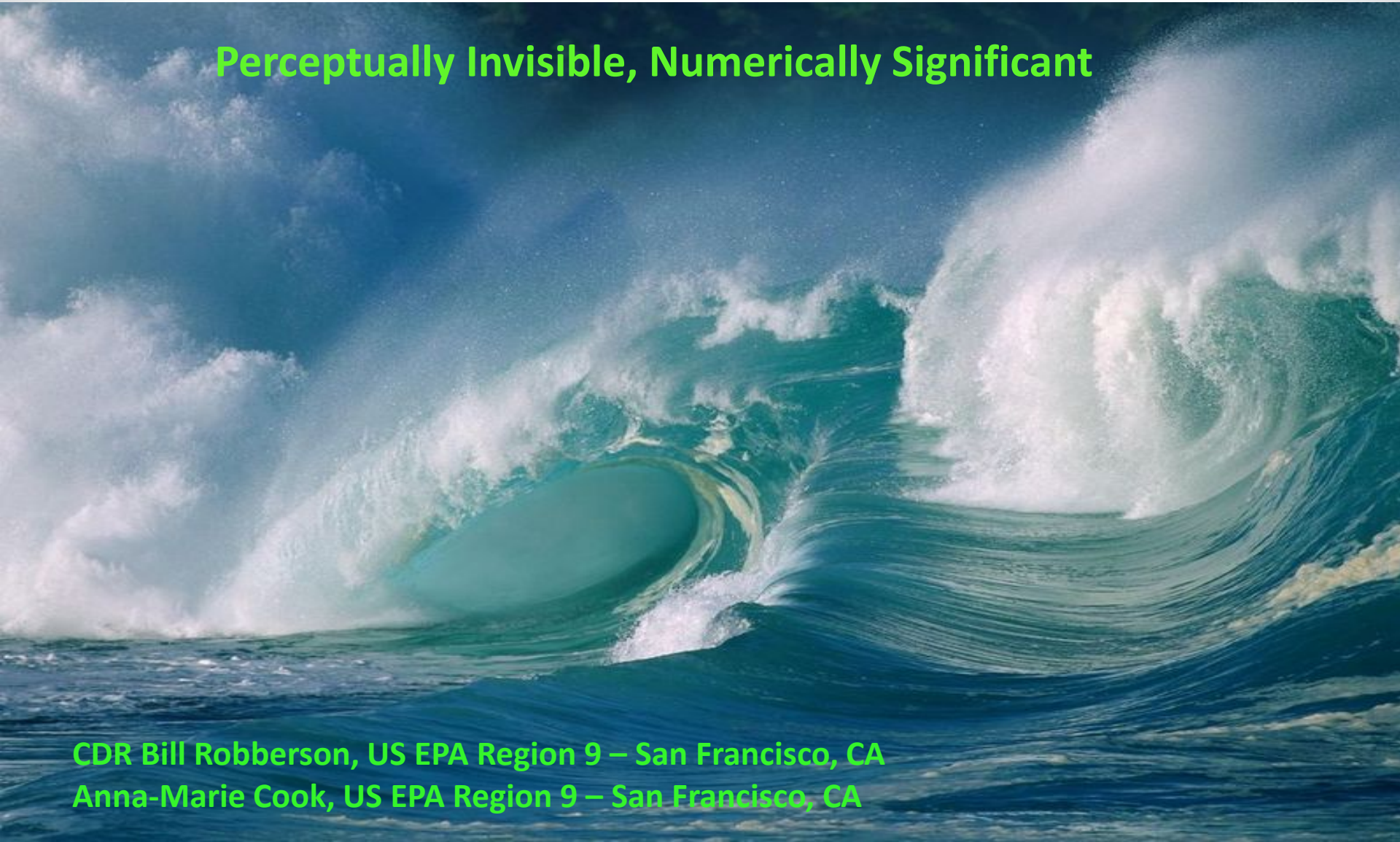
Plastic Particle Pollution (Microplastics) – An Emerging Environmental Threat



Perceptually Invisible, Numerically Significant

CDR Bill Robberson, US EPA Region 9 – San Francisco, CA
Anna-Marie Cook, US EPA Region 9 – San Francisco, CA

Priority Concern for State and Territories – Toxicological Impacts to Food Chain/Human Health

What we know:

Plastic Production continues to increase exponentially

- Since 1964, plastics production has increased twenty-fold, 311 million tons in 2014
- Plastics production is expected to double again in 20 years and almost quadruple by 2050.

