Microplastic biomagnification in invertebrates, fish, and cormorants of Lake Champlain

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Introduction

- **Microplastics** are plastic particles < 5 mm in size and can be divided into two main categories.
  - **Primary microplastics** are most commonly used in cosmetics or produced for industrial uses (nurdles). These are typically discharged into watersheds through wastewater treatment plant (WWTP) effluent and onward into waterbodies.
  - **Secondary microplastics** are derived from the breakdown of larger plastic debris via mechanical and biological processes, and photodegradation (Galloway et al. 2011). They are also comprised of marine debris (e.g., lures, line/rope, nets).
- Microplastics can be further characterized as fibers, fragments, films, foams, pellets, and nurdles, which readily pass through WWTP filtration and into local watersheds.
- Microplastics are hydrophobic particles that adsorb pollutants and biomagnify within the food web (Stevens 2015).
- Microplastics are ubiquitous in aquatic systems, found within organisms of all sizes, from invertebrates to whales (Fig. 1; Baulch et al. 2014).

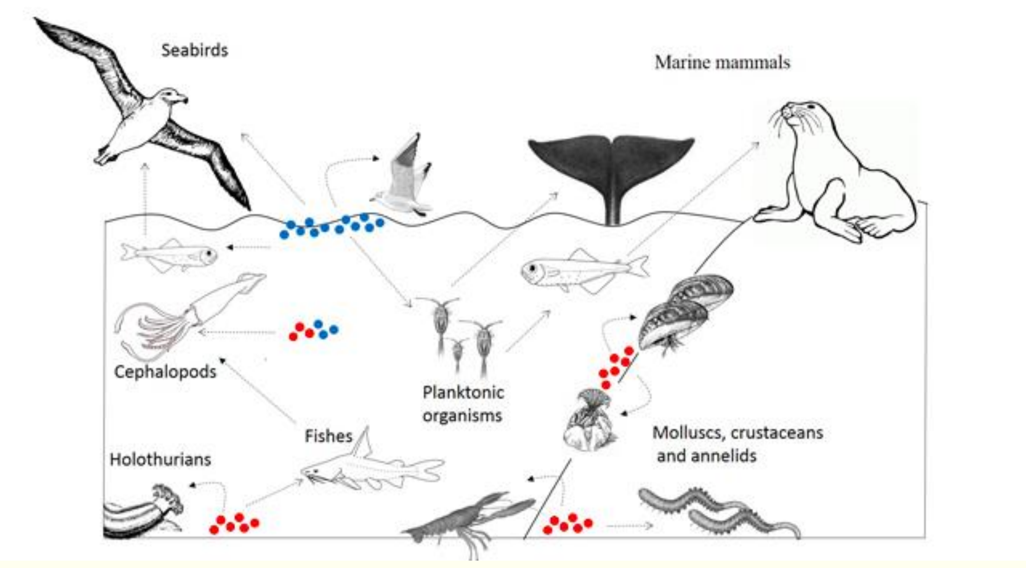


Fig. 1. Microplastics biomagnifying in marine system (Ivar du Sol et al. 2013).

