Microplastics Research in Delaware Bay and the Delaware Inland Bays

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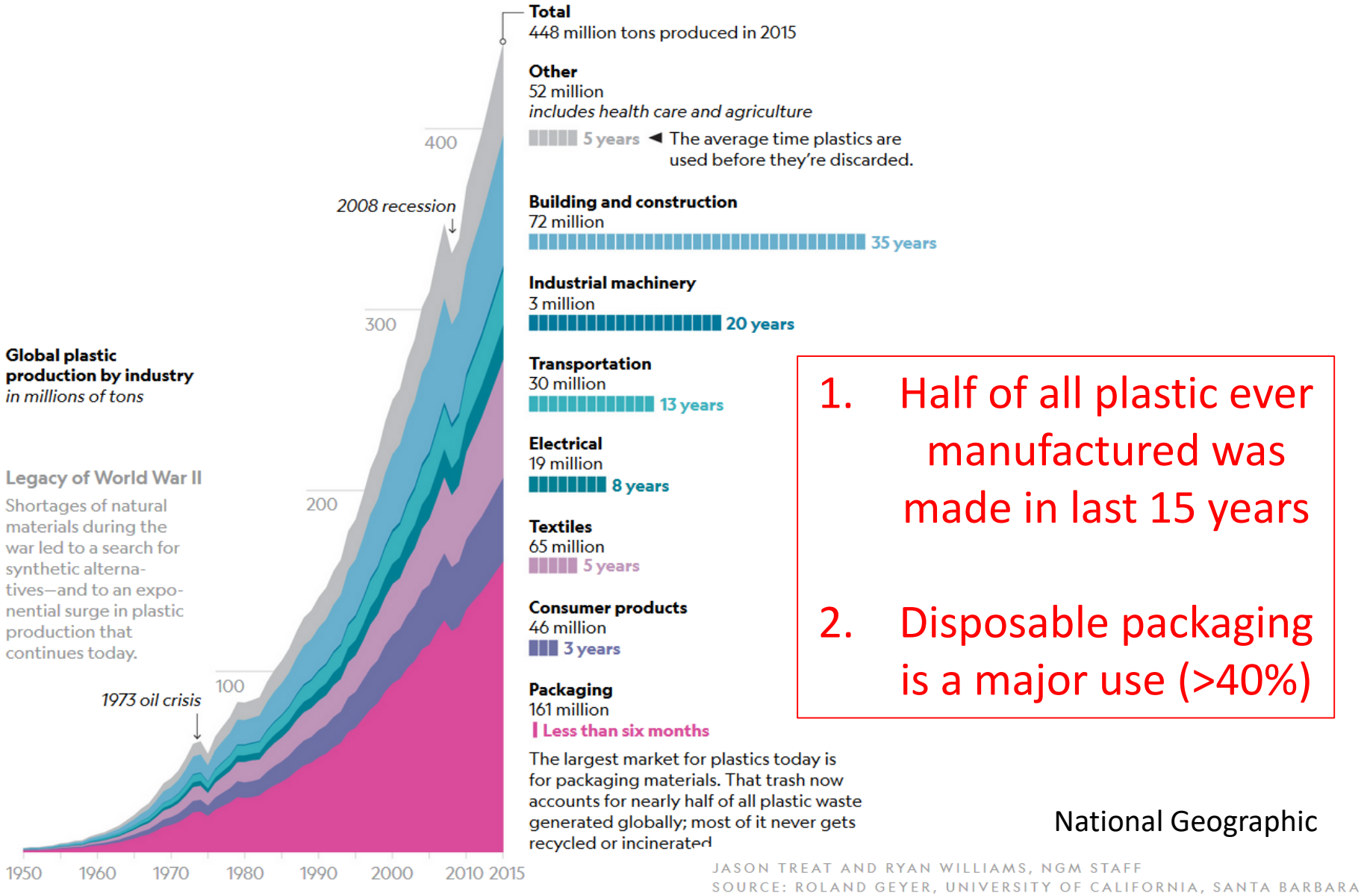
Post-WWII surge in plastic production



1. Half of all plastic ever manufactured was made in last 15 years

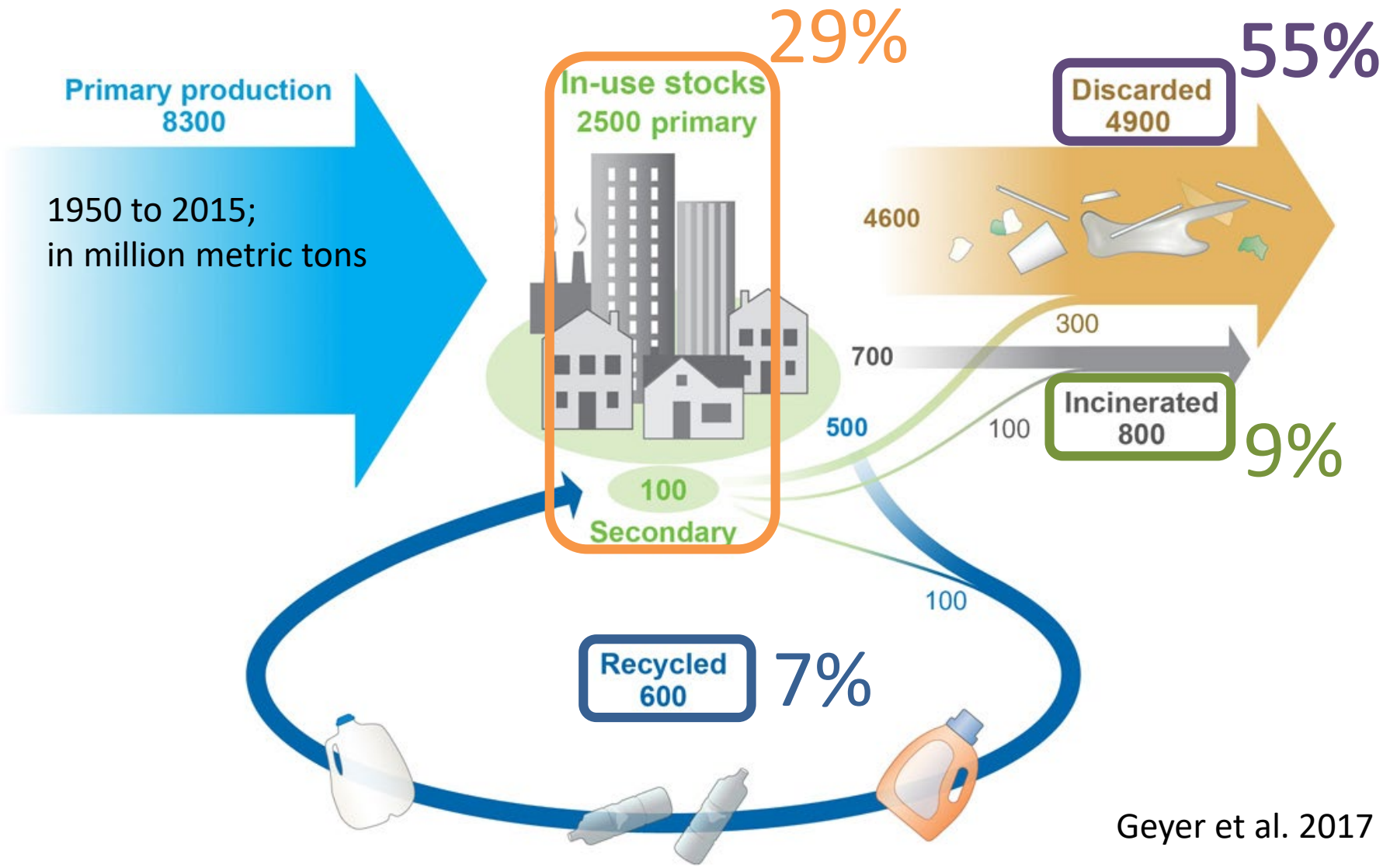
2. Disposable packaging is a major use (>40%)

National Geographic

JASON TREAT AND RYAN WILLIAMS, NGM STAFF
SOURCE: ROLAND GEYER, UNIVERSITY OF CALIFORNIA, SANTA BARBARA

What has happened to all this plastic?

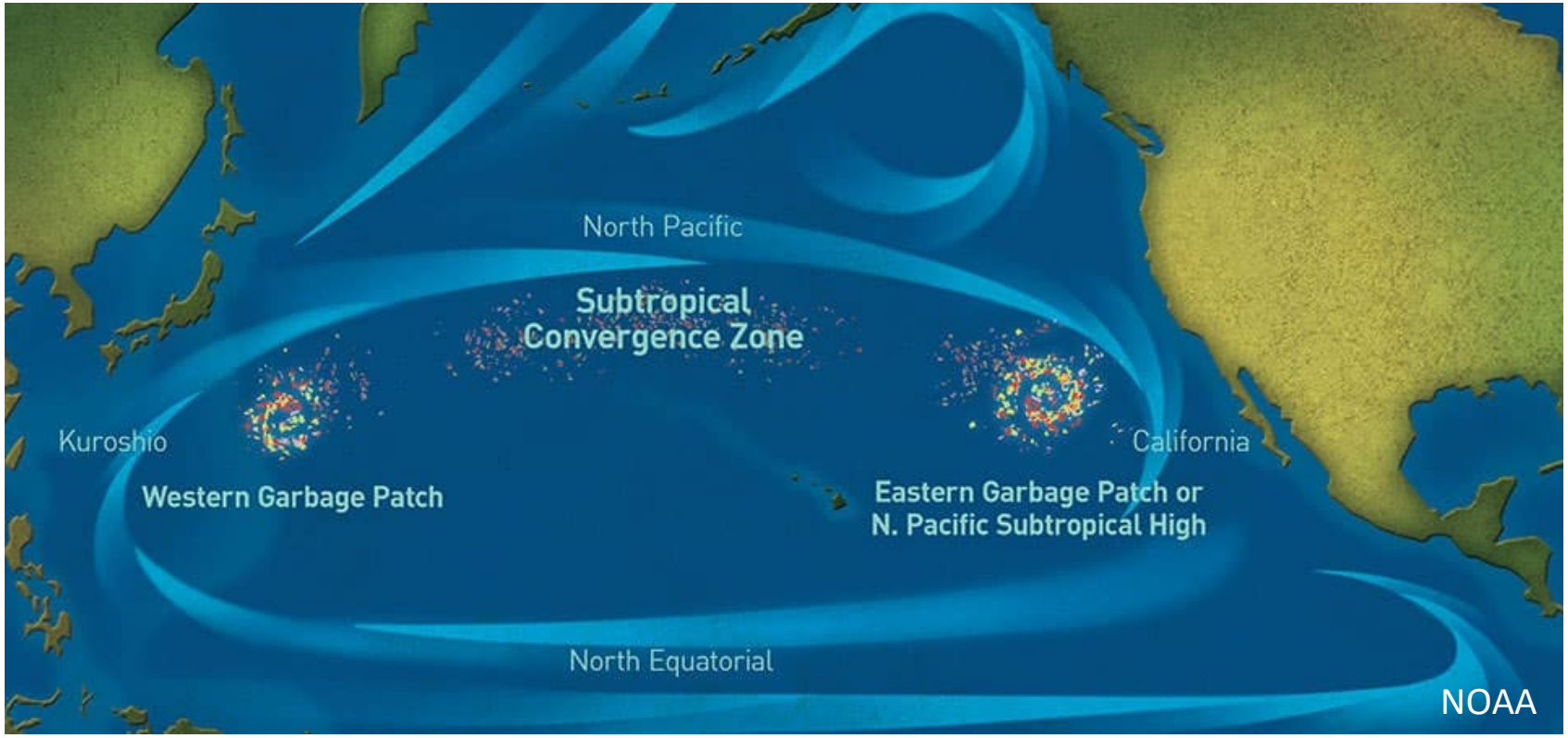
Global production, use, and fate of polymer resins, synthetic fibers, and additives



Geyer et al. 2017

Where does ocean plastic come from?

Garbage Patches



greenprophet.com

juiceonline.com

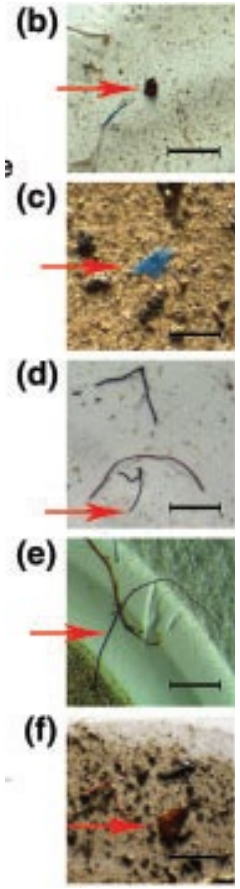
Microplastic is the most abundant debris

5 millimeter-sized particles or smaller

Beaches

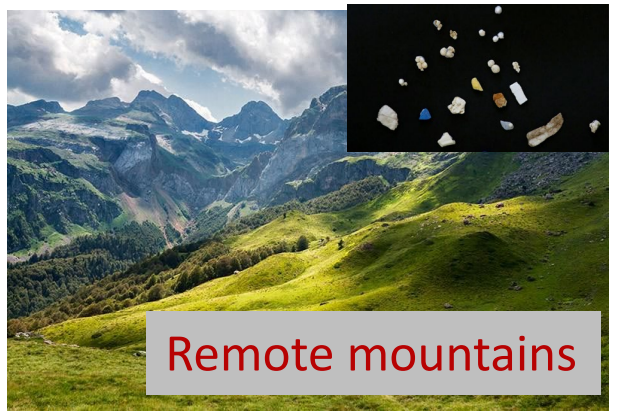
Nicholas Mallos/Ocean Conservancy

Arctic sea ice



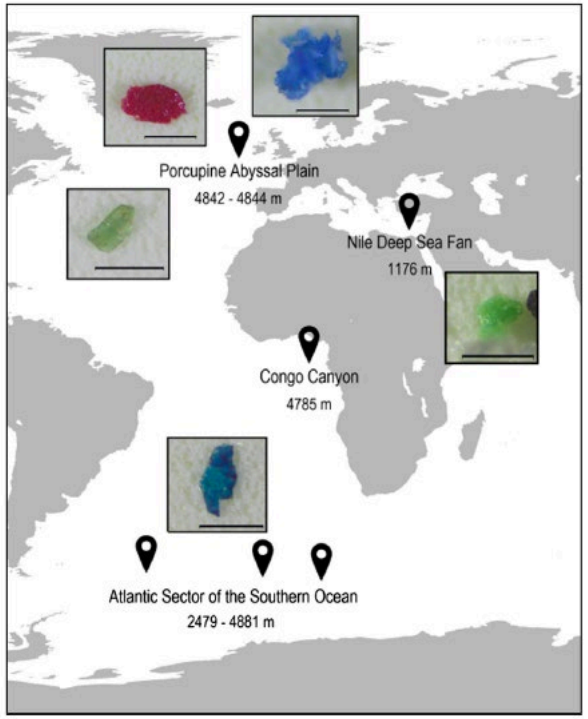
Obbard et al. (2014)

Remote mountains



Allen et al. (2019)

