Microplastic Research to Inform Management Strategies in California

Dr. Leah Thornton Hampton
Southern California Coastal Water Research Project

San Diego Environmental Professionals

4 October 2022

- Background
- Methods
- Health Effects
- Future Directions

Microplastics are Everywhere

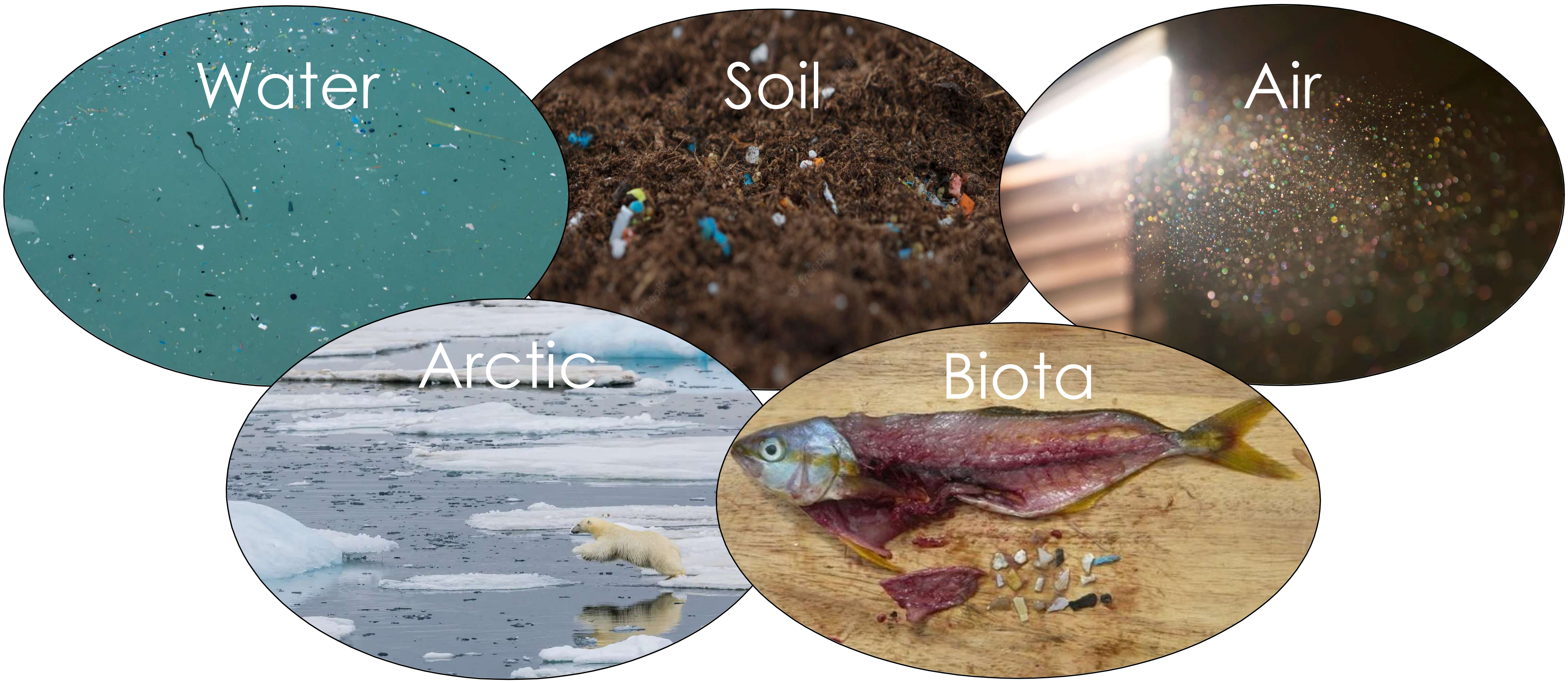
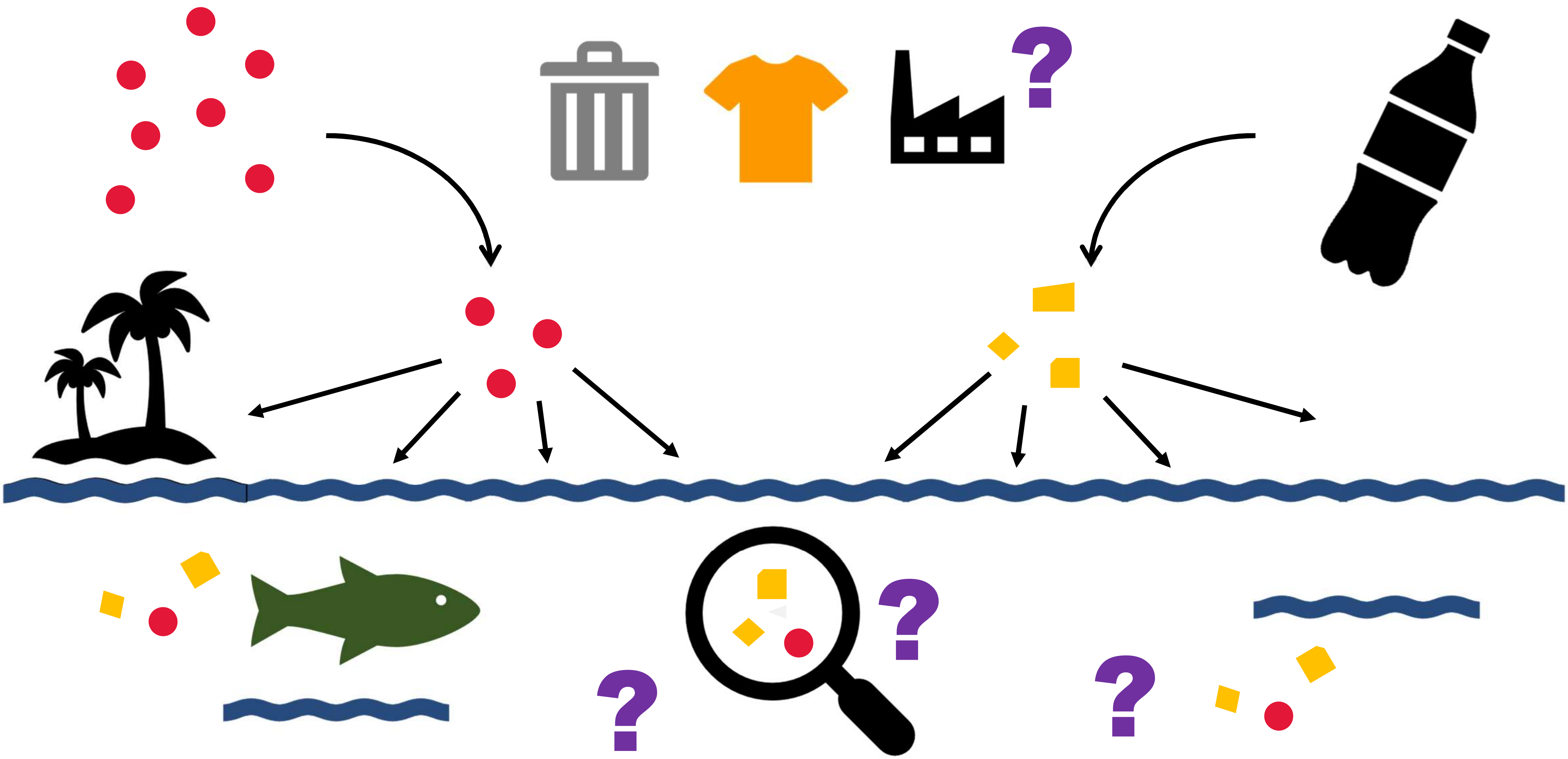


