MICROPLASTIC AND NANOPLASTIC RISKS IN DREDGED SEDIMENTS: FROM DATABASES TO STRATEGIC RESPONSES

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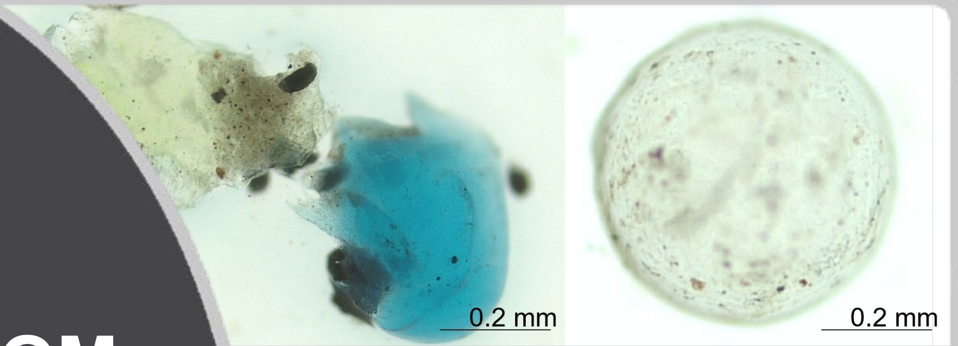