Deep-sea sediments



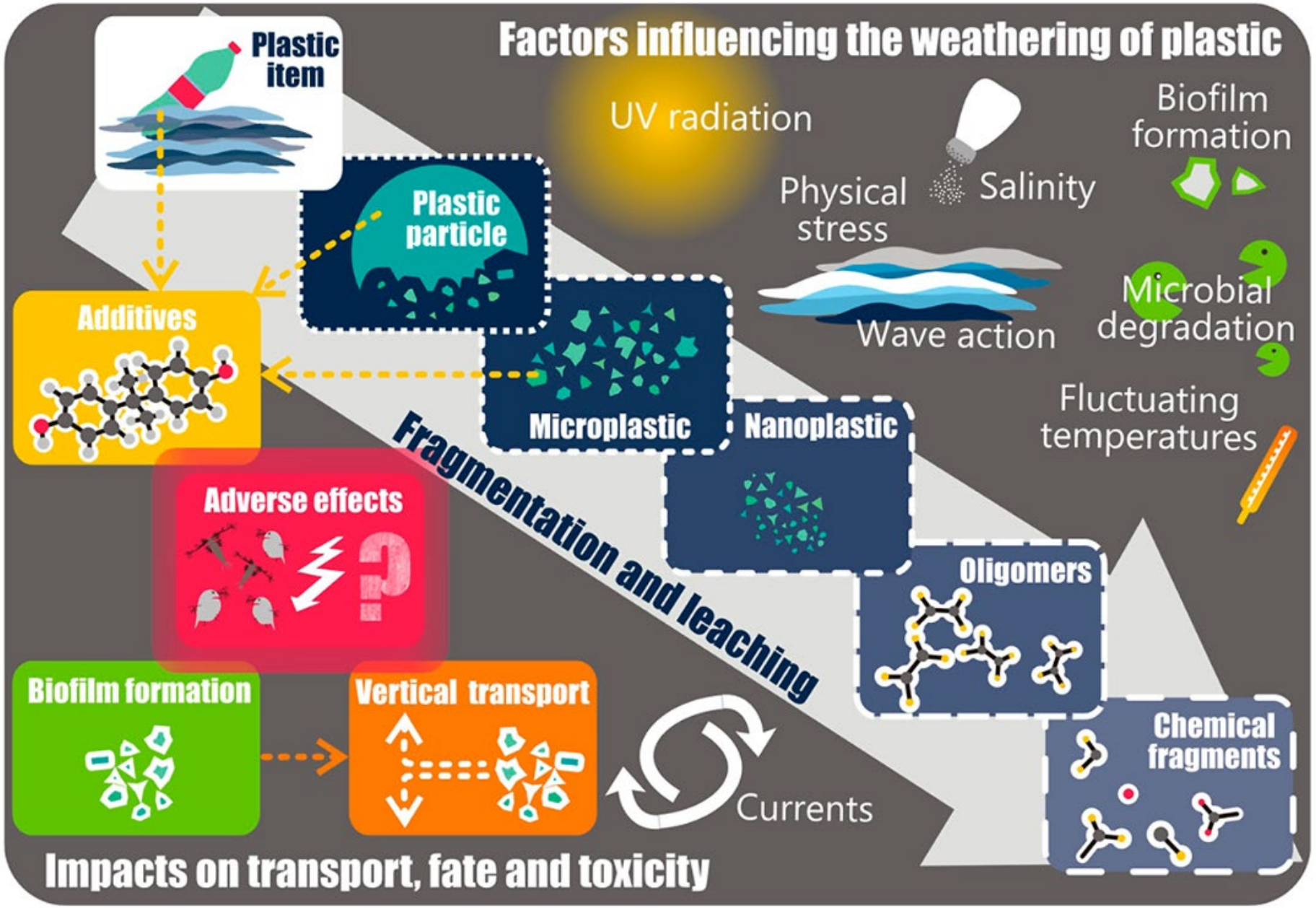
Van Cauwenberghe et al. (2013)

Sea surface

Giora Proskurowski/Sea Education Association

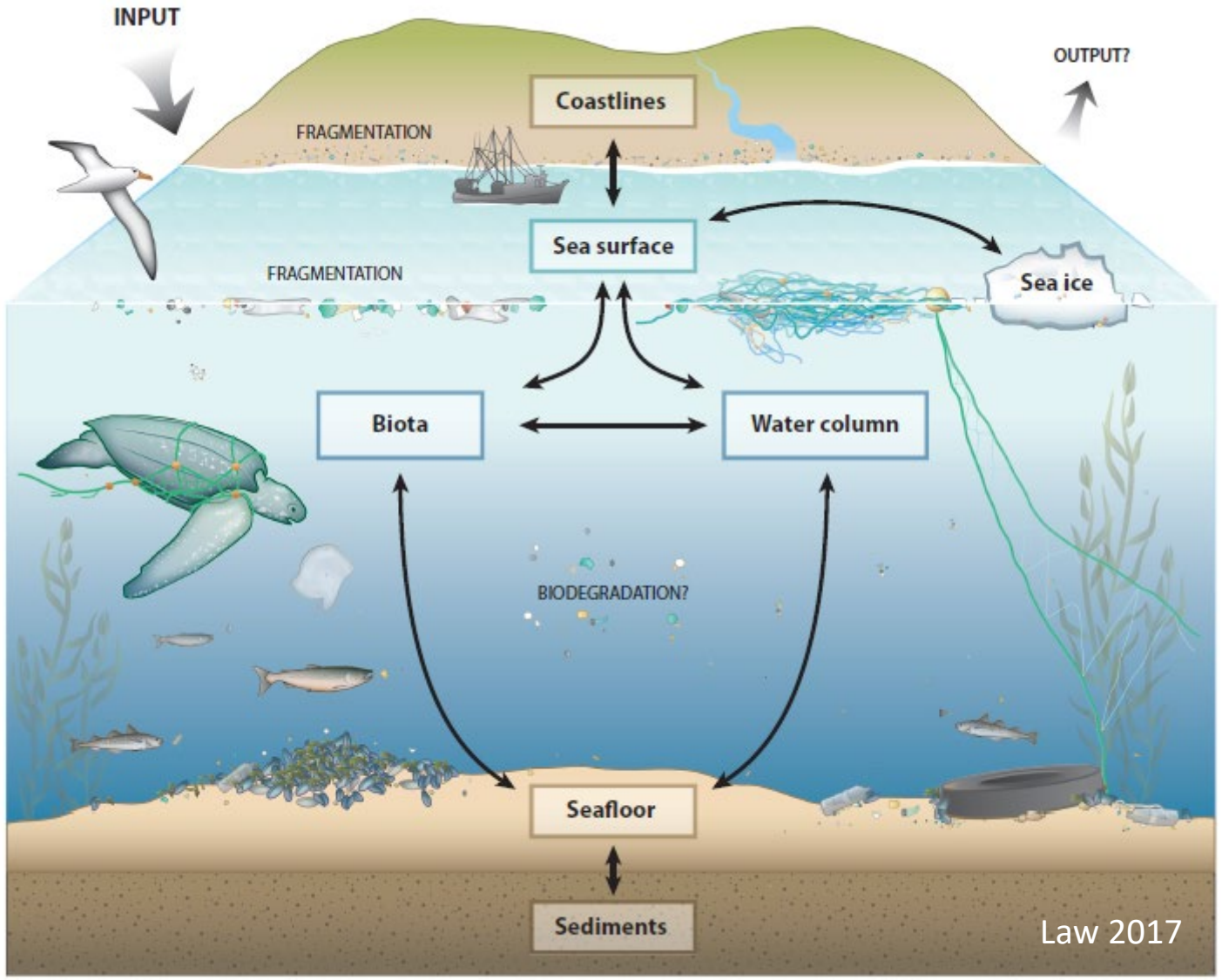
A bit more on **Microplastics**

Images: OSU, IFAS/UFL



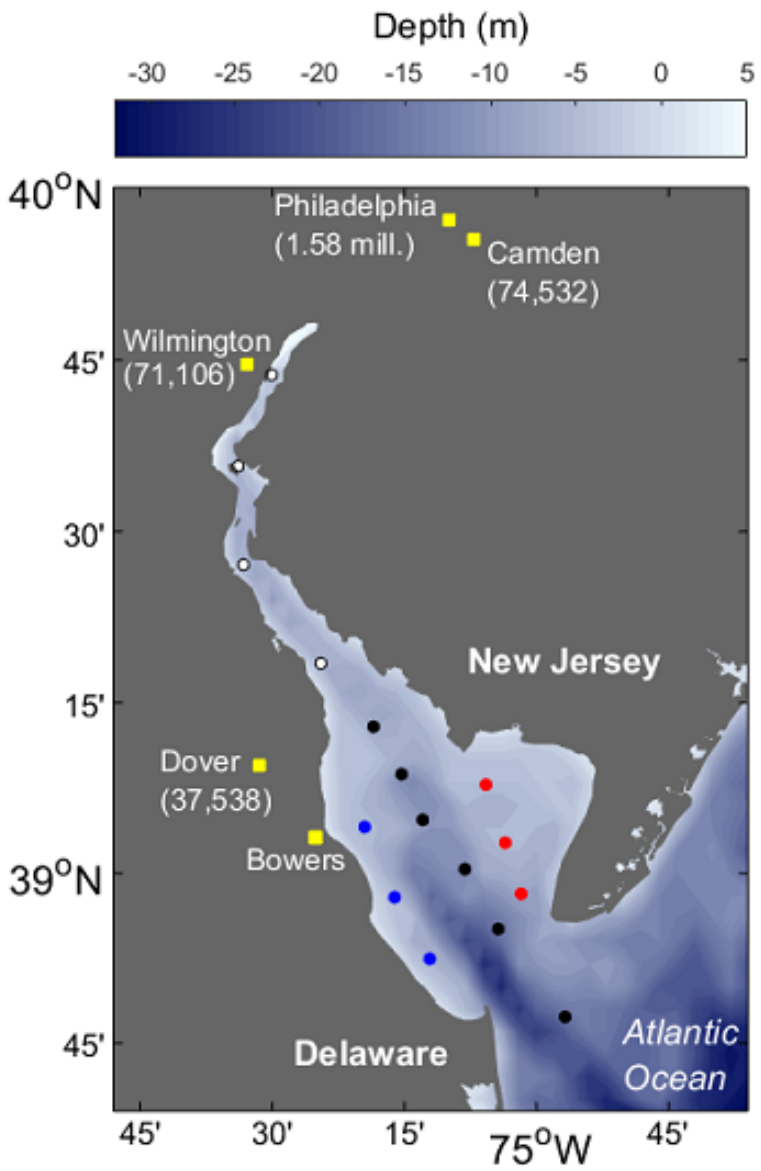
Jahnke et al. 2017. Environ. Sci. Technol. Lett.

So instead of floating garbage patches, ocean plastic pollution looks more like a soup



Law 2017

Seasonal Zooplankton Sampling 2014-2018



1) MP in Inland Bays
2) MP in Delaware Bay

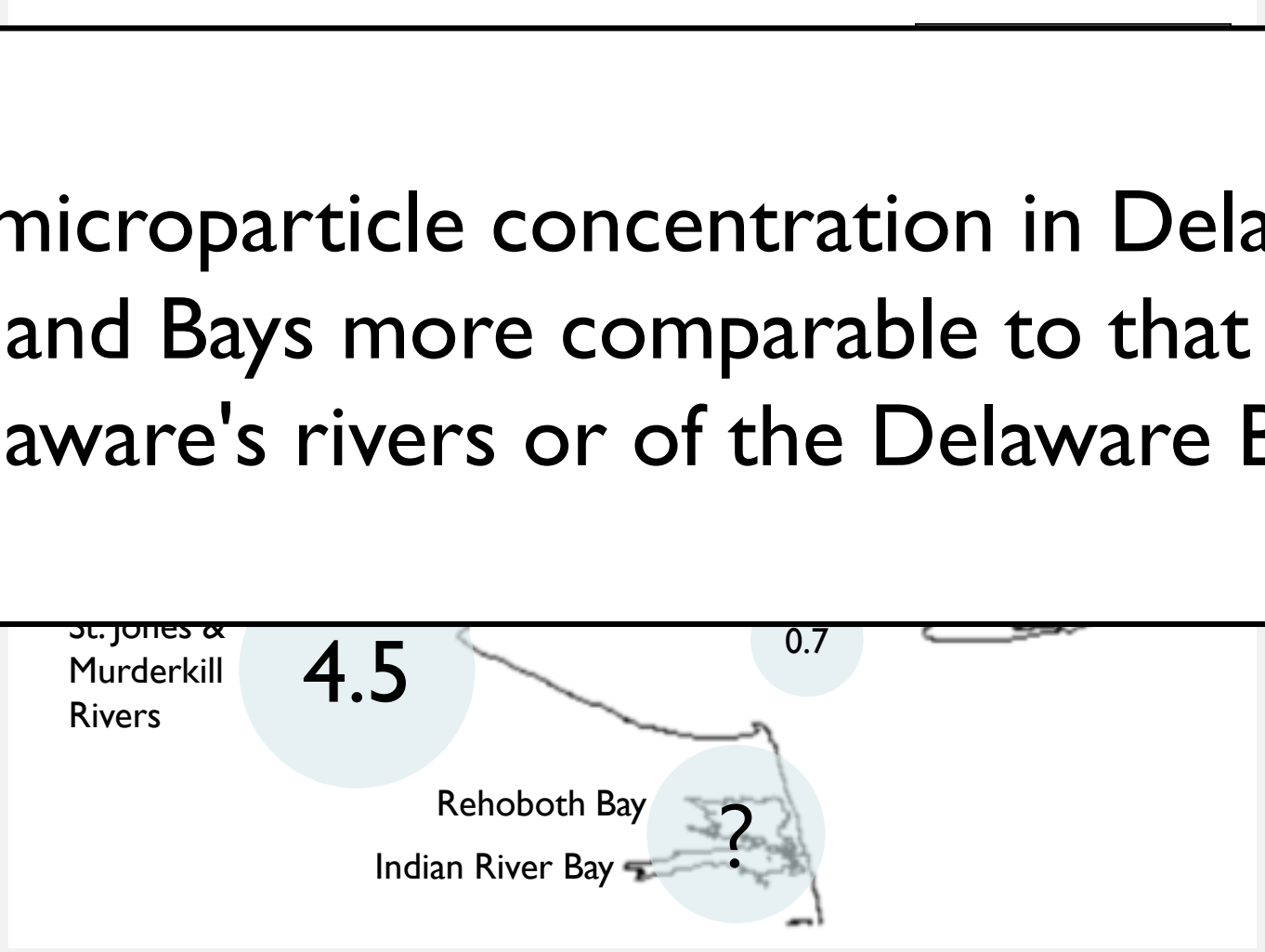
DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

Sea Grant Delaware

Are microplastics an environmental concern in Delaware Bay and the Inland Bays?