Photo: Florida Sea Grant

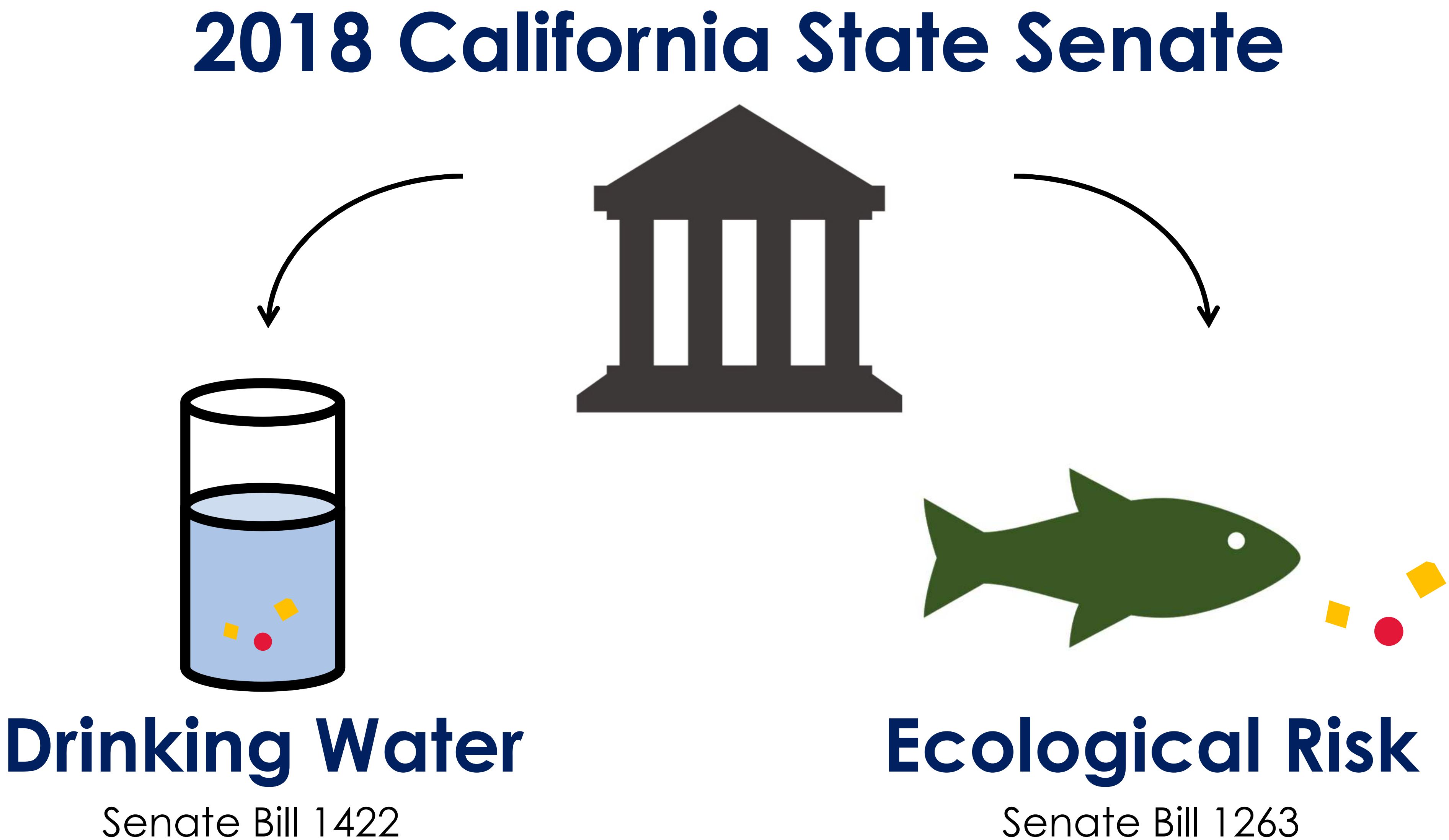
…but our understanding is incomplete



Managing Microplastics

We need to understand microplastics so that we can effectively and efficiently manage them

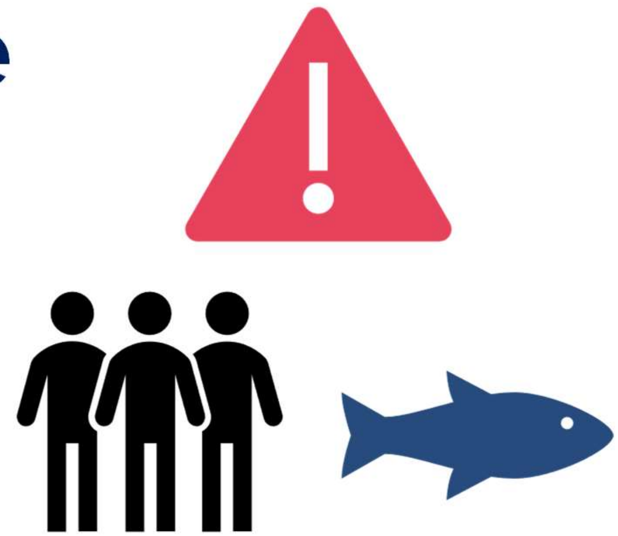
- **Monitoring**
  - How do we measure and describe microplastic pollution?
- **Impact**
  - What microplastics are the most harmful?
  - What are the adverse effects?
  - How much is too much?
- **Mitigation**
  - How do we reduce microplastic pollution?


2018 California State Senate
Drinking Water
Senate Bill 1422
Ecological Risk
Senate Bill 1263

The Regulatory Challenge

Best methods for monitoring?

No Standardized Methods



Relevant effects and critical thresholds?

