An assessment of microplastic impacts on the health of the *Centropristis striata* fishery

http://www.ncfishes.com/families/serranidae/

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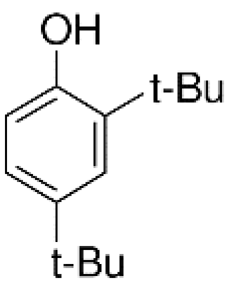
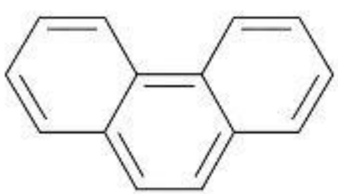
Microplastics

- Plastic production far outpacing capacity for disposal, recycling, or reuse
- Hundreds of species affected by marine debris (entanglement, ingestion)
- Primary and secondary sources of micro and nanoplastics (<5 mm)
- Tendency to accumulate in coastal zones, estuaries
- Potential vector for associated primary and secondary pollutants
- Evidence for sublethal effects.

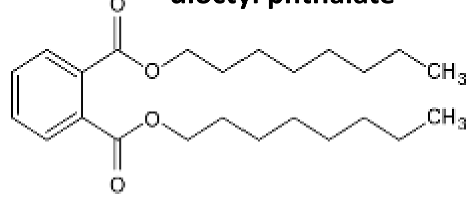


2,4 DTBP

phenanthrene



dioctyl phthalate



Jambeck et al. 2015; Andrady 2011, Rochman et al. 2013; Brander et al. 2011

https://www.theepochtimes.com/scientist-we-could-be-inhaling-microplastics-laden-with-chemicals_2087885.html

Black sea bass

Figure 1. Sites sampled for wild black sea bass (*C. striata*).

- *Centropristis striata* are a widely distributed temperate reef fish
- Occur from Maine to the Gulf of Mexico
- Estimates of stock size are difficult to make, are hermaphrodites
- Important fishery, cultured for seafood
- Grazes opportunistically on a wide range of prey, 5 yr life span
- Utilize estuaries as nursery habitat
- Sensitive to pollutants
- Human health implications

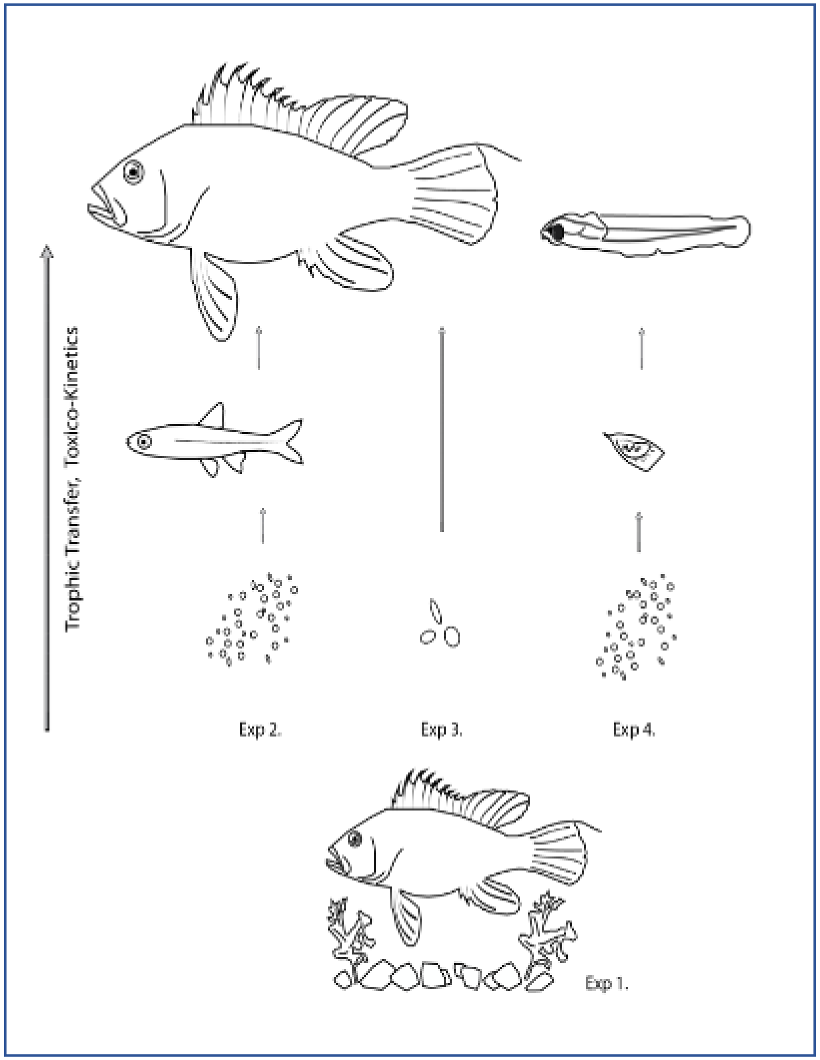
Gravato and Santos 2002; Rabalais 2015

Research objective

To investigate microplastic ingestion, bioavailability, trophic transfer, effects and toxicokinetics in a commercial fishery species in the laboratory and field.

Project design

- Experiment 1. collection of wild sea bass,



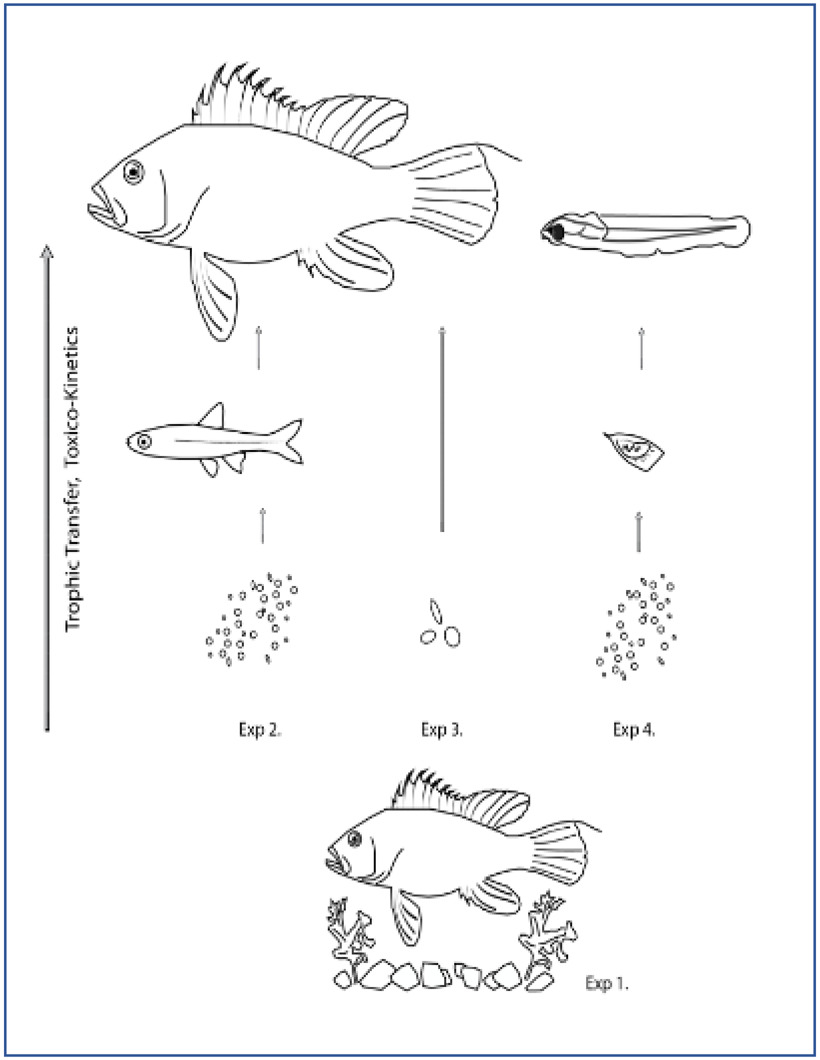
Project design

Wild sea bass – plastic ingestion, condition index

Juvenile sea bass (lab) – gut /gill accumulation from water and prey, respiration, immune response (96 hr exp)