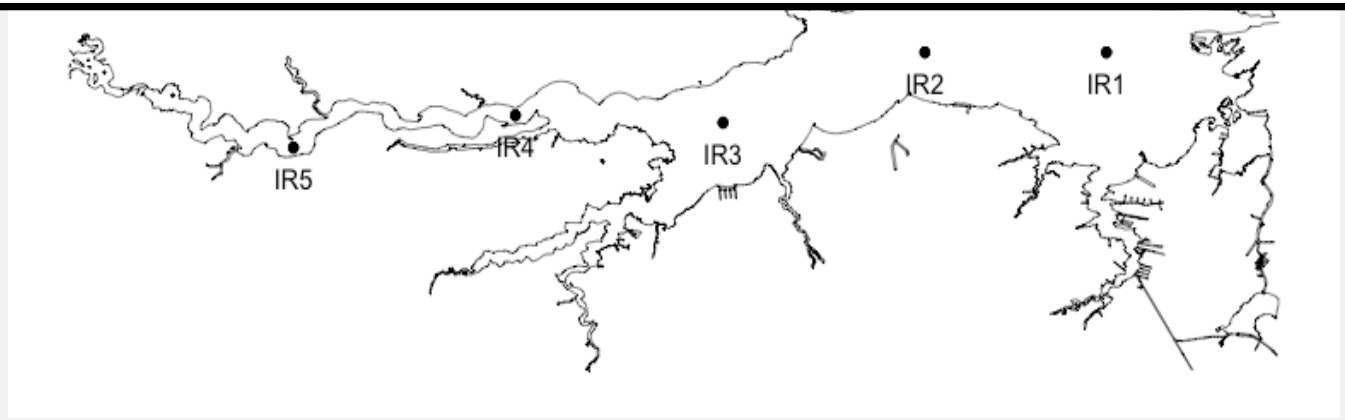
RESEARCH QUESTION

Is the microparticle concentration in Delaware's Inland Bays more comparable to that of Delaware's rivers or of the Delaware Bay?

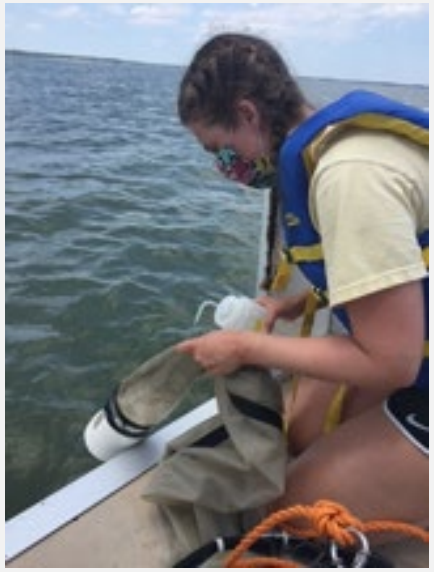


APPROACH

(1) Collect & quantify microparticles using net-based digestion and grab-based fluorescence approaches
(2) Analyze polymer composition of microparticles to determine microplastic identity & quantify microplastics

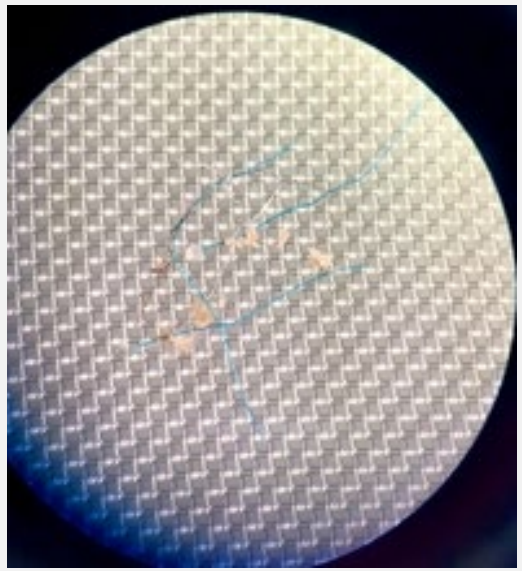


METHODS: WET PEROXIDE OXIDATION

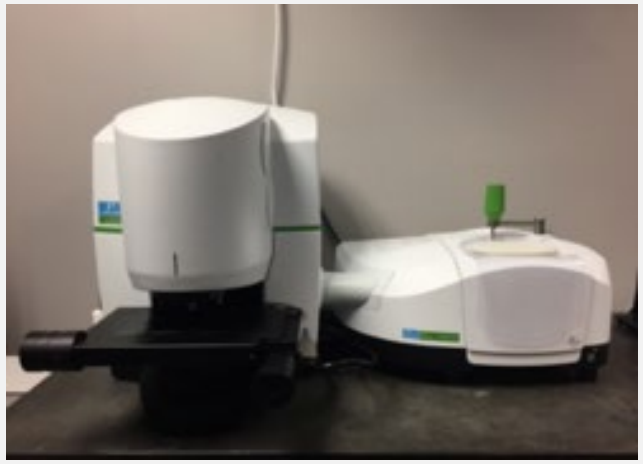


Net-Based Collection

Size Fractioning,
Wet-Peroxide Oxidation,
& Density Separation
(Masura et al. 2015)



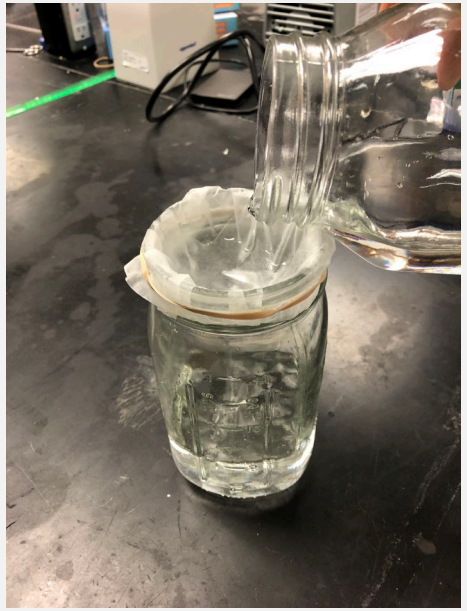
Enumeration &
Categorization



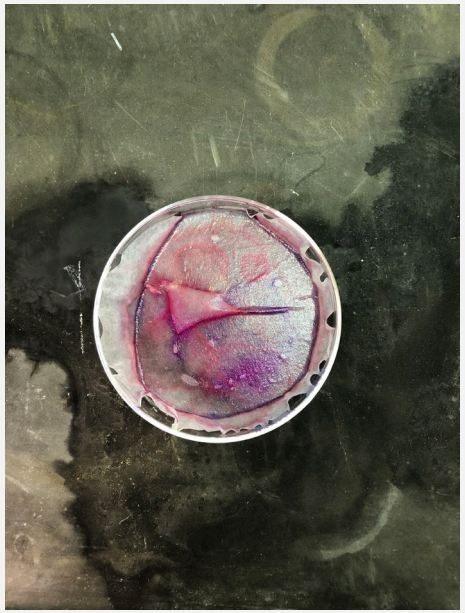
Micro-FTIR Analysis

METHODS: NILE RED STAIN

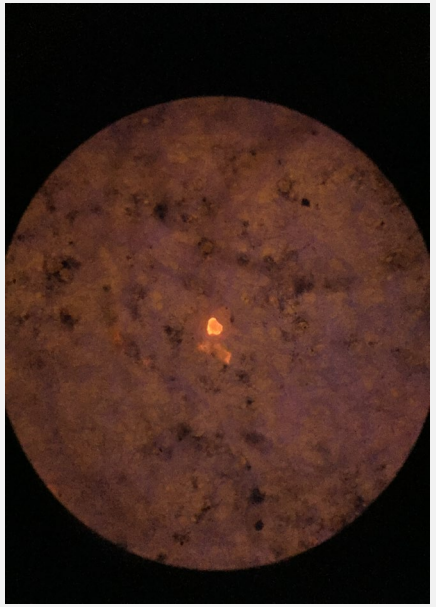
Water-Grab Collection



Filtration



Staining



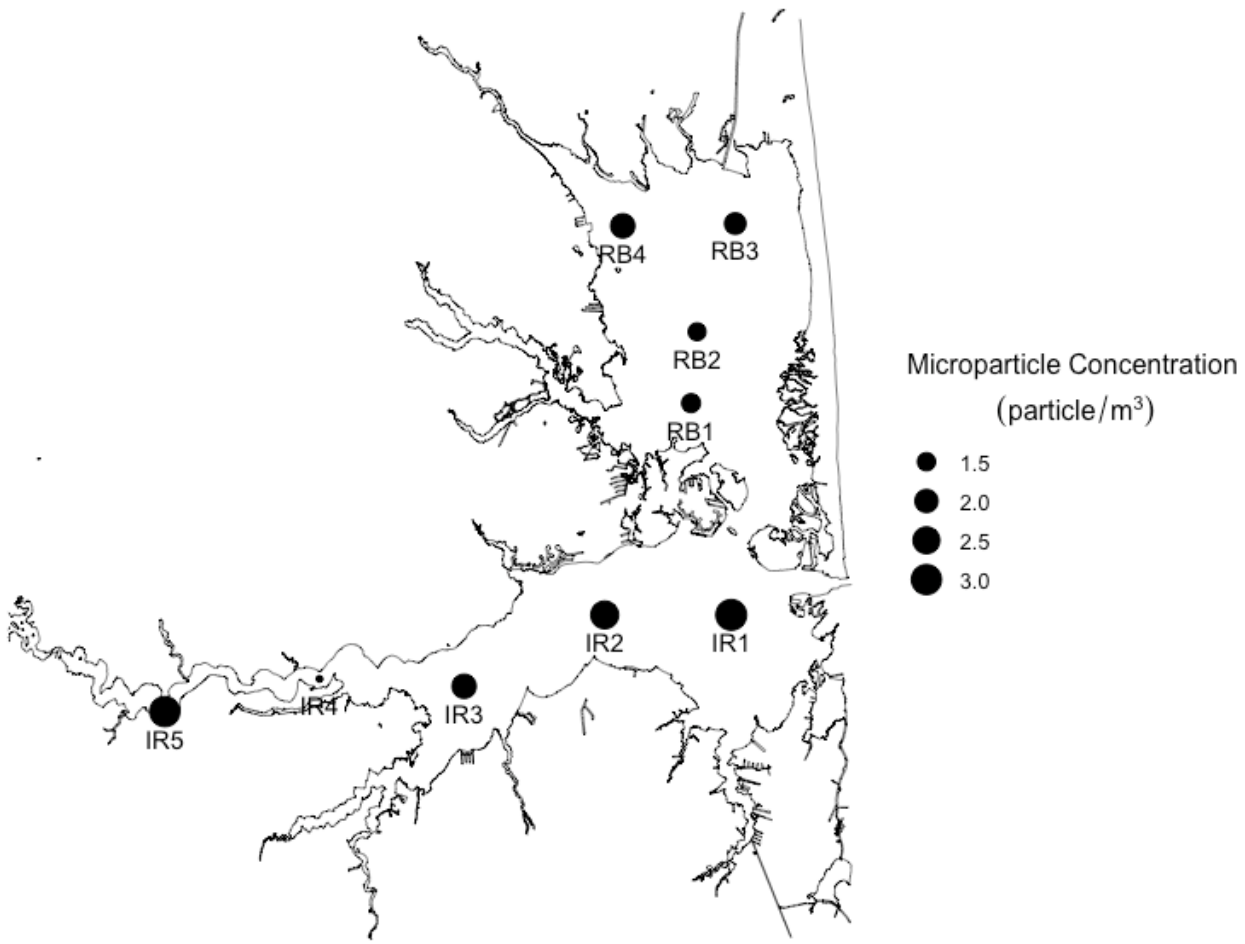
Fluorescence and Enumeration

After Davis (2020) – MappingMicroplastics.org

JULY 29 (NET-BASED COLLECTION): MICROPARTICLE CONCENTRATION

- Indian River Bay average microparticle concentration: 2.4 ± 0.9 pieces/m^3
- Rehoboth Bay average microparticle concentration: 1.8 ± 0.3 pieces/m^3

Delaware Tidal Creeks	Inland Bays	Delaware Bay
3.5 pieces/m^3	> 2.1 pieces/m^3	> 0.7 pieces/m^3