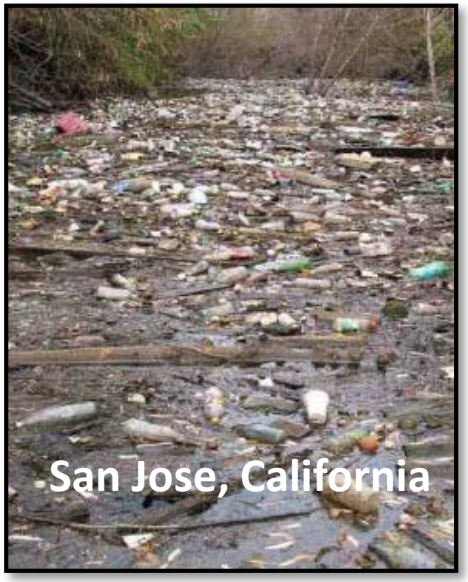
Recycling rates for plastic packaging the last forty years remain at 5%

- After a short first-use cycle, 95% of plastic packaging material value, or USD 80–120 billion annually, is lost to the economy.

What we hear, but do not know:

- By 2050 oceans could contain more plastics than fish (by weight)
- 32% of plastic packaging escapes collection systems

Plastics Everywhere!



What risk does microplastic pollution present to human health and the environment?

Risk Assessment

Problem Formulation

What is the nature, extent, fate and transport of microplastics and associated sorbed POPs and PBTs?

- Human health risk from microplastic toxicity via Food Web / Food Chain
  - EPA R9: California / American Samoa / Marianas Islands (Guam) / Hawaii, EPA R5: Great Lakes, EPA R2: Puerto Rico
- Hawaiian Monk Seal Health in French Frigate Shoals - NW HI Islands
  - EPA R9: Hawaii / US FWS / NOAA

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Characterization of Exposure and Effect

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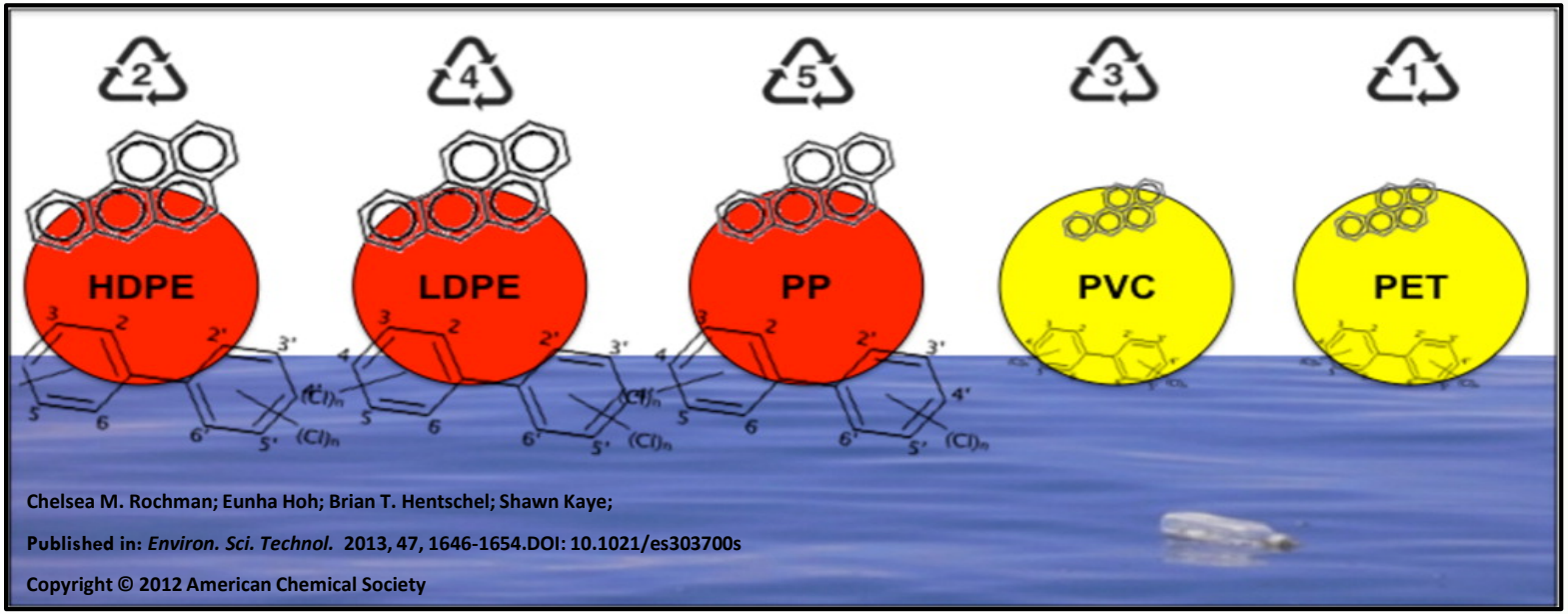
Risk Characterization