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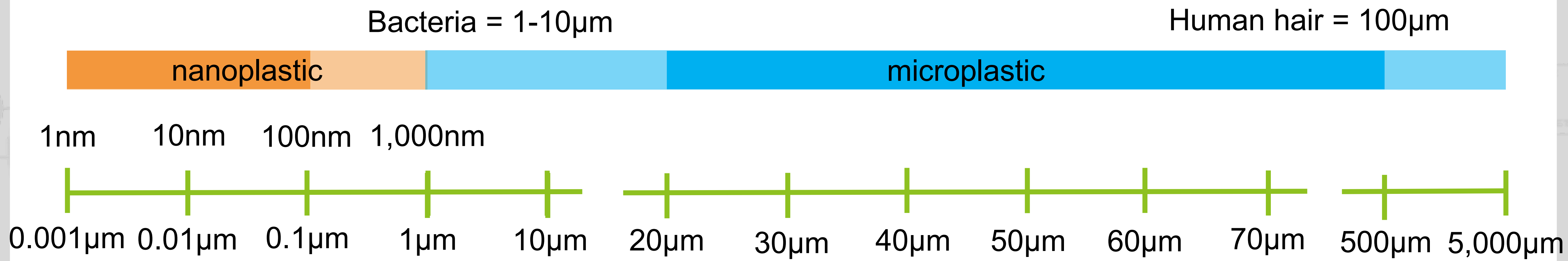
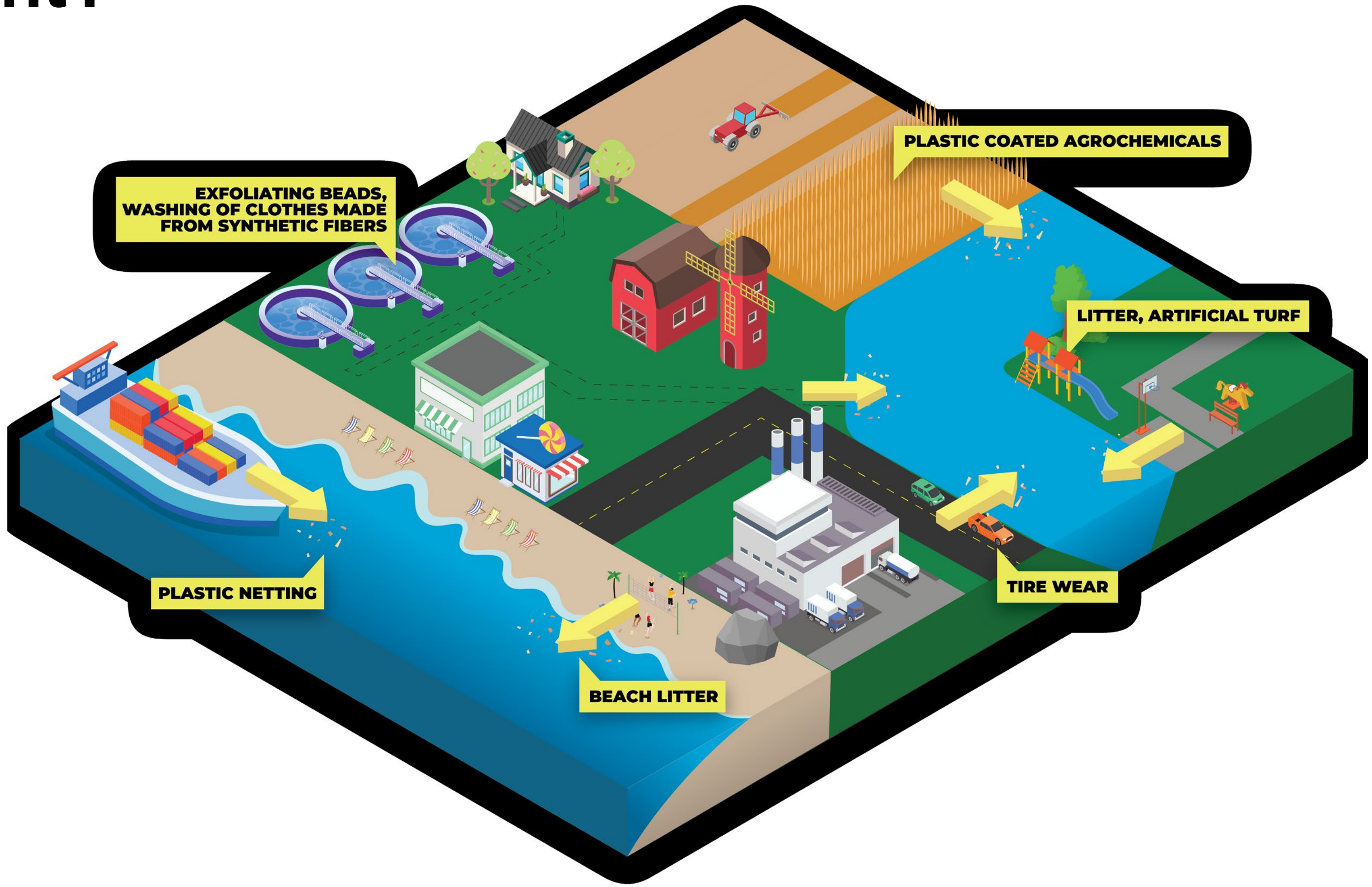
What are microplastics (MP) and nanoplastics (NP)?