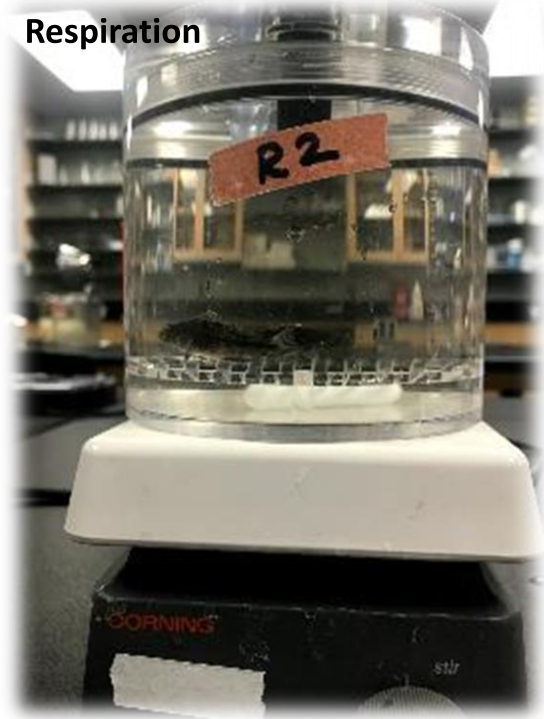
Adult sea bass (lab) – fed pellets (2-3 mm), clean vs. biofilm, 0 vs 10% phthalate, gene expression (120 hrs)

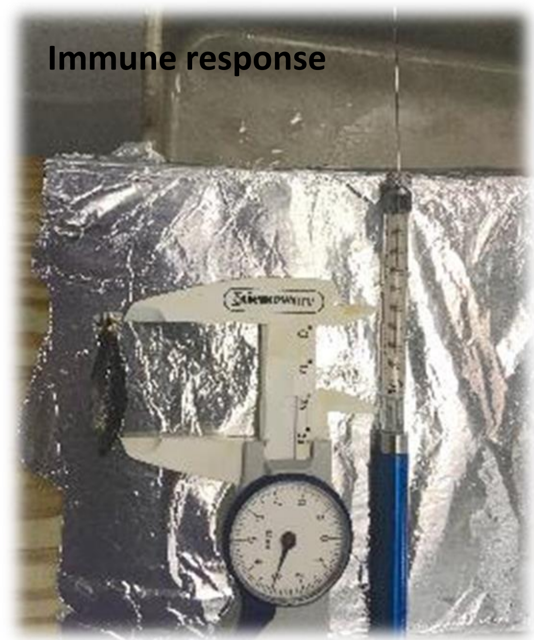
Larval sea bass (lab) – quantified ingestion from water and prey (2 hr exp)

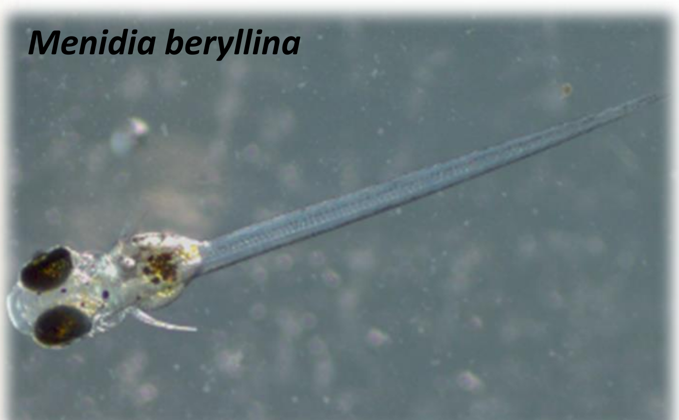


Project objectives

- Assess plastic ingestion in a commercial fishery species in field and laboratory
- Study of sublethal effects in the in lab (immune response, respiration)
- Acquisition of microplastics from water and from prey
- Potential for pollutant leaching from plastics in adult sea bass

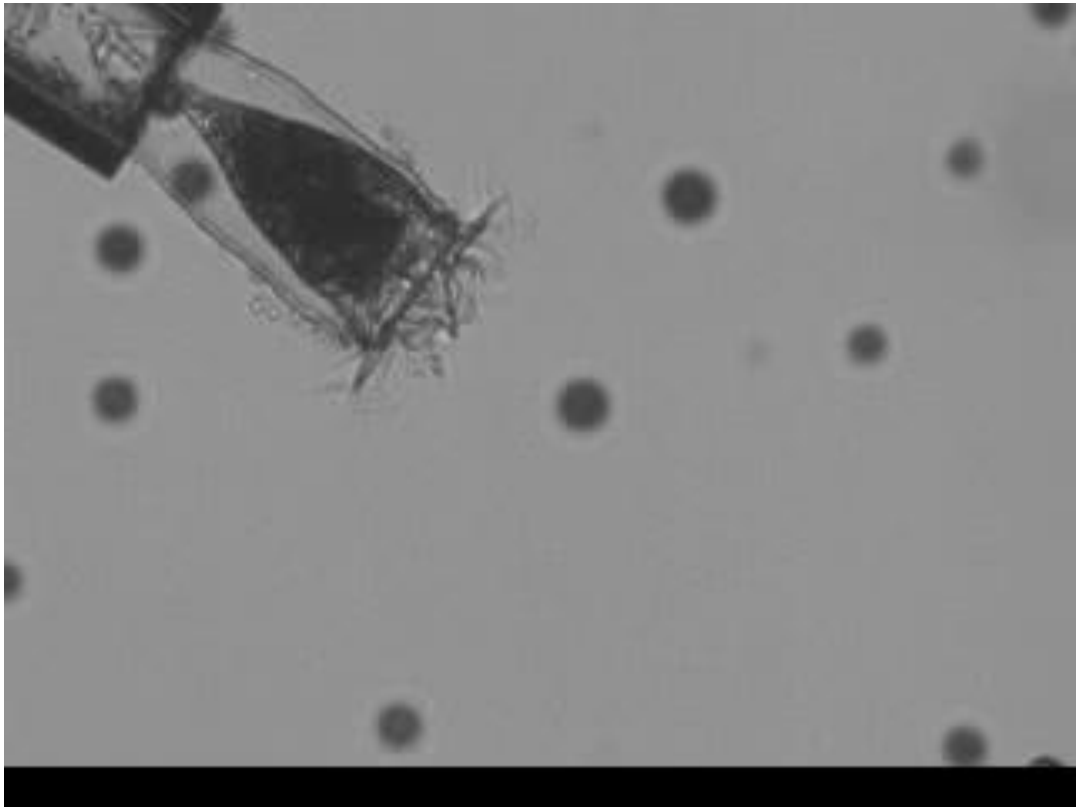






Athey et al. in prep (planned submission to Limnology and Oceanography)