Microplastics - attract, hyperaccumulate and transport contaminants into the Food Chain



Plastic particles….

- Tend to fragment into smaller particles, increasing surface area relative to volume
- They are not inert; plastic particles readily sorb and hyper-accumulate POPs/PBTs
- Fish and birds mistake them for food - plastic acts as a transport mechanism….
  - Entrained plasticizers as well as sorbed POPs carry into the food web
  - Contaminants bioaccumulate and biomagnify within the organisms

Scientific Work Needed and *Underway…*

Risk Assessment

Problem Formulation

What is the nature, extent, fate and transport of microplastics and associated sorbed POPs and PBTs?

Characterization of Exposure and Effect

Methodologies Development for Extraction, Identification & Analysis

Lab/Analytical:
- Water column
- Waste water
- *Sediment*
- *Fish Stomachs*
- *Fish Tissue*

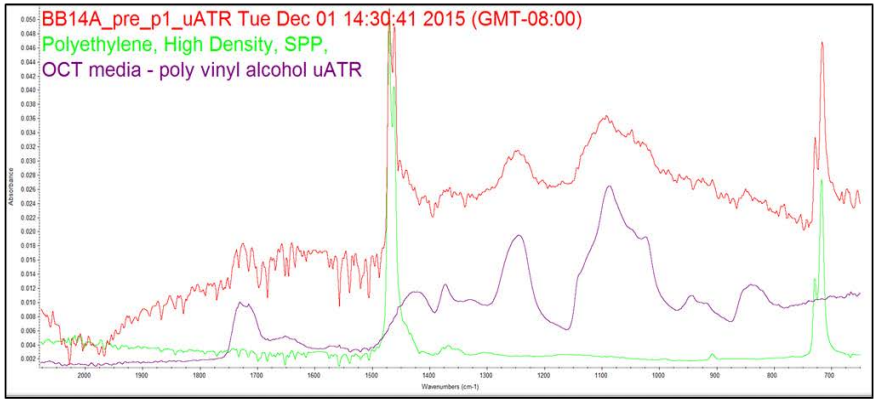
In-Situ:
- Water column
- Waste Water
- Sediment

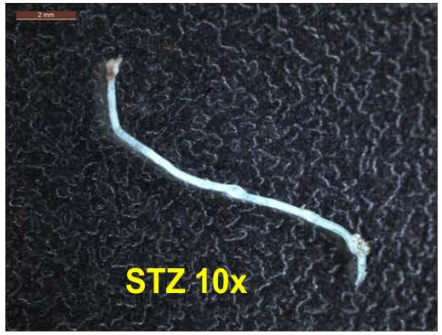
Trophic Level Studies:
- Exposure
  - Bioaccumulation
  - Biomagnification
- Impact

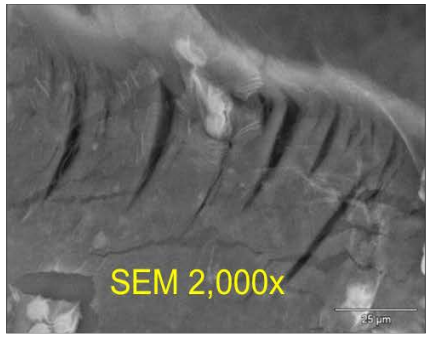
Risk Characterization

Microplastics in Fish Stomachs

Stereozoom (STZ), SEM, and FTIR images and spectra of 13 x 0.2 mm PE microplastic fiber extracted from Atlantic Ocean Myctophid stomach BB14A







Sutapa Ghosal, Jeff Wagner, Zhong-Min Wang, and Stephen Wall
California Department of Public Health

Supporting CERCLA decision-making...