- Multiple definitions
- Primary and secondary microplastics
- For NP, may have unique physical characteristics (e.g. colloidal behavior) that should be included in definition

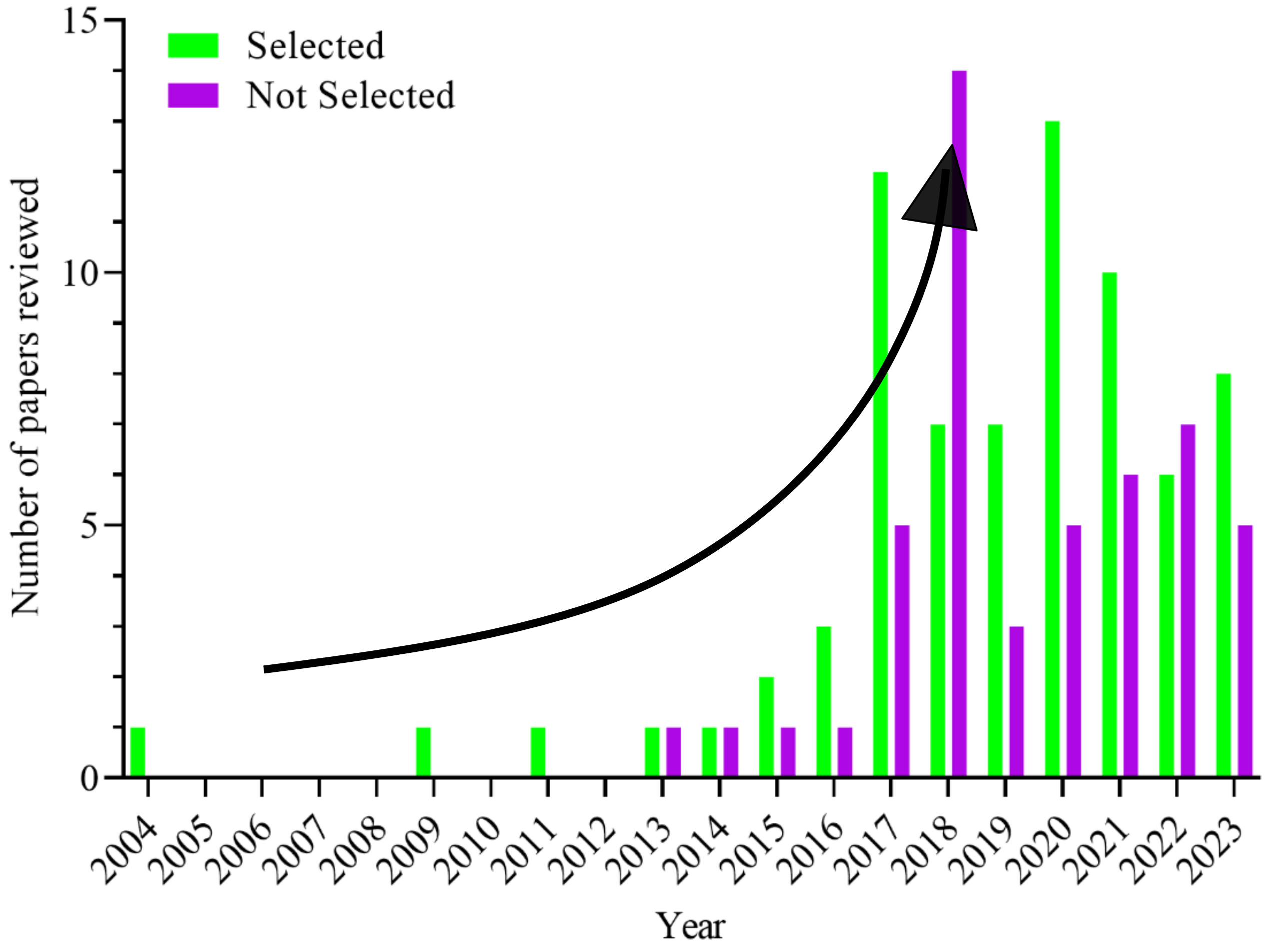


How do micro- and nanoplastics end up in dredged sediment?



Introduction

- **International and national focus** on plastic pollution
- **Exponential increase** in number of plastic pollution papers
- **Increasing public awareness** and risk perception of micro- and nano-plastics in environment
- **Need to capture and communicate** this information for freshwater and marine environments to appropriately inform **potential risks and actionable decisions**



Objectives

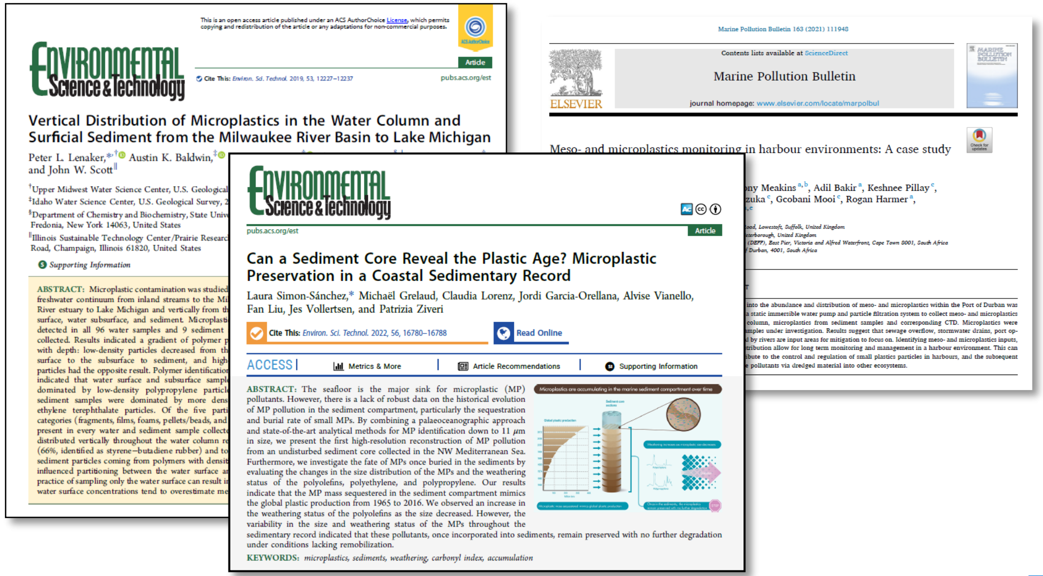
1. Conduct literature review to characterize microplastic and nanoplastic **concentrations in sediments** to **understand background and potential exposures**