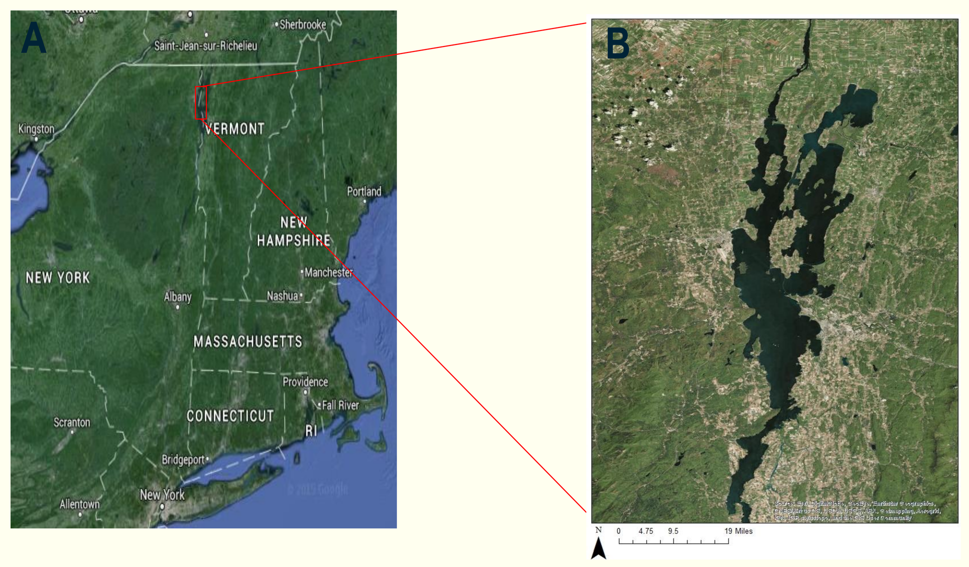
Goal

To survey and characterize microplastics found within the digestive tracts of aquatic organisms including *Phalacrocorax auritus* (Double-crested cormorants), as well as various fish and invertebrate species.

Hypothesis

We predict greater microplastic abundance in organisms occupying higher trophic levels and predominantly fibers.

Lake Champlain Basin



Figs. 2. A) Lake Champlain Basin relative to NY and VT B) Lake Champlain.

Field Methodology

Sources of organisms:

- Rainbow smelt, alewife → Vermont Fish & Game monitoring surveys
- Double-crested cormorants→ NYS DEC management project
- Mysids, amphipods, zebra mussels, and fish→ Lake Champlain Research Institute (LCRI) via 250 µm Bongo and kick nets
- Lake trout, large and smallmouth bass, northern pike, Atlantic salmon, sheepshead, rock bass, white and yellow perch → Lake Champlain International Father's Day Derby
- Yellow perch→ SUNY Plattsburgh's fishing team

Laboratory Methodology

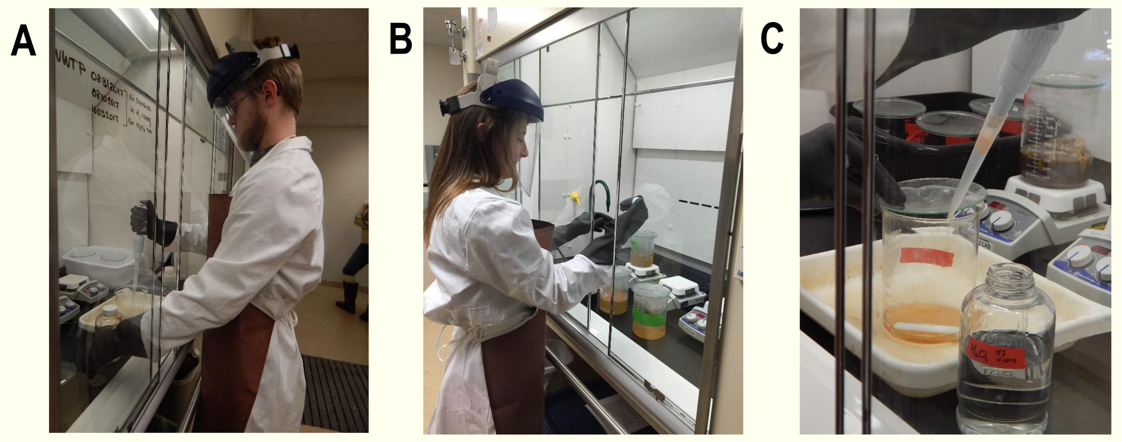


Fig. 3. (A) Josh adding KOH (strong base), **(B,C)** Alex adding H_2O_2 and heating/stirring of wet peroxide oxidation.

