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  https://clu-in.org/conf/itrc/Microplastics/

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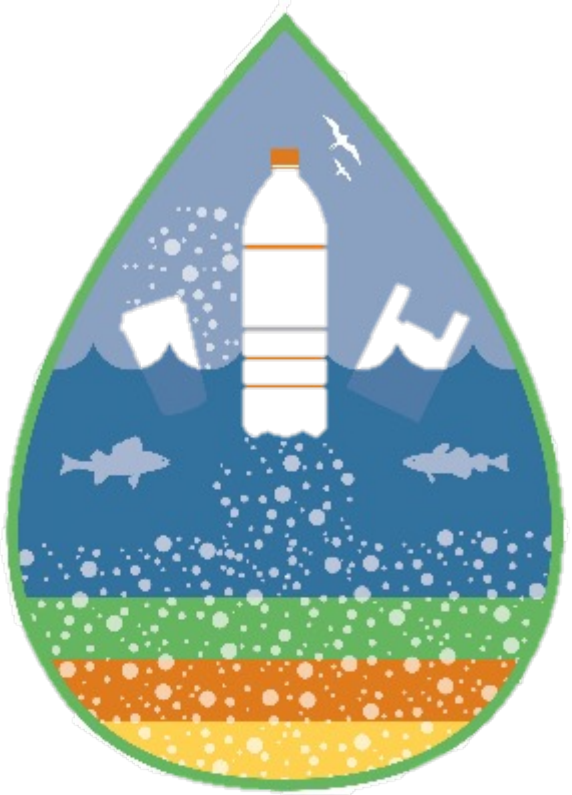
Welcome!

Microplastics (MP-1)
ITRC Guidance Document



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Sponsored by: Interstate Technology and Regulatory Council (www.itrcweb.org)
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Read trainer bios at https://clu-in.org/conf/itrc/Microplastics/

Today's Training Road Map

Introduction to Microplastics

Introduce the Interactive Case Study

Environmental Distribution, Fate & Transport

Sampling & Analysis

Q&A Session

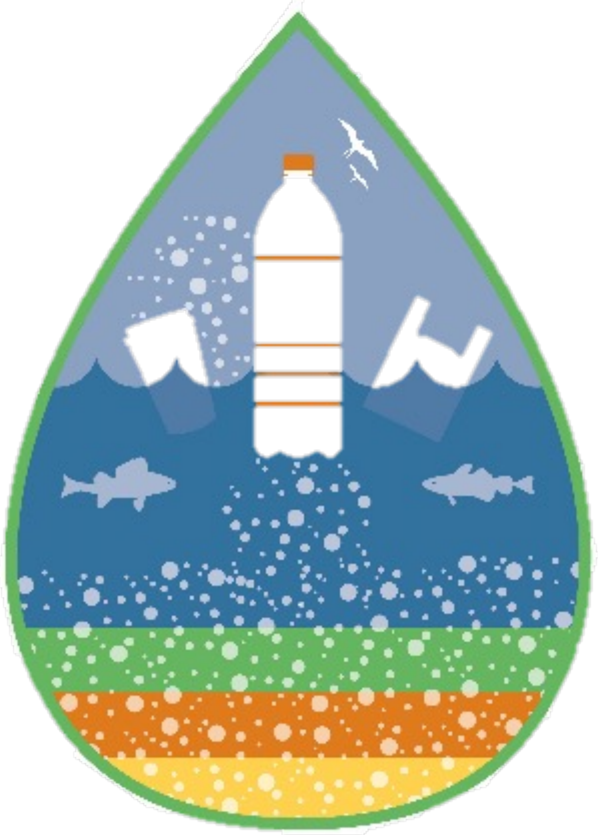
Human Health and Ecological Effects

Regulatory Context

Mitigation and Abatement

Wrap-up Slides

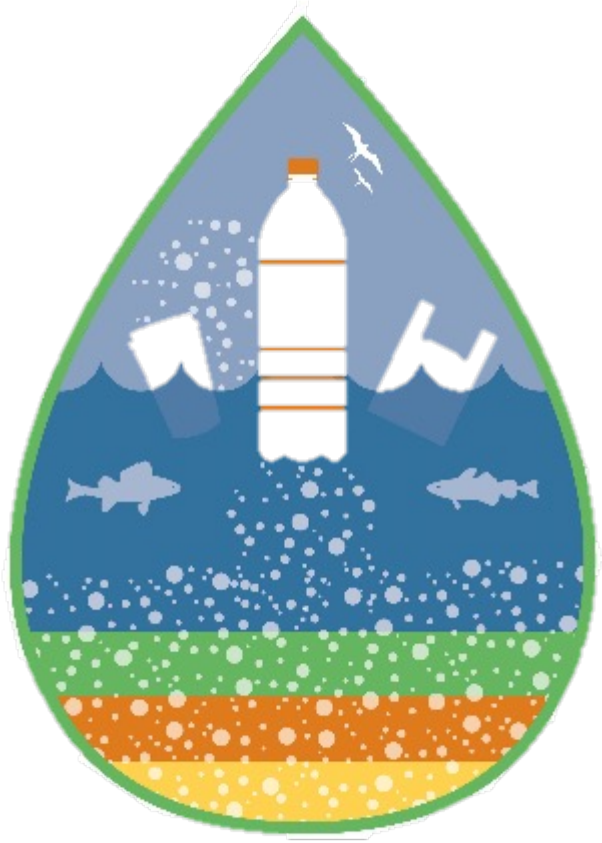
Q&A Session



Microplastics Guidance Document

Overarching Goal:

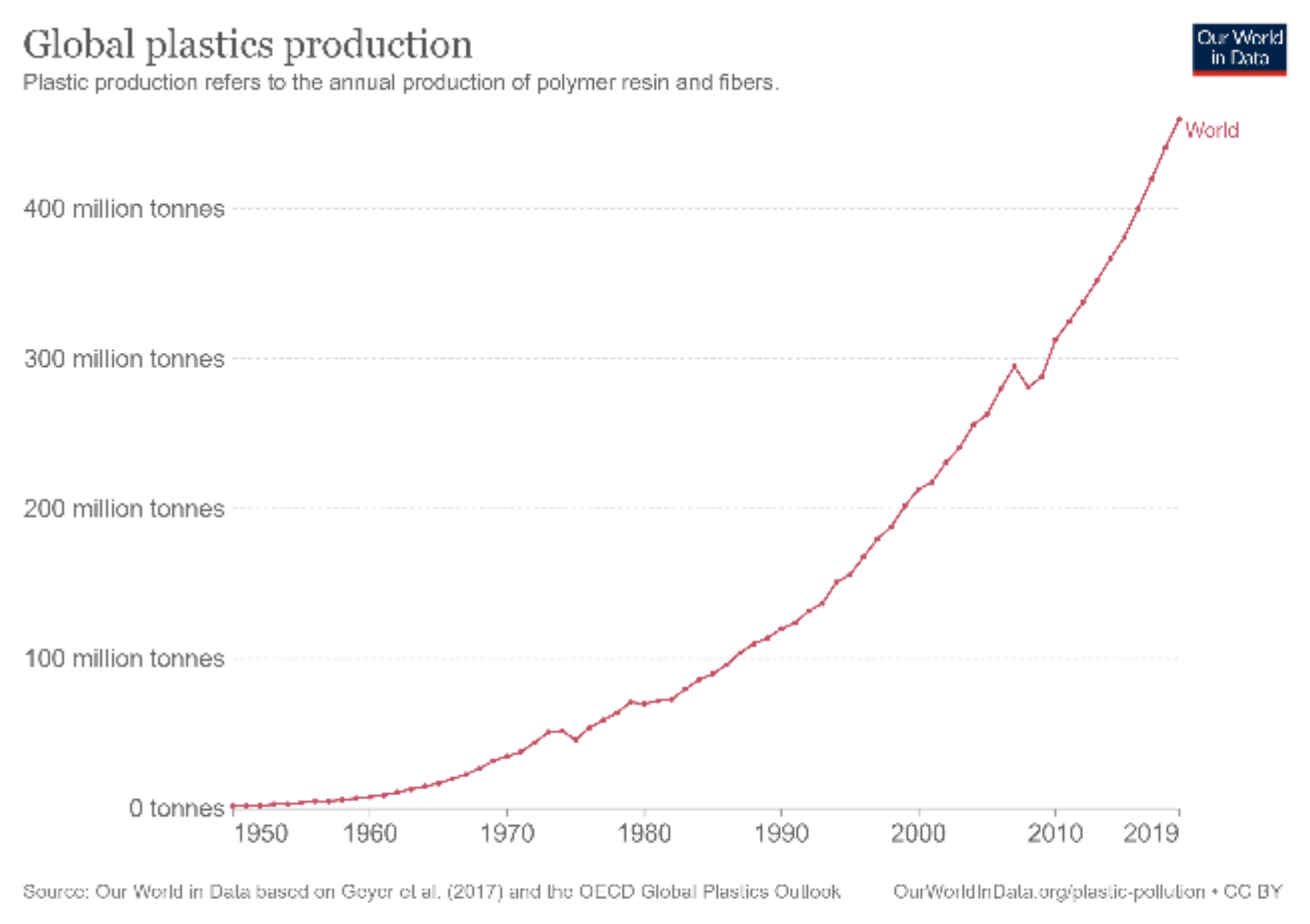
The guidance will provide an understanding of microplastics and the state of the applied science without having to go to the scientific literature.



Topics Covered

- Introduction to Microplastics and their Sources
- Environmental Distribution, Fate & Transport
- Sampling and Analysis Techniques
- Human Health and Ecological Effects
- Current Regulations
- Mitigation and Abatement

Global Plastic Production



Source: OurWorldData, CC-BY-SA

Invention of first synthetic plastic	Innovation of variety of plastics	Growth of plastic industry	Innovation of biobased and biodegradable plastics
1907	1933-1945	1950	1970s and beyond

Source: D. Yardimci
Data sourced from
https://www.plasticsindustry.org/history-plastics

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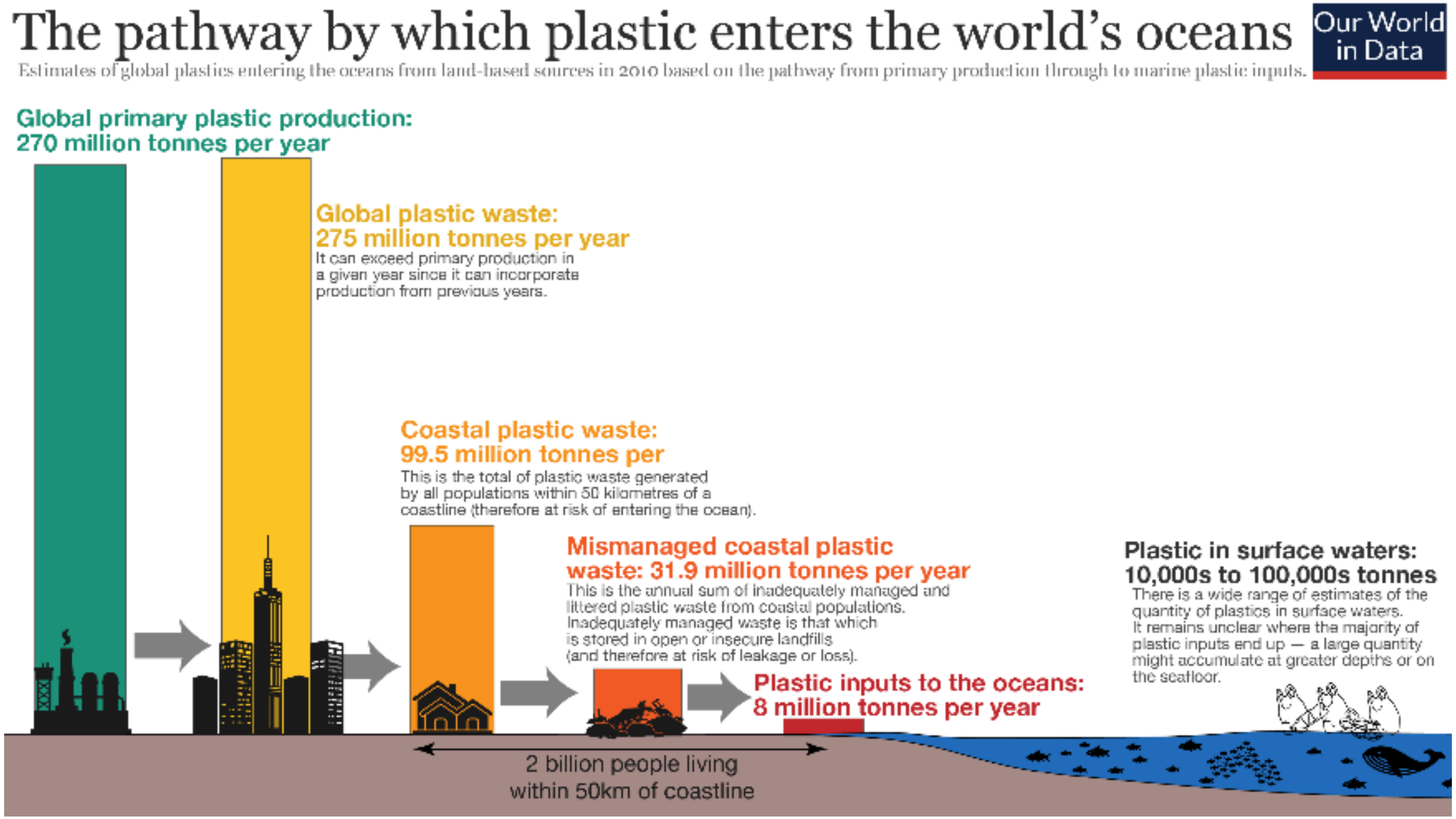
Global Plastic Waste



Source: OurWorldData, CC-BY-SA

Why Do We Care About Microplastics?