Project prey



Tintinnid ciliates found globally

Common microzooplankton prey item of larval fish (100 micron)

Single celled protozoan

Potentially important vector for microplastics in estuarine and marine food webs

Appear not to eject particles once ingested

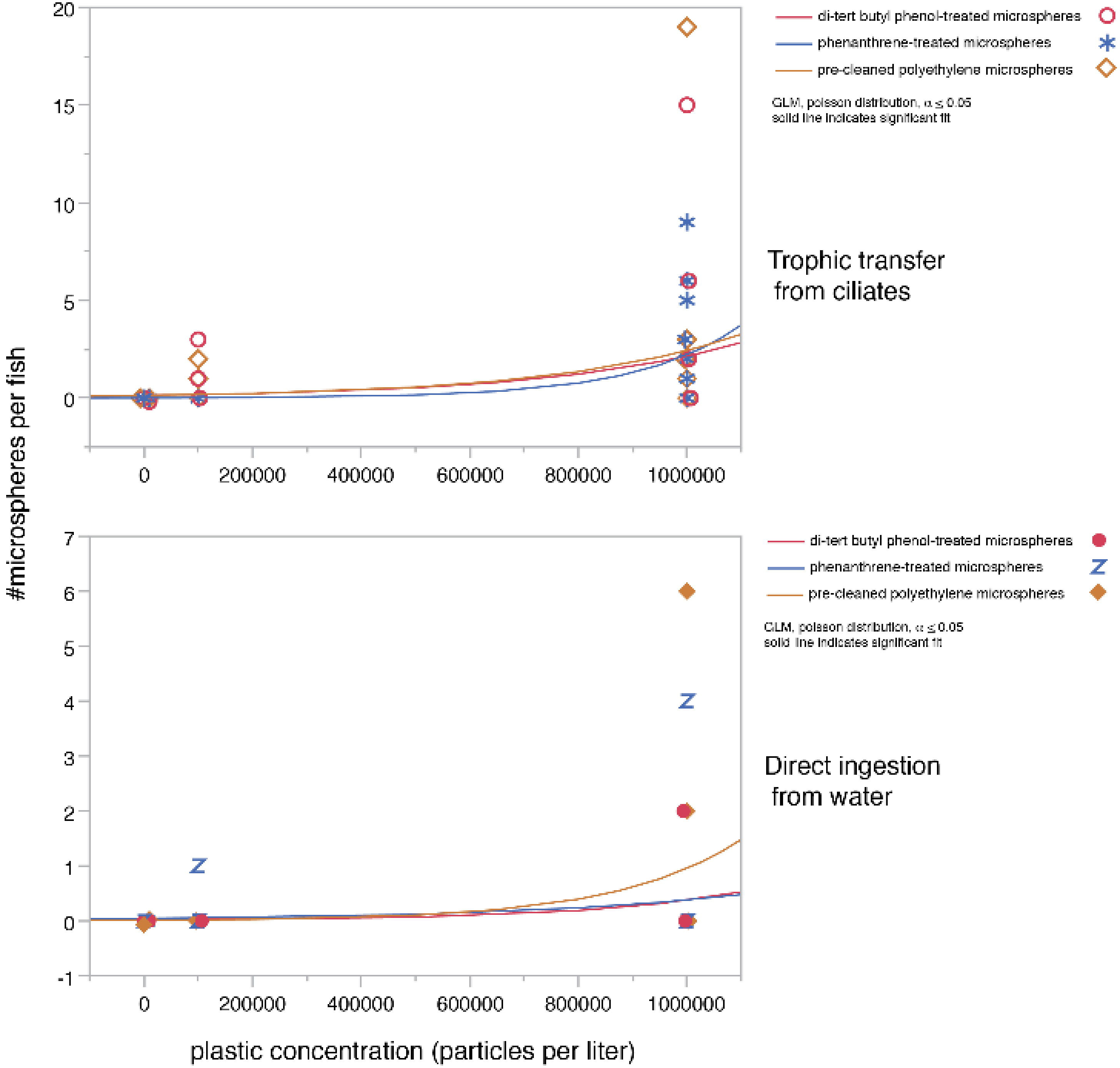
Do not discriminate between contaminated and “clean” microplastic particles

Setala et al. 2014; Zingel 2012; Echevarria et al. 2014, Athey et al (in review)

Outline

- Results: Larval ingestion
- Results: Juvenile respiration
- Results: Juvenile immune response
- Results: Adult ingestion, phthalate chemistry
- Results: Macro and microplastics in wild fish
- Conclusions
- Future directions

Results – Cultured larvae Ingestion



3 concentrations used:

10,000 / liter

100,000 / liter

1,000,000 / liter

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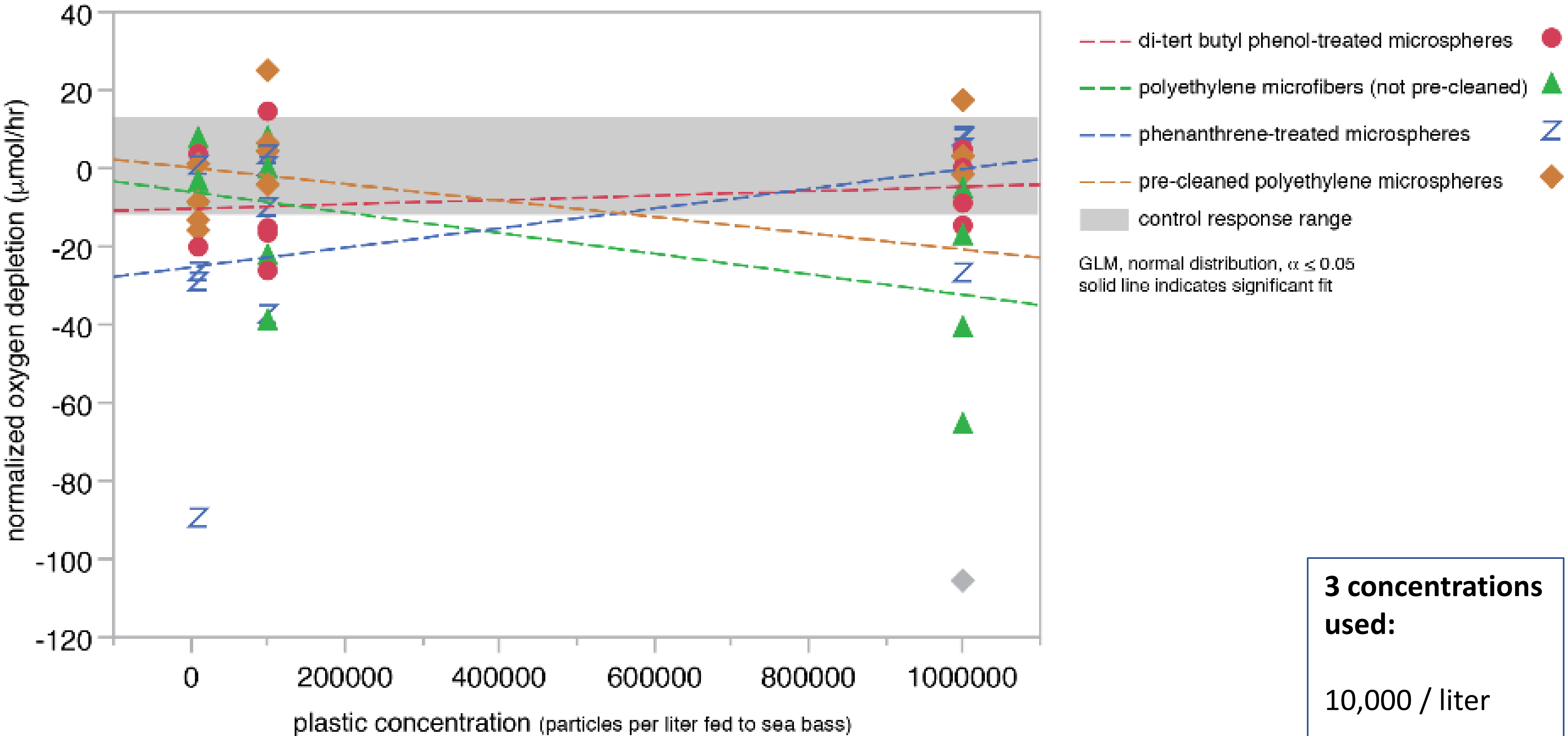
Results – Cultured juveniles
Respiration, direct ingestion



