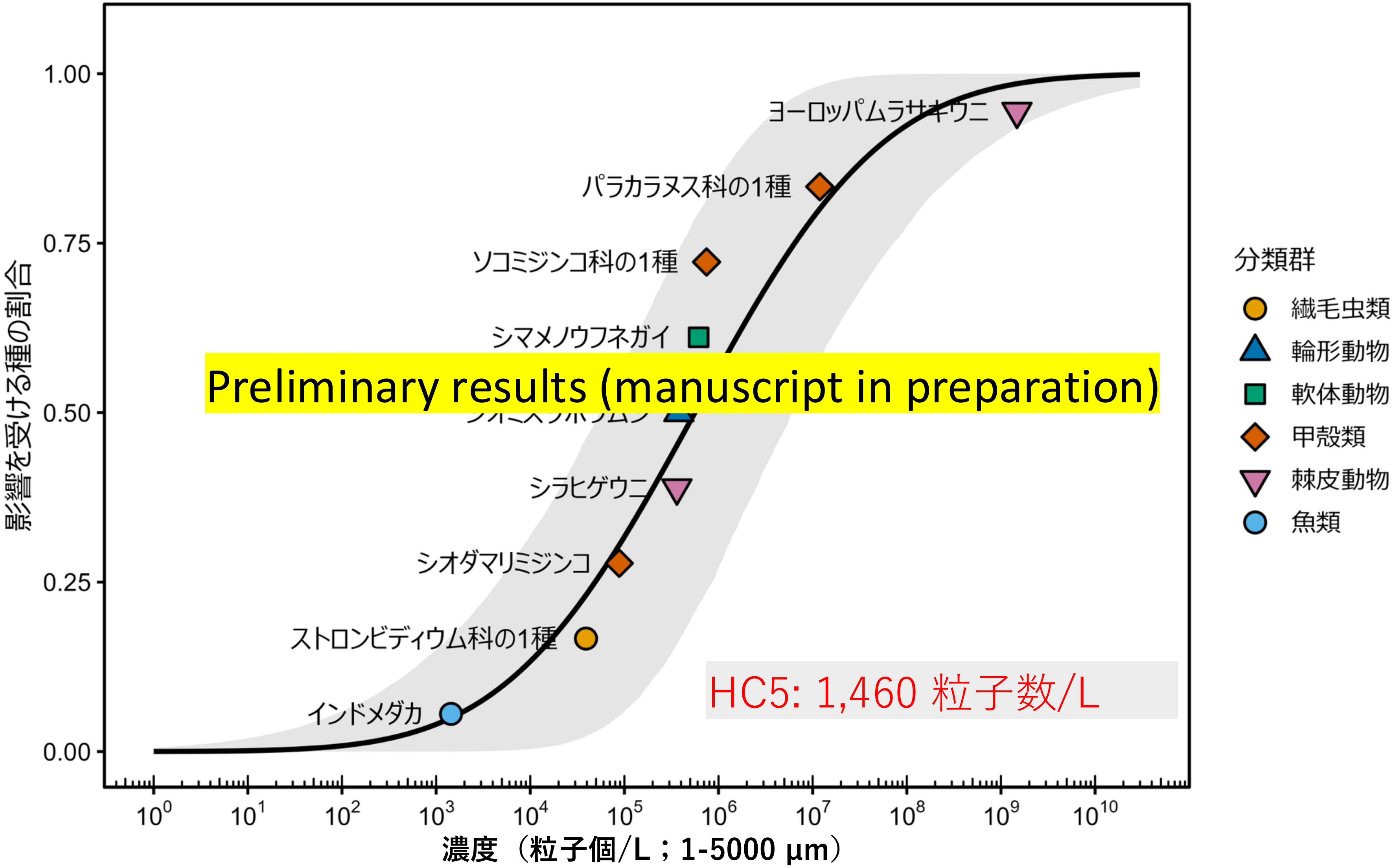
複数種データから影響閾値を導出