2. Compile **ecotoxicity data** on microplastics and nanoplastics for organisms used in dredged material evaluations to **inform potential risks and identify sensitive organisms**

Methods – Microplastic Concentrations

1 Web of Science
Google Scholar

Search terms
"Microplastic"
"Nanoplastic"
"Sediment"
"Dredge"
"Dredging"



2 Included Data Representative of Dredged Sediment

- Subtidal zones
- Nearshore marine and estuarine
- Harbors and ports
- Riverine
- Lacustrine
- Great Lakes
- Natural lake
- Reservoir

3 Prioritized for Areas Representative of Plastic Pollution in US

- North America, Europe, South America, Africa

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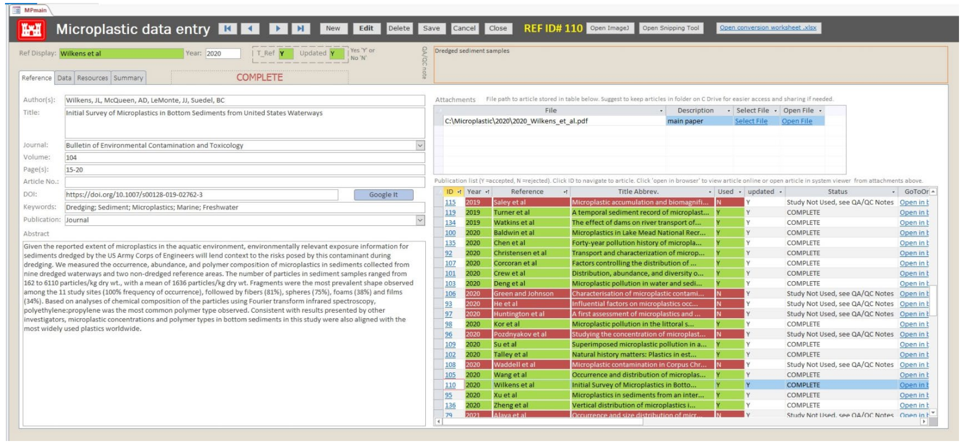
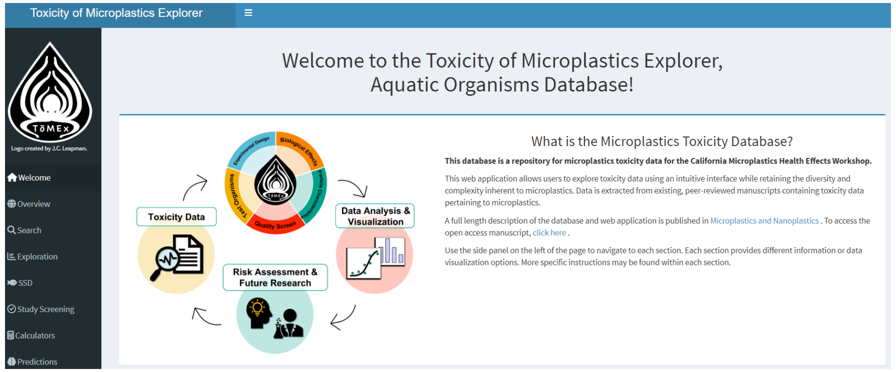