- 30 mL of 4M KOH was added to sample before being heated to 60ºC and stirred to initiate tissue breakdown.
- KOH dosed samples were removed from heat and 5 mL of 30% H_2O_2 was added and stirred at 350 rpm for 15 min.
- Samples were then sieved through a 125 µm sieve and rinsed with DI water.
- **Wet-peroxide oxidation:** 20 mL of $FeSO_4$ and 20 mL H_2O_2 were added to samples, heated at 75ºC while stirring at 350 rpm. Aliquots of 20 ml H_2O_2 were added as needed for clearing.
- Digested samples were filtered through 1 mm, 355 µm, and 125 µm sieves for size separation and washed with DI water.
- Microplastics were characterized by type and color (e.g., fiber, film, fragment, foam, pellet/bead, and nurdle) using Leica Ez4 and Zeiss Stemi 2000-c stereomicroscopes, and stored in 5 mL shell vials and DI water.
- Polymeric confirmation will proceed in the future with Fourier Transform Infrared Spectroscopy (FT-IR).

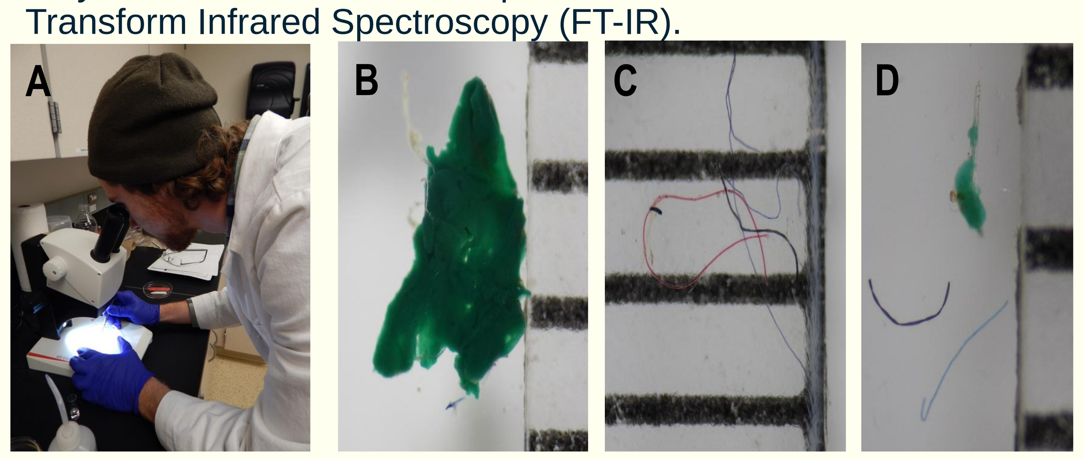


Fig. 5. (A) James identifying microplastics stereoscopically. **(B-D)** Microplastic found within rainbow smelt and alewife digestive tracts. Ruler scale (1 mm).

Results

- All species contained microplastics with the exception of terrestrial isopods.