No Health Based Thresholds

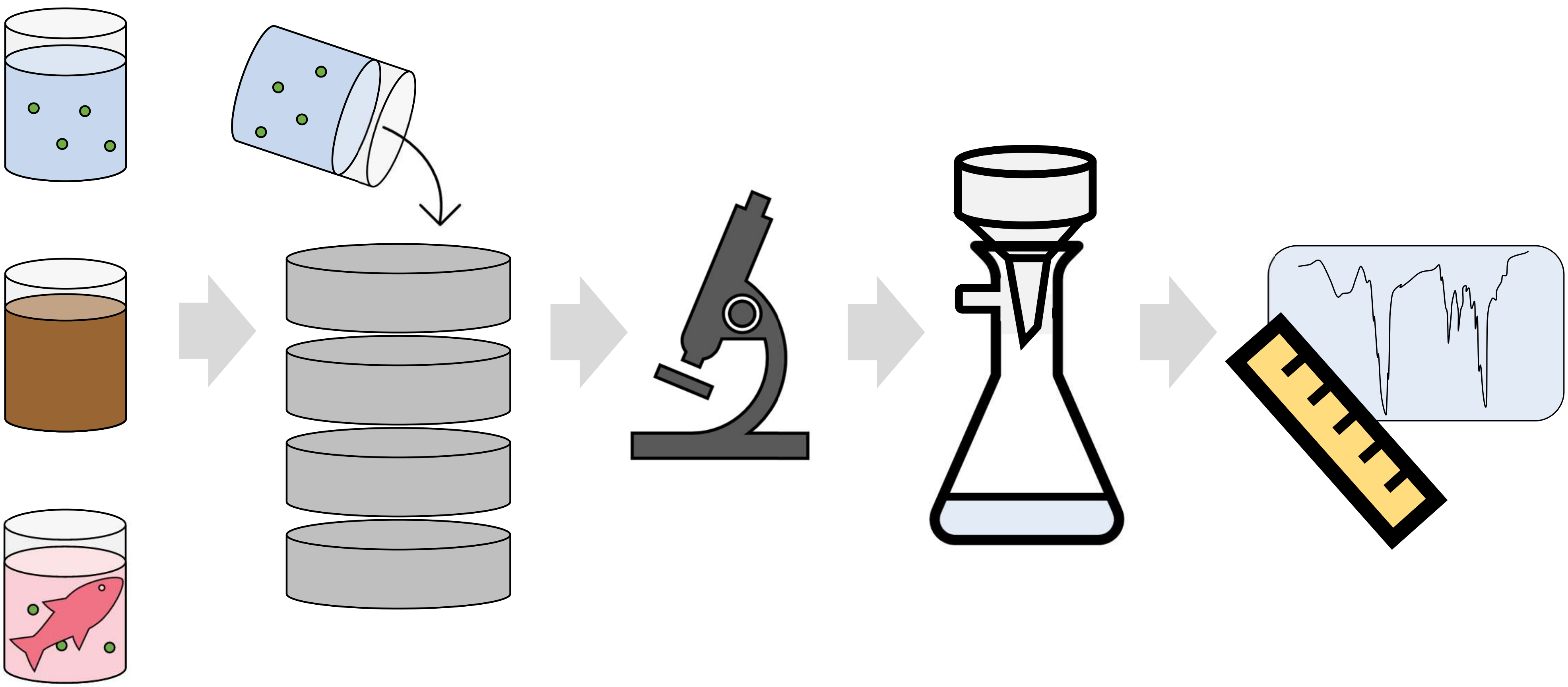
Background

Methods

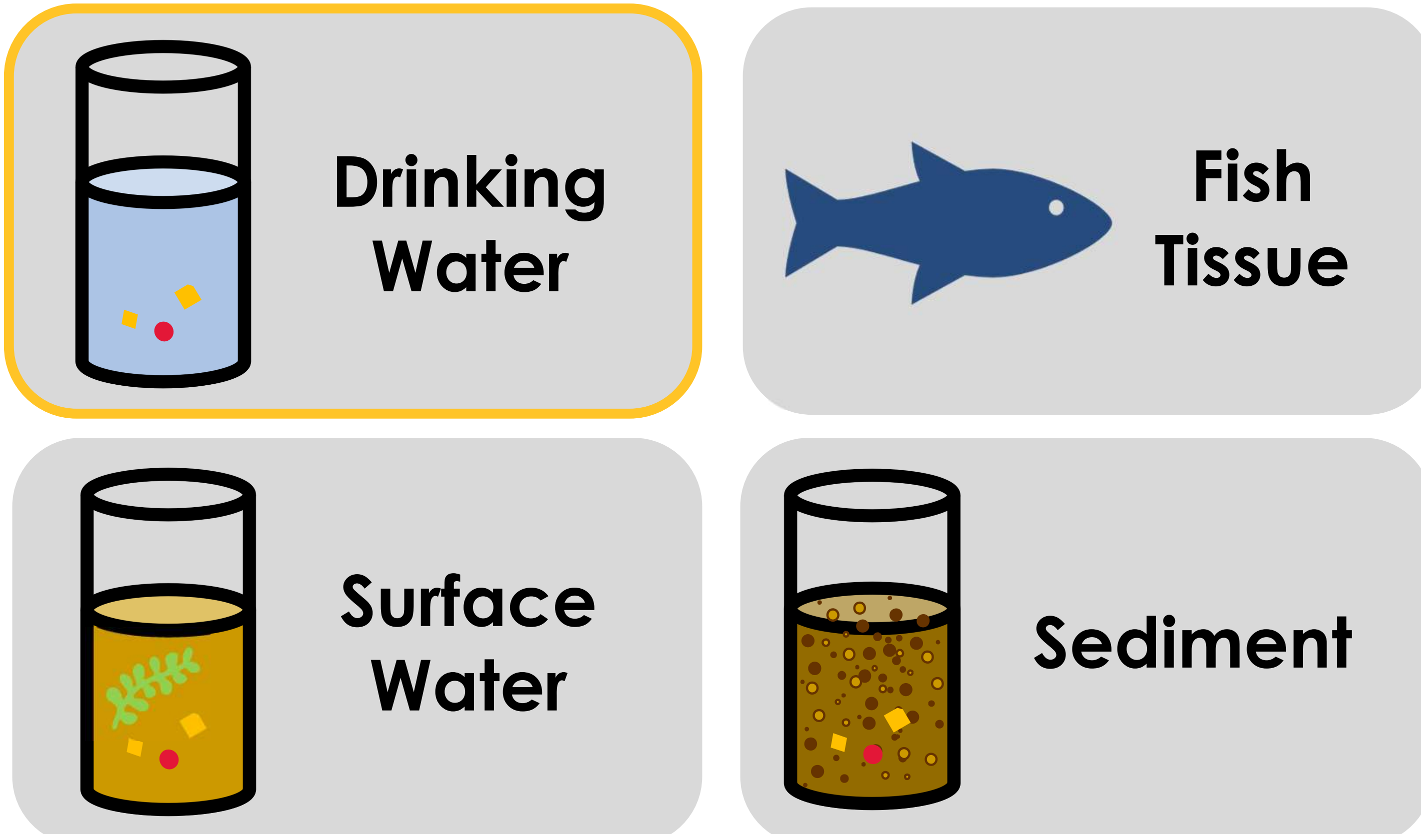
Health Effects

Future Directions

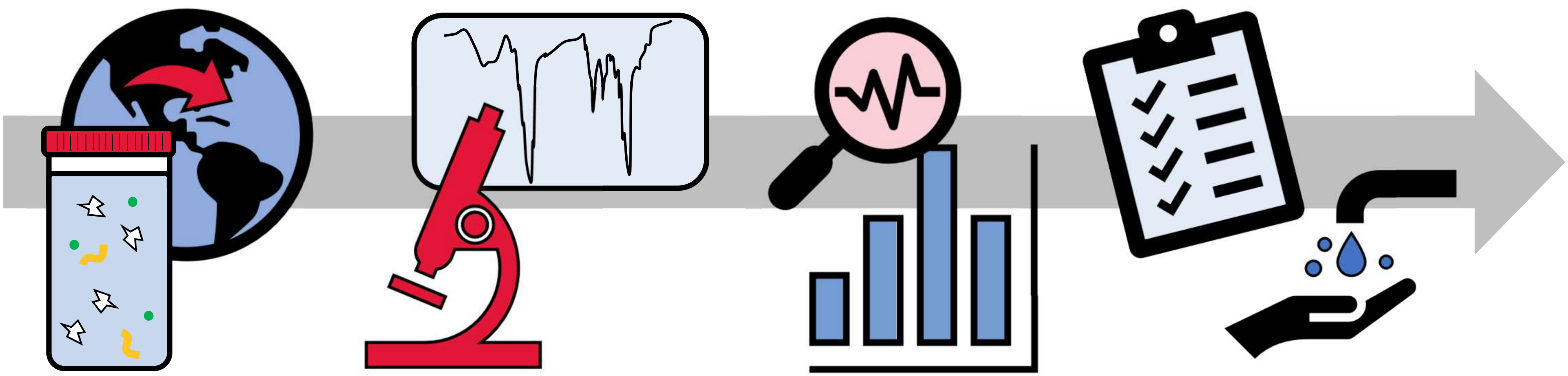
Microplastics Workflow



Microplastics Methods Evaluation Study



Microplastics Methods Evaluation Study



Sample Creation & Distribution

Sample Extraction & Processing

Performance Evaluation

Monitoring Method Recommendations

Particle Recovery

Data redacted –
Manuscript under revision

Particle Recovery

Data redacted –
Manuscript under revision

Spectroscopy

Data redacted –
Manuscript under revision

Time Per Sample

Data redacted –
Manuscript under revision

Methods for Monitoring Microplastics Adopted

- Methods for monitoring microplastics in **drinking water** adopted
- Methods are applicable to particles greater than 20 µm in size
- Visual microscopy for particle counts and Raman or Infrared spectroscopy for chemical identification

Accreditation Now Available

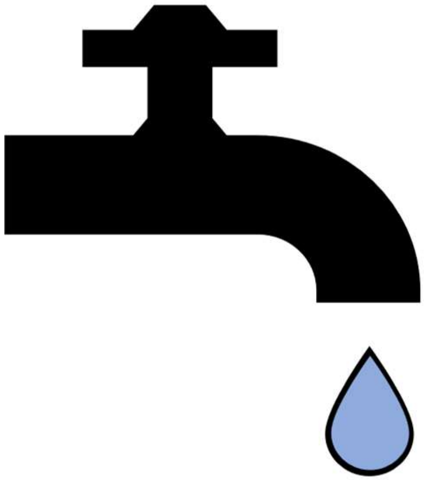
Environmental Laboratory Accreditation Program
STATE WATER RESOURCES CONTROL BOARD

- Laboratory accreditation now available through the Environmental Laboratory Accreditation Program

- Microplastic analytes listed in ELAP’s field of accreditations include:
  - > 500 µm
  - 500-212 µm
  - 212-20 µm
  - 212-50 µm

Drinking Water Monitoring

- Policy handbook adopted late this summer
- **Pilot drinking water monitoring to begin in 2023**
  - Evaluate **sample collection** methods
  - Gather preliminary occurrence data in **drinking water sources**
  - Development of training materials and additional guidance documents



