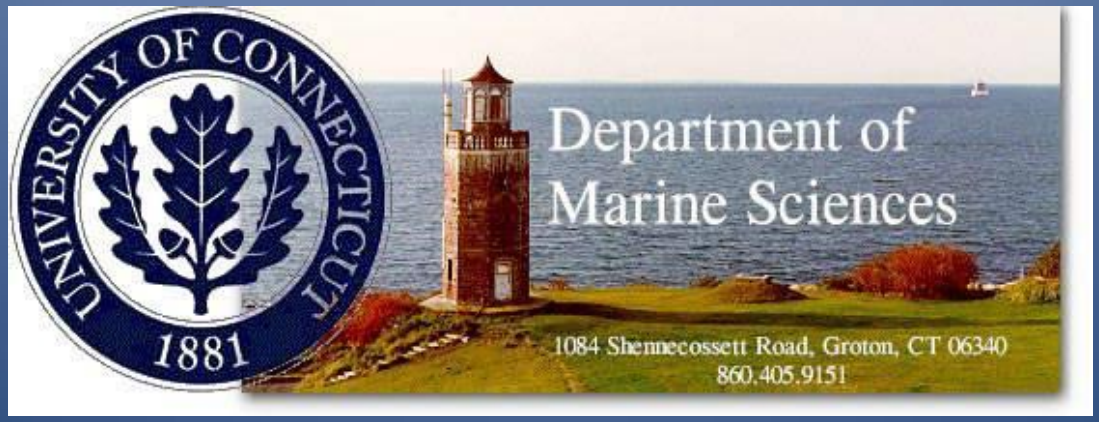
Are bivalve molluscs good indicators of microplastic pollution in the environment?

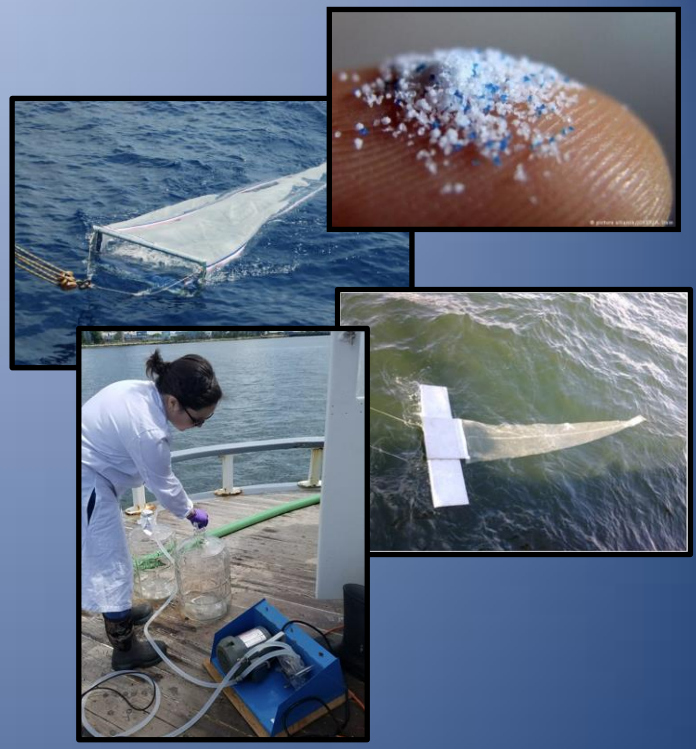
J. Evan Ward

S. Zhao, K. Mladinich, T. Griffin, B. Holohan & S. Shumway



Background – environmental concentration?

- [Microplastic] varies considerably
  - Location (population size)
  - Stochastic ocean processes
- Little standardization of sampling methods
  - Difficult and time consuming
  - Episodic