Risk Assessment

Problem Formulation

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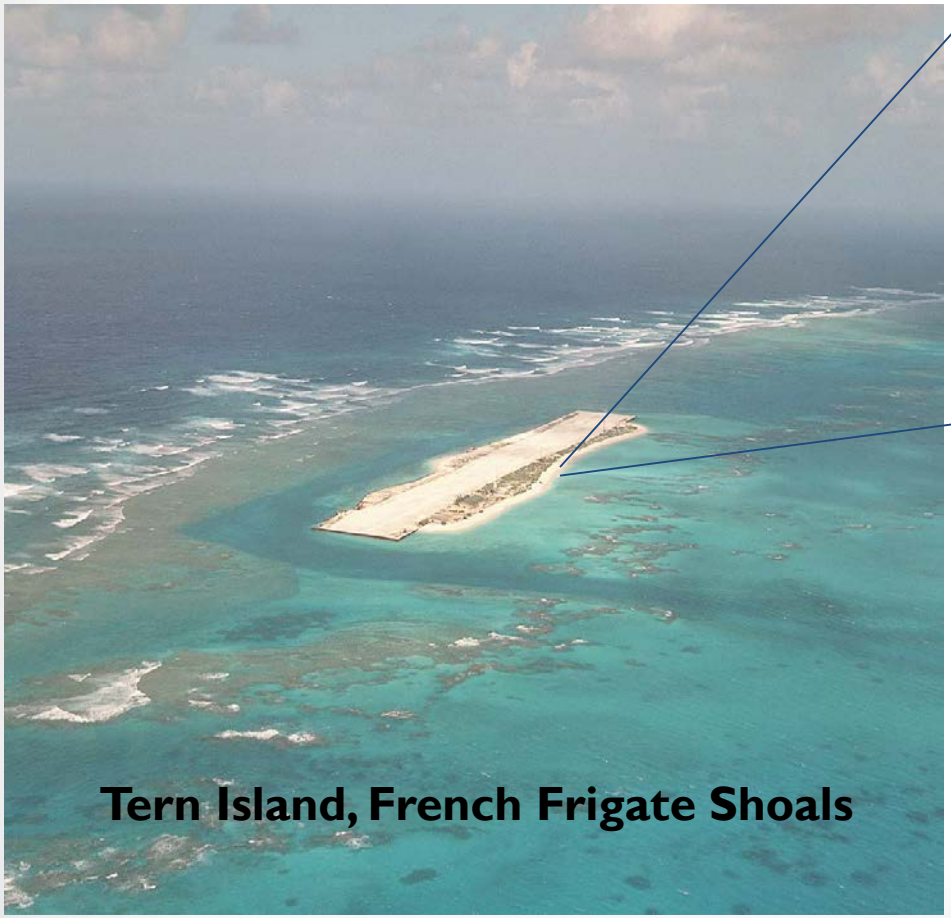
Risk Characterization

- Develop Threshold Levels for POPs/PBTs on plastics (by polymer type?) for endpoint receptors including Hawaiian Monk Seal (Mammals/ Humans)
- Refine fingerprinting of POPs/PBTs on plastic to differentiate sources, in support of CERCLA removal/remedial program requirements

Time-Critical Environmental Need - Supporting EPA R9 / Hawaii / USFWS / NOAA



Concentrations of PCBs in Seawater and Higher Trophic Levels at Tern Island	
Seawater	0.00449 µg/L
Coral	21 ng/g
Moray Eel	96,470 ng/g
Hawaiian Monk Seal	8,800 ng/g