Background

Methods

Health Effects

Future Directions

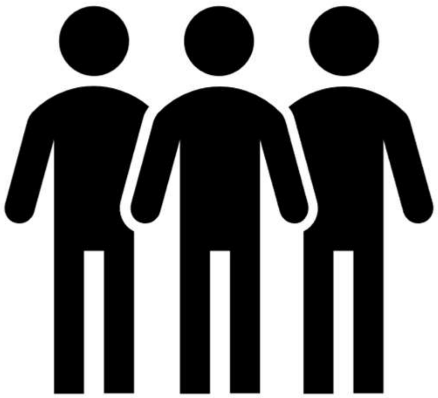
SCCWRP Health Effects Workshop

Humans

Aquatic Organisms

Human Health Effects Summary

- Mammalian toxicity data is **severely limited**
  - Only 12 in vivo toxicity studies deemed fit for threshold development
  - Most use only polystyrene spheres
- Consistent trend in effects related to **inflammation** and **oxidative stress**
- Conservative **screening level** derived to inform monitoring but not possible to derive human health-based threshold

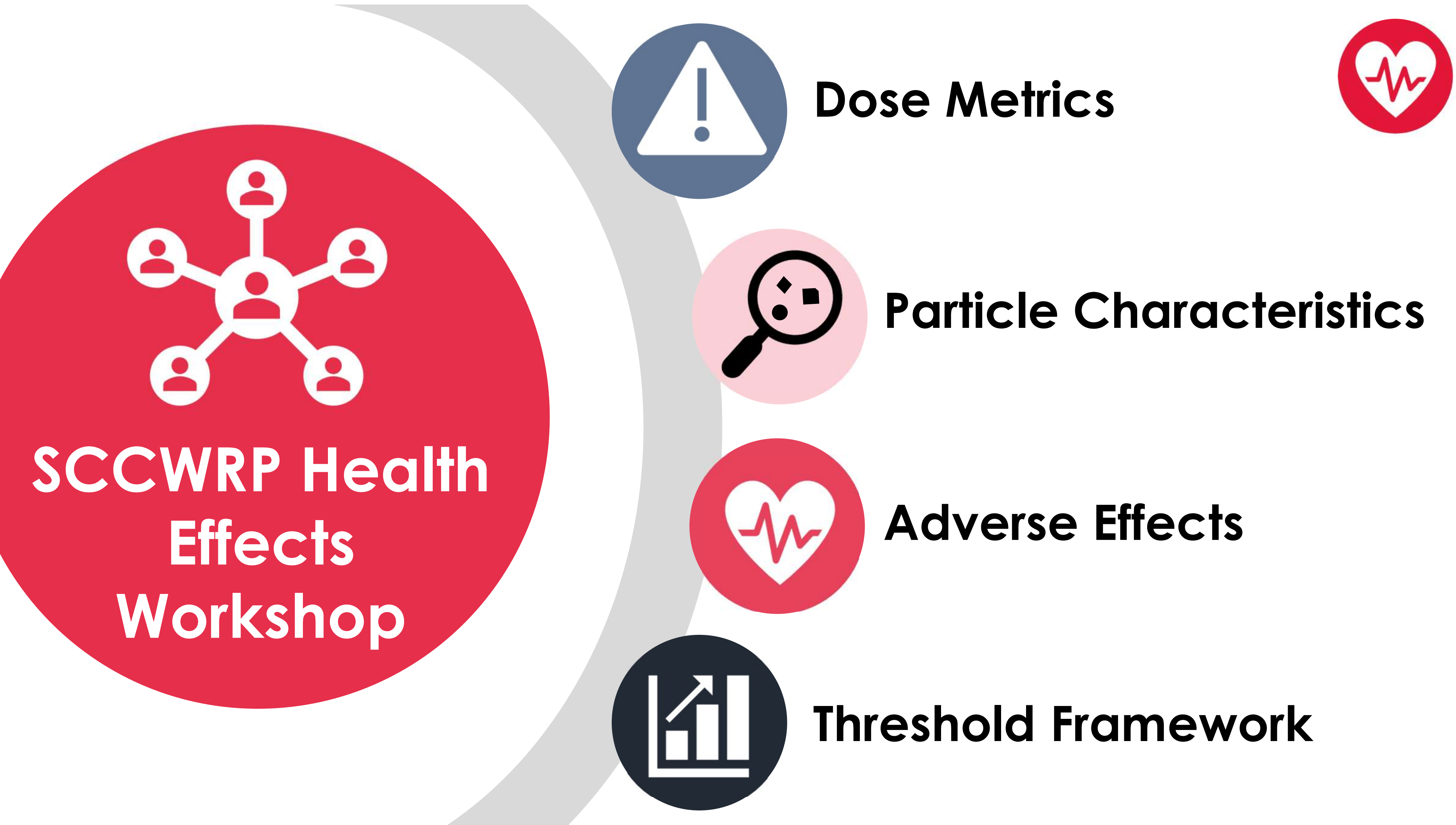


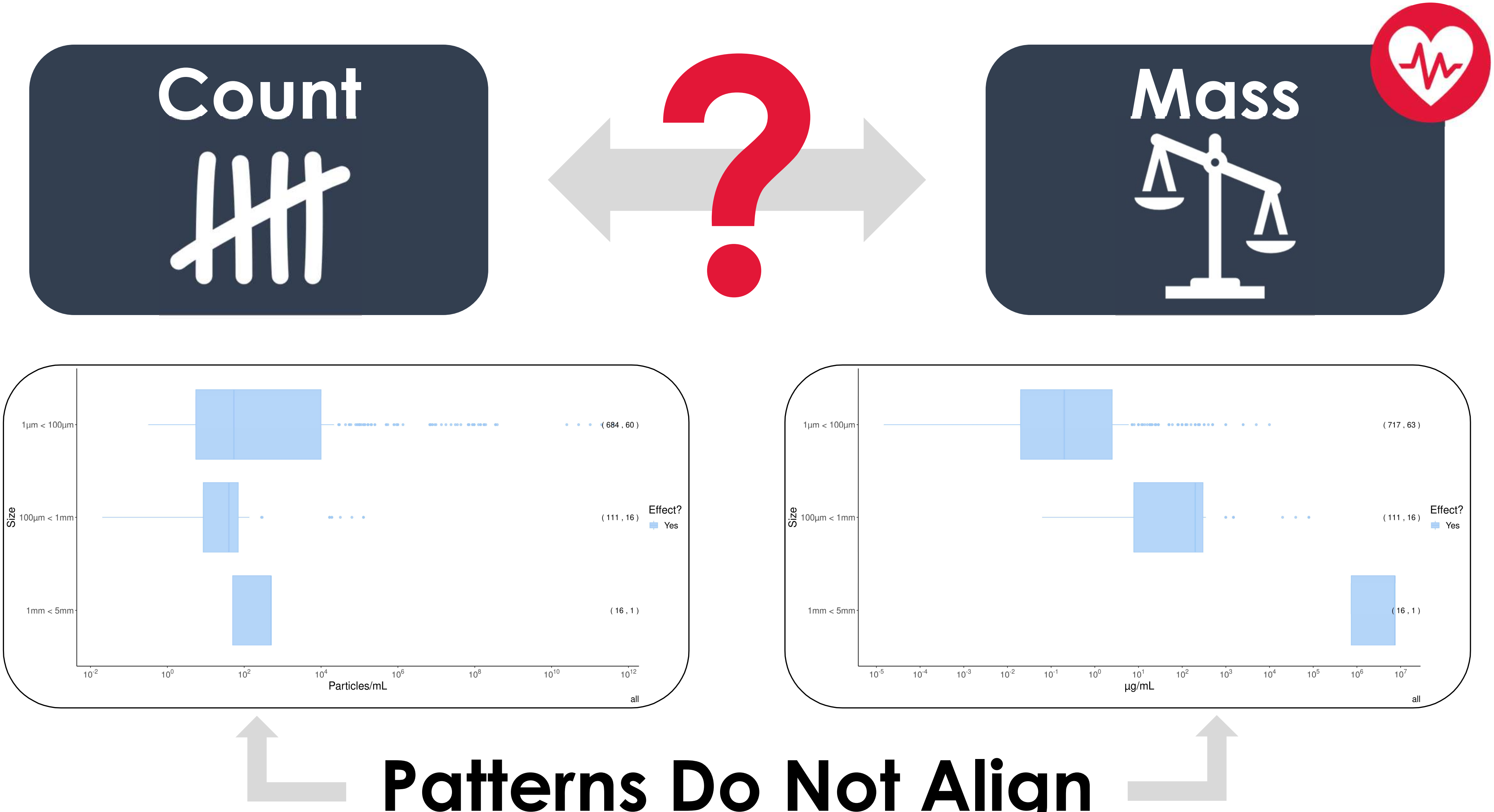
Coffin et al., 2022, *Microplastics and Nanoplastics*