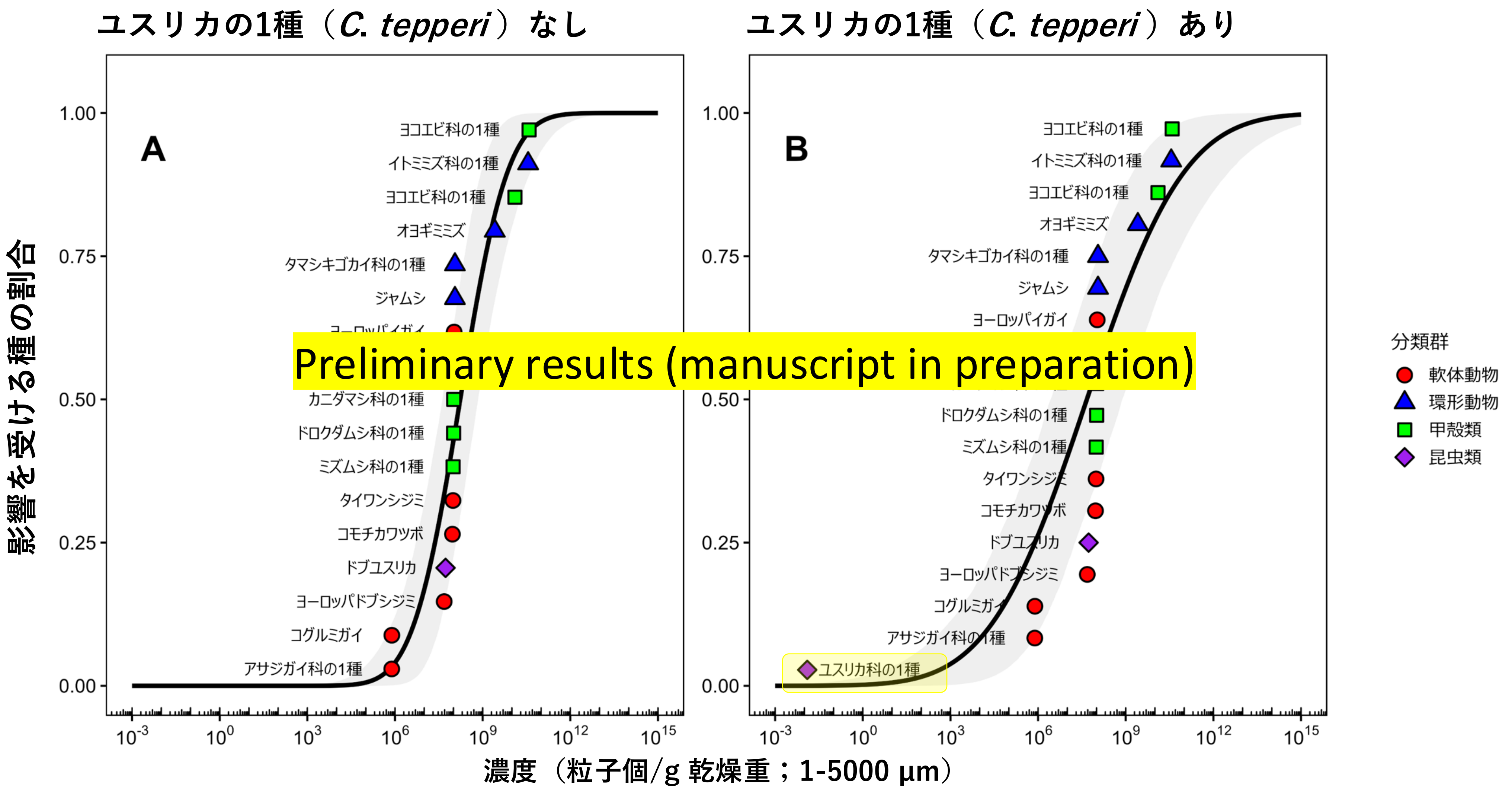
https://sccwrp.shinyapps.io/aq_mp_tox_shiny/