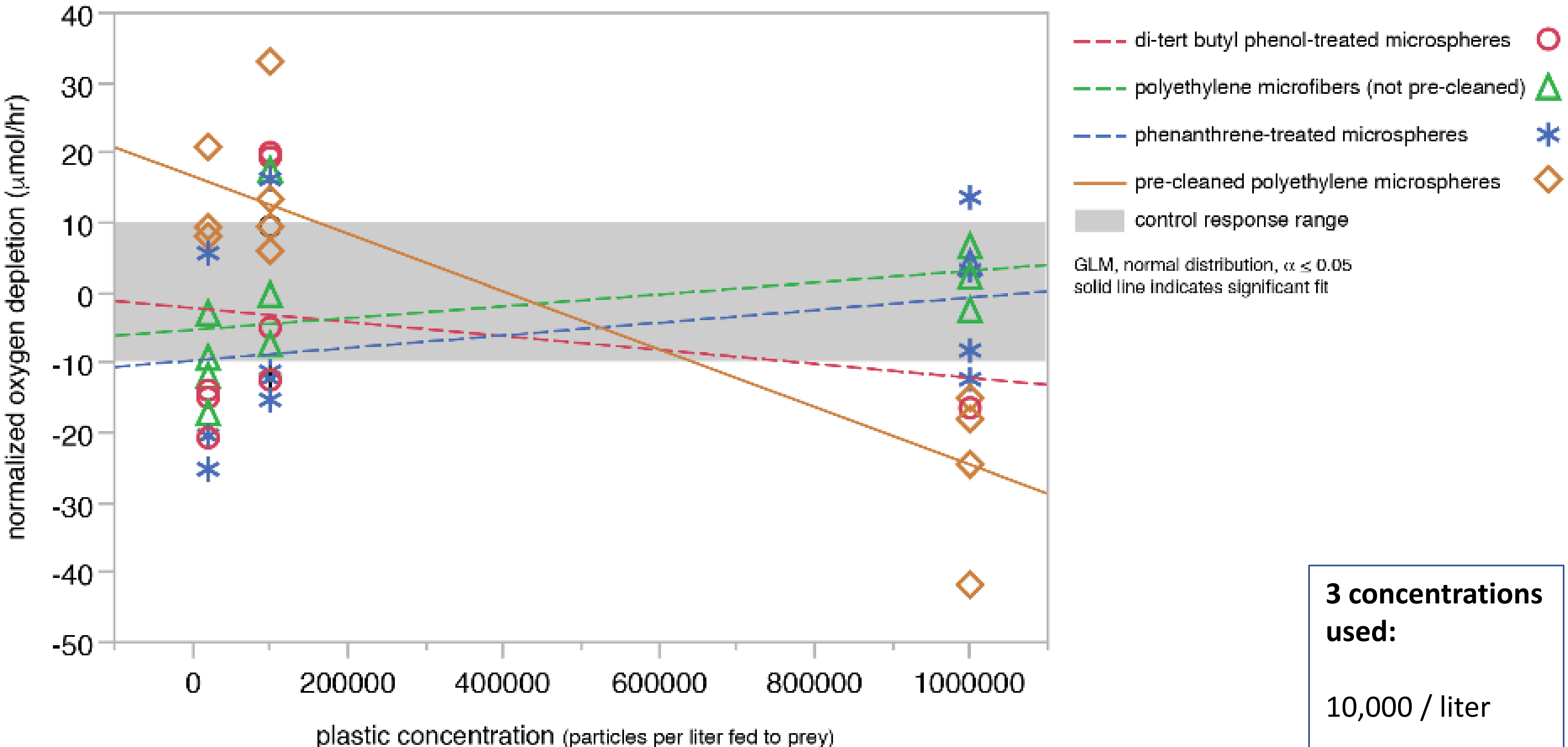
3 concentrations used:

10,000 / liter

100,000 / liter

1,000,000 / liter

Results – Cultured juveniles
Respiration, trophic transfer



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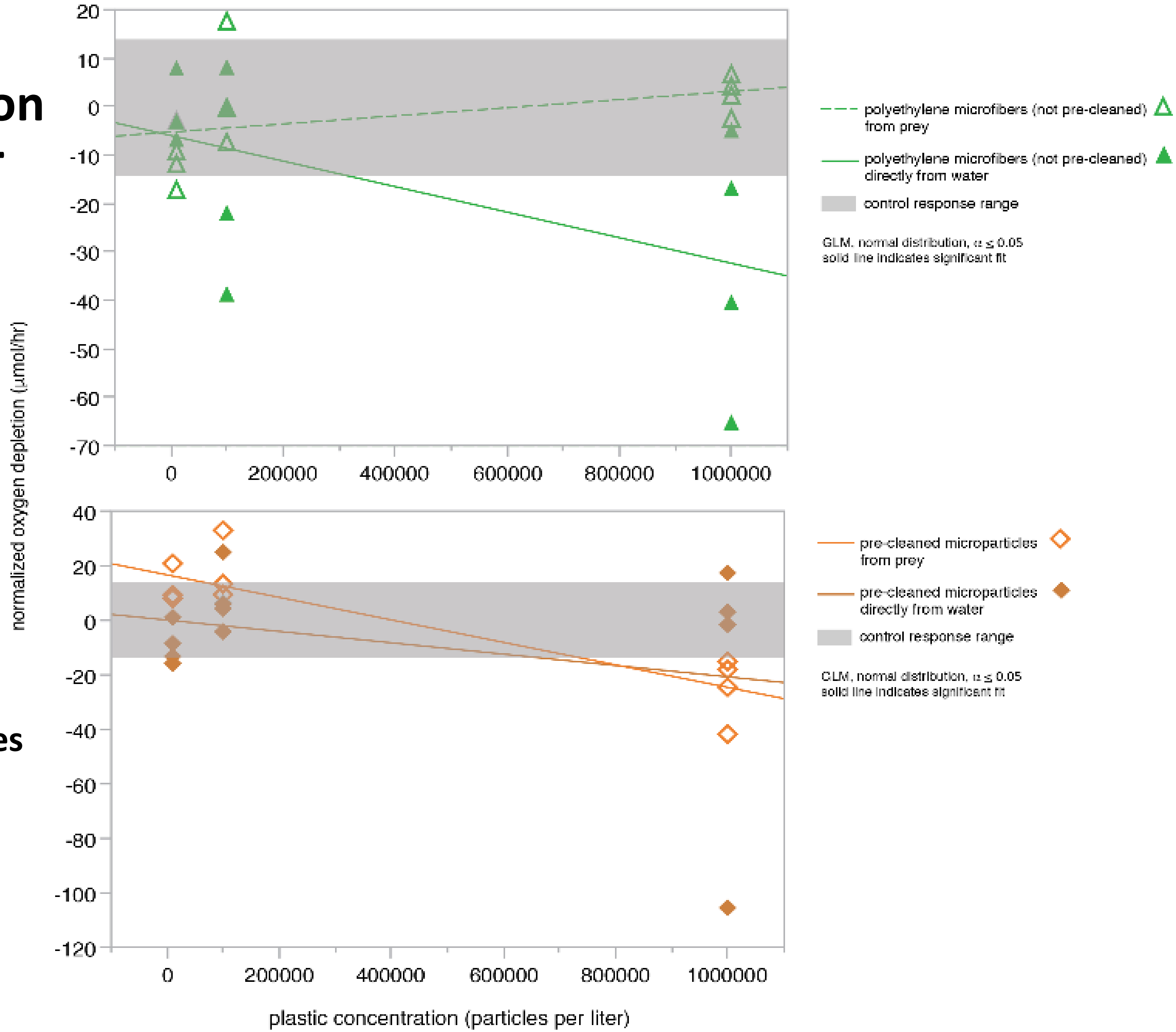
Results respiration DI vs. TT