Methods – Ecotoxicity Data

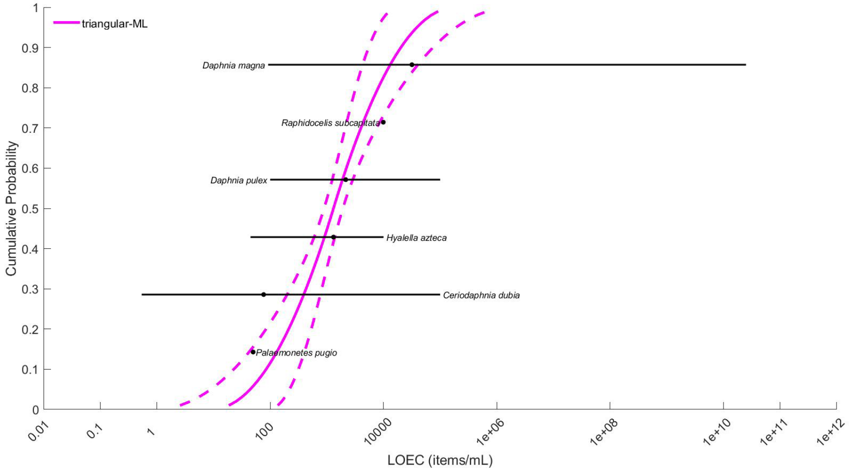
1 Data from Toxicity of Microplastics Explorer



2 Filtered data to include information relevant to dredged material evaluations

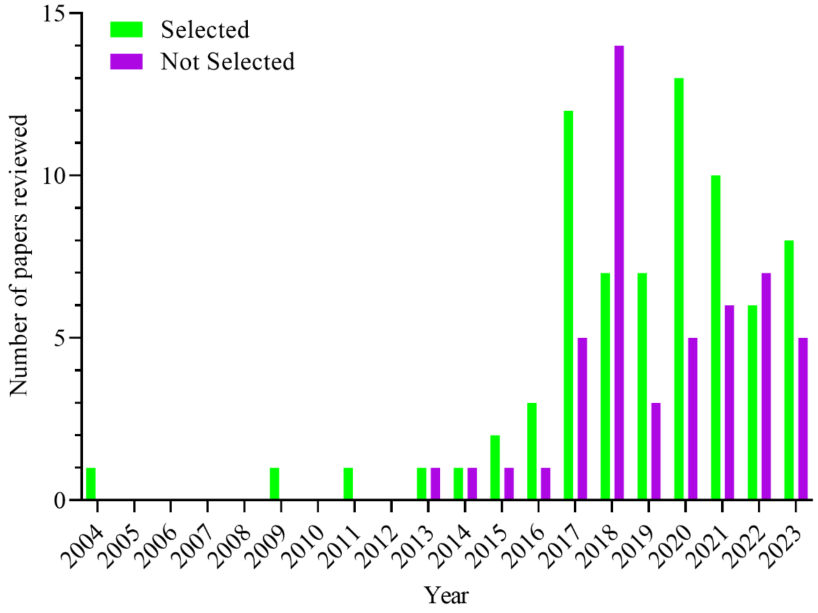
Species	Endpoint	Specific Endpoint
Amphipod Crustaceans, *Hyalella azteca*	Development	Algal Density
Cladoceran Crustaceans, *Ceriodaphnia dubia*	Growth	Body Length
Cladoceran Crustaceans, *Daphnia galeata*	Mortality	Body Mass
Cladoceran Crustaceans, *Daphnia magna*	Reproduction	Clutch Size
Cladoceran Crustaceans, *Daphnia pulex*		Fecundity
Sheepshead minnow, *Cyprinodon variegatus*		First Clutch Size
Fathead minnow, *Pimephales promelas*		First Three Clutch Sizes
Midges, *Chironomus riparius* (formerly *tentans*)		Growth Rate
Oligochaete worms, *Tubifex spp.*		Immobilization
Polychaete worms, *Arenicola marina*		Length
Bivalve Mussels, *Mytilus edulis*		Mortality
Bivalve Mussels, *Mytilus galloprovincialis*		Number of Clutches
Grass shrimp, *Palaemonetes pugio*		Number of Offspring
Green alga, *Raphidocelis subcapitata* (formerly *Selenastrum capricornutum*)		Reproductive Frequency
		Size
		Time to Offspring