Ylitalo et al 2008, Miao et al 2000

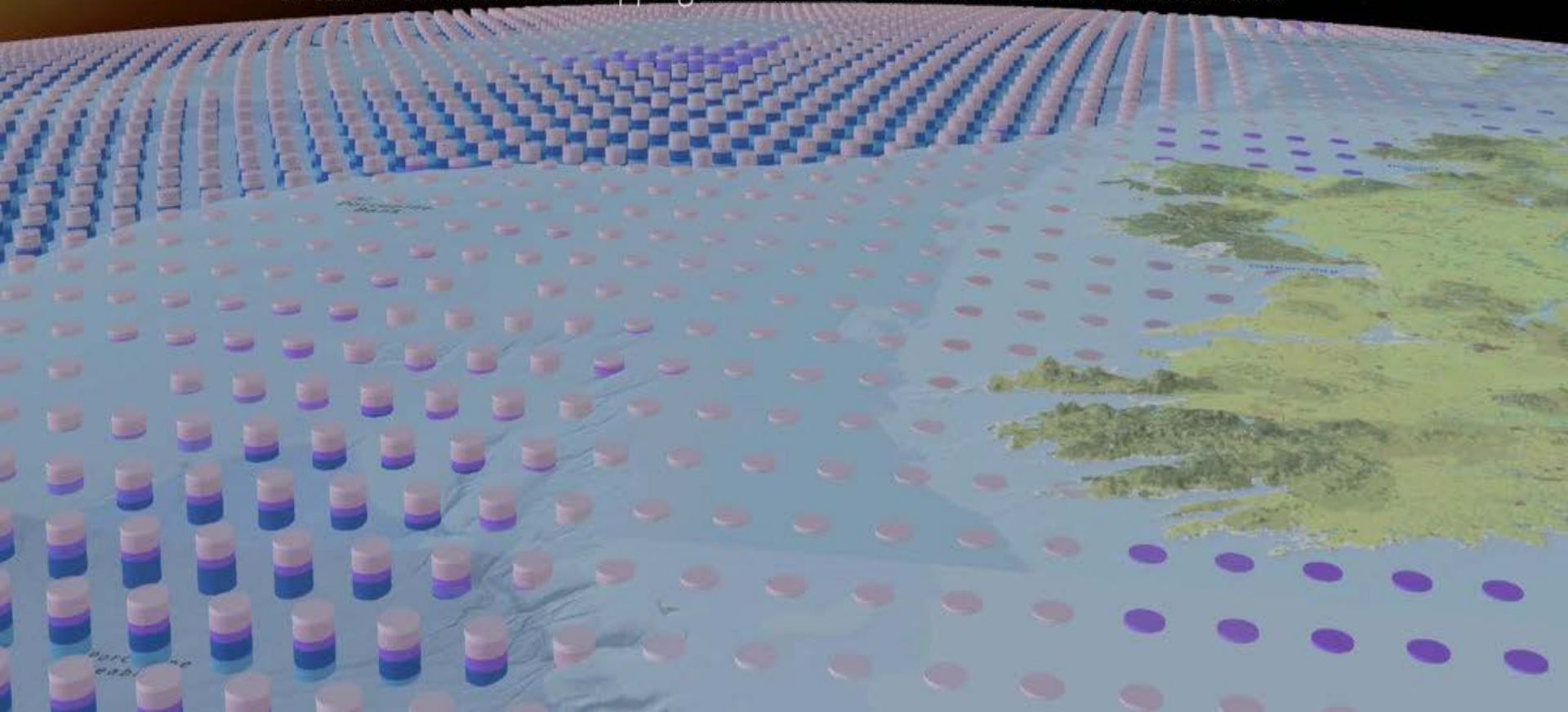
How products will be used…

We need Standardized Collection, Extraction and Identification Methodologies:

- Projections of the **abundance of plastics in the oceans** are undoubtedly vastly **underestimated** and highly variable, ranging in magnitude from 7,000 – 268,940 metric tons on the ocean's surface, a discrepancy of **several orders of magnitude**.
- **Wastewater treatment plant operators** are requesting fast-throughput, low-cost sampling and analytical methods to evaluate effluent discharge.
- Purveyors of **drinking water** from **surface water sources** want to know whether microplastics are present in the source-water.
- EPA's **Ocean Dumping Program** wants to be able to test sediment for microplastics prior to dumping and to know whether the presence of plastic is going to present an environmental threat to ocean sites, wetlands restoration, beach augmentation, etc.
- **Sediment cleanup/remediation conceptual-site models -** (e.g. Pearl Harbor, HI; Apra Harbor, Guam) may be confounded by plastic particle presence (acting as both sources and sinks of POPs) in the sediment and water-column matrix.

Ecological Marine Units

A Three-Dimensional Mapping of the Ocean based on Environmental Data



Essential EMU Framework

A simple guide to model marine data

Build Your Mesh

Construct an empty, regularly spaced 3D mesh of points from ocean surface to seafloor covering the extent of your study area.

Attach Your Data

Attribute the point mesh with in situ observations. When the in situ points are irregularly spaced, use the Spatial Join tool and specify a match option of Intersect 3D and a search radius.