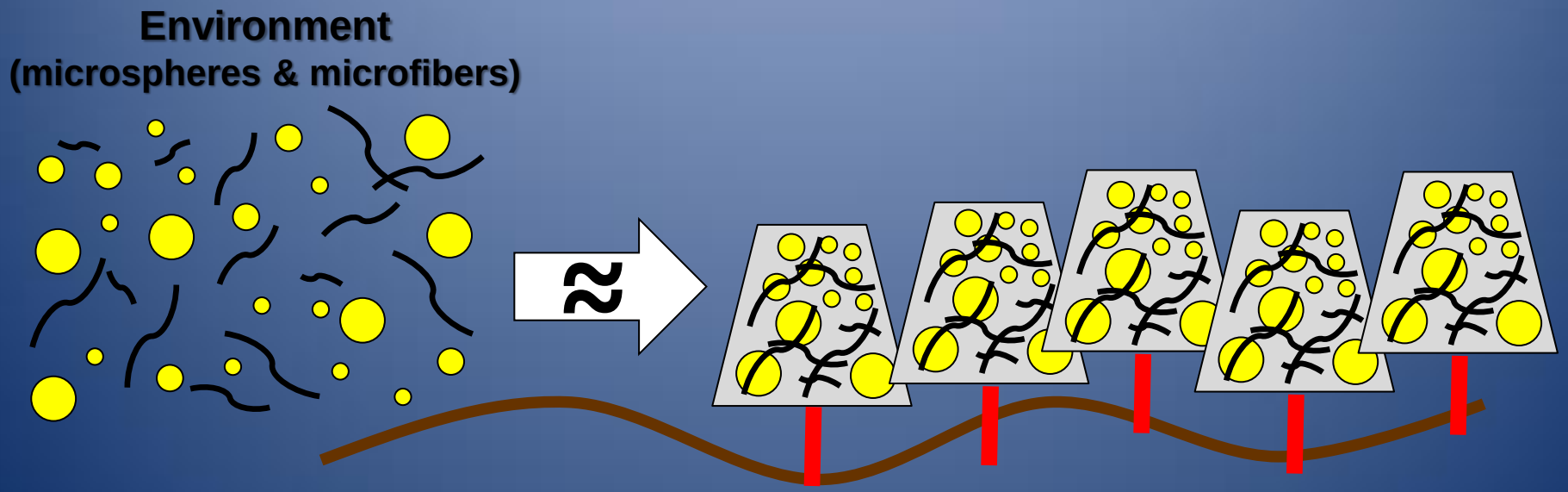


- What about biomonitoring microplastics?
  - Continuous sampling
  - Easy to collect and process
- Similar to biomonitoring of other anthropogenic materials
  - POP, Oils, Heavy Metals

Photos: Monmouth College, F. Norén

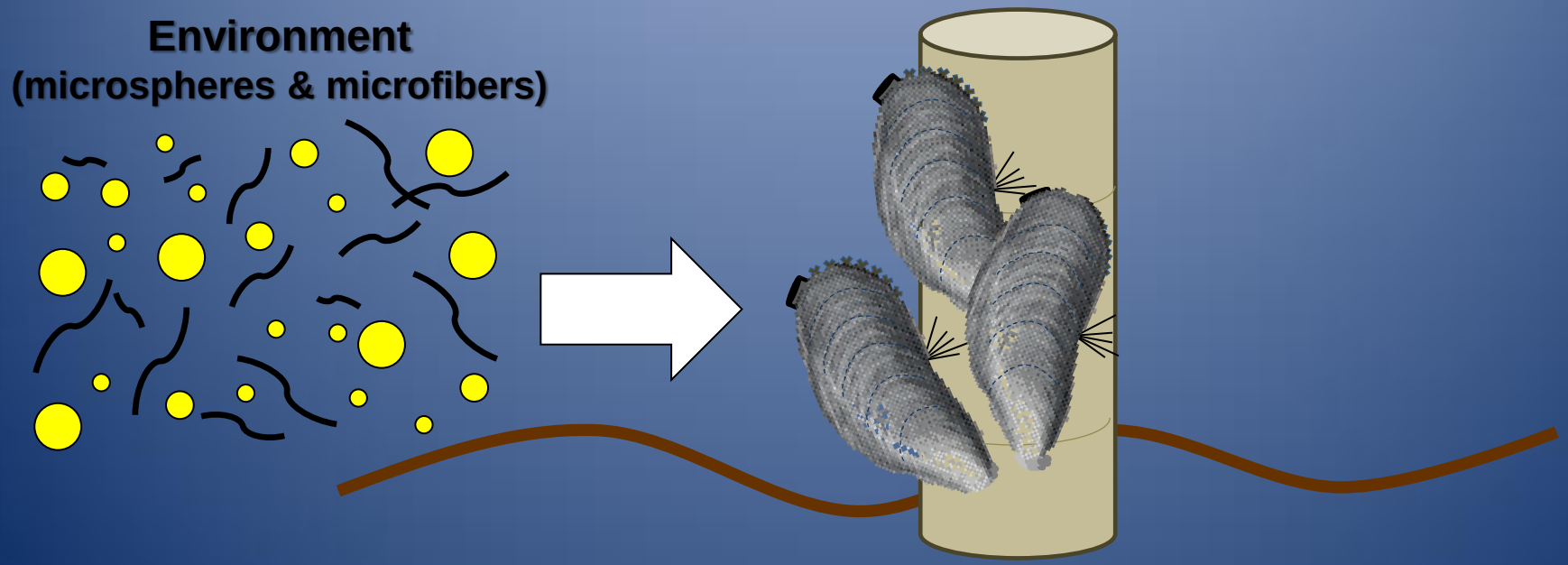
Background – microplastic bioindicator?