3 Modeled Species Sensitivity Distribution (SSD) with USEPA's SSD Toolbox



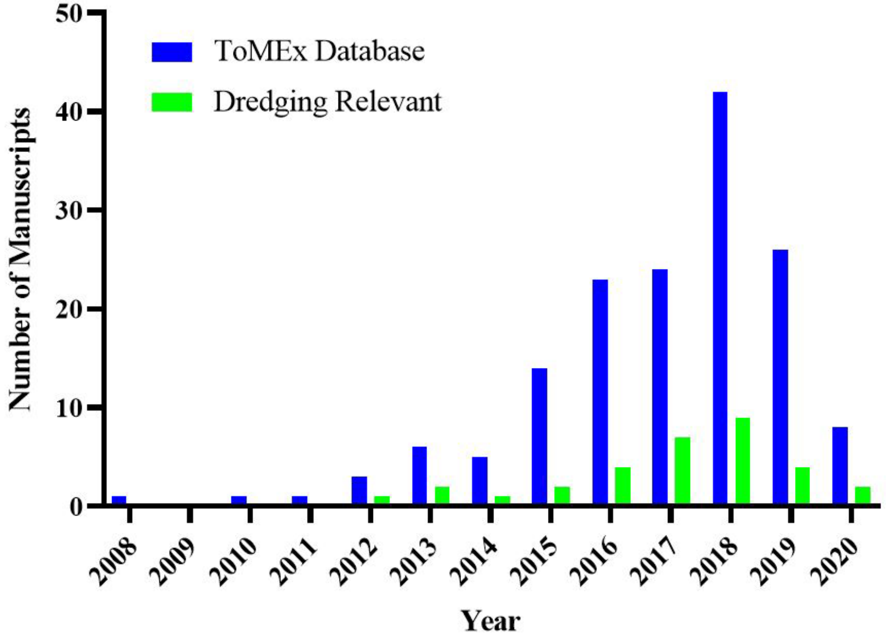
Results – Number of Papers/Data Reviewed

Microplastic Concentrations



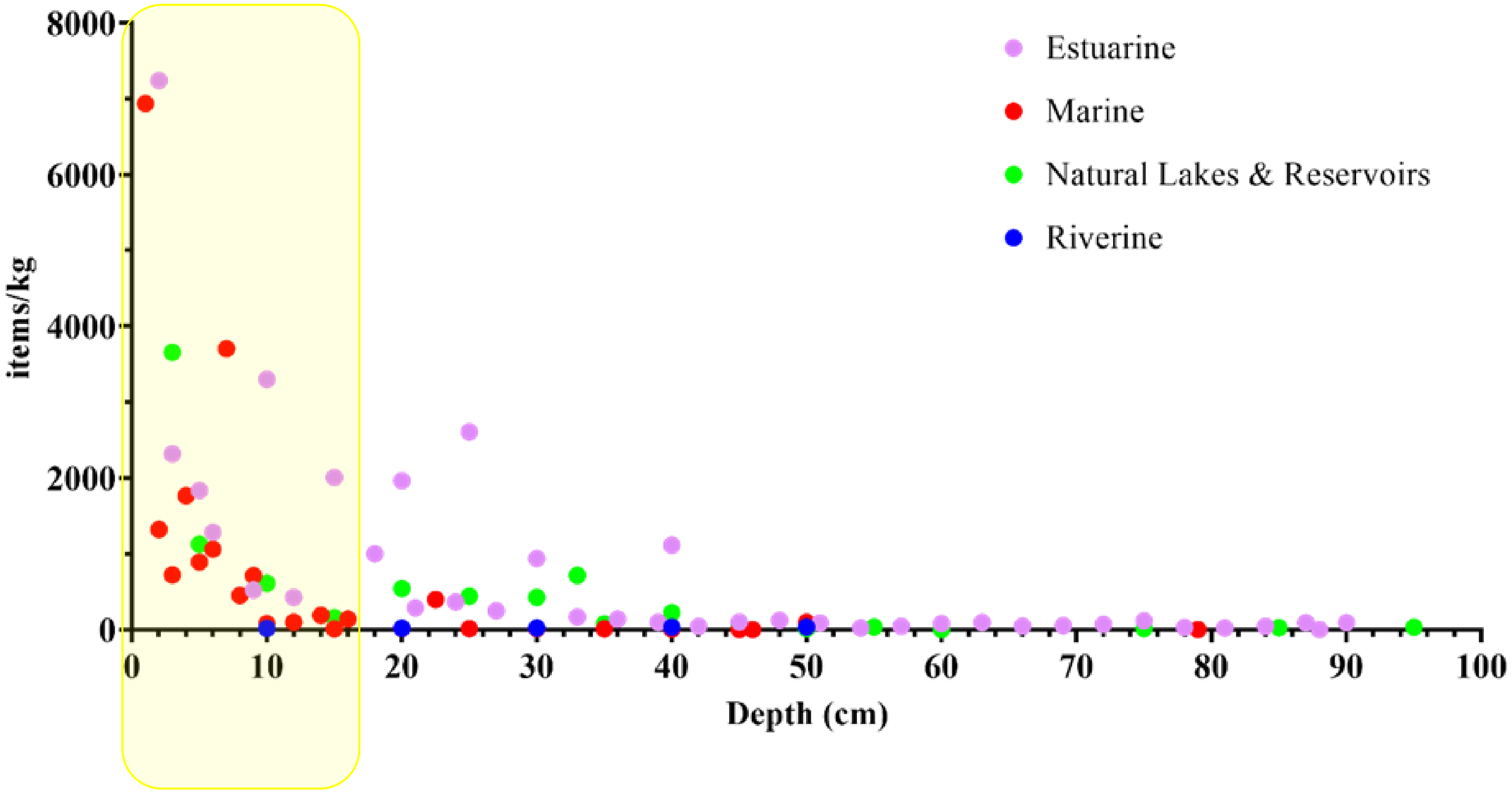
- Reviewed 122 papers – included 73
- Plastic particles in sediments were influenced by method for measurement and ranged from 40 – 5,000μm
- No nanoplastics were measured