- Ubiquitous in the environment
- Accumulate and persist long time in the environment
- Contain harmful chemical contaminants and additives
- Consumed by humans and other organisms
- Cause adverse health impacts on humans and other organisms

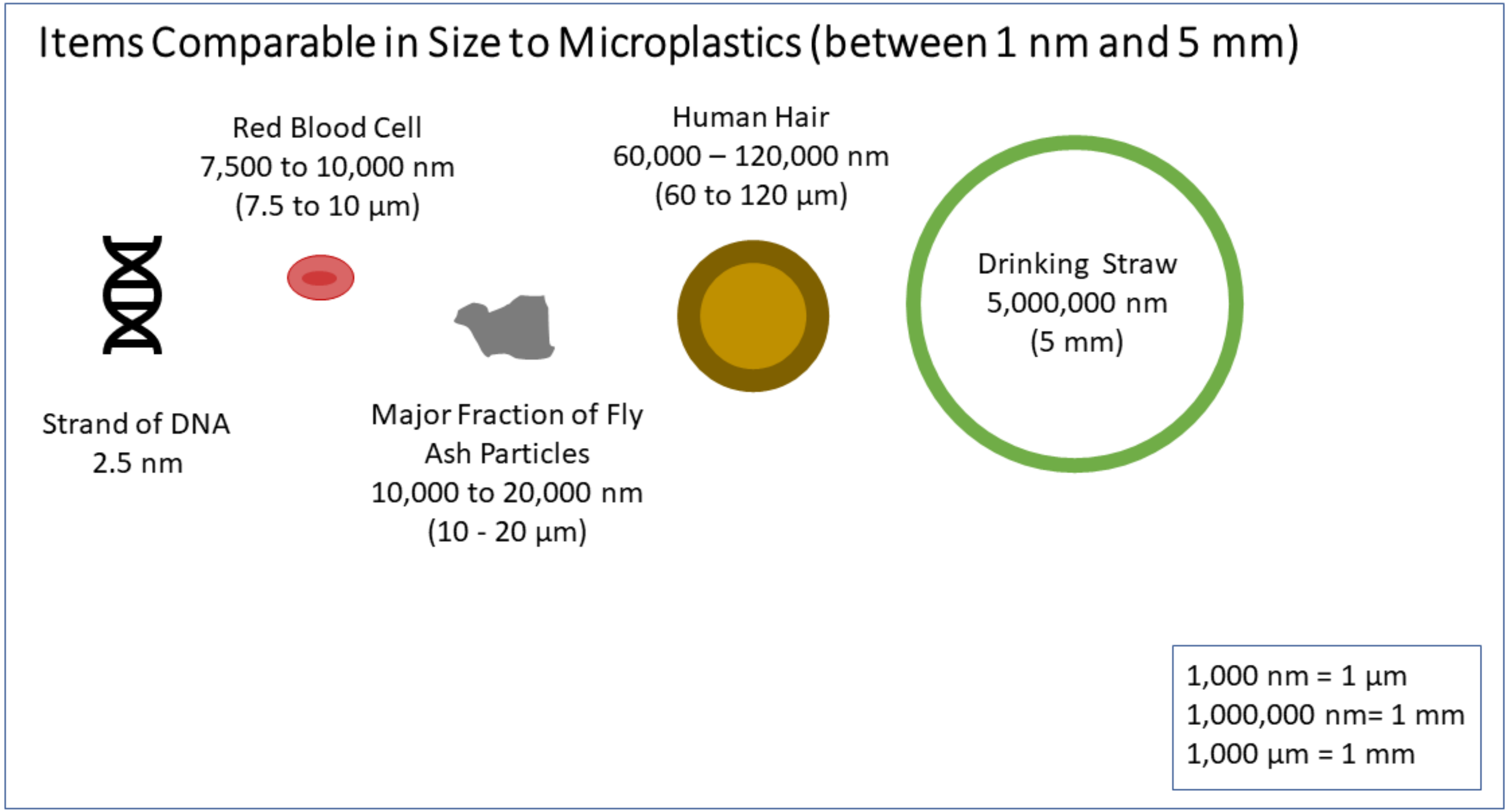
Source Top: Flickr, Global Water Forum
Source Bottom: Oregon State University, : CC-BY-SA-2.0

Microplastics Definition

Particles that are ***greater than 1 nanometer (nm)*** and ***less than 5 millimeters (mm)*** in their longest dimension and comprised of solid polymeric materials to which chemical additives or other substances may have been added.

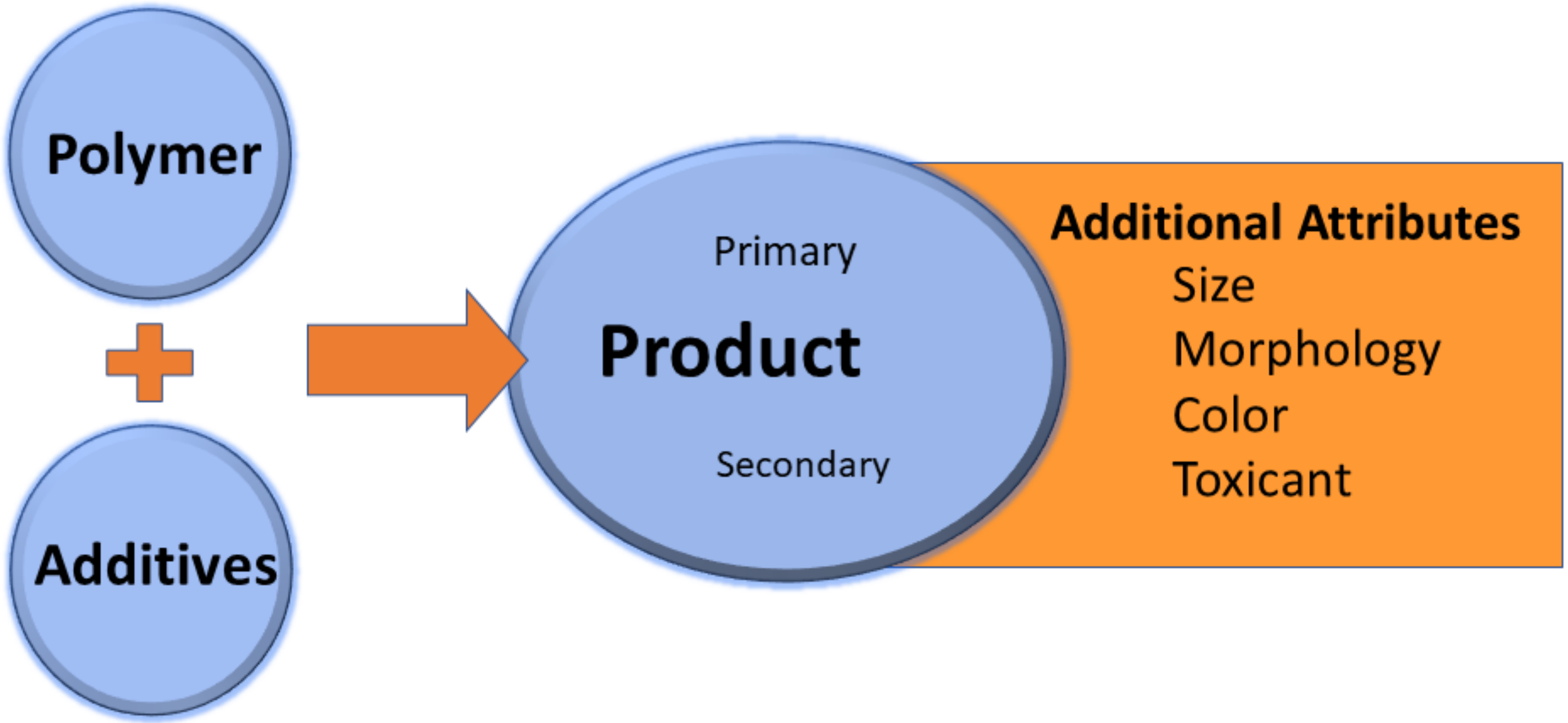
Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded

Microplastic Size



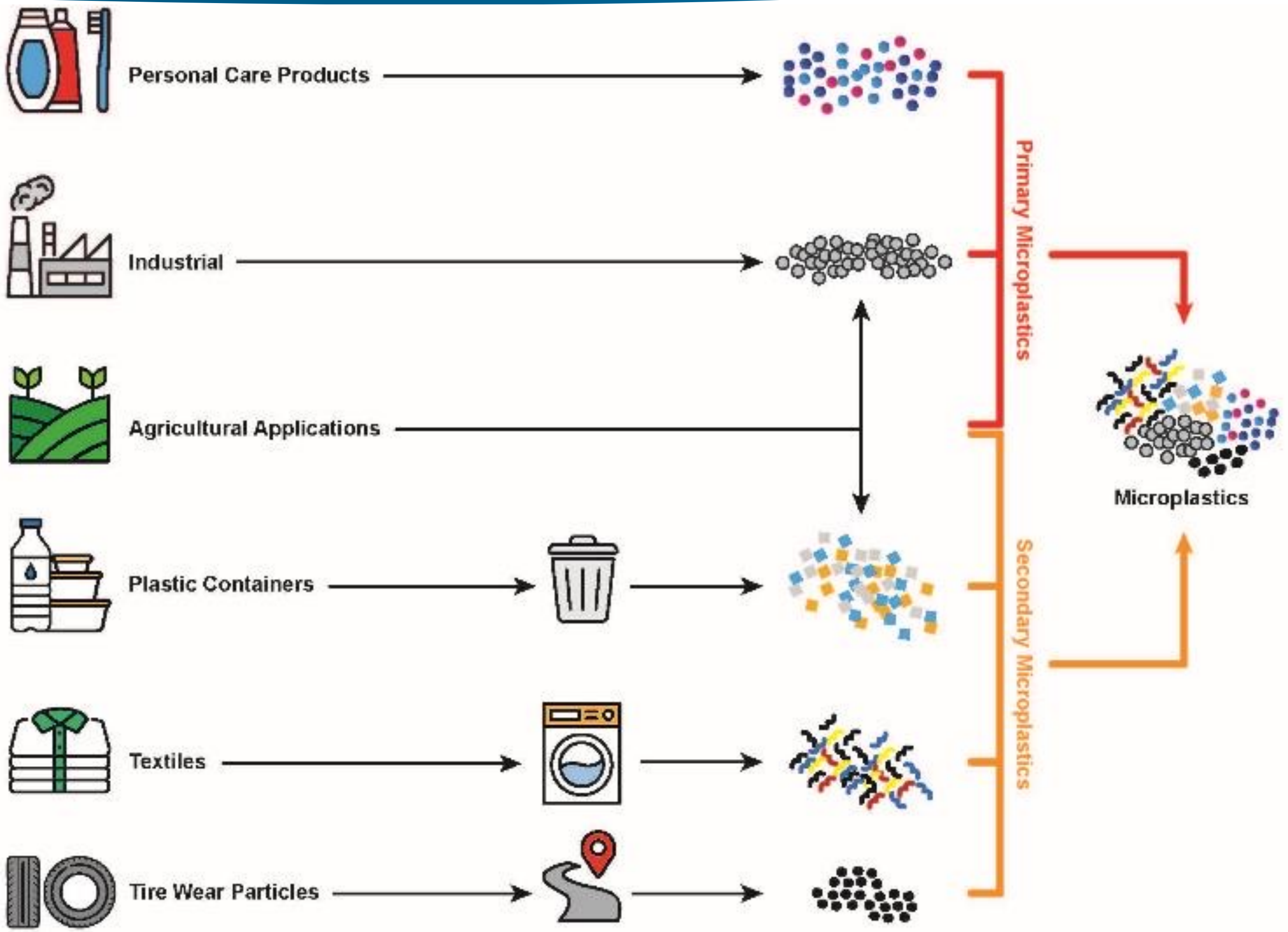
ITRC MP Figure 1-2
Source: V. Hanley

Variety of Microplastics



Source: C. Baysinger

Primary vs. Secondary Microplastics



ITRC MP Figure 2-1
Source: J. McDonald

Primary Microplastics

Intentionally manufactured for specific applications or products

microbeads in personal care products

pre-production pellets (nurdles)

Case Study: Appendix A.4: Nurdles Along the Gulf Coast

ITRC MP Figure A.4- 2

Source: Tunnell et al. 2020

Highlights how citizen science can play a significant role in understanding and evaluating emerging contaminants, as well as drive litigation, which can ultimately impact policy

Secondary Microplastics

Originate from larger plastics that fragment into smaller pieces

wear and tear of car tires

fragmentation of consumer products

fibers/filaments from synthetic textiles

Sources: S. Viinamäki/ CC-04, Streetwise Cycle /CC-04, B. Schumin/ CC-03, B. Spragg/CCO-1.0

Case Study: Appendix A.3: Impact of Disposable PPE and Single Use Plastic Items During the COVID-19 Pandemic

ITRC MP Figure A.3- 1.

Source: C. Huang

Microplastic Shape

- Fragments
- Beads
- Pellets
- Foams
- Films
- Sheets
- Filaments
- Fibers

ITRC MP Figure 1-4
Source: Martindale et al, 2020

Microplastics Adsorb Harmful Chemicals

- Enhance sorption of heavy metals (e.g., lead, cadmium)
- Enhance sorption of persistent organic pollutants (POPs)
  - Polycyclic aromatic hydrocarbons (PAHs)
  - Polychlorinated biphenyls (PCBs)
  - Per- and polyfluoroalkyl substances (PFAs)
  - Organochlorine pesticides (dichlorodiphenyltrichloroethane, DDT)

Factors Enhance Chemical Adsorption Capacity of Microplastics

- High hydrophobicity
- High surface area to volume ratio
  - Smaller size
  - Rougher shapes
  - Weathered and aged
- Polymer type
  - Low-density plastics (PE, PP) > High-density plastics (PET, PVC)
  - Rubbery plastics (PE, PP) > Glassy plastics (PET, PVC)

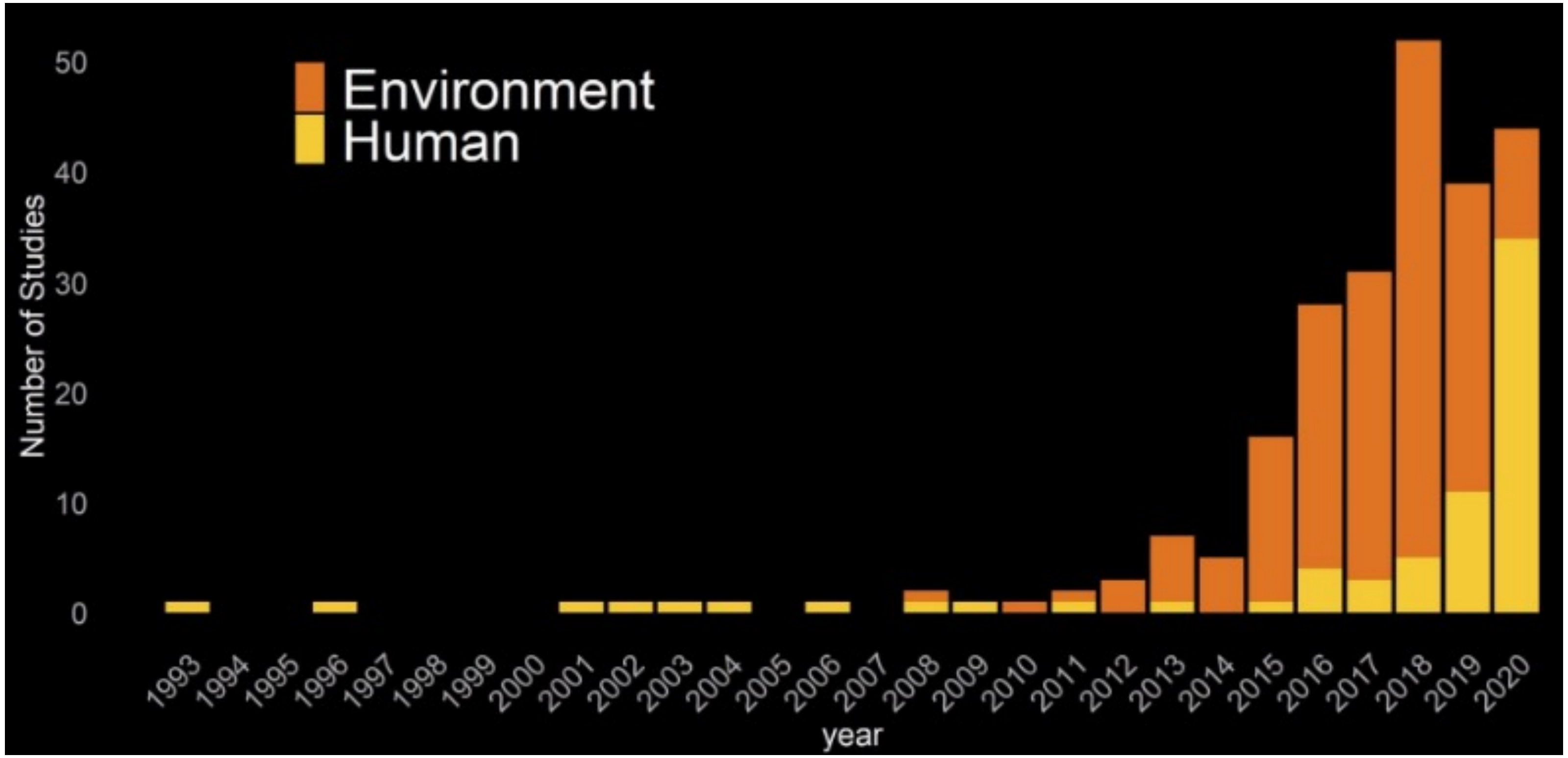
Microplastics as Vectors

- Allow formation of biofilms -> vector for bacterial pathogens
- Spread of antibiotic-resistant bacteria (ARB)
- Long-distance transport of chemical contaminants
- Source of contaminants in aquatic environments, sediments, and biota