Perform Analysis

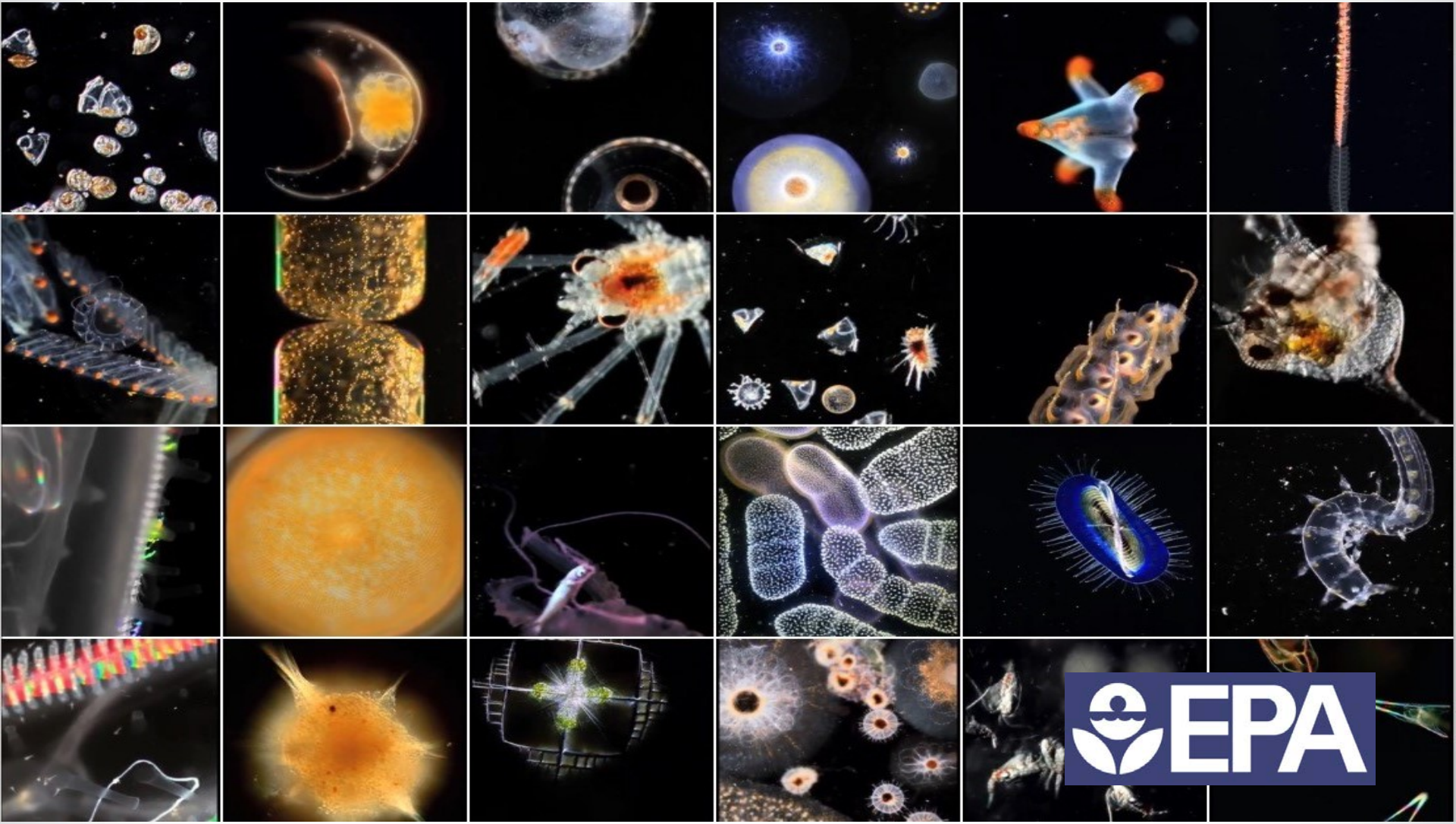
EMUs are the result of a kmeans clustering algorithm which may be repeated locally to see how a local clustering compares globally. Beyond clustering, several tools in the *Measuring Geographic Distribution* toolset

Visualize

Use a local or global scene in ArcGIS Pro to visualize the results of your analysis. ArcGIS Pro has a rich set of 3D symbology and markers to help you visualize your analytical results.

Share Your Results

Exchange insights as a 3D web scene in ArcGIS Online or package your maps and the data referenced by the layers it contains into one portable convenient file called a map package.


EPA