- Attributes of a good bioindicator
  - Sedentary (or resident)
  - Interact significantly with the surrounding environment
  - Ubiquitous and relatively easy to collect
  - Uptake, without bias, the pollutant in question



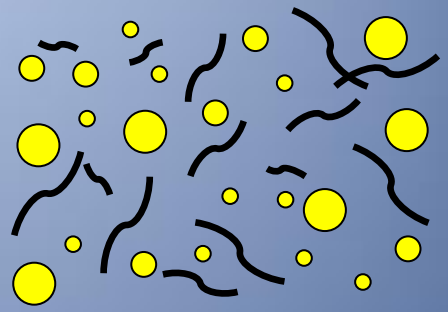
Background – microplastic bioindicator?

- What about bivalve molluscs?
  - Sedentary
  - Interact significantly with the environment (3-5 L/hr/g mass)
  - Ubiquitous and relatively easy to collect
  - Used as indicators of dissolved pollutants (mussel watch)
  - But…..do they uptake, without bias, microplastics…????

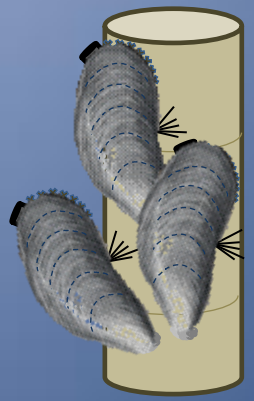


Objective

- Experimentally determine if bivalves indiscriminately ingest and egest microplastics of different size and shape

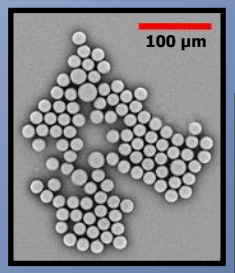


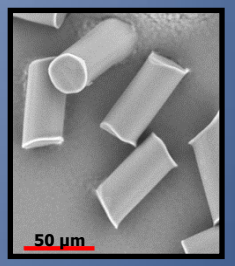
- Implications for bivalves as bioindicators



- Implications for transfer of microplastics to higher trophic levels

Methods – general





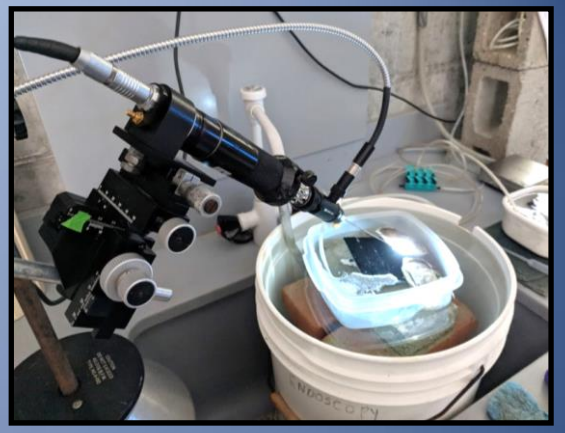
- Oysters and mussels exposed to polystyrene microspheres & nylon microfibers
  - Sphere diameters = 20, 113, 287, 510, 1000 µm
  - Fiber lengths = 75, 587, 1075 x 30 µm

- Two different experimental approaches
  - First – video endoscopy experiments (qualitative)
  - Second – feeding assays (quantitative)

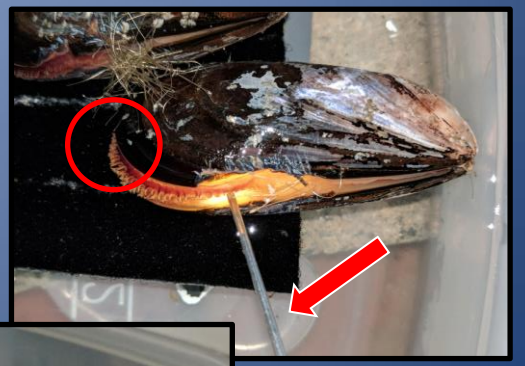
- Microplastics delivered near inhalant aperture
  - Five to six doses per animal (1 every 20 min)
  - Concentrations below excess pseudofeces production (< 735 spheres; < 495 fibers)

Methods – endoscopy exp.