IR = Indian River Bay; RB = Rehoboth Bay

JULY 29 (NET-BASED COLLECTION): MICROPARTICLE SHAPE

Indian River Bay

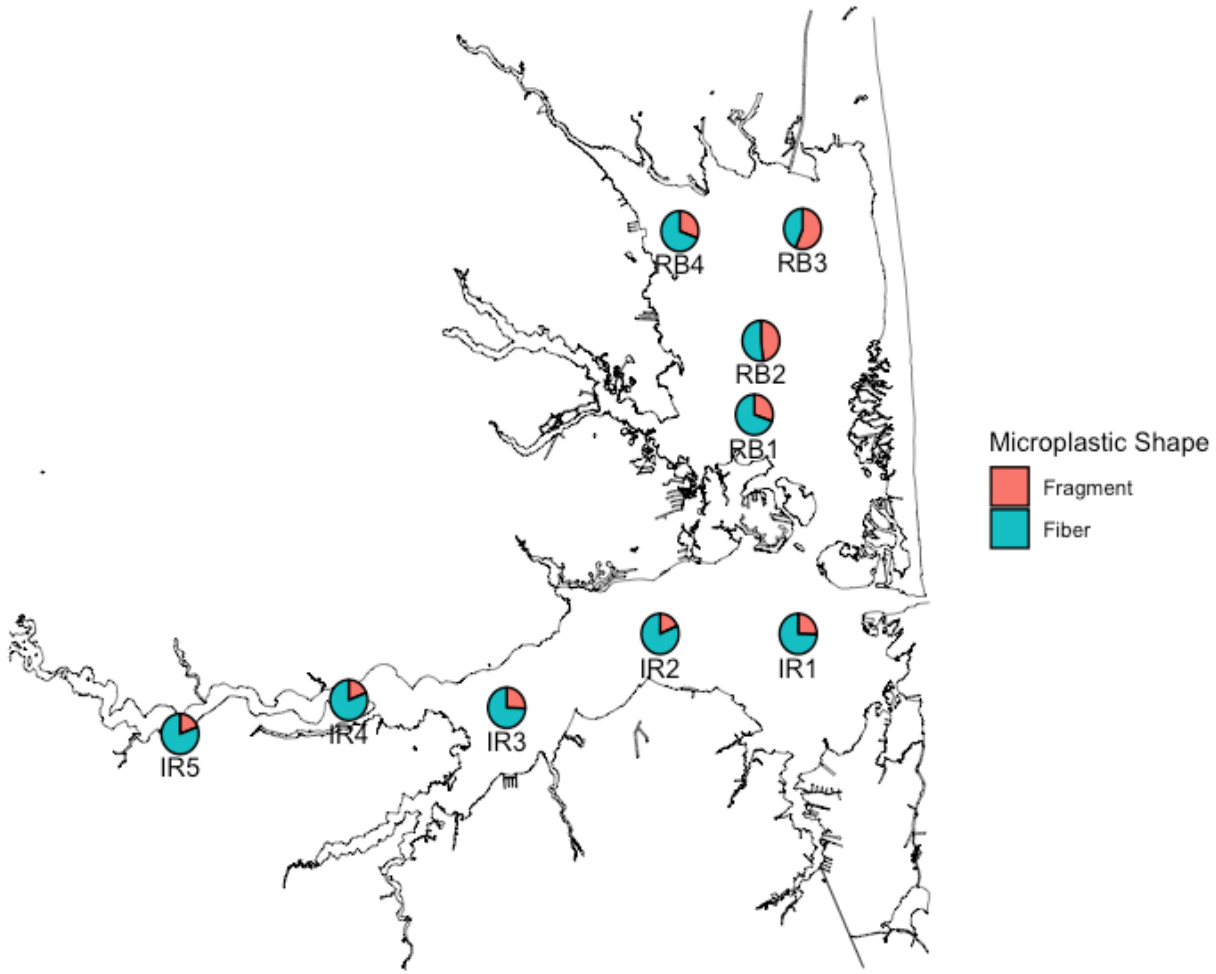
Fibers: 78.3%

Fragments: 21.7%

Rehoboth Bay

Fibers: 59.4%

Fragments: 40.6%

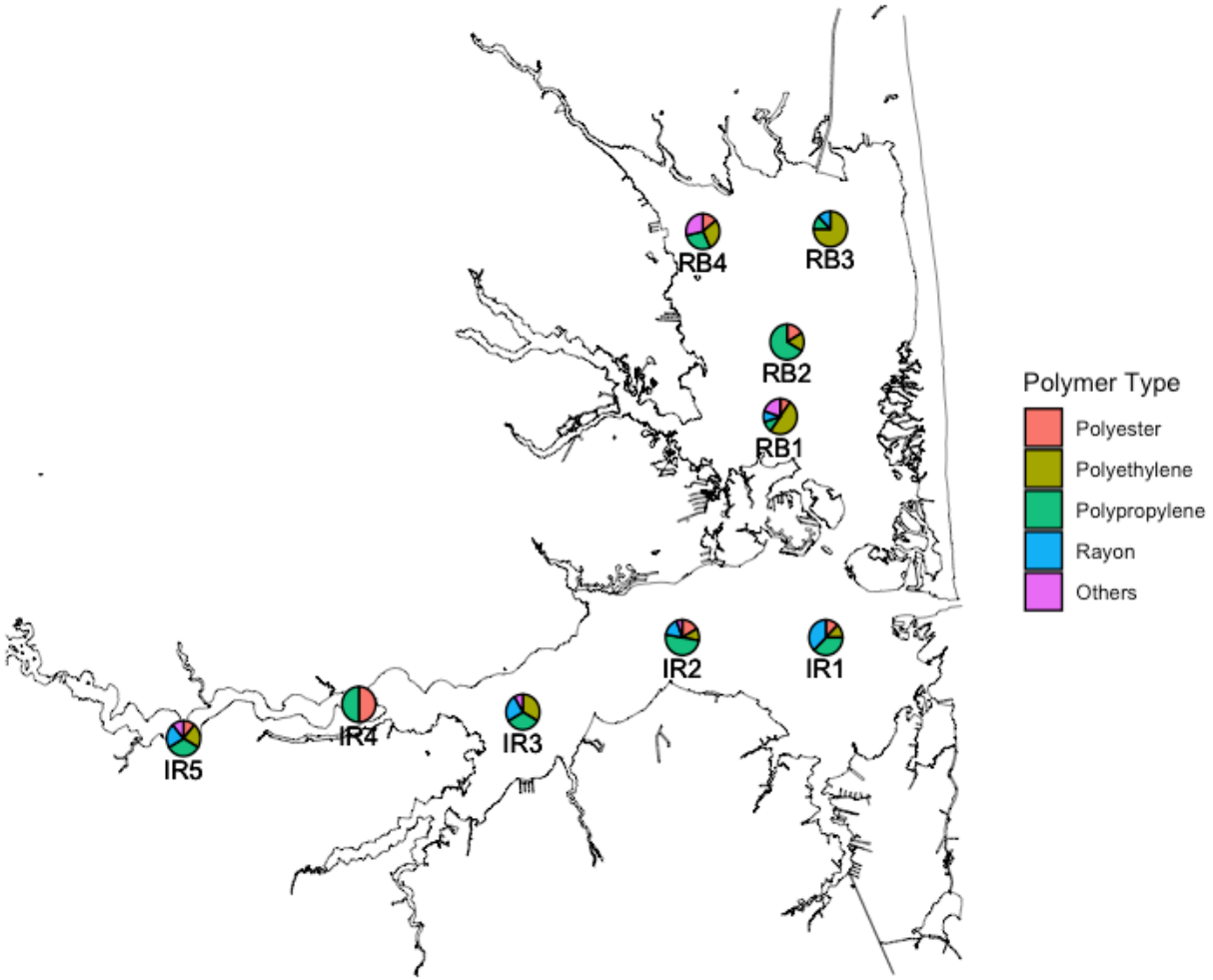


IR = Indian River Bay; RB = Rehoboth Bay

JULY 29 (NET-BASED COLLECTION): MICROPLASTIC CONCENTRATION AND POLYMER TYPE

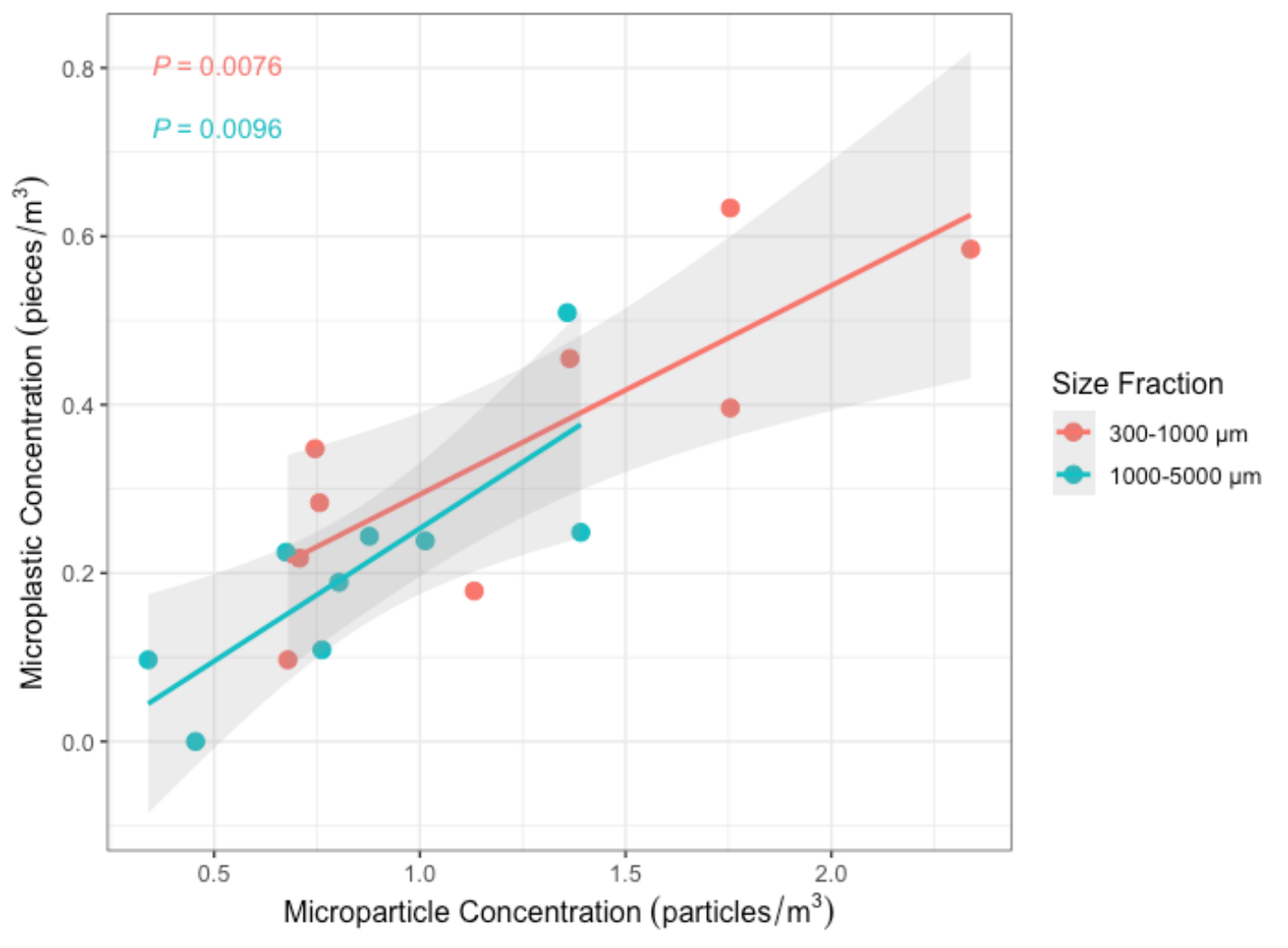
- 85% of tested microparticles (*n* = 123) were microplastics (*n* = 99)
- Indian River Bay average microplastic concentration: 0.7 ± 0.3 pieces/m^3
- Rehoboth Bay average microplastic concentration: 0.5 ± 0.1 pieces/m^3
- Inland Bays microplastic concentration: 0.6 ± 0.3 pieces/m^3

- Polypropylene was the dominant polymer type in Indian River Bay (38%)
- Polyethylene was the dominant polymer type in Rehoboth Bay (45%)



IR = Indian River Bay; RB = Rehoboth Bay

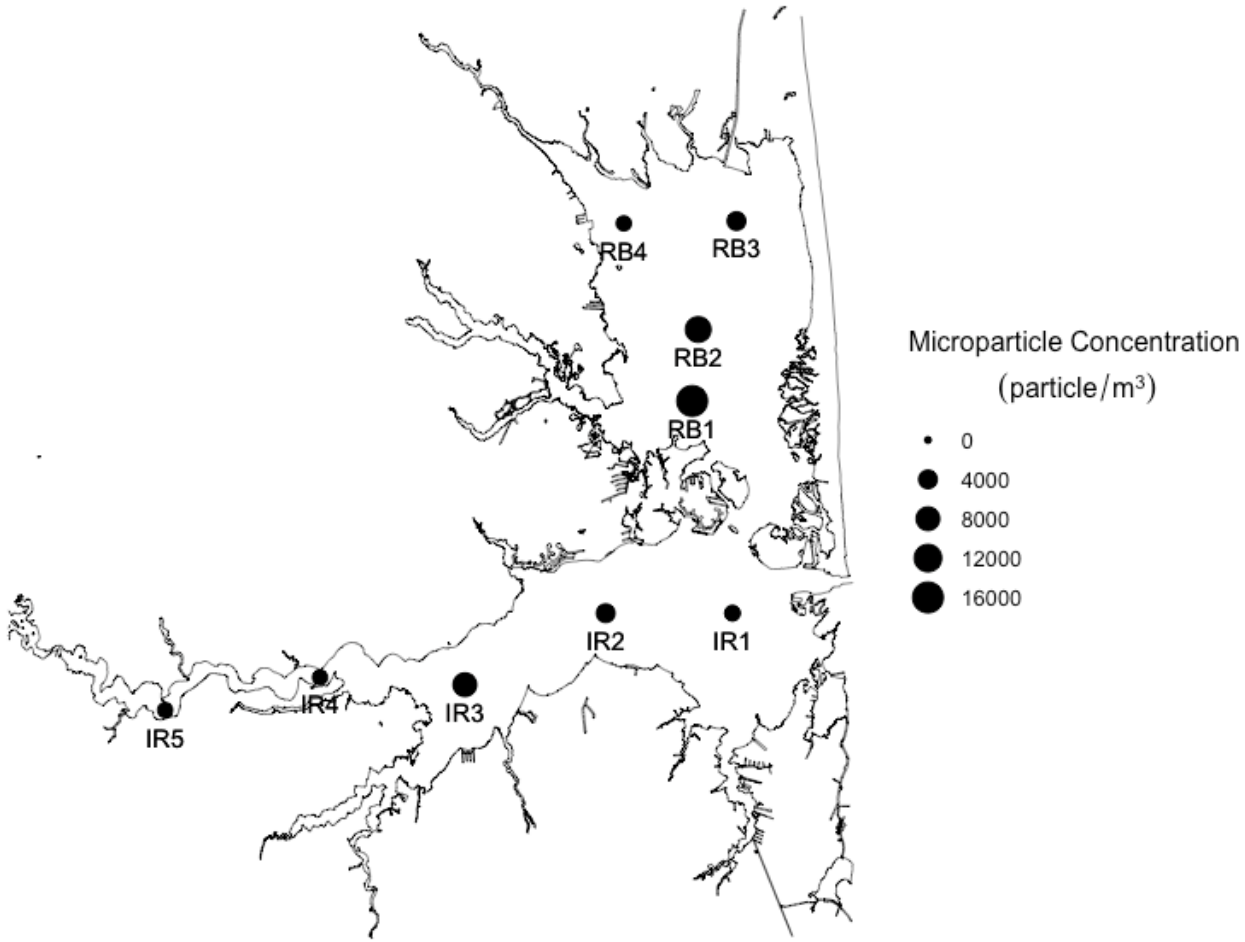
JULY 29 (NET-BASED COLLECTION): MICROPARTICLE VS MICROPLASTIC CONCENTRATION



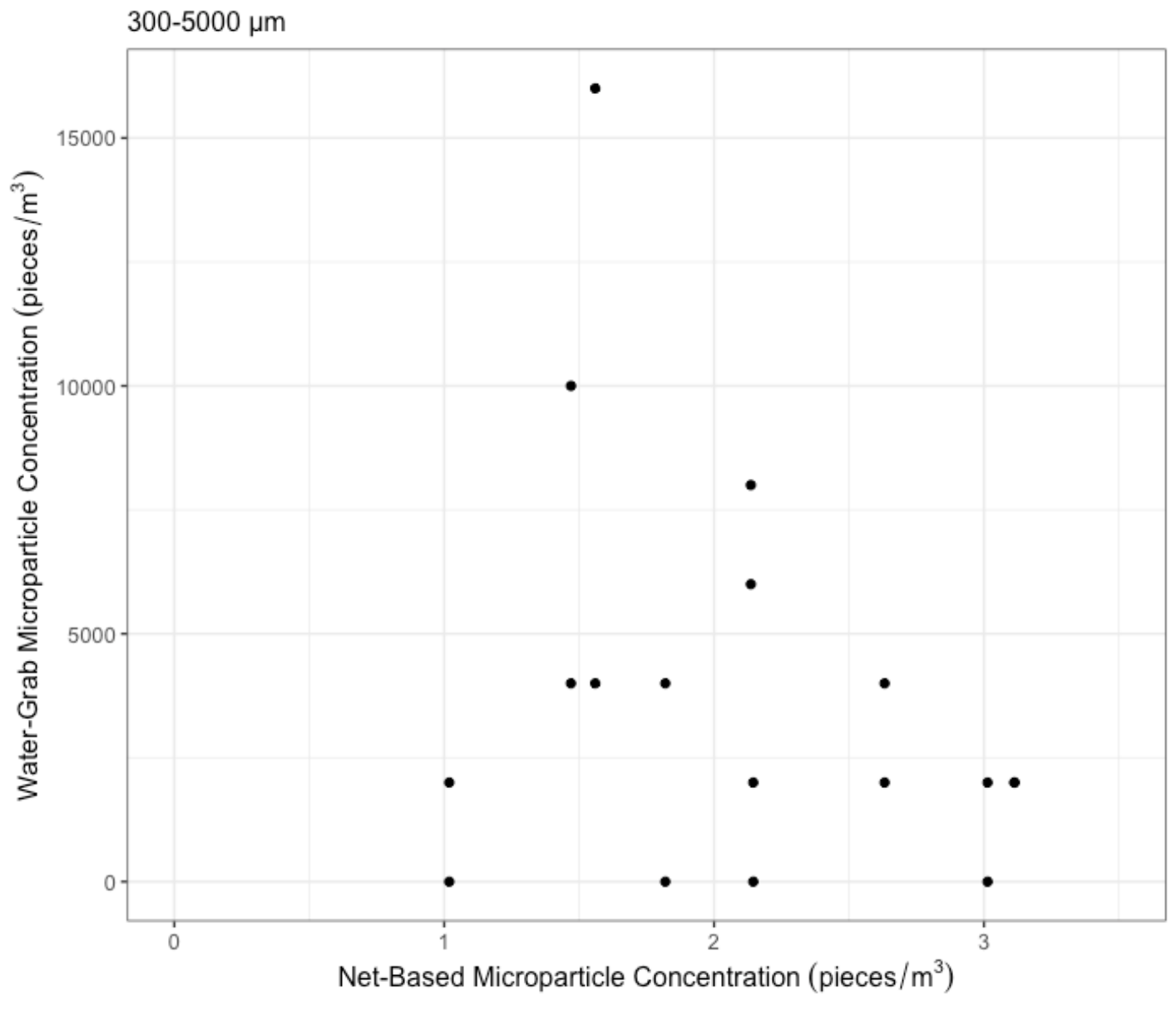
- Statistically significant relationship between microparticle concentration and microplastic concentration