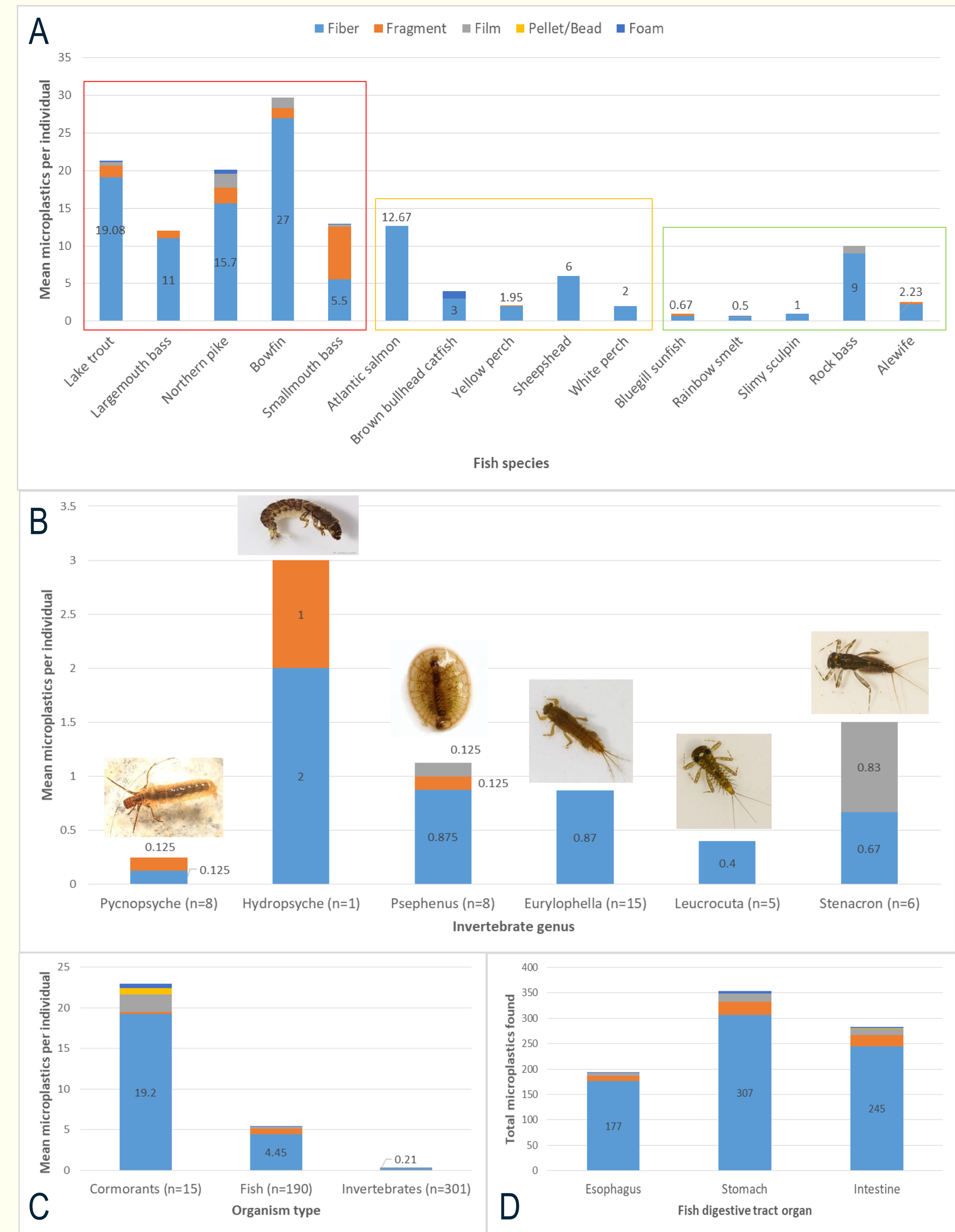