Microfibers

Pre-cleaned microparticles



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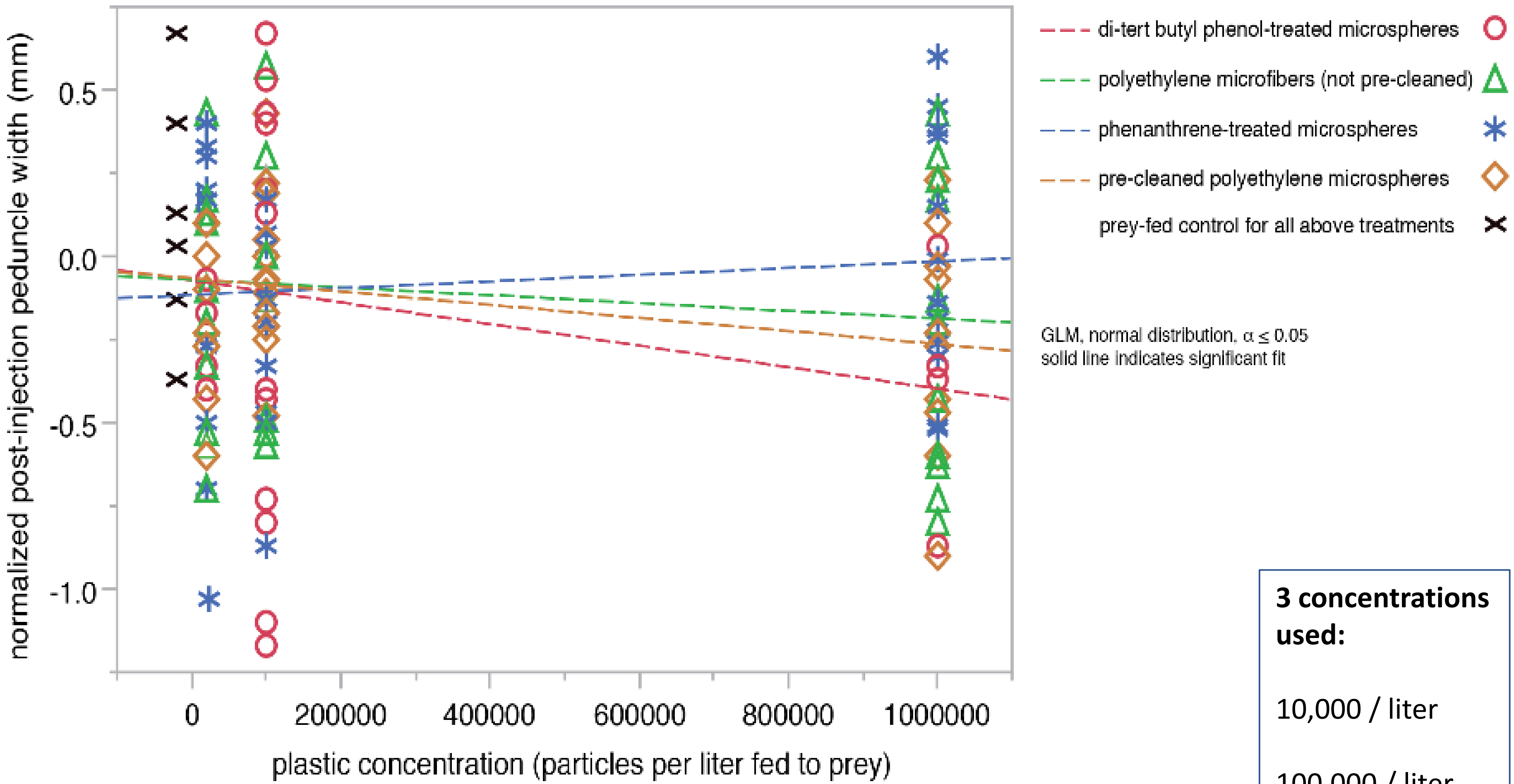
Results – Cultured juveniles
Immune response, trophic transfer