- Bivalves held in 1-L chambers
  - Supplied with air
  - Fed low concentration of microalgae (<5,000 c/ml)

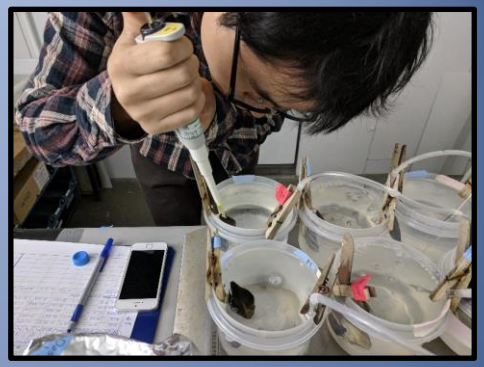


- Optical insertion probe positioned
  - Within the mantle cavity (gill and labial palps)
  - Near the pseudofeces-discharge site

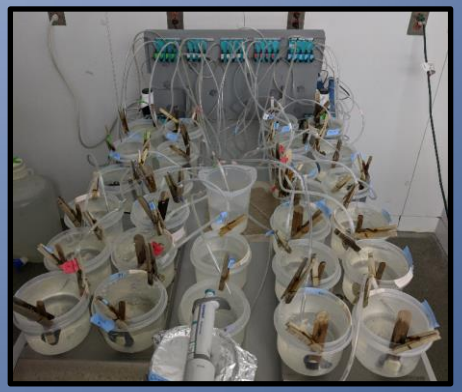


- Microplastics delivered
- Video digitally recorded and analyzed

Methods – feeding assays



- Bivalves held in individual 750 ml chambers
  - Supplied with air
  - Fed low concentration of microalgae (<5,000 c/ml)
  - Microplastics delivered



- Held in original chambers for 3 hrs
  - Then transferred to clean chambers
  - Held for additional 45 hrs (with food)

- Pseudofeces (rejecta) & feces collected
  - Stereomicroscope used for collections - critical
- Biodeposits digested (NaOH)
  - Plastic particles quantified using microscopy

Results – endoscopy

All video is real time

- Capture & transport of plastics
  - Mussel (flat gill)
  - Oyster (plicate gill)

1) **Both species capture & transport all microplastics**
2) **Oysters select plastics on gill**