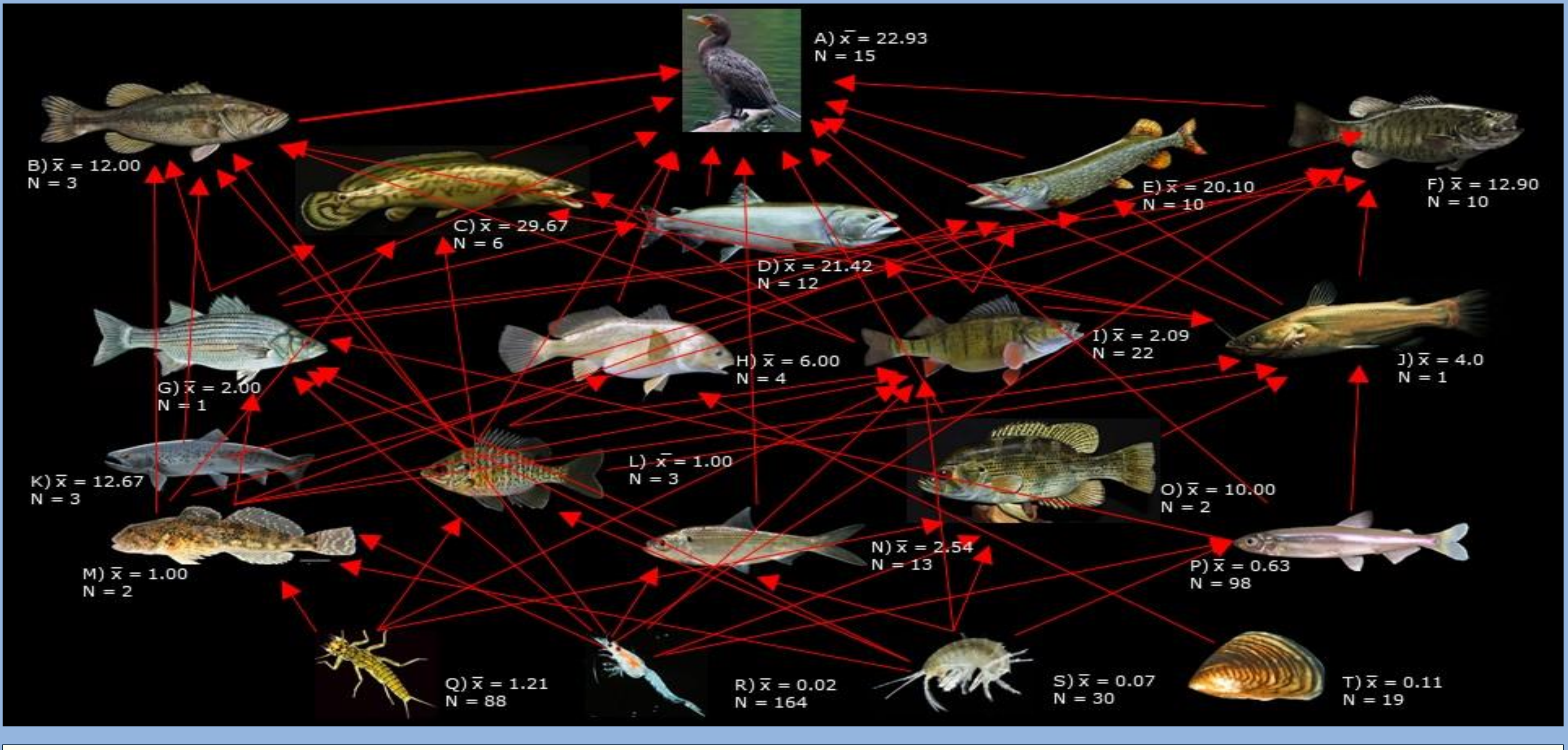