More studies needed to understand vector effects of microplastics

Evolving State of Science of Microplastics

- Emerging contaminant of concern
- Rapidly evolving state of science
- Increase in number of microplastics toxicity studies



Source: S. Coffin 2021

Today's Training Road Map

Introduction to Microplastics

⇩

➡ **Introduce the Interactive Case Study**

⇩

Environmental Distribution, Fate & Transport

⇩

Sampling & Analysis

⇩

Q&A Session

⇩

Human Health and Ecological Effects

⇩

Regulatory Context

⇩

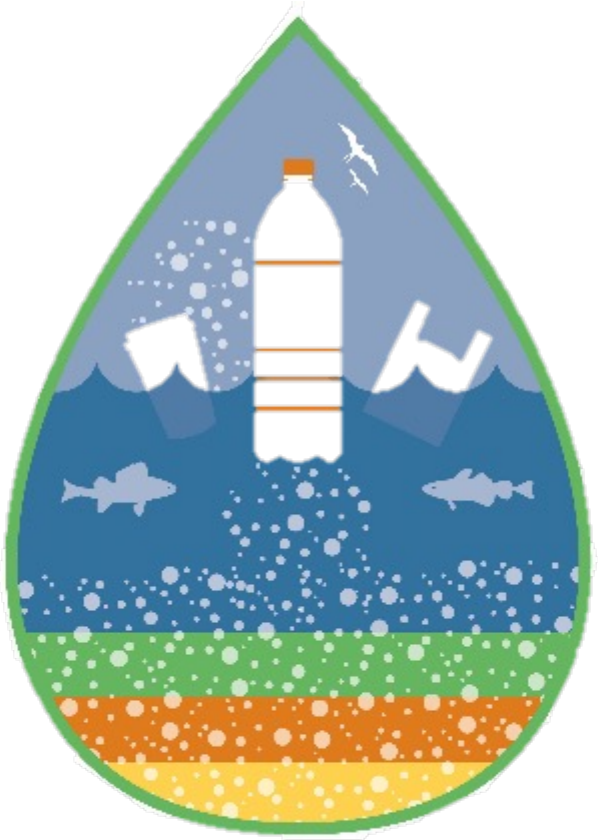
Mitigation and Abatement

⇩

Wrap-up Slides

⇩

Q&A Session



Interactive Case Study - Objectives

Source: A. MacDonald

- Start with hypothetical environment
- Identify sources, pathways, receptors
- Develop recommendations for investigation and evaluation

Case Study – Step 1 – MP Sources

- Identify the MP Sources:
- Please use the chat function to type in your answers

Case Study – Step 1 - MP Sources

Possible MP Sources

- Roadway
- Waste treatment plant
- Farm biosolids
- Housing
- Factory
- Fishing Boat
- Landfill
- Car Tires
- Beach Use

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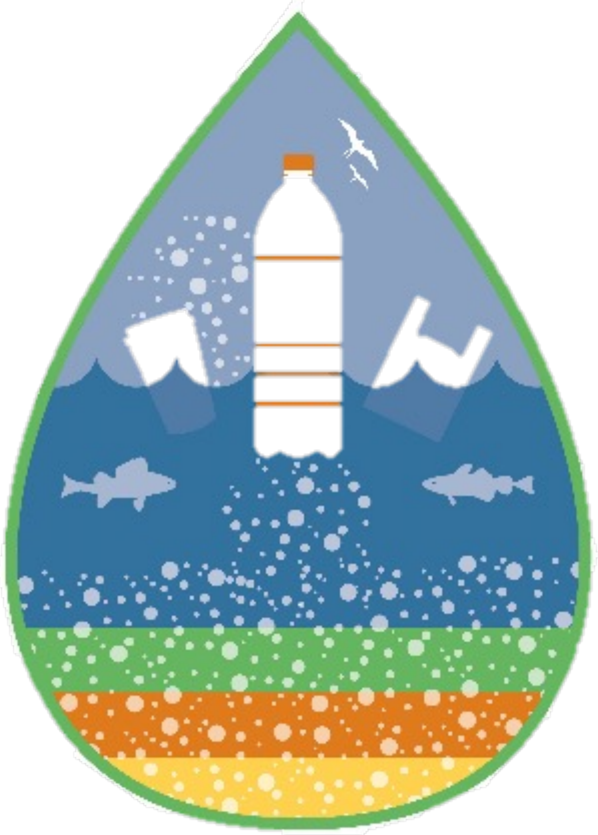


Conceptual Site Model (CSM)

- Multifunctional Tool
  - Overview Information
  - Document Navigation

Source: J. McDonald

CSM: Point Sources

CSM: Non-Point Sources

Microplastics can be transported through the atmosphere and deposited far away from the source

(Macro)Plastic trash washes into the ocean, then breaks down into smaller and smaller pieces, eventually becoming microplastics

Microplastics generated through typical tire wear and breakdown of roadway materials

Microplastics may be present in household products such as toothpaste or facial cleaners. Microplastics can be generated through household activities such as laundering of clothing

Microplastics may be present in agricultural lands due to direct application of fertilizer pellets, biosolids from wastewater treatment plants, or due to breakdown of plastic sheeting

Case Study: Appendix A.5: Tire Wear Particles and Coho Salmon

Tire wear particles are a specific type of microplastic

Additive 6PPD can **leach** from these particles and transform into 6PPD-quinone

Coho salmon are uniquely sensitive to toxic effects of 6PPD-quinone

Source: Kalernna/ CC 3.0

ITRC MP Figure A.5- 1

Source: Bureau of Land Management

How Microplastics are Generated

- Abiotic and biotic processes – Chemical, physical, and biological reactions
- Important in fate and transport; size distribution
  - Biofouling, aggregation, flocculation, fragmentation, time of residence, and transportation routes
- Photodegradation – initial process at surface of land and water
  - Can change physicochemical and mechanical properties
- Biodegradation in aphotic (no light) zones

Environmental Distribution – MP in the Fluvial Environment

ITRC MP Figure 2-3, Source: J. McDonald and T. Miller

- MP transport – rivers and streams
- Prevalent at surface, throughout water column, and in sediments
- MP sinks – lakes and inland areas of decreased flow velocity
- Two-way transport affects distribution

  water ↔ land ↔ air

Environmental Distribution – Surface Water

Section 2.3.1
MP in Surface Water

ITRC MP Figure 2-1

- Rivers, Lakes, and Streams
- Stormwater
- Bays and Estuaries
- WWTP as sources

Environmental Distribution – Wastewater

Section 2.3.2
MP in Wastewater

ITRC MP Figure 2-1

- Industrial and domestic product sources for MP entering WWTPs
- WWTP processes remove MP—no standard treatments or analysis methods
- Biosolid products, re-release by land application and landfilling
- MP in wastewater effluent predominantly smaller then 0.5 mm

Environmental Distribution – Groundwater

Section 2.3.3
MP in
Groundwater

ITRC MP Figure 2-1

- Limited studies indicate lower prevalence of MP than other water types
- Current sampling obstacles due to plastic monitoring well construction
- Movement affected by particle size, density, soil moisture, pH, salinity, and ionic strength – aided by preferential pathways
- Reported presence in Illinois (US), as well as Germany, and South Africa – shallow and deep groundwater
- Higher concentrations near WWTP, landfills, and agricultural sites

Environmental Distribution – Oceans

Section 2.3.4
MP in Oceans

ITRC MP Figure 2-1

- Enter from estuaries, rivers, outfalls, and the atmosphere – move at surface by currents towards central, slower moving oceanic gyres
- Denser MP sink, then distributed by subsurface currents – reported from all ocean depths – highest concentrations at depths 200 m to 600 m
- Transport of floating debris – ocean currents, convergence zones, Stokes drift, tides, wind force, Langmuir circulation, ice formation and melt, drift, etc.
- Vertical transport – Factors include degradation/aggregation, biofouling; positive, negative, neutral buoyancy

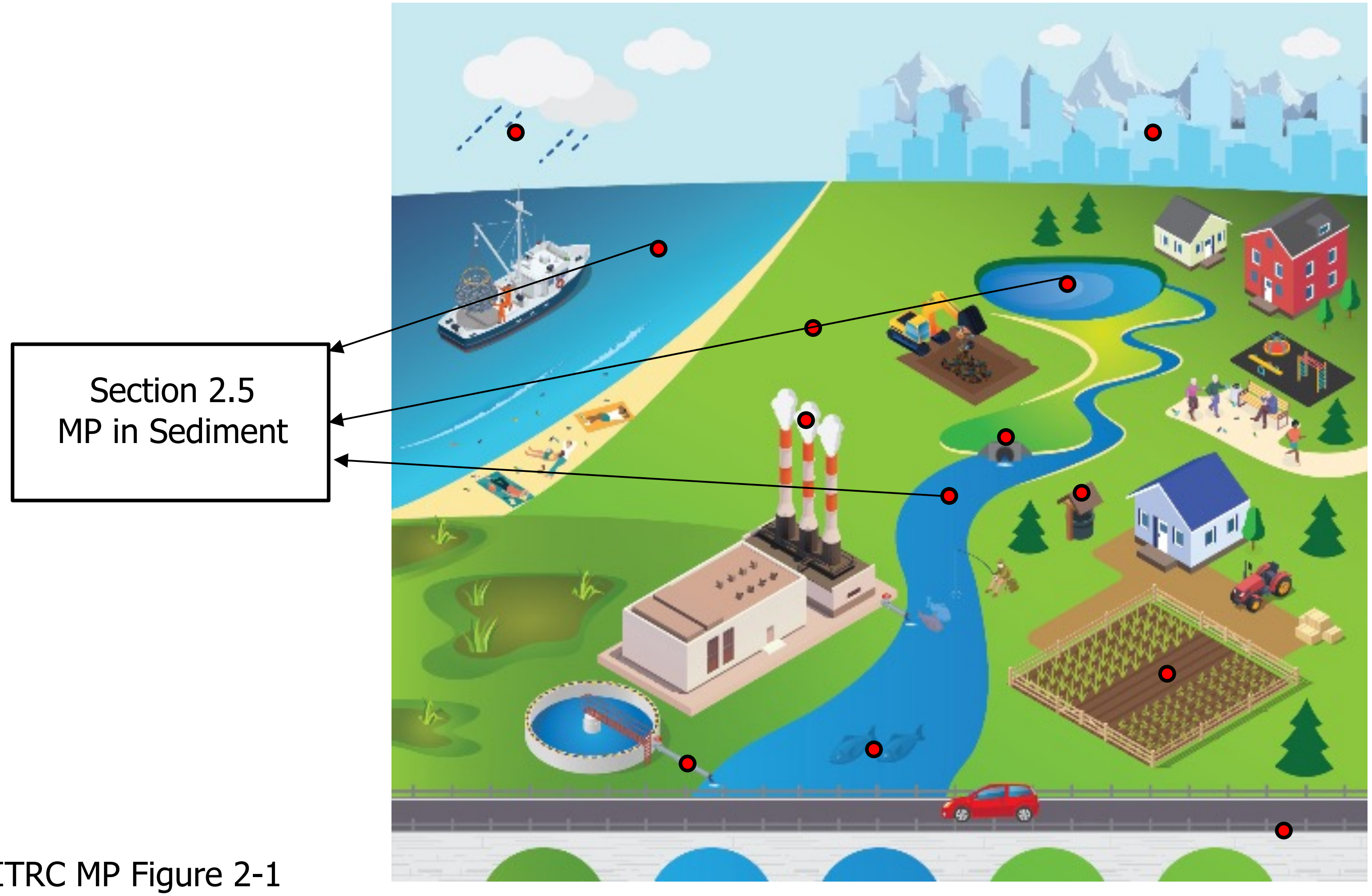
Environmental Distribution – Soils

Section 2.4
MP in Soils

ITRC MP Figure 2-1

- Likely to be long term sinks for MP since most plastics are used and disposed of on land.
- High MP abundance – Lands close to busy roads, waste management and agricultural areas, and home gardens
  - Other factors – soil type and management, plastic size and density, and precipitation
- Potential to alter soil properties such as bulk density and water retention capacity – vary with type, fibers have distinctly negative impact compared to foams, films, or particles

Environmental Distribution-Sediment



ITRC MP Figure 2-1

- Suspended MP settle from the water column to combine with sediments – found in marine and freshwater, flowing and non-flowing systems
- Fibers and fragments common – higher density MP more likely to settle, abundance decreases with sediment depth
- Research shows sediments higher in total organic carbon (TOC) tend to have more MP
- Residence time in river headwaters is high especially in low flow conditions – rivers are a key pathway of transport to other areas
- Resuspension and redistribution from sediment is a key process

Environmental Distribution – Air

Section 2.6
MP in Air

ITRC MP Figure 2-1

- Increased occurrence and transport of MP in densely populated areas – denser human populations and activities, industrialization
- Atmospheric deposition – precipitation events; rain and snow
- Emergent component of air pollution due to inhalation and combination with other pollutants (e.g., mercury, PAHs)
- Transport – wind speed, up/down drafts, convection lift, and turbulence
  - Also affects distribution of plastic pollution in terrestrial and marine environments, potential for long-distance transport
- Small MP sizes, various shapes; fibers, fragments, and films

Environmental Distribution – Urban Litter

Section 2.7
MP in Urban Litter

ITRC MP Figure 2-1

- Macroplastic litter breaks down to MP
- Plastic portion of litter can vary dramatically – San Francisco Bay area stormwater study showed plastic items were 2.2% to 15.1% of litter by volume, whereas a Mississippi River basin study showed plastic accounted for 74% of litter
- Storm events play important role – Los Angeles River study showed MP increased 7-fold at the coast near Long Beach after a storm
- A Great Lakes area study showed fragments, films, foams, and pellets, all found in urban watersheds at higher concentrations as result of rainfall or snowmelt events

Environmental Distribution – Biota

Section 2.8
MP in Biota

ITRC MP Figure 2-1

- MP found in plants, invertebrates, birds, mammals, and fish
- MP are being ingested
- Plants – studies show uptake by crop plants through roots and transported to shoots
- Marine biota – Filter feeders at greater risk due to suspension feeding

Environmental Distribution- Summary

ITRC MP Figure 2-1

- Section 2.3: Fluvial Environment
  - Surface water
  - Wastewater
  - Groundwater
  - Oceans
- Section 2.4: Soils
- Section 2.5: Sediments
- Section 2.6: Air
- Section 2.7: Urban Litter
- Section 2.8: Biota

Case Study – Step 2 – MP Transport Pathways and Media

- Identify the possibly MP-impacted media:
- Please use the chat function to type in your answers