SCCWRP Health Effects Workshop

Humans

Aquatic Organisms


SCCWRP Health Effects Workshop
Dose Metrics
Particle Characteristics
Adverse Effects
Threshold Framework



Thornton Hampton et al., 2022, *Microplastics and Nanoplastics*

Most Meaningful Dose Metric Depends on Effect Mechanism

Our Understanding of Microplastic Toxicity is Incomplete

We Should be Flexible

Thornton Hampton et al., 2022, *Microplastics and Nanoplastics*

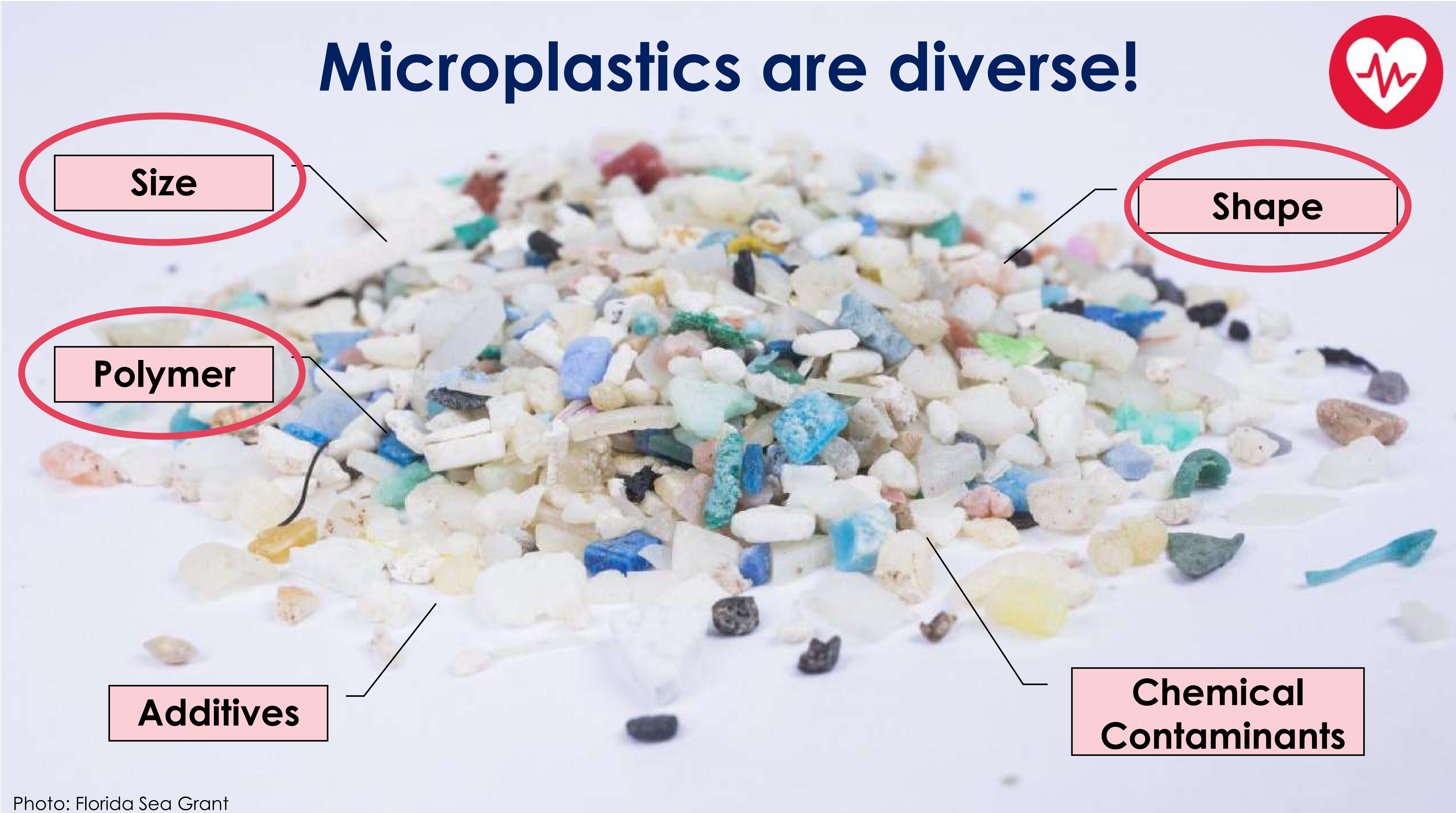


Photo: Florida Sea Grant

Key Particle Characteristics

- Limited evidence that particle **shape** and **polymer** *might* matter

- **Strong evidence that size matters**

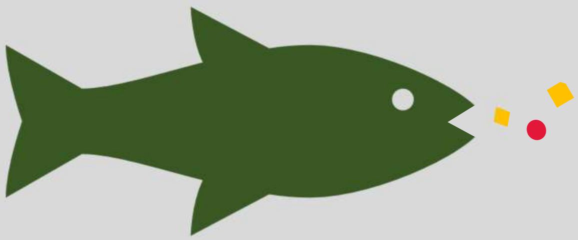
  Thornton Hampton et al., 2022, *Microplastics and Nanoplastics*

Large particles more toxic at lower concentrations

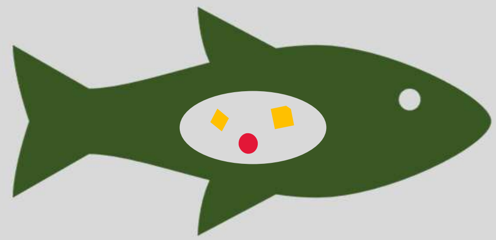
Small particles more toxic at higher concentrations

Size Dependent Toxicity

Food Dilution

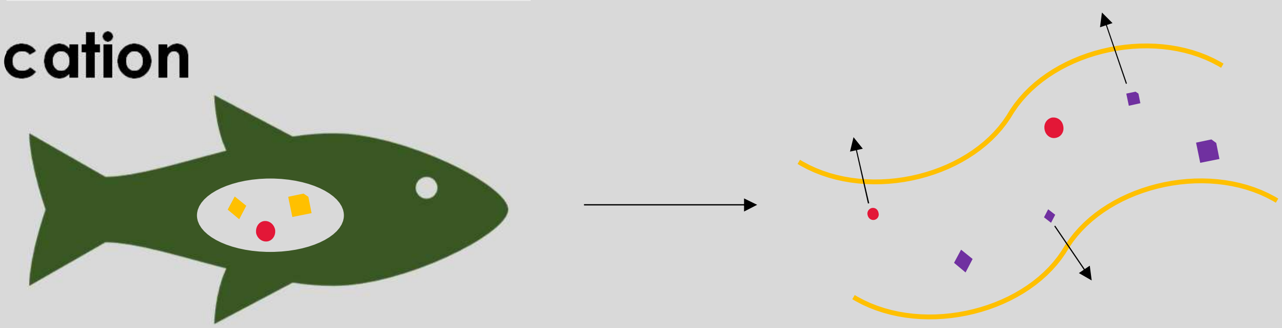


Ingestibility



Volume in Gut

Translocation



Smaller Particles More Likely to Translocate

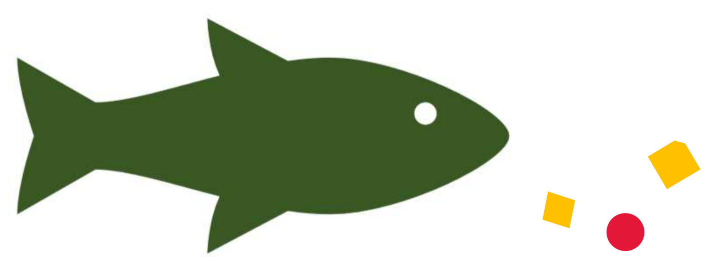
Thornton Hampton et al., 2022, *Microplastics and Nanoplastics*