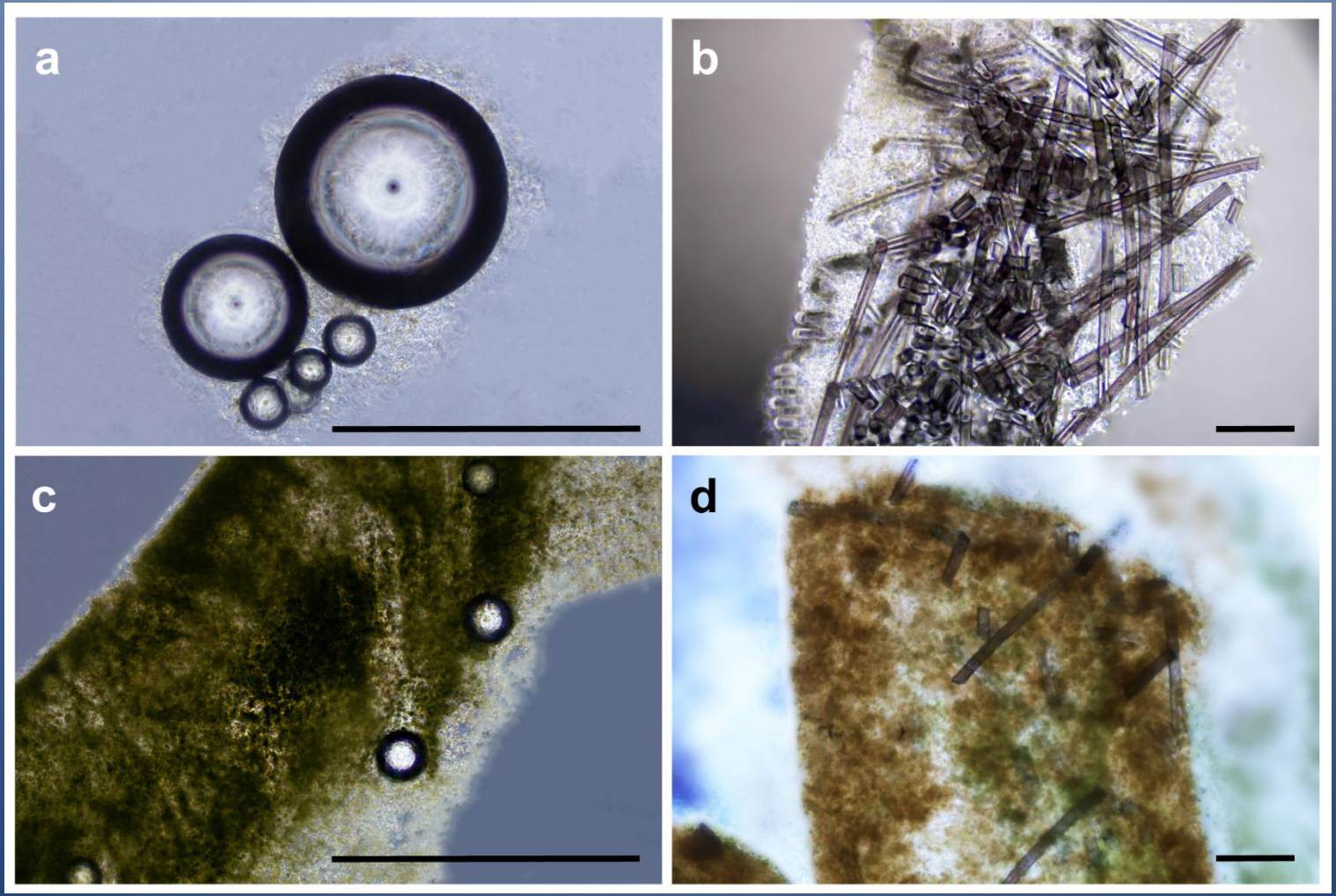
- Rejection of plastics

Mussel

Oyster

1) **Rejection occurs within minutes of exposure**
2) **Pseudofeces too small to be seen by unaided eye**

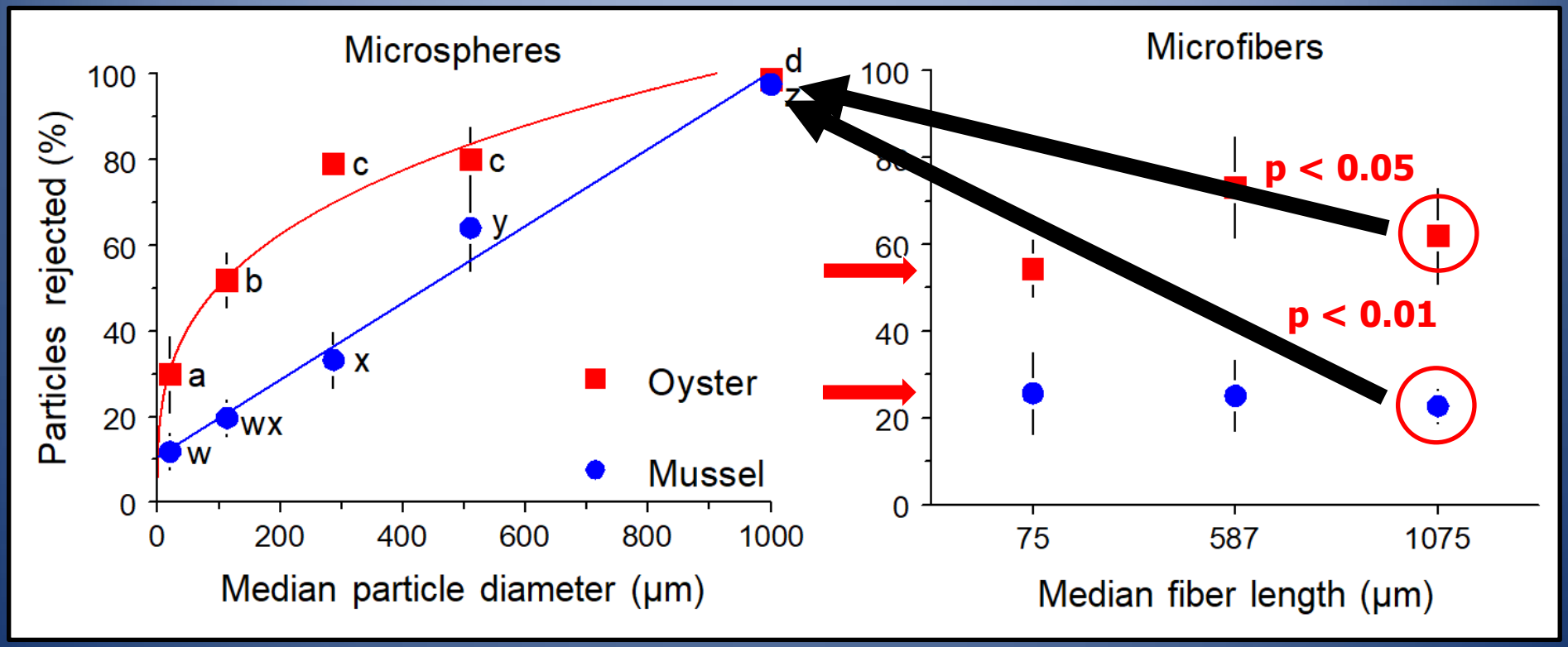
Results – feeding assays (biodeposits)