Case Study – Step 2 – MP Transport Pathways and Media

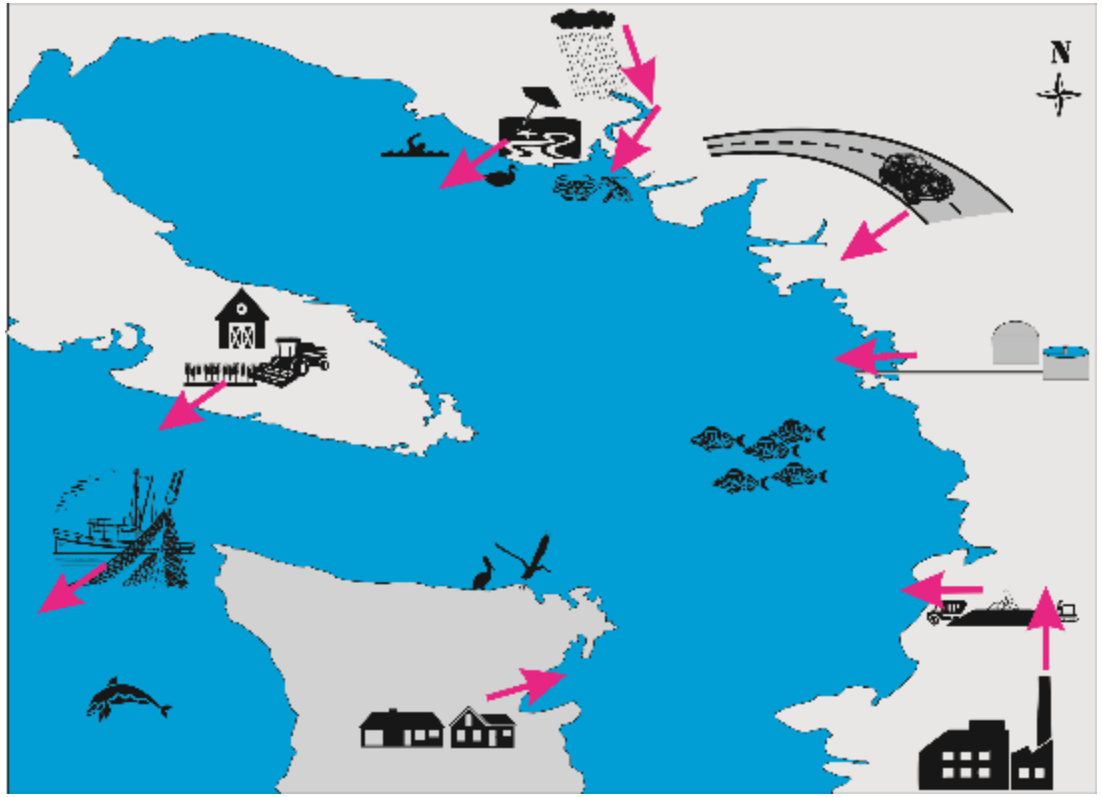
Possible MP-impacted media

- Ambient air
- Subsurface Soils
- Surface soils
- Surface water
- Groundwater
- Beach sand
- Crops/Produce

Case Study – Step 2 – MP Transport Pathways and Media

- Identify the possibly MP-Transport Pathways:
- Please use the chat function to type in your answers

Case Study – Step 2 - MP Transport Pathways and Media



Possible MP transport pathways

- Urban runoff
- Rainfall
- Stormwater discharge
- Factory stack emissions
- Wind-blown wastes
- Wastewater discharge
- Agricultural soil disturbance

Today's Training Road Map

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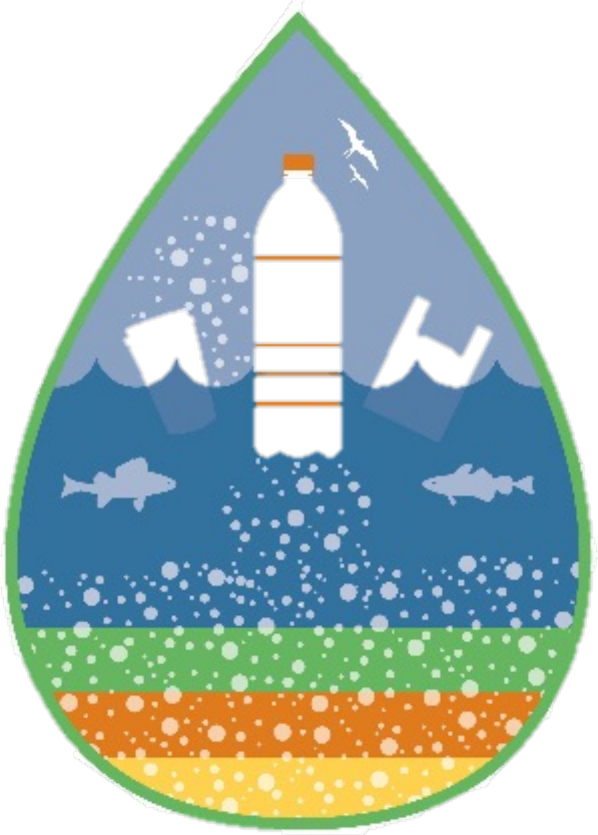

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Overview – Sampling & Analysis

- Considerations for selecting appropriate methods
- ITRC tools to help choose appropriate methods
  - Sampling = Sample Collection Tool
  - Analysis = Table 4-2. Characterization Techniques Summary
- Standard/adopted methods
- Minimizing sample contamination

CSM – Sampling & Analysis

Air
Section 3.4.3 sample collection
Section 3.6.3 sample preparation

Surface Water - Freshwater
Section 3.4.1.2.1-sample collection
Section 3.6.1.2-sample preparation
Sediment
Section 3.4.2.2-sample collection
Section 3.6.2-sample preparation

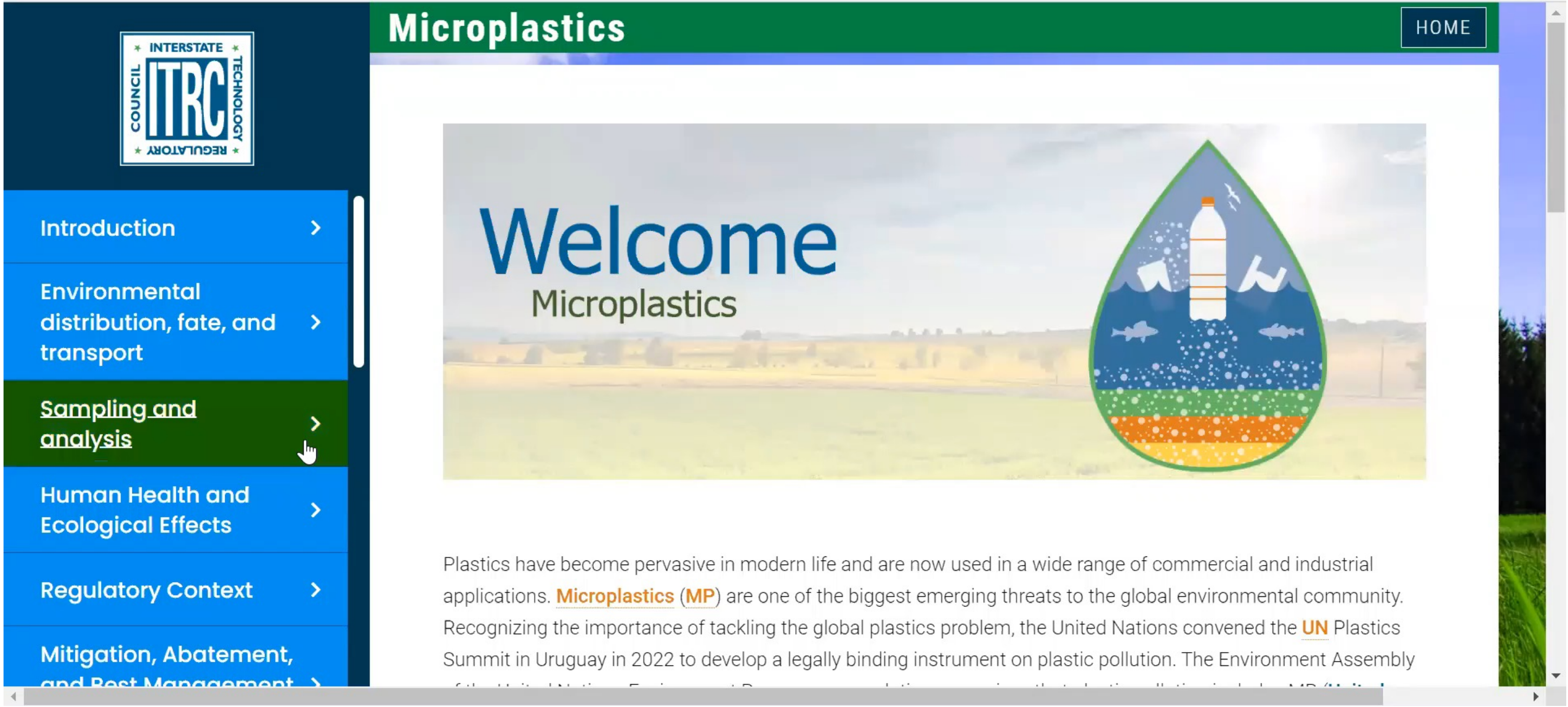
Soil
Section 3.4.2.1-sample collection
Section 3.6.2 sample preparation

ITRC MP Figure 3-1

Selecting Appropriate Methods

- What are your data quality objectives?
  - sample media
  - particle size
  - minimum detectable amount
  - data needed (size, shape, polymer, units, etc.)
  - equipment/cost available

Sample Collection Tool



Standardized Sampling Methods

ASTM D8332-20 (July 2020)

- Drinking water, surface waters, wastewater influent and effluent (secondary and tertiary), and marine waters
- Pump or existing sample tap + series of sieves
- Large volume (400 – 1,400 gallons)

California Water Boards (Yuen et al. 2022)

- Drinking water
- In-line sieve filtration
- Large volume (1,000 L)

Analytical Methods

Description	Analysis Time/ Sample	Size Detection Limit	Measurement Preparation	Identifies Polymer Types	Detects Additives /Surface Chemicals	Detects Particles or Mass
Visual Methods						
NE Naked eye	Hours	1 mm	None	No	No	Particle
SM Stereo microscopy	Hours	100 µm	On filter	No	No	Particles
FM Fluorescence microscopy	Hours	50 µm (Possibly smaller based on objective lens used)	On filter	No	No	Particles
SEM Scanning electron microscopy	Hours	0.001 µm	On filter	Yes	No	Particles
Spectroscopic Methods						
FPA-FTIR Focal plane array-Fourier transform infrared spectroscopy (in	Hours	20 µm	On special filter	Yes	No	Particles

Excerpt From ITRC MP Table 3-1. Characterization Techniques Summary

Analytical Methods - California

ITRC MP Table 3-1. Characterization Techniques Summary Excerpt

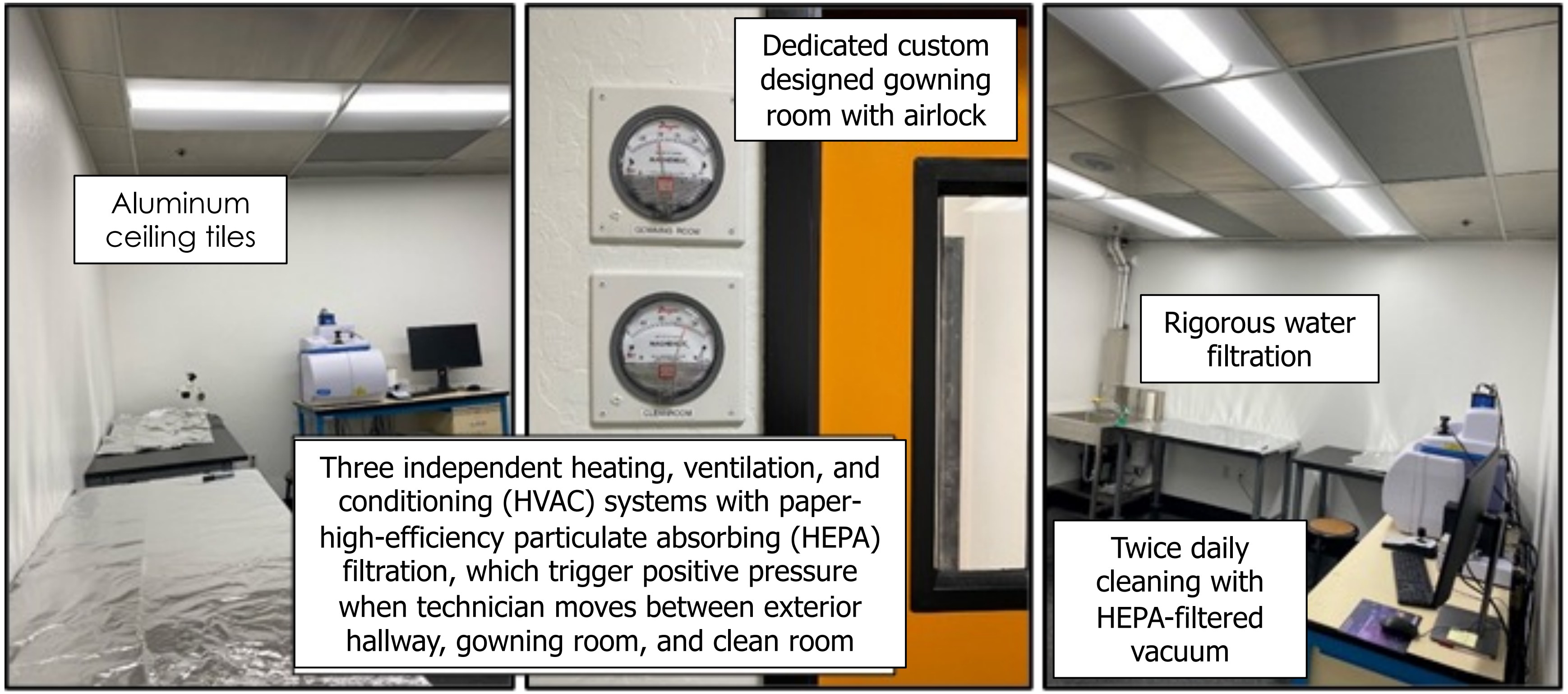
Description	Analysis Time/ Sample	Size Detection Limit	Measurement Preparation	Identifies Polymer Types	Detects Additives /Surface Chemicals	Detects Particles or Mass
FTIR Fourier transform infrared spectroscopy (in transmission mode)	Days	20 µm	On special filter	Yes	No	Particles
LIDR Laser direct infrared spectroscopy	Minutes particles/ hour	20 µm	Special microscope slide	Yes	No	Particles
NIR, vizNIR Near infrared spectroscopy, visible-near infrared spectroscopy	Hours	Unspecified	On filter	Yes	Surface Chemicals only	Particles
Raman Spectroscopy	Days	1 µm (Theoretically but challenging to achieve)	Extraction and placed on filter	All polymers	Yes	Particles

Recently, the California State Water Resources Control Board adopted FTIR and Raman methods for MP identification in drinking water samples.