Threshold Development Approach

1. Select appropriate decision framework for microplastics assessment in ambient waters

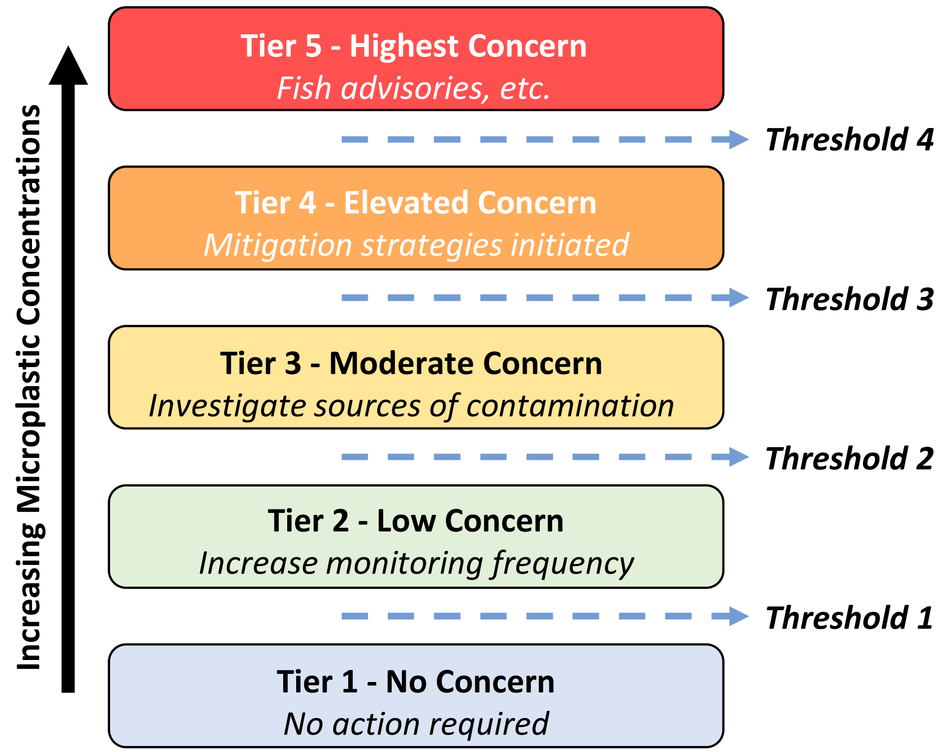
2. Develop and apply process to calculate thresholds

3. Conduct expert evaluation of the confidence level in the framework, analytical process, and thresholds



Tiered Management Framework

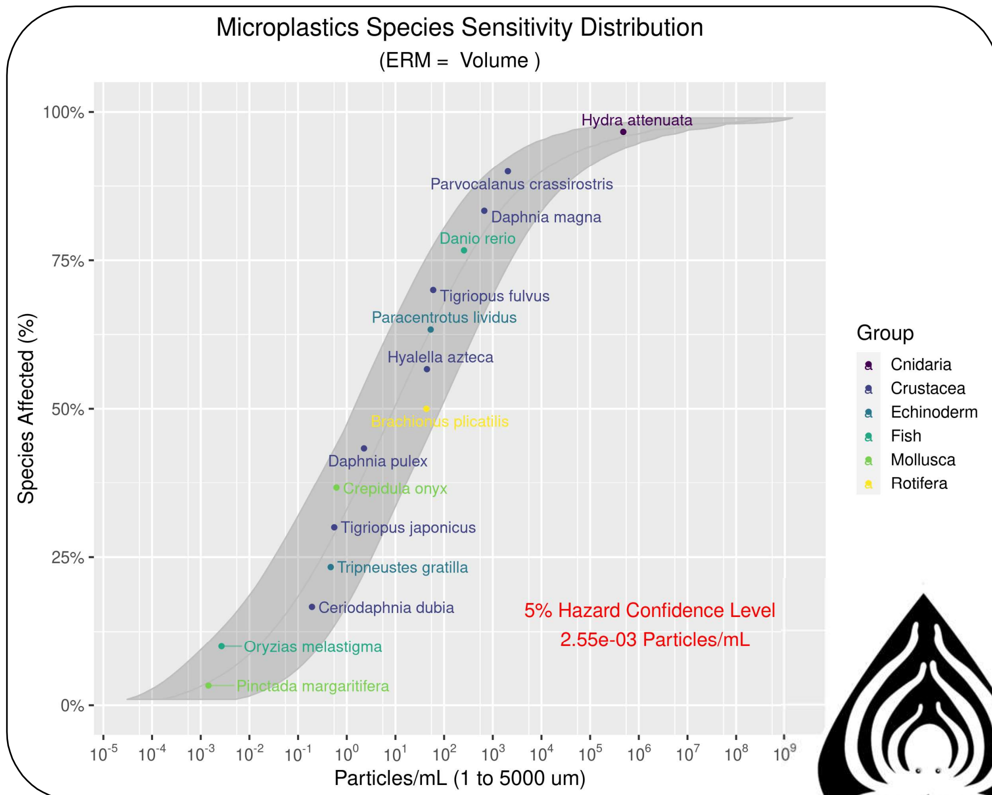
- ❖ Experts agreed on the development of multiple thresholds
- ❖ Decision framework adapted from model used by the state of California to monitor emerging contaminants



Mehinto et al., 2022, *Microplastics and Nanoplastics*

Deriving Thresholds

- ❖ Species Sensitivity Distribution
- ❖ Microplastics toxicity database (ToMEx)
- ❖ Microplastics toxicity data screened to meet specific quality criteria



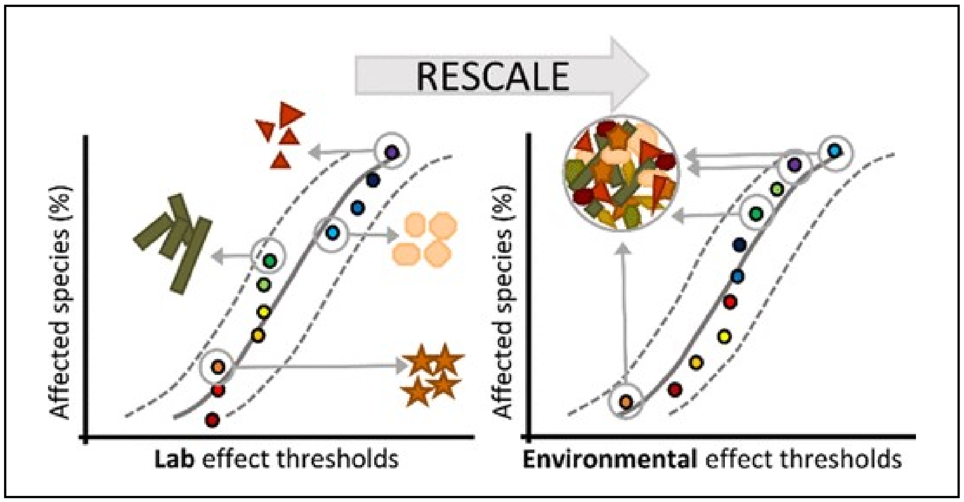
Deriving Thresholds

Concentration at which 5% of species present an effect

Threshold	Hazard concentration (HC)	Data collapsing	HC metric	Biological endpoints
1- Investigative monitoring	HC5	1^{st} Quartile	Lower 95%	Molecular to Population
2- Discharge monitoring	HC5	1^{st} Quartile	Mean	Molecular to Population
3- Management planning	HC5	Median	Mean	Organism and Population
4- Source control measures	HC10	Median	Mean	Organism and Population

Mehinto et al., 2022, *Microplastics and Nanoplastics*

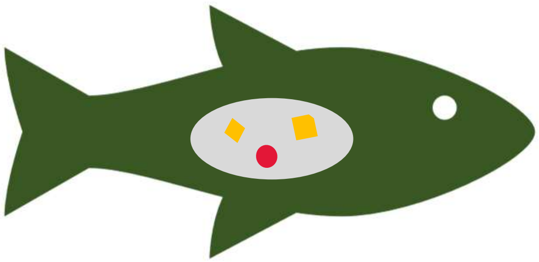
Deriving Thresholds



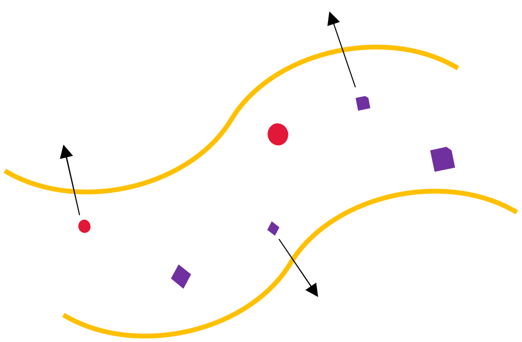
Koelmans et al., 2020, *Environmental Science and Technology*