- 毒性データベース(ToMEx)を利用
- 種の感受性分布(SSD)を構築
- HC5 を閾値として設定

種の感受性分布と影響閾値(HC5)（表層水）



種の感受性分布と影響閾値(HC5) （底質）

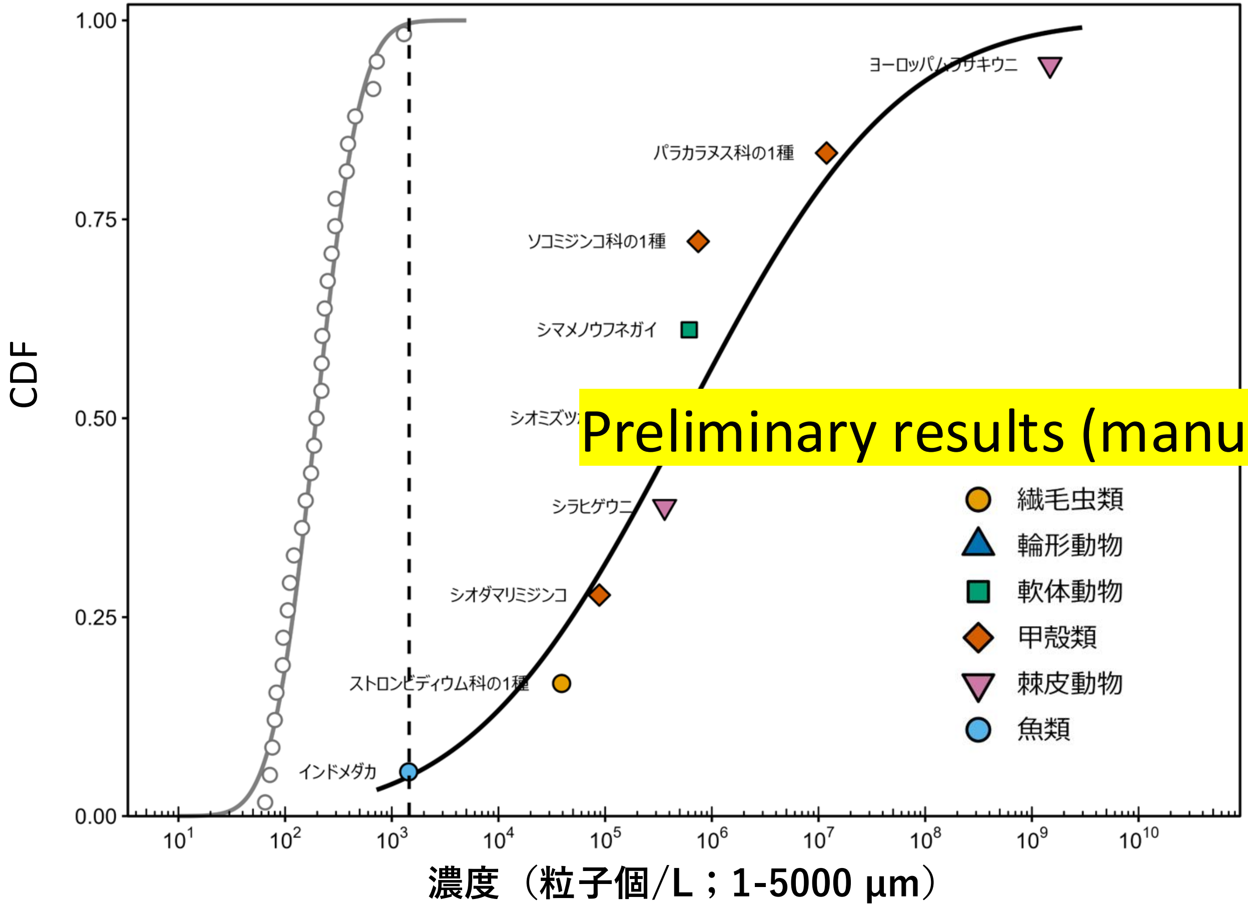


HC5: 134,0000 粒子個/g 乾燥重

HC5: 2,170 粒子個/g 乾燥重

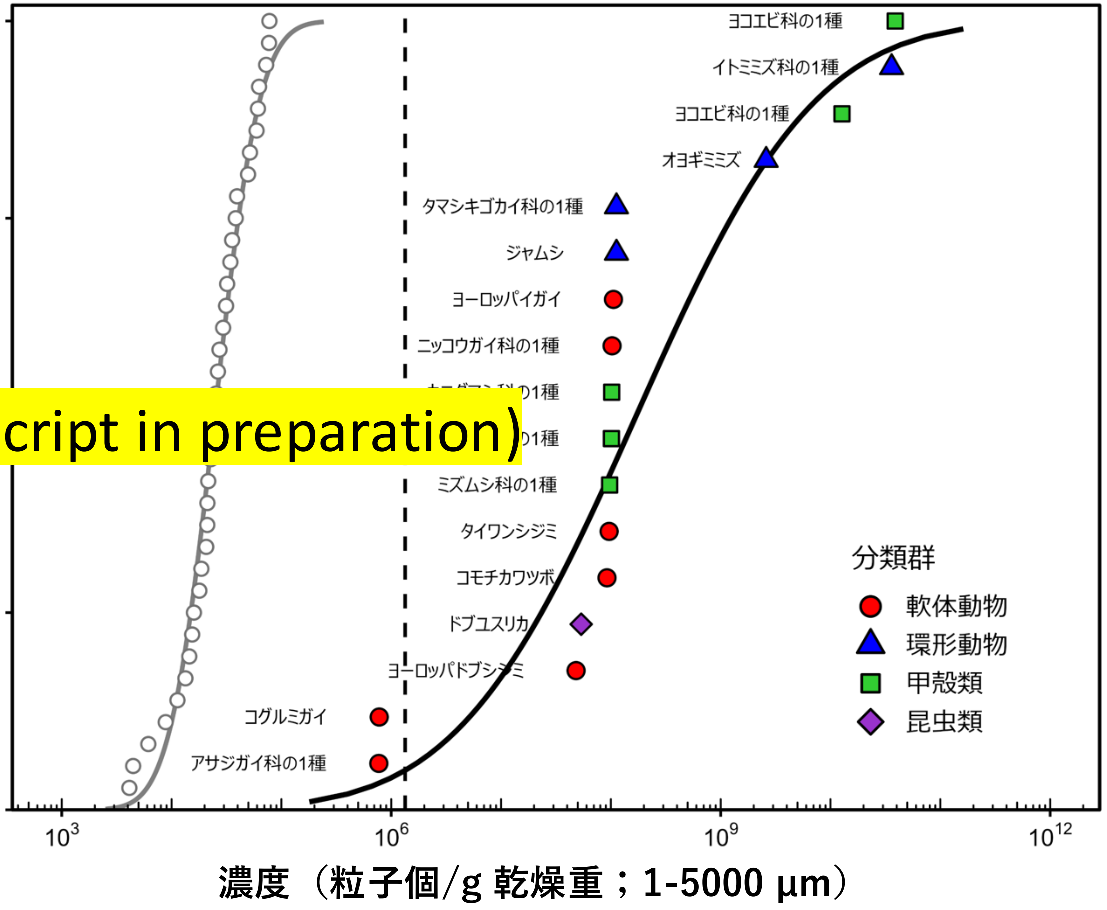
東京湾における推定MP濃度分布とSSDの比較

表層水

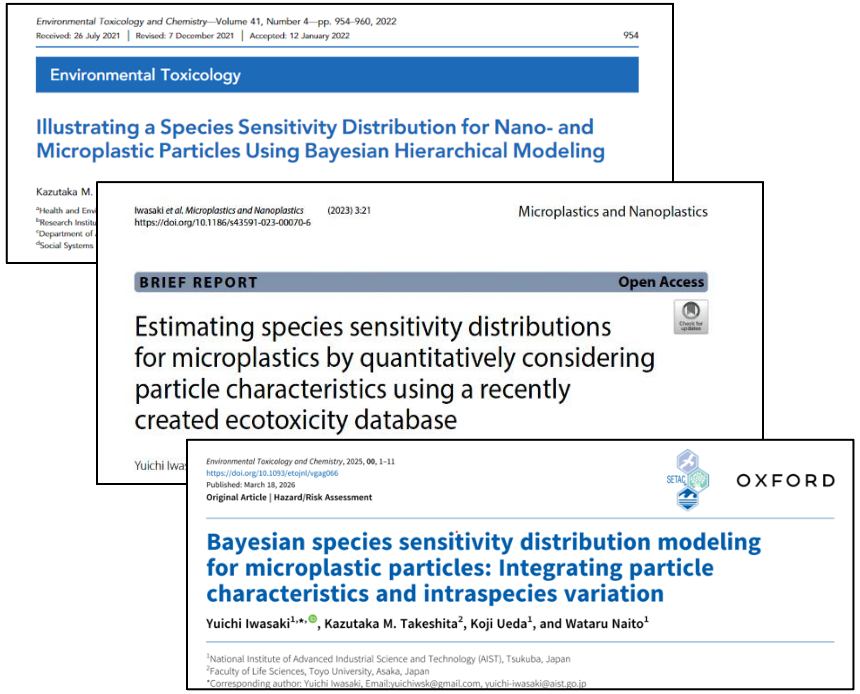


Preliminary results (manuscript in preparation)

底質



MP粒子の有害性評価法の高度化
階層ベイズモデリングによるアプローチ


Environmental Toxicology and Chemistry—Volume 41, Number 4—pp. 954–960, 2022
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Environmental Toxicology
Illustrating a Species Sensitivity Distribution for Nano- and Microplastic Particles Using Bayesian Hierarchical Modeling
Kazutaka M.