Keep it "Clean"

- Minimize contamination
  - Eliminate or limit plastic products used for sampling/processing
  - Set up a clean laboratory
- Account for contamination
  - Collect air & procedural blanks to measure contamination introduced during processing

Example Laboratory Considerations

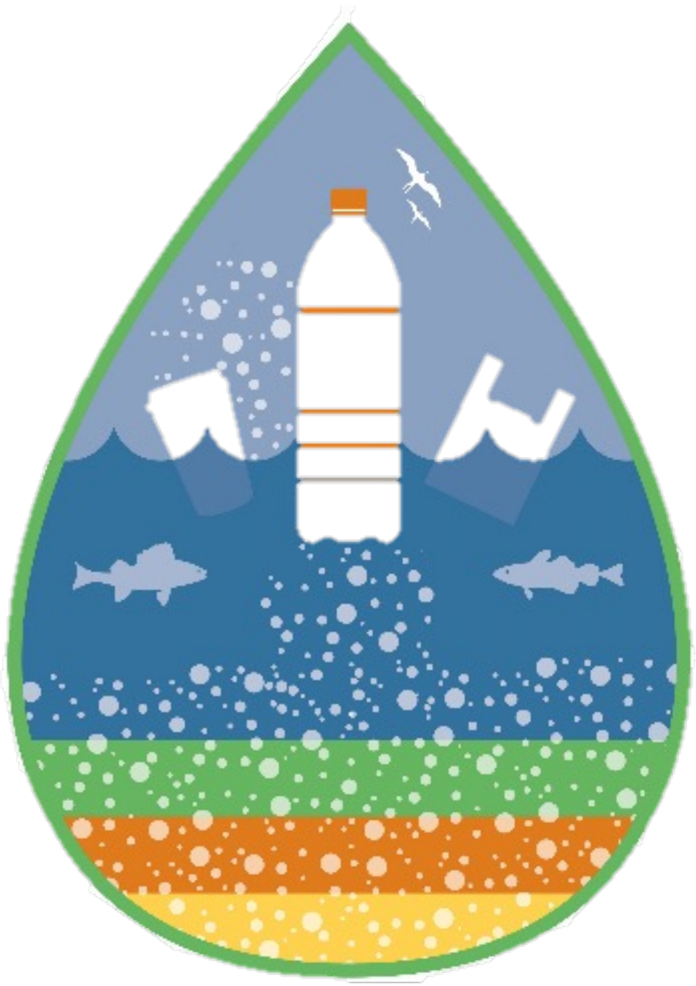


ITRC MP- Figure 3-2
Source: A. Enright
Photos: Eurofins

Summary – Sampling & Analysis

- Standardized sampling methods available for water
- FTIR & Raman analytical methods adopted for drinking water in CA
- For other media/scenarios, use ITRC tools to select methods
- Minimize & account for contamination

Question and Answer Break



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Wrap-up Slides
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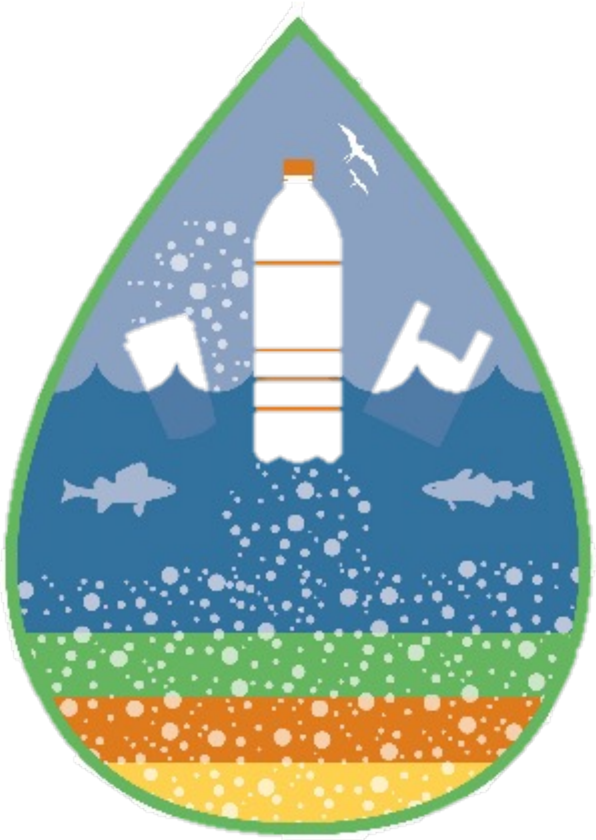
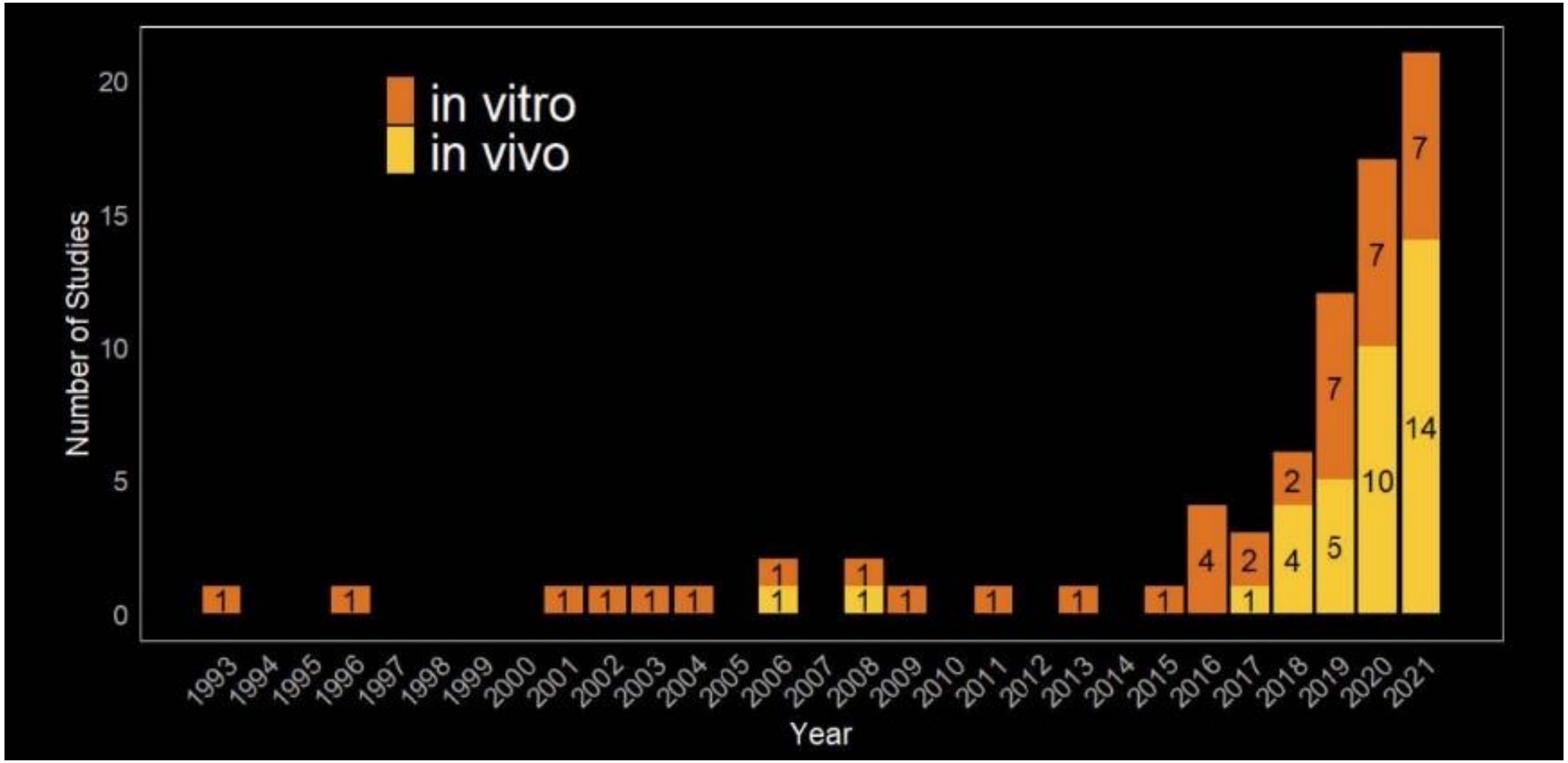


Overview

- Human Health
  - Exposure
  - Effects
  - Uncertainties

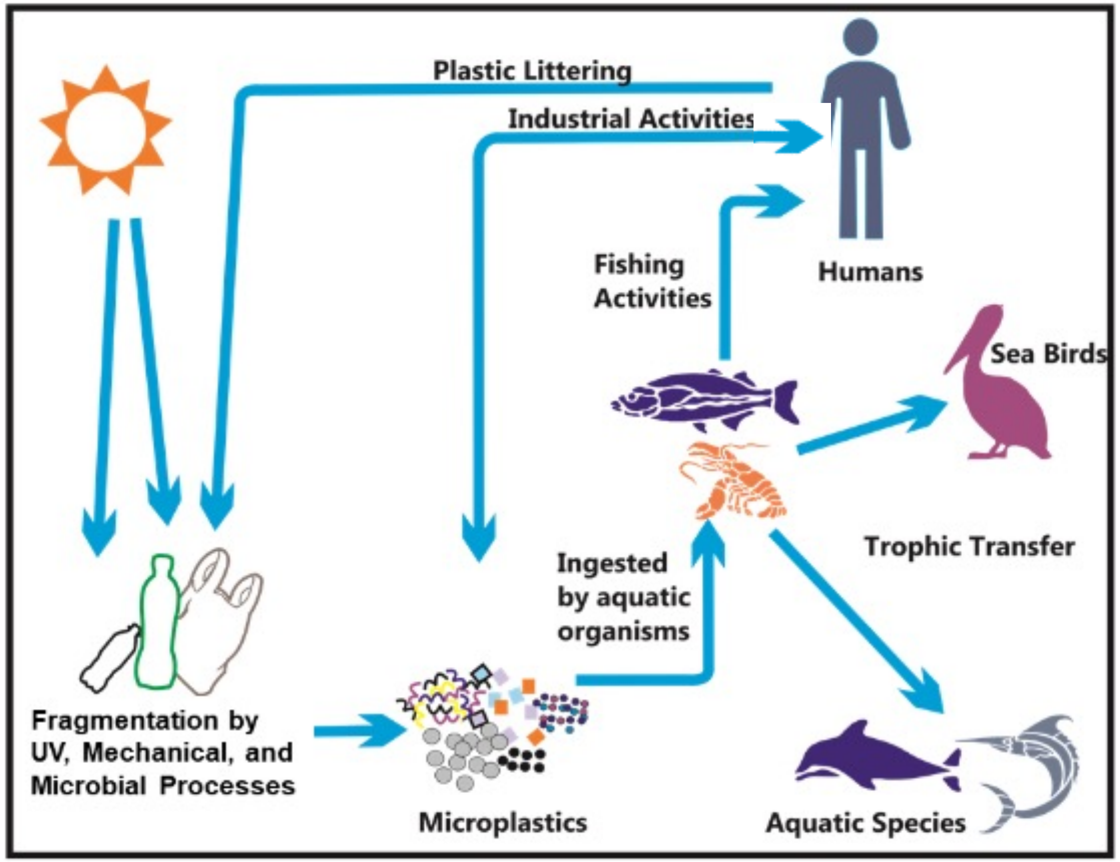
- Ecological Receptors
  - Effects
  - Toxicity tools
  - Interpretation

Increase in number of microplastics toxicity studies



ITRC MP Figure 1-4, Source: Coffin (2022)

Human Health – Exposures



ITRC MP Figure 4-2
Source: A. MacDonald

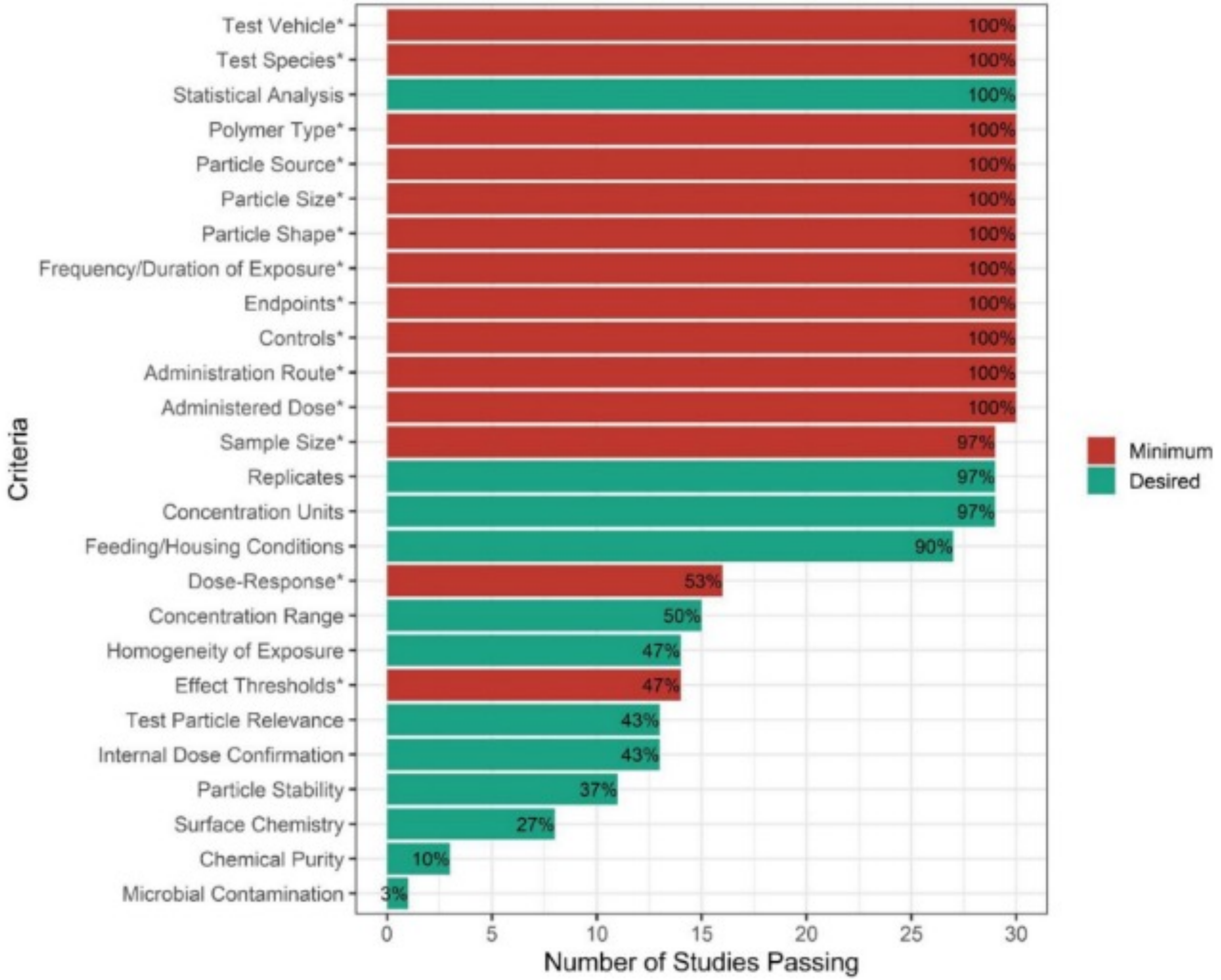
- Multiple media and pathways for human exposure to MP
- Includes both plastics and associated chemicals (MP focus)
- Magnitude of pathways varies by population and locality
- Current estimates: inhalation > dietary ingestion > incidental ingestion > dermal

Challenges in Toxicity Research

- Numerous non-human mammalian studies available but usability varies
- Uncertainties due to study design, exposure concentration, data quality, reporting, data gaps
- Exposure ≠ Adverse health effect