Fig. 6. (A). Species-specific mean number of microplastics found per individual fish and trophic level (lowest: green, highest: red). **(B)** Mean number of microplastics found per invertebrate genus **C)** Mean number of microplastics found per organism type (fiber values displayed). **(D)** Total number of microplastics per fish organ. (fiber values displayed).



Figs. 7. (A-T). Organisms sampled within the Lake Champlain food web. Mean microplastics consumed and organism abundance reported. **A)** double-crested cormorant **B)** largemouth bass **C)** bowfin **D)** lake trout **E)** northern pike **F)** smallmouth bass **G)** white perch **H)** sheepshead **I)** yellow perch **J)** bullhead catfish **K)** Atlantic salmon, **L)** bluegill sunfish **M)** slimy sculpin, **N)** alewife **O)** rock bass **P)** rainbow smelt **Q)** arthropods **R)** mysids **S)** amphipods **T)** zebra mussels.

Size separation via sieves (excluding amphipods and zebra mussels):

- **1 mm** → 310 fibers, 23 films, 9 fragments, 5 foams, and 3 pellets
- **355 µm** → 429 fibers, 37 films, 27 fragments, 6 foam, and 2 pellets
- **125 µm** → 468 fibers, 33 films, 109 fragments, 8 foams, and 8 pellets

Discussion

- Presence of MP's was noted in macroinvertebrates ($\bar{\chi} = 0.36$), 15 fish species ($\bar{\chi} = 5.45$), and double-crested cormorants ($\bar{\chi} = 22.93$) (Figs. 6, 7) demonstrating biomagnification in Lake Champlain.
  - Among digested fish, stomachs contained the greatest mean number of MP's ($\bar{\chi} = 5.62$), followed by the esophagus ($\bar{\chi} = 5.36$) and intestines ($\bar{\chi} = 4.80$).
  - Hydropsyche, the only filter-feeding insect digested, contained the greatest mean number of MP's ($\bar{\chi} = 3.0$). Filter feeders might be more susceptible to long-term accumulation of MP's (Goldstein, 2013).
- Fibers (80.1%) were the most common type of particulate found in all organisms.
  - ➢ Other particles included fragments (9.64%), films (6.36%), foam (3.01%), and pellets (<1%).
  - ➢ Most abundant plastics in North Sea fish digestive tracts were rayon and polyamide textile fibers (Lusher et al. 2013).
  - ➢ 87% of MP's found in freshwater tubifex worms were fibers ranging from 55 um - 4.1 mm (Hurley et al. 2017).
- Many organisms mistake these MP's for food (Foekema et al. 2013).
  - ➢ Studies have shown that MP's adhere to algae (Gutow et al. 2016).
  - ➢ 61% surveyed zooplankton contained MP's (Frias et al. 2014).
  - ➢ 19.8% of fish, across 17 species, ingested MP's and 32.7% of them had more than one MP. Fish length/age and proximity to urbanization increased particulate load (Neves et al. 2015).
  - ➢ MP holding time likely linked to capacity for bioaccumulation (Santana et al. 2017).
- Negative impacts of MP exposure in aquatic systems have been reported, including reduced feeding activity, enhanced absorption of contaminants (Besseling et al. 2012), reduced energy reserves (Wright et al. 2013), and lesser reproductive output (Ziajahromi et al. 2017).
- Human risks range from consumption of seafood (Van Cauwenberghe and Janssen 2014), beer (Liebezeit and Liebezeit 2014), and sea salt (Yang et al. 2015), to pathogenic spread (Keswani et al. 2016).
  - ➢ MP's linked to physical and cellular damage, inflammation, and lacerations of gastrointestinal (GI) tract (Rochman et al. 2015).
- We suggest that aquatic and semi-aquatic organisms can intake MP's cascading through the trophic web in addition to direct consumption.
  - Our evidence illustrates the need for people to reevaluate and reduce their dependency on plastic products.

Future Directions

- Continue characterizing microplastics to polymer type using FT-IR (Fourier Transform Infrared spectroscopy).
- Finish processing digestive tracts to increase diversity across guilds.
- Encourage outreach regarding consumer behavioral changes, including reducing plastic purchases, and laundering using fiber catchers such as the Guppy Friend bag (Patagonia) and Cora Ball (Rozalia Project) (Fig. 8).

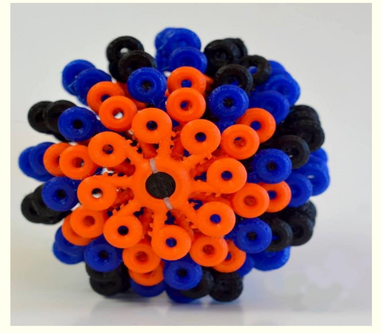


Fig. 8. Cora Ball microfiber catcher.

Acknowledgements

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