AUGUST 12 (WATER-GRAB): MICROPARTICLE CONCENTRATION & SHAPE

- Indian River Bay average microparticle concentration: 2800 ± 2529.8 pieces/m^3
- Rehoboth Bay average microparticle concentration: 5000 ± 5451.1 pieces/m^3



IR = Indian River Bay; RB = Rehoboth Bay



MICROPARTICLE COMPARISON: NETS VS GRABS

- No significant relationship between net-based and water-grab-based microparticle concentrations

CONCLUSIONS

Microparticle Concentration

Delaware Tidal Creeks > Inland Bays > Delaware Bay

- The majority of microparticles found in the Inland Bays are fibers.
- Polyethylene and polypropylene microplastics are the most prevalent in the Inland Bays.
- Water-grab collection results are inconsistent with net-based collection results.
- Nile red citizen science method potentially valuable for locating relative microplastic hotspots.

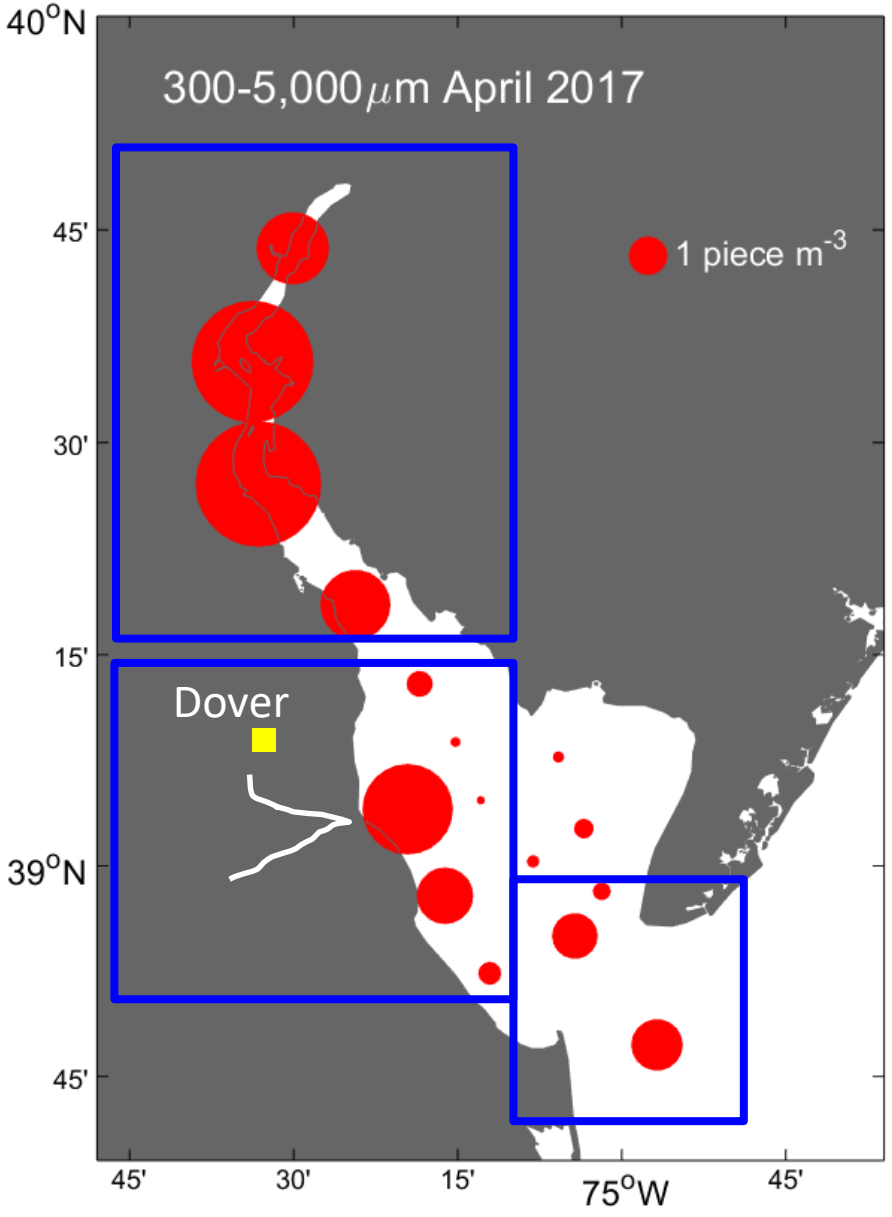
Our Approach for Delaware Bay

Observations from boats

Computer simulations

What have we learned?

How much microplastic is in Delaware Bay?



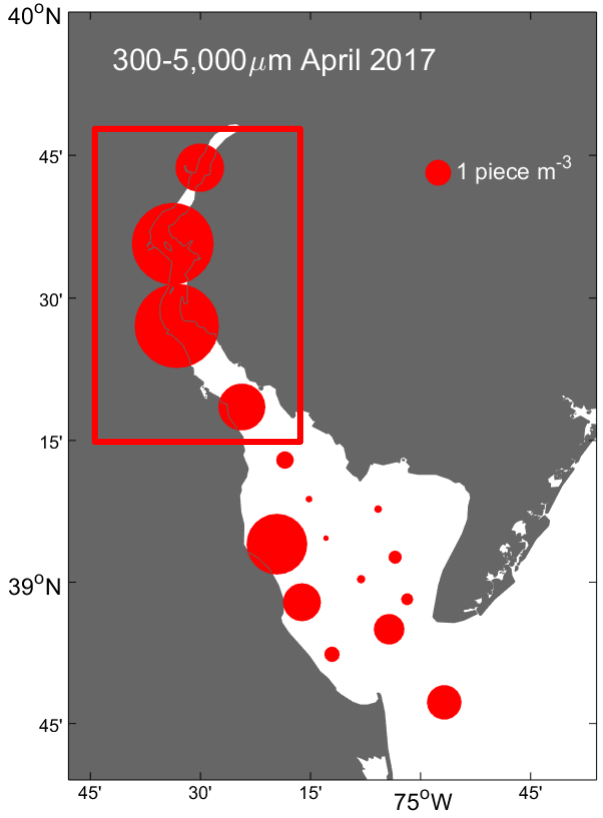
- More plastic upstream
  - Higher population densities
  - Trapped in upper bay?
- Additional inputs from rivers around Dover (Murderkill and St. Jones Rivers)? We'll return to this later…
- Follows major currents and tidal movement in the Bay
- Overall: unexpected amount of variability across the Bay

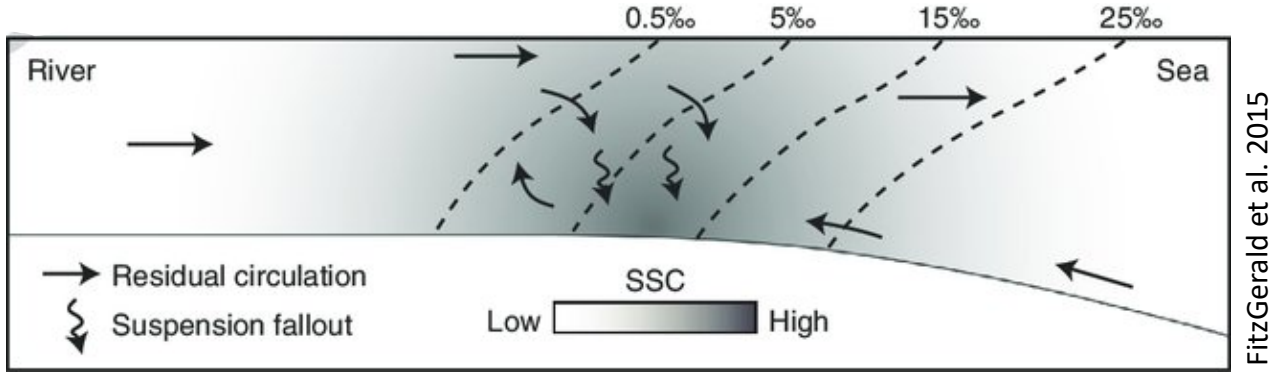
What plastic shapes & types are in Delaware Bay?

Shape
Types

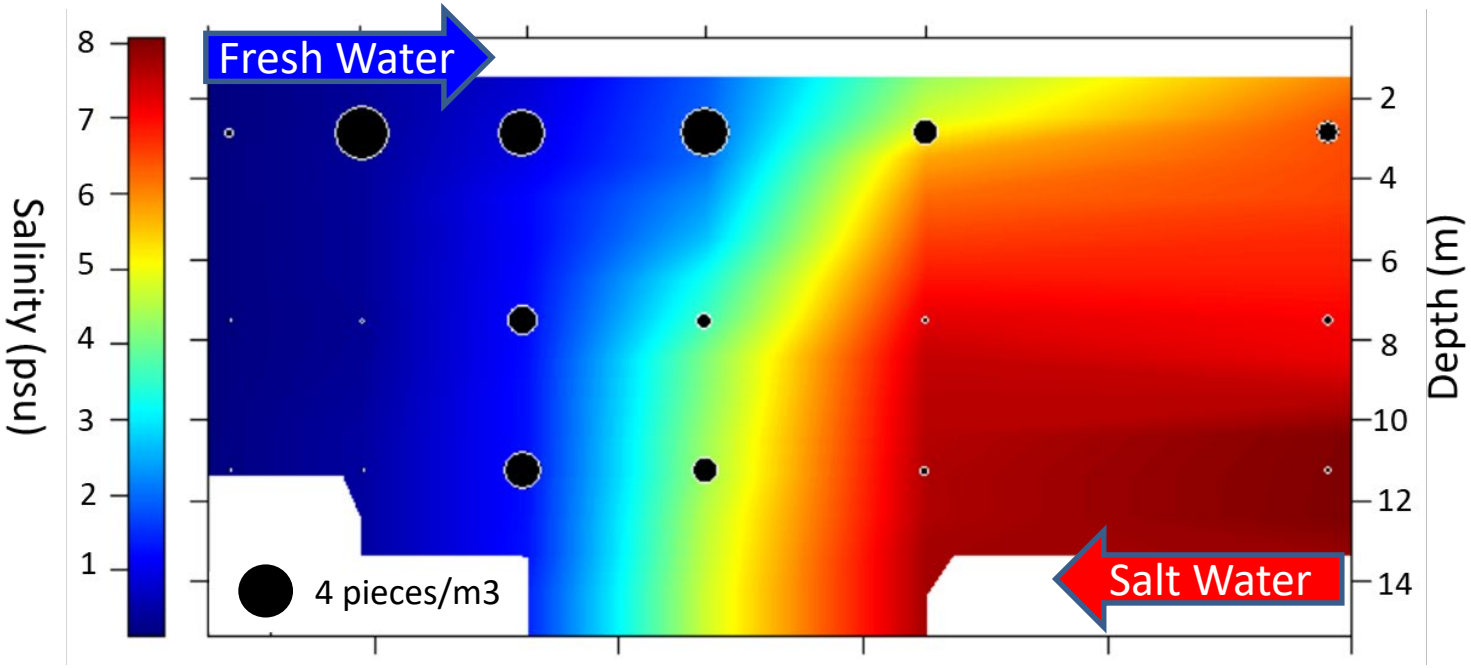
Observations – net sampling – ETM in more detail