Source: Thornton Hampton et al. 2022

Human Health – Test Quality Criteria

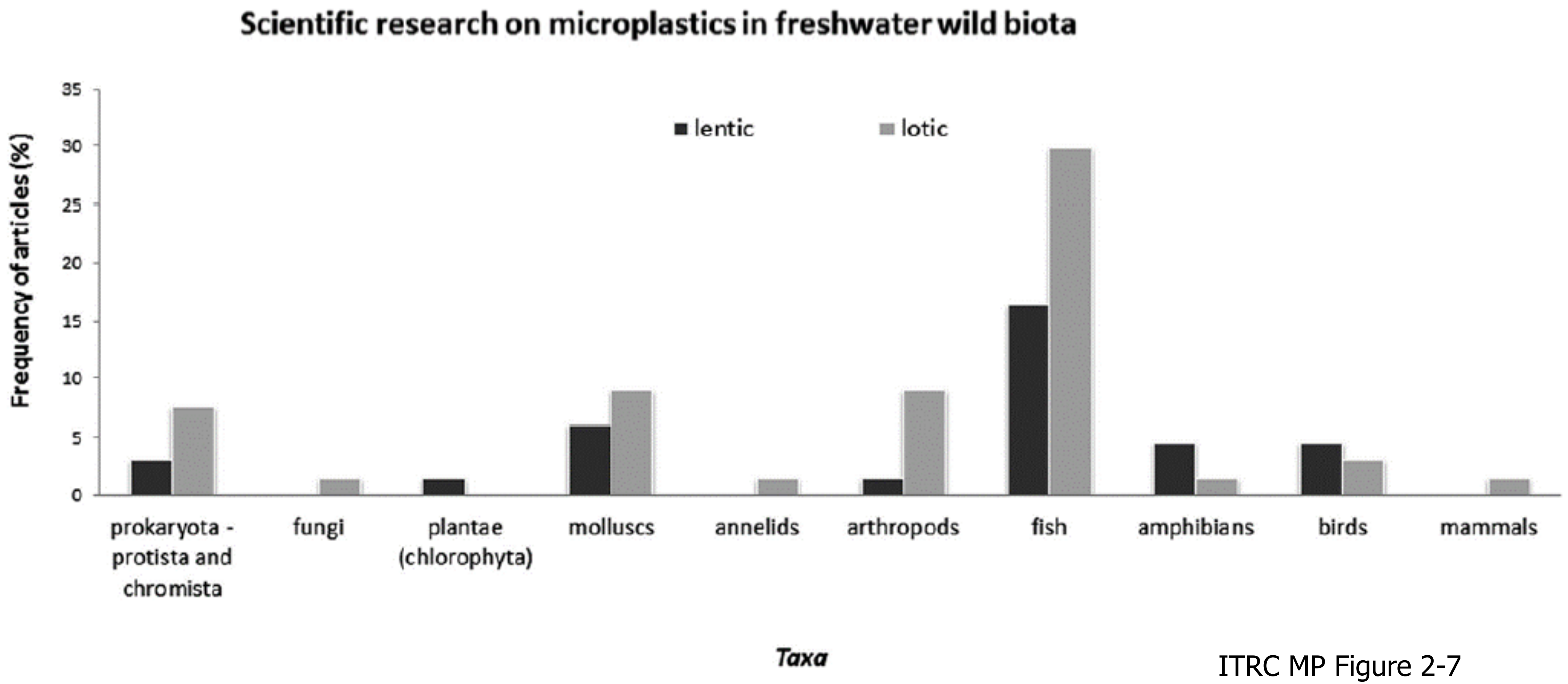


Source: Coffin et al. 2022

Human Health – Reported Effects

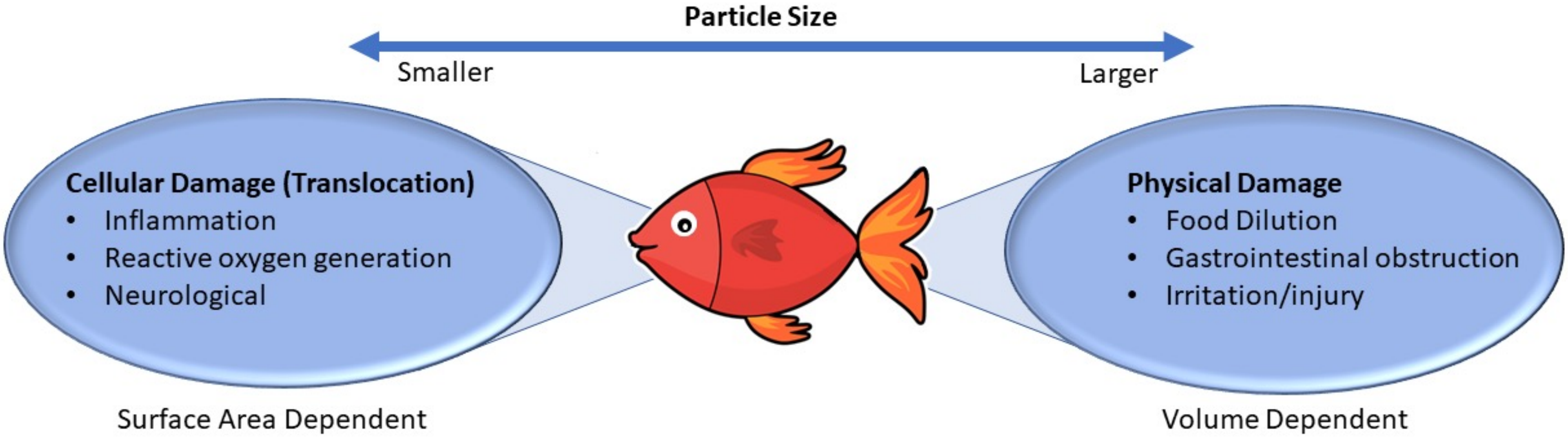
- Most consistently reported
  - Immune response, inflammation, oxidative stress
  - Heart, liver, metabolic, others
- Reported with high uncertainty
  - Systemic, Organ effects
  - Reproductive effects
  - Gut microbiome

Microplastics Studies By Ecological Group



ITRC MP Figure 2-7
Source: Cera and Scalici 2021

Factors Affecting Aquatic Toxicity



ITRC MP Figure 4-3
Source: Microplastics Team, created using concepts described in Mehinto et al. (2022)

Influencing Factors

Cellular Damage

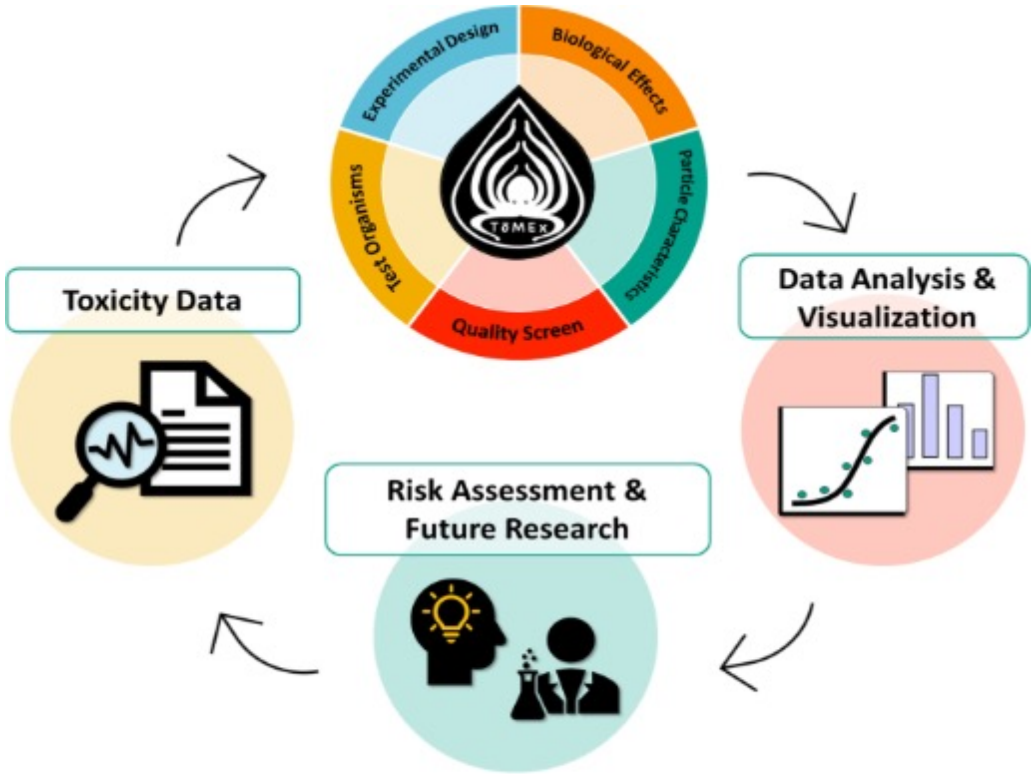
- Size ranges matter
- Particles <83 µm have ability to translocate
  - Fibers are the most commonly found microplastic but are understudied with regards to tissue translocation

Nutritional Deficiencies

- Microplastics mistaken as food can cause nutritional deficiencies due to food dilution
- Preferential consumption of particles by size, shape, color

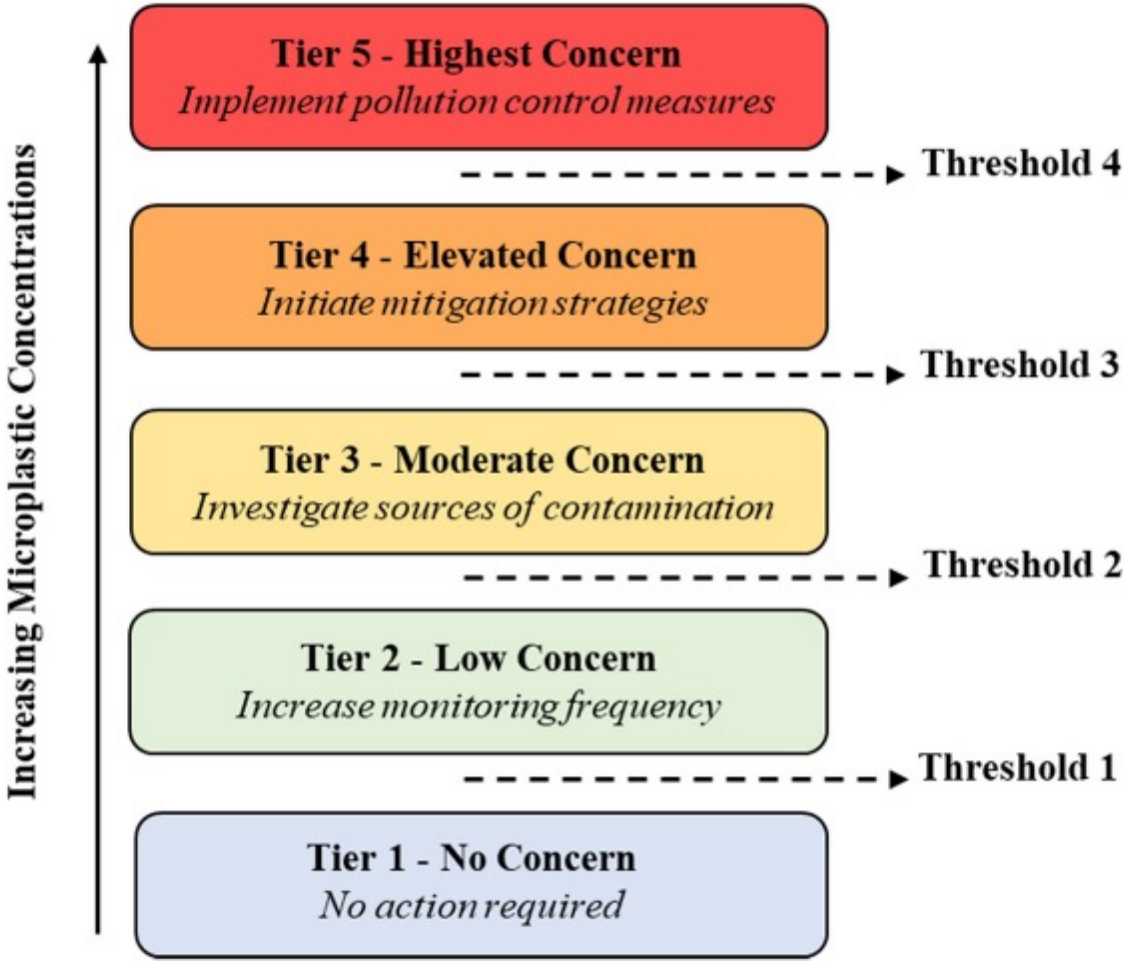
Source: Mehinto et al. 2022

Toxicity Microplastics Explorer (ToMEx) Application

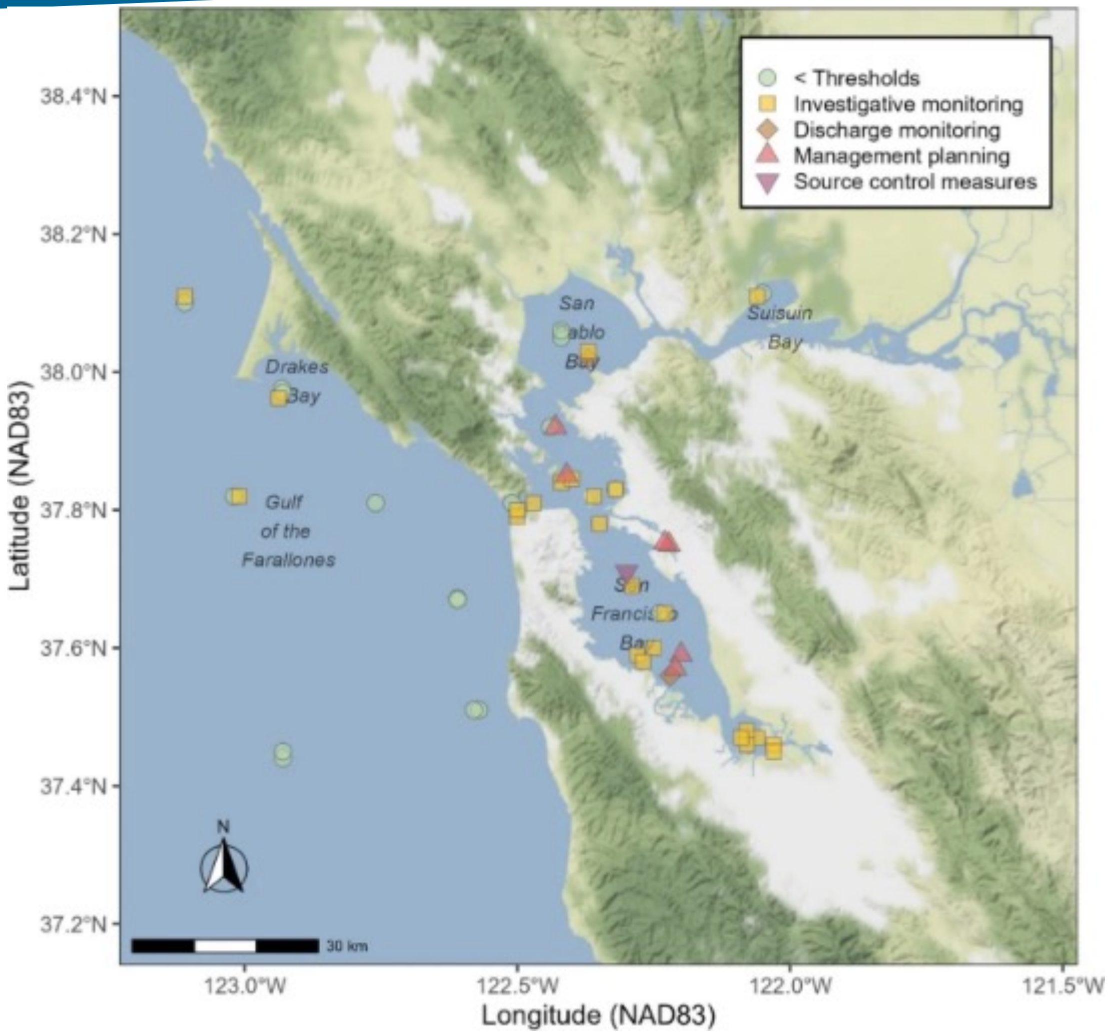


ITRC MP Figure 4-4
Source: Thornton Hampton et al. 2022
https://microplastics.sccwrp.org/

Application of Aquatic Risk Threshold to San Francisco Bay, California



ITRC MP Figure A.1- 5 Source: Mehinto et al. 2022



ITRC MP Figure A.1- 6 Source: Coffin et al. 2022

Case Study: Appendix A.2: Consequences of Microplastics on Various Ecological Endpoints in the Chesapeake Bay

ITRC MP Figure A.2-2
Source: NOAA

ITRC MP Figure A.2-1
Source: NASA/USGS Landsat 5

ITRC MP Figure A.2-3
Source: US Fish and Wildlife Service

Health Effects Summary

- Microplastics can and do exert adverse health effects due to
  - their physical properties such as size and shape, and
  - chemical properties such as their composition and other associated chemicals