Ecotoxicity Data



- Over 160 manuscripts and 5,853 data entries in ToMEx 1.0
- Included 601 data entries relevant to dredging and “particle only” exposures
- Microplastics - Data for 5 invertebrate animals and 1 green alga for species sensitivity distributions (SSDs)
- Nanoplastics – Data for 3 invertebrate animals

Results – Microplastic Concentration at Depth



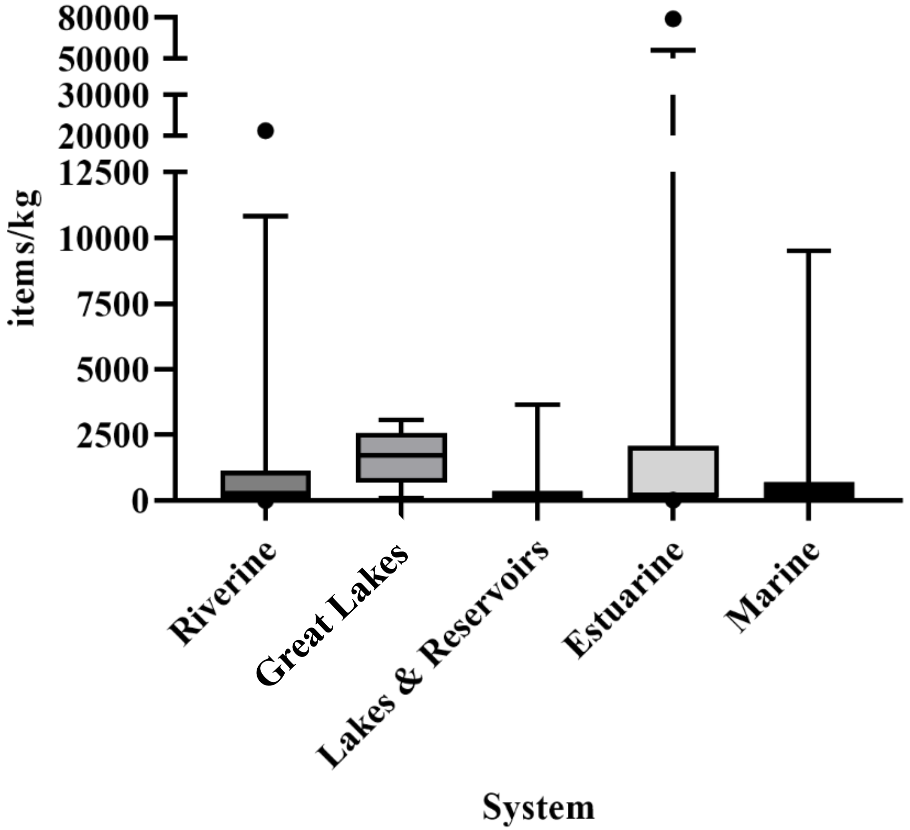
- Highest MP concentrations in top 15 cm
- MP concentrations decline as sediment depth increases
- Fibers most common plastic shape