Retention within
estuarine turbidity maximum

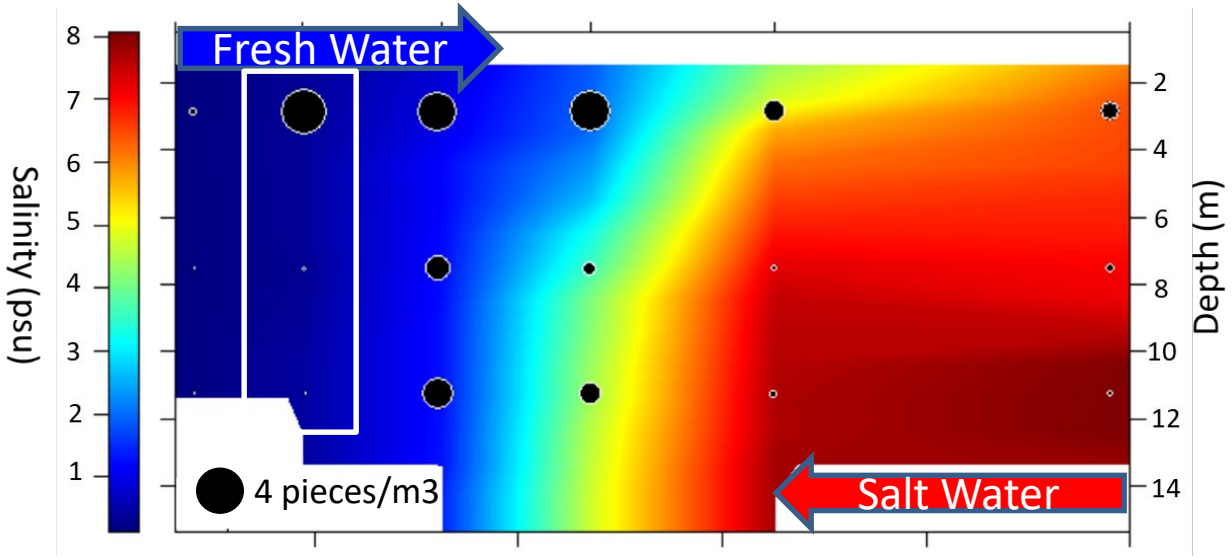




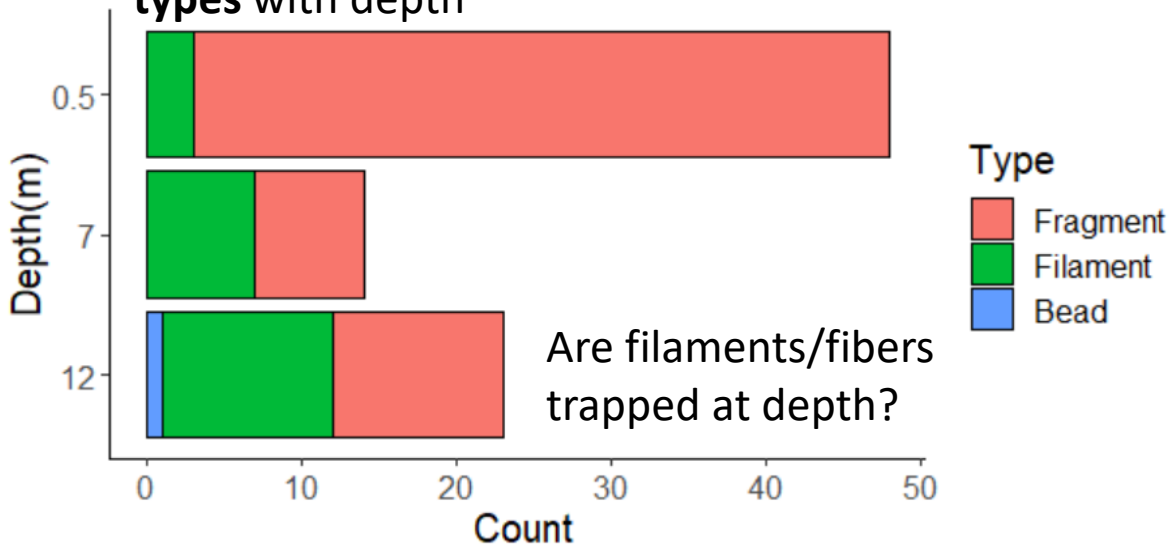
FitzGerald et al. 2015



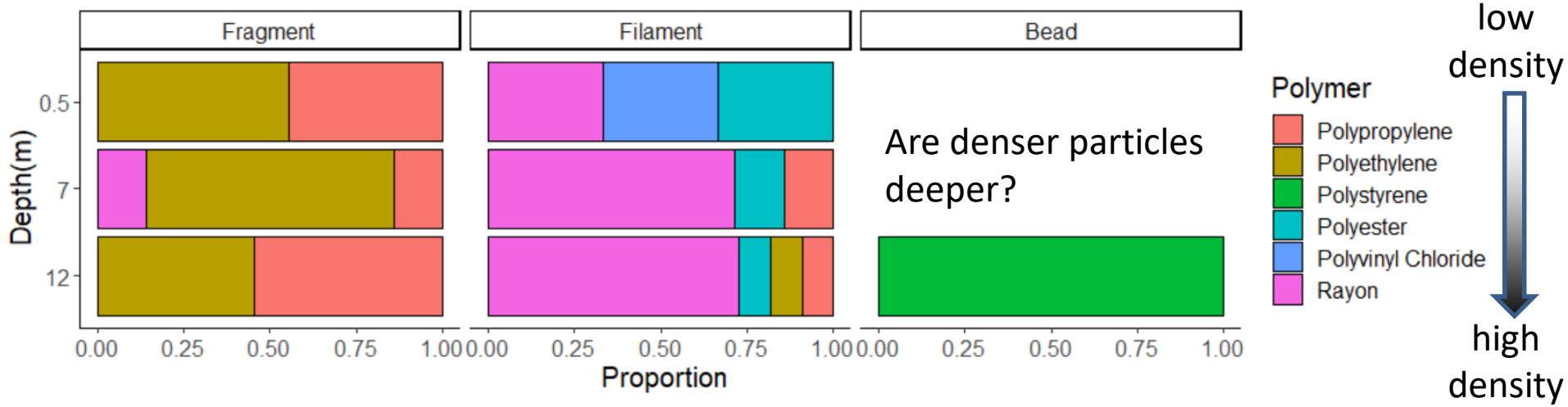
Observations – net sampling – ETM in more detail



Changes in relative proportions of microplastic **types** with depth

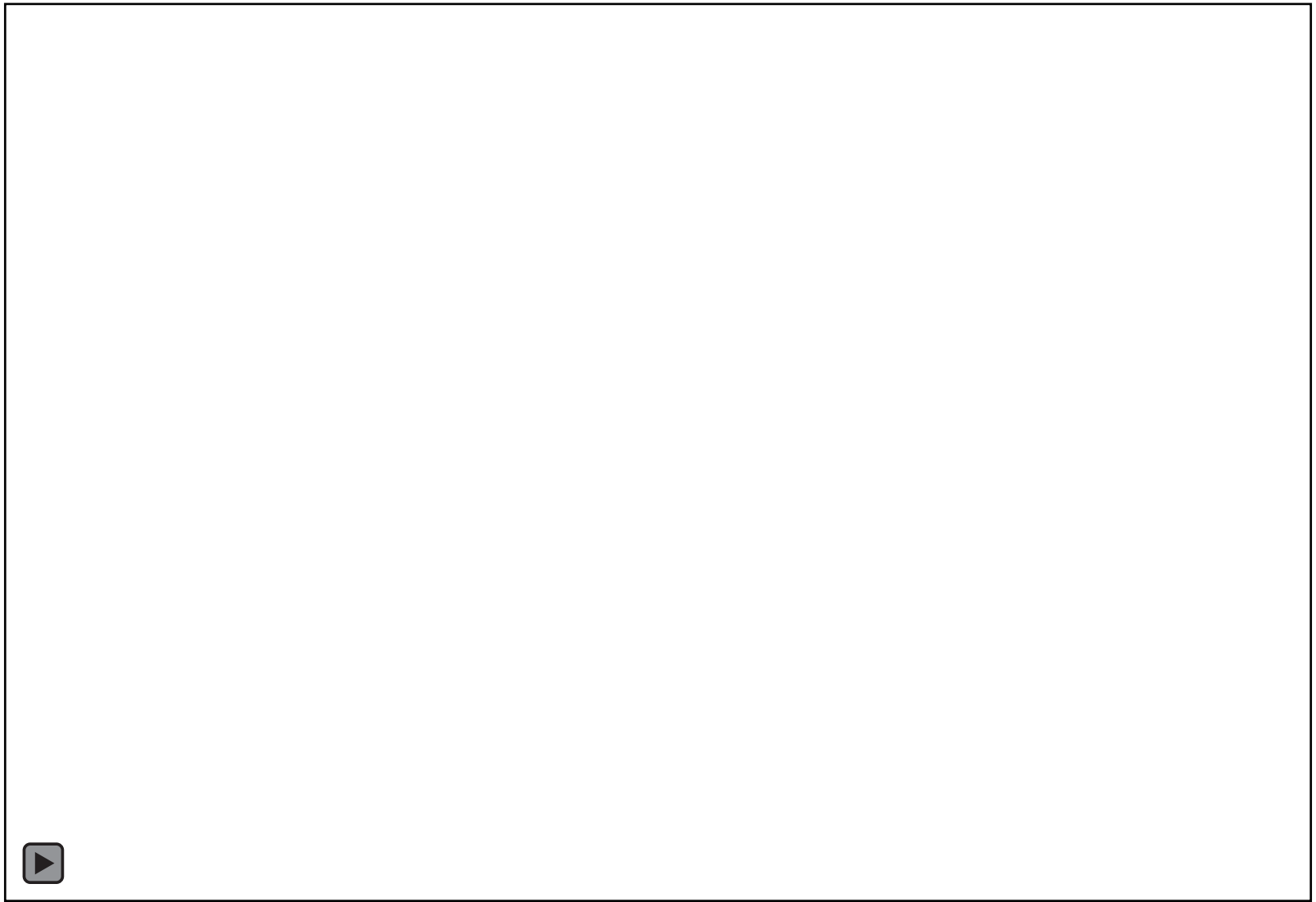


Polymer types dominated by PE, PP, Rayon



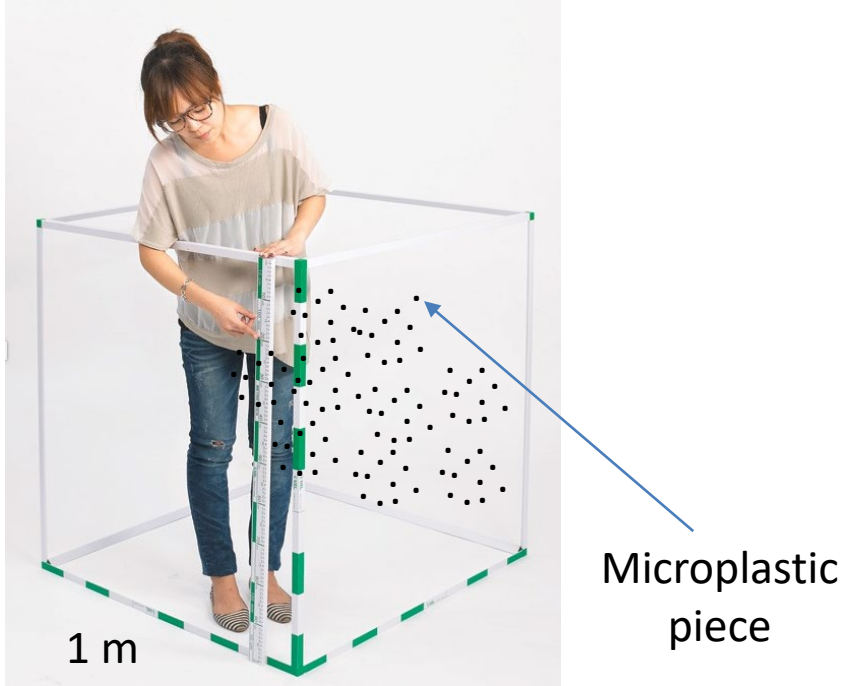
Computers can help us fill in the gaps

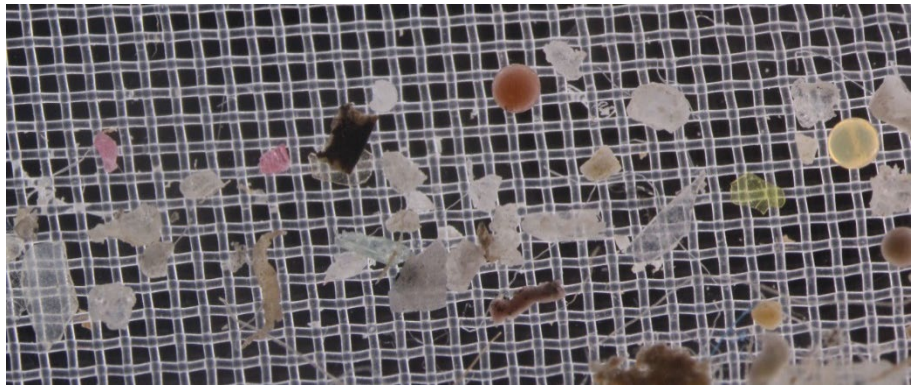
- What if we spread a layer of buoyant plastic particles across Delaware Bay, then let them float wherever currents and waves and wind pushed them
  - Buoyant particles are not homogeneously distributed throughout Bay
  - Instead, "hot spots" form where salty and fresher water mix



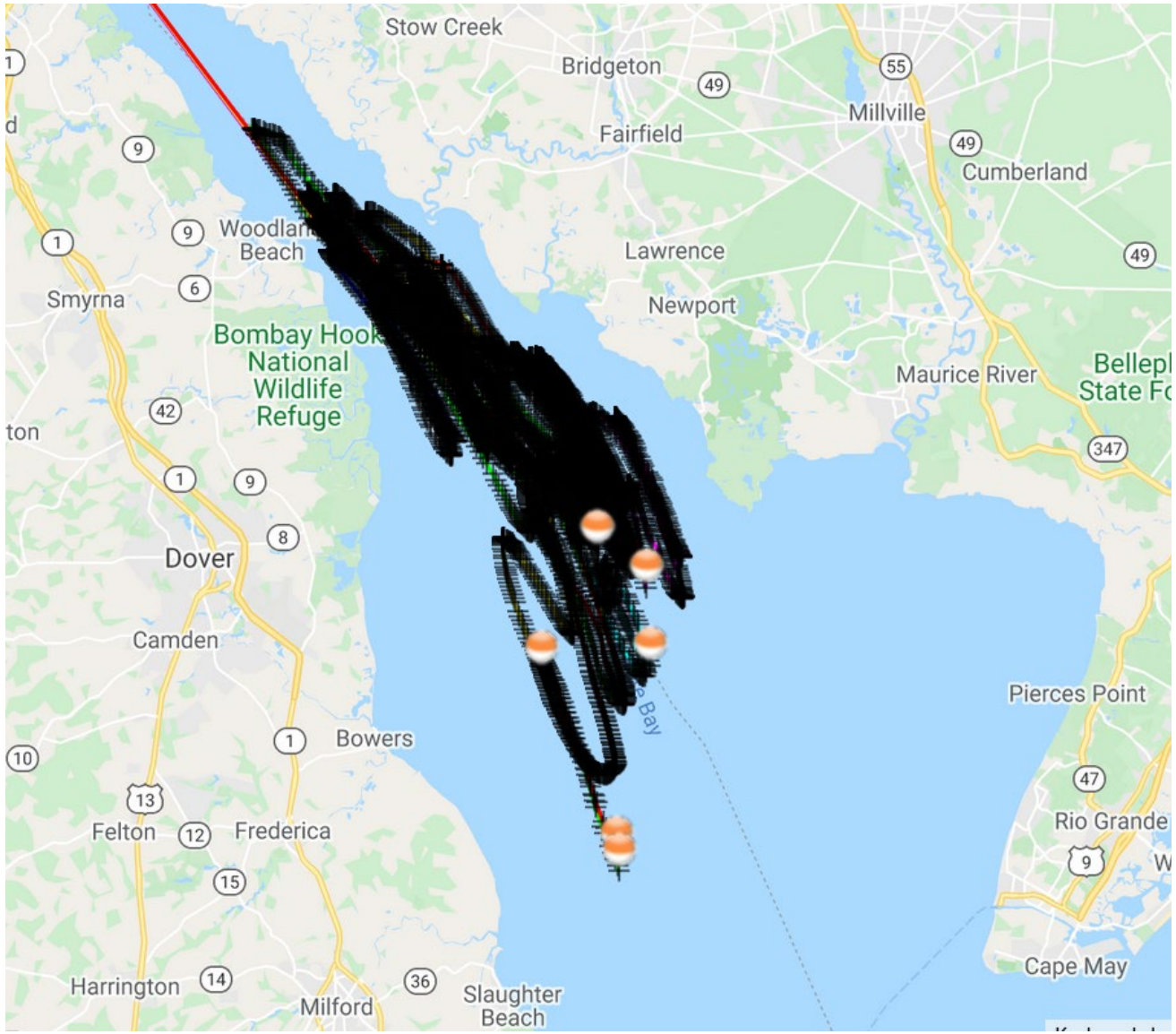
So, how much microplastic is in Delaware Bay?