- ❖ Difficult to compare lab-based effect concentrations across studies
- ❖ Lab-based studies do not reflect complexity of environmental microplastics
- ❖ Applied modelling approach developed by Koelmans Lab

Deriving Thresholds



Food Dilution → **Volume**



Translocation → **Surface Area**

Thornton Hampton et al., 2022, *Microplastics and Nanoplastics*

Proposed Microplastic Thresholds

Threshold	Food Dilution		Translocation	
	mg/L	Particles/L	mg/L	Particles/L
1- Investigative monitoring	**0.05**	**0.3**	**10**	**60**
2- Discharge monitoring	**0.4** (0.05-11)	**3** (0.3-66)	**51** (10-770)	**312** (57-4680)
3- Management planning	**0.9** (0.07-36)	**5** (0.4-219)	**146** (19-3120)	**890** (118-19000)
4- Source control measures	**6** (0.4-141)	**34** (3-859)	**676** (81-11400)	**4110** (493-69100)

Threshold 1 is the lower 95% CI of the HC5 for Threshold 2. Therefore, CI cannot be reported for this threshold.

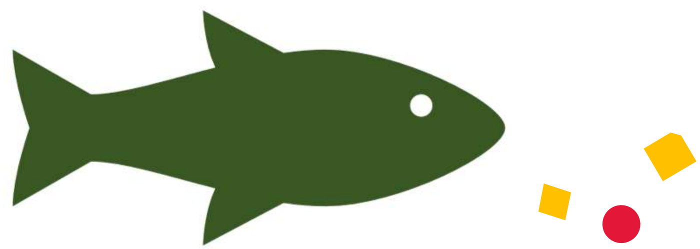
Mehinto et al., 2022, *Microplastics and Nanoplastics*

Confidence

❖ High confidence in the framework and analytical methods

❖ Low to medium confidence in the thresholds

❖ Underlying data is limited and imperfect



Ocean Protection Council Statewide Microplastics Strategy

The New York Times

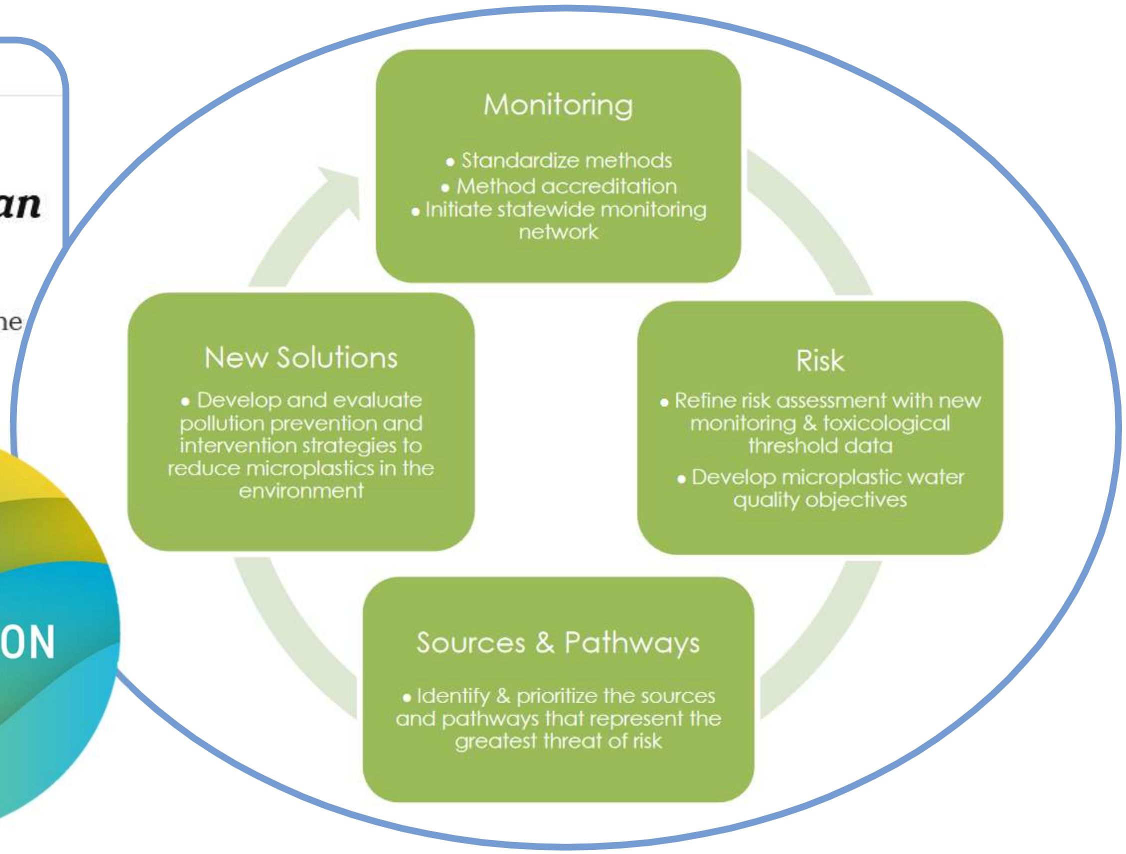
CALIFORNIA TODAY

In a First, California Plans to Clean Up Microplastics

The state has adopted a strategy to monitor and reduce the ubiquitous form of pollution.

By Livia Albeck-Ripka

March 7, 2022



Background

Methods

Health Effects

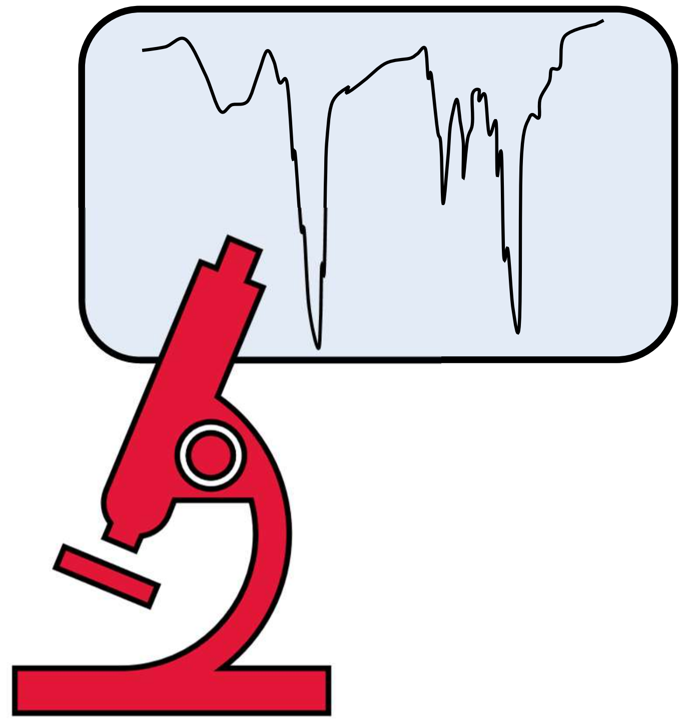
Future Directions

Research Recommendations for Methods

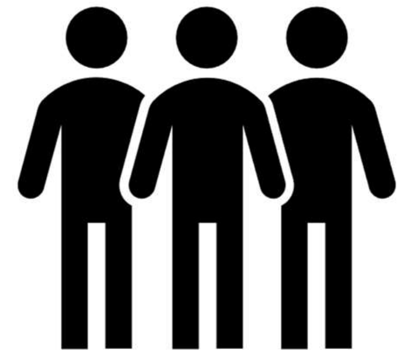
1. Improve method performance for particles **<50 μm**