Results – Microplastic Concentration by System

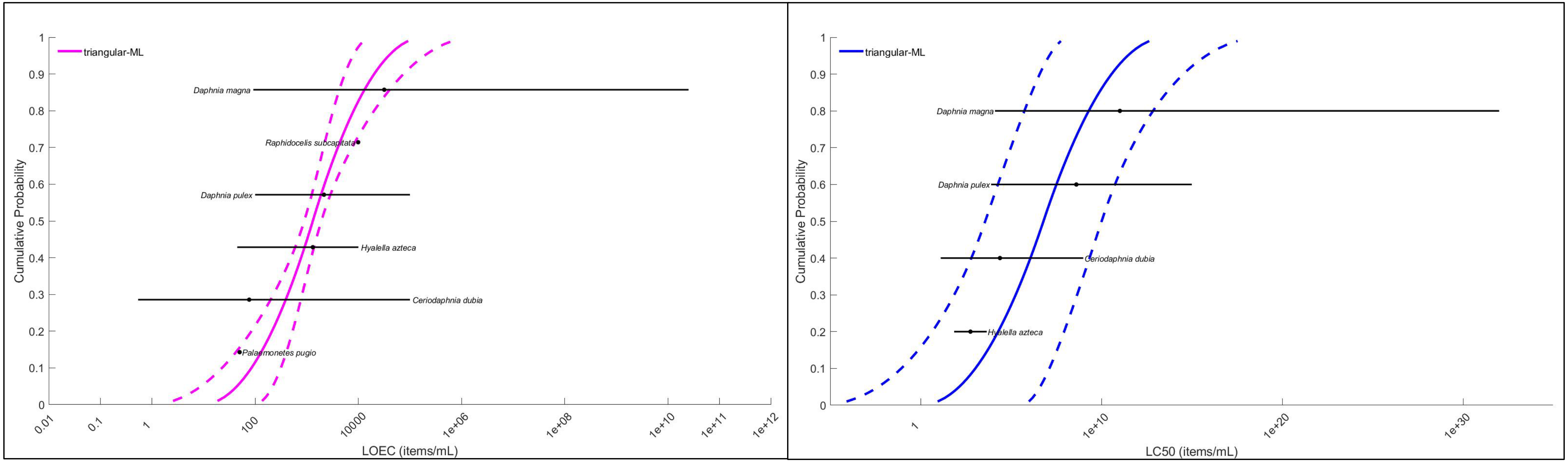
- High variability in MP concentrations among and within systems

- Based on median MP concentrations from lowest to highest were:

Natural Lakes and Reservoirs < Estuarine < Riverine < Marine < Great Lakes



Results – Microplastic Ecotoxicity Data



- Order of sensitivity from most to least was *Palaemonetes pugio* (grass shrimp) > *C. dubia* (Cladoceran) = *Hyalella azteca* (Amphipod Crustacean) > *D. pulex* (Cladoceran) > *Raphidocelis subcapitata* (green algae) > *D. magna* (Cladoceran)
- Multiple limitations/challenges of dataset

Results – Nanoplastic Data

- NP data are available for 3 cladocerans, *D. galeata*, *D. magna* and *D. pulex*

- LOECs ranged from 4.95×10^{6} items/mL for *D. pulex* to 1.63×10^{11} items/mL for *D. magna*

- Plastics used in toxicity tests = spheres and are not representative of NP in environment

Conclusions

- Median MP concentrations ranged from 89 items/kg dry sediment in lakes and reservoirs to 1,716 items/ kg dry sediment in Great Lakes sediments

- Most to least sensitive test species were:
    - *Palaemonetes pugio* (grass shrimp) > *C. dubia* (Cladoceran) = *Hyalella azteca* (Amphipod Crustacean) > *D. pulex* (Cladoceran) > *Raphidocelis subcapitata* (green algae) > *D. magna* (Cladoceran)

- Notable data gaps exist for NP exposure and toxicity data extremely limited

- First step towards development of proactive communication tools and decision support documents for MP and NP contamination in dredged sediment

Photo Credit: Justin Wilkens, ERDC

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https://doer.el.erdc.dren.mil/

THANK YOU!

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