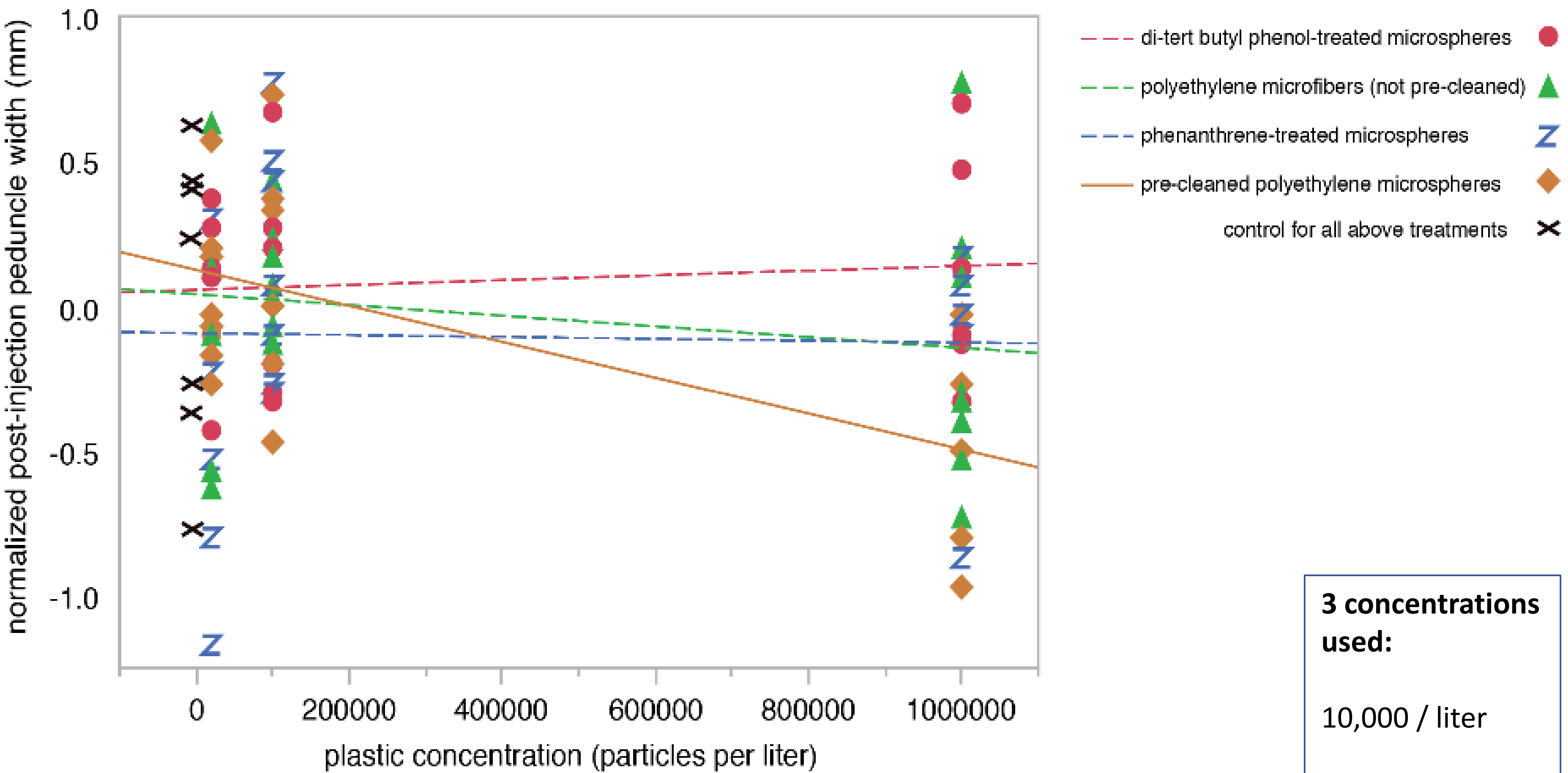
3 concentrations used:

10,000 / liter

100,000 / liter

1,000,000 / liter

Results – Cultured juveniles
Immune response, direct ingestion



3 concentrations used:

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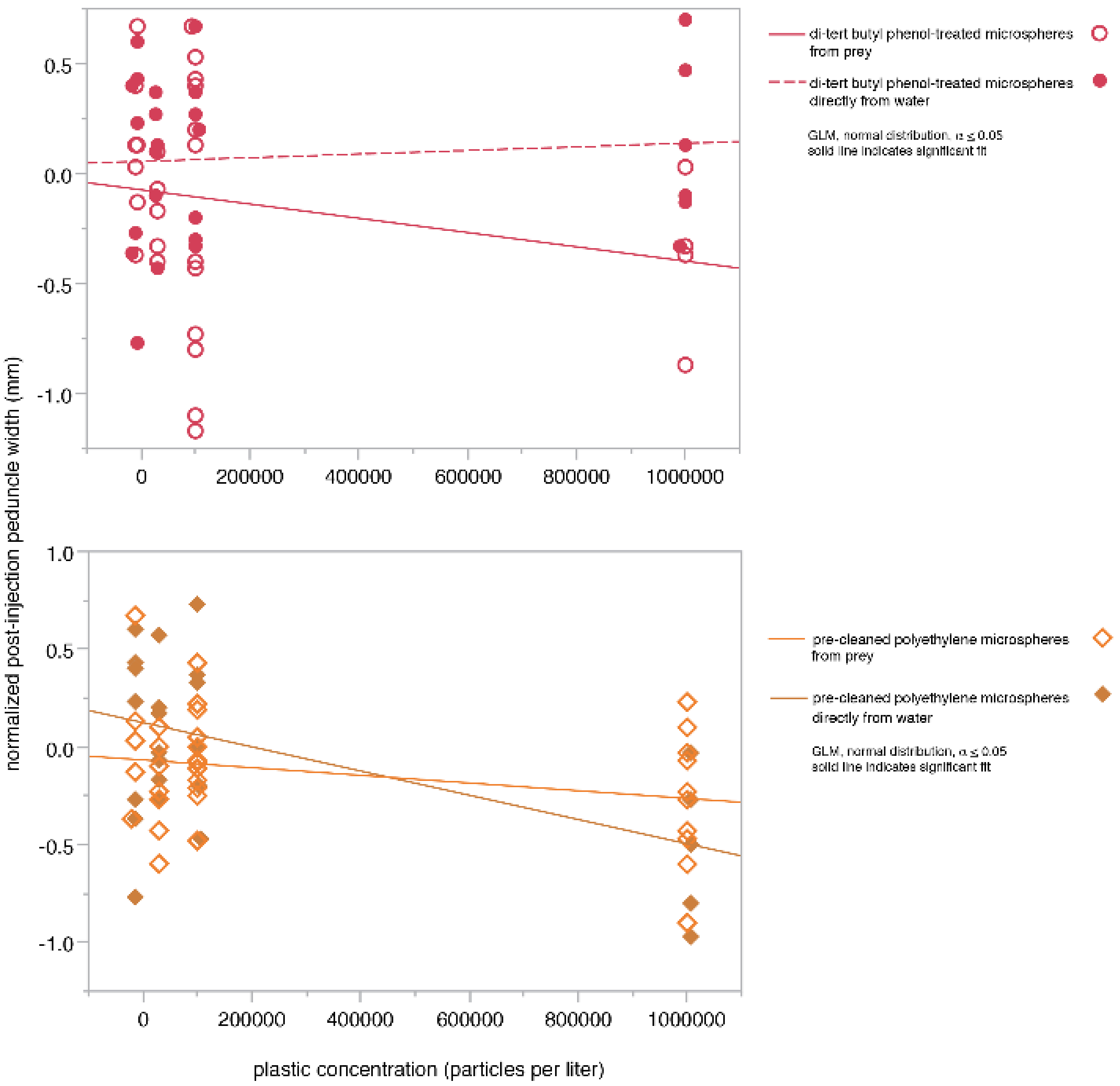
Results