- <1 to 5 pieces per m^3
  - Exceeds open ocean "garbage patches"
- There are likely areas (e.g., tidelines) with concentrations 100-1000x these levels

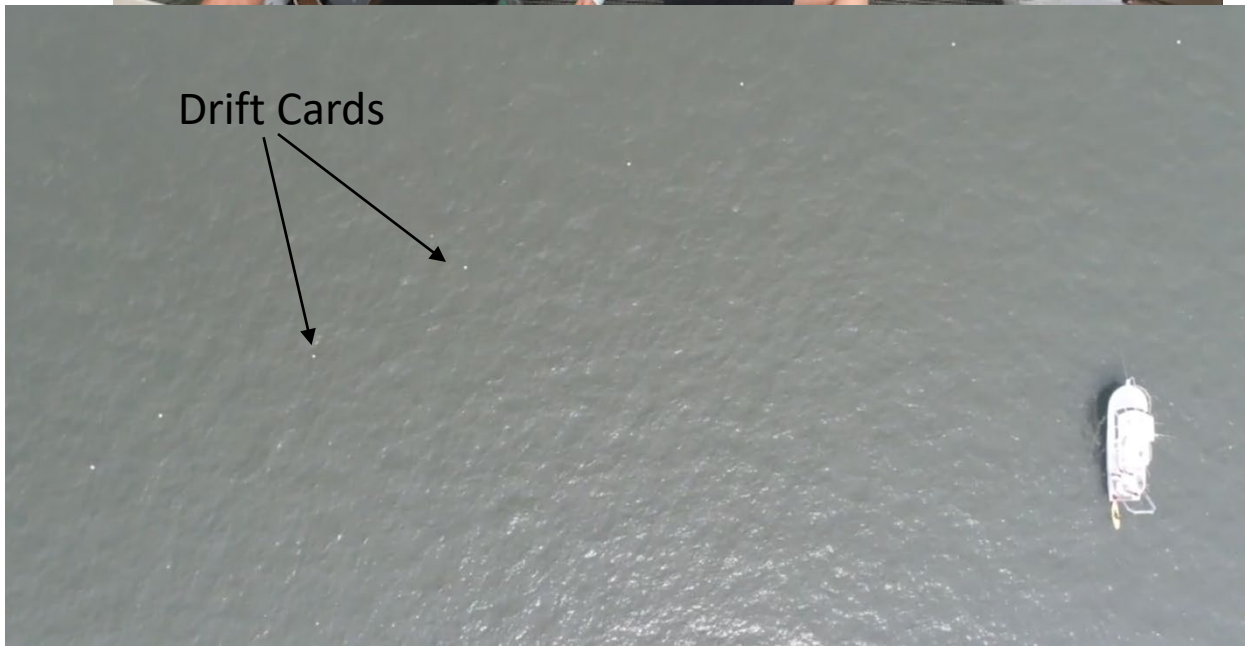




GPS Drifters

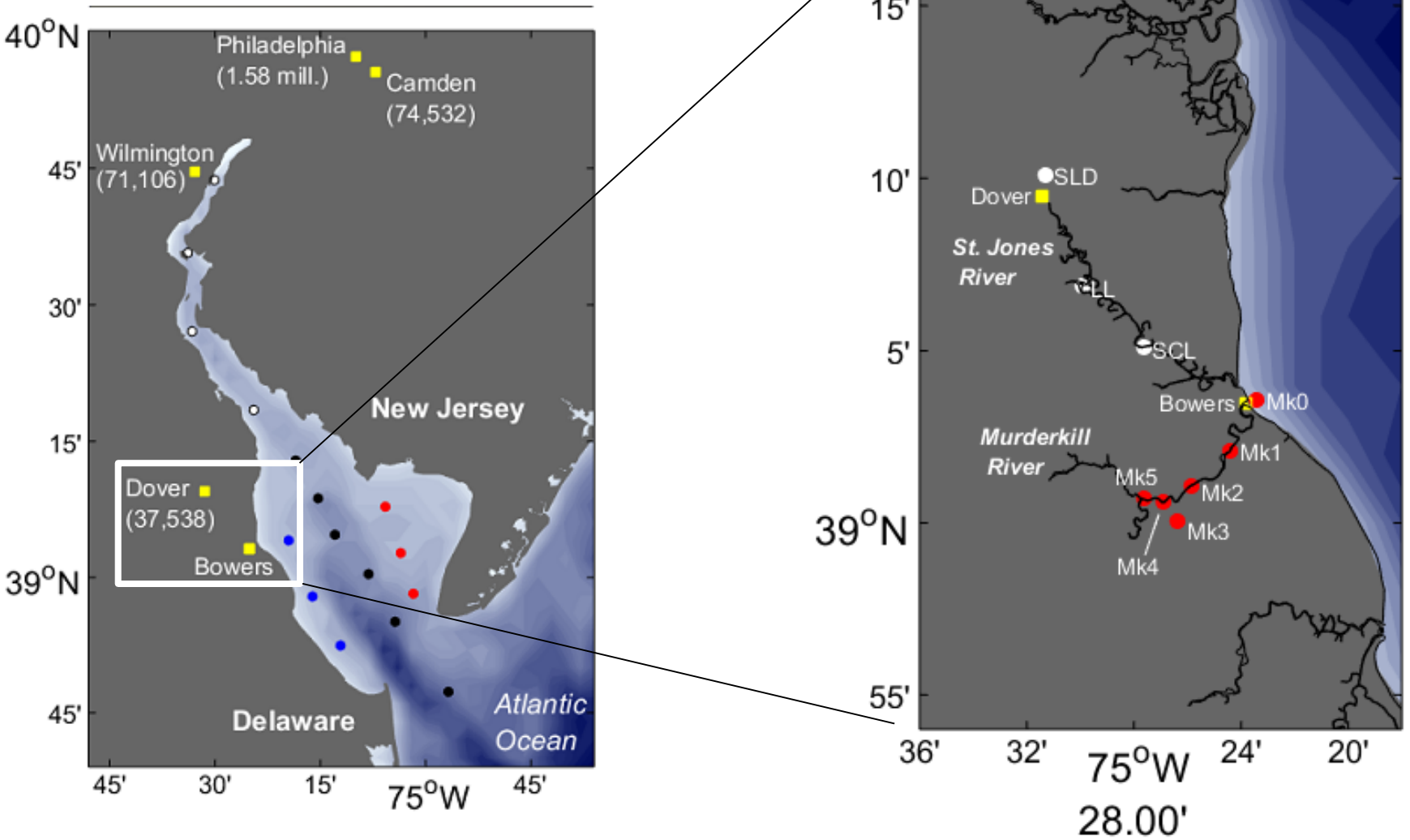


Drift Cards

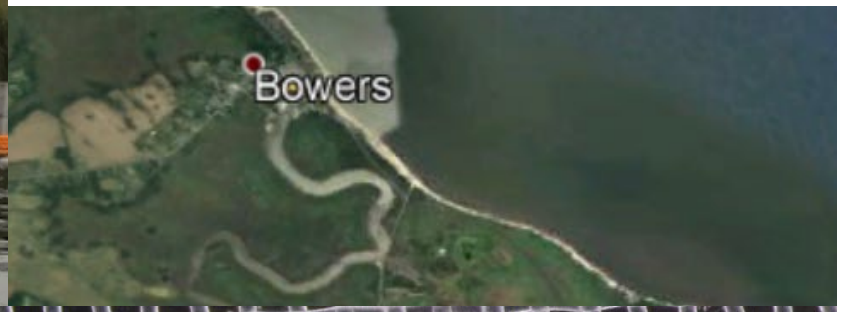


Are tidal rivers sources of microplastics to Delaware Bay?

Summer 2019 study in the Murderkill River, DE

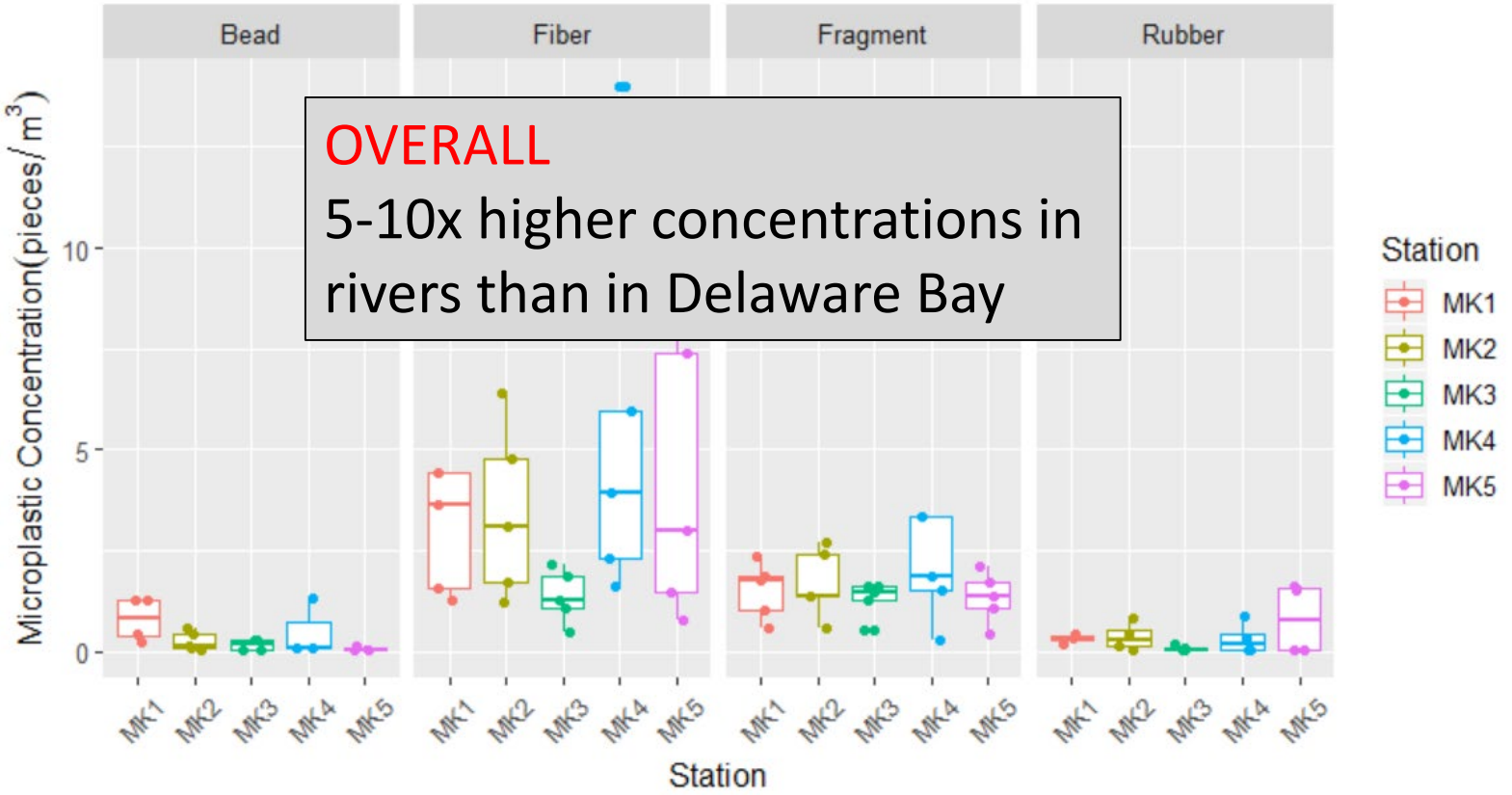


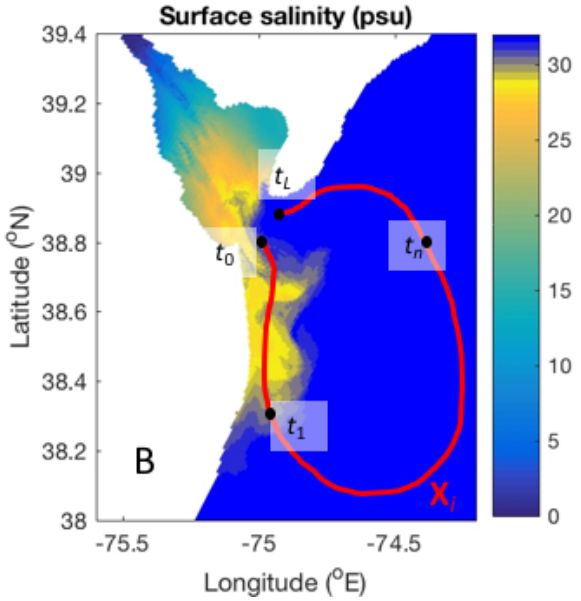
Are tidal rivers sources of microplastics to Delaware Bay?



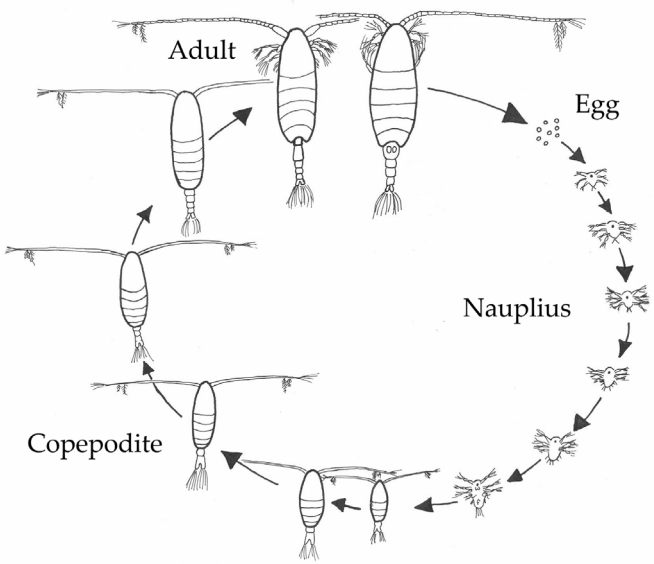
Are tidal rivers sources of microplastics to Delaware Bay?