We still have a lot more to learn

Case Study – Step 3 – MP Receptors

- Identify the possible receptors (human and ecological):
- Please use the chat function to type in your answers

Case Study – Step 3 – MP Receptors

Possible Human and Ecological Receptors

- Beach user
- Bay swimmer
- Agricultural worker
- Factory worker
- Urban residents
- Local anglers
- Produce/crop consumers
- Fish
- Aquatic birds
- Aquatic mammals
- Vegetation
- Cattle/herbivores
- Soil invertebrates

Case Study – Step 4 – Next Steps

- Conceptual Site Model Development
- Develop Sampling and Analysis Plan

Today’s Training Road Map

Introduction to Microplastics

Introduce the Interactive Case Study

Environmental Distribution, Fate & Transport

Sampling & Analysis

Q&A Session

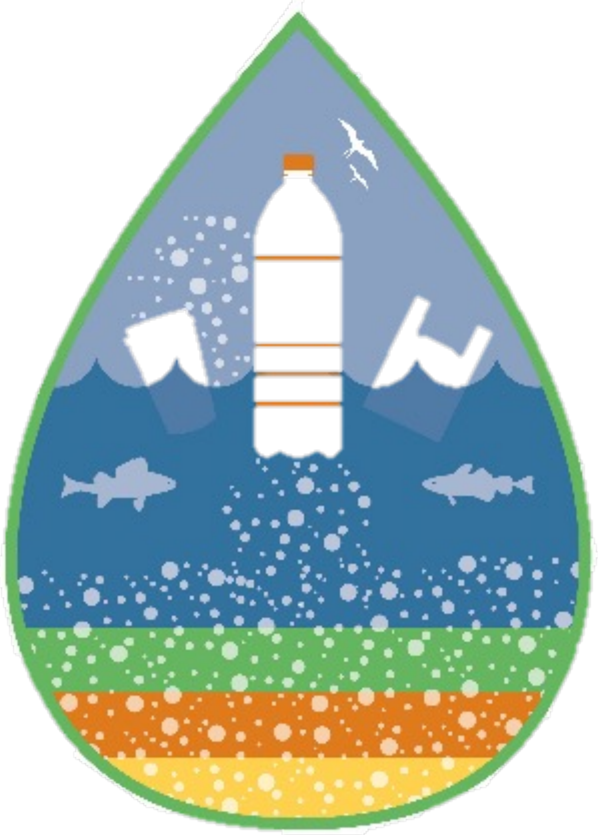
Human Health and Ecological Effects

Regulatory Context

Mitigation and Abatement

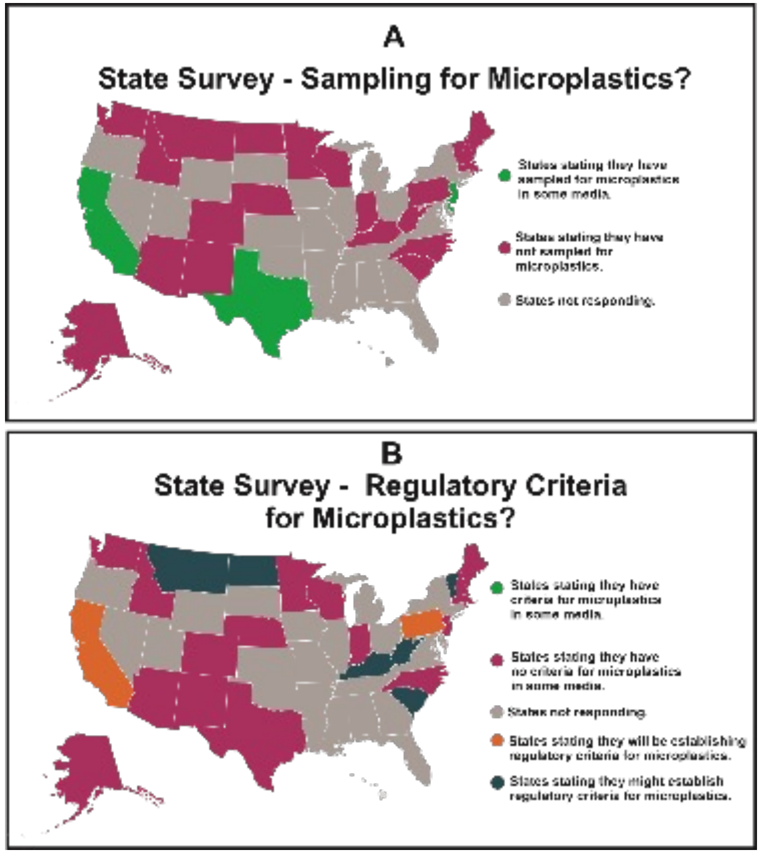
Wrap-up Slides

Q&A Session



Survey of State Regulatory Efforts

- Survey sent to states through ITRC points of contact (June 2021)
- Key Results – Responses received from 25 states
  - California, Texas, and New Jersey have sampled for microplastics
  - No states had regulatory criteria and only two states, California and Pennsylvania, are looking at establishing criteria
  - Six states stated that they may establish regulatory criteria



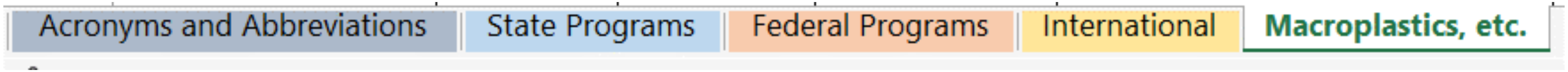
ITRC MP Figure 5-1

Regulatory Efforts - Examples

- Most states have focused on plastics in general
- Common efforts – recycling mandates; phase-out of plastic single-use bags, restaurant utensils and food packaging (primarily carry-out)
- Some states have banned local implementation of these types of restrictions

Appendix C: Regulatory Context Tables

- Summary of statutes and regulations
- Tables for:
  - State
  - Federal
  - International Regulations
  - Macroplastics



State Regulatory Context

3	State	Legislation or Executive Order	Program other than Column B	Agency	Program Area	Description	Date Added to the table	Weblinks
19	Connecticut	Senate Bill No. 1502, Public Act 15-5 Sec. 5 (2015)		State Legislature	Consumer Products	Bans the use, sale, import or manufacture of synthetic microbeads for personal care products in the State of Connecticut	7/6/2021	https://www.cga.ct.gov/2015/act/pa/pdf/2015PA-00005-R00SB-01502SS1-PA.pdf
20	Connecticut	Substitute House Bill No. 5360, Public Act 18-181 Sec. 6 (2018)		State Legislature	Consumer Products	Establishes a working group of representatives from both the retail and apparel industry and the environmental community to focus on synthetic microfiber pollution. This working group is meeting to develop consumer awareness and education programs in order to present information regarding synthetic microfibers in clothing to the public.	7/6/2021	https://www.cga.ct.gov/2018/ACT/pa/pdf/2018PA-00181-R00HB-05360-PA.pdf

Acronyms and Abbreviations | State Programs | Federal Programs | International | Macroplastics, etc. | Sheet1

- Summarizes state statutes or regulations
- Provides links for more information

International Regulatory Context

- Provides information on statutes and regulations from a number of different countries

ITRC Microplastics Team Material

9/13/2022

Row	Location	Legislation or Executive Ord	Agency	Program Area	Description	Date Added to the table	Weblinks
42	Ireland	Microbeads Prohibition Act 2019	Irish Environmental Protection Agency	Consumer Products	Effective February 2020, the Act prohibites the manufacture or sale of cosmetic and cleaning products containing microbeads	12/3/2021	https://www.irishstatutebook.ie/eli/2019/act/52/enacted/en/html
43	Japan	Bill to reduce use of microplastics (2018)	House of Councillors	Consumer products	Urges voluntary action by companies to reduce plastic microbeads in cosmetics, facial cleansers and toothpastes	12/30/2021	https://www.nippon.com/en/news/yjj2018061500400/;
44	Latin American countries	Plastic litter and microplastics waste management	Varies by country	All plastics	Compendium of national and regional Strategies, Action Plans and Initiatives to monitor and manage plastic wastes and litter	9/14/2022	Marine_EN.pdf (unep.org)
45	Sweden	Roadmap for Sustainable Use of Plastics	Swedish EPA	All plastics	General plan for plastics, including microplastics	12/3/2021	https://visita.se/app/uploads/2021/06/Fardplan-Hallbar-plastanvandning_eng.pdf
46	Sweden	Legislation to prevent the spread of microplastics	Swedish Parliament	Tax	Tax on plastic bags, effective April 2020	12/3/2021	https://www.loc.gov/item/global-legal-monitor/2020-01-31/sweden-parliament-votes-to-adopt-tax-plastic-bags/
			Swedish Medical products		Ban on plastic microbeads in cosmetic products, effective		https://www.kemi.se/en/rules-and-regulations/rules-applicable-in-sweden-only/certain-swedish-re

Acronyms and Abbreviations | State Programs | Federal Programs | International | Macroplastics, etc. | Sheet1

Case Study: Appendix A.1: California Approach for Microplastics

Senate Bill 1422: Adopt a definition of microplastics in drinking water

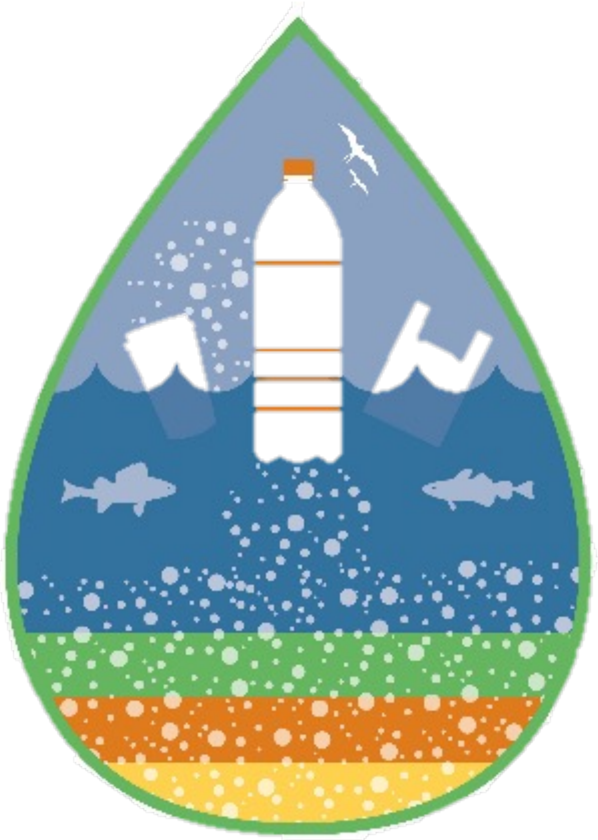
Adopt a standard methodology to test drinking water for microplastics

Establish requirements for four years of testing and reporting microplastics in water

Senate Bill 1263: Adopt and Implement a Statewide Microplastics Strategy

Today's Training Road Map

Introduction to Microplastics
↓
Introduce the Interactive Case Study
↓
Environmental Distribution, Fate & Transport
↓
Sampling & Analysis
↓
Q&A Session
↓
Human Health and Ecological Effects
↓
Regulatory Context
↓
➡ **Mitigation and Abatement**
↓
Wrap-up Slides
↓
Q&A Session



Overview: Mitigation and Abatement

Prevention and Mitigation

Remediation Technologies

The Best Defense is Good Offense

- Preventing MP from entering the environment
- More studies necessary to achieve removal of MP in different media

ITRC MP Figure 6-3
Source: Adapted from USEPA.

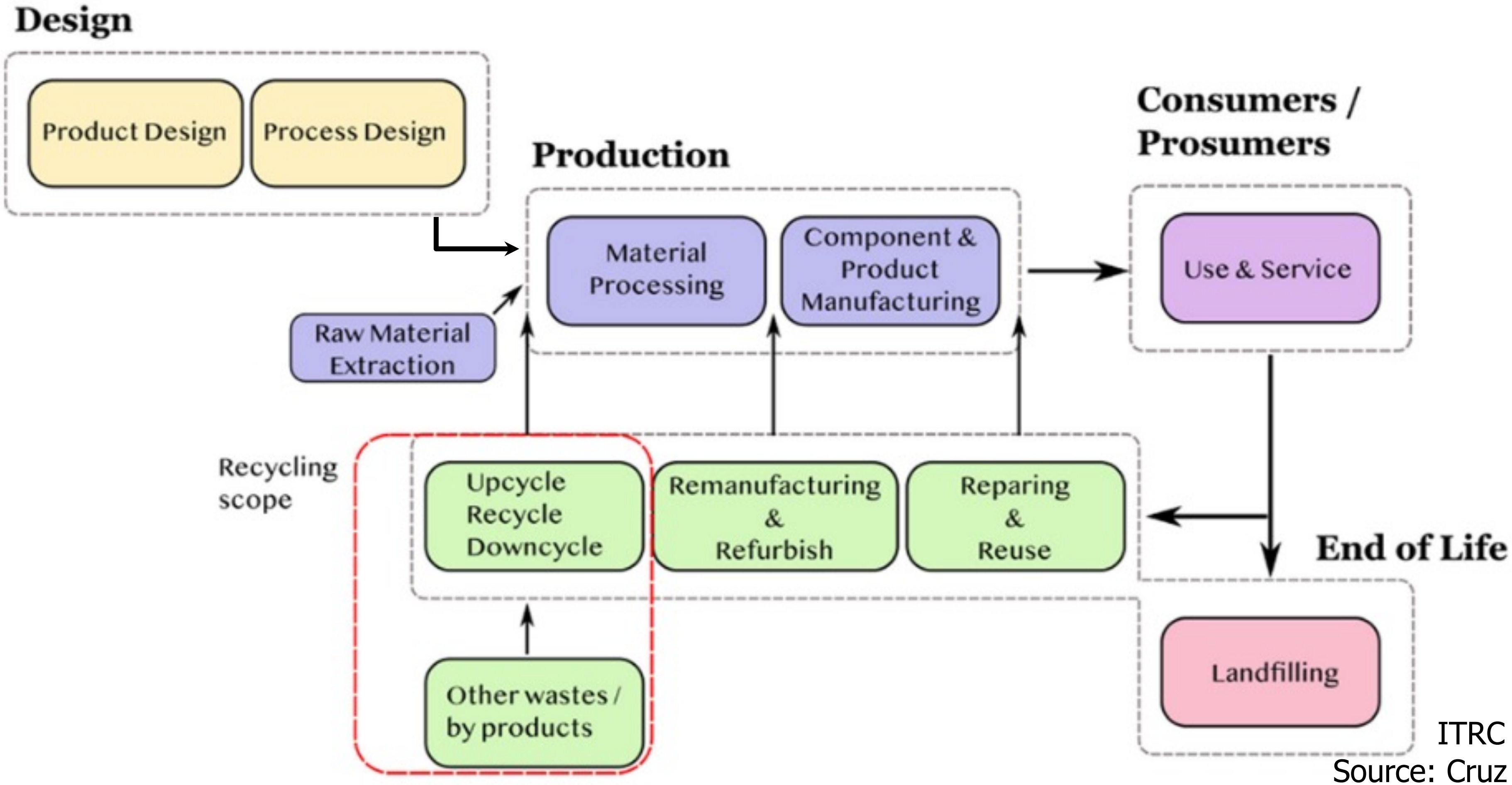
Mitigation and Prevention Strategies

Section 6.1.1
Manufacturing & Packaging
Section 6.1.2
Improving production efficiency

ITRC MP Figure 6-1

- Reduction of plastic packaging and increasing the reuse
- Improvements in plastics production at an industrial level including life cycle assessments (LCA)

LCAs to Limit Plastics in Use



ITRC MP Figure 6-2
Source: Cruz Sanchez et al. (2020)