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https://doi.org/10.1186/s43591-023-00070-6
Microplastics and Nanoplastics
BRIEF REPORT Open Access
Estimating species sensitivity distributions for microplastics by quantitatively considering particle characteristics using a recently created ecotoxicity database

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Bayesian species sensitivity distribution modeling for microplastic particles: Integrating particle characteristics and intraspecies variation
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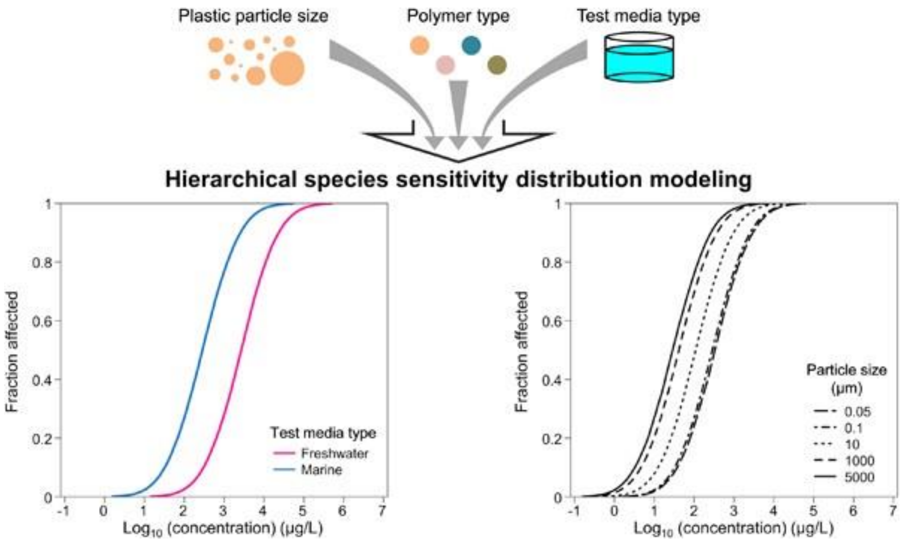
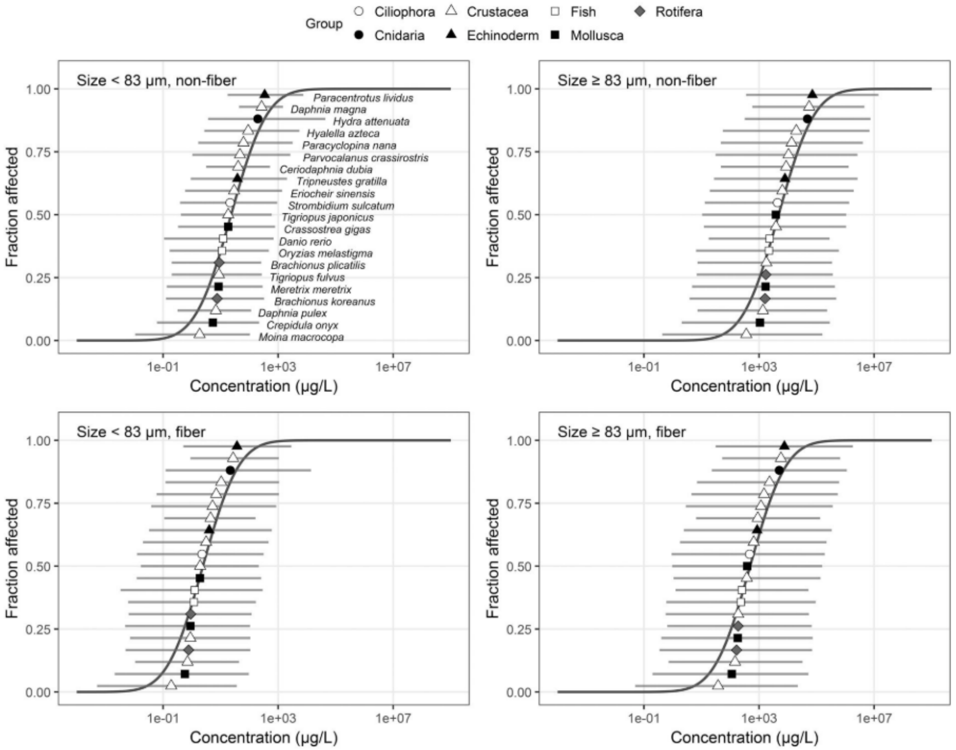
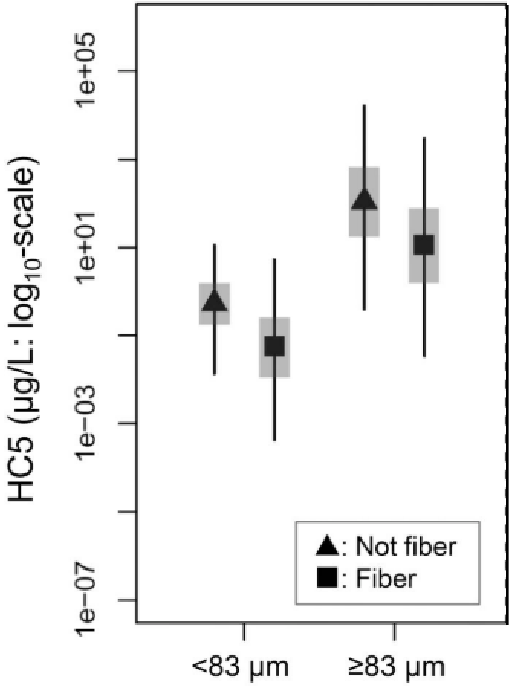