2. Develop or revise methods to **reduce sample processing time**

Challenges become more pronounced in complex matrices

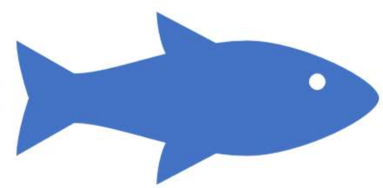


Research Recommendations for Health Effects



1. Adequate **particle characterization and selection** for toxicity testing

2. Appropriate experimental designs for the **derivation of dose-response relationships**



3. Establishment of **adverse outcome pathways** for microplastics

4. Clearer **understanding of exposure**

Thornton Hampton et al., 2022, *Microplastics and Nanoplastics*

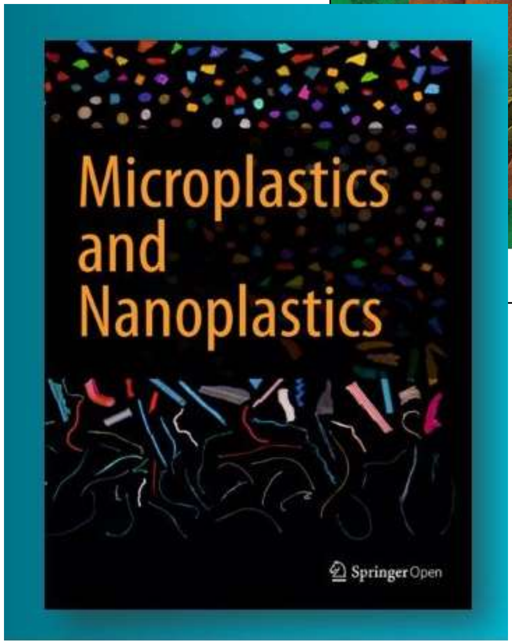
Special Journal Issues

Methods:

- ❖ Chemosphere
- ❖ Not open access
  - ❖ Request articles through SCCWRP

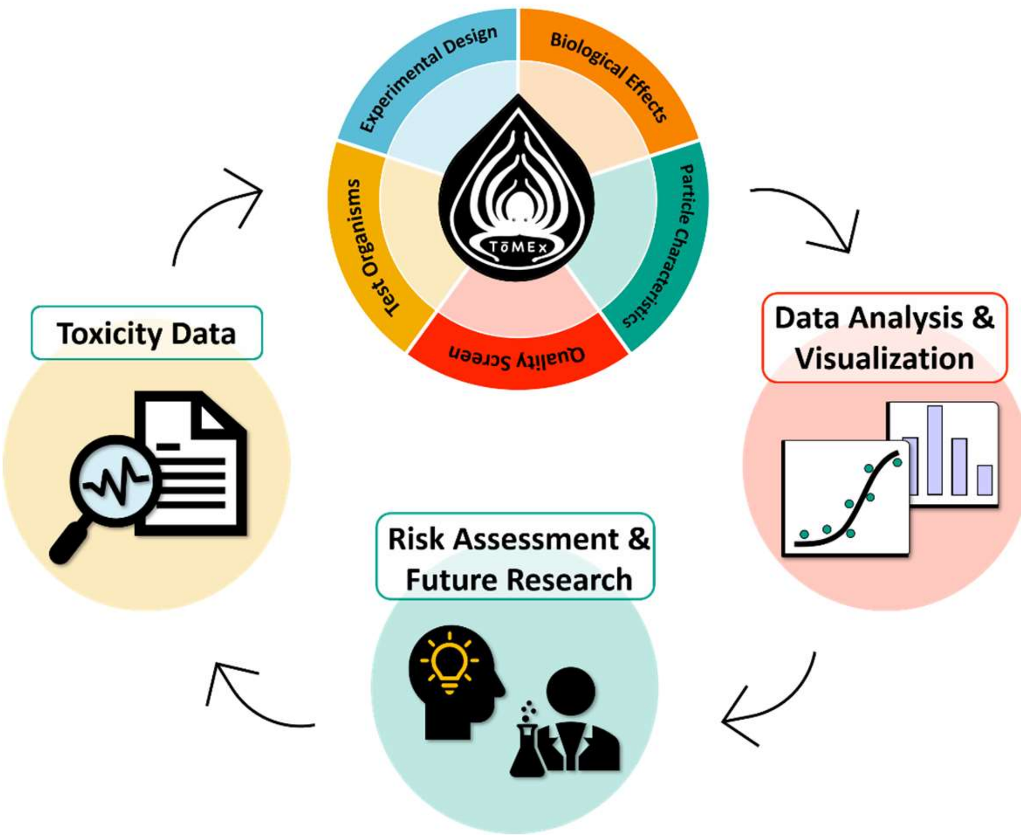
Health Effects:

- ❖ Microplastics and Nanoplastics
- ❖ Open Access



Toxicity of Microplastics Explorer

- ❖ Database for Microplastics Toxicity + R Shiny App
- ❖ Tool to summarize, explore, and analyze toxicity data during workshop
- ❖ Open access
- ❖ Living database



https://microplastics.sccwrp.org/

@ToMExApp

Multiple Parallel Efforts Supporting California Microplastics Legislation

Methods:

- European Commission Joint Research Commission
- ASTM International

Health Effects:

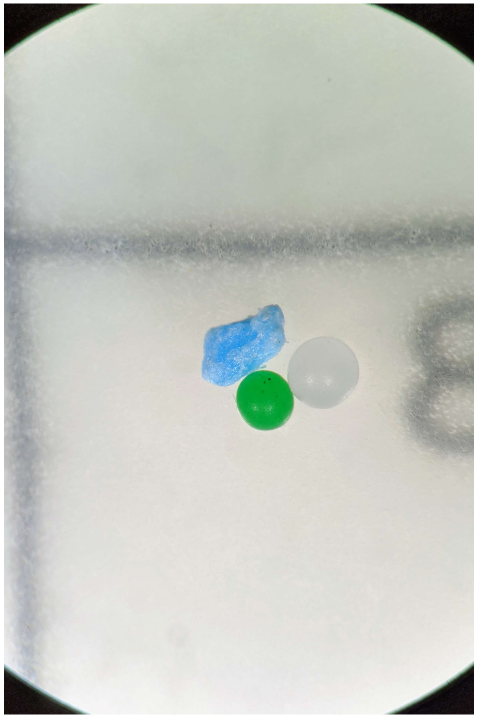
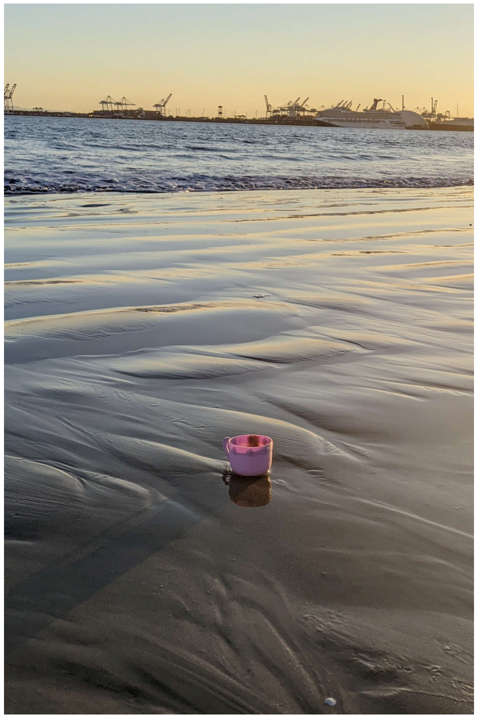
- World Health Organization
  - Microplastics in Drinking Water, Report Released 2019
- California Ocean Science Trust
  - Precautionary Framework for Risk Assessment, Report Released Spring 2021

Acknowledgements

Government
Elaine Khan – California OEHHA
Scott Coffin – California Water Resources Control Board
Holly Wyer – California Ocean Protection Council*
Anna-Marie Cook – US Environmental Protection Agency*
Sherry Lippiatt - NOAA*
Christine Lemieux – Health Canada
Leah Hampton – SCCWRP
Alvina Mehinto – SCCWRP

* Has subsequently retired or change affiliation

Academia/Other
Martin Wagner - Norwegian Univ of Science & Technology
Matt Cole - Plymouth Marine Laboratory
Ludovic Hermabessiere – University of Toronto
Allen Burton - University of Michigan
Ezra Miller – San Francisco Estuary Institute
Stephanie Wright - Imperial College London
Chelsea Rochman – University of Toronto
Bart Koelmans - Wageningen University
Susanne Brander – Oregon State University
Todd Gouin - TG Environmental
Hans Bouwmeester - Wageningen University


Leah Thornton Hampton
Southern California Coastal Water Research Project
leahth@sccwrp.org
@DrLeahTH

Thank you!