Scale bars = 200 µm

Results – feeding assays

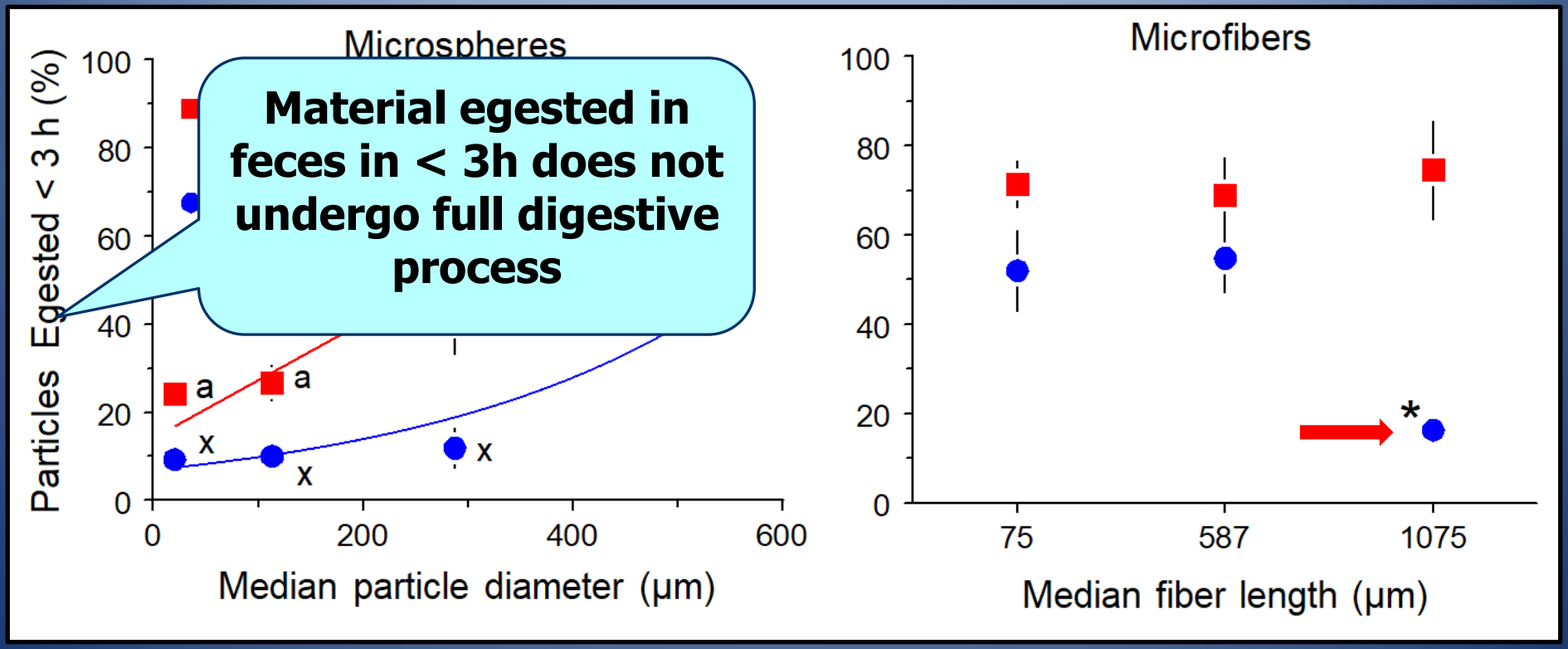
- Rejection of microplastics in pseudofeces



Data are means +/- SE (n = 7-11 oysters and 8-10 mussels); Tukey HSD test

Results – feeding assays

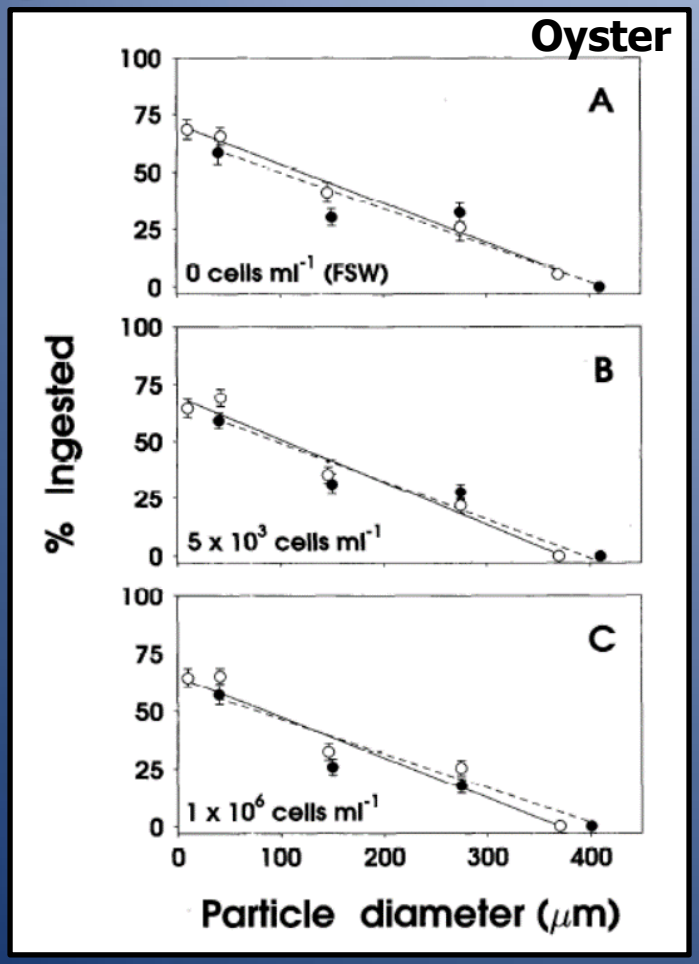
- Egestion of microplastics in feces in < 3 hr