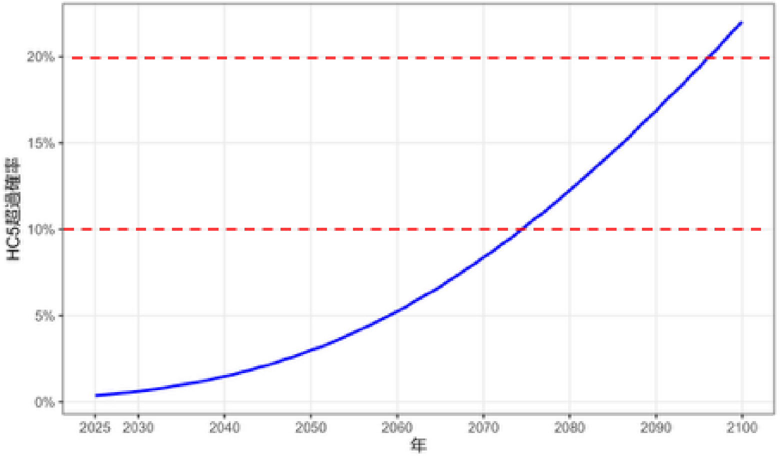
微細な粒子（83 μm未満）ほど毒性が高い傾向
繊維状粒子は毒性が高い傾向（ただし不確実性あり）
影響閾値（HC5）は仮定により大きく変動

→ 粒子特性はリスク推定に大きく影響する

リスク評価の結果はどのように解釈すれば良いか？

- 潜在的なリスクを示すものであり（スクリーニングであり）、確定的な結論ではない
- 仮定と利用可能なデータに大きく依存する
- **優先順位付けや意思決定の支援に活用**

東京湾ではモニタリングデータは概ねHC5を下回った
→ スクリーニングレベルではリスク超過の可能性は極めて低いと判断される（が不確実性は残る）



プラスチック生産量の増加を仮定した
東京湾におけるHC5超過の将来推計

HC5超過は現時点では低いが、
増加シナリオでは2100年までに約20%へ
上昇する可能性

まとめ

- MPのばく露と影響を整合化する評価の枠組みを用いて、東京湾のモニタリングデータに基づく環境リスク評価を実施
- MP濃度には大きなばらつきがあり、微小粒子が優占していたことから、粒子の多様性を考慮する重要性を確認
- 未計測の微小粒子を考慮すると、推定ばく露レベルは大幅に上昇
- SSDから導出される影響閾値（HC5）は、特に底質でデータ選択と仮定に大きく依存
- 現時点の結果は、スクリーニングレベルではリスクは極めて小さいが、不確実性は大きい
- 将来推計ではリスクが時間とともに増加する可能性がある

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産総研

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