Immune response

DI vs. TT

DTBP

Pre-cleaned microparticles



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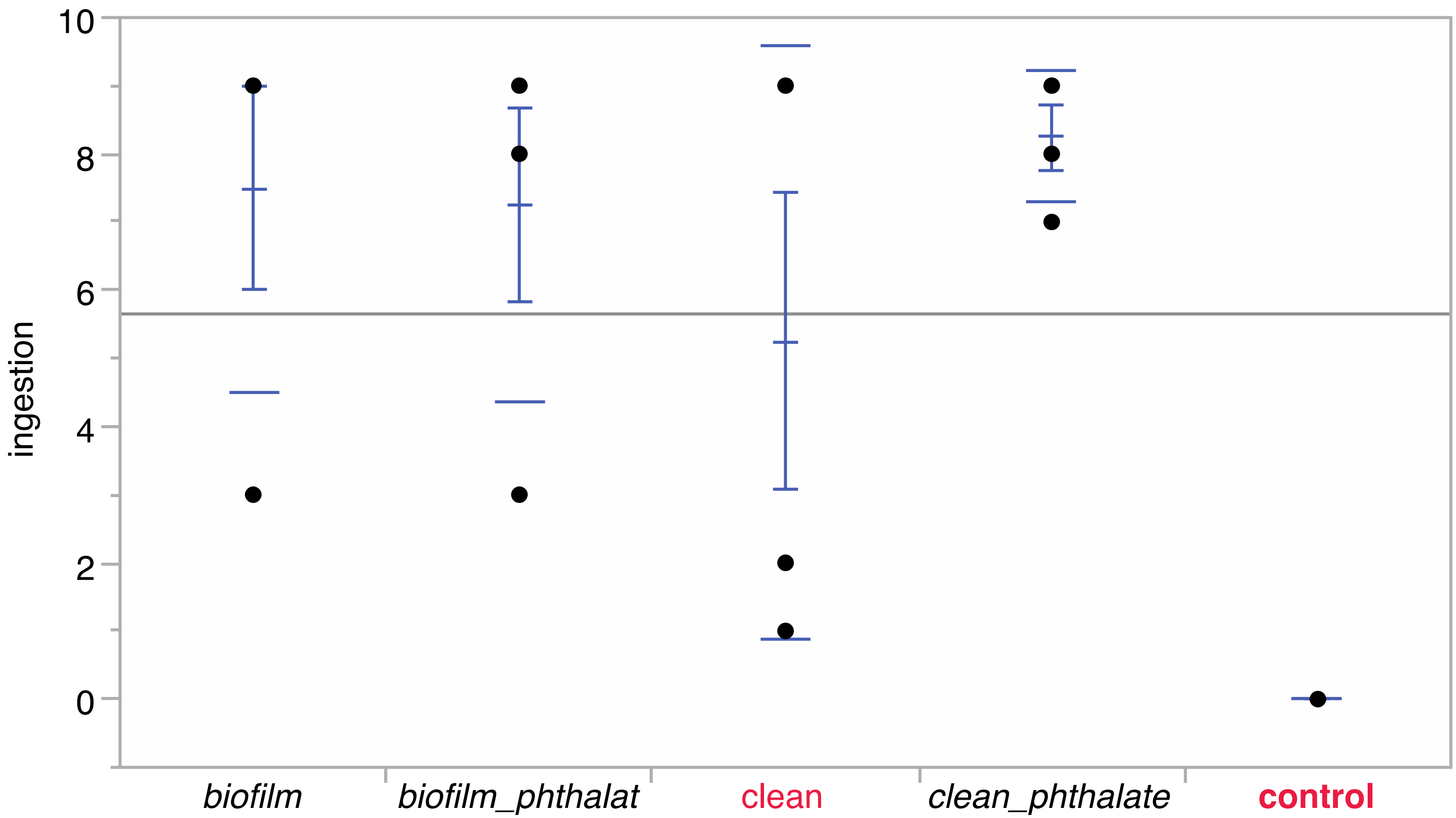
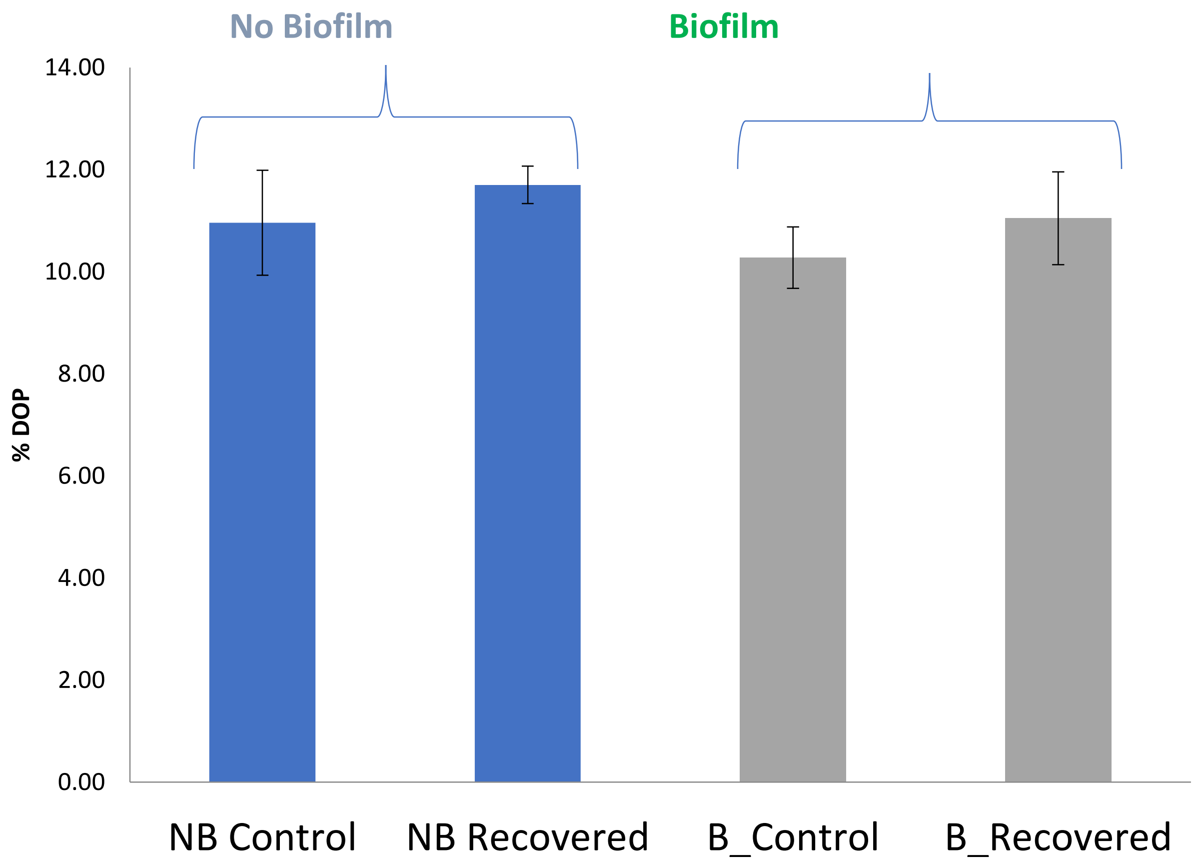
Results
Pellet feeding



Clean pellet treatment not significantly different from control (no plastic).

Dunn's comparison, $\alpha = 0.05$, non-parametric JMP

Results
Di-octyl-phthalate leaching



P values from t-test:

No bofilm pellets: 0.294
Biofilm pellets: 0.204

Phthalate levels on both no biofilm and biofilm pellets are not significantly different in control vs. recovered PVC pellets

Outline

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Results – Wild sea bass
Plastic ingestion, analytical chemistry

Polyethylene terephthalate (PETE)
- Bottle production, clothing.

Dibutyl phthalate

Ramen, ATR-FTIR, GC-MS

Polyvinyl alcohol (PVA)
- Used in sport fishing, PVA capsules filled with bait.