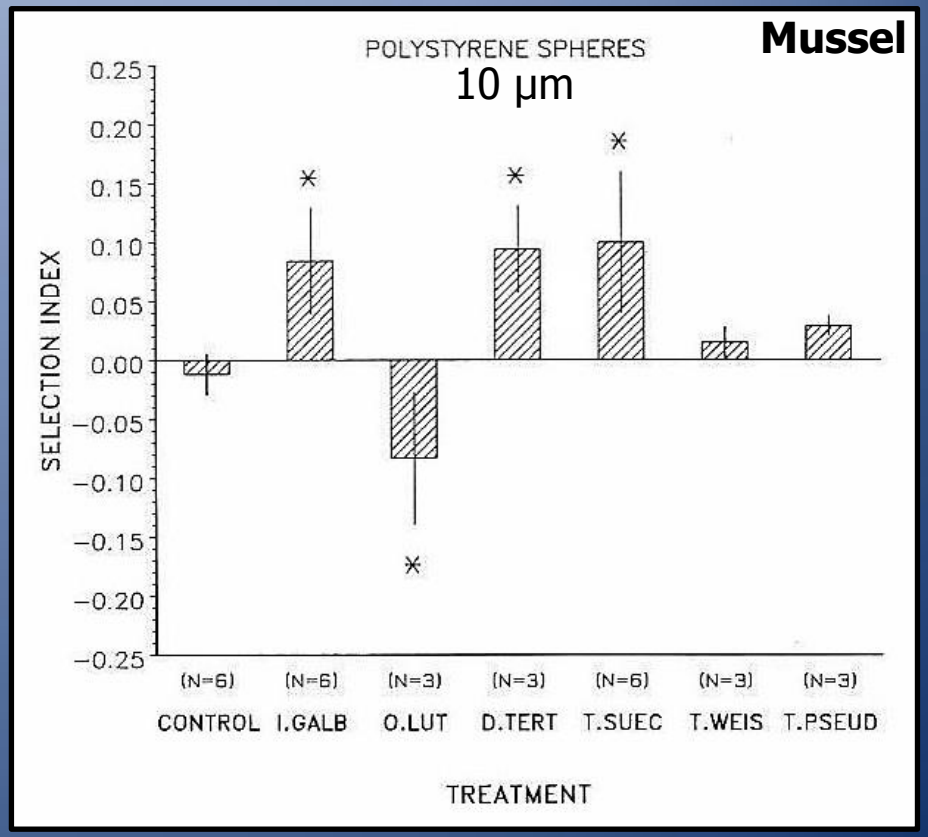
Data are means +/- SE (n = 7-11 oysters and 8-10 mussels); Tukey HSD test