- Fibers are most common in the river
  - In contrast to Fragments in the bay
  - Similar to other areas (e.g., Chesapeake)
- Rubber upstream by Rt. 1, Beads downstream by beach
- No strong signal from the Wastewater Treatment Plant effluent





Ecological Risk Assessment Framework



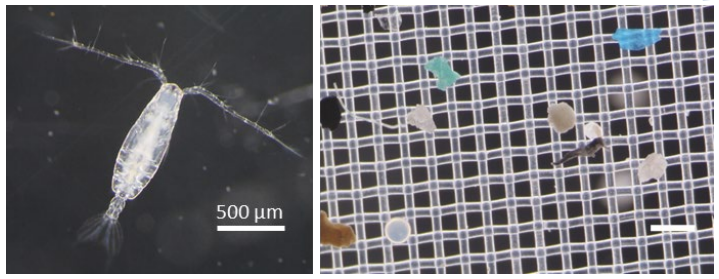
Modelling and Observations (microplastics & organisms)

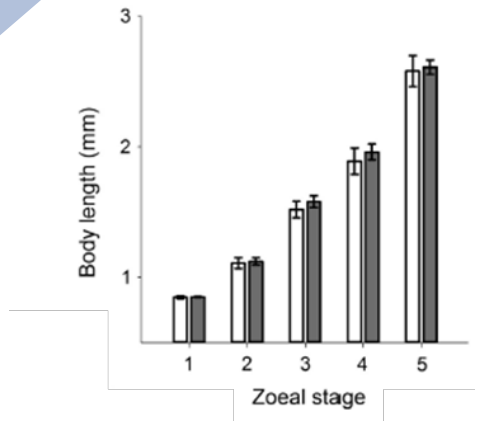
- Determines time-integrated exposure (E)

Laboratory Experiments (survival & growth)

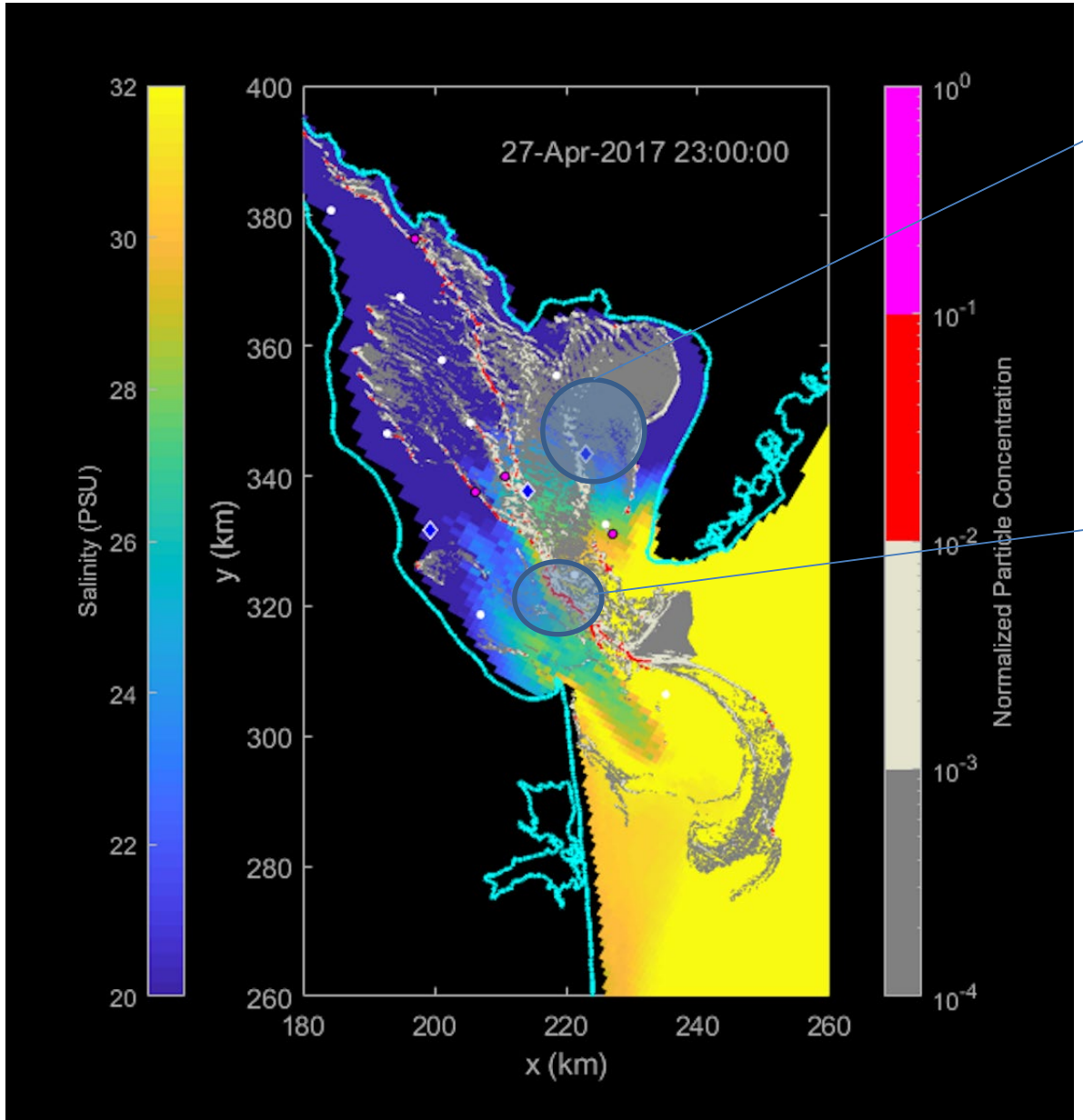
- Determines adverse response function (A)

Risk (R)

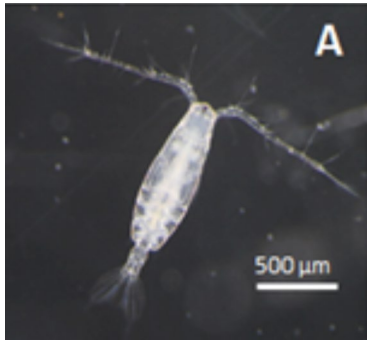




Ecological Risk Assessment for MP exposure



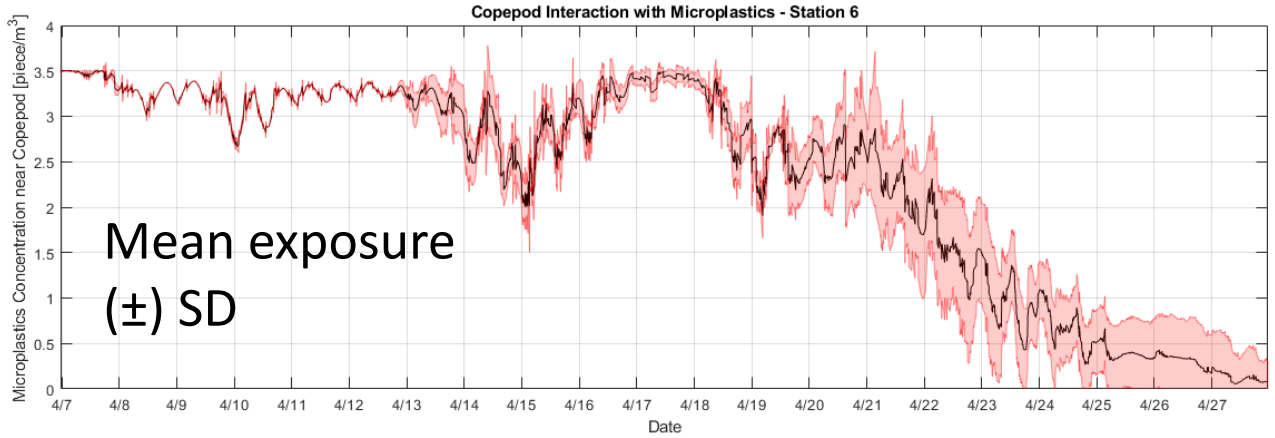
copepods
and crabs

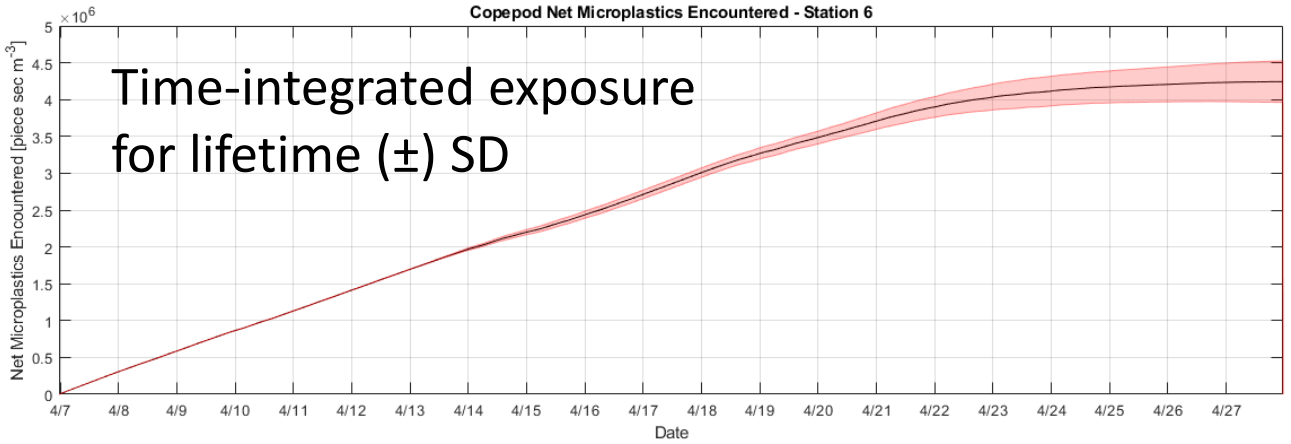


Risk =
MPMD **Exposure**
x
adverse response at a given exposure level

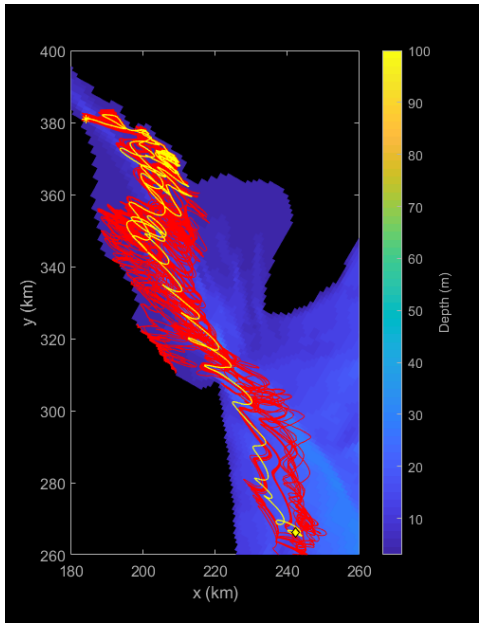
Requires: (1) assessment of MP and organism distributions and (2) adverse response functions

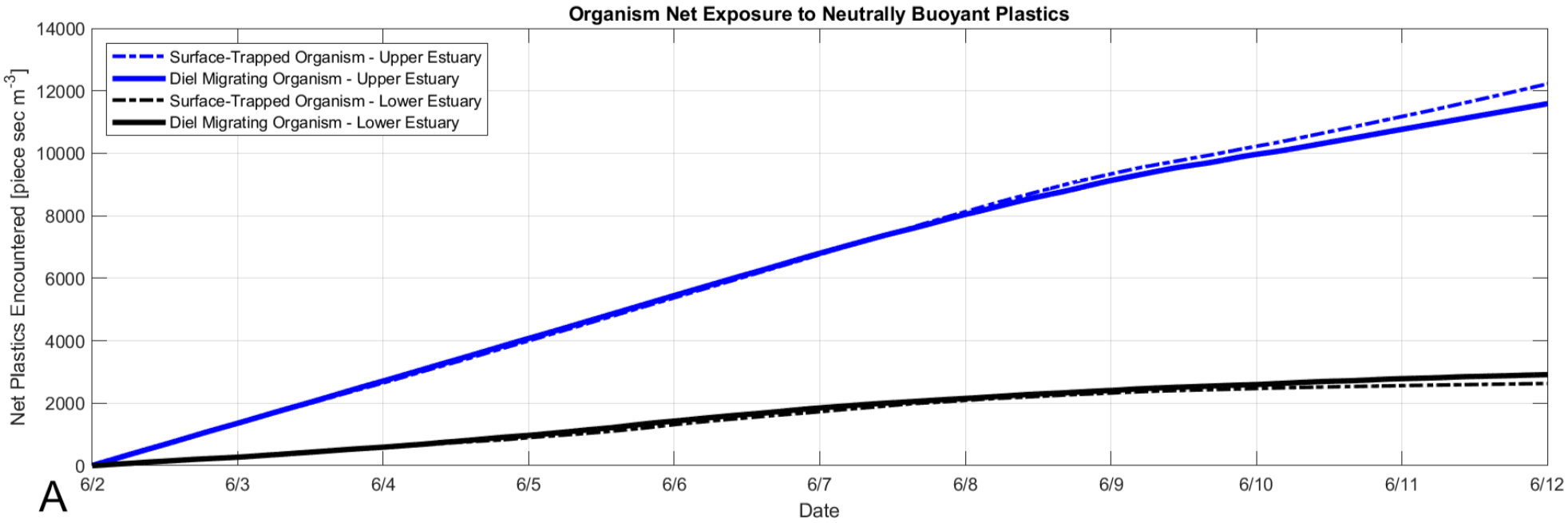
Model simulations for MP exposure in a copepod





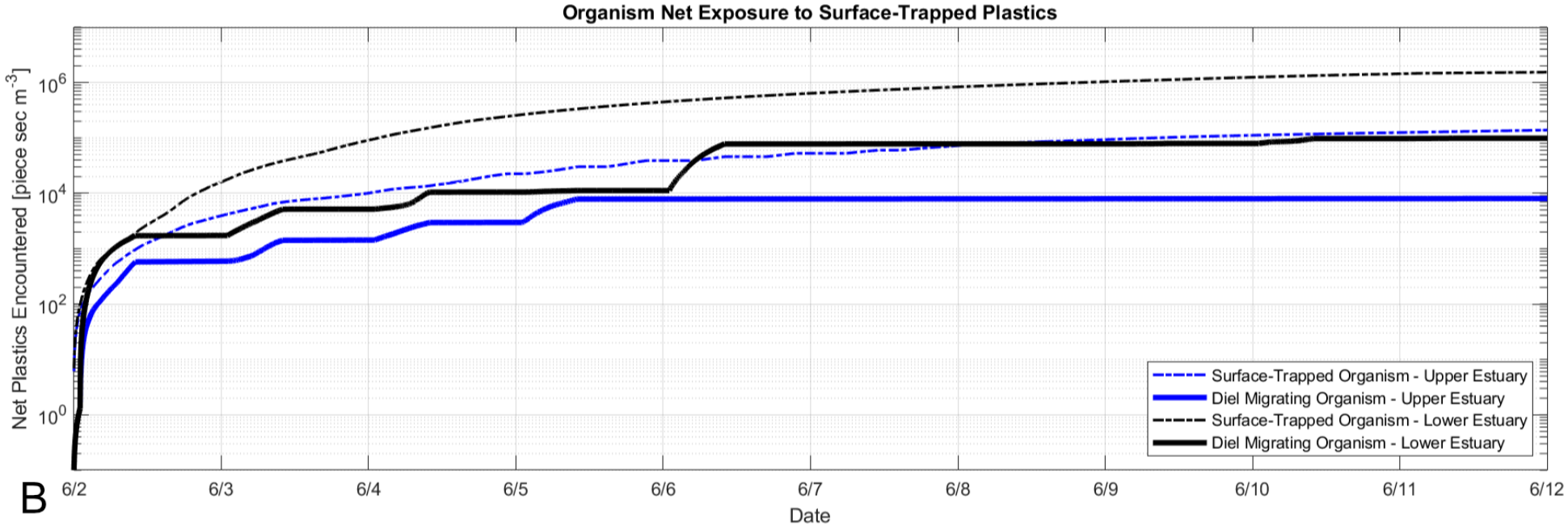
50 “copepod” tracks from one mid-Bay station





Neutrally-buoyant Plastics:

- Upper estuary exposure far exceeds lower estuary exposure



Surface-trapped Plastics:

- High exposure in lower estuary accumulation zones
- Vertical migration reduces exposure

Research going forward

- Relating land use to microplastic concentrations in waterways (sources)

- Understanding microplastics “hot spots” (fate and transport)

- Microplastic/organism interactions (ecological consequence)
  - zooplankton
  - shellfish and finfish
  - blue crabs