Mitigation and Prevention Strategies

Section 6.1.3
Reducing Consumption

ITRC MP Figure 6-1

- Reduce consumption of plastics
  - Product Substitution
  - Education & Awareness

Mitigation and Prevention Strategies

Section 6.1.4
Improving Disposal of Waste

ITRC MP Figure 6-1

- Source Collection and Post-Separation Disposal
- Reuse &/or Repurposing
- Waste to Energy and Feedstock
- Landfilling
- Bio-based and Biodegradable Plastic Alternatives
- Electronic Waste Recycling
- Enhancing Distribution/Storage/Transportation
- Stormwater Control

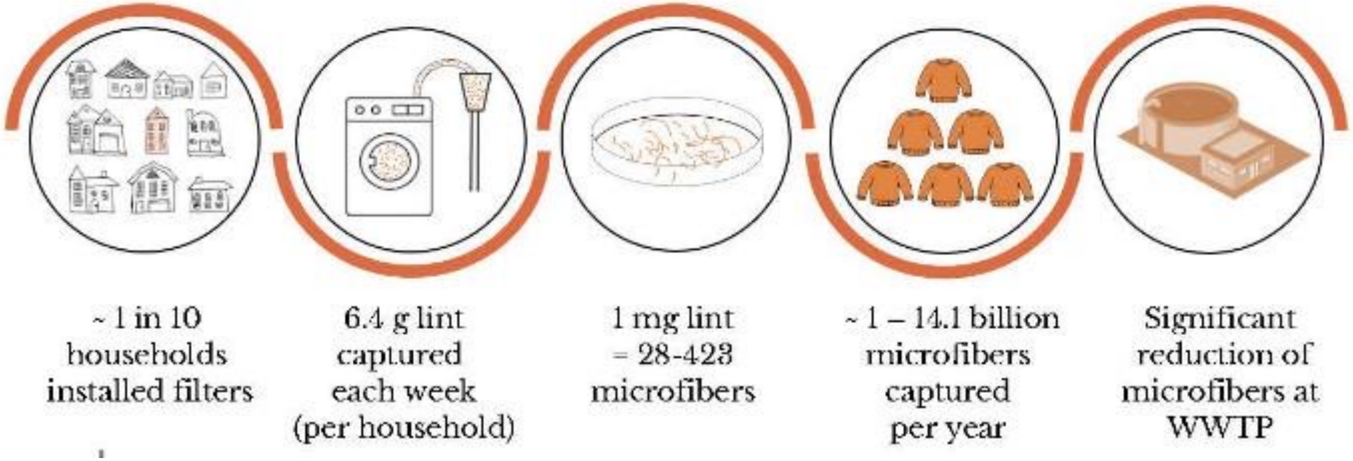
Mitigation Wrap-Up

Prevention and Mitigation

Remediation Technologies

What can you do?

Case Study, Appendix A.6: Washing Machine Filters Reduce Microfiber Emissions to Aquatic Ecosystems



Source: Erdle, et al (2021)

Abatement Strategies

Section 6.2.1: Water

Section 6.2.2 Soil

Section 6.2.3: Sediment

Section 6.2.4: Air

ITRC MP Figure 6-1

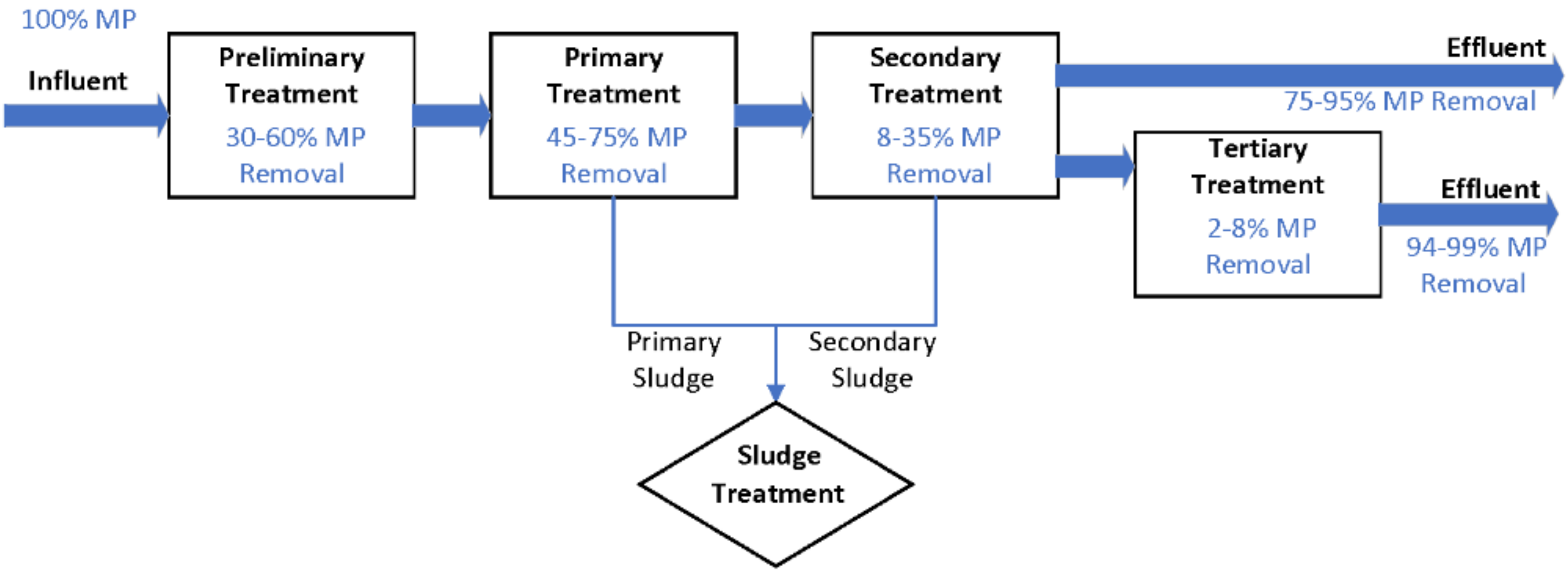
Field Implemented

Demonstrated under full-scale conditions at multiple sites, by multiple practitioners and multiple applications, and are well documented in practice or peer-reviewed literature

Developing Technologies

Researched at the laboratory or bench scale, but have not been field demonstrated

Estimation of MP Removal in Wastewater Treatment Plants



ITRC MP Figure 6-5 (Modified)

Source: Renee Lu, modified from Ali et al. (2021)

Treatment Technologies by Media – ITRC MP Tables 6-3 and 6-4

Table 6-3. Treatment technologies for MP in water

Treatment Category	Treatment Technology	Media	Advantages/ Efficiencies	References
Biological	**Field Implemented (for Select Media)/General Remediation Technology**			
	Rain garden (bioretention cell)	Stormwater	Up to 98% MP removal efficiency	Werbowski et al. (2021) [illegible]
	Developing Technology or at Lab Scale			
	Biodegradation	Surface water, groundwater, wastewater, marine, soil, sediments	75–99% MP removal efficiency A consortium of organisms can be used as a treatment strategy	Gan and Zhang (2019), Han et al. (2017), Hu et al. (2021), Pathak and Navneet (2017)
Chemical	**Developing Technology or at Lab Scale**			
	Chemical degradation (oxidation, hydrolysis)	Surface water	Up to 56% MP weight loss for Fenton-like system Builds off treatment technologies used for other contaminants	Hu et al. (2021) [278]
	Electrochemical oxidation	Surface water, groundwater, marine, wastewater, soil	58% MP removal efficiency, and up to 86.8% with an additional oxidant Quick treatment time; particularly effective for MP and NP destruction and effective for reducing MP size and mass and mineralizing NP	Kiendrebeogo et al. (2021) [322]
	Field Implemented (for Select Media)/General Remediation Technology			

Table 6-4. Potential treatment technologies for MP in soil

Treatment Category	Treatment Technology	Media	Advantages/ Efficiencies	References
Developing Technology or at Lab Scale				
Biological	Biodegradation	Surface water, groundwater, wastewater, marine, soil, sediments	75–99% MP removal efficiency A consortium of organisms can be used as a treatment strategy.	Gan and Zhang (2019), Han et al. (2017), Hu et al. (2021), Pathak and Navneet (2017)
Chemical	Electrochemical oxidation	Surface water, groundwater, marine, wastewater, soil	58% MP removal efficiency, and up to 86.8% with an additional oxidant. Quick treatment time. Particularly effective for MP and NP destruction and effective for reducing MP size and mass and mineralizing NP.	Kiendrebeogo et al. (2021) [322]
Physical	Thermal (that is, pyrolysis and gasification)	Surface water, soil	54% in MP weight loss for catalytic advanced oxidation process with hydrothermal hydrolysis.	Hu et al. (2021) [278]
	General Technology			
	Incineration	Sludge/biosolids, soil, air	Can be used for energy generation.	(Geyer, Jambeck, and Lavender Law 2017)

Treatment Technologies by Media – ITRC MP Table 6-4

Treatment Category	Treatment Technology	Media	Advantages/ Efficiencies	References
Developing Technology or Lab Scale				
Biological	Biodegradation	Surface water, groundwater, wastewater, marine, soil, sediments	75–99% MP removal efficiency A consortium of organisms can be used as a treatment strategy.	Gan and Zhang (2019), Han et al. (2017), Hu et al. (2021), Pathak and Navneet (2017)
Chemical	Electrochemical oxidation	Surface water, groundwater, marine, wastewater, soil	58% MP removal efficiency, and up to 86.8% with an additional oxidant. Quick treatment time. Particularly effective for MP and NP destruction and effective for reducing MP size and mass and mineralizing NP.	Kiendrebeogo et al. (2021) [322]
Physical	Thermal (that is, pyrolysis and gasification)	Surface water, soil	54% in MP weight loss for catalytic advanced oxidation process with hydrothermal hydrolysis.	Hu et al. (2021) [278]
	General Technology			
	Incineration	Sludge/biosolids, soil, air	Can be used for energy generation.	(Geyer, Jambeck, and Lavender Law 2017)

Note: Removal % is based on lab studies

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Summary from Mitigation & Abatement

- Source reduction critical in reducing MP in the environment
- Improve disposal of waste
- Considering different strategies simultaneously
- Existing treatment technologies have varied success
- Management of wastes produced during the treatment of MPs
- Further research on existing and new technologies is necessary

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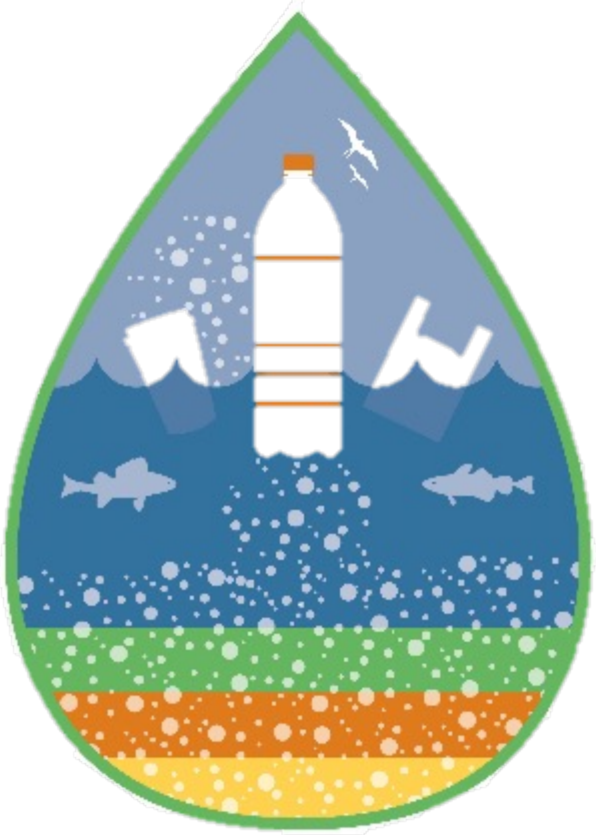


Web-based Document: ITRC MP-1

Figure 1-1. Microplastics in the environment.

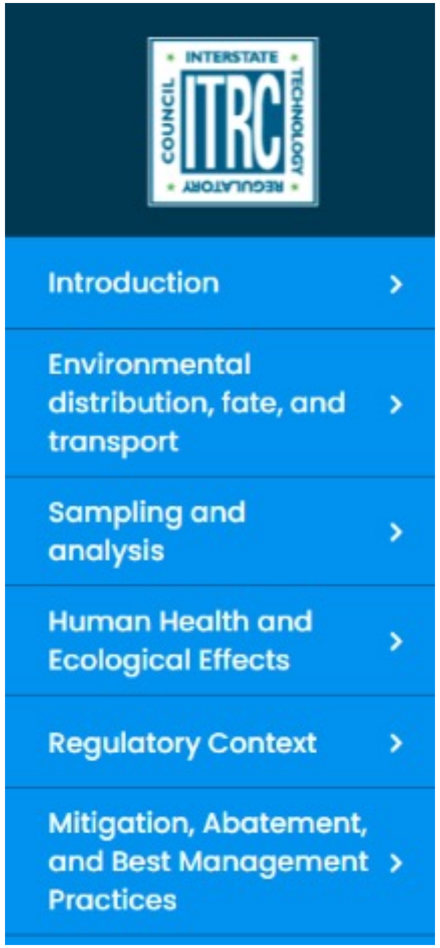
Source: Jonathan McDonald

1.1 What Are Microplastics?

Various organizations, agencies, and researchers have defined MP in different ways. For the purposes of this document, MP are particles that are greater than 1 nanometer (nm) and less than 5,000,000 nm (or 5 millimeters [mm]) in their longest dimension and consist of solid polymeric materials to which chemical additives or other substances may have been added (CA SWRCB 2020 [99]). Polymers that are derived in nature (for example, cellulose, amber, proteins, wool, or silk) that have not been chemically modified (other than by hydrolysis) are excluded from the scope of this document. Plastic particles less than 1,000 nm in their longest dimension are also referred to as nanoplastics (NP); as such, some, but not all, NP fall within the range of MP defined herein. Although the definition of NP is still being debated, it is accepted in scientific literature that they are produced by the fragmentation of MP (or larger particles), measure between 1 nm and 1,000 nm in length, and demonstrate a colloidal behavior. Figure 1-2 shows the sizes of various items that fall within the MP size range, including a strand of DNA (approximately 2.5 nm), a red blood cell (7,500–10,000 nm), a fly ash particle (10,000–20,000 nm), the diameter of a human hair (60,000–120,000 nm), and a drinking straw (approximately 5,000,000 nm). This guidance document is not

https://mp-1.itrcweb.org/

Topics Covered



- Introduction to Microplastics
- Environmental Distribution, Fate & Transport
- Sampling and Analysis
- Human Health and Ecological Effects
- Regulatory Context
- Mitigation and Abatement

Conceptual Site Model (CSM)

- Multifunctional Tool
  - Overview Information
  - Document Navigation

Section 7: Data Gaps and Future Research Needs

- Fate and Transport
- Sampling and Analysis
- Health Risks
- Trophic Transfer
- Ecological Exposure
- Mitigation and Abatement

Case Studies: Appendix A

- A.1: California Approach for Microplastics
- A.2: Consequences of Microplastics on Various Ecological Endpoints in the Chesapeake Bay and its Tributary Estuary, the Potomac River
- A.3: Impact of Disposable PPE and Single Use Plastic Items During the Pandemic
- A.4: Nurdles Along the Gulf Coast
- A.5: Effects of 6PPD-quinone on Coho and Chum Salmon
- A.6: Washing Machine Filters Reduce Microfiber Emissions to Aquatic Ecosystems

ITRC Microplastics Outreach Toolkit

New 2023 ITRC Team focused on developing an "Outreach Toolkit" to aid regulators and stakeholders in communicating with the public about Microplastics

Question and Answer Session