Other evidence – lab studies

- Similar results found for plastic & glass



- Ingestion / rejection depends on coating



Left: Tamburri & Zimmer-Faust 1996; Right: Ward & Targett 1989

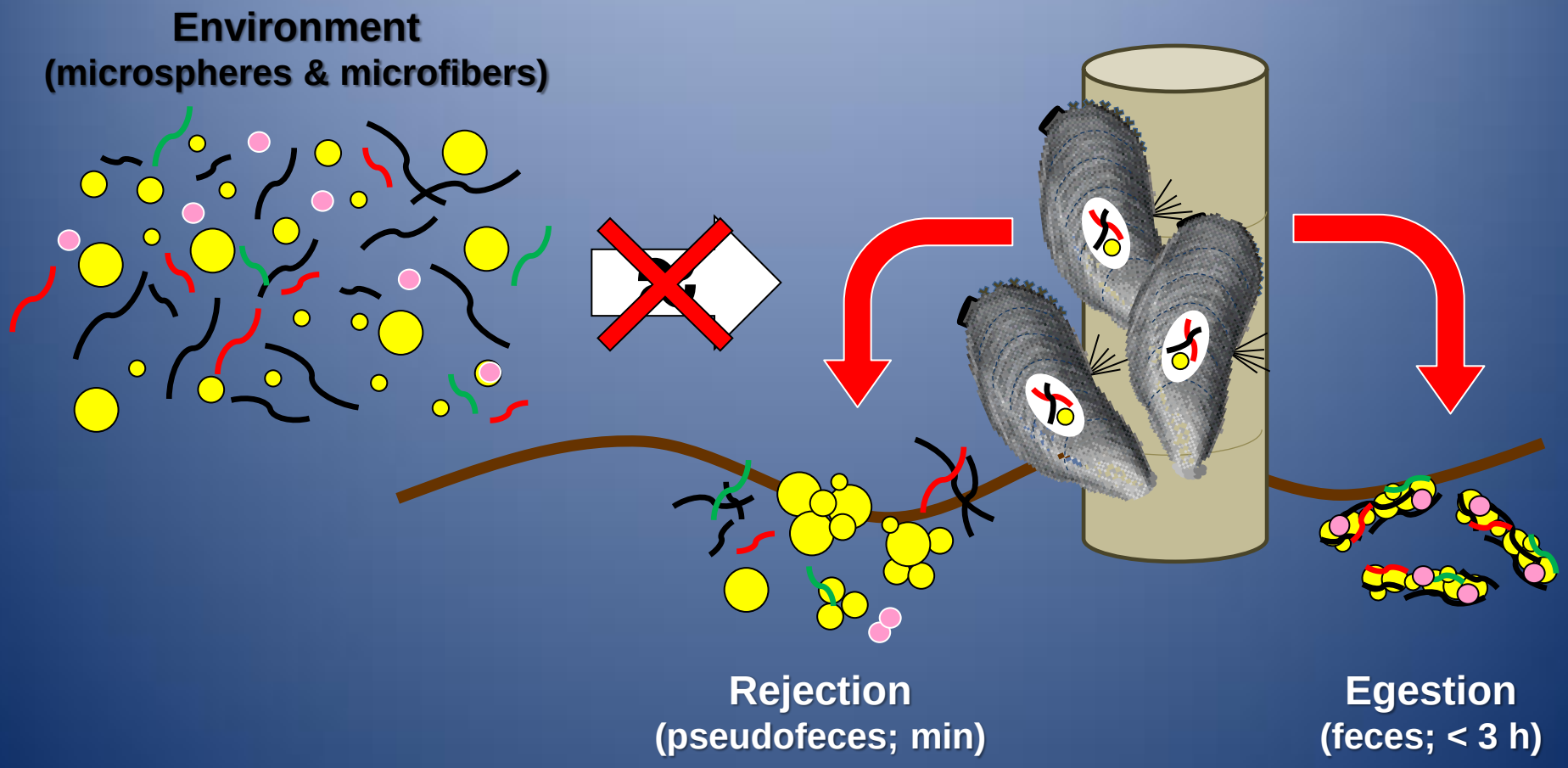
Other evidence – field studies

- Microplastic in the environment
  - Water & aggregates (in 76%: 1.3 particles/L)
  - Mussels (0-2 particles/animal)
  - Zhao et al. 20[illegible]3 (ES&T)
- Theoretical uptake of microplastics *in situ*
  - Considering mussel size, temperature & pumping rate
  - Mussels could clear/ingest 25-45 particles/day

Raman & FTIR analyses

Perspective

- Movement of plastic particles into and out of mussels is rapid



Conclusions

- Bivalves capture and process a wide range of microplastics
  - But only a fraction of the particles are ingested
- Pseudofeces is produced even at low particle concentrations
  - Much cannot be seen with the unaided eye
- Ingestion and egestion depends on particle size and shape
  - Low-aspect ratio particles – small ones ingested & retained longer
  - High-aspect ratio particles – no differences with length
    - still 25% to 55% rejected & > 50% rapidly egested
- Bivalves are not good bioindicators of environmental microplastics
  - Complexity of bivalve feeding needs to be considered

Future questions

- Which types of plastic particles are more likely ingested?
  - Ongoing: particle shape, polymer type, surface characteristics
  - Ongoing: developing model to predict ingestion
- Which suspension feeders would be good bioindicators of MP?
  - Ongoing: investigation into particle selection capabilities
- What is the environmental fate of MP-laden biodeposits?
  - Implication for deposit feeders

Acknowledgements

- **Assistants**
  - **Jenn Wozniac (Undergraduate)**
  - **Vena Haynes (Graduate Student)**

- **Funding agency**
  - **NOAA, Marine Debris Program**
  - **USDA, National Institute of Food and Agriculture Program**

Background – environmental concentration

- Varies considerably
  - Location (population)
  - Stochastic ocean processes
- Little standardization of methods
  - Sampling
  - Extraction & isolation
  - Identification
- Verified concentrations
  - ca. < 1 to 5 particles / L
  - Zhao et al. 2018 (ES&T)