Found in two fish

Ramen and ATR-FTIR

<u>Microplastics :</u> Our preliminary analysis identified over 60 particles from 102 samples processed (Figure 12) and the classification was based on color, shape, and morphological properties. Based on the shape, we grouped them into several types and the percentage of each type is shown in pie chart (Figure 13). Our results showed approximately 60 % as fibers, which is comparable to what others have observed. Further analyses are required for the unambiguous identification of collected particles as microplastics.

Figure 12: Photographs of possible microplastics collected from the digestive tracts of wild-caught sea bass a) green particle, 63 um filter , 3x mag. b) yellow strand, 1 mm filter , 1x mag. c) light blue fiber, 5 um filter, 4x mag. d) transparent film, 1 mm filter, 1x mag. e) fragment, 5 um filter, 4x mag.

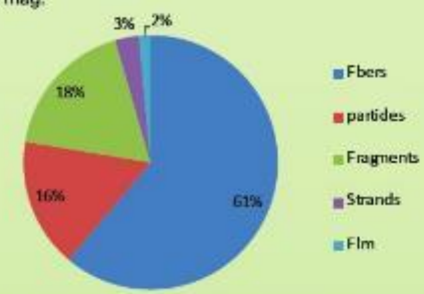
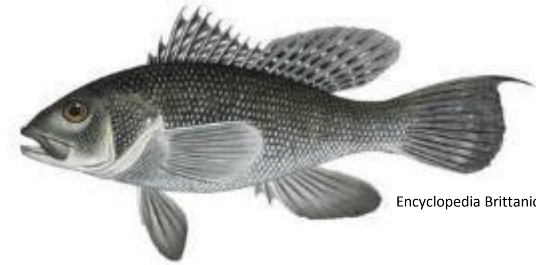


Figure 13: Pie chart showing the percentage of each type of anthropogenic particles.

Will be analyzed via micro-FTIR at a collaborating facility

Summary

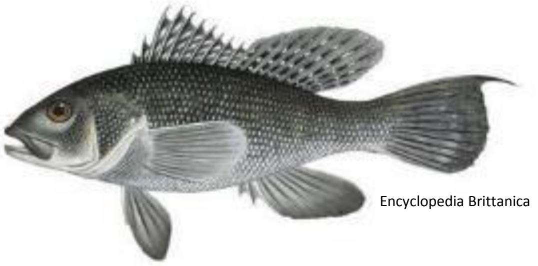

Encyclopedia Brittanica

- Cultured larvae (13-14 days post hatch) ingested an increasing number of microplastics (10-20 micron) with increasing plastic concentration
  - Ingested more microplastics from prey (tintinned ciliates)
  - Ingested more pre-cleaned plastics than contaminated directly from water

Summary

- Cultured larvae (13-14 days post hatch) ingested an increasing number of microplastics (10-20 micron) with increasing plastic concentration
  - Ingested more microplastics from prey (tintinned ciliates)
  - Ingested more pre-cleaned plastics than contaminated directly from water
- Cultured juveniles (50-60 dph) had no significant difference in respiration between direct ingestion treatments, but trophically transferred pre-cleaned plastics caused increased O2 consumption
- Microfibers encountered directly in water also caused increased O2 consumption
- Immune response was only significantly affected in pre-cleaned plastic when comparing across direct ingestion treatments, DTBP (from prey) may also have an effect on immune response
- Wild sea bass are ingesting macro and microplastics
- Ingestion may depend on biofilm presence and chemical type, results unclear

Implications, Questions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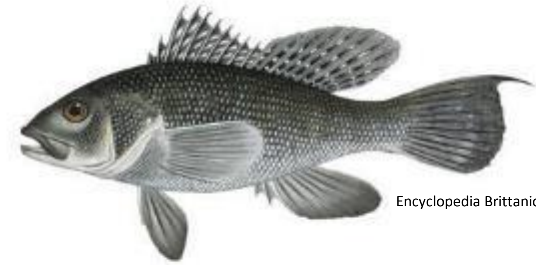
- Can sea bass larvae discriminate between contaminated and ”cleaned” microparticles, more pre-cleaned particles directly ingested
- Larval silverside prey may also discriminate between contaminated and clean particles? Same trend with juveniles re: trophically transferred pre-cleaned particles affecting juvenile sea bass respiration
- Microfibers encountered by juvenile sea bass in water cause increased respiration, are they getting caught in gills?

Implications, Questions



- Can sea bass larvae discriminate between contaminat microparticles, more pre-cleaned particles directly ingested

- Larval silverside prey may also discriminate between contaminated and clean particles? Same trend with juveniles re: trophically transferred pre-cleaned particles affecting juvenile sea bass respiration

- Microfibers encountered by juvenile sea bass in water cause increased respiration, are they getting caught in gills?

- Juvenile immune response was also only affected in directly ingested pre-cleaned plastics treatment

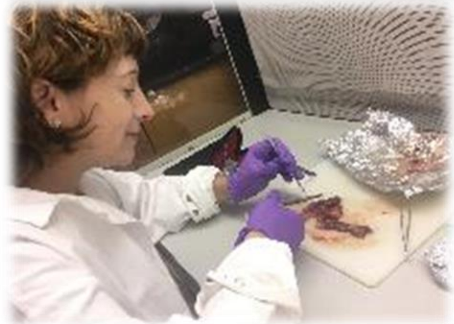
- Most surprising result thus far is that more pre-cleaned plastics are ingested by larval sea bass, and appear to cause sublethal effects in juveniles

- Are associated chemicals adding more to exposure from food and water, or perhaps not? Likely chemical and species dependent.

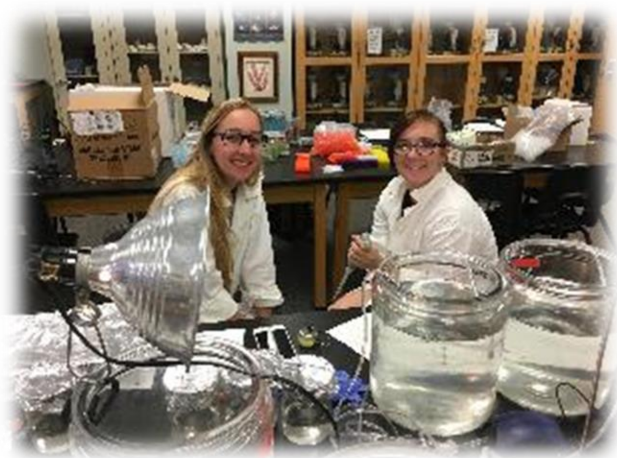
Future Directions

- Analysis of microplastics in wild fish
- Analysis of livers in adult pellet-fed fish
  - Phthalates, gene expression

- Weight of evidence analysis / risk assessment based on combined evaluation of field and laboratory data



Acknowledgments



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Any Questions?

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% DOP on control Vs. recovered pellets

No biofilm pellets		Biofilm pellets	
NB- Control	NB- Recovered	B-Control	B-Recovered
E50 pellets (% DOP)	Tank 12 and 13 (% DOP)	Tank#15 uneaten pellets (% DOP)	Tank#16,17 (% DOP)
10.2	11.3	10.6	11.5
12.4	12.0	9.6	10.8
11.1	11.8	10.6	11.8
10.2			11.2
			12.0
			11.1
			11.0
			8.8
			11.2

Sierra 785 Raman

ATR-FTIR (Nicolet iS5 with